FREIGHTLINER

Run Smart

BUSINESS CLASS TRUCKS SERVICE MANUAL

Models: FL50
FL60
FL70
FL80
FL106
FL112
MB50
MB60
MB70
MB80

STI-267, S34 (1/08P)

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

Foreword

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

Instructions and procedures are those recommended by Daimler Trucks North America LLC or the component manufacturer.

Maintenance schedules and additional service information are included in the *Business Class® Trucks Maintenance Manual*.

IMPORTANT: Descriptions and specifications in this manual were in effect at the time of printing. Daimler Trucks North America LLC reserves the right to discontinue models at any time, or change specifications and design without notice and without incurring obligation.

For additional information, please contact Daimler Trucks North America LLC, Service Systems and Documentation, P.O. Box 3849, Portland, OR 97208-3849, U.S.A. or refer to www.Daimler-TrucksNorthAmerica.com and www.FreightlinerTrucks.com.

Environmental Concerns and Recommendations

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

NOTICE: Parts Replacement Considerations

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

© 1995-2008 Daimler Trucks North America LLC

All rights reserved. No part of this publication, in whole or in part, may be translated, reproduced, stored in a retrieval system, or transmitted in any form by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of Daimler Trucks North America LLC.

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

Descriptions of Service Publications

Daimler Trucks North America LLC distributes the following major service publications.

Workshop/Service Manual

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

Maintenance Manual

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

Driver's/Operator's Manual

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

Parts Technical Manual

Daimler Trucks North America LLC publishes this manual to aid in the identification of serviceable replacement vehicle parts. This manual is used in conjunction with the parts book and the service parts catalog microfiche.

Service Bulletins

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

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

Recall Bulletins

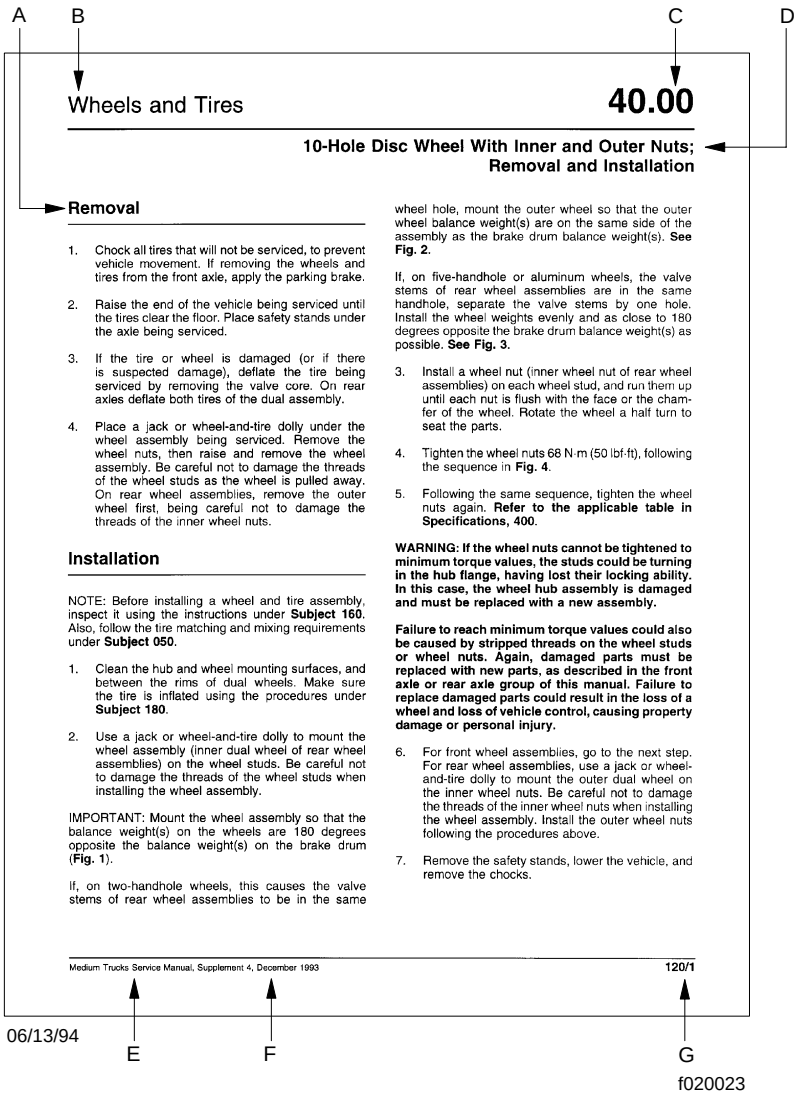
These bulletins pertain to special situations that involve service work or replacement of parts in connection with a recall notice. Recall bulletins pertain to matters of vehicle safety. All bulletins are distributed to dealers; customers receive notices that apply to their vehicles.

Field Service Modifications

This publication is concerned with non-safety-related service work or replacement of parts. All field service modifications are distributed to dealers; customers receive notices that apply to their vehicles.

Page Description

For a page example of the printed manual, see **Fig. 1**.



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

Fig. 1, Page Example of the Printed Manual

Service Manual Contents

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

Vehicle Receipt

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

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

Refer to Section 3 of the Freightliner LLC *Warranty Manual* for details.

Vehicle Storage

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

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

See Section 3 of the Freightliner LLC *Warranty Manual* for instructions on storage of new vehicles.

Pre-Delivery Information

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

Refer to Section 3 of the Freightliner LLC *Warranty Manual* for details.

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

Hoses and Electrical Wiring Routing Standards

Cooling System

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

HVAC System

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

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

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

Engine Plumbing

The engine oil pressure line should not rub or chafe against the Teflon® discharge line.

Electrical Wiring

1. Wires that are bundled together should be fastened at 8- to 12-inch (203- to 305-mm) intervals. If anchor clamps are more than 12 inches (305 mm) apart, a tie strap must be used between the anchor clamps.
2. Bundles of wires that are located in an exposed area, such as under the cab or outside the frame rail, need to be fastened with heavy-duty cable ties.
3. Any wiring that will be exposed to water or heat must be covered with either loom or convoluted tubing. Loom or convoluted tubing need not butt up against Weather Pack® connectors.
4. Any wiring routed across the vehicle, on the engine crossmember, or across the rear of the engine, must be secured with a clamp or tie strap, and covered with either convoluted tubing or a loom.
5. Any wiring that may come into contact with sharp points and edges (such as nuts, bolts, brackets, and frame rail edges), moveable parts, and sources of abrasion, cutting, pinching, or crushing, must be protected by either a loom or convoluted tubing.
6. Unprotected breakouts (individual wires) of up to eight inches (203 mm) are acceptable as long as these wires are routed safely away from sharp

points and edges, moveable parts, and sources of abrasion, cutting, pinching, or crushing.

7. Gray, flame-retardant convoluted tubing may be used to protect wiring in the cab or the chassis. Black nylon convoluted tubing may only be used in the chassis.
8. All wiring must be routed so that regularly serviced components, such as fuel filters, fuel/water separators, oil filters, air filters, belts, and fill and drain plugs, are readily accessible for adjustment or replacement without the need to relocate or remove any wiring.
9. In exposed locations, such as the road light harness near the headlights, loose loops of wire must be secured with tie straps.
10. All wiring should be routed a minimum of four inches (102 mm) from the exhaust. In situations where the wiring is less than four inches (102 mm) from the exhaust, a heat shield must be placed between the wiring and the exhaust.

Battery Cables

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

Fuel Lines

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

Chassis Air Lines and Brake Hoses

1. Hoses may come in contact with each other if they are parallel, or if they are bundled together.
2. If the hoses lie on the curve or flat surface of a bracket or crossmember, they do not need convoluted tubing.
3. Brake hoses may be clamped at the top of the axle housing, and touch or lie against the axle housing in its path to the brake chamber as this assembly moves together.
4. Brake hoses must have slack between the last clamping point on the rail and brake chamber to allow for full range of suspension travel.
5. Brake hoses should have butterfly clamps at breakout points.
6. Air lines and brake hoses that are bundled together should be fastened at 8- to 12-inch (203- to 305-mm) intervals. If anchor clamps are more than 12 inches (305 mm) apart, a tie strap must be used between the anchor clamps. Tie straps may be closer than 12 inches (305 mm) apart.
7. Hoses or lines that may come into contact with the sharp edge of a bracket or frame rail are to be protected by convoluted tubing.
8. Air lines and brake hoses that are parallel may be fastened together. Air lines and brake hoses that cross or that rub on metal, plastic, or electrical parts need to be separated with butterfly clamps.
9. Nylon or STX (wire braid) chassis air lines may be fastened together to prevent rubbing, as long as the lines are stationary.

Refer to tables in this subject for conversion factors.

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

General Information

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

VIN for Vehicles Built through April 30, 2000

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

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

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

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

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

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

NOTE: Always specify the VIN when ordering parts.

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

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

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

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

VIN for Vehicles Built through April 30, 2000

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

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

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

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

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

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

VIN for Vehicles Built through April 30, 2000

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

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

* MY = Model Year

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

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

VIN for Vehicles Built through April 30, 2000

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

VIN for Vehicles Built through April 30, 2000

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

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

VIN for Vehicles Built through April 30, 2000

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

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

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

Table 7, VIN Position 10 (Vehicle Model Year)

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

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

Table 8, VIN Position 11 (Plant of Manufacture)

VIN for Vehicles Built from May 1, 2000

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

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

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

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

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

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

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

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

NOTE: Always specify the VIN when ordering parts.

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

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

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

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

VIN for Vehicles Built from May 1, 2000

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

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

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

Table 3, VIN Position 4 (Chassis Configuration)

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

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

VIN for Vehicles Built from May 1, 2000

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

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

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

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

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

VIN for Vehicles Built from May 1, 2000

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

VIN for Vehicles Built from May 1, 2000

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

VIN for Vehicles Built from May 1, 2000

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

VIN for Vehicles Built from May 1, 2000

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

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

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

Table 6, VIN Position 10 (Model Year)

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

Table 7, VIN Position 11 (Build Location)

General Information

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

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

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

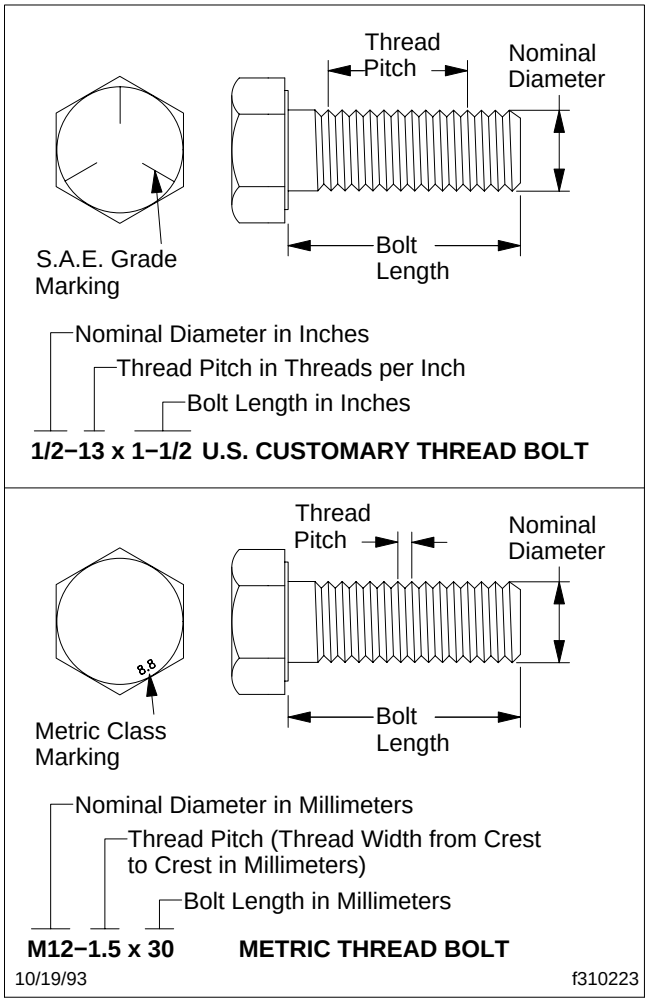


Fig. 1

Fastener Grades and Classes

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

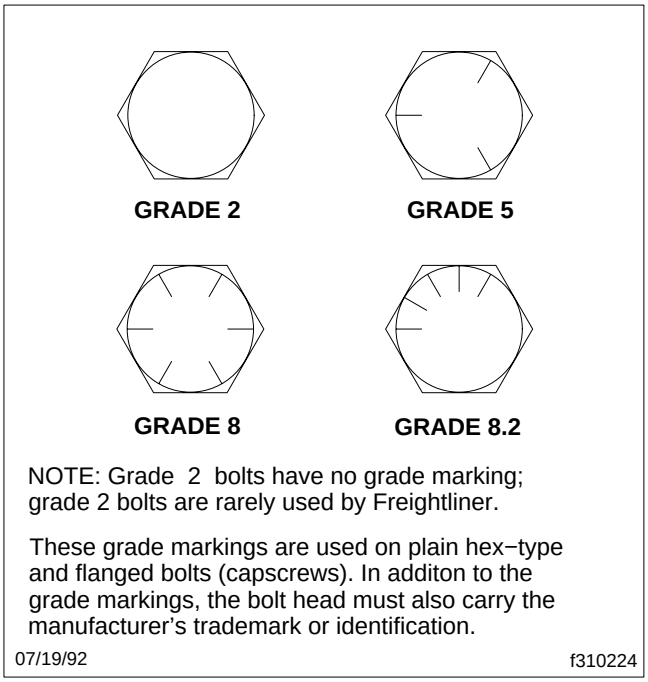


Fig. 2

General Information

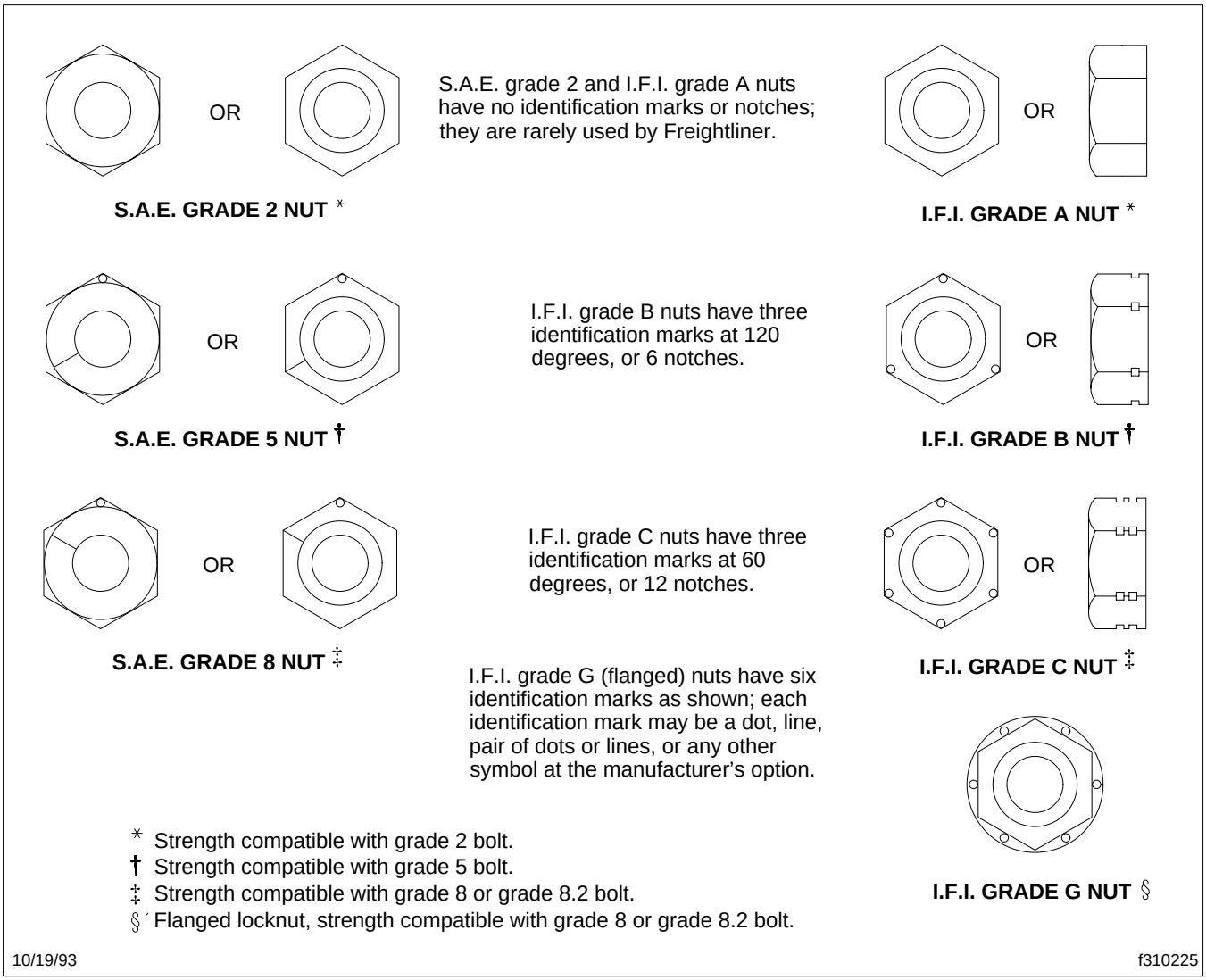


Fig. 3

Fasteners with metric threads are divided into classes adopted by the American National Standards Institute (ANSI). The higher the class number, the stronger the fastener. Bolt classes can be identified by the numbers forged on the head of the bolt. **Refer to Fig. 4.** Hexnut (and locknut) classes can be identified by the marks or numbers on various surfaces of the nut. **Refer to Fig. 5.** Class 8 hexnuts are always used with class 8.8 bolts; class 10 hexnuts with class 10.9 bolts.

Frame Fasteners

For most components attached to the frame, grade 8 and 8.2 phosphate-and oil-coated hexhead bolts and grade C cadmium-plated and wax-coated prevailing torque locknuts are used. The prevailing torque locknuts have distorted sections of threads to provide torque retention. For attachments where clearance is minimal, low-profile hexhead bolts and grade C prevailing torque locknuts are used. **See Fig. 6.**

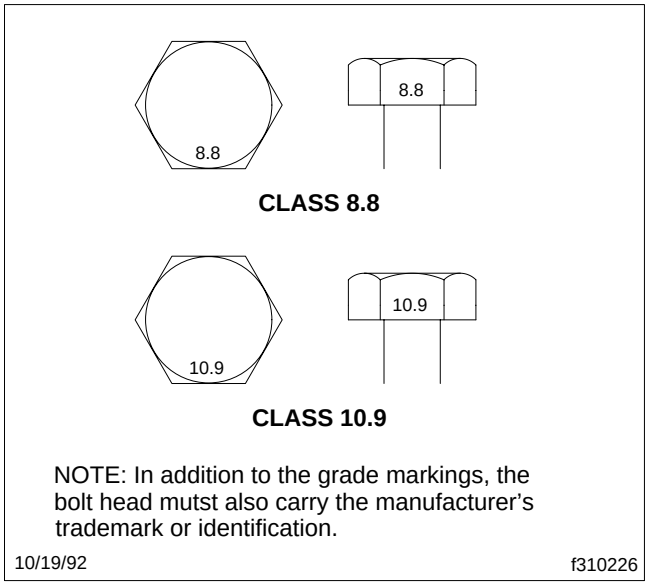


Fig. 4

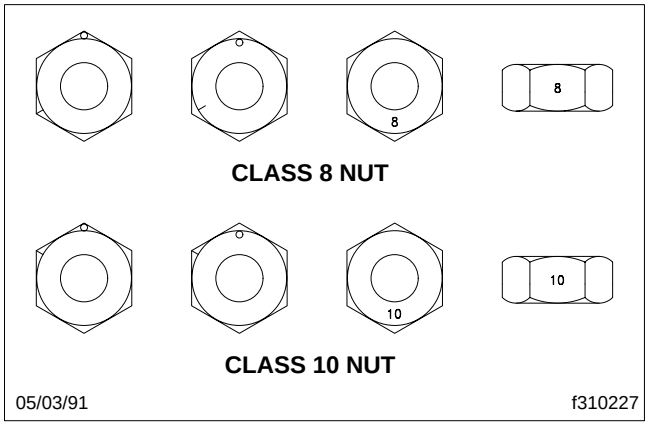
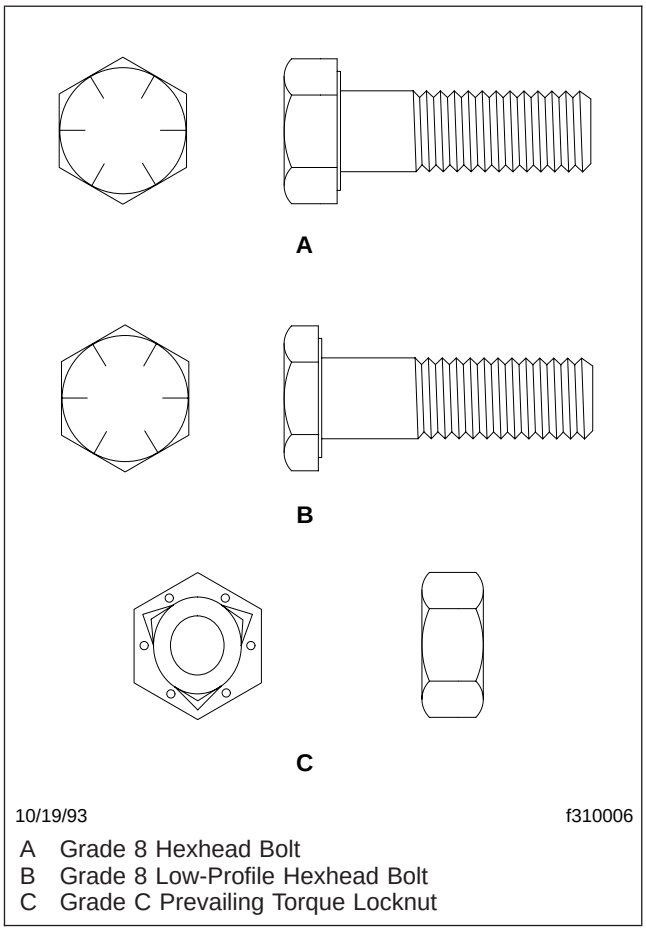


Fig. 5

Tightening Fasteners

When a capscrew is tightened to its torque value in a threaded hole, or a nut is tightened to its torque value on a bolt, the shank of the capscrew or bolt is stretched slightly. This stretching (tensioning) results in a preload that reduces fatigue of the fasteners. The torque values given in the tables in Subject 400 have been calculated to provide enough clamping force on the parts being fastened, and the correct tensioning of the bolt to maintain the clamping force.

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



A Grade 8 Hexhead Bolt
B Grade 8 Low-Profile Hexhead Bolt
C Grade C Prevailing Torque Locknut

Fig. 6

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

The amount of torque required to tighten a fastener is reduced when the amount of friction is reduced. If a fastener is dry (unlubricated) and plain (unplated), the amount of friction is high. If a fastener is wax-coated or oiled, or has a zinc phosphate coating or cadmium plating, the amount of friction is reduced.

General Information

Each of these coatings and combinations of coatings has a different effect. Using zinc-plated hardened flatwashers under the bolt (capscrew) head and nut reduces the amount of friction. Dirt or other foreign material on the threads or clamping surfaces of the fastener or clamped part also changes the amount of friction.

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

Fastener Replacement

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

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

Fastener Selection and Installation

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

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

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

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

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

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

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

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

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

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

Fastener Tightening

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

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

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

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

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

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

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

Tighten frame fasteners periodically to offset the effects of "bedding in" (seating). Continued vehicle operation with loose frame fasteners could result in component, bracket, and frame damage. Refer to the Maintenance Schedule and Group 31 of the vehicle maintenance manual for intervals.

Thread Locking Compound Application

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

General Instructions

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

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

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

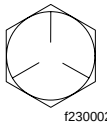
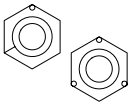
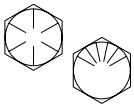
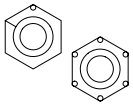
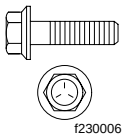
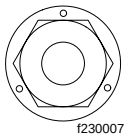
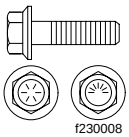
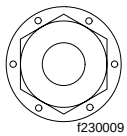
1. Clean the male and female threads of the fasteners, removing all dirt, oil, and other foreign material. If parts are contaminated, use Stoddard solvent for cleaning; then allow the fasteners to air dry for 10 minutes. Be sure solvent is completely gone before applying adhesive.
2. Transfer a small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

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

Specifications

This subject contains the following tables:

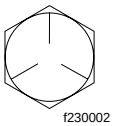
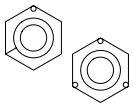
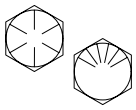
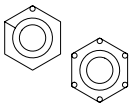
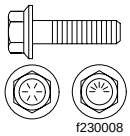
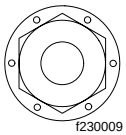
- Torque Values for U.S. Customary Thread Fasteners with Lubricated or Plated Threads
- Torque Values for U.S. Customary Thread Fasteners with Dry (Unlubricated) or Plain (Unplated) Threads
- Torque Values for Metric Thread Fasteners with Lubricated or Plated Threads

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

* Freightliner recommends that all plated and unplated fasteners be coated with oil before installation.
† Use these torque values if either the bolt or nut is lubricated or plated (zinc-phosphate conversion-coated, cadmium-plated, or waxed).

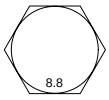
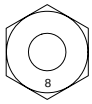
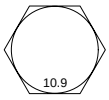
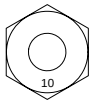
Table 1, Torque Values for U.S. Customary Thread Fasteners With Lubricated or Plated Threads

Specifications

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

* Threads may have residual oil, but will be dry to the touch.
† Male and female threads (bolt and nut) must both be unlubricated and unplated; if either is plated or lubricated, use **Table 1**. Freightliner recommends that all plated and unplated fasteners be coated with oil before installation.

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

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

* Freightliner recommends that all plated and unplated fasteners be coated with oil before installation.
† Use these torque values if either the bolt or nut is lubricated or plated (zinc-phosphate conversion-coated, cadmium-plated, or waxed).

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

List of Abbreviations

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

A ..... amperes
ABS ..... antilock braking system
ABS ..... acrylonitrile-butadiene-styrene
A/C ..... air conditioner
AC ..... alternating current
ACPU ..... air conditioning protection unit
ADLO ..... auto-disengagement lockout
a.m. ..... *ante meridiem* (midnight to noon)
AM ..... amplitude modulation
amp(s) .... ampere(s)
AMU ..... air management unit
ANSI ..... American National Standards Institute
API ..... American Petroleum Institute
ARI ..... Air Conditioning and Refrigeration Institute
ASA ..... American Standards Association
ASF ..... American Steel Foundries
ASR ..... automatic spin regulator
assy. ..... assembly
ASTM ..... American Society for Testing and Materials
ATC ..... automatic temperature control
ATC ..... automatic traction control
ATC ..... automatic transmission control
ATF ..... automatic transmission fluid
attn ..... attention
aux. ..... auxiliary
av ..... *avoirdupois* (British weight system)
AWG ..... American wire gauge
AWS ..... American Welding Society
BAT ..... battery
BBC ..... bumper-to-back-of-cab
BOM ..... bill of material
BTDC ..... before top dead center
Btu(s) ..... British thermal unit(s)
C ..... common (terminal)
CAC ..... charge air cooler
CAN ..... controller area network
CARB ..... California Air Resources Board
CAT ..... Caterpillar
CB ..... circuit breaker
CB ..... citizens' band
CCA ..... cold cranking amperes
CD-ROM .. compact-disc/read-only memory
CDTC ..... constant discharge temperature control
CEL ..... check-engine light
CFC ..... chlorofluorocarbons (refrigerant-12)
cfm ..... cubic feet per minute
CFR ..... Code of Federal Regulations
CLS ..... coolant level sensor
cm ..... centimeters
cm^3 ..... cubic centimeters
CMVSS .... Canadian Motor Vehicle Safety Standard
Co. ..... company
COE ..... cab over engine
Corp. ..... corporation
CPU ..... central processing unit
cSt ..... centistokes (unit of measurement for describing the viscosity of general liquids)
cu ft ..... cubic feet
cu in ..... cubic inches
CUM ..... Cummins
CWS ..... collision warning system
DC ..... direct current
DDA ..... Detroit Diesel Allison
DDC ..... Detroit Diesel Corporation
DDE ..... Detroit Diesel Engines
DDEC ..... Detroit Diesel Electronic (engine) control
DDR ..... diagnostic data reader
DDU ..... driver display unit
DGPS ..... differential global positioning system
dia. ..... diameter
DIP ..... dual inline package (switch)
DLA ..... data link adaptor
DLU ..... data logging unit
DMM ..... digital multimeter
DOT ..... Department of Transportation
DRL ..... daytime running lights
DRM ..... dryer reservoir module
DSM ..... district service manager
DTC ..... discharge temperature control
DVOM ..... digital volt/ohm meter
ea. ..... each
EBS ..... electronic braking system
ECAP ..... electronic control analyzer programmer
ECAS ..... electronically controlled air suspension
ECI ..... electronically controlled injection
ECM ..... electronic control module
ECU ..... electronic control unit
EDM ..... electronic data monitor
EEPROM .. electrically erasable programmable read-only memory
EMI ..... electromagnetic interference
EOA ..... electric over air
EP ..... extreme pressure (describes an antiwear agent added to some lubricants)
EPA ..... Environmental Protection Agency
EPS ..... engine position sensor
etc. ..... *et cetera* (and so forth)
ETEC ..... electronic truck engine control
EUI ..... electronic unit (fuel) injectors
FAS ..... Freightliner air suspension
Fig. ..... figure
fl oz ..... fluid ounces
FLA ..... post-1984 advancements Freightliner COE
FLB ..... enhanced Freightliner FLA COE
FLC ..... steel-cab Freightliner 112 Conventional
FLD ..... post-1984 advancements Freightliner 112/120 aluminum-cab Conventional
FM ..... frequency modulation
FMCSA .... Federal Motor Carrier Safety Administration
FMI ..... failure mode identifier
FMSI ..... Friction Materials Standards Institute
FMVSS .... Federal Motor Vehicle Safety Standard
FRP ..... fiberglass reinforced plastic
FSA ..... field service authorization
ft ..... feet
ft^3 ..... cubic feet
ft^3/min ..... cubic feet per minute
FTL ..... Freightliner
F.U.E.L. .... fuel usage efficiency level
g ..... grams

List of Abbreviations

gal ..... gallons
GAWR ..... gross axle weight rating
GL ..... gear lubricant
GND ..... ground
gpm ..... gallons per minute
GPS ..... global positioning system
GVWR ..... gross vehicle weight rating
HCU ..... hydraulic control unit
HD ..... heavy-duty
HEPA ..... high-efficiency particulate air (filter)
HFC ..... hydrogenated fluorocarbons (refrigerant-134a)
hp ..... horsepower
hp ..... high pressure
HRC ..... Rockwell "C" hardness
hr(s) ..... hour(s)
htr ..... heater
HVAC ..... heating, ventilating and air conditioning
H/W ..... hardware
ICU ..... instrumentation control unit
i.d. ..... inside diameter
ID ..... identification
IFI ..... Industrial Fasteners Institute
IGN ..... ignition
ILO ..... *in lieu of* (in the place of)
in ..... inches
in^3 ..... cubic inches
Inc. ..... incorporated
inH_2O ..... inches of water
inHg ..... inches of mercury
IP ..... instrument panel
ISO ..... International Organization for Standardization
k ..... kilo (1000)
kg ..... kilograms
km ..... kilometers
km/h ..... kilometers per hour
kPa ..... kilo Pascals
kW ..... kilowatts
L ..... liters
lb ..... pounds
lbf·ft ..... pounds force feet
lbf·in ..... pounds force inches
LCD ..... liquid crystal display
LED ..... light-emitting diode
LH ..... left-hand
LH DR ..... left-hand drive
LHK ..... liters per hundred kilometers
LHS ..... low hydrogen steel
LLC ..... limited liability company
L/min ..... liters per minute
LPG ..... liquefied petroleum gas
m ..... meters
max. ..... maximum
MESA ..... Mining Enforcement Safety Act
mfr. ..... manufacturer
mi ..... miles
MID ..... message identifier
MIL ..... military specification
min. ..... minutes
min. ..... minimum
misc. ..... miscellaneous
mL ..... milliliters
mm ..... millimeters
mod. ..... module
mpg ..... miles per gallon
mph ..... miles per hour
MSHA ..... Mining Safety and Health Administration
MVDA ..... Motor Vehicle Dealers Association
n ..... negative (front axle wheel alignment specification)
N/A ..... not applicable
N·cm ..... Newton-centimeters
NC ..... normally closed (terminal or switch)
NHTSA ..... National Highway Traffic Safety Administration
NIOSH ..... National Institute for Occupational Safety and Health
NLGI ..... National Lubricating Grease Institute
N·m ..... Newton-meters
NO ..... normally open (terminal or switch)
no. ..... number
NPT ..... national pipe thread
NPTF ..... national pipe thread fitting
NSBU ..... neutral start/backup
NT ..... nylon tube or nylon tubing
OCV ..... open circuit voltage
o.d. ..... outside diameter
O.D. ..... overdrive
OEM ..... original equipment manufacturer
OSHA ..... Occupational Safety and Health Administration
oz ..... ounces
ozf·in ..... ounces force inches
p ..... positive (front axle wheel alignment specification)
parm ..... parameter
PC ..... personal computer
PCB ..... printed circuit board
PDC ..... parts distribution center
PDM ..... power distribution module
PEEC ..... programmable electronic engine control
PID ..... parameter identifier
PLC ..... power line carrier
PLD ..... *Pumpe-Linie-Düse* (pump-line-nozzle)
p.m. ..... *post meridiem* (noon to midnight)
p/n ..... part number
PSA ..... pressure sensitive adhesive
psi ..... pounds per square inch
psia ..... pounds per square inch, atmosphere
psig ..... pounds per square inch, gauge
pt ..... pints
pt ..... points
PTCM ..... pressure time control module
PTO ..... power take-off
pvc ..... polyvinyl chloride
PWM ..... pulse width modulation
qt ..... quarts
qty. ..... quantity
R & O ..... rust inhibitors and oxidants
R–12 ..... refrigerant-12 (CFC)
R–134a ..... refrigerant-134a (HFC)
RAM ..... random access memory
recirc ..... recirculation
Ref(s). ..... reference(s)
RFI ..... radio frequency interference
RH ..... right-hand
RH DR ..... right-hand drive
R/I ..... removal and installation
RMA ..... return material authorization
ROM ..... read-only memory
rpm ..... revolutions per minute
R/R ..... removal and replacement
RSG ..... road speed governor
RTV ..... room temperature vulcanizing

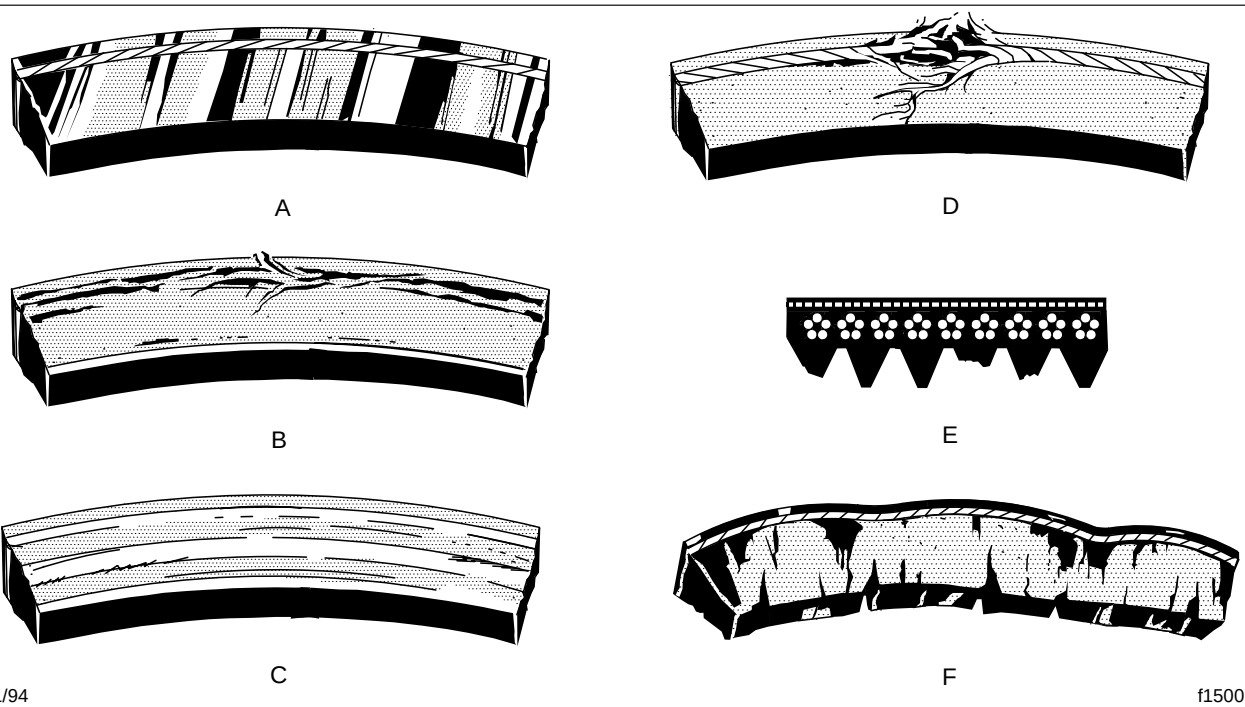
List of Abbreviations

RV ..... recreational vehicle
SAE ..... Society of Automotive Engineers
SB ..... service bulletin
SD ..... severe duty
SDU ..... step deployment unit
SEL ..... shutdown engine light
SI ..... service information
SI ..... *Système International*
SID ..... subsystem identifier
SMC ..... sheet molded compound
S/N ..... serial number
SPACE .... seat pretensioner activation for crash survival enhancement
SRT ..... standard repair time
SSD ..... side sensor display
SST ..... stainless steel
std. ..... standard
S/W ..... software
SW ..... switch
TAM ..... thermocouple amplifier module
TBS ..... turbo boost sensor
TCU ..... transmission control unit
TDC ..... top dead center
TDR ..... technician diagnostic routine
temp ..... temperature
TIG ..... tungsten inert gas
TPS ..... thermal protection switch
TPS ..... throttle position sensor
TRS ..... timing reference sensor
TSO ..... truck sales order
U.D. ..... underdrive
UNC ..... unified national coarse
UNF ..... unified national fine
U.S. ..... United States
U.S.A. ..... United States of America
USC ..... United States customary (measures)
V ..... volts
VDC ..... vehicle data computer
Vdc ..... volts, direct current
VIN ..... vehicle identification number
VIP ..... vehicle instrumentation and protection (Kysor)
VOC ..... volatile organic compounds
VOM ..... volt-ohmmeter
VSG ..... variable speed governor
VSS ..... vehicle speed sensor
WB ..... wire braid
WI ..... work instructions
WOT ..... wide open throttle
- ..... minus or negative
+ ..... plus or positive
± ..... plus-or-minus
> ..... greater than
< ..... less than
x ..... by (used in fastener size descriptions)
" ..... inches
° ..... degrees (of an angle)
°C ..... degrees Celsius (centigrade)
°F ..... degrees Fahrenheit
..... number
% ..... percent
& ..... and
© ..... copyright
™ ..... trademark
® ..... registered trademark

Pulley and Drive Belt Inspection

Inspection

Inspect all used drive belts (including those that are being replaced). **See Fig. 1.**



A. Glazing
B. Separating Layers
C. Streaked Sidewalls
D. Tensile Break
E. Uneven Ribs
F. Cracks

Fig. 1

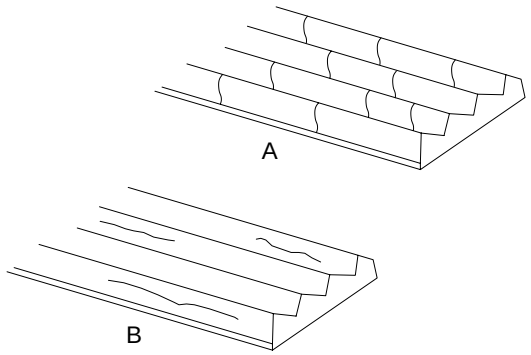
NOTE: For an installed belt, gently twist it about 90 degrees so you can see the sidewalls and bottom.

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

1. Inspect for glazing (shiny sidewalls). See Ref. A. Glazing is caused by friction created when a loose belt slips in the pulleys. It can also be caused by oil or grease on the pulleys.
2. Inspect for separating layers. See Ref. B. Oil, grease, or belt dressings can cause the belt to fall apart in layers. If engine parts are leaking, repair the leaks. Do *not* use belt dressings on any belt.
3. Check for jagged or streaked sidewalls. See Ref. C. These are the result of a foreign object (such as sand or small gravel) in the pulley, or a rough pulley wall surface.
4. Check for tensile breaks (breaks in the cord body). See Ref. D. Cuts in a belt are usually caused by large foreign objects in the pulley, or by prying or forcing the belt during installation or removal.
5. On poly-V belts, check for uneven ribs. See Ref. E. Foreign objects in the pulley will erode the undercord ribs, causing the belt to lose its gripping power.
6. Inspect for cracks. See Ref. F. Small, irregular cracks are usually signs of an old belt.

   When inspecting serpentine drive belts (used on Dodge gasoline engines), look for cracks that run along the ribs. **See Fig. 2.** These are not normal. Replace any belt with cracks running along the ribs. Small cracks that run across the ribbed surface are normal.

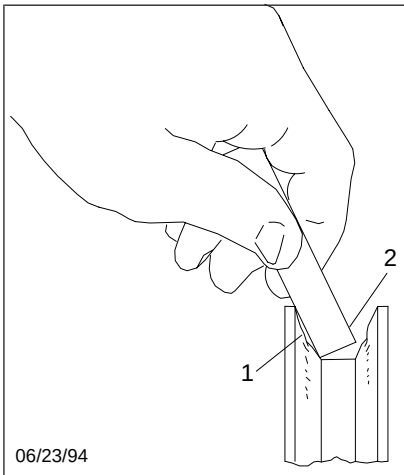
Pulley and Drive Belt Inspection



A. Normal Cracks, Belt Okay
B. Not Normal Cracks, Replace Belts

Fig. 2

7. Check all pulley bearings for roughness. Replace the bearings if they're rough.
8. Inspect all pulleys for foreign objects, oil, or grease in the grooves. Use a non-flammable cleaning solvent to remove oils. Use a wire brush to remove rust, and a file to remove burrs.
9. Inspect the pulleys for wear on the inner walls. Hold a small straightedge against the inside of the pulley walls **(Fig. 3)**, or use your little finger or fingernail to find grooves in the inner walls. If there are any grooves, replace the pulley.



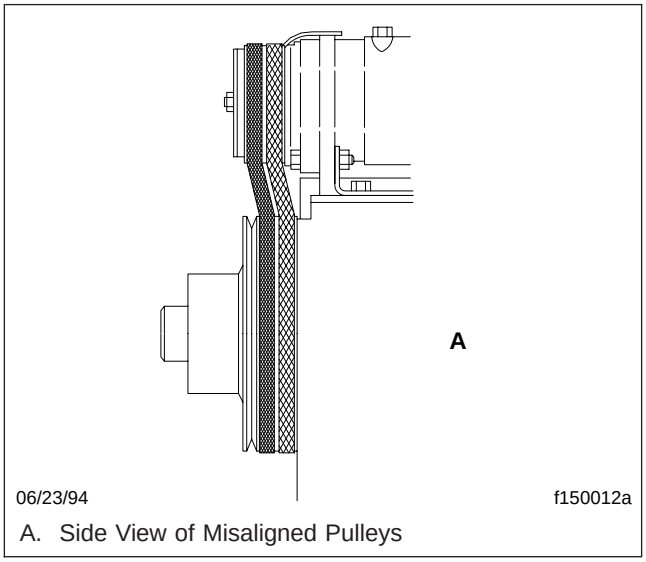
1. Groove in Pulley Wall
2. Small Straightedge

Fig. 3

10. Check the alignment of pulleys. **See Fig. 4.** Use a thin straightedge that is longer than the longest span between the pulleys. Place the straightedge into the V-grooves of two pulleys at a time. The straightedge should be parallel to the outer edges of the pulleys; if not, the pulleys are misaligned.

    Pulley misalignment must not be more than 1.6 mm for each 305 mm (1/16-inch for each foot) of distance between the centers of the pulleys.

    If the pulleys are misaligned, adjust them or their brackets if possible. Replace bent or broken pulleys, pulley brackets, or shafts.



A. Side View of Misaligned Pulleys

Fig. 4

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

Air Compressor Belt Replacement, Mercedes-Benz OM 366LA Engine

Replacement (See Fig. 1)

1. Loosen the belt tensioner.
   - 1.1 Loosen the bolt (Ref. A) in the center of the belt tensioning assembly.
   - 1.2 Loosen the pinch-bolt (Ref. B) in the tensioning assembly clamp.
   - 1.3 Back off the adjusting nut (Ref. C) until the tensioning assembly is drawn up off the air compressor belts.
2. Remove the belts from the air compressor and fan pulleys.
3. Inspect the pulleys and belts (even if installing new belts) as instructed under **"Pulley and Drive Belt Inspection, 100."**
4. Loop the belts around the fan and air compressor pulleys.
5. Tighten the belts to the correct belt tension.
   - 5.1 Tighten the adjusting nut (Ref. C) against the tensioning assembly clamp until the assembly is forced down against the belts.

     Check the belt tension while turning the nut, use your thumb to apply about 11 kg (25 lb) of force at the center of the longest belt free-span until the belt deflection equals one belt thickness per 305 mm (1 ft) of pulley-center distance.
   - 5.2 Install belt tension gauges at the center of the belts' longest free-spans.

     Turn the adjusting nut (Ref. C) against the tensioning assembly clamp to move the assembly down and tension the belts.

     Tighten the belts to 23 kg (50 lb).

   IMPORTANT: Do not overtighten the belts; too much tension shortens belt and bearing life.
   - 5.3 Tighten the tensioning assembly clamp pinch bolt (Ref. B) 80 N·m (59 lbf·ft).
   - 5.4 Tighten the bolt through the tensioning assembly (Ref. A) 80 N·m (59 lbf·ft).
6. Check the belt tension again, and adjust if needed.

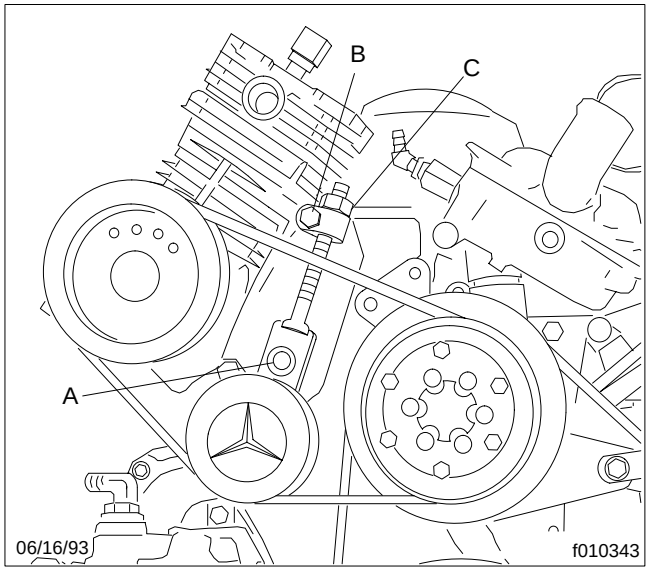


Fig. 1

7. If installing new belts, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation. If necessary, adjust the belts to 23 kg (50 lb).

Fan and Alternator Belt Replacement, Cummins B Series Engine

Replacement

1. If the vehicle is equipped with air conditioning, remove the refrigerant compressor belt. For instructions, see **Refrigerant Compressor Belt Replacement, Cummins B Series Engine, 120**.
2. Insert a 3/8-inch breaker bar in the belt tensioner (see **Fig. 1**), and rotate the tensioner up and off the belt (see **Fig. 2**).

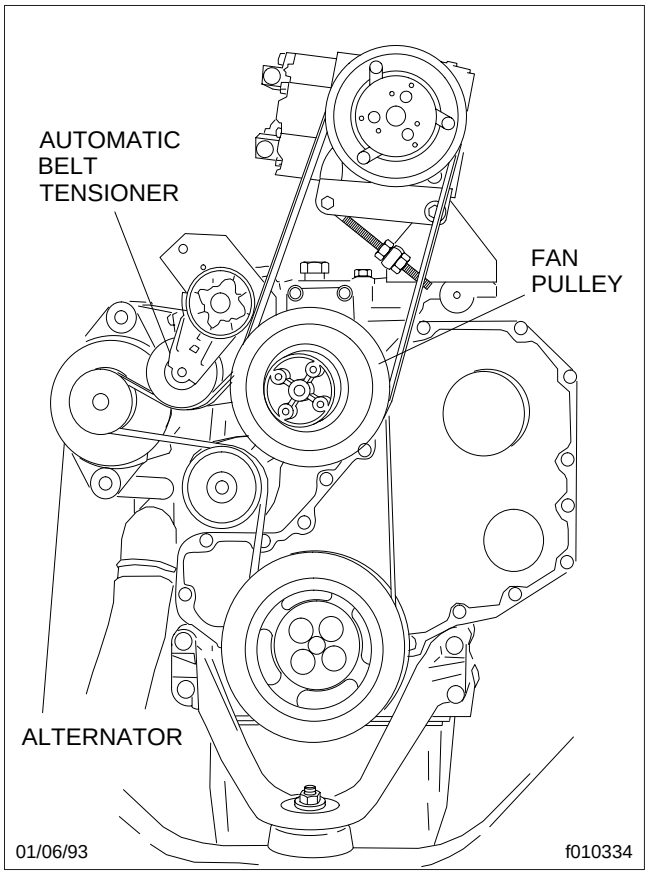


Fig. 1

3. Holding the belt tensioner up, remove the belt from the alternator pulley.
4. Slowly release the belt tensioner, and remove the breaker bar.
5. Lower the belt, and take it off the vibration damper.
6. Raise the belt, and take it off over the fan.

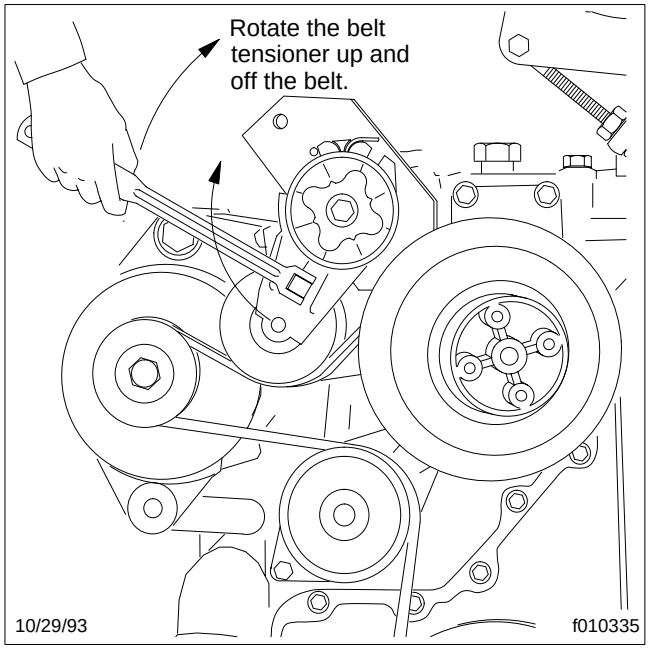


Fig. 2

7. Inspect the pulleys and the belt (even if installing a new belt) as instructed under **Pulley and Drive Belt Inspection, 100**.
8. Loop the belt around the fan and align it in the rear channel of the fan pulley (see **Fig. 2**).
9. Loop the belt down and around the vibration damper pulley.
10. Insert a 3/8-inch breaker bar in the belt tensioner (see **Fig. 2**), and rotate the tensioner up while installing the belt on the alternator pulley.
11. Slowly release the tensioner assembly onto the belt. The tensioner automatically tightens the belt to the correct tension.
12. Remove the breaker bar from the tensioner.
13. The Cummins belt tensioner automatically adjusts the fan and alternator belt to the correct tension. If the belt slips, repair or replace the tensioner. For instructions, see the *Cummins Shop Manual B Series Engines*.

Fan and Alternator Belt Replacement, Mercedes-Benz OM 366LA Engine

Replacement (See Fig. 1)

1. If the vehicle is equipped with air conditioning, remove the refrigerant compressor belt. For instructions, refer to **"Refrigerant Compressor Belt Replacement, Mercedes-Benz OM 366LA Engine, 125."**
2. If the vehicle is equipped with air brakes, remove the air compressor belt. For instructions, refer to **"Air Compressor Belt Replacement, Mercedes-Benz OM 366LA Engine, 105."**
3. Loosen the alternator mounting nut (Ref. C).
4. Back off the alternator adjusting rod nut (Ref. A).
5. Loosen the capscrew on the adjusting rod guide (Ref. B).
6. Rotate the alternator inward, and remove the belt from the alternator pulley.
7. Loop the belt down and off the vibration damper pulley.
8. Loop the belt up and off the fan pulley.
9. Inspect the pulleys and the belt (even if installing a new belt) as instructed under **"Pulley and Drive Belt Inspection, 100."**
10. Loop the belt around the fan and align it in the front channel of the large, two-channel fan pulley.
11. Loop the belt down and around the vibration damper pulley. Align the belt in the front channel of the two large pulley channels.
12. To install the belt on the alternator, rotate the alternator inward along its adjusting rod.
13. Loop the belt onto the alternator pulley, and align it in the front channel of the two alternator pulley channels.
14. Tighten the belt by turning the adjusting rod nut (Ref. A) against the adjusting rod guide until the alternator rotates outward against the belt.

    Check the tension while turning the nut, use your thumb to apply about 11 kg (25 lb) of force at the center of the longest belt free-span until the belt deflection equals one belt thickness per 305 mm (1 ft) of pulley-center distance.
15. Install a belt tension gauge at the center of the belt's longest free-span.
16. Turn the alternator adjusting rod nut (Ref. A) against the adjusting rod guide to move the alternator outward and tension the belt.
17. Tighten the belt to 75 kg (160 lb).

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

18. Tighten the capscrew securing the adjusting rod guide (Ref. B) 80 N·m (59 lbf·ft).
19. Tighten the alternator mounting nut (Ref. C) 80 N·m (59 lbf·ft).
20. Check the belt tension again, and adjust if needed.
21. If installing a new belt, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

    If necessary, adjust the belt to 75 kg (160 lb).

Fan and Alternator Belt Replacement, Mercedes-Benz OM 366LA Engine

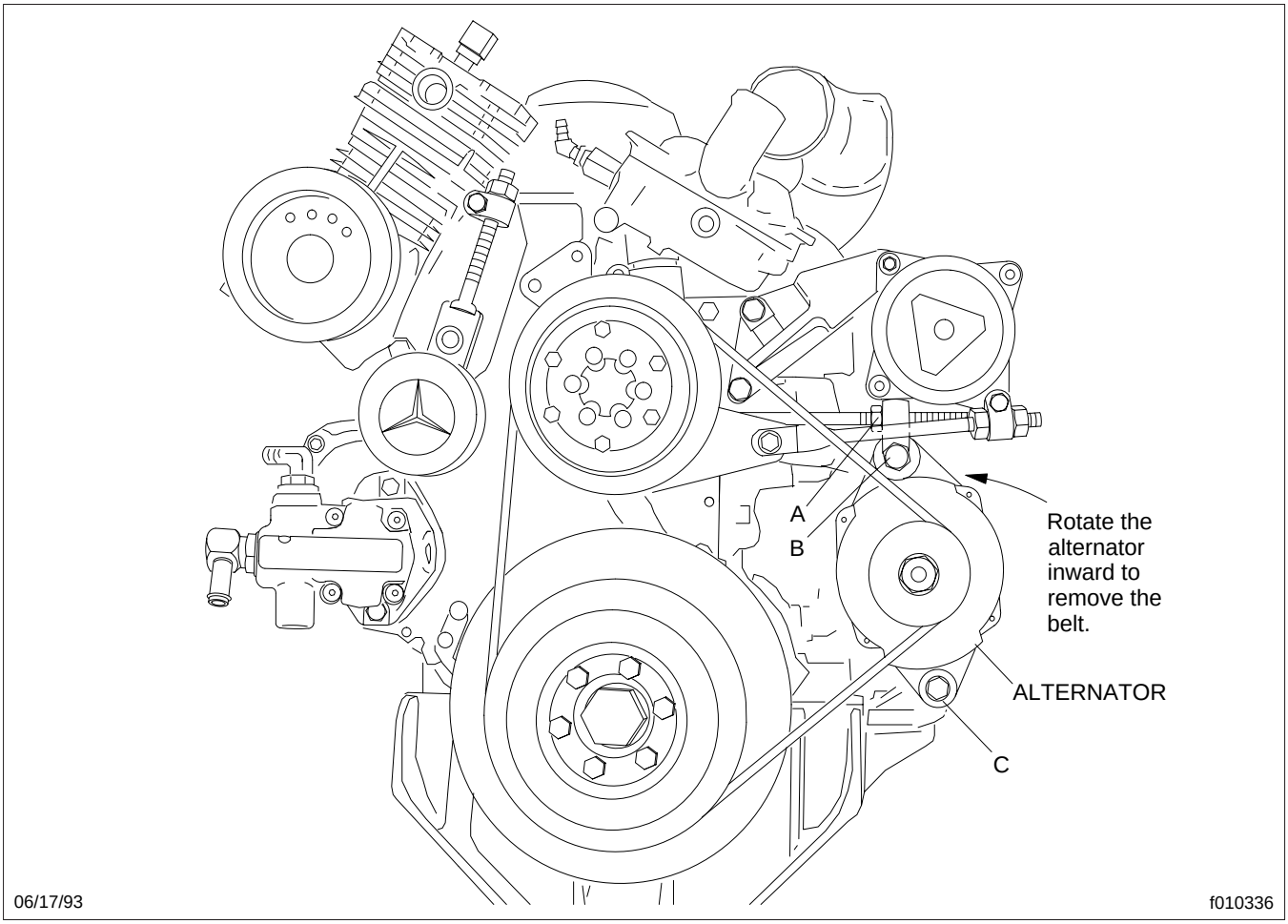


Fig. 1

Refrigerant Compressor Belt Replacement, Cummins B Series Engine

Replacement (See Fig. 1)

1. Loosen the refrigerant compressor mounting nuts (Ref. A).
2. Loosen the adjusting rod locknut (Ref. C), then back off the adjusting rod nut (Ref. B) until the belt can be removed.
3. Remove the belt. Don't pry or roll it off the pulleys.
4. Inspect the pulleys and the used belt (even if installing a new belt) as instructed under **"Pulley and Drive Belt Inspection, 100."**
5. Loop the belt around the fan and the compressor, and align it in the front channels of the pulleys.
6. Tighten the belt by turning the adjusting rod nut (Ref. B) against the compressor mount until the compressor moves up.

   Check the belt tension while turning the nut, use your thumb to apply about 11 kg (25 lb) of force at the center of the longest belt free-span until belt deflection equals one belt thickness per 305 mm (1 ft) of pulley-center distance.
7. Install a belt tension gauge at the center of the belt's longest free-span.
8. Tighten the compressor belt, by turning the adjusting rod nut (Ref. B) against the compressor mount to rotate the compressor up and away from the fan pulley. Tighten the belt to 45 kg (100 lb).

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

9. Tighten the adjusting rod jam nut (Ref. C) against the compressor mount 80 N·m (59 lbf·ft).
10. Tighten the compressor mounting nuts (Ref. A) 80 N·m (59 lbf·ft).
11. Check the belt tension again, and adjust if needed.
12. If installing a new compressor belt, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

    If necessary, adjust the belt to 45 kg (100 lb).

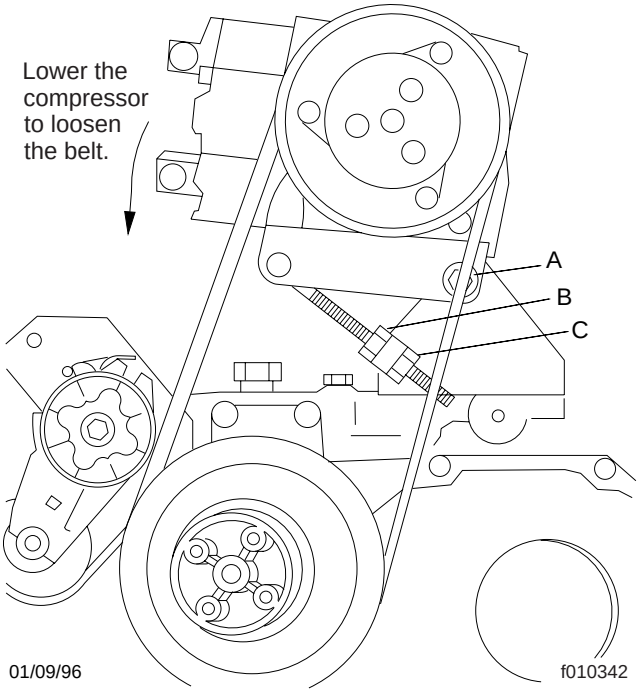


Fig. 1

Refrigerant Compressor Belt Replacement, Mercedes-Benz OM 366LA Engine

Replacement (see Fig. 1)

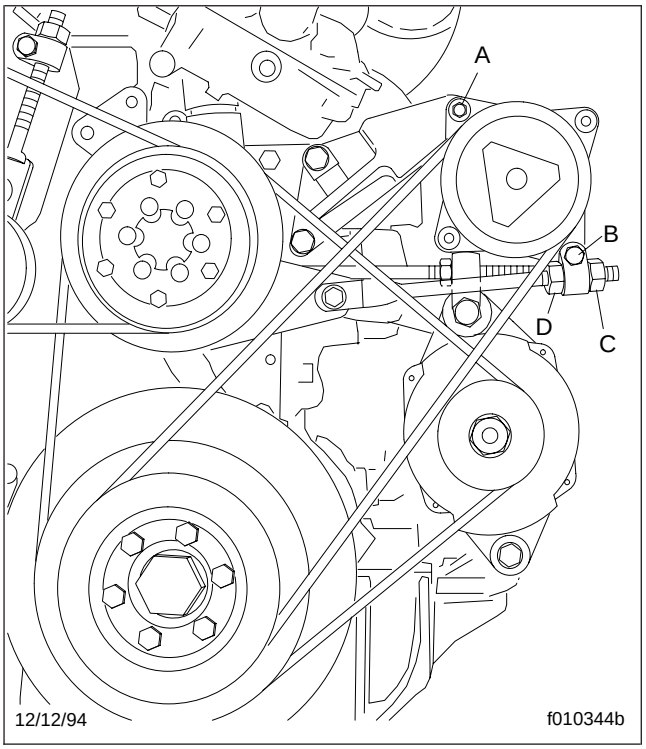


Fig. 1

1. Remove the refrigerant compressor belt.
   - 1.1 Loosen the compressor mounting nuts (Ref. A), and back off the adjusting rod nut (Ref. D).
   - 1.2 Loosen the nut on the adjusting rod guide bolt (Ref. B).
   - 1.3 Lower the compressor by sliding the guide down along the adjusting rod. Remove the belt from the compressor and vibration damper pulleys.
2. If removed, install and adjust the fan and alternator belt. For instructions, refer to **Fan and Alternator Belt Replacement, Mercedes-Benz OM 366LA Engine, 115.**
3. Inspect the pulleys and the belt (even if installing a new belt) as instructed under **Pulley and Drive Belt Inspection, 100.**
4. Loop the belt around the small vibration damper pulley.
5. Loop the belt around the compressor pulley, and align it in the rear channel of the two pulley channels.
6. Tighten the belt by turning the adjusting rod nut (Ref. D) against the adjusting rod guide until the compressor rises against the belt.

   Check the belt tension while turning the nut, use your thumb to apply about 11 kg (25 lb) of force at the center of the longest belt free-span until belt deflection equals one belt thickness per 305 mm (1 ft) of pulley-center distance.
7. Install a belt tension gauge at the center of the belt's longest free-span.
8. Turn the adjusting rod nut (Ref. D) against the adjusting rod guide to rotate the compressor upward and tension the belt.
9. For a regular V-belt, tighten the belt to 45 kg (100 lb). For a Powerband® V-belt (**see Fig. 2**), tighten the belt to 64 kg (140 lb).

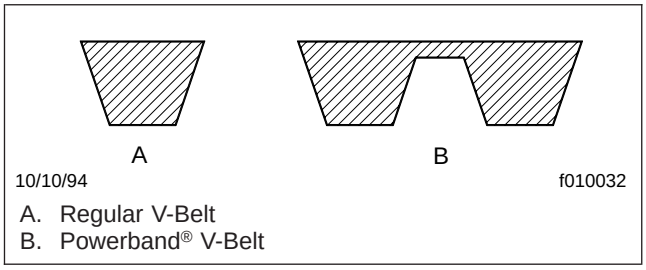


Fig. 2, Drive Belts, Cross Sections Shown

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

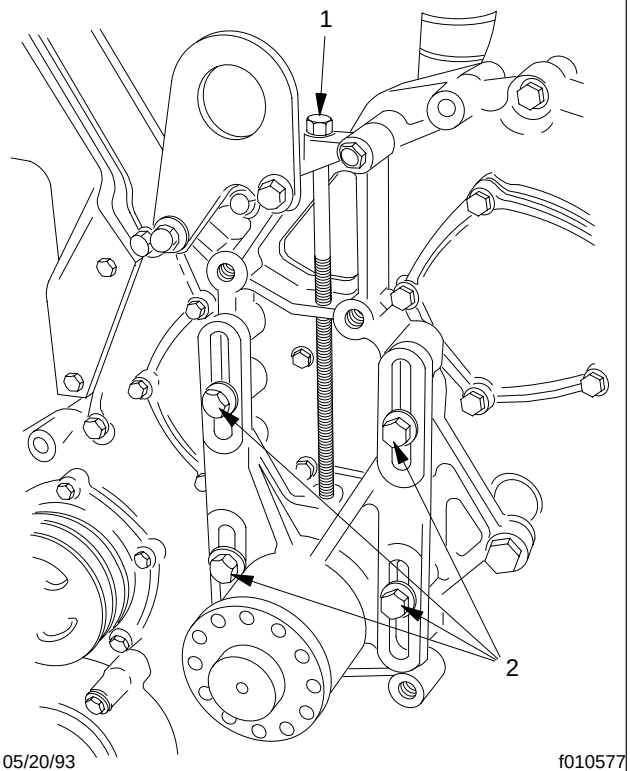
10. Tighten the nut on the adjusting rod guide (Ref. B) 45 N·m (33 lbf·ft).
11. Tighten the refrigerant compressor mounting nuts (Ref. A) 45 N·m (33 lbf·ft).
12. Tighten the adjusting rod jam nut (Ref. C) 190 N·m (140 lbf·ft).
13. Check the belt tension again, and adjust if needed.
14. If installing a new belt, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

    If necessary, adjust the belt to 45 kg (100 lb).

Fan Belt Replacement, Detroit Diesel Series 50 Engine

Replacement (See Fig. 1)

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



1. Adjusting Rod
2. Mounting Capscrews

Fig. 1, Fan Belt Adjustment

4. Inspect the pulleys and belts (even if installing new belts) as instructed in **"Pulley and Drive Belt Inspection."**
5. Work the belts over the fan blades, one blade at a time. Install the belts on the pulleys without prying or rolling them into place.
6. While keeping the belts seated in the pulley grooves, turn the adjusting rod to increase belt tension. Use your thumb to apply about 25 lb (11 kg) of force at the center of the longest belt free-span to check the tension while turning the adjusting rod.
7. When belt deflection is about 1/2 to 3/4 inch (13 to 19 mm), install a belt tension gauge at the center of the belt's longest free-span.
8. Turn the adjusting rod to increase or decrease belt tension. Final tension must be 60 to 80 lb (27 to 36 kg).

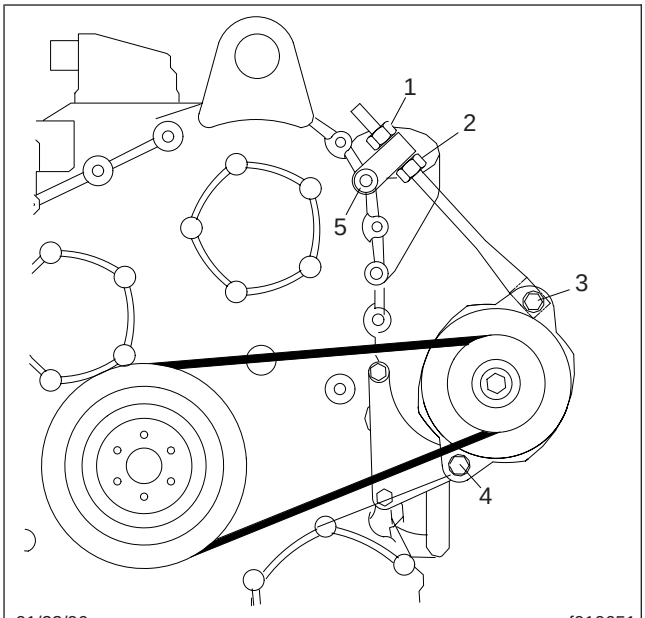
IMPORTANT: Do not overtighten the belts; too much tension shortens belt and bearing life.

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

Alternator Belt Replacement, Detroit Diesel Series 50 Engine

Replacement (Refer to Fig. 1)

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



01/22/96 f010651

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

Fig. 1, Alternator Belt Adjustment

6. Inspect the pulleys and used belts (even if installing new belts) as instructed in **"Pulley and Drive Belt Inspection."**
7. Work the belts over the fan blades, one blade at a time. Install the belts on the pulleys without prying or rolling them into place.
8. Install a belt tension gauge at the center of the belt's longest free-span.
9. While keeping the belts seated in the pulley grooves, turn the adjusting rod nut to rotate the alternator away from the engine and increase belt tension. Turn the adjusting rod nut until final belt tension is 60 to 80 lb (27 to 36 kg).

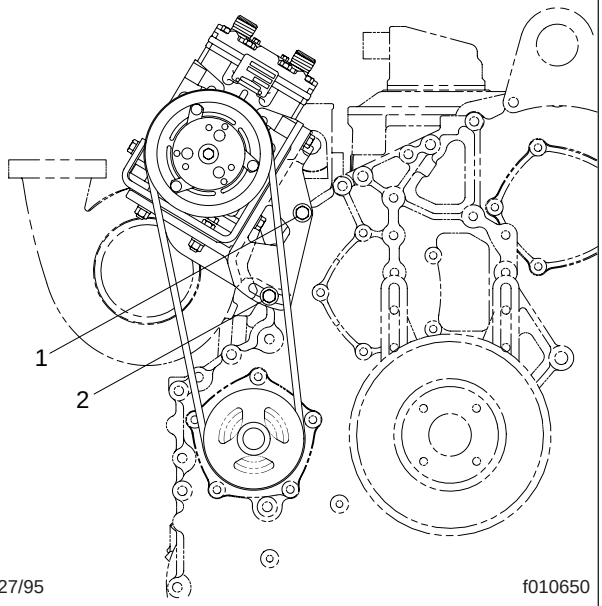
IMPORTANT: Do not overtighten the belts; too much tension shortens belt and bearing life.

10. Tighten the adjusting rod jam nut 176 N·m (130 lbf·ft).
11. Tighten the alternator mounting bolt and the adjusting rod mounting bolt 123 N·m (91 lbf·ft).
12. Tighten the adjusting rod guide mounting bolt 46 N·m (34 lbf·ft).
13. Operate the engine for about 30 minutes (or 15 miles), then check the belt tension. Check again after 8 hours (or 250 miles). Adjust belt tension as needed.

Refrigerant Compressor Belt Replacement, Detroit Diesel Series 50 Engine

Replacement (See Fig. 1)

1. Loosen the compressor mounting bolt and the compressor adjustment bolt that attach the compressor bracket to the engine.



1. Compressor Mounting Bolt
2. Compressor Adjustment Bolt

Fig. 1, Refrigerant Compressor Belt Adjustment

2. Rotate the compressor downward, toward the engine to allow belt removal without using force.
3. Remove the belt without prying or rolling it off the pulleys.
4. Inspect the pulleys and belts (even if installing new belts) as instructed in **"Pulley and Drive Belt Inspection."**
5. Loop the belt around the pulleys.
6. Install a belt tension gauge at the center of the belt's longest free-span.
7. While keeping the belt seated in the pulley grooves, rotate the compressor up and away from the engine until the belt is tensioned 41 to 45 kg (90 to 100 lb).

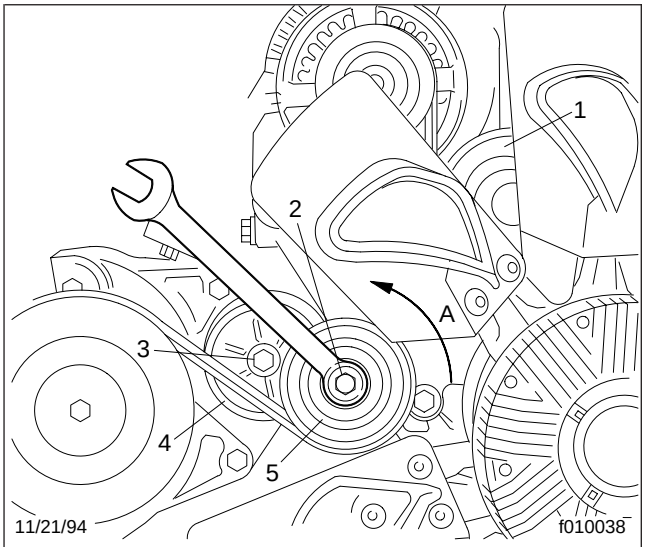
IMPORTANT: Do not overtighten the belts; too much tension shortens belt and bearing life.

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

Accessory Drive Belt Replacement, Dodge Magnum Engines

Replacement

1. Place a 5/8-inch wrench over the pulley bolt on the automatic belt tensioner, and turn the wrench counterclockwise to relax the belt tensioner. **See Fig. 1.**



A. Turn counterclockwise to remove the belt.
1. Idler Pulley
2. Tensioner Pulley Bolt
3. Tensioner Mounting Bolt
4. Tensioner
5. Tensioner Pulley

Fig. 1, Relieving Belt Tension

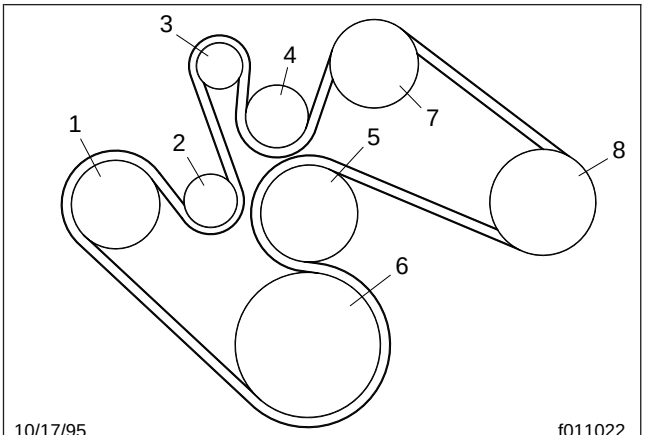
2. Remove the engine accessory drive belt.
3. Inspect the pulleys and the drive belt (even if installing a new belt) as instructed in **Subject 100**.

CAUTION

When installing a serpentine drive belt, route the belt correctly. If the belt is not routed correctly, the water pump pulley may rotate in the wrong direction, allowing the engine to overheat.

NOTE: If the pulley must be removed from the automatic belt tensioner: The pulley bolt has left hand threads.

4. Position the drive belt over all the pulleys *except the drive belt tensioner.* For the correct belt routing, **see Fig. 2** and **Fig. 3**.



1. Air Injection Pump
2. Automatic Tensioner
3. Alternator
4. Idler
5. Water Pump
6. Crank Pulley
7. Refrigerant Compressor
8. Power Steering Fluid Pump

Fig. 2, Drive Belt Routing with a Refrigerant Compressor

5. Place a 5/8-inch wrench over the pulley bolt on the automatic belt tensioner, and turn the wrench counterclockwise to relax the belt tensioner. Finish installing the belt. **See Fig. 1.**
6. Correct drive belt tension is required for optimum performance of belt-driven engine accessories. If the specified belt tension is not maintained, check and repair the following:

   Make sure the correct belt is installed.

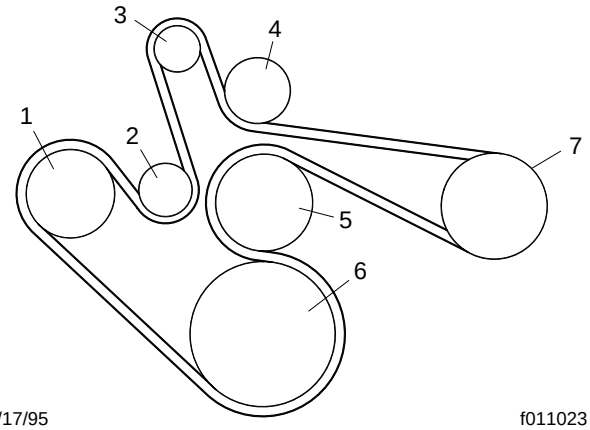
   Make sure the belt is routed correctly.

   Check for worn bearings on all the engine accessory pulleys.

   Check for a loose engine accessory pulley.

   Check for misalignment between accessory pulleys.

Accessory Drive Belt Replacement, Dodge Magnum Engines



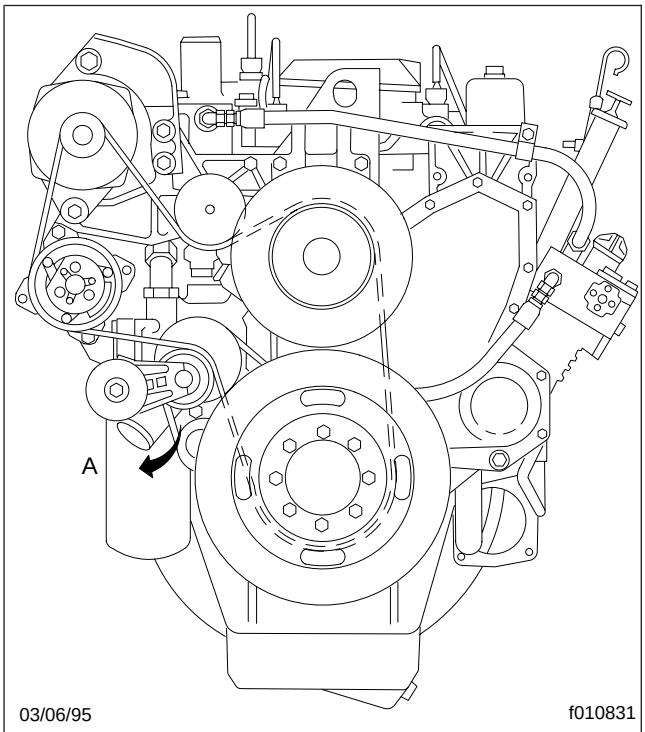
1. Air Injection Pump
2. Automatic Tensioner
3. Alternator
4. Idler Pulley
5. Water Pump
6. Crank Pulley
7. Power Steering Fluid Pump

Fig. 3, Drive Belt Routing without a Refrigerant Compressor

Accessory Drive Belt Replacement, Caterpillar CFE Series Engine

Replacement

1. Insert a 1/2-inch rachet drive into the square hole in the belt tensioner, and turn the tensioner clockwise. **See Fig. 1.**



A. Turn the belt tensioner clockwise, off the belt.

Fig. 1, Accessory Drive Belt, Caterpillar CFE Series Engine

2. Remove the engine accessory drive belt.
3. Inspect the pulleys and the drive belt (even if installing a new belt) as instructed in **Subject 100**.

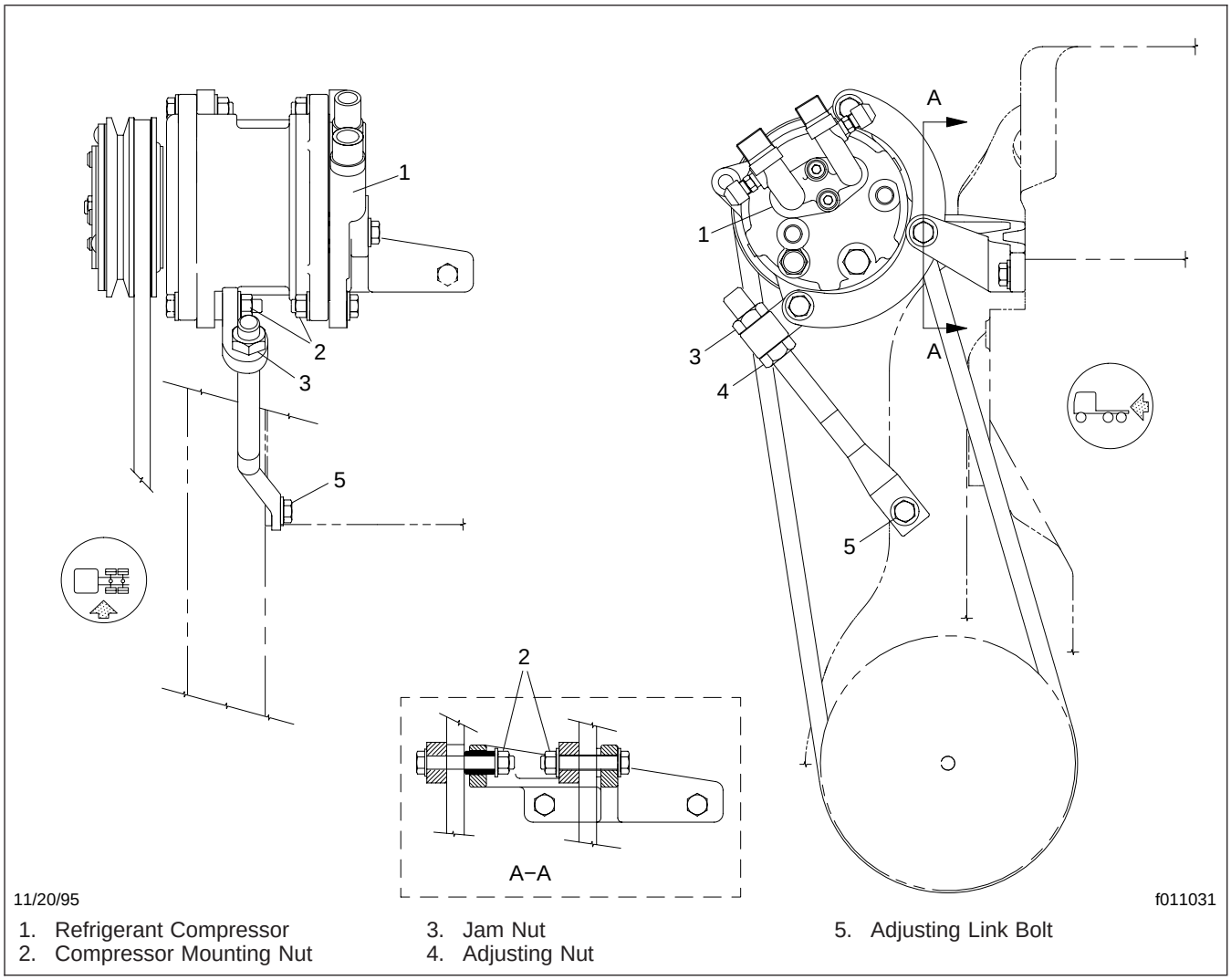
CAUTION

When installing a serpentine drive belt, route the belt correctly. If the belt is not routed correctly, the water pump pulley may rotate in the wrong direction, allowing the engine to overheat.

4. Position the drive belt over all the pulleys *except the drive belt tensioner.* For the correct belt routing, **see Fig. 1**.
5. Insert a 1/2-inch rachet drive into the square hole in the belt tensioner, and turn the tensioner clockwise. **See Fig. 1.**
6. Position the tensioner against the belt, and remove the rachet drive from the tensioner.

Refrigerant Compressor Belt Replacement, Cummins M11 Engine

Replacement (See Fig.1or Fig.2)

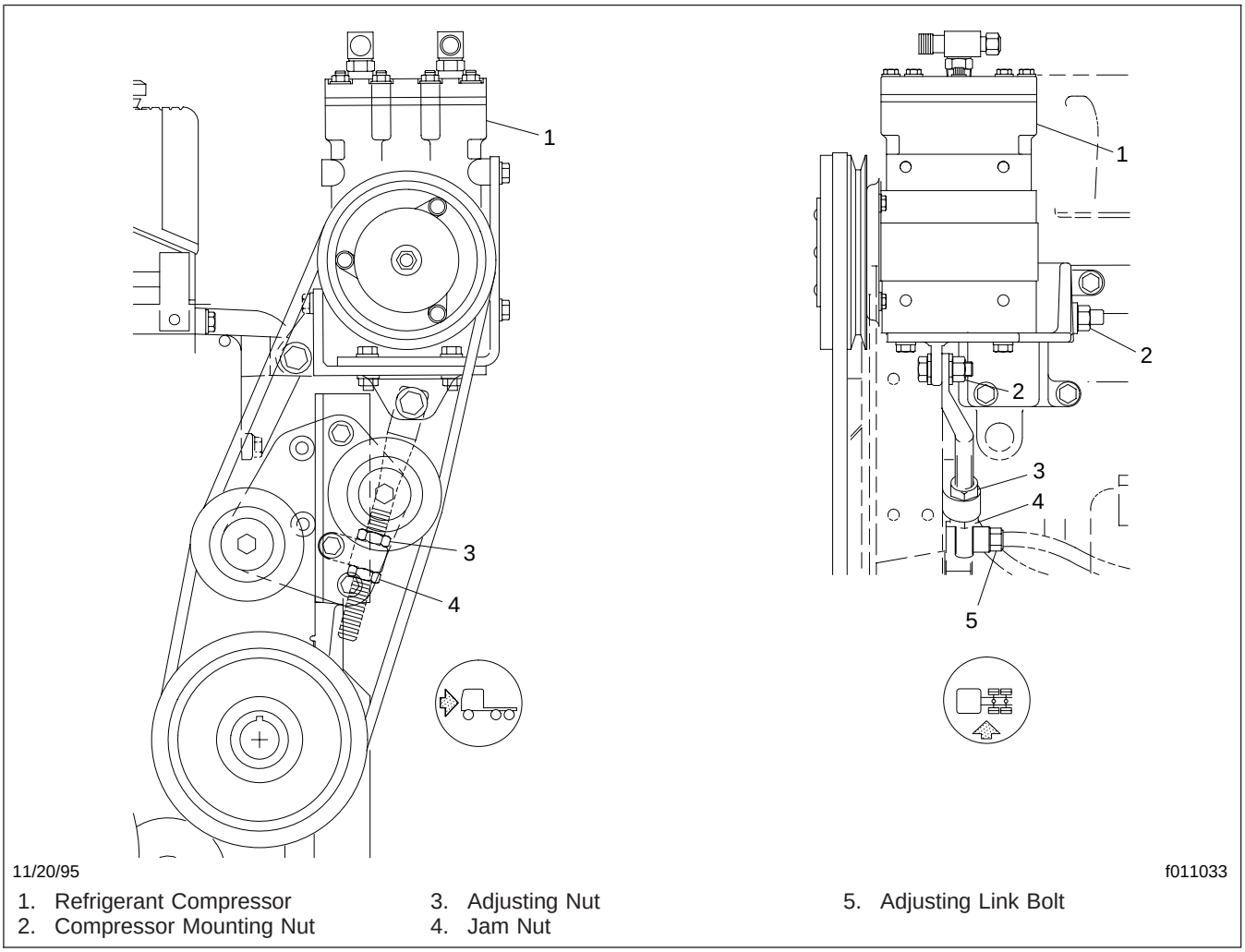


1. Refrigerant Compressor
2. Compressor Mounting Nut
3. Jam Nut
4. Adjusting Nut
5. Adjusting Link Bolt

Fig. 1, Rotary-Type Compressor Installation

1. Remove the belt.
   - 1.1 Back off the adjusting nut. Loosen the mounting nuts and the adjusting link bolt just enough to allow movement of the compressor.
   - 1.2 Push the loosened compressor toward the drive pulley until the distance between them is short enough to allow belt removal without using force.
   - 1.3 Remove the belt, without prying or rolling it off of the pulleys.
2. Install the belt.
   - 2.1 Inspect the pulleys and used refrigerant compressor belt (even if a new belt is being installed) as instructed in **Subject 100**.

Refrigerant Compressor Belt Replacement, Cummins M11 Engine



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

Fig. 2, Piston-Type Compressor Installation

2.2 Make sure the distance between the pulleys is short enough to allow belt installation without using force.

2.3 Install the belt on the pulleys without prying or rolling it into place.

2.4 Back off the jam nut to the end of the adjusting rod.

2.5 While keeping the belt seated in the pulley grooves, turn the adjusting nut against the adjusting link to increase belt tension. Use your thumb to apply about 11 kg (25 lbs) of force at the center of the belt free-span to check the tension while turning the nut. When belt deflection equals one belt thickness per 305 mm (1 foot) of pulley-center distance, stop.

3. Adjust the belt.

3.1 If not already done, back off the adjusting link jam nut to the end of the adjusting rod, and loosen the mounting nuts and adjusting link bolt just enough to allow movement of the compressor.

3.2 Install a belt tension gauge at the center of the belt free-span.

3.3 Turn the adjusting nut to adjust the tension to a reading of 59 kg (130 lbs) for a new belt, or 36 to 45 kg (80 to 100 lbs)

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

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

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

3.5 Tighten the compressor mounting nuts 41 N·m (30 lbf·ft), and the adjusting link bolt 88 N·m (65 lbf·ft).

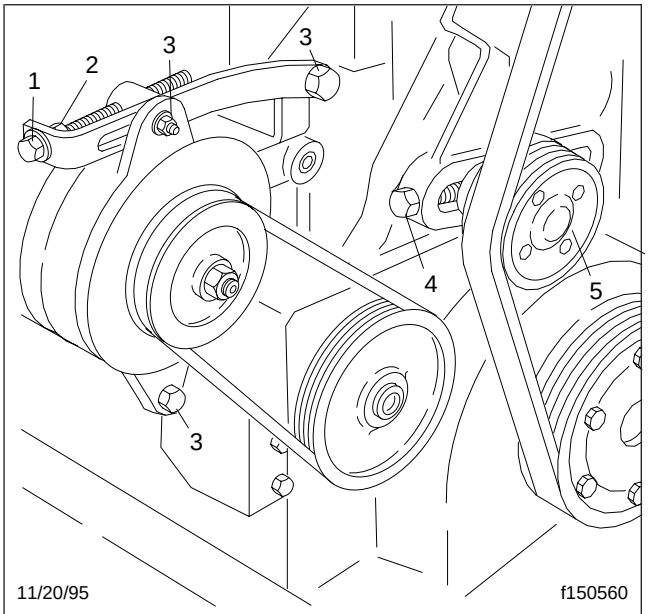
3.6 Check the belt tension, and adjust it if needed.

3.7 If a new refrigerant compressor belt was installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

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

Fan Belt Replacement, Cummins M11 Engine

Replacement (See Fig. 1)



1. Adjusting Screw
2. Adjusting Screw Jam Nut
3. Alternator Mounting Fastener
4. Idler Pulley Adjustment Capscrew
5. Idler Pulley

Fig. 1, Fan and Alternator Belt Installation

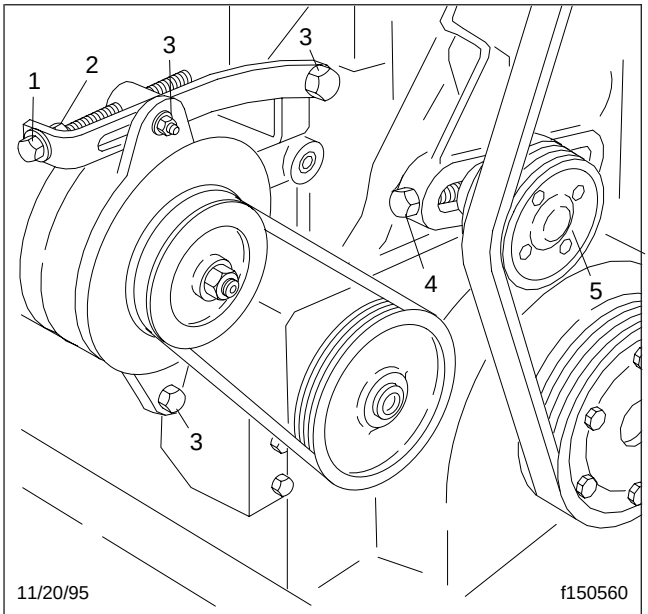
1. Remove the belt.
   - 1.1 Loosen the locknut that secures the idler pulley to the fan bracket.
   - 1.2 Turn the idler pulley adjustment capscrew until there is minimal distance between the pulley centers.
   - 1.3 Remove the fan belt by slipping it off of the pulleys and working it over one fan blade at a time. Don't roll or pry the belt off of the pulleys; the distance between the pulley centers must be short enough to allow belt removal without using force.
2. Install the belt.
   - 2.1 Inspect the pulleys and used fan belt (even if a new belt is being installed) as instructed in **Subject 100**.
   - 2.2 Make sure the distance between the pulleys is short enough to allow belt installation without using force.
   - 2.3 Work the belt over the fan blades, one blade at a time. Install the belt on the pulleys without prying or rolling it into place. Be sure the ribs on the belt are seated in the grooves on each pulley.
   - 2.4 While keeping the belt seated in the pulley grooves, turn the idler pulley adjustment capscrew to increase the belt tension. Use your thumb to apply about 11 kg (25 lbs) of force at the center of the belt free-span to check the tension while turning the capscrew. When belt deflection equals one belt thickness per 305 mm (1 foot) of pulley-center distance, stop.
3. Adjust the belt.
   - 3.1 If not already done, loosen the locknut that secures the idler pulley to the fan bracket.
   - 3.2 Install a belt tension gauge at the center of the belt's longest free-span.
   - 3.3 Turn the idler pulley adjustment capscrew to increase or decrease belt tension, but do not adjust the tension to the full value with the idler pulley adjustment capscrew; belt tension can increase when the idler pulley locknut is tightened. Final tension must be 36 to 45 kg (80 and 100 lbs).

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

   - 3.4 Tighten the idler pulley locknut 163 to 190 N·m (120 to 140 lbf·ft).
   - 3.5 Loosen the idler pulley adjustment capscrew one-half turn, to prevent breakage.
   - 3.6 Check the belt tension, and adjust it if needed.
   - 3.7 If a new fan belt was installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.
   - 3.8 If the fan belt tension is not between 36 to 45 kg (80 and 100 lbs), adjust the tension.

Alternator Belt Replacement, Cummins M11 Engine

Replacement (See Fig. 1)



1. Adjusting Screw
2. Adjusting Screw Jam Nut
3. Alternator Mounting Fastener
4. Idler Pulley Adjustment Capscrew
5. Idler Pulley

Fig. 1, Alternator and Fan Belt Installation

1. Remove the belt.
   - 1.1 Loosen the three mounting fasteners just enough to allow movement of the alternator.
   - 1.2 Loosen the adjusting screw jam nut.
   - 1.3 Turn the adjusting screw counterclockwise, backing off the alternator toward the drive pulley far enough to allow belt removal without using force.
   - 1.4 Remove the belt, without prying or rolling it off of the pulleys.
2. Install the belt.
   - 2.1 Inspect the pulleys and used alternator belt (even if a new belt is being installed) as instructed in **Subject 100**.
   - 2.2 Make sure the distance between the pulleys is short enough to allow belt installation without using force.
   - 2.3 Install the belt on the pulleys without prying or rolling it into place. Be sure the ribs on the belt are seated in the grooves on each pulley.
   - 2.4 While keeping the belt seated in the pulley grooves, turn the adjusting screw clockwise to increase the belt tension. Use your thumb to apply about 11 kg (25 lbs) of force at the center of the belt free-span to check the tension while turning the adjusting screw. When belt deflection equals one belt thickness per 305 mm (1 foot) of pulley-center distance, stop.
3. Adjust the belt.
   - 3.1 If not already done, loosen the adjusting screw locknut, and loosen the three mounting fasteners, just enough to allow movement of the alternator.
   - 3.2 Install a belt tension gauge at the center of the belt free-span.
   - 3.3 Turn the adjusting screw to adjust the tension to a reading of 36 to 45 kg (80 and 100 lbs).

   IMPORTANT: Do not overtighten the belt; too much tension shortens belt life and bearing life.
   - 3.4 Tighten the adjusting screw locknut 129 N·m (95 lbf·ft).
   - 3.5 Tighten the alternator mounting fastener 81 N·m (60 lbf·ft), the adjusting block nut 47 N·m (35 lbf·ft), and the adjusting arm bolt 75 N·m (55 lbf·ft).
   - 3.6 Check the belt tension, and adjust it if needed.
   - 3.7 If a new alternator belt was installed, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.
   - 3.8 If the alternator belt tension is not 36 to 45 kg (80 and 100 lbs), adjust the tension.

Specifications

This subject contains the following tables:

- Fastener Torques, Cummins B Series Engine
- Fastener Torques, Mercedes-Benz OM 366LA Engine
- Drive Belt Tensions, Cummins B Series Engine
- Drive Belt Tensions, Mercedes-Benz OM 366LA Engine

Description	Grade	Size	Torque N·m (lbf·ft)
Refrigerant Compressor Mounting Nuts	5	1/2–13	80 (59)
Refrigerant Compressor Adjusting Rod Jam Nut	5	1/2–13	80 (59)

Table 1, Fastener Torques, Cummins B Series Engine

Description	Grade	Size	Torque N·m (lbf·ft)
Alternator Adjusting Rod Guide Capscrew	8	1/2–13	80 (59)
Alternator Mounting Nuts	8	1/2–13	80 (59)
Air Compressor Tensioning Assembly Clamp Pinch Bolt	8.8	M12 x 1.5	80 (59)
Air Compressor Tensioning Assembly Bolt	8.8	M12	80 (59)
Refrigerant Compressor Adjusting Rod Guide Bolt Nut	8	3/8–16	45 (33)
Refrigerant Compressor Mounting Nuts	8	3/8–16	45 (33)
Refrigerant Compressor Adjusting Rod Jam Nut	5	5/8–18	190 (140)

Table 2, Fastener Torques, Mercedes-Benz OM 366LA Engine

Description	Tension kg (lb)
Refrigerant Compressor Belt	45 (100)

Table 3, Drive Belt Tensions, Cummins B Series Engine

Description	Tension kg (lb)
Refrigerant Compressor Belt	45 (100)
Air Compressor Belts	23 (50)
Fan/Alternator Belt	75 (160)

Table 4, Drive Belt Tensions, Mercedes-Benz OM 366LA Engine

General Description

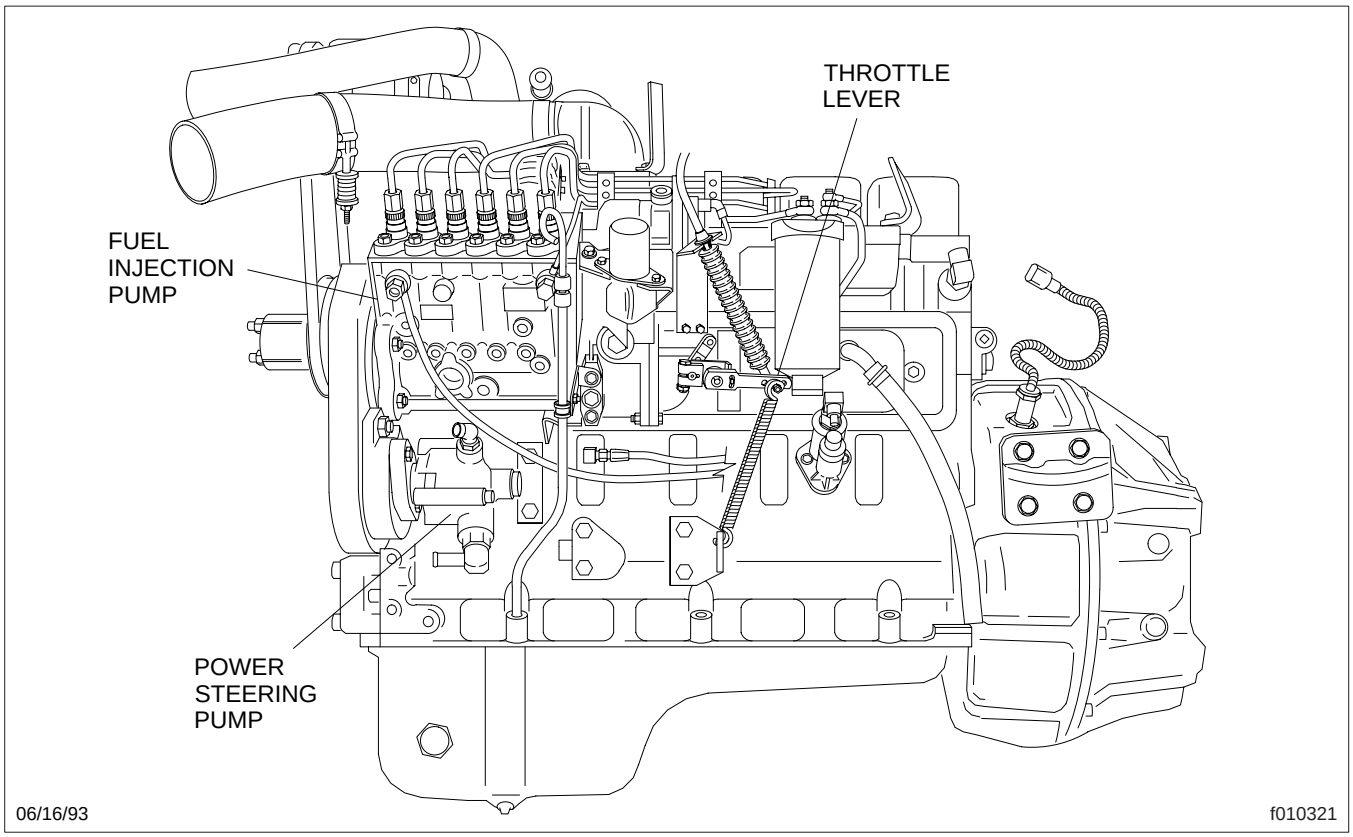


Fig. 1

The Cummins B Series engine **(see Fig. 1 and Fig. 2)** is supported by three engine mounts: two are at the rear of the engine— one on each side— and fastened to the frame rails. The other is at the front of the engine, fastened to the underslung crossmember.

Because the engine provides the main support for the transmission, removing them as an assembly is easier than disconnecting them, if the engine has to be removed.

For detailed repair procedures and other engine service not covered in this section, refer to the *Cummins B Series Operation and Maintenance Manual* , *Cummins Troubleshooting and Repair Manual B Series* , and *Cummins Workshop Manual B Series* .

General Description

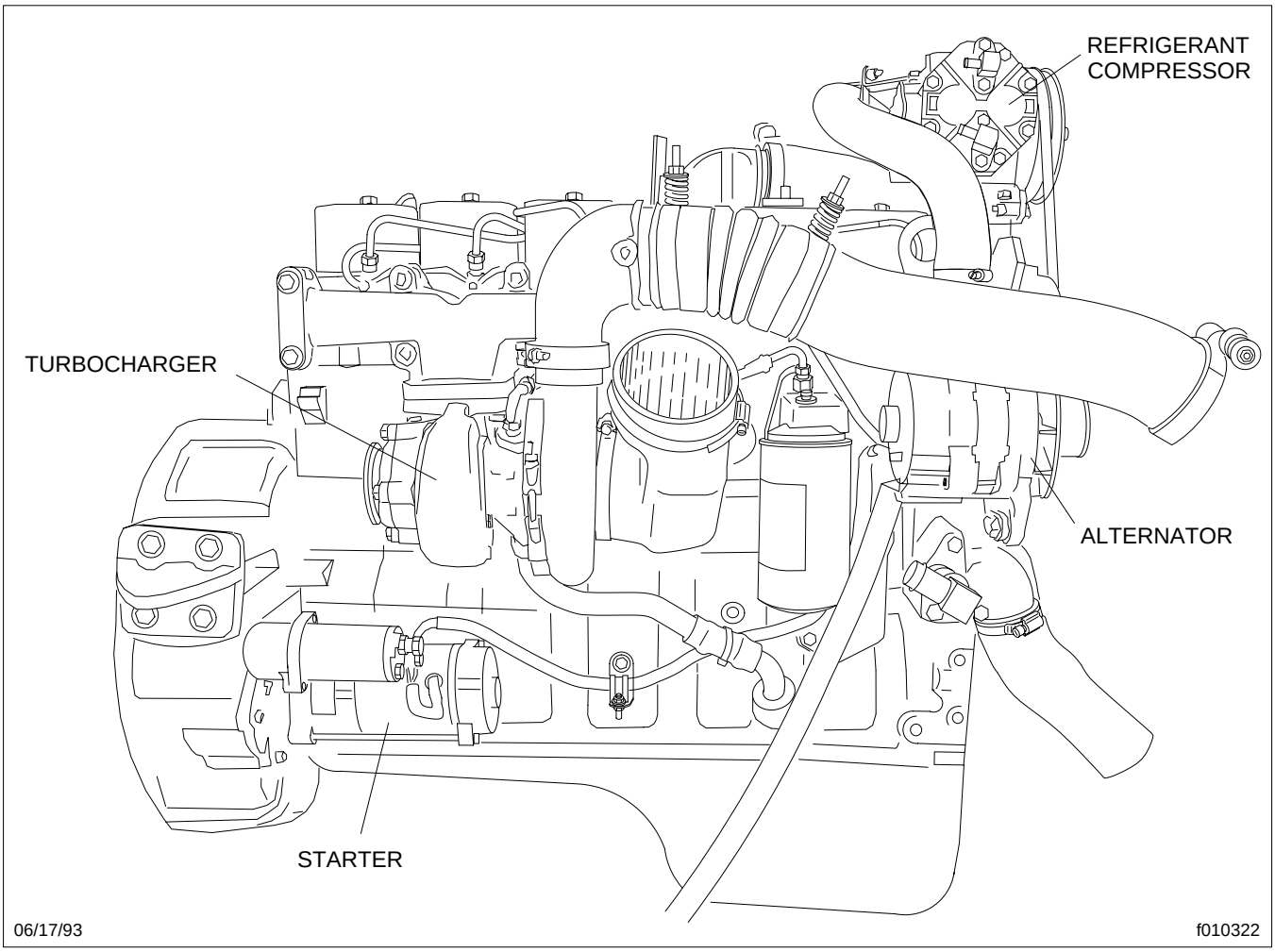


Fig. 2

Removal

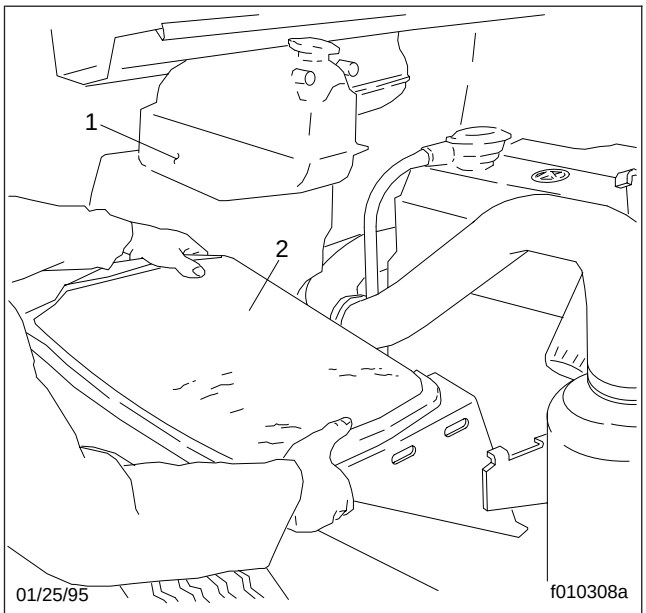
NOTE: Because the transmission is supported entirely by the engine, removing them as an assembly (as described below) is easier than disconnecting them and removing the engine only.

1. Apply the parking brakes, chock the tires, and (if applicable) drain the air system.
2. Disconnect the batteries or, if the vehicle is equipped with a battery shutoff switch, turn off the switch.
   - 2.1 Disconnect the battery ground cable at the vehicle frame.
   - 2.2 Disconnect the positive battery cable from the batteries.
3. Remove the hood and bumper. For instructions, see **Group 88**.
4. Drain the radiator.

⚠ WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

   - 4.1 Open the petcock at the bottom of the radiator to drain the engine coolant.
   - 4.2 Loosen the surge tank cap.
5. Remove the right fender splash shield. See **Fig. 1**.
6. Remove the air cleaner.
   - 6.1 Remove the air intake pipe from the top of the air cleaner. See **Fig. 2**.
   - 6.2 Remove the four nuts from the inside of the air cleaner mounting bracket. See **Fig. 3**.
   - 6.3 Remove the air cleaner from its mounting bracket.
7. Disconnect or remove the air intake, exhaust pipe, and hoses.
   - 7.1 If the vehicle is equipped with air brakes, disconnect the air compressor outlet line.



1. Surge Tank
2. Splash Shield

Fig. 1, Remove the Right Fender Splash Shield

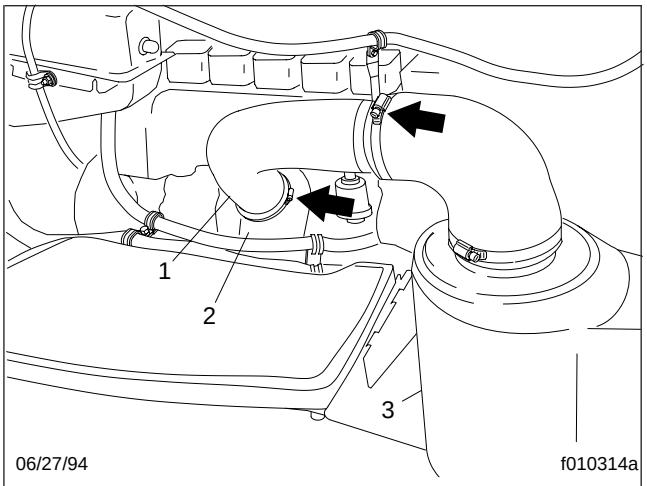
   - 7.2 If the vehicle is equipped with air brakes, disconnect the two air signal lines from the air governor at the top of the compressor.
   - 7.3 Disconnect the air inlet and outlet hoses from the charge air cooler. See **Fig. 4**.
   - 7.4 Disconnect the air intake pipe from the turbocharger. See **Fig. 2**.
   - 7.5 Disconnect the V-clamp connecting the exhaust pipe to the rear of the turbocharger. Remove the pipe from the turbocharger.
8. Disconnect the coolant hoses.
   - 8.1 Disconnect the coolant inlet and outlet hoses from the radiator. See **Fig. 4**.
   - 8.2 Disconnect the vent hose from the radiator, and remove the hose bracket from the condenser mounting bolt. See **Fig. 4**.
   - 8.3 Disconnect the fill hose from the bottom of the surge tank.
   - 8.4 Disconnect the heater inlet hose at the valve near the firewall. See **Fig. 5**.

Removal and Installation

8.5 Disconnect the heater outlet hose at the firewall. See **Fig. 5**.

9. Remove the refrigerant compressor and condenser.

9.1 Disconnect the compressor electrical connectors.



1. Air Intake Pipe
2. Turbocharger

Fig. 2, Air Intake Pipe

9.2 Remove the adjusting rod jam nut. See **Fig. 6**, Ref. 3.

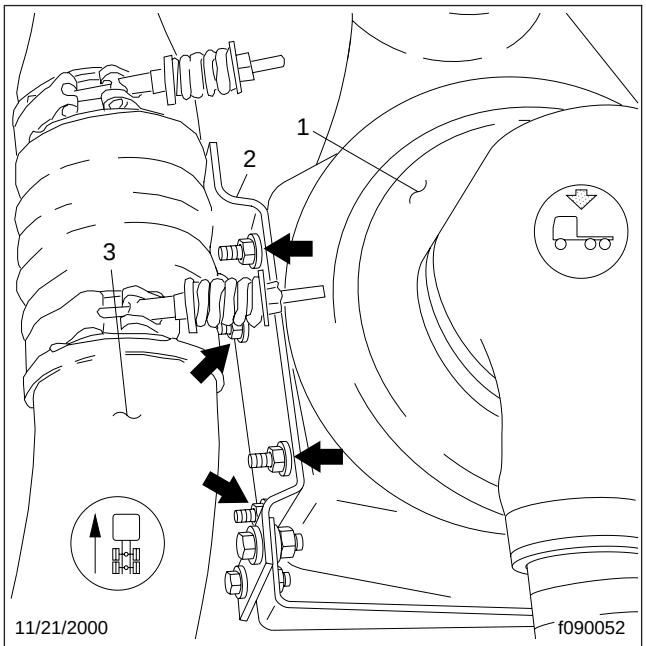
9.3 Back off the adjusting nut (**Fig. 6**, Ref. 2), and remove the belt running between the compressor and the vibration damper.

9.4 Remove the two bolts securing the compressor to its mount. See **Fig. 6**, Ref. 1.

9.5 Remove the four bolts holding the condenser to the charge air cooler. See **Fig. 7**.

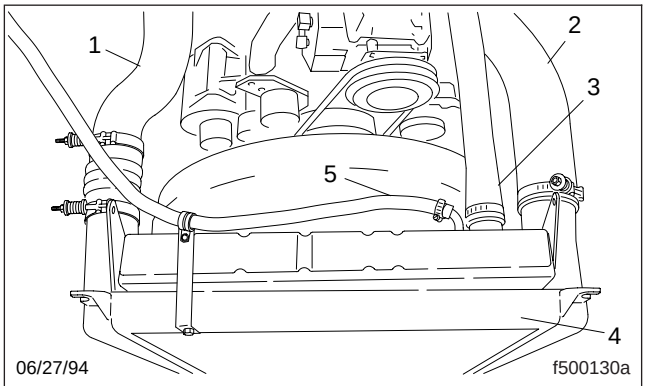
9.6 To keep the refrigerant system intact, with no leaks and no need for purging and recharging, move the condenser and the refrigerant compressor to the side at the same time. See **Fig. 8**.

9.7 Wrap the condenser in a protective blanket, or sandwich it between two sheets of cardboard or wood to prevent damage to the condenser fins. Secure the compressor and condenser out of the way with wire. See **Fig. 9**.



1. Air Cleaner Housing
2. Mounting Bracket
3. Charge Air Cooler Outlet Hose

Fig. 3, Air Cleaner Housing Mounting Fasteners

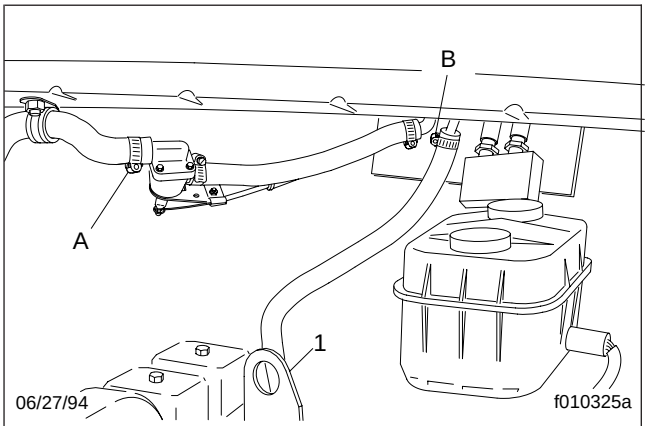


1. Charge Air Cooler Inlet Hose
2. Charge Air Cooler Outlet Hose
3. Radiator Inlet Hose
4. Charge Air Cooler
5. Radiator Vent Hose

Fig. 4, Top View of Radiator

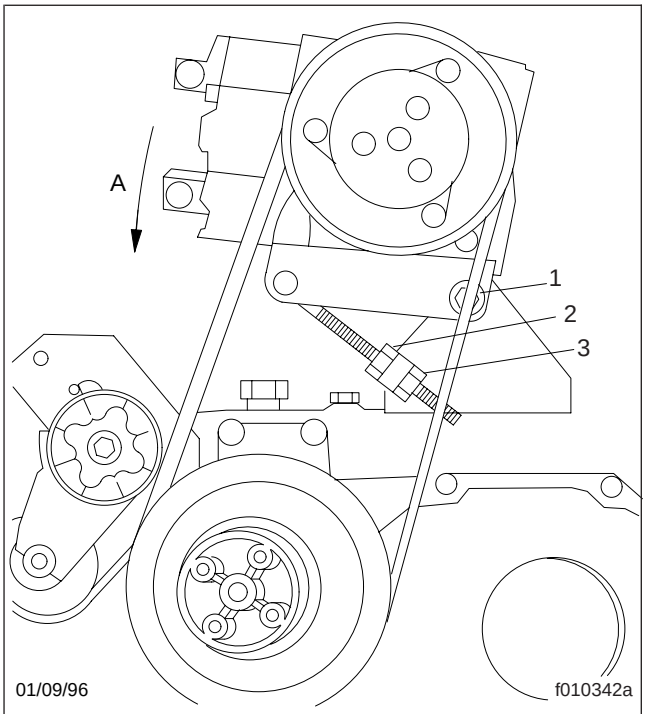
10. Remove the radiator and charge air cooler assembly.

10.1 Remove the left air recirculation shield from the left charge air cooler mounting tab. See **Fig. 10**.



A. Disconnect the heater inlet hose at the valve.
B. Disconnect the heater outlet hose at the firewall.
1. Rear Lifting Eye

Fig. 5, Disconnecting the Heater Hoses



A. Lower the compressor to loosen the belt.
1. Compressor Mounting Bolt
2. Adjusting Nut
3. Jam Nut

Fig. 6, Removing the Refrigerant Compressor

10.2 Hook a lifting chain to the radiator and charge air cooler assembly (see **Fig. 11**), and fasten the chain to a crane.

10.3 Remove the nuts, washers, and rubber isolators from the forward ends of the radiator struts. See **Fig. 12**.

10.4 Remove the nuts and washers from the radiator mounts. See **Fig. 12**.

10.5 Lift the radiator and charge air cooler from the vehicle as a single unit. See **Fig. 11**.

11. Remove the two power steering pump mounting bolts, and move the pump aside while keeping the steering fluid system intact.

12. Disconnect the engine fuel and oil system components.

12.1 Disconnect the fuel delivery line below the fuel filter. See **Fig. 13**.

12.2 Disconnect both ends of the throttle return springs. See **Fig. 13**.

12.3 Disconnect the throttle cable from the cable bracket and the engine throttle lever. See **Fig. 13**.

12.4 Disconnect the fuel return line from the injection pump. See **Fig. 14**.

12.5 Disconnect the oil pressure gauge line under the fuel injection pump. See **Fig. 14**.

12.6 Disconnect the turbocharger oil return line at the turbocharger.

13. Disconnect the engine electrical connections.

13.1 Disconnect the ground strap from the engine.

13.2 Disconnect the wires from the starter and label them for reassembly. See **Fig. 15**.

13.3 Disconnect the engine wiring harness from the rear of the alternator, then the coolant temperature sensors, the refrigerant compressor clutch, the fuel shutoff solenoid, and other applicable options.

13.4 Remove the heat shield from the wiring harness routed above the exhaust pipe.

Removal and Installation

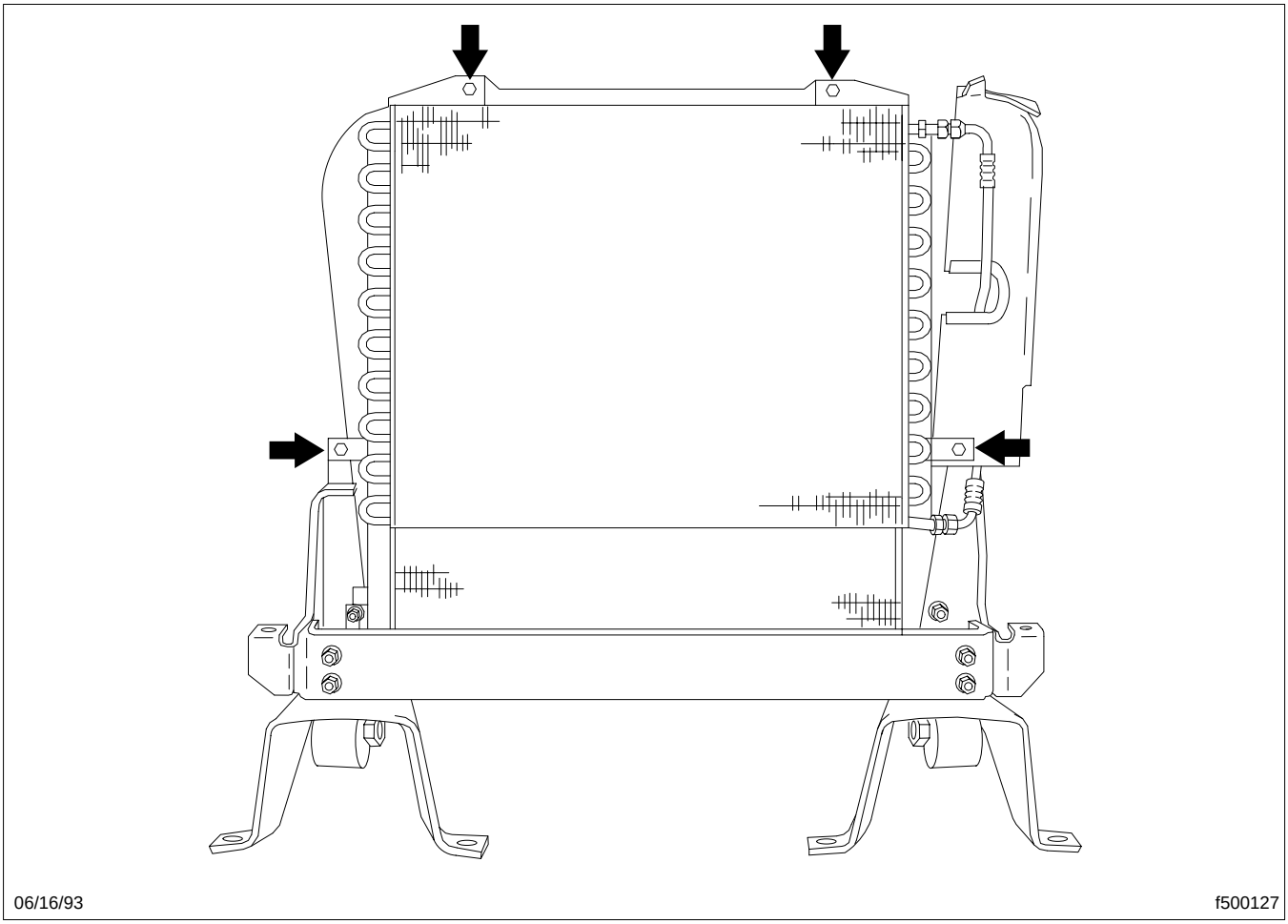


Fig. 7, Condenser Mounting Bolts

13.5 Disconnect the wiring harness brackets secured to the firewall. See **Fig. 16**.

13.6 Remove the engine wiring harness from the engine.

14. Disconnect the top of the left front shock absorber, and remove the top shock absorber mount from the frame rail.

15. Disconnect the transmission-mounted components.

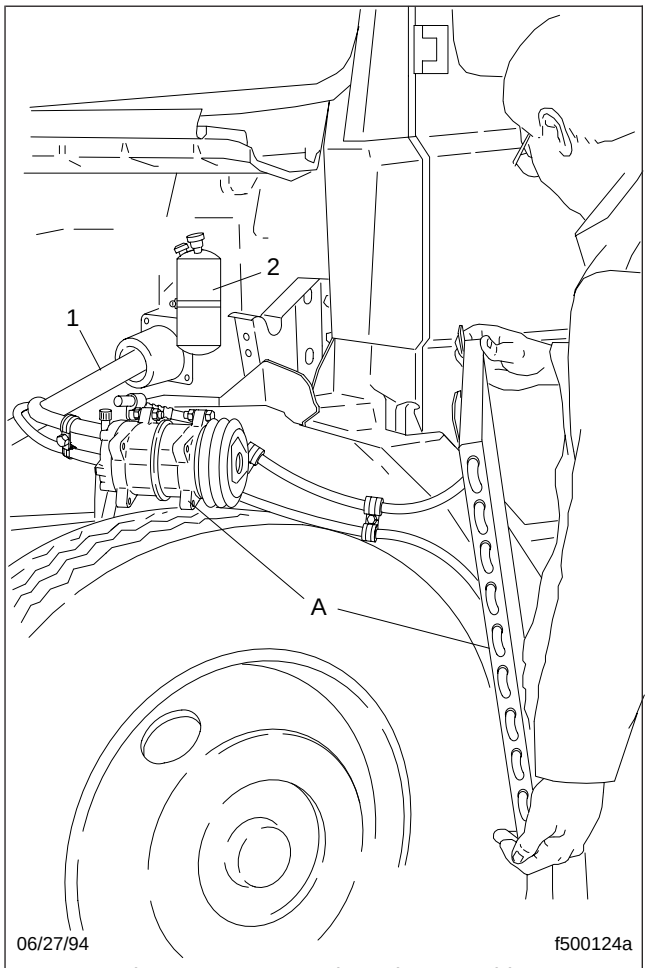
15.1 Disconnect the tachometer sensor at the engine flywheel. See **Fig. 13**.

15.2 Disconnect the speedometer sensor at the transmission output.

15.3 If the vehicle is equipped with hydraulic brakes, release the parking brake, and disconnect the parking brake cable from the parking brake. See **Fig. 17**.

15.4 Remove the shift tower from the transmission. See **Fig. 18**. Cover the shift tower hole in the top of the transmission with a piece of cardboard, and secure the cover by screwing the tower bolts back through it.

15.5 Remove the clevis pin from the clutch release lever (see **Fig. 19**), then remove the clutch slave cylinder from its mounting bracket on the right side of the transmission. See **Fig. 20**.



A. Move the compressor and condenser aside.
1. Steering Driveline
2. Receiver-Dryer

Fig. 8, Moving the Air Conditioner Components

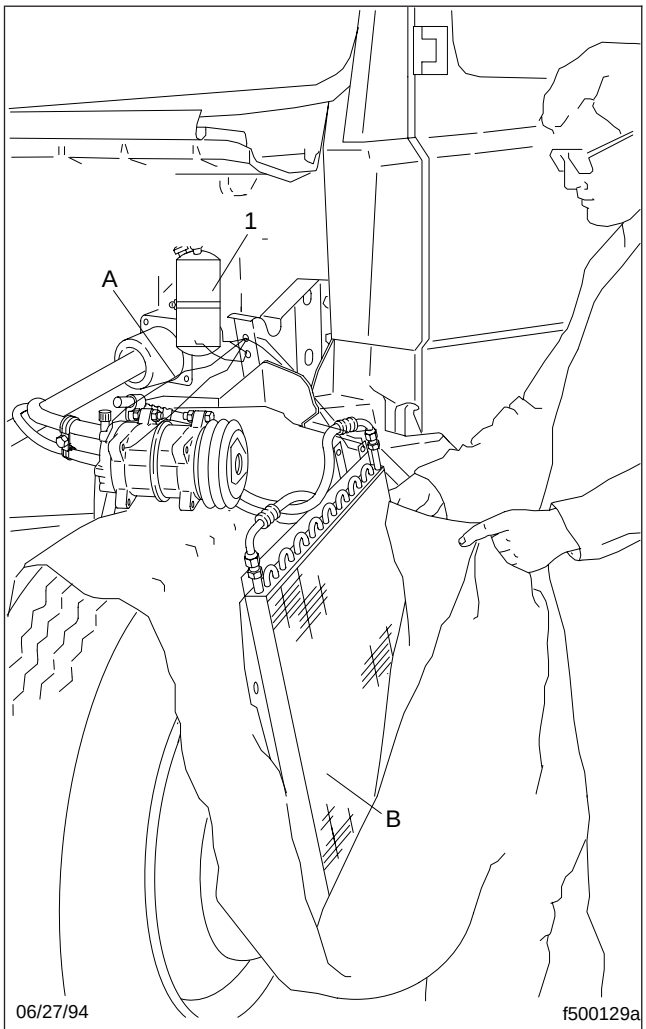
15.6 At the transmission bell housing, remove the bracket that supports the exhaust pipe. See **Fig. 19**.

15.7 Remove the driveshaft from the transmission output end yoke. For instructions, see **Group 41**.

16. Remove the engine from the vehicle.

⚠ WARNING

The crane and lifting chains used to remove the engine must be capable of safely lifting and supporting two metric tons. Once the engine mounts are disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

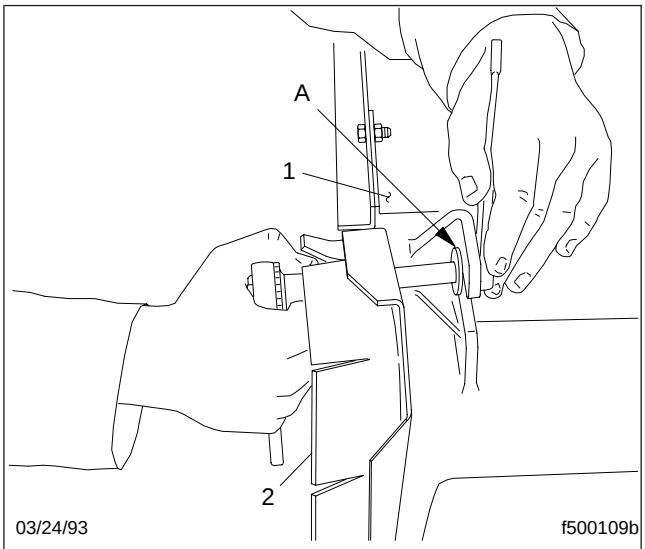


A. Secure the compressor and the condenser with wire.
B. Wrap the condenser to protect it.
1. Receiver-Dryer

Fig. 9, Securing the Air Conditioner Components

16.1 Attach a chain to the two engine lifting eyes (see **Fig. 21**), and position a crane to lift the engine. Attach the chain to the crane, and raise the chain to remove any slack.

Removal and Installation



A. Remove the air recirculation shield from the mounting tab.
1. Charge Air Cooler
2. Air Recirculation Shield

Fig. 10, Side View

16.2 Remove the bolt from the front engine mount. See **Fig. 22**.

16.3 Remove the bolts from the two rear engine mounts. See **Fig. 23** and **Fig. 24**.

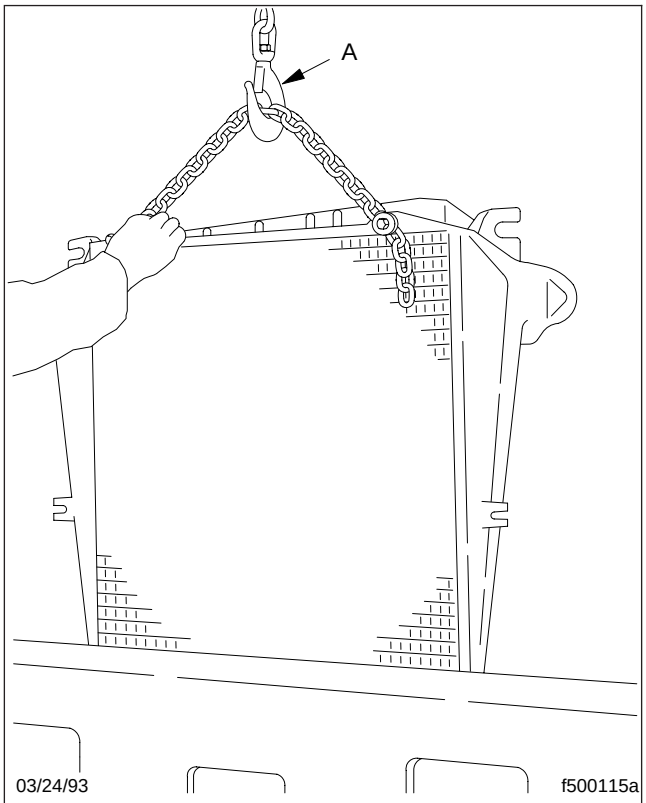
16.4 Carefully lift the engine and pull it forward to remove it from the engine compartment. See **Fig. 25**.

Installation

1. Examine all engine support components for damage and extreme wear. Replace components as necessary.
2. Install the engine in the vehicle.

⚠ WARNING

The crane and lifting chains used to install the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely installed on the engine mounts. An unsecured engine may fall, causing personal injury or death, and component damage.



A. Use a crane to lift the radiator and charge air cooler.

Fig. 11, Lifting the Radiator

2.1 Attach a chain to the lifting eyes of the engine. Attach the chain to a crane, and raise the chain to remove any slack.

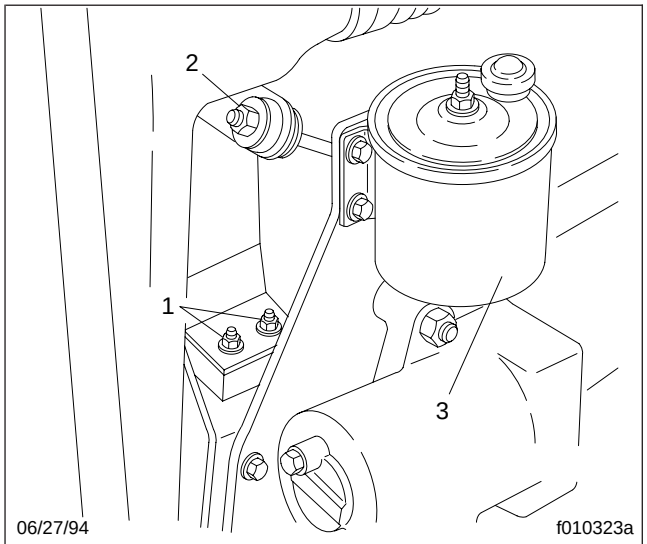
2.2 Carefully lower the engine, and push it back onto the engine mounts. See **Fig. 25**.

2.3 Install the bolts in the two rear engine mounts, and tighten them 241 lbf·ft (327 N·m).

2.4 Install the bolt in the front engine mount and tighten it 150 lbf·ft (203 N·m).

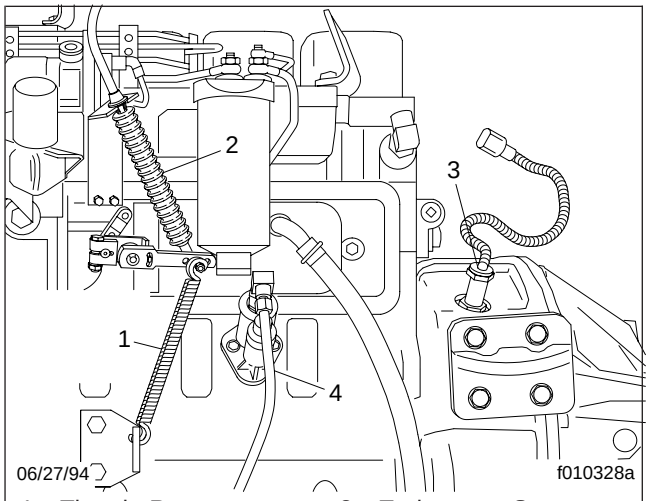
2.5 Remove the lifting chain from the two engine lifting eyes.

3. Install the heat shield over the wiring harness where it passes over the exhaust pipe.
4. Install the upper, front shock absorber mount on the left frame rail. Tighten the mounting bolts 135



1. Left Radiator Mounting Nuts
2. Left Radiator Strut
3. Power Steering Fluid Reservoir

Fig. 12, Left Radiator Strut Location

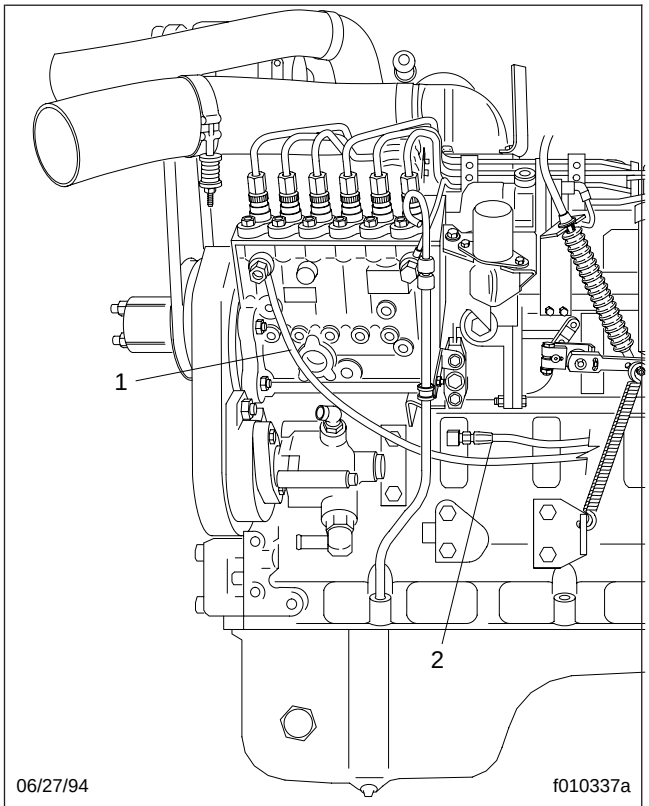


1. Throttle Return Springs
2. Throttle Cable
3. Tachometer Sensor
4. Fuel Delivery Line

Fig. 13, Left-Side View

lbf·ft (183 N·m). Install the shock on the mount, and tighten the shock mounting bolt 240 lbf·ft (325 N·m).

5. Connect the transmission-mounted components.



A.
1. Fuel Return Line
2. Oil Pressure Gauge Line

Fig. 14, Left-Side View

5.1 Connect the driveline to the transmission output end yoke. See **Group 41** for instructions.

5.2 Install the exhaust pipe bracket on the transmission bell housing. See **Fig. 19**.

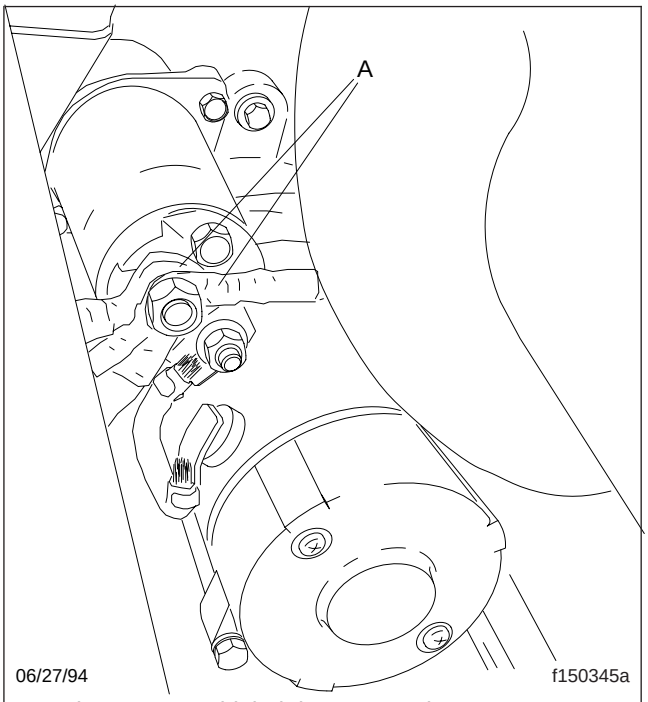
5.3 Connect the clutch release lever with a new clevis pin (see **Fig. 19**), and install the clutch slave cylinder on the bracket at the right side of the transmission. See **Fig. 20**.

5.4 Install the transmission shift tower.

5.5 Connect the parking brake cable to the parking brake. See **Fig. 17**.

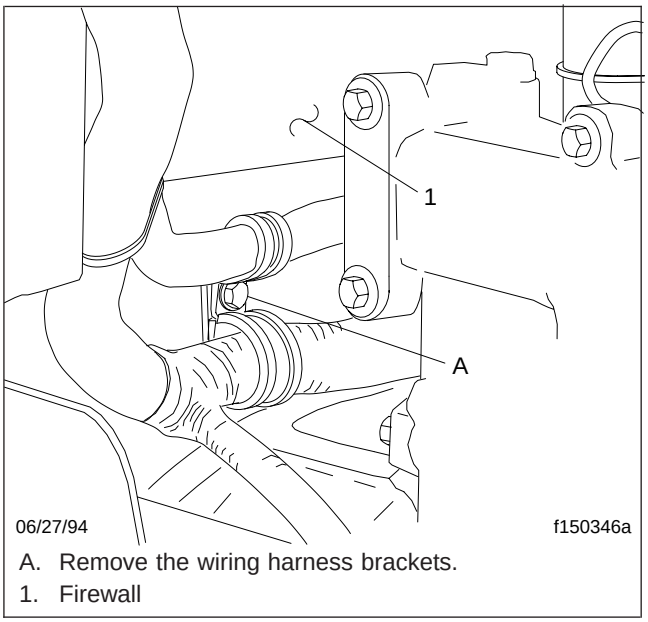
5.6 Connect the speedometer sensor at the transmission output.

Removal and Installation



A. Disconnect and label the starter wires.

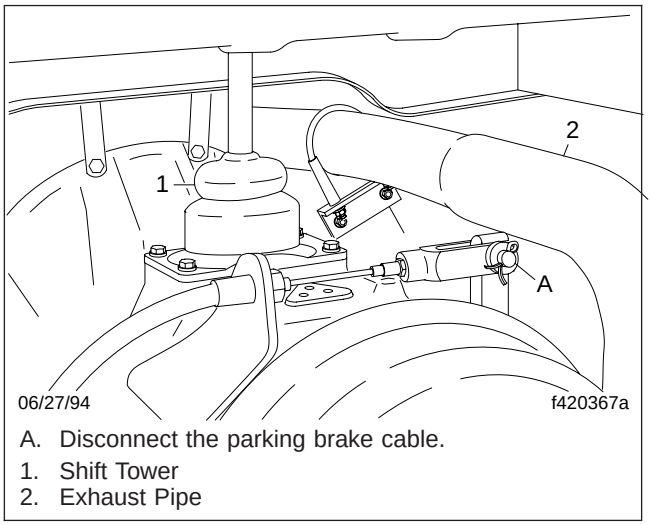
Fig. 15, Starter Wires



A. Remove the wiring harness brackets.
1. Firewall

Fig. 16, Right Wiring Harness Bracket

5.7 Connect the tachometer sensor at the engine flywheel. See **Fig. 13**.



A. Disconnect the parking brake cable.
1. Shift Tower
2. Exhaust Pipe

Fig. 17, Parking Brake Cable Location

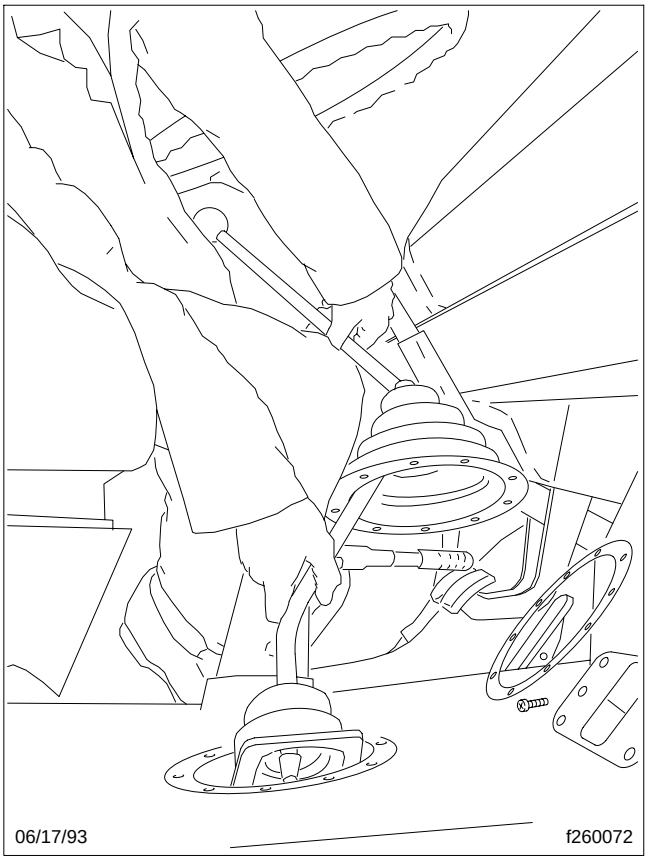
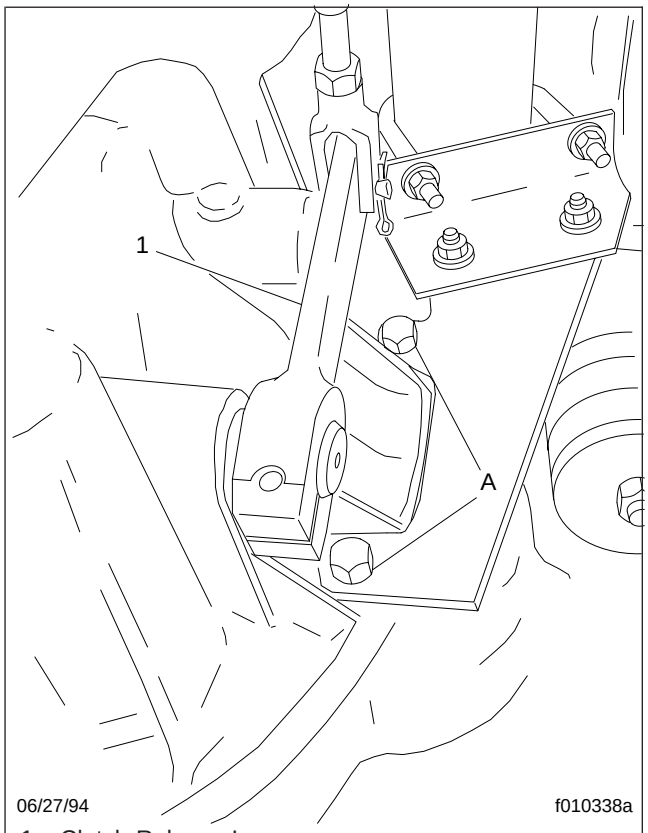


Fig. 18, Removing the Shift Lever

6. Connect the engine electrical connections.



1. Clutch Release Lever
2. Exhaust Pipe Bracket Fastener

Fig. 19, Removing the Exhaust Pipe Bracket

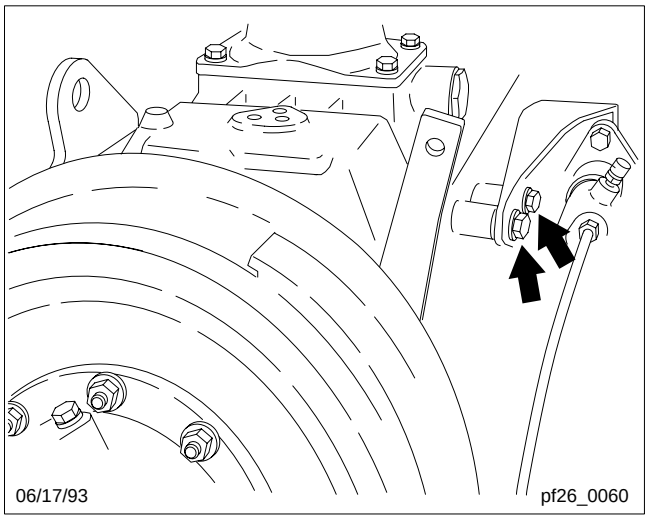


Fig. 20, Mounting Bracket Bolts

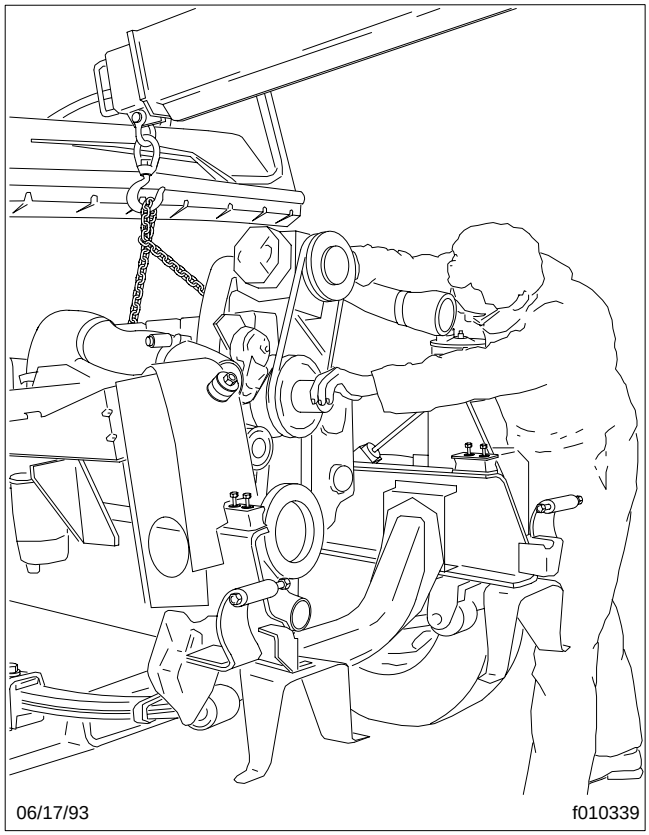


Fig. 21, Attaching Lifting Chains

6.1 Route the engine wiring harness, attaching it at the injection pump, then the fuel shutoff solenoid, the coolant temperature sensors, the rear of the alternator, and at any other applicable options.

6.2 Connect the wiring harness brackets to the firewall. See **Fig. 16**.

6.3 Connect the starter wires. See **Fig. 15**.

6.4 Connect the engine ground strap to the frame rail.

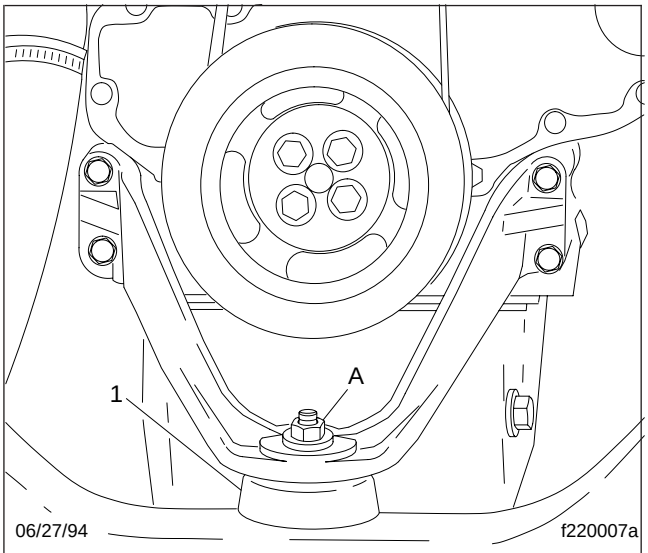
7. Connect the fuel and oil components.

7.1 Connect the oil pressure gauge line at the fuel injection pump. See **Fig. 14**.

7.2 Connect the fuel return line at the injection pump. See **Fig. 14**.

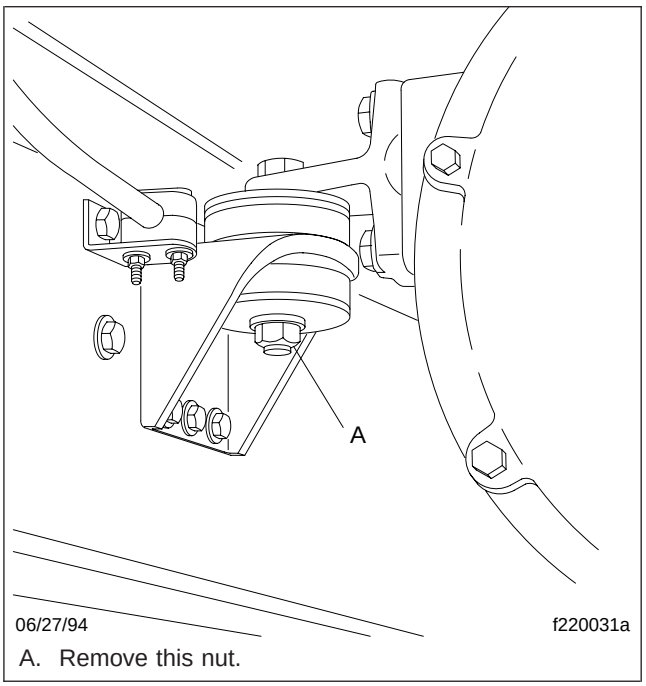
7.3 Connect the throttle cable to the engine throttle arm. See **Fig. 13**.

Removal and Installation



A. Remove this nut.
1. Front Engine Mount

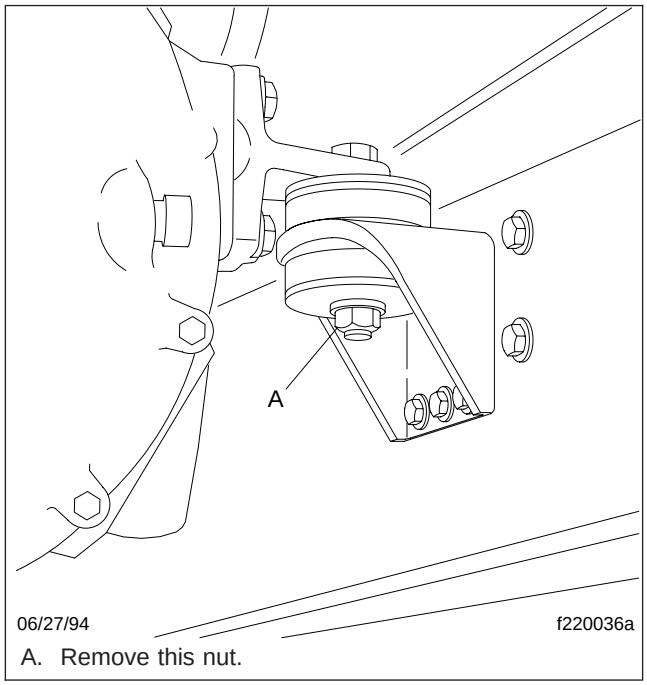
Fig. 22, Front Engine Mount



A. Remove this nut.

Fig. 23, Left Rear Engine Mount

7.4 Connect both ends of the throttle return springs. See **Fig. 13**.



A. Remove this nut.

Fig. 24, Right Rear Engine Mount

7.5 Connect the fuel delivery line below the fuel filter. See **Fig. 13**.

7.6 Connect the oil return line to the turbocharger.

8. Install the power steering pump on the engine, and tighten the mounting bolts 28 lbf·ft (38 N·m).

9. Install the radiator and charge air cooler assembly.

9.1 Using a crane and lifting chains, lift the radiator and charge air cooler as a single assembly. Position the assembly on the radiator mounting studs.

9.2 Install the nuts and washers on the radiator mounting studs. See **Fig. 12**. Tighten the nuts 30 lbf·ft (40 N·m).

9.3 Install the washers, rubber isolators, and nuts on the radiator struts. See **Fig. 12**. Tighten the nuts 35 lbf·ft (47 N·m).

9.4 Remove the lifting chain from the assembly.

9.5 Install the air recirculation shield over the left charge air cooler mounting tab, and

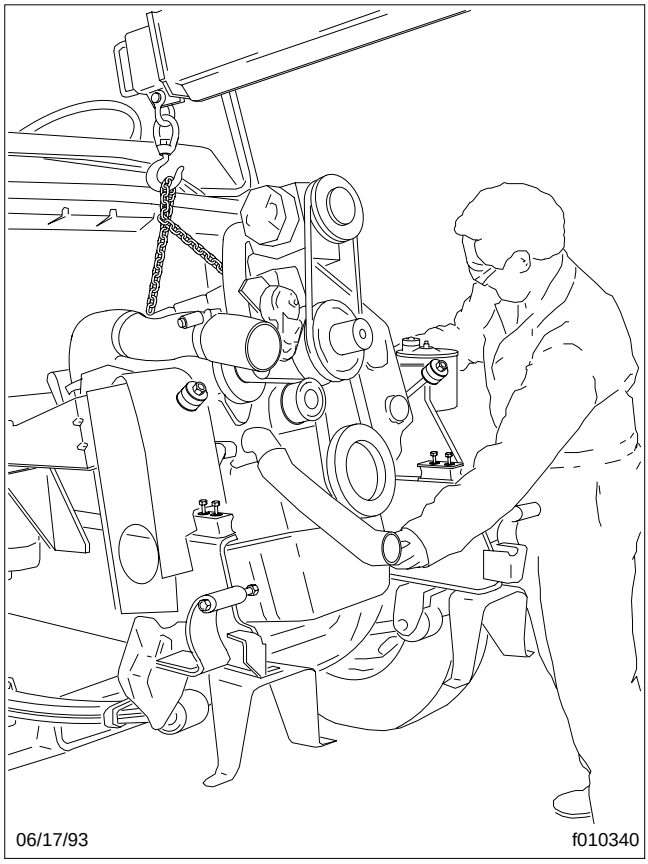


Fig. 25, Removing the Engine

tighten the shield bolt 15 lbf·ft (20 N·m). See **Fig. 10**.

10. Install the air conditioning components on the engine.
    - 10.1 Carefully move the refrigerant compressor and condenser back into place.
    - 10.2 Install the four bolts to hold the condenser in place over the charge air cooler. See **Fig. 7**. Tighten the bolts 15 lbf·ft (20 N·m).
    - 10.3 Position the compressor on its mount, and insert the two mounting bolts. See **Fig. 6**, Ref. A.
    - 10.4 Insert the adjusting rod through the compressor mount. See **Fig. 6**.
    - 10.5 Install the compressor drive belt on the compressor pulley and tighten the belt. For instructions, refer to "Drive Belts" in this group. Tighten the adjusting rod jam nut 59 lbf·ft (80 N·m). See **Fig. 6**, Ref. C.
    - 10.6 Tighten the compressor mounting bolt nuts 59 lbf·ft (80 N·m). See **Fig. 6**, Ref. A.
    - 10.7 Connect the compressor electrical connectors to the wiring harness.
11. Connect the coolant hoses.
    - 11.1 Connect the heater outlet hose at the firewall. See **Fig. 5**.
    - 11.2 Connect the heater inlet hose at the valve near the firewall. See **Fig. 5**.
    - 11.3 Connect the vent hose to the radiator. See **Fig. 4**. Connect the hose bracket at the condenser.
    - 11.4 Connect the coolant inlet and outlet hoses to the radiator. See **Fig. 4**.
    - 11.5 Connect the fill hose to the bottom of the surge tank.
12. Connect or install the air intake, exhaust pipe, and hoses.
    - 12.1 Connect the air inlet and outlet hoses to the charge air cooler. See **Fig. 4**. Tighten the hose clamps 60 lbf·in (680 N·cm).
    - 12.2 Connect the exhaust pipe to the rear of the turbocharger, and install the V-clamp that secures the pipe. Tighten the V-clamp 85 lbf·in (940 N·cm).
    - 12.3 Install the air intake pipe on the turbocharger. See **Fig. 2**.
    - 12.4 If the vehicle is equipped with air brakes, connect the air outlet line to the air compressor.
    - 12.5 If the vehicle is equipped with air brakes, connect the two air signal lines to the air governor on top of the compressor.
13. Install the air cleaner.
    - 13.1 Position the air cleaner on its bracket, and secure the cleaner with four nuts. See **Fig. 3**. Tighten the nuts 28 lbf·ft (38 N·m).
    - 13.2 Connect the air intake pipe to the top of the air cleaner. See **Fig. 2**.

Removal and Installation

14. Install the right fender splash shield. See **Fig. 1**.
15. Install the bumper and hood. For instructions, see **Group 88**.
16. Connect the batteries or, if the vehicle is equipped with a battery shutoff switch, turn on the switch.
    - 16.1 Connect the positive battery cable to the batteries.
    - 16.2 Connect the battery ground cable to the vehicle frame.
17. Fill the engine coolant system.
    - 17.1 Close the petcock on the bottom of the radiator.
    - 17.2 Fill the system with coolant at the surge tank. For coolant specifications, see the vehicle maintenance manual.
    - 17.3 Tighten the surge tank cap.
18. Start the engine and check for leaks. Eliminate any leaks.
19. After the engine has run for about 20 minutes, check the coolant level and add coolant if needed.
20. Fill and bleed the power steering system as needed. For instructions, see **Group 46**.
21. Lower the hood, and remove the chocks from the tires.

Specifications

Description	Grade	Size	Torque	
			N·m (lbf·ft)	N·cm (lbf·in)
Rear Engine Mount Bolt	8	3/4 inch	244-325 (180-240)	—
Front Engine Mount Bolt	8	5/8 inch	163-203 (120-150)	—
Radiator Strut Nuts	2	1/2–13	47 (35)	—
Radiator Mount Nuts	5	3/8–16	40 (30)	—
Air Recirculation Shield Bolt	5	5/16 inch	20 (15)	—
Shock Absorber Mounting Bolt	8	3/4 inch	325 (240)	—
Shock Absorber Mount Mounting Bolts	8	5/8 inch	183 (135)	—
Refrigerant Compressor Adjusting Rod Jam Nut	5	1/2 inch	80 (59)	—
Refrigerant Compressor Mounting Nuts	5	1/2 inch	80 (59)	—
Condenser Mounting Bolts	5	5/16 inch	20 (15)	—
Aftercooler Hose Clamps	5	6.3 mm	—	680 (60)
Air Cleaner Mounting Nuts	5	3/8–16	38 (28)	—
Power Steering Pump Mounting Bolts	8.8	25 mm	38 (28)	—

Table 1, Fastener Torques

General Description

The Mercedes-Benz OM 366LA engine **(see Fig. 1 and Fig. 2)** is supported by three engine mounts: two are at the rear of the engine— one on each side— and fastened to the frame rails. The other is at the front of the engine, fastened to the underslung crossmember.

Because the engine provides the main support for the transmission, removing them as an as-sembly is easier than disconnecting them, if the engine has to be removed. To further save time and expense, the refrigerant system remains intact simply by moving the refrigerant compressor and condenser out of the way, before lifting out the engine.

For detailed repair procedures and other engine service not covered in this section, refer to the Mercedes-Benz *Engine Model OM 366LA Workshop Manual* .

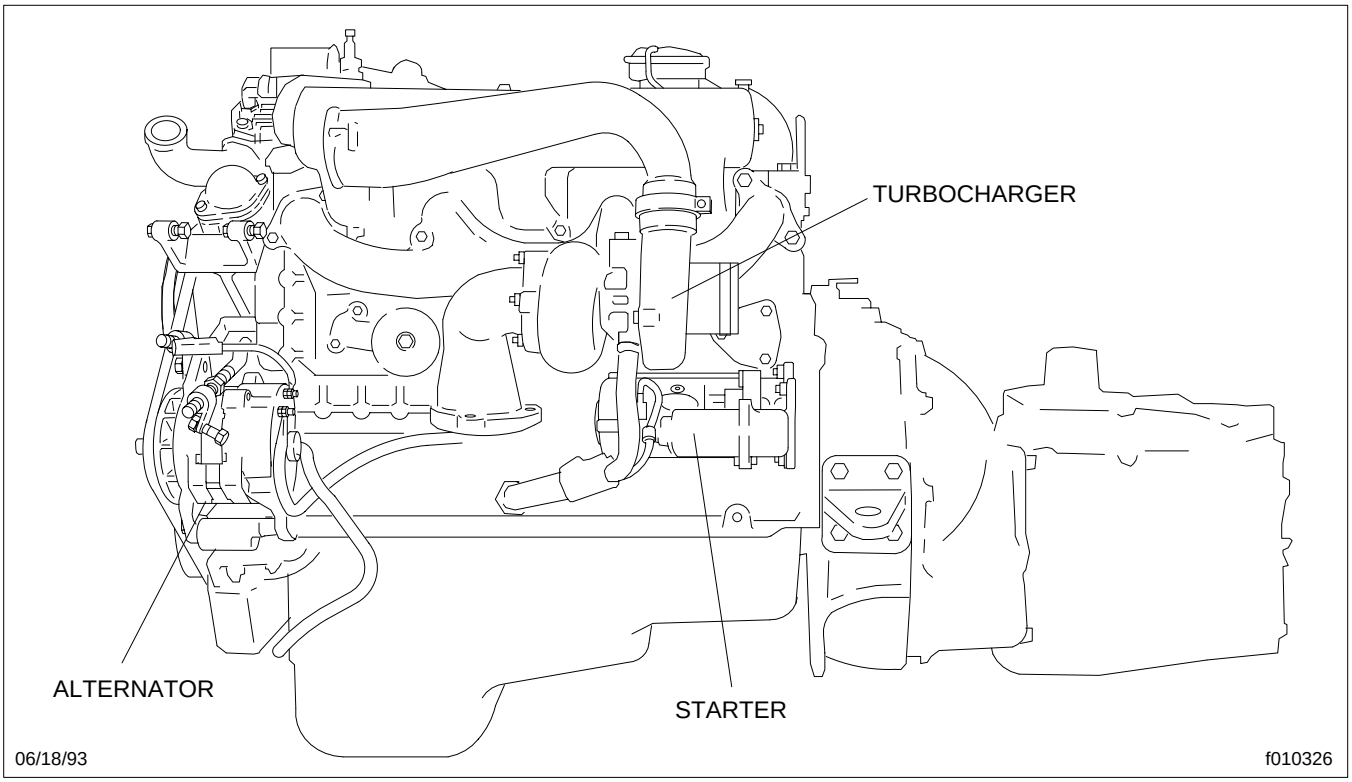


Fig. 1

General Description

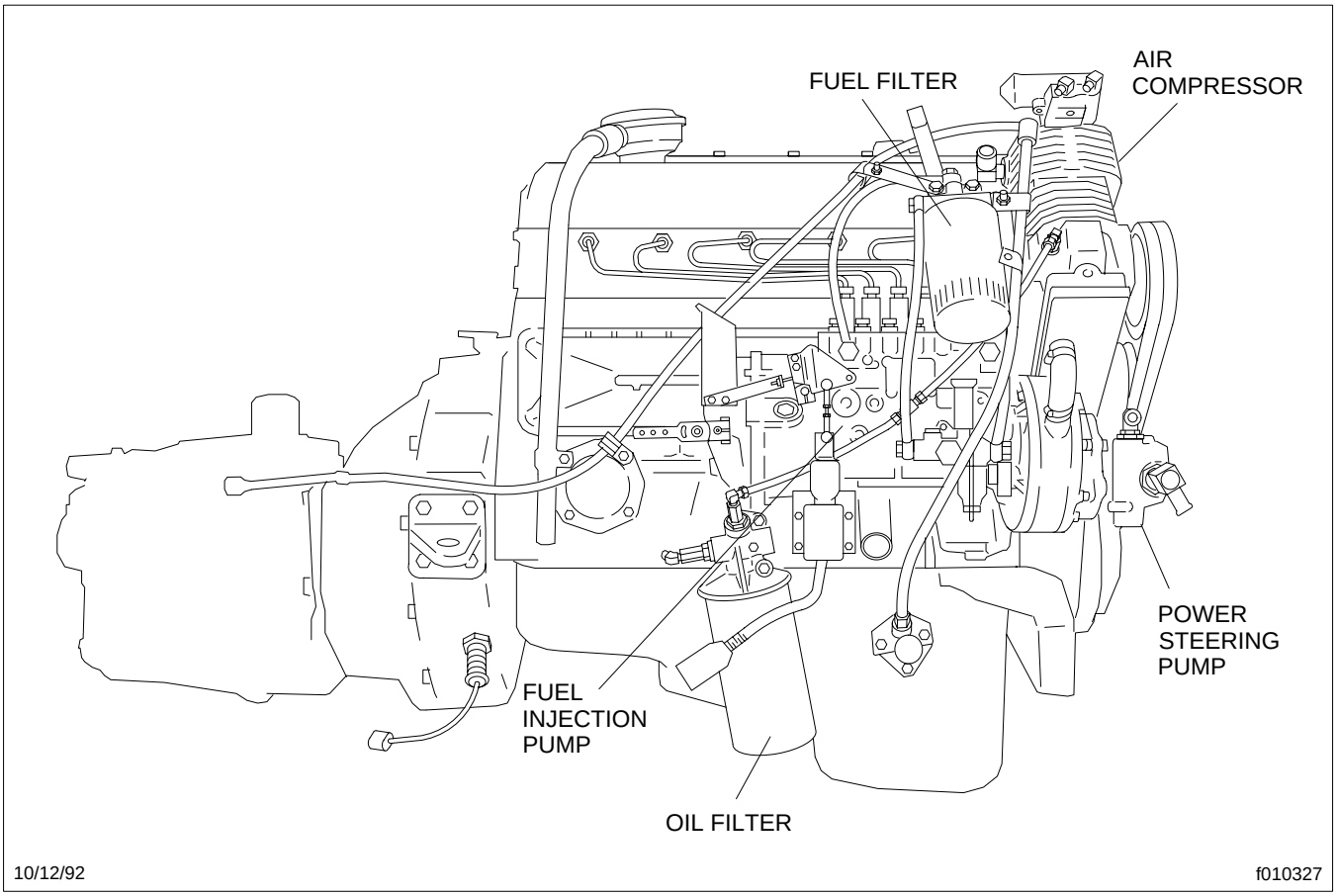


Fig. 2

Removal

NOTE: Because the transmission is supported entirely by the engine, removing them as an assembly (as described below) is easier than disconnecting them and removing the engine only.

1. Apply the parking brakes, chock the tires, and (if applicable) drain the air brake system.
2. Disconnect the batteries or, if the vehicle is equipped with a battery shutoff switch, turn off the switch.
   - 2.1 Disconnect the battery ground cable at the vehicle frame.
   - 2.2 Disconnect the positive battery cable from the batteries.

⚠ WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

3. Drain the radiator.
   - 3.1 Open the petcock at the bottom of the radiator to drain the engine coolant.
   - 3.2 Loosen the surge tank cap.
4. Remove the hood and bumper. For instructions, see **Group 88**.
5. Remove the right fender splash shield. See **Fig. 1**.
6. Remove the air cleaner.
   - 6.1 Remove the air intake pipe from the top of the air cleaner. See **Fig. 2**.
   - 6.2 Remove the four nuts from the inside of the air cleaner mounting bracket. See **Fig. 3**.
   - 6.3 Remove the air cleaner from its mounting bracket.
7. Disconnect or remove the air intake, exhaust pipe, and hoses.
   - 7.1 If the vehicle is equipped with air brakes, disconnect the compressor air intake hose from the air intake pipe. See **Fig. 4**.

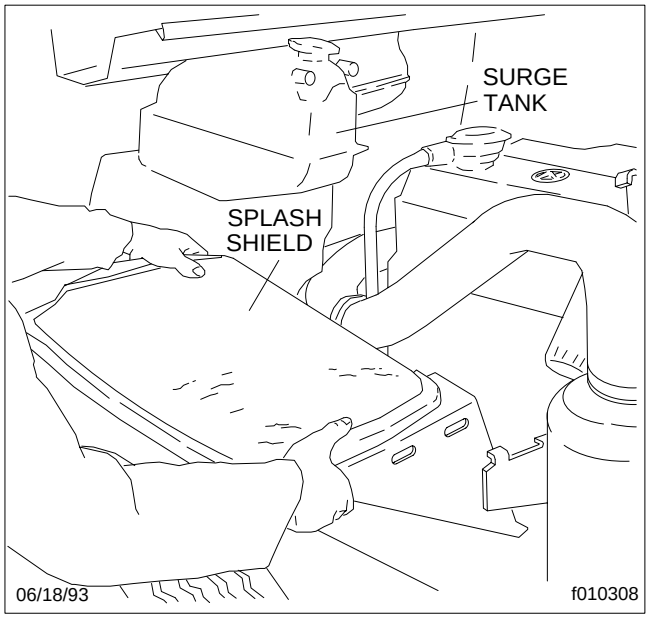


Fig. 1, Remove the Right Fender Splash Shield

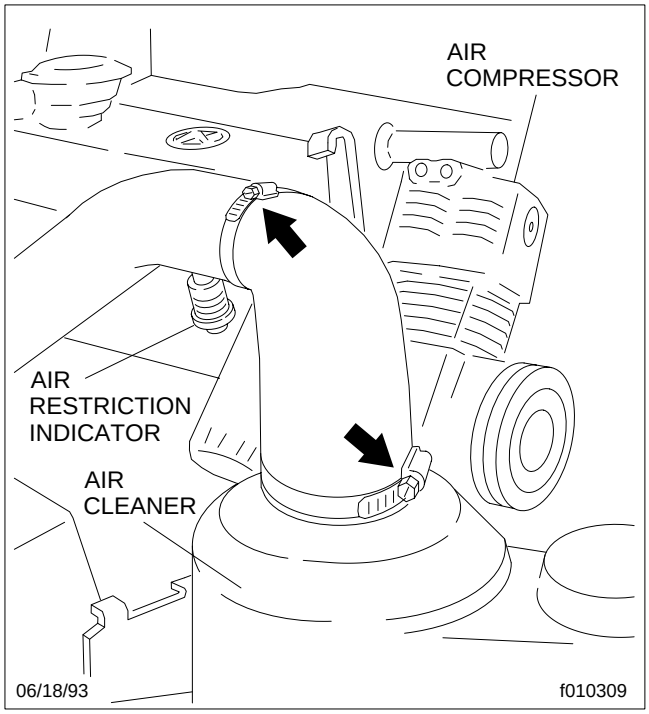
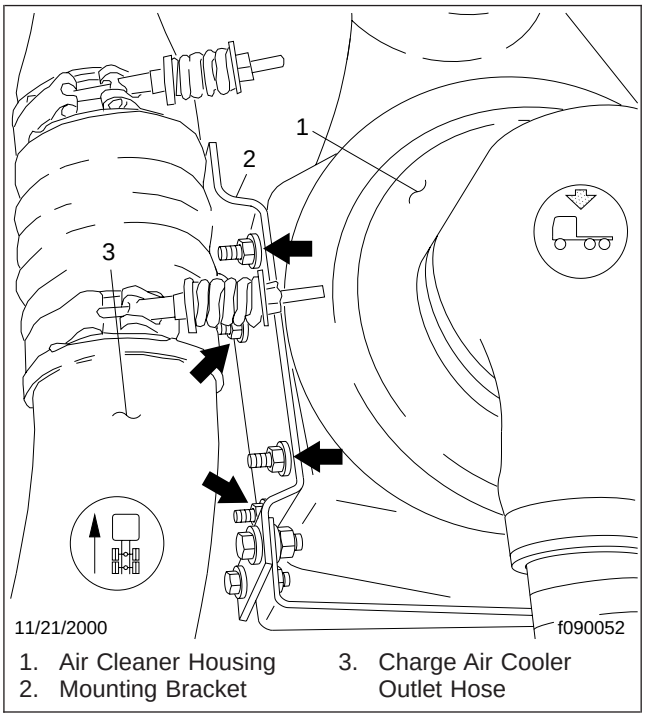


Fig. 2, Remove the Air Intake Pipe

   - 7.2 If the vehicle is equipped with air brakes, disconnect the air signal lines from the air

Removal and Installation



1. Air Cleaner Housing
2. Mounting Bracket
3. Charge Air Cooler Outlet Hose

Fig. 3, Air Cleaner Housing Mounting Fasteners

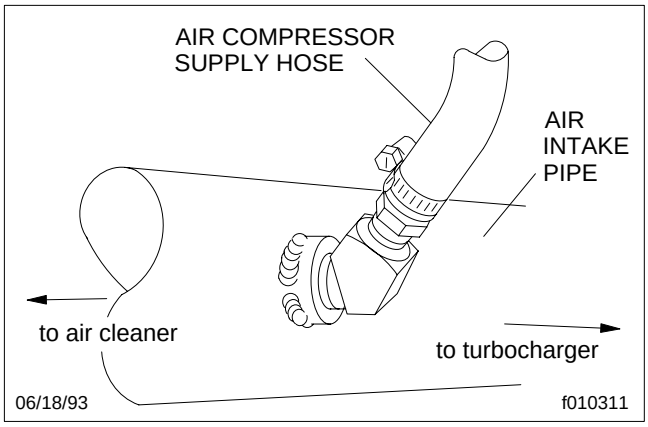


Fig. 4, Disconnect the Air Compressor Intake Hose

governor on top of the air compressor. See **Fig. 5**, Ref. A.

7.3 Disconnect the compressor outlet line. See **Fig. 6**.

7.4 Remove the air intake pipe from the pipe around the rear of the engine.

7.5 Remove the air intake pipe routed around the rear of the engine to the turbocharger. Two screws secure the pipe to the rear of the engine, and a clamp holds it to the turbocharger. See **Fig. 7**.

7.6 Disconnect the air inlet and outlet hoses from the aftercooler. See **Fig. 8**.

7.7 Disconnect the exhaust pipe from the rear of the turbocharger. Remove the bracket holding the exhaust pipe to the engine. See **Fig. 9**.

8. Disconnect or remove the coolant hoses.

8.1 Disconnect the fill hose from the bottom of the surge tank and the heater inlet hose from the valve at the firewall. See **Fig. 10** and **Fig. 11**. With the heater and fill hoses attached, remove the coolant outlet hose between the engine and the bottom of the radiator. See **Fig. 12**.

8.2 Disconnect the radiator inlet hose between the engine thermostat and the radiator. See **Fig. 8**.

8.3 Disconnect the surge tank vent hose from the radiator (see **Fig. 13**), and remove the hose bracket from the condenser. Disconnect the surge tank vent hose from the engine. See **Fig. 13**.

8.4 Disconnect the heater outlet hose running between the firewall and the engine (just behind the engine thermostat). See **Fig. 14**.

9. Remove the refrigerant compressor and condenser (see **Fig. 15**).

9.1 Disconnect the compressor electrical connectors.

9.2 Remove the adjusting rod guide from the adjusting rod.

9.3 Remove the belt running between the rear pulley of the compressor and the front pulley of the vibration damper.

9.4 Remove the two bolts securing the compressor to its mount.

9.5 Remove the four bolts holding the condenser to the aftercooler. See **Fig. 16**.

9.6 To keep the refrigerant system intact, with no leaks and no need for purging and recharging, move the condenser and the

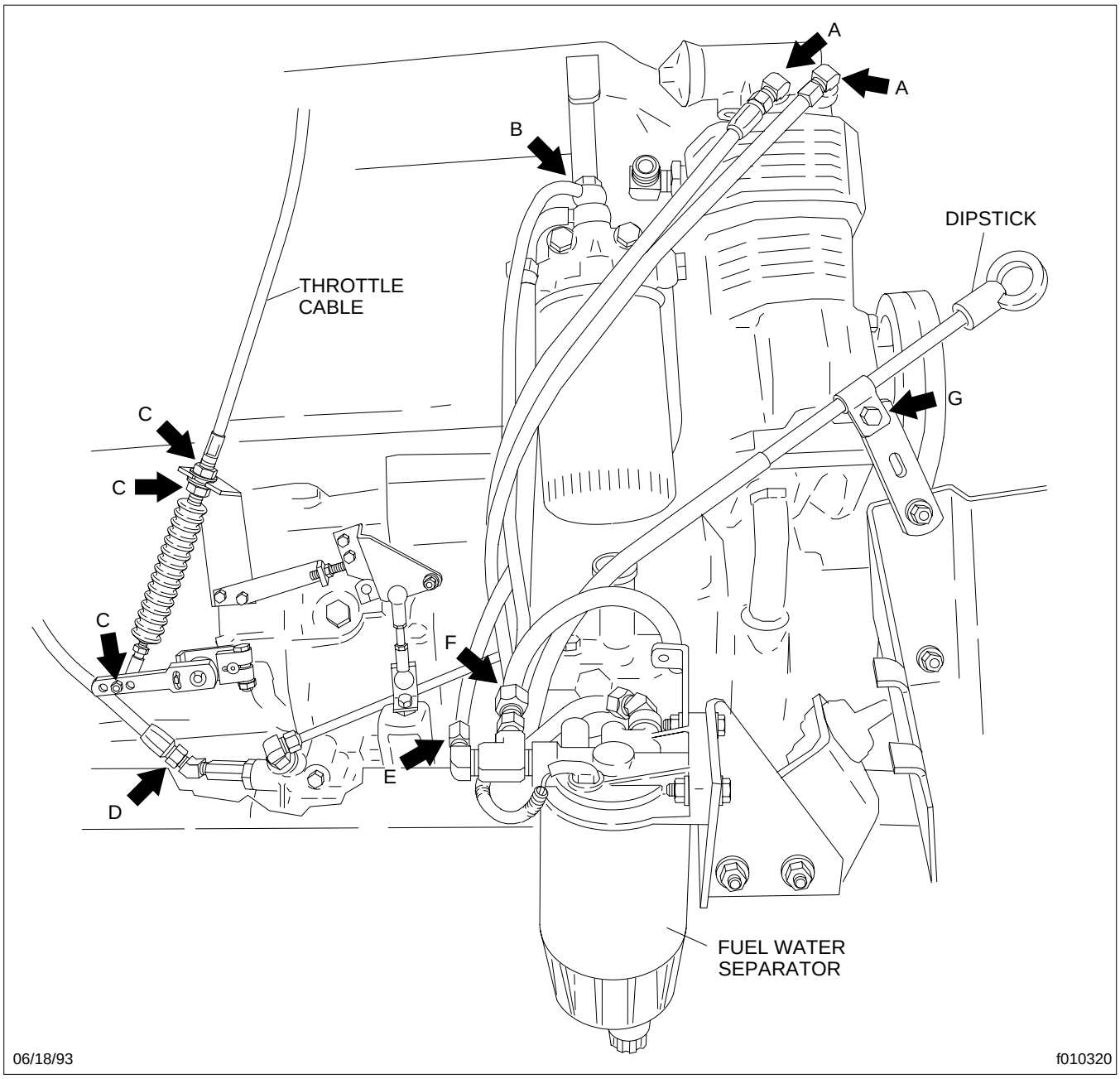


Fig. 5

refrigerant compressor to the side at the same time. See **Fig. 17**.

9.7 Wrap the condenser in a protective blanket, or sandwich it between two sheets of cardboard or wood to prevent damage to the condenser fins. Secure the compressor and condenser out of the way with wire. See **Fig. 18**.

10. Remove the radiator and aftercooler assembly.

Removal and Installation

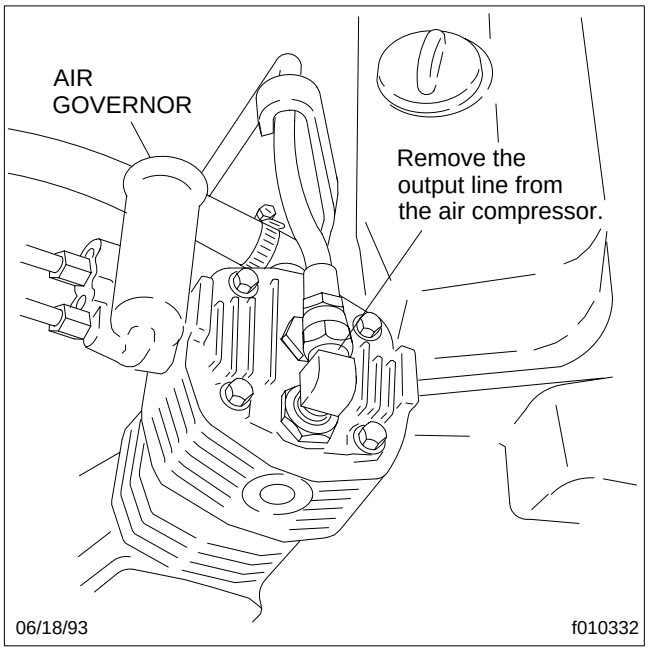


Fig. 6

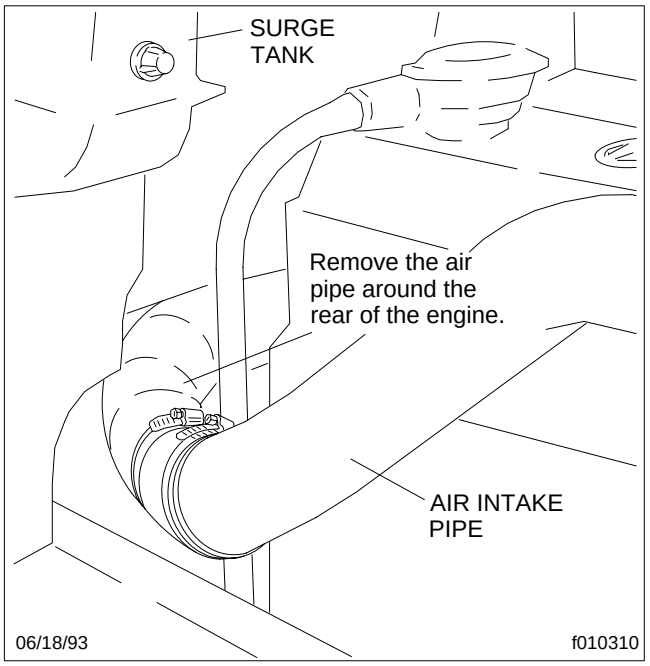


Fig. 7

10.1 Remove the left air recirculation shield to uncover the left aftercooler mounting tab. See **Fig. 19**.

10.2 Hook a lifting chain to the radiator and aftercooler assembly (see **Fig. 20**), and fasten the chain to a crane.

10.3 Remove the nuts, washers, and rubber isolators from the forward ends of the radiator struts. See **Fig. 21**.

10.4 Remove the nuts and washers from the radiator mounts. See **Fig. 21**.

10.5 Lift the radiator and aftercooler from the vehicle as a single unit. See **Fig. 20**.

11. Remove the two power steering pump mounting bolts, and move the pump aside while keeping the steering fluid system intact.

12. Disconnect the engine fuel and oil system components.

12.1 Remove the dipstick tube from the air cleaner mounting bracket. See **Fig. 5**, Ref. G.

12.2 Disconnect the throttle cable from the engine throttle arm and the throttle cable bracket. See **Fig. 5**, Ref. C.

12.3 Disconnect the oil pressure gauge line from the rear of the oil filter housing. See **Fig. 5**, Ref. D.

12.4 Disconnect the fuel return line running between the engine and the fuel water separator. See **Fig. 5** , Ref. E.

12.5 Disconnect the fuel delivery line from the fuel water separator. See **Fig. 5**, Ref. F.

12.6 Disconnect the fuel return line from the fuel filter. See **Fig. 5**, Ref. B.

12.7 Disconnect the turbocharger oil return line at the turbocharger.

13. Disconnect the engine electrical connections.

13.1 Disconnect the wiring connector for the fuel shutoff solenoid.

13.2 Remove the wiring ring terminals from the starter, and label them for reassembly. See **Fig. 22**.

13.3 Remove the alternator ground wire and engine ground strap from the frame rail.

13.4 Disconnect the engine wiring harness from the flame start (and other options as

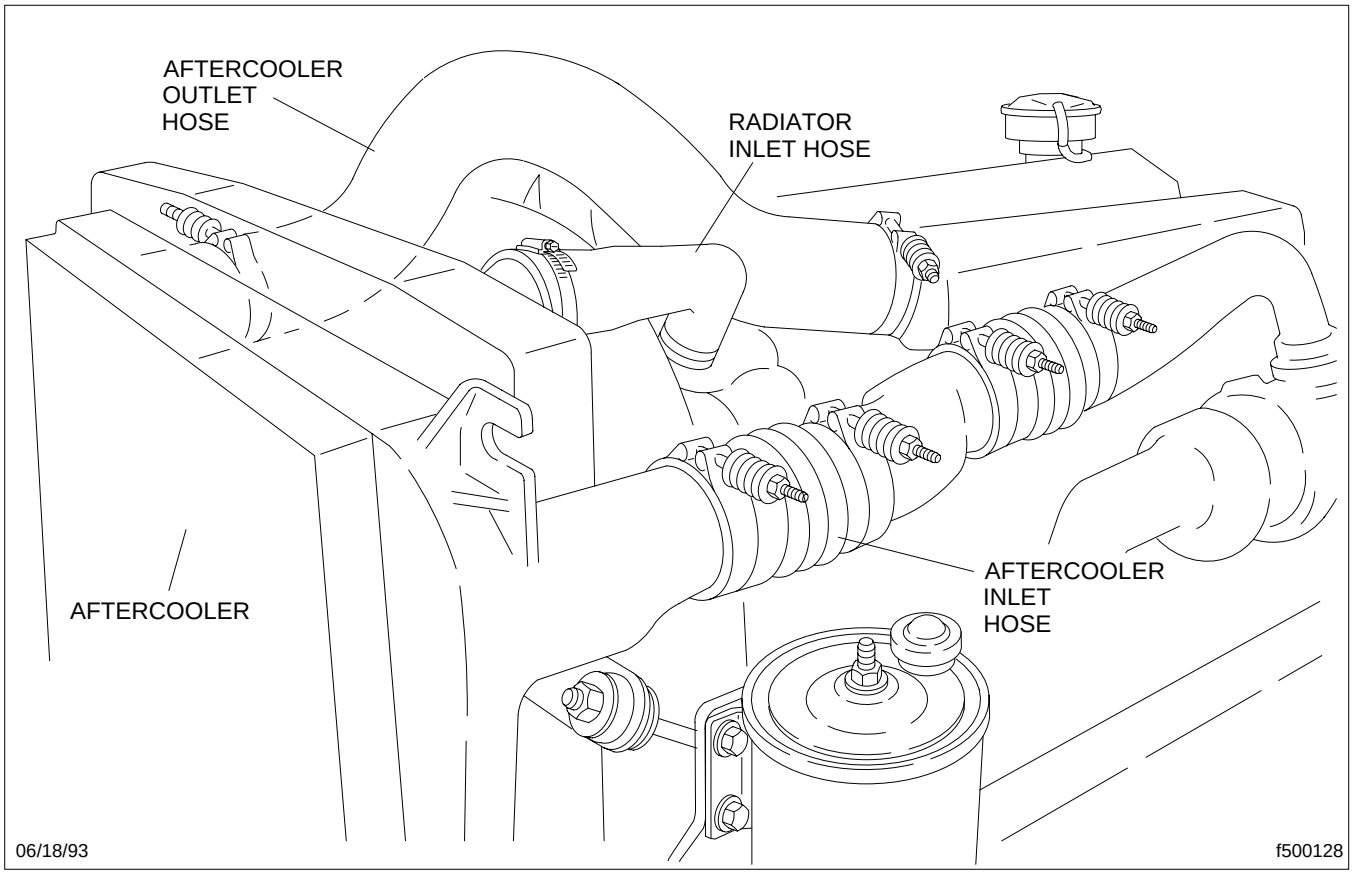


Fig. 8, Disconnect the Aftercooler Hoses and Radiator Inlet Hose

applicable), the coolant temperature sensors, and the alternator. Pull the harness off to the right side, away from the engine.

14. Disconnect the top of the left front shock absorber, and remove the top shock absorber mount from the frame rail.
15. Disconnect the transmission-mounted components.
    - 15.1 Remove the shift tower from the transmission. See **Fig. 23**. Cover the shift tower hole in the top of the transmission.
    - 15.2 Disconnect the back-up alarm sensor at the rear of the transmission. See **Fig. 24**.
    - 15.3 Disconnect the tachometer sensor at the engine flywheel. See **Fig. 24**.
    - 15.4 Disconnect the speedometer sensor at the transmission output. See **Fig. 24**.
    - 15.5 Remove the clevis pin from the clutch release lever, then remove the clutch slave cylinder from the clutch housing. See **Fig. 25**.
    - 15.6 Remove the driveshaft from the transmission output end yoke. For instructions, see **Group 41**.
    - 15.7 If the vehicle is equipped with air brakes, disconnect the air compressor outlet line from the chassis air delivery line, and remove the outlet line from the bracket mounted on the transmission bell housing. See **Fig. 24**.
16. Remove the engine from the vehicle.

Removal and Installation

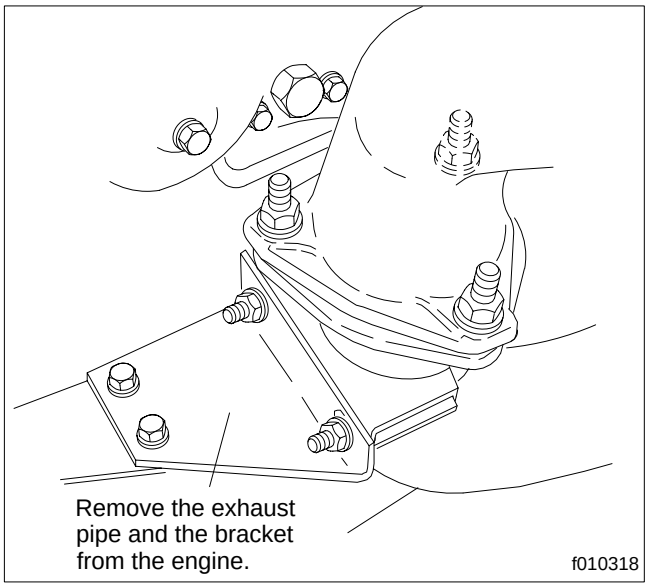


Fig. 9

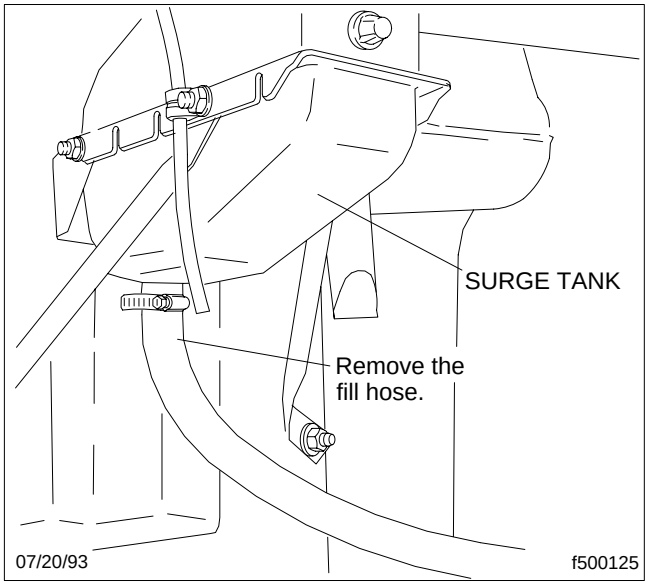


Fig. 10

⚠ WARNING

The crane and lifting chains used to remove the engine must be capable of safely lifting and supporting two metric tons. Once the engine mounts are disconnected, do not get under the engine until it is securely supported on engine stands.

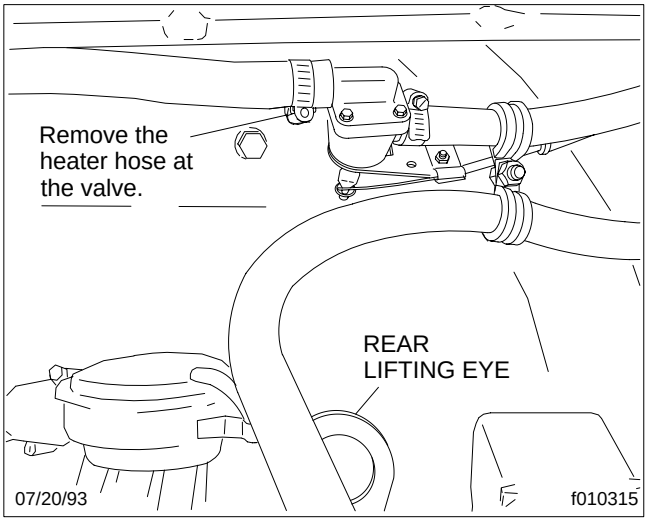


Fig. 11

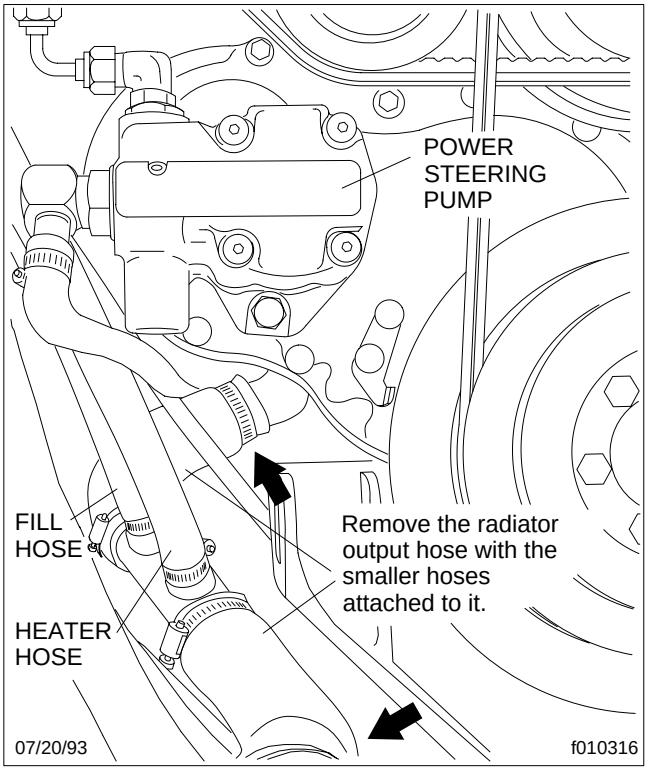


Fig. 12

An unsecured engine may fall, causing personal injury or death, and component damage.

16.1 Attach a chain to the engine lifting eye at the rear of the engine and to the lifting

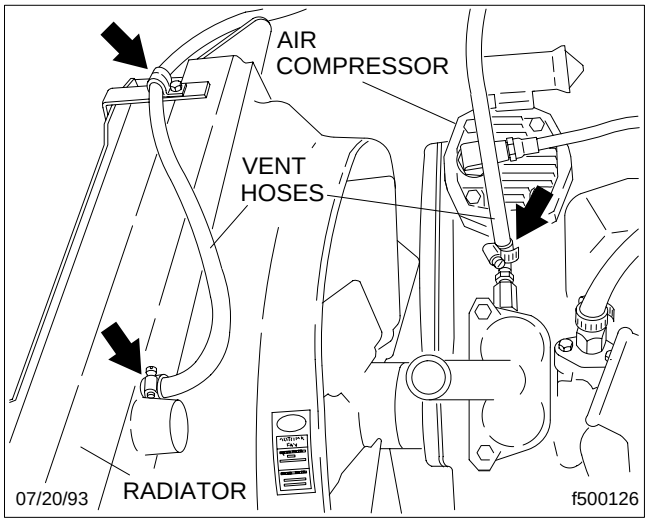


Fig. 13, Disconnect the Vent Hoses

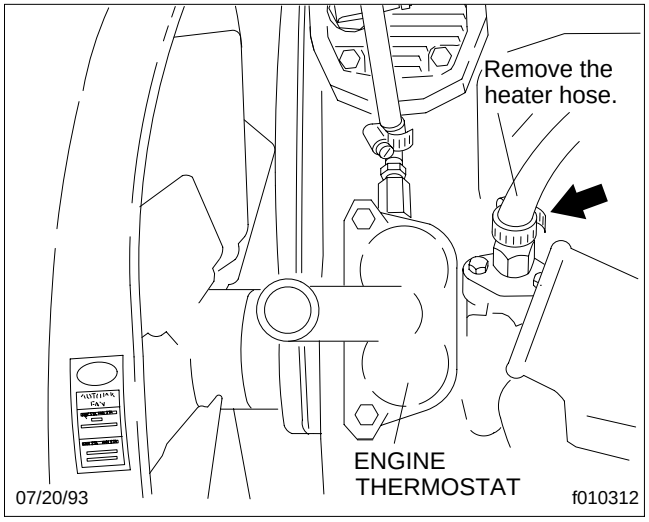


Fig. 14

hook at the front. See **Fig. 26**. Attach the chain to a crane, and raise the chain to remove any slack.

16.2 Remove the bolt from the front engine mount. See **Fig. 27**.

16.3 Remove the bolts from the two rear engine mounts. See **Fig. 28** and **Fig. 29**.

16.4 Gradually lift the engine and pull it forward to remove it from the engine compartment.

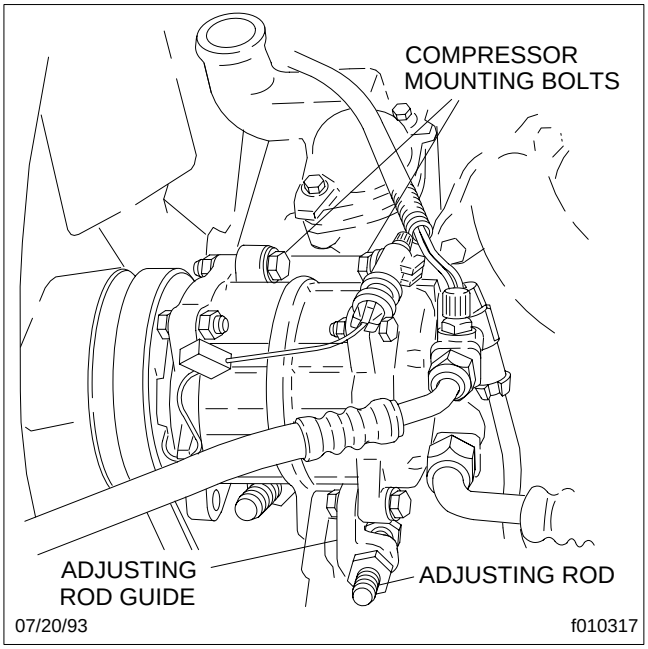


Fig. 15, Refrigerant Compressor

NOTE: If necessary to lift the engine, remove the blow-by vent from the engine cover. See **Fig. 30**.

Installation

1. Examine all engine support components for damage and extreme wear. Replace components as necessary.
2. Install the engine in the vehicle.

⚠ WARNING

The crane and lifting chains used to install the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely installed on the engine mounts. An unsecured engine may fall, causing personal injury or death, and component damage.

2.1 Attach a chain to the lifting eye at the rear of the engine and to the lifting hook at the front. See **Fig. 26**. Attach the chain to a crane, and raise the chain to remove any slack.

Removal and Installation

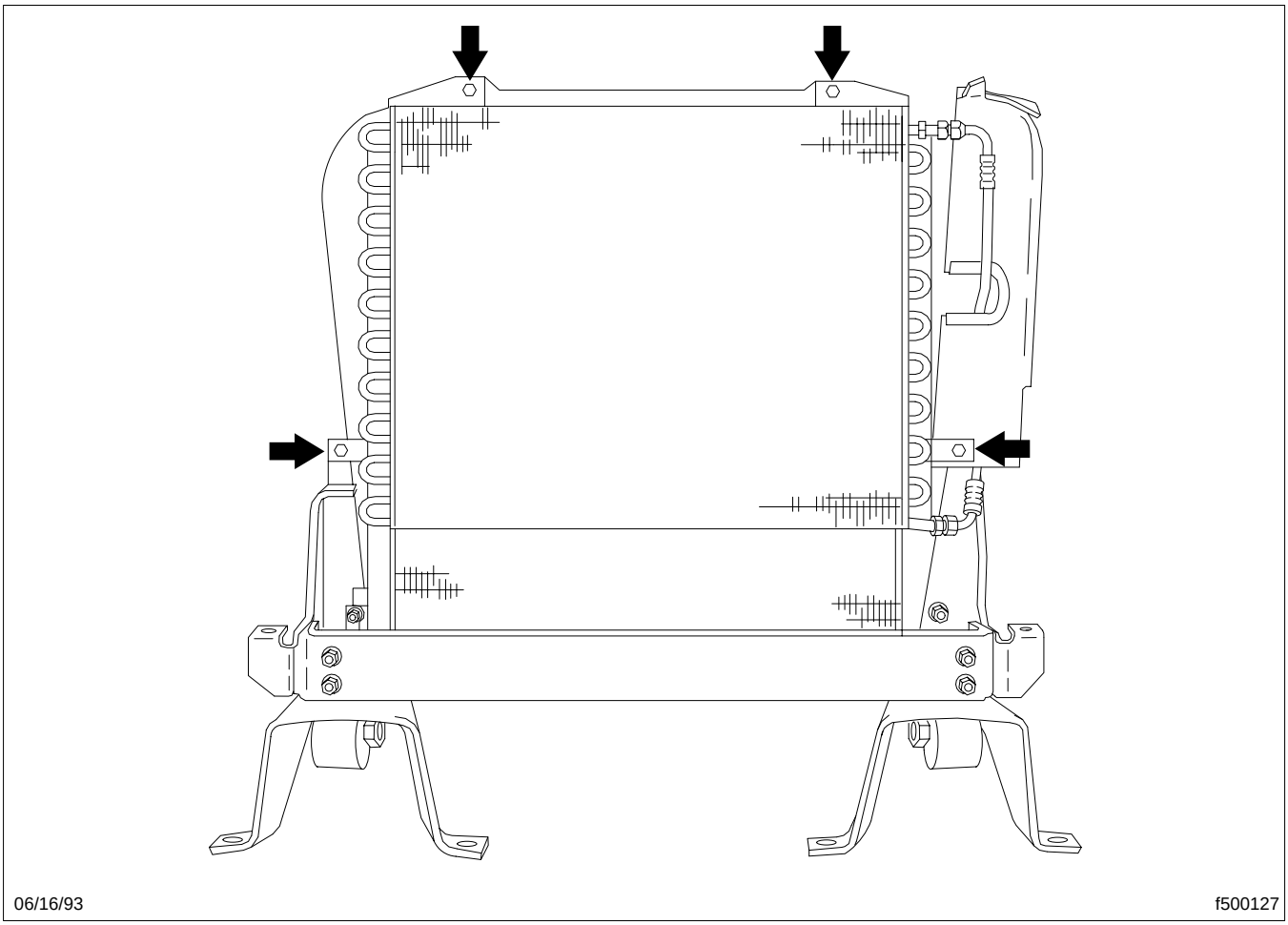


Fig. 16, Condenser Mounting Bolts

2.2 Carefully lower the engine and push it back onto the engine mounts.

2.3 Install the bolts in the two rear engine mounts, and tighten the bolts 327 N·m (241 lbf·ft).

2.4 Install the bolt in the front engine mount, and tighten it 203 N·m (150 lbf·ft).

2.5 Remove the lifting chain from the engine lifting eye and hook.

2.6 If it was removed for engine removal, install the blow-by vent on the engine cover. See **Fig. 30**.

3. Install the upper, front shock absorber mount on the left frame rail. Tighten the mounting bolts 183 N·m (135 lbf·ft). Install the shock on the mount, and tighten the shock mounting bolt 325 N·m (240 lbf·ft).

4. Connect the transmission-mounted components.

4.1 Connect the driveshaft to the transmission output end yoke. For instructions, see **Group 41**.

4.2 If the vehicle is equipped with air brakes, connect the air compressor outlet line to the chassis air delivery line, and secure the outlet line to the bracket on the transmission bell housing. See **Fig. 24**.

4.3 Connect the clutch release lever with a new clevis pin, and install the clutch slave cylinder on the clutch housing. See **Fig. 25**.

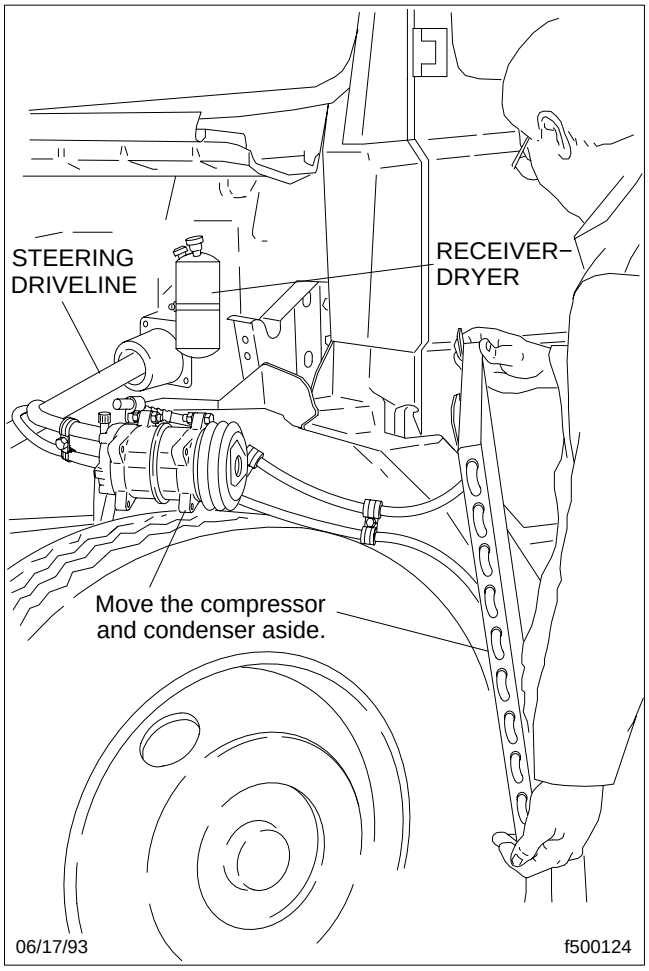


Fig. 17

4.4 Connect the speedometer sensor at the transmission output. See **Fig. 24**.

4.5 Connect the tachometer sensor at the engine flywheel. See **Fig. 24**.

4.6 Connect the back-up alarm sensor at the rear of the transmission. See **Fig. 24**.

4.7 Install the shift tower on the transmission. See **Fig. 23**.

5. Connect the engine electrical connections.

5.1 Connect the engine wiring harness at the alternator, the coolant temperature sensors, the flame start, and other options as applicable.

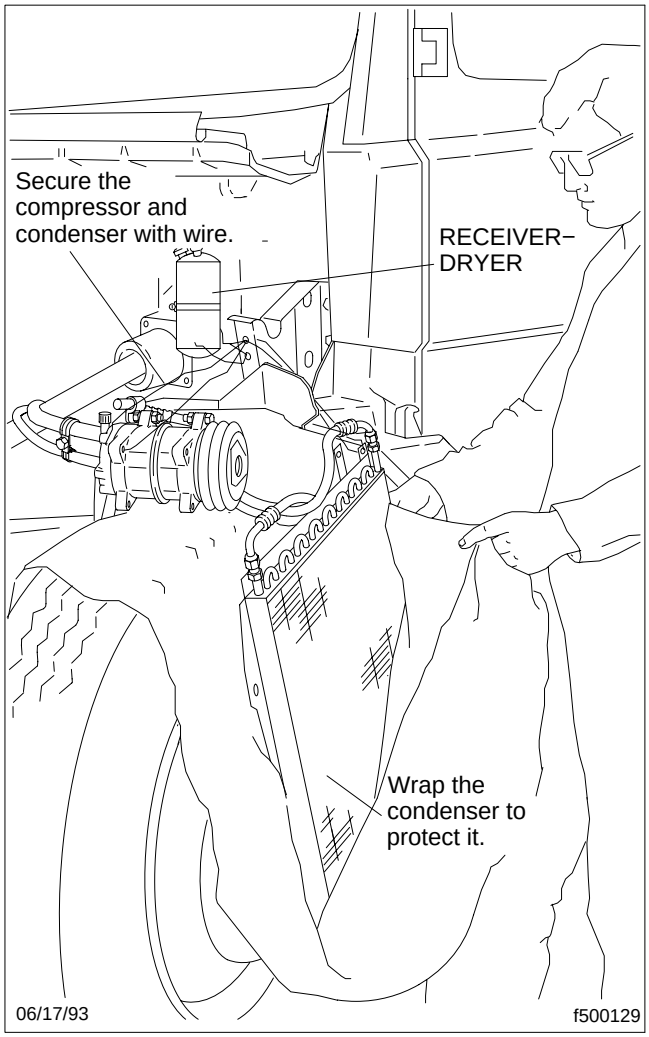


Fig. 18

5.2 Connect the alternator ground wire and the engine ground strap to the frame rail.

5.3 Connect the wiring ring terminals to the starter. See **Fig. 22**.

5.4 Connect the wiring connector to the fuel shutoff solenoid.

6. Connect the fuel and oil system components.

6.1 Connect the fuel return line to the fuel filter. See **Fig. 5**, Ref. B.

6.2 Connect the fuel delivery line to the fuel water separator. See **Fig. 5**, Ref. F.

Removal and Installation

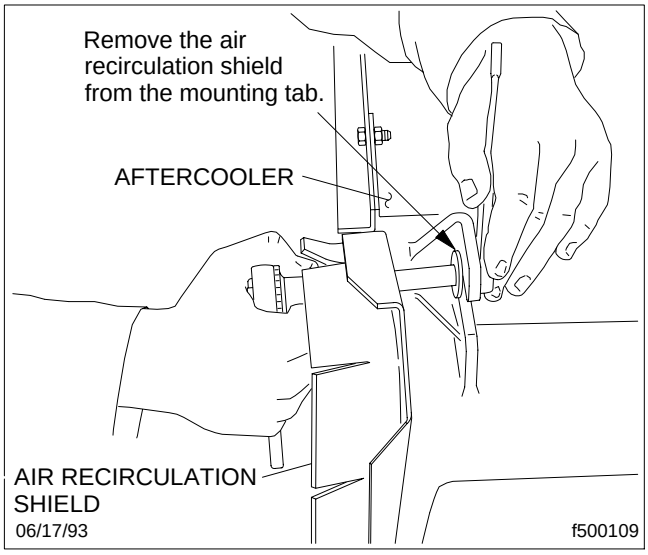


Fig. 19

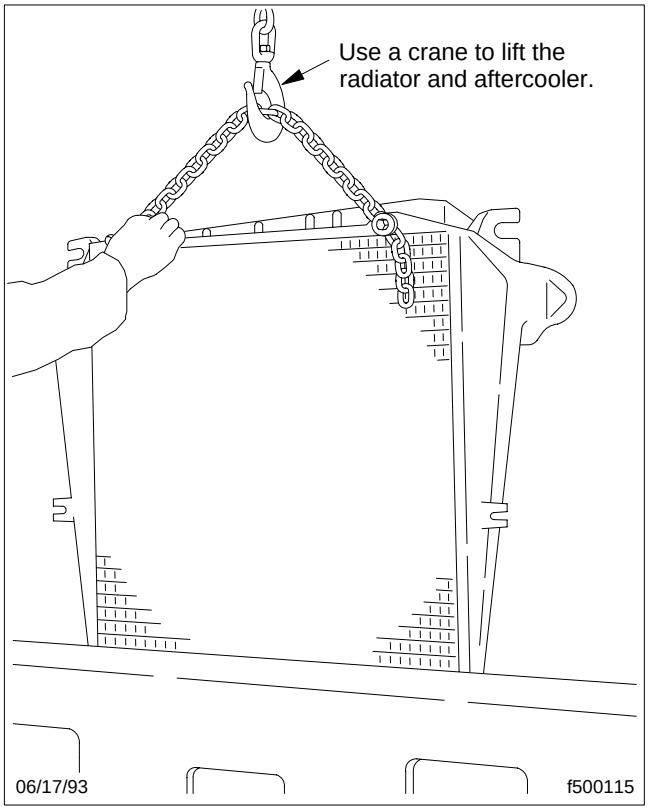


Fig. 20

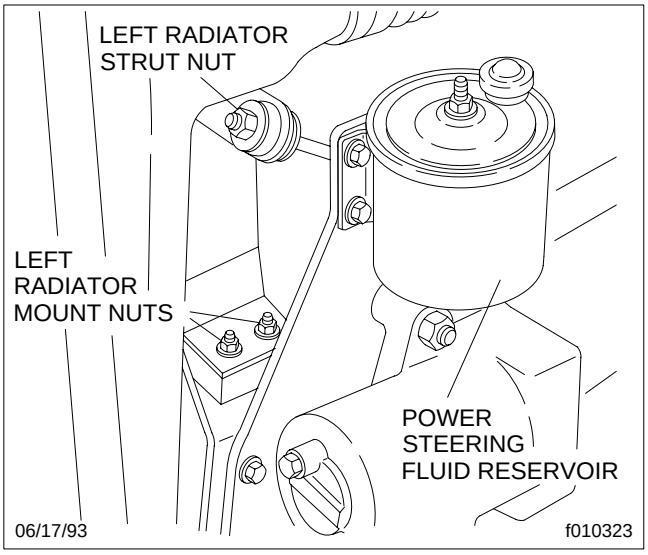


Fig. 21

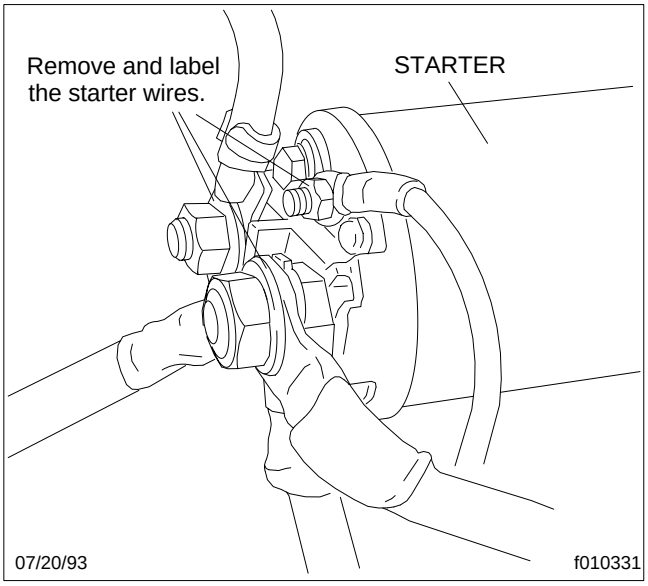


Fig. 22

6.3 Connect the fuel return line running between the engine and the fuel water separator. See **Fig. 5**, Ref. E.

6.4 Connect the oil pressure gauge line at the rear of the oil filter housing. See **Fig. 5**, Ref. D.

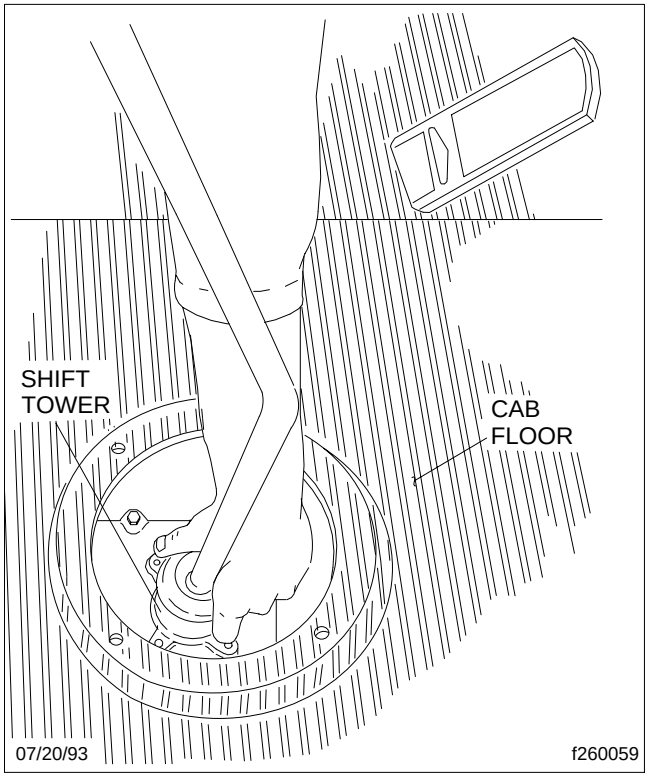


Fig. 23

6.5 Connect the throttle cable to the engine throttle lever and the throttle cable bracket. See **Fig. 5**, Ref. C.

6.6 Connect the dipstick tube to the air cleaner mounting bracket. See **Fig. 5**, Ref. G.

6.7 Connect the oil return line to the turbocharger.

7. Install the power steering pump on the engine, and tighten the mounting bolts 38 N·m (28 lbf·ft).

8. Install the radiator and aftercooler assembly.

8.1 Using a crane and lifting chains, lift and install the radiator and aftercooler as a single unit on the radiator mounting studs. For stability, leave the radiator attached to the crane until the radiator mounting fasteners are secure.

8.2 Install the nuts and washers on the radiator mounting studs, and tighten the nuts 40 N·m (30 lbf·ft). See **Fig. 21**.

8.3 Install the nuts, washers and rubber isolators on the radiator struts and tighten the nuts 47 N·m (35 lbf·ft). See **Fig. 21**.

8.4 Remove the lifting chains and crane from the assembly.

8.5 Install the air recirculation shield over the left aftercooler mounting tab. See **Fig. 19**. Tighten the shield bolt 20 N·m (15 lbf·ft).

9. Install the air conditioning system on the engine.

9.1 Carefully move the refrigerant compressor and condenser back into place.

9.2 Install the four bolts to hold the condenser in place over the aftercooler. See **Fig. 16**. Tighten the bolts 20 N·m (15 lbf·ft).

9.3 Position the compressor on its mount, and insert the two mounting bolts. See **Fig. 15**.

9.4 Place the adjusting rod guide on the adjusting rod.

9.5 Install the compressor drive belt on the compressor pulley and tighten the belt. For instructions, see "Drive Belts" in this group. Tighten the adjusting rod guide capscrew 45 N·m (33 lbf·ft).

9.6 Tighten the compressor mounting bolt nuts 45 N·m (33 lbf·ft).

9.7 Connect the compressor electrical connectors to the wiring harness.

10. Connect and install the coolant hoses.

10.1 Connect the heater return hose between the firewall and the engine (just behind the engine thermostat). See **Fig. 14**.

10.2 Connect the vent hose to the radiator. Secure the hose bracket at the top, right condenser mounting bolt. See **Fig. 13**.

10.3 Connect the vent hose to the engine. See **Fig. 13**.

10.4 Install the radiator inlet hose between the engine thermostat and the radiator. See **Fig. 8**.

10.5 Install the radiator outlet hose between the bottom of the radiator and the engine. Of the two hoses branching from that

Removal and Installation

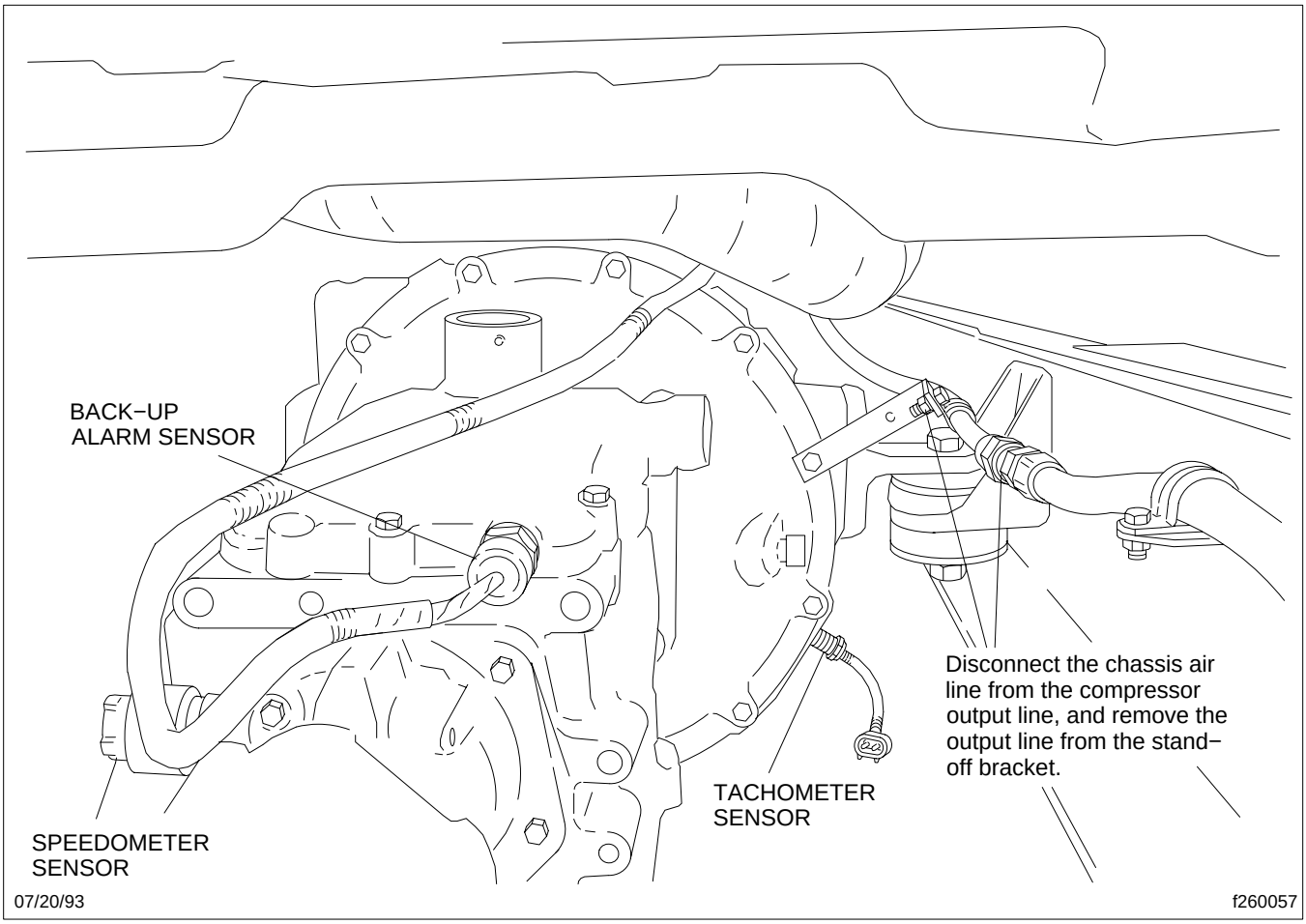


Fig. 24, View Under Back of Cab

hose, connect the shorter branch hose to the bottom of the surge tank, and connect the longer to the heater water valve at the firewall. See **Fig. 10**, **Fig. 11**, and **Fig. 12**.

11. Connect or install the air intake, exhaust pipes and hoses.

    11.1 Install the air intake pipe around the rear of the engine. See **Fig. 7**. Secure it to the engine with two screws, and clamp it to the turbocharger.

    11.2 Connect the exhaust pipe to the rear of the turbocharger. Secure the exhaust pipe bracket to the engine. See **Fig. 9**.

    11.3 If the vehicle is equipped with air brakes, connect the two air signal lines to the air governor at the top of the air compressor. See **Fig. 5**, Ref. A.

    11.4 If the vehicle is equipped with air brakes, connect the air compressor outlet line to the top of the air compressor. See **Fig. 6**.

    11.5 Connect the air inlet and outlet hoses to the aftercooler. See **Fig. 8**. Tighten the constant torque hose clamps 680 N·cm (60 lbf·in).

    11.6 Install the air intake pipe from the air cleaner to the air intake pipe routed around the rear of the engine. See **Fig. 7**. If the vehicle is equipped with air brakes,

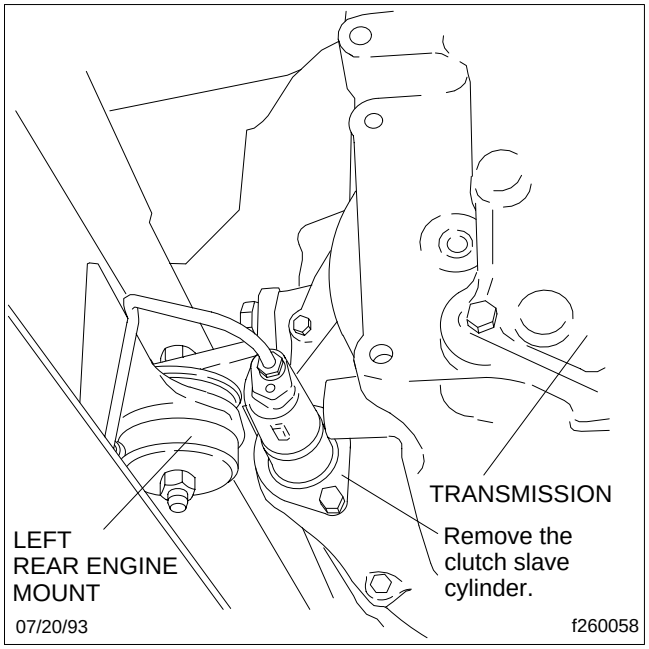


Fig. 25

connect the air compressor air intake hose to the air intake pipe. See **Fig. 4**.

12. Install the air cleaner.
    - 12.1 Position the air cleaner on its mounting bracket, and install the four nuts on the air cleaner mounting studs. See **Fig. 3**. Tighten the nuts 38 N·m (28 lbf·ft).
    - 12.2 Install the air intake pipe on the top of the air cleaner. See **Fig. 2**.
13. Install the right fender splash shield. See **Fig. 1**.
14. Install the bumper and hood. For instructions, see **Group 88**
15. Connect the batteries or, if the vehicle is equipped with a battery shutoff switch, turn on the switch.
    - 15.1 Connect the positive battery cable to the batteries.
    - 15.2 Connect the battery ground cable to the vehicle frame.
16. Fill the engine coolant system.
    - 16.1 Close the petcock on the bottom of the radiator.
    - 16.2 Fill the system with coolant at the surge tank. For coolant specifications, see the vehicle maintenance manual.
    - 16.3 Tighten the surge tank cap.
17. Start the engine and check for leaks. Eliminate any leaks.
18. After the engine has run for about 20 minutes, check the coolant level and add coolant if needed.
19. Fill and bleed the power steering system as necessary. For instructions, see **Group 46**.
20. Lower the hood, and remove the chocks from the tires.

Removal and Installation

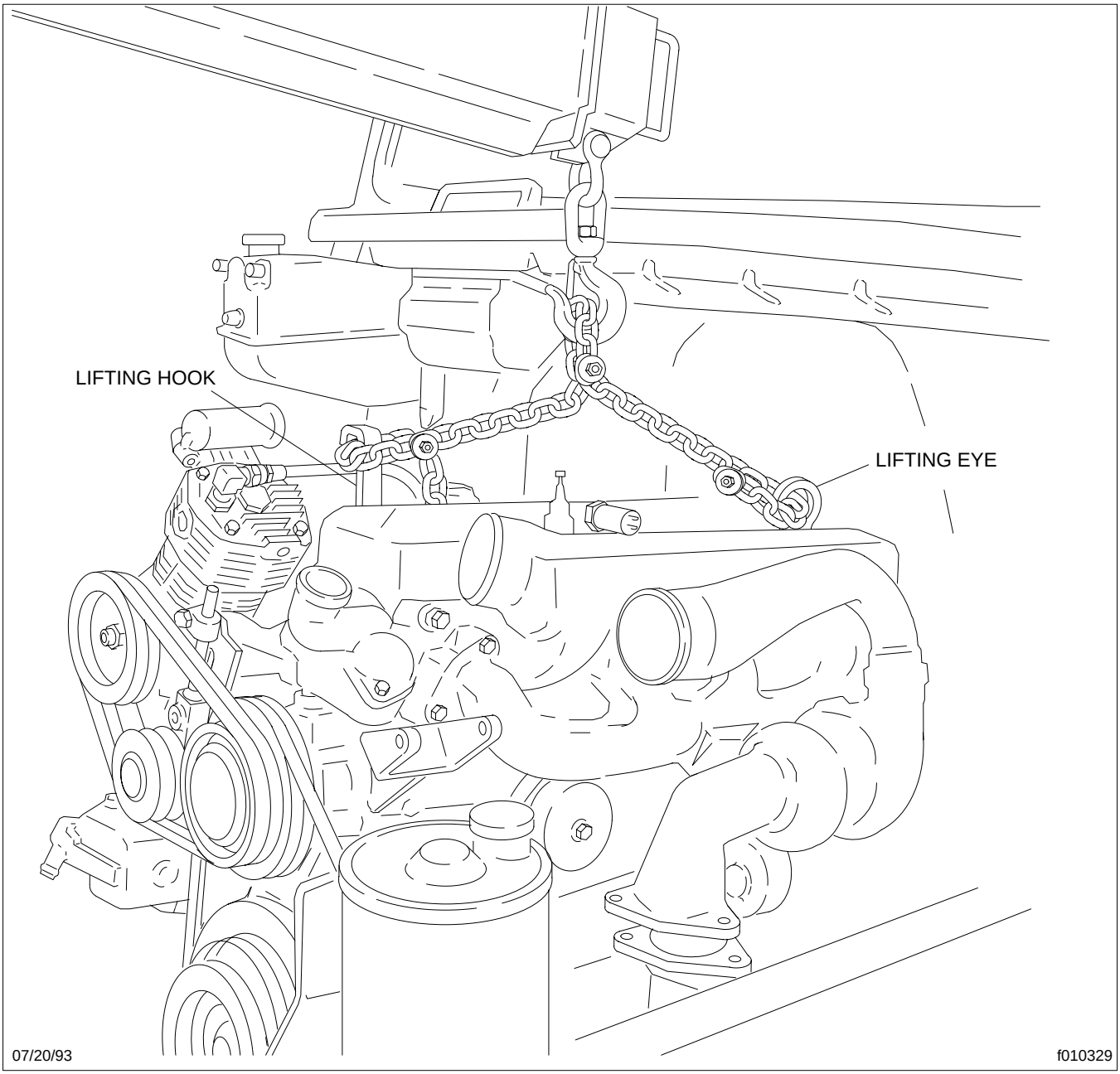


Fig. 26, Lifting the Engine

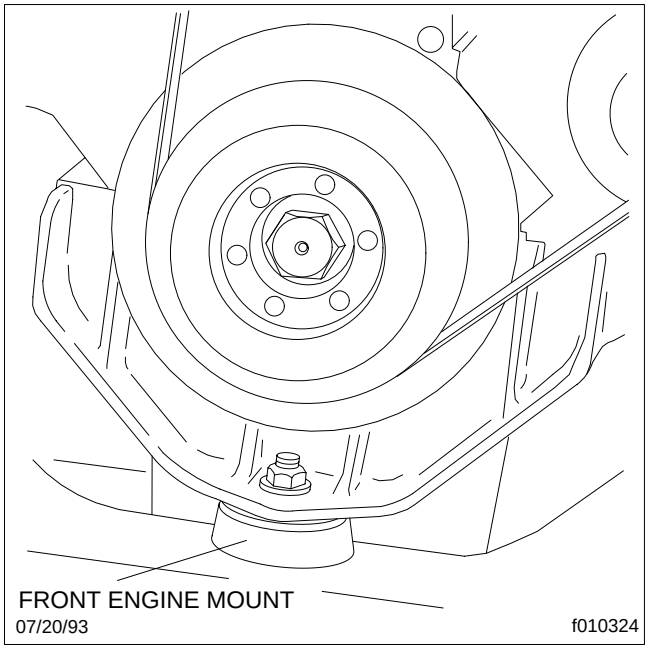


Fig. 27

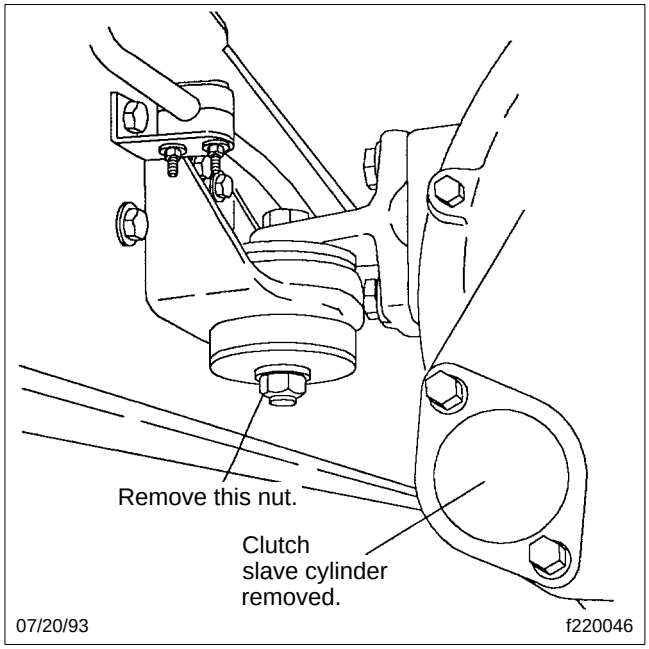


Fig. 29, Left Rear Engine Mount

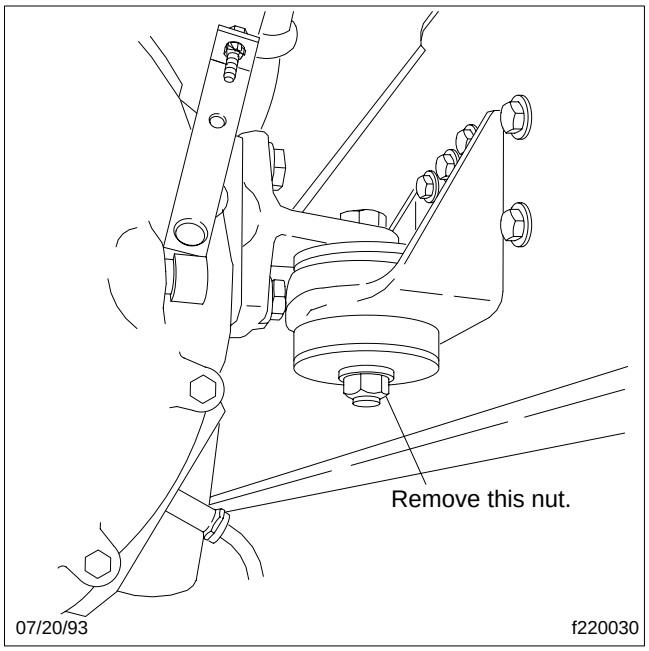


Fig. 28, Right Rear Engine Mount

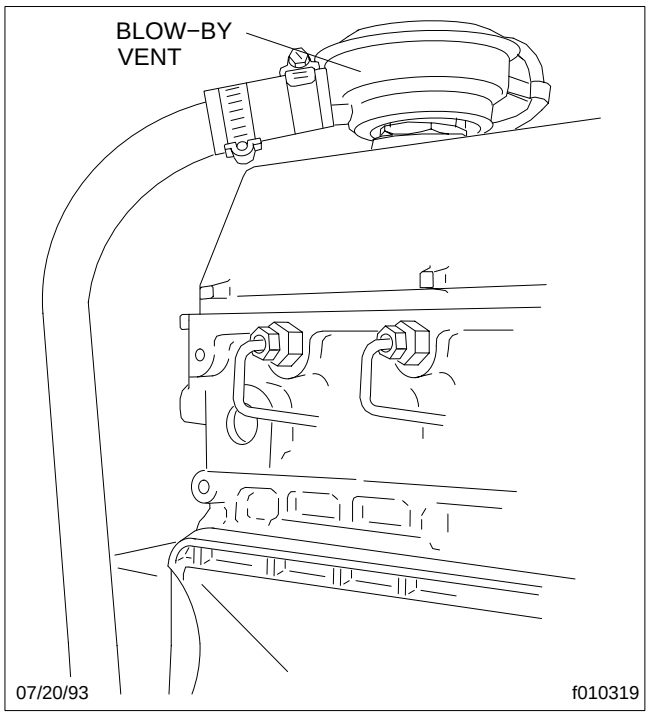


Fig. 30

Specifications

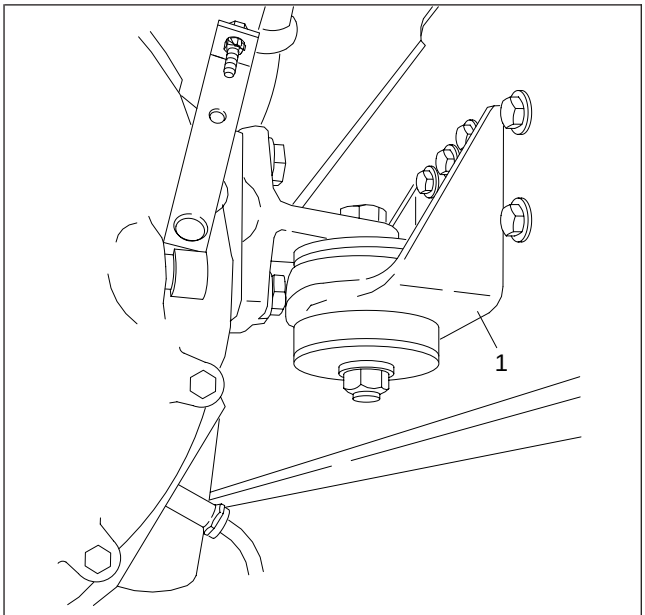
Description	Grade	Size	Torque	
			N·m (lbf·ft)	N·cm (lbf·in)
Rear Engine Mount Bolts	8	3/4 inch	244-325 (180-240)	—
Front Engine Mount Bolt	8	5/8 inch	163-203 (120-150)	—
Radiator Strut Nuts	2	1/2–13	47 (35)	—
Radiator Mount Nuts	5	3/8–16	40 (30)	—
Air Recirculation Shield Bolt	5	5/16 inch	20 (15)	—
Refrigerant Compressor Adjusting Rod Guide Capscrew	8	3/8 inch	45 (33)	—
Refrigerant Compressor Mounting Nuts	8	3/8 inch	45 (33)	—
Shock Absorber Mounting Bolt	8	3/4 inch	325 (240)	—
Shock Absorber Mount Mounting Bolts	8	5/8 inch	183 (135)	—
Condenser Mounting Bolts	5	5/16 inch	20 (15)	—
Aftercooler Hose Clamps	5	6.3 mm	—	680 (60)
Air Cleaner Mounting Nuts	5	3/8–16	38 (28)	—
Power Steering Pump Mounting Bolts	8.8	25 mm	38 (28)	—

Table 1, Fastener Torques

General Description

Three mounts support the engine and transmission, holding a total of almost 816 kg (1800 lb). *On diesel engines,* two of the engine mounts support the rear of the engine and transmission assembly. The third supports the front of the assembly. *On gasoline engines,* two of the engine mounts support the front of the engine and transmission assembly. The third supports the rear of the assembly.

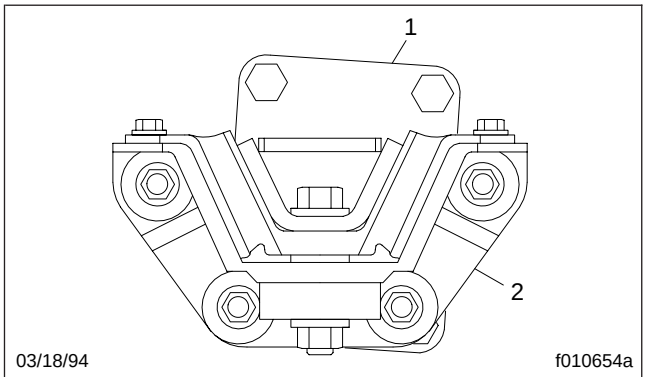
On diesel engines, each of the rear engine mounts (**Fig. 1**, **Fig. 2** or **Fig. 3**) is bolted to the inside of the frame rail near the flywheel housing. These mounts support legs which are bolted to the flywheel housing. Caterpillar, Cummins B and C series and Mercedes-Benz engines use a rear engine leg which rests flat on the mount; Detroit Diesel and Cummins M11 engines use a V-shaped rear engine leg which sets into a V-shaped rear engine mount.



NOTE: Right mount shown.
1. Rear Engine Mount

Fig. 1, Rear Engine Mount, Caterpillar, Cummins and Mercedes-Benz Engines

The front engine mount is an underslung crossmember under the front of the engine. It supports a bracket (**Fig. 4** and **Fig. 5**) which is bolted to the engine at each side of the vibration damper pulley.



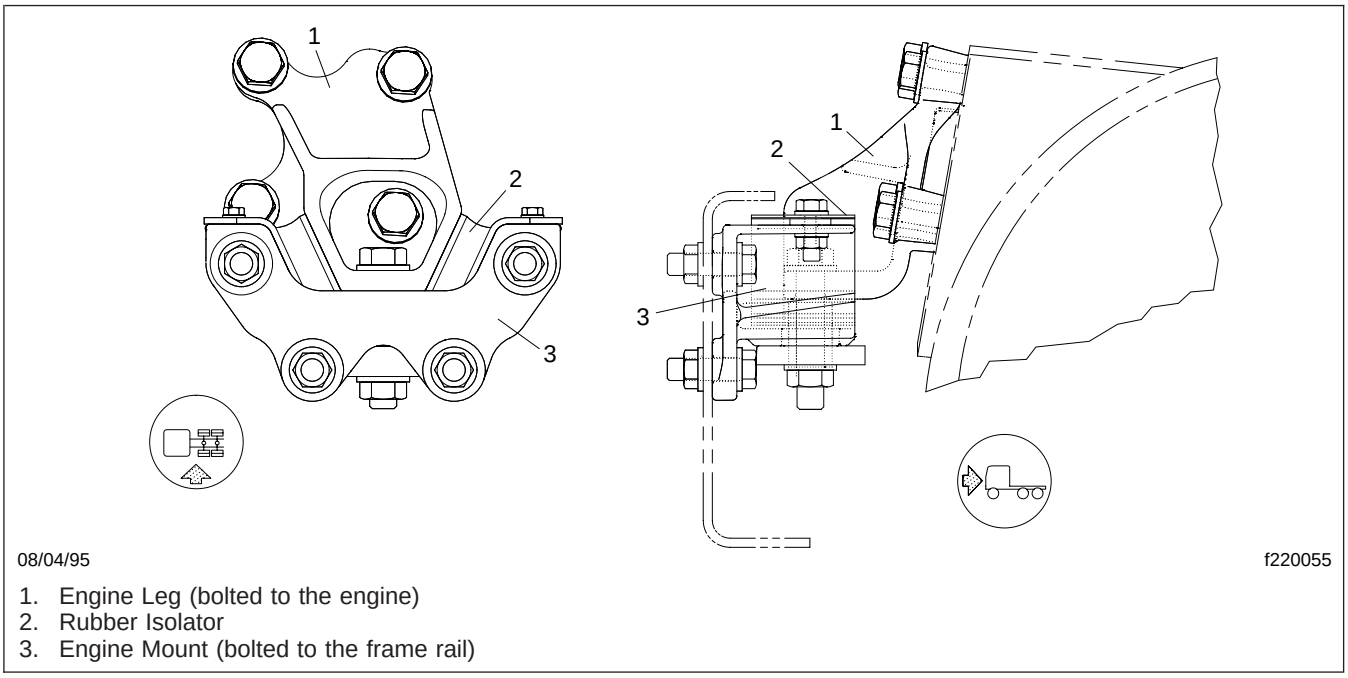
1. Engine Leg (bolted to the engine)
2. Engine Mount (bolted to the frame rail)

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

To isolate the engine and transmission from road shock, and to isolate the vehicle frame from engine vibration, the engine mounts are sandwiched between rubber isolator cushions (sometimes called restriction pads). Steel snubbers protect the cushions from wearing on the engine support brackets, and a single bolt runs through the mount, cushions, and snubbers to hold the assembly together and hold the engine on the mount.

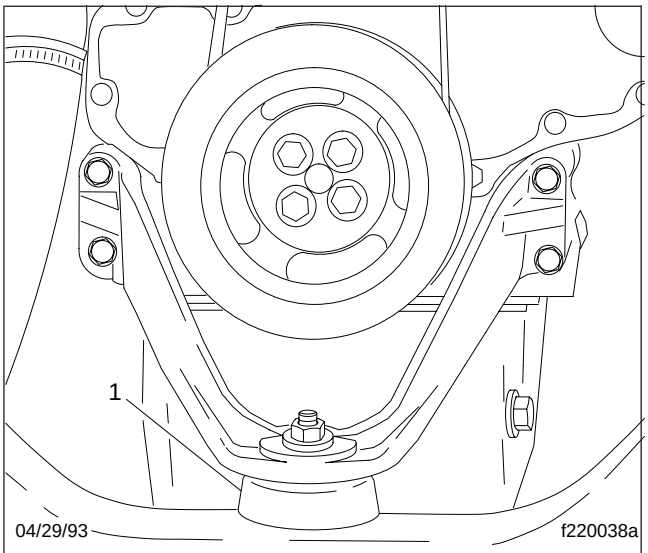
On gasoline engines, the forward engine mounts (**see Fig. 6**) are bolted to the inside of the frame rails near the center of each exhaust manifold. These mounts support brackets which are bolted to the engine. A bolt runs through the mount and the engine bracket to hold the two together (**Fig. 7** and **Fig. 8**), and rubber cushions (also called restriction pads) isolate the engine and transmission from road shock and isolate the vehicle frame from engine vibration. The rear engine mount is an underslung crossmember under the transmission. It supports a bracket (**Fig. 9**) bolted to the underside of the transmission. A rubber isolator pad between the bracket and the crossmember protects the transmission from road shock.

General Description



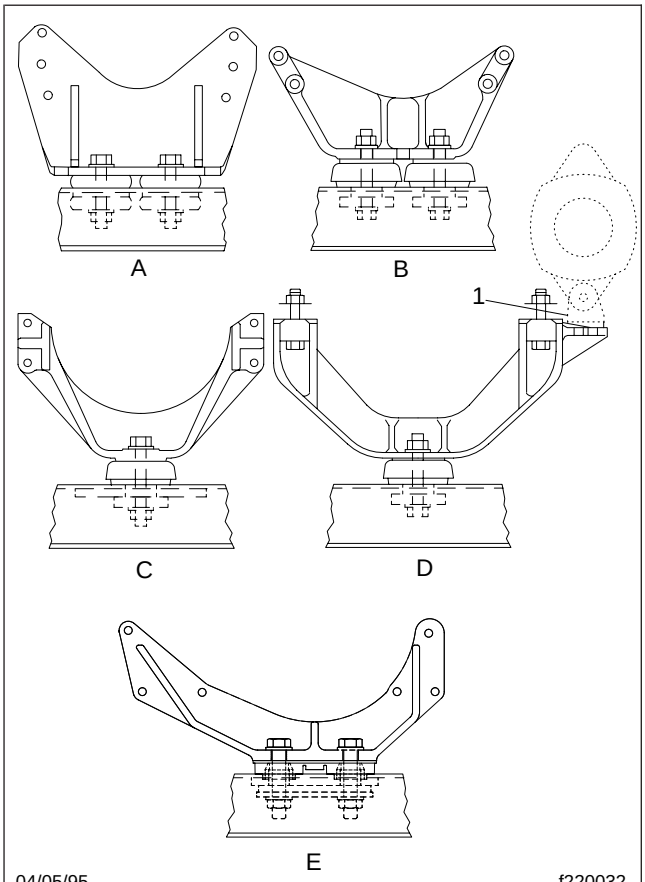
1. Engine Leg (bolted to the engine)
2. Rubber Isolator
3. Engine Mount (bolted to the frame rail)

Fig. 3, Rear Engine Mount, Cummins M11 Engine



1. Front Engine Mount

Fig. 4, Front Engine Mount, Cummins B Series Engine Shown



A. Caterpillar 3126 Engine
B. Cummins C Series Engine
C. Cummins B Series Engine
D. Mercedes-Benz OM 366LA Engine
E. Cummins M11 Engine
1. Alternator Mount

Fig. 5, Front Engine Support Brackets, Caterpillar, Cummins and Mercedes-Benz Engines

General Description

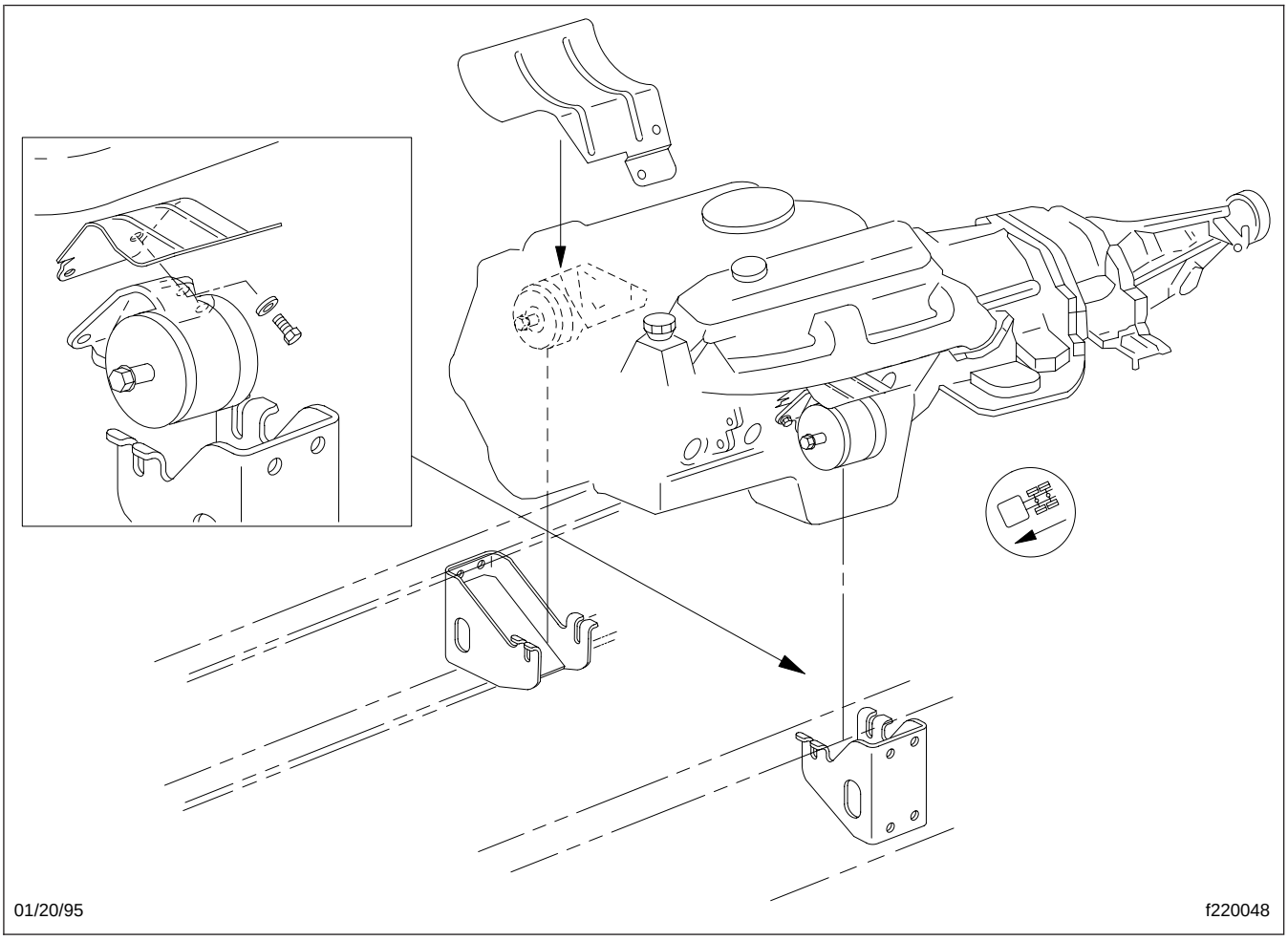
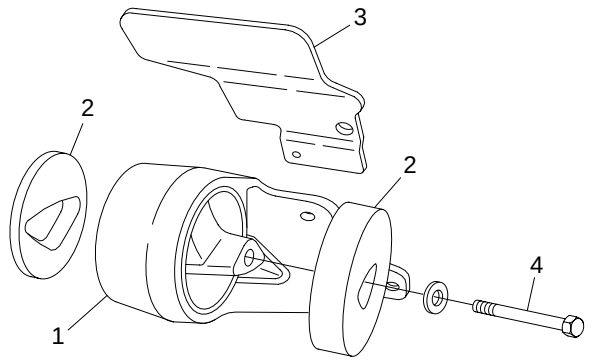


Fig. 6, Front Engine Mounts, Dodge Magnum Engine



1. Engine Support Bracket (mounted on engine)
2. Isolator (Restriction Pad)
3. Heat Shield
4. 1/2-13 x 6, Grade 8 Capscrew

Fig. 7, Front Engine Support Bracket Assembly, Exploded, Dodge Magnum Engine

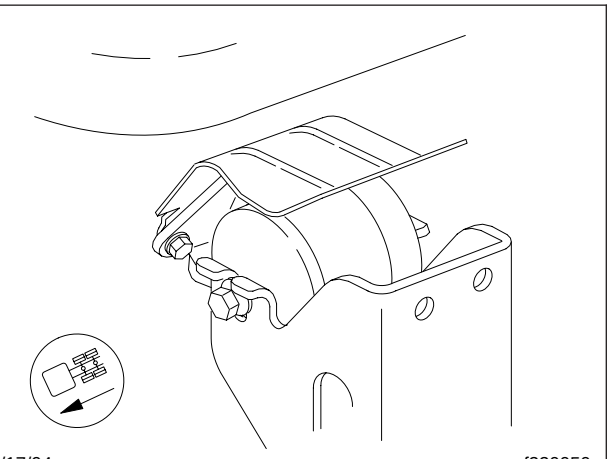
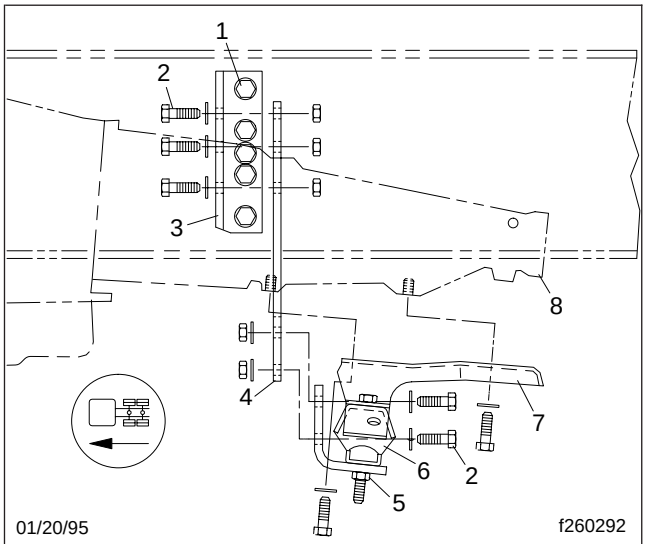


Fig. 8, Front Engine Support Bracket Assembly, Assembled, Dodge Magnum Engine



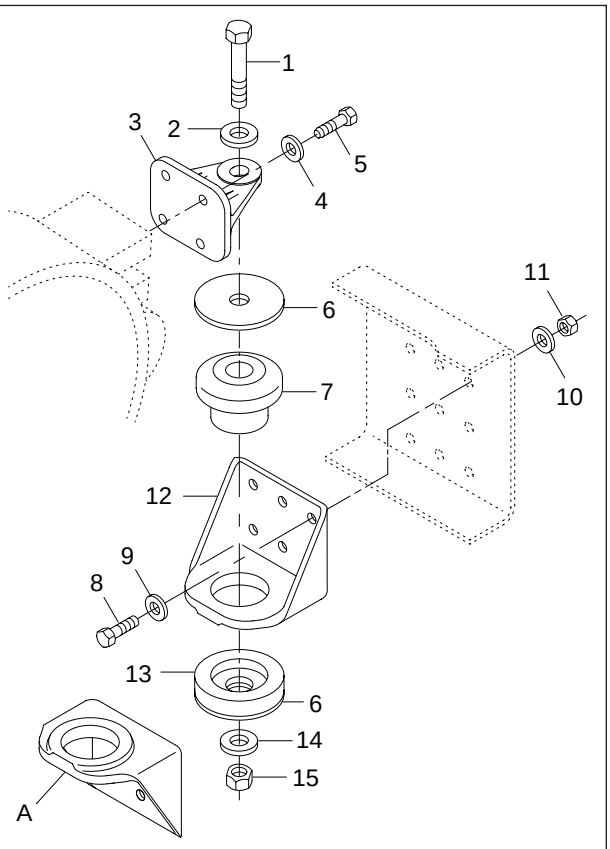
1. Capscrew, 5/8-11, Grade 8
2. Capscrew, 1/2-13, Grade 8
3. Engine Support Crossmember Bracket (mounted on the framerail)
4. Engine Support Crossmember
5. Locknut, M10
6. Rubber Isolator
7. Transmission Support Bracket
8. Transmission

Fig. 9, Rear Engine Mount and Support Bracket Assembly, Exploded, Dodge Magnum Engine

Rear Engine Mount Replacement, Diesel Engines

Replacement (See Fig. 1, Fig. 2 , or Fig. 3)

1. Apply the parking brakes, chock the tires, and (if applicable) drain the air brake system.

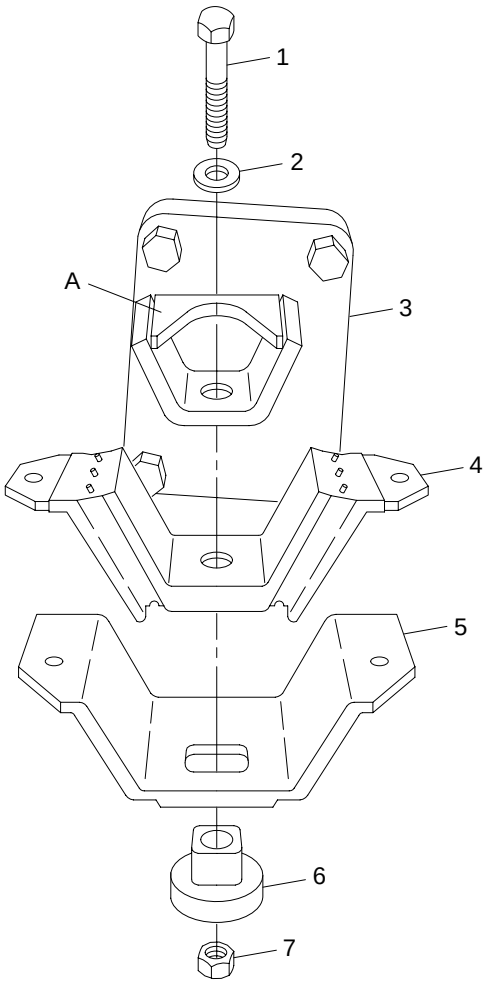


12/13/93 f220035

A. Engine mount inverted for Cummins B Series engine.

1. Bolt
2. Hardened Washer
3. Engine Support Bracket
4. Hardened Washer
5. Bolt
6. Snubber
7. Upper Isolator
8. Bolt
9. Hardened Washer
10. Hardened Washer
11. Nut
12. Rear Engine Mount
13. Lower Isolator
14. Hardened Washer
15. Nut

Fig. 1, Rear Engine Mount Assembly for Caterpillar, Cummins B and C Series, and Mercedes-Benz Engines



03/18/94 f010652a

A. Earlier Medium Trucks may not have this reinforcing plate.

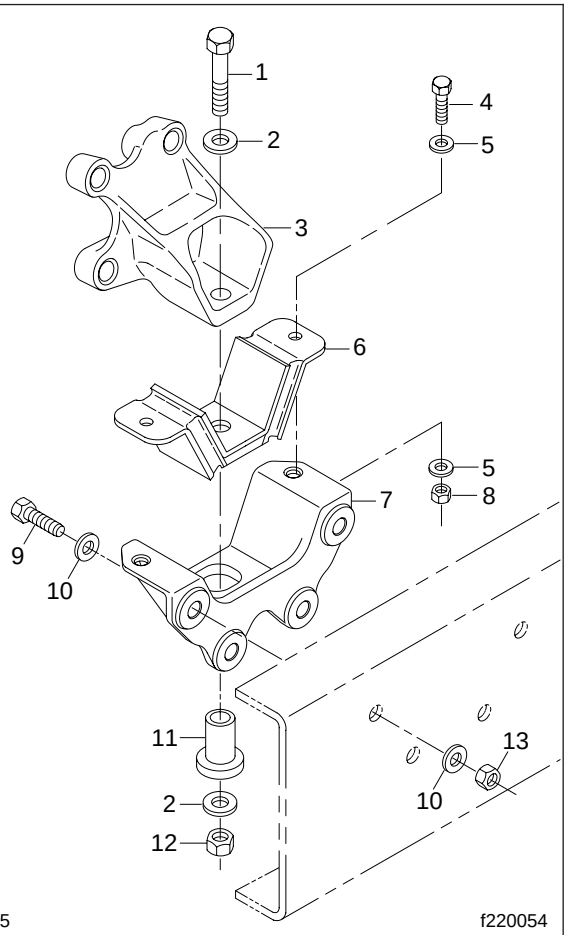
1. Bolt
2. Hardened Washer
3. Engine Support Bracket
4. Upper Isolator
5. Rear Engine Mount
6. Lower Isolator
7. Nut

Fig. 2, Rear Engine Mount Assembly for Detroit Diesel Engines

⚠ WARNING

WARNING: The jack used to lift the engine must be capable of safely lifting and supporting two metric tons. Once the engine mount is discon-

Rear Engine Mount Replacement, Diesel Engines



1. Capscrew, 3/4-10 x 4.5 Inch, Grade 8
2. Washer
3. Engine Leg
4. Capscrew, 5/16-18 x 1 Inch, Grade 8
5. Washer
6. Upper Isolator
7. Rear Engine Mount
8. Nut, 5/16-18
9. Capscrew, 5/8-11 x 2.5 Inch, Grade 8
10. Washer
11. Lower Isolator
12. Nut, 3/4-10
13. Nut, 5/8-11

Fig. 3, Rear Engine Mount Assembly for Cummins M11 Engines

nected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

2. Disconnect the engine from the right rear engine mount.

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

   2.2 Remove the bolt from the right rear engine mount. Save the fasteners, rubber isolator cushions, and snubbers.

   2.3 Lift the engine slightly to take its weight off the right rear engine mount. Place engine stands under the engine to keep it off the engine mount.

3. Remove the bolts which secure the mount to the frame rail. Remove the mount from the frame rail.

   If necessary, remove the four bolts which secure the right engine support bracket to the flywheel housing, and remove the bracket from the engine.

4. Place a new engine mount against the inside of the frame rail, and secure it with bolts, washers, and nuts. Tighten the nuts as follows:

   For Caterpillar engines: tighten the nuts 61 N·m (45 lbf·ft).

   For Cummins B and C Series and Mercedes-Benz engines: tighten the nuts 108 N·m (80 lbf·ft).

   For Cummins M11 engines: tighten the nuts 183 N·m (135 lbf·ft).

   For Detroit Diesel engines: tighten the nuts 92 N·m (68 lbf·ft).

5. If removed, install the engine support bracket on the right side of the flywheel housing. Apply thread lock compound to the bracket mounting bolts, and tighten them as follows:

   On Caterpillar engines: tighten the bolts 136 N·m (100 lbf·ft).

   On Cummins B and C Series engines: tighten the bolts 75 to 88 N·m (55 to 65 lbf·ft). Cummins B Series engines used with Allison automatic transmissions have an iron flywheel housing instead of the standard aluminum housing. On B Series engines with iron flywheel housings, tighten the support bracket bolts 81 to 103 N·m (60 to 76 lbf·ft).

Rear Engine Mount Replacement, Diesel Engines

On Cummins M11 engines: tighten the bolts 327 N·m (241 lbf·ft).

On Detroit Diesel Series 50 engines: tighten the capscrews 184 N·m (136 lbf·ft).

On Mercedes-Benz OM 366LA engines: tighten the bolts 177 to 224 N·m (130 to 165 lbf·ft).

6. Inspect the engine mount rubber isolators for wear or damage and replace them if necessary.

⚠ CAUTION

CAUTION: Do not lubricate the components with oil, grease, or silicone lubricants; they will deteriorate the rubber isolators.

7. Install the upper isolator in the engine mount. If applicable, place the snubber on the isolator.

⚠ WARNING

WARNING: The jack used to lower the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely installed on the engine mount. An unsecured engine may fall, causing personal injury or death, and component damage.

8. Secure the engine to the engine mounts.
   - 8.1 If not in place, set a jack under the rear of the engine and raise the jack until it is braced against the engine.
   - 8.2 Lift the engine slightly to remove the engine stands. Remove the stands, and carefully lower the engine onto the engine mount.
   - 8.3 Holding the lower isolator and snubber in place, install the bolt in the right rear engine mount, and secure it with the nut and hardened washer. Tighten the nut 327 N·m (241 lbf·ft).

⚠ WARNING

WARNING: The jack used to lift the engine must be capable of safely lifting and supporting two metric tons. Once the engine mount is disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

9. Disconnect the engine from the left rear engine mount.
   - 9.1 Place a jack under the rear of the engine, and raise the jack until it's braced against the engine.
   - 9.2 Remove the bolt from the left rear engine mount. Save the fasteners, rubber isolator cushions, and snubbers.
   - 9.3 Lift the engine slightly to take its weight off the left rear engine mount. Place engine stands under the engine to keep it off the engine mount.
10. Remove the capscrews which secure the mount to the frame rail. Remove the mount from the frame rail.

    If necessary, remove the four capscrews which secure the left engine support bracket to the flywheel housing, and remove the bracket from the engine.
11. Place a new engine mount against the inside of the frame rail, and secure it with bolts, washers, and nuts. Tighten the nuts as follows:

    For Caterpillar engines: tighten the nuts 61 N·m (45 lbf·ft).

    For Cummins B and C Series and Mercedes-Benz engines: tighten the nuts 108 N·m (80 lbf·ft).

    For Cummins M11 engines: tighten the nuts 183 N·m (135 lbf·ft).

    For Detroit Diesel engines: tighten the nuts 92 N·m (68 lbf·ft).
12. If removed, install the engine support bracket on the right side of the flywheel housing. Apply thread lock compound to the bracket mounting bolts, and tighten them as follows:

    On Caterpillar engines: tighten the bolts 136 N·m (100 lbf·ft).

    On Cummins B and C Series engines: tighten the bolts 75 to 88 N·m (55 to 65 lbf·ft). Cummins B Series engines used with Allison automatic transmissions have an iron flywheel housing instead of the standard aluminum housing. On B

Rear Engine Mount Replacement, Diesel Engines

Series engines with iron flywheel housings, tighten the support bracket bolts 81 to 103 N·m (60 to 76 lbf·ft).

On Cummins M11 engines: tighten the bolts 327 N·m (241 lbf·ft).

On Detroit Diesel Series 50 engines: tighten the capscrews 184 N·m (136 lbf·ft).

On Mercedes-Benz OM 366LA engines: tighten the bolts 177 to 224 N·m (130 to 165 lbf·ft).

13. Inspect the engine mount rubber isolators for wear or damage and replace them if necessary.

⚠ CAUTION

CAUTION: Do not lubricate the components with oil, grease, or silicone lubricants; they will deteriorate the rubber isolators.

14. Install the upper isolator in the engine mount. If applicable, place the snubber on the isolator.

⚠ WARNING

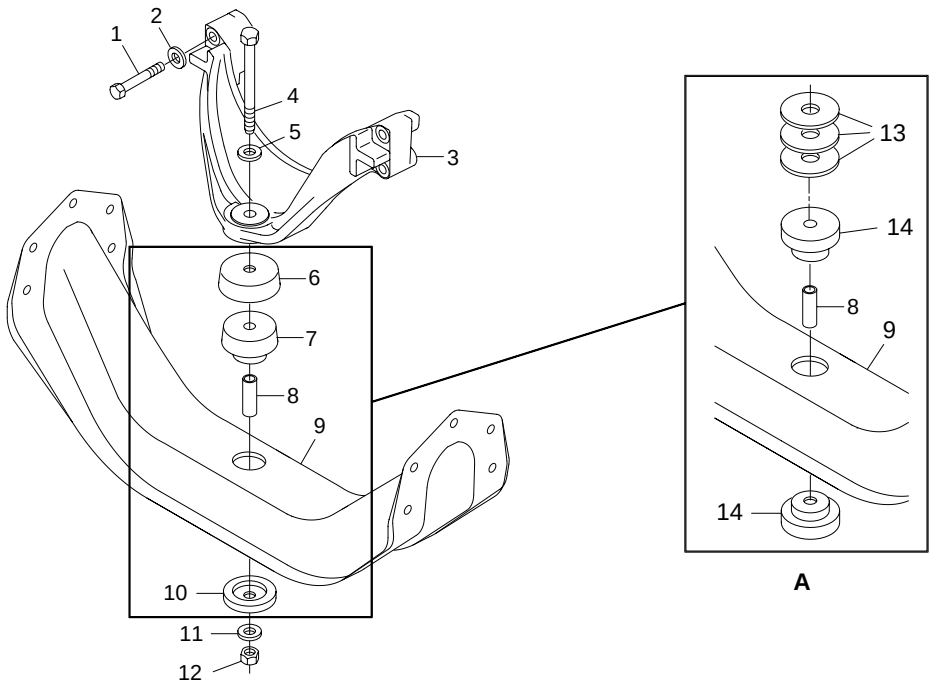
WARNING: The jack used to lower the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely installed on the engine mount. An unsecured engine may fall, causing personal injury or death, and component damage.

15. Secure the engine to the engine mounts.
    - 15.1 If not in place, set a jack under the rear of the engine and raise the jack until it is braced against the engine.
    - 15.2 Lift the engine slightly to remove the engine stands. Remove the stands, and carefully lower the engine onto the engine mount.
    - 15.3 Holding the lower isolator in place, install the bolt in the left rear engine mount, and secure it with the nut and hardened washer. Tighten the nut 327 N·m (241 lbf·ft).
16. Remove the jack from under the engine, and remove the chocks from the tires.

Front Engine Mount Replacement, Diesel Engines

Replacement

(See Fig.1,Fig.2,Fig.3,Fig.4,or Fig.5)



06/21/99 f220070

A. Cummins ISB Engine

1. Hexbolt, M12
2. Hardened Washer
3. Front Engine Support Bracket
4. Hexbolt, 5/8–11
5. Hardened Washer
6. Snubber
7. Upper Isolator
8. Isolator Sleeve
9. Front Underslung Crossmember
10. Lower Isolator
11. Hardened Washer
12. Nut
13. Spacers
14. Isolator

Fig. 1, Front Mount Assembly, Cummins B Series and ISB Engines

1. Apply the parking brakes, chock the tires, and (if applicable) drain the air brake system.

⚠ WARNING

The lifting device and chain used to lift the engine must be capable of safely lifting and supporting two metric tons. Once the engine mount is disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

2. Disconnect the engine from the front engine mount.

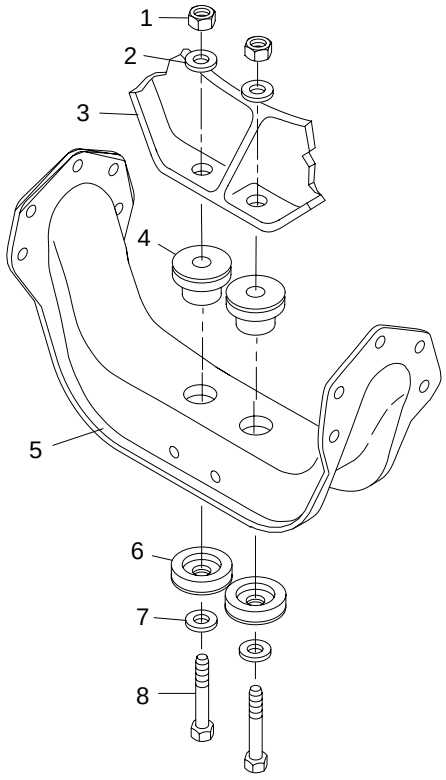
2.1 Attach a chain to the front engine lifting hook(s), and position a lifting device to lift the engine. Attach the chain to the lifting device, and raise the chain to remove any slack.

2.2 Remove the bolt(s) from the front engine mount. Save the fasteners, rubber isolator cushions, and snubber(s).

NOTE: In order to raise the front of the engine, you may have to loosen the bolts that run through the rear engine mounts.

2.3 Lift the engine slightly to take its weight off the front engine mount. Place engine

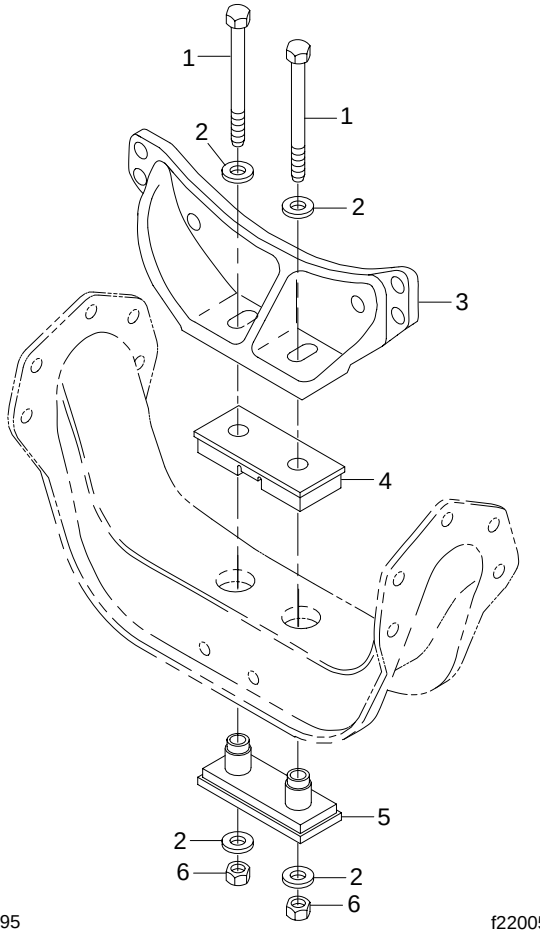
Front Engine Mount Replacement, Diesel Engines



06/16/99 f220068

1. Hexnut, 5/8–11 (2 qty.)
2. Hardened Washer (2 qty.)
3. Front Engine Support Bracket
4. Upper Isolator
5. Front Underslung Crossmember
6. Lower Isolator (2 qty.)
7. Flatwasher (2 qty.)
8. Hexbolt, 5/8–11 (2 qty.)

Fig. 2, Front Mount Assembly, Cummins C Series and ISC Engines



03/20/95 f220052

1. Capscrew, 3/4-10 x 4 Inch, Grade 8
2. Washer
3. Front Engine Support Bracket
4. Upper Isolator
5. Lower Isolator
6. Nut, 3/4-10

Fig. 3, Front Engine Mount Assembly, Cummins M11 and ISM Engines

stands under the engine to keep it off the engine mount.

3. If necessary, remove the bolts which secure the engine support bracket to the front of the engine. Remove the bracket from the engine.

   On vehicles equipped with Mercedes-Benz OM 366LA engines, remove the alternator and exhaust mount fasteners that tie in with the left end of the engine support bracket.

4. If necessary, install a new engine support bracket on the front of the engine. Secure it with two bolts at each side of the vibration damper pulley, and tighten the bolts as follows:

   For Cummins B Series/ISB engines: tighten the bolts 55 to 65 lbf·ft (75 to 88 N·m).

   For Cummins C Series/ISC engines: tighten the bolts 75 to 90 lbf·ft (102 to 122 N·m).

   For Detroit Diesel Series 50 engines: tighten the bolts 118 to 148 lbf·ft (160 to 200 N·m).

For Mercedes-Benz OM 366LA engines: tighten the bolts 90 to 110 lbf·ft (122 to 150 N·m).

For MBE900 engines: tighten the bolts 100 lbf·ft (136 N·m).

On vehicles equipped with Mercedes-Benz OM 366LA engines, install the alternator and exhaust mount fasteners that tie in with the ends of the engine support bracket.

5. Inspect the engine mount rubber isolators for wear or damage and replace them if necessary.

⚠ CAUTION

Do not lubricate the components with oil, grease, or silicone lubricants; they will deteriorate the rubber isolators.

6. Install the upper isolator(s) in the engine mount. If applicable, place the snubber(s) on the isolator(s).

⚠ WARNING

The lifting device and chain used to lower the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely installed on the engine mount. An unsecured engine may fall, causing personal injury or death, and component damage.

7. Secure the engine to the front engine mount.

   7.1 Attach a chain to the front engine lifting hook(s). Attach the chain to a lifting device, and raise the chain to remove any slack.

   7.2 Lift the engine slightly to remove the engine stands. Remove the stands, and carefully lower the engine onto the engine mount.

   7.3 Holding the lower isolator(s) and tube(s) in place, install the bolt(s) in the front engine mount and secure it with the nut(s) and washer(s). Tighten the nut(s) as follows:

   For Caterpillar engines: tighten the nuts 136 lbf·ft (184 N·m).

   For Cummins B Series/ISB engines: tighten the nuts 136 lbf·ft (184 N·m).

   For Cummins C Series/ISC engines: tighten the nuts 68 lbf·ft (92 N·m).

   For Cummins M11/ISM engines: tighten the nuts 241 lbf·ft (327 N·m).

   For Detroit Diesel engines: tighten the nuts 241 lbf·ft (327 N·m).

   For Mercedes-Benz OM 366LA engines: tighten the nuts 150 lbf·ft (203 N·m).

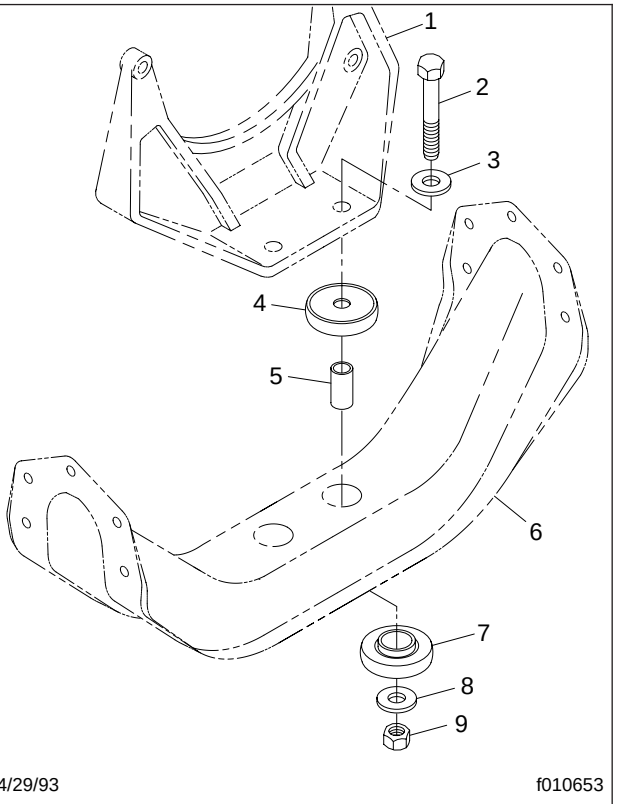
   For MBE900 engines: tighten the nuts 136 lbf·ft (184 N·m).

   NOTE: If you loosened the bolts that run through the rear engine mounts, tighten those bolts 241 lbf·ft (327 N·m) for all engines.

   7.4 Remove the lifting chain from the engine lifting hooks.

8. Remove the chocks from the tires.

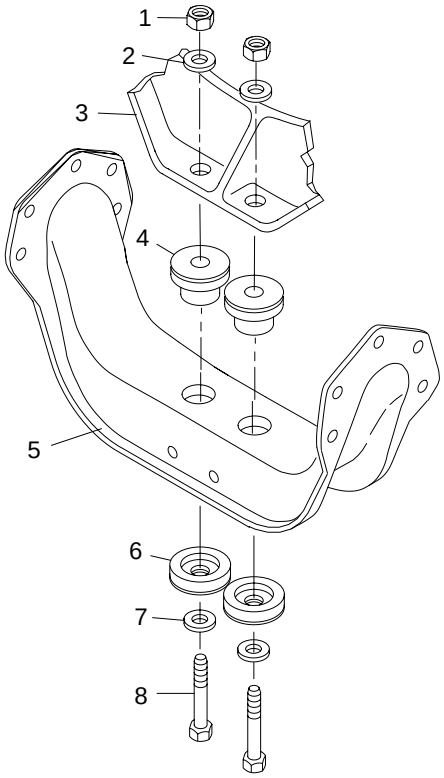
Front Engine Mount Replacement, Diesel Engines



04/29/93 f010653

1. Front Engine Support Bracket
2. Bolt
3. Hardened Washer
4. Upper Isolator
5. Tube
6. Front Underslung Crossmember
7. Lower Isolator
8. Hardened Washer
9. Nut

Fig. 4, Front Engine Mount Assembly, Detroit Diesel Series 50 Engine



06/16/99 f220068

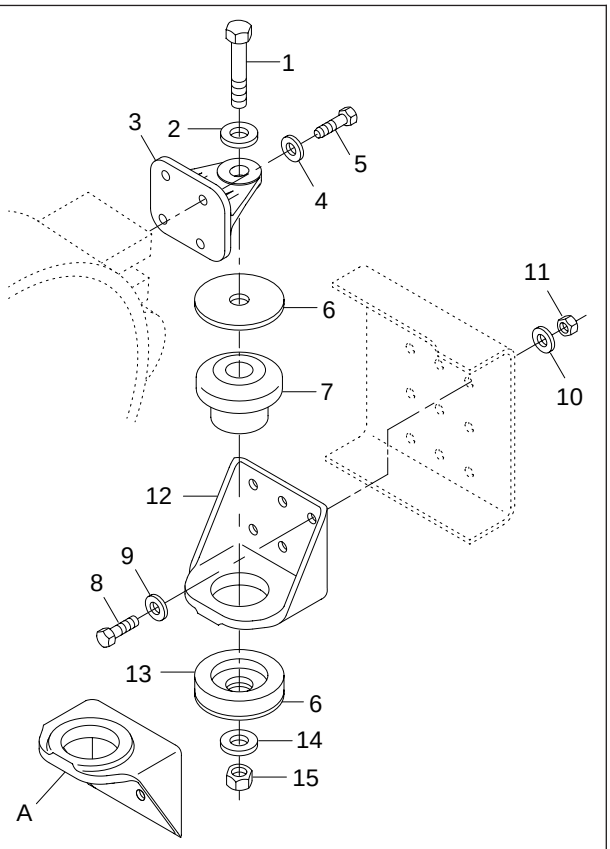
1. Front Engine Support Bracket
2. Hexnut, 5/8–11
3. Hardened Washer
4. Upper Isolator
5. Isolator Sleeve
6. Crossmember
7. Lower Isolator
8. Hexbolt, 5/8–11

Fig. 5, Front Mount Assembly, MBE900 Engines

Rear Engine Mount Isolator Replacement, Diesel Engines

Replacement (See Fig. 1, Fig. 2 , or Fig. 3)

1. Apply the parking brakes, chock the tires, and (if applicable) drain the air brake system.

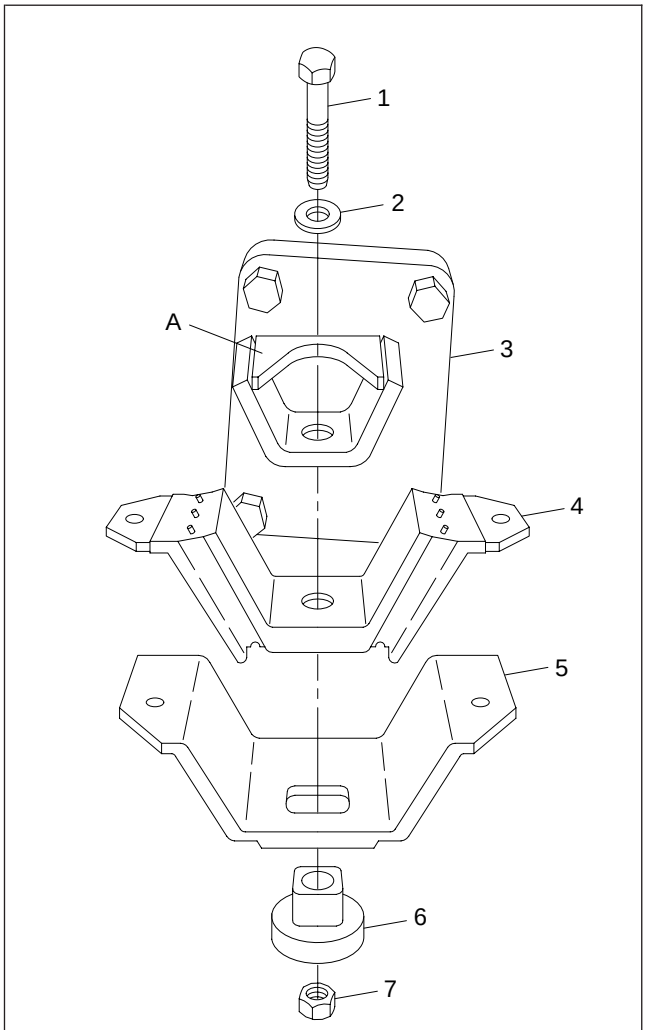


12/13/93 f220035

A. Framerail mount inverted for Cummins B Series engine.

1. Bolt
2. Hardened Washer
3. Engine Support Bracket
4. Hardened Washer
5. Bolt
6. Snubber
7. Upper Isolator
8. Bolt
9. Hardened Washer
10. Hardened Washer
11. Nut
12. Rear Engine Mount
13. Lower Isolator
14. Hardened Washer
15. Nut

Fig. 1, Rear Engine Mount Assembly, Caterpillar, Cummins B and C Series, and Mercedes-Benz Engines



03/18/94 f010652a

A. Earlier Medium Trucks may not have this reinforcing plate.

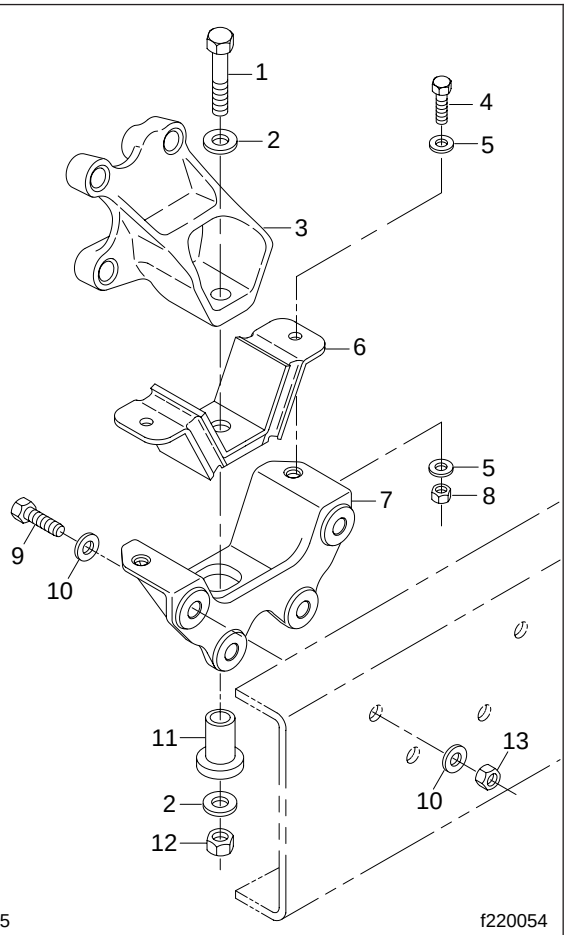
1. Bolt
2. Hardened Washer
3. Engine Support Bracket
4. Upper Isolator
5. Rear Engine Mount
6. Lower Isolator
7. Nut

Fig. 2, Rear Engine Mount Assembly, Detroit Diesel Engines

WARNING

WARNING: The jack used to lift the engine must be capable of safely lifting and supporting two metric tons. Once the engine mount is discon-

Rear Engine Mount Isolator Replacement, Diesel Engines



1. Capscrew, 3/4-10 x 4.5 Inch, Grade 8
2. Washer
3. Engine Leg
4. Capscrew, 5/16-18 x 1 Inch, Grade 8
5. Washer
6. Upper Isolator
7. Rear Engine Mount
8. Nut, 5/16-18
9. Capscrew, 5/8-11 x 2.5 Inch, Grade 8
10. Washer
11. Lower Isolator
12. Nut, 3/4-10
13. Nut, 5/8-11

Fig. 3, Rear Engine Mount Assembly, Cummins M11 Engines

nected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

2. Disconnect the engine from the right rear engine mount.

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

   2.2 Remove the bolt from the right rear engine mount. Save the fasteners and snubbers. Discard the rubber isolators.

   To remove the top isolator from a Detroit Diesel or Cummins M11 engine mount, remove the two capscrews that hold the ends of the isolator to the engine mount.

   2.3 Lift the engine slightly to take its weight off the right rear engine mount. Place engine stands under the engine to keep it off the engine mount.

3. Inspect the new engine mount rubber isolators for wear or damage and replace them if necessary.

⚠ CAUTION

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

4. Install the new upper isolator in the engine mount. If applicable, place the snubber on the isolator.

   If replacing the upper isolator on a Detroit Diesel or Cummins M11 engine mount, secure the isolator to the mount with two capscrews and locknuts, tighten the locknuts 22 N·m (16 lbf·ft).

⚠ WARNING

WARNING: The jack used to lower the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely installed on the engine mount. An unsecured engine may fall, causing personal injury or death, and component damage.

5. Secure the engine to the engine mount.

   5.1 If not in place, set a jack under the rear of the engine and raise the jack until it is braced against the engine.

Rear Engine Mount Isolator Replacement, Diesel Engines

5.2 Lift the engine slightly to remove the engine stands. Remove the stands, and carefully lower the engine onto the engine mount.

5.3 Holding the lower isolator in place, install the bolt in the right rear engine mount, and secure it with the nut and hardened washer. Tighten the nut 327 N·m (241 lbf·ft).

⚠ WARNING

WARNING: The jack used to lift the engine must be capable of safely lifting and supporting two metric tons. Once the engine mount is disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

6. Disconnect the engine from the left rear engine mount.

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

   6.2 Remove the bolt from the left rear engine mount. Save the fasteners and snubbers. Discard the rubber isolators.

   To remove the upper isolator from a Detroit Diesel or a Cummins M11 engine mount, remove the two capscrews that hold the ends of the isolator to the engine mount.

   6.3 Lift the engine slightly to take its weight off the left rear engine mount. Place engine stands under the engine to keep it off the engine mount.

7. Inspect the new engine mount rubber isolators for wear or damage and replace them if necessary.

⚠ CAUTION

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

8. Install the new upper isolator in the engine mount. If applicable, place the snubber on the isolator.

   If replacing the upper isolator on a Detroit Diesel or Cummins M11 engine mount, secure the isolator to the mount with two capscrews and locknuts, tighten the locknuts 22 N·m (16 lbf·ft).

⚠ WARNING

WARNING: The jack used to lower the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely installed on the engine mount. An unsecured engine may fall, causing personal injury or death, and component damage.

9. Secure the engine to the engine mount.

   9.1 If not in place, set a jack under the rear of the engine and raise the jack until it is braced against the engine.

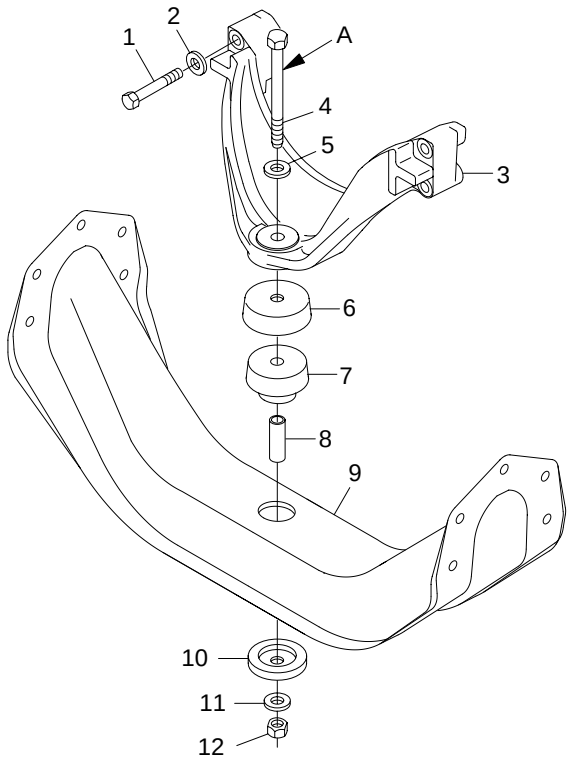
   9.2 Lift the engine slightly to remove the engine stands. Remove the stands, and carefully lower the engine onto the engine mount.

   9.3 Holding the lower isolator in place, install the bolt in the left rear engine mount, and secure it with the nut and hardened washer. Tighten the nut 327 N·m (241 lbf·ft).

10. Remove the jack from under the engine, and remove the chocks from the tires.

Front Engine Mount Isolator Replacement, Diesel Engines

Replacement (See Fig.1,Fig.2, or Fig.3)



04/29/93 f220034

A. The bolt runs up through the mounting assembly for Cummins C Series and Mercedes-Benz OM 366LA engines.

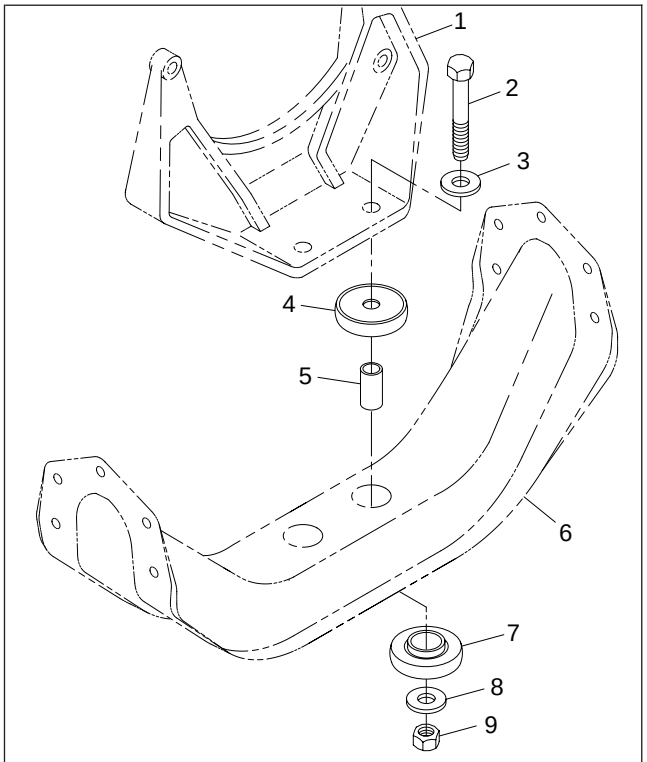
1. Bolt
2. Hardened Washer
3. Front Engine Support Bracket
4. Bolt
5. Hardened Washer
6. Snubber
7. Upper Isolator
8. Tube
9. Front Underslung Crossmember
10. Lower Isolator
11. Hardened Washer
12. Nut

Fig. 1, Front Mount Assembly, Cummins B Series Engine

1. Apply the parking brakes, chock the tires, and (if applicable) drain the air brake system.

WARNING

WARNING: The lifting device and chain used to lift the engine must be capable of safely lifting and supporting two metric tons. Once the engine mount is disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.



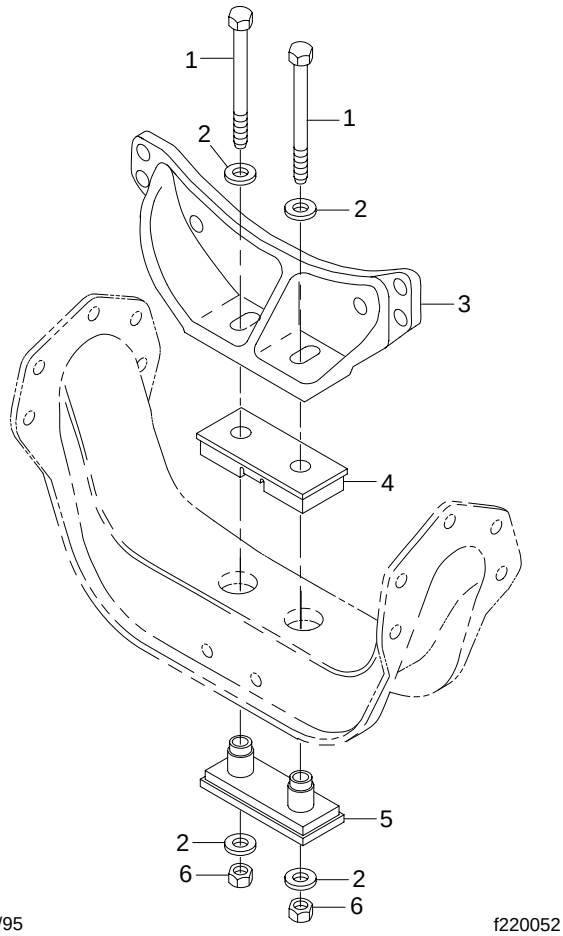
04/29/93 f010653

1. Front Engine Support Bracket
2. Bolt
3. Hardened Washer
4. Upper Isolator
5. Tube
6. Front Underslung Crossmember
7. Lower Isolator
8. Hardened Washer
9. Nut

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

2. Disconnect the engine from the front engine mount.
   - 2.1 Attach a chain to the front engine lifting hook(s), and position a lifting device to lift the engine. Attach the chain to the lifting device, and raise the chain to remove any slack.
   - 2.2 Remove the bolt(s) from the front engine mount. Save the fasteners, tube(s), and

Front Engine Mount Isolator Replacement, Diesel Engines



1. Capscrew, 3/4-10 x 4 Inch, Grade 8
2. Washer
3. Front Engine Support Bracket
4. Upper Isolator
5. Lower Isolator
6. Nut, 3/4-10

Fig. 3, Front Engine Mount Assembly, Cummins M11 Engine

snubber(s). Discard the rubber isolator cushions.

NOTE: In order to raise the front of the engine, you may have to loosen the bolts that run through the rear engine mounts.

2.3 Lift the engine slightly to take its weight off the front engine mount. Place engine stands under the engine to keep it off the engine mount.

3. Inspect the new front engine mount rubber isolators for wear or damage and replace them if necessary.

CAUTION

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

4. Install the upper isolator(s) in the engine mount.

WARNING

WARNING: The lifting device and chain used to lower the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely installed on the engine mount. An unsecured engine may fall, causing personal injury or death, and component damage.

5. Secure the engine to the front engine mount.

5.1 Attach a chain to the front engine lifting hook(s). Attach the chain to a lifting device, and raise the chain to remove any slack.

5.2 Lift the engine slightly to remove the engine stands. Remove the stands, and carefully lower the engine onto the engine mount.

5.3 Holding the lower isolator(s) and tube(s) in place, install the bolt(s) in the front engine mount and secure it with the nut(s) and washer(s). Tighten the nut(s) as follows:

For Caterpillar engines: tighten the bolts 184 N·m (136 lbf·ft).

For Cummins B and C Series and Mercedes-Benz engines: tighten the bolts 203 N·m (150 lbf·ft).

For Cummins M11 engines: tighten the bolts 327 N·m (241 lbf·ft).

For Detroit Diesel engines: tighten the nuts 327 N·m (241 lbf·ft).

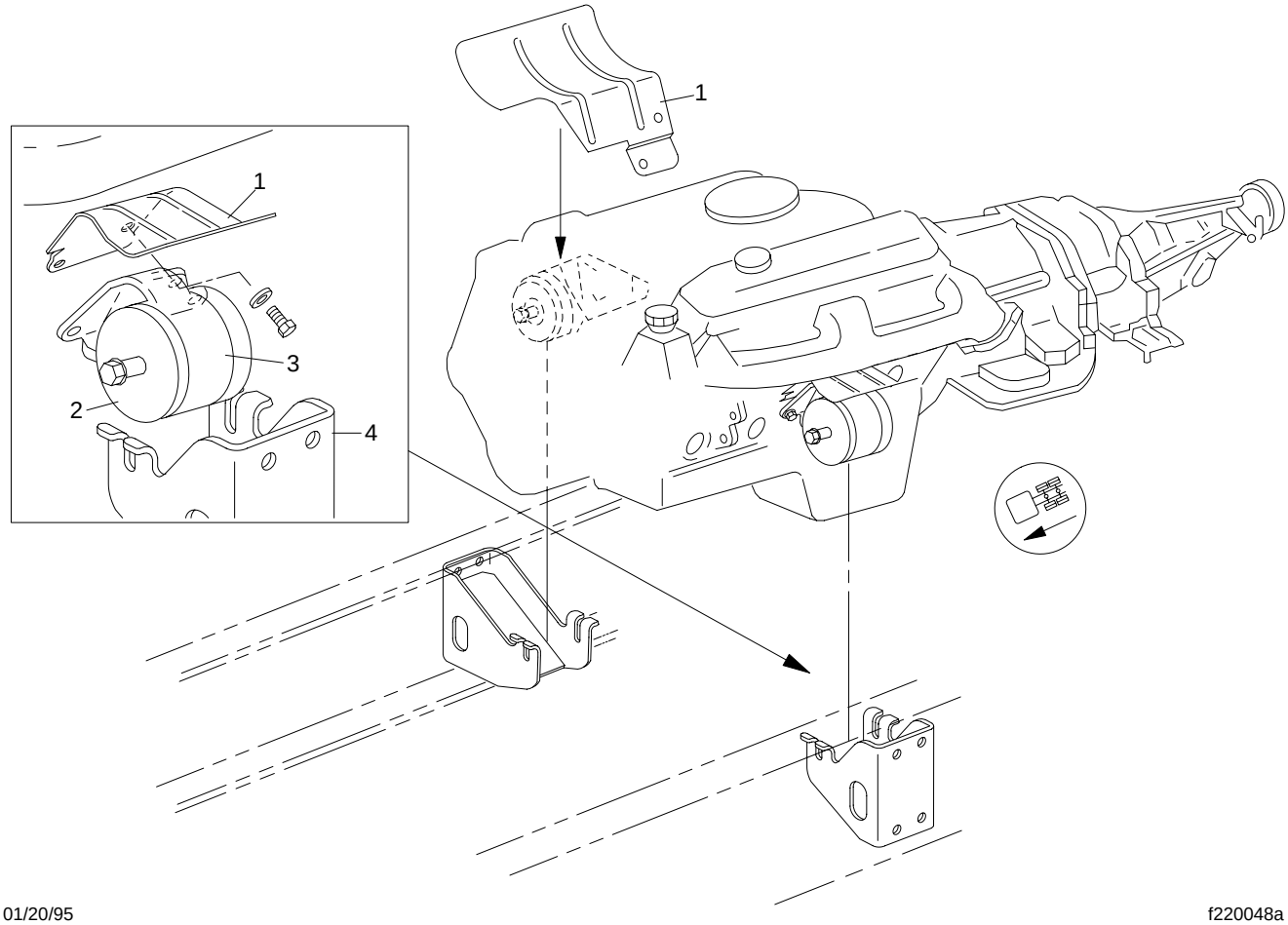
NOTE: If you loosened the bolts that run through the rear engine mounts, tighten those bolts 327 N·m (241 lbf·ft).

5.4 Remove the lifting chain from the engine lifting hook(s).

6. Remove the chocks from the tires.

Front Engine Mount Replacement, Gasoline Engines

Replacement (See Fig. 1)



1. Heat Shield
2. Isolator Cushion (Restriction Pad)
3. Engine Support Bracket
4. Front Engine Mount (Driver's Side Mount)

Fig. 1, Front Engine Mounts, Dodge Magnum Engine

1. Apply the parking brakes, and chock the tires.

⚠ WARNING

WARNING: Do not lift the engine by the intake air manifold. Lifting the engine by the manifold could result in the engine falling and causing personal injury or property damage.

2. Lift the engine slightly.

⚠ WARNING

WARNING: The crane, lifting eyes, and lifting chain used to remove the engine must be capable of safely lifting and supporting two metric tons. Once the engine mounts are disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine, or an engine lifted with unsuitable tools may fall, causing personal injury or death, and component damage.

Front Engine Mount Replacement, Gasoline Engines

2.1 Remove and save the upper inboard hexbolt from the power steering pump bracket; then install a 3/8-inch x 1-3/4-inch hexbolt and lifting eye in its place. Tighten the bolt firmly. **See Fig. 2.**

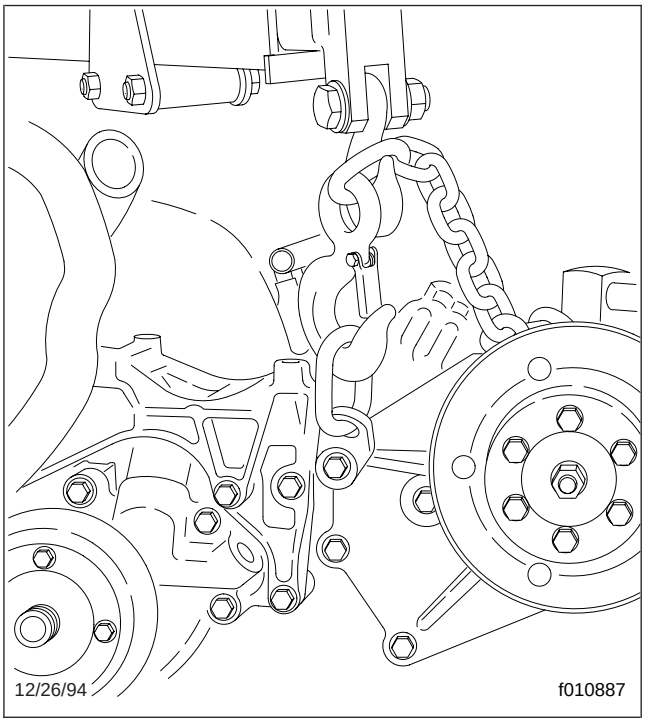
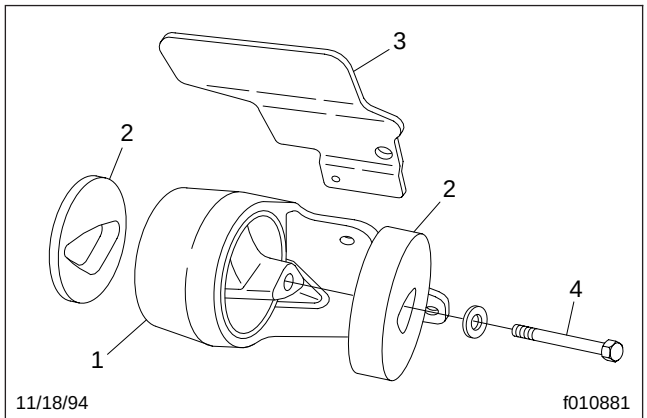


Fig. 2, Front Engine Lifting Eye

2.2 Attach a lifting chain to the lifting eye.

2.3 Attach the chain to a suitable lifting device, and raise the chain to lift the engine *slightly*.

3. Remove the bolts that run through the front engine mounts, rubber isolator cushions, and engine support brackets. **See Fig. 3.**
4. If necessary, remove the bolts that hold the engine support brackets and heat shields to the engine.
5. Remove the bolts which secure the mount to the frame rail. Remove the mount from the frame rail.
6. Place a new engine mount against the inside of the frame rail, and secure it with bolts, washers, and nuts. Tighten the nuts 61 N·m (45 lbf·ft).



1. Engine Support Bracket (mounted on engine)
2. Isolator (Restriction Pad)
3. Heat Shield
4. Bolt, 1/2-13 x 6, Grade 8

Fig. 3, Front Engine Support Bracket Assembly, Exploded, Dodge Magnum Engine

7. If the engine support brackets were removed from the engine, install the brackets and heat shields back on the engine using new mounting bolts. Tighten the bolts 81 N·m (60 lbf·ft).
8. Install the bolts through the rubber isolator cushions and engine support brackets, but do not install the nuts on the bolts.
9. Lower the engine, while making sure the bolt through each engine support bracket settles in the notch in the engine mount.
10. Install a nut on each of the bolts running through the front engine mounts and engine support brackets, and tighten the nuts 68 N·m (50 lbf·ft). **See Fig. 4.**
11. Remove the lifting eye and chain from the engine, and install the bolt removed earlier from the power steering pump bracket.
12. Remove the chocks from the tires.

Front Engine Mount Replacement, Gasoline Engines

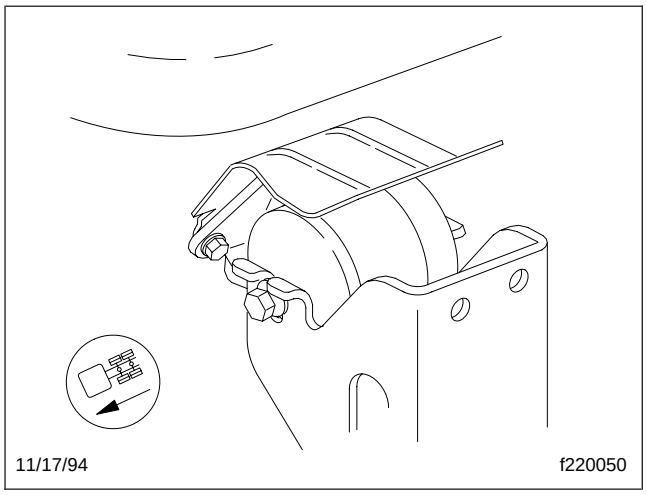
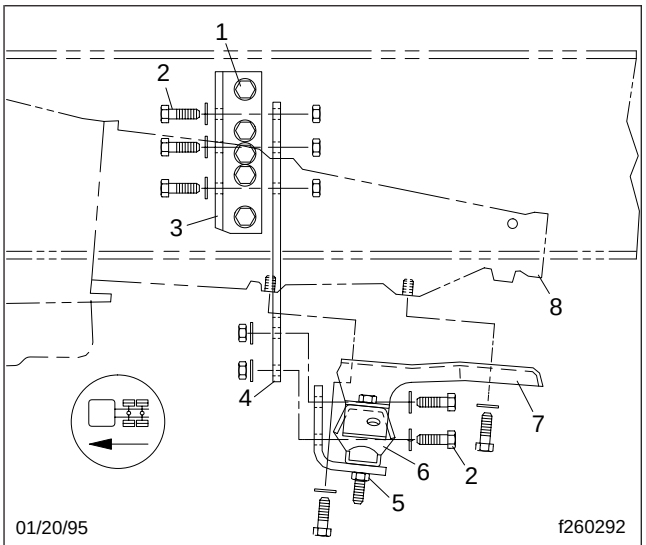


Fig. 4, Front Engine Support Bracket Assembly, Assembled, Dodge Magnum Engine

Rear Engine Mount Replacement, Gasoline Engines

Replacement (See Fig. 1)



1. Capscrew, 5/8-11, Grade 8
2. Capscrew, 1/2-13, Grade 8
3. Engine Support Crossmember Bracket (mounted on the framerail)
4. Engine Support Crossmember
5. Locknut, M10
6. Rubber Isolator
7. Transmission Support Bracket
8. Transmission

Fig. 1, Rear Engine Mount and Support Bracket Assembly, Exploded, Dodge Magnum Engine

1. Apply the parking brakes, and chock the tires.

⚠ WARNING

WARNING: Do not lift the engine by the intake air manifold. Lifting the engine by the manifold could result in the engine falling and causing personal injury or property damage.

2. Lift the rear of the engine and transmission assembly slightly.

⚠ WARNING

WARNING: The jack used to lift the engine must be capable of safely lifting and supporting two metric tons. Once the engine mount is disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

   2.1 Position a transmission jack under the transmission.

   2.2 Remove the locknuts that hold the rubber isolator to the engine support crossmember.

   2.3 Use the transmission jack to raise the rear of the engine and transmission assembly *slightly*.

3. Remove the bolts that hold the rubber isolator to the transmission support bracket.
4. If necessary, remove the bolts that hold the transmission support bracket to the transmission.
5. If the transmission support bracket was removed from the transmission, install it with new bolts, and tighten the bolts 102 N·m (75 lbf·ft).
6. Install the rubber isolator on the underside of the transmission support bracket and tighten the mounting nuts 47 N·m (35 lbf·ft).
7. Using the transmission jack, lower the transmission and rubber isolator onto the engine support crossmember.
8. Install the locknuts that hold the isolator on the crossmember, and tighten the locknuts 47 N·m (35 lbf·ft).
9. Remove the transmission jack.
10. Remove the chocks from the tires.

Specifications

Engine Mount Torque for Diesel Engines			
Description	**Grade**	**Size**	**Torque lbf·ft (N·m)**
Rear Engine-Mount to Support-Bracket, All Engines	8	3/4–10	241 (327)
Rear Engine Mount to Frame Rail Bolts:			
Caterpillar Engines	8	1/2–13	45 (61)
Cummins B Series/ISB, C Series/ISC, and Mercedes-Benz Engines	8	1/2 –13	68 (92)
Cummins M11/ISM Engines	8	5/8–11	135 (183)
Detroit Diesel Engines	8	1/2–13	68 (92)
MBE 900 Engines	8	1/2–13	68 (92)
Rear Support Bracket to Engine Bolts:			
Caterpillar Engines	10.9	M14 x 35	100 (136)
Cummins B Series/ISB and C Series/ISC Engines	10.9	M12	55 to 65 (75 to 88)
Cummins M11/ISM Engines	8	3/4–10	241 (327)
Detroit Diesel Engines	8	5/8–11	136 (184)
Mercedes-Benz Engines	10.9	M16	130 to 165 (177 to 224)
MBE 900 Engines	10.9	M16	155 (210)
Front Support Bracket to Engine Bolts:			
Cummins B Series/ISB Engines	10.9	M12	55 to 65 (75 to 88)
Cummins C Series/ISC Engines	10.9	M12	75 to 90 (102 to 122)
Detroit Diesel Engines	—	—	118 to 148 (160 to 200)
Mercedes-Benz Engines	10.9	M12	90 to 110 (122 to 150)
MBE 900 Engines	10.9	M14	100 (136)
Front Engine Mount Bolt:			
Caterpillar Engines	8	5/8–11	136 (184)
Cummins B Series/ISB and Mercedes-Benz Engines	8	5/8–11	136 (184)
Cummins C Series/ISC Engines	8	1/2–13	68 (92)
Cummins M11/ISM Engines	8	3/4–10	241 (327)
Detroit Diesel Engines	8	3/4–10	241 (327)
MBE 900 Engines	8	5/8–11	136 (184)

Table 1, Engine Mount Torques for Diesel Engines

Engine Mount Torques for Gasoline Engines			
Description	**Grade**	**Size**	**Torque lbf·ft (N·m)**
Bolt Through Front Engine Mount and Engine Support Bracket	8	1/2–13 x 6 inch	50 (68)
Front Engine Mount to Frame Rail Bolt	8	1/2–13 x 1.75 inch	45 (61)

Specifications

Engine Mount Torques for Gasoline Engines			
Description	**Grade**	**Size**	**Torque lbf·ft (N·m)**
Engine Support Bracket (and heat shield) Mounting Bolt	—	—	60 (81)
Rear Engine Mount (transmission support bracket) to Underslung Crossmember Mounting Locknut	—	M10	35 (47)
Transmission Support Bracket to Transmission Mounting Bolt	—	—	75 (102)
Rubber Isolator Cushion to Transmission Support Bracket Mounting Nuts	—	—	35 (47)

Table 2, Engine Mount Torques for Gasoline Engines

General Description

The Phillips Temro oil pan heater keeps the crankcase oil about 32°C (90°F) warmer than the ambient air temperature. In cold weather, the heater helps prevent water from condensing in the oil, it creates a better seal in the combustion chambers for start-up, and it keeps the oil free-flowing for instant lubrication.

The heater consists of a 150-or 300-watt element that screws into the side of the engine oil pan. **See Fig. 1.** A cord plugs onto the outside end of the element, and the cord runs to a receptacle mounted below the driver's door. **See Fig. 2.**

NOTE: When a vehicle is also equipped with an engine block heater, the engine block heater is wired in tandem with the oil pan heater. The cord from the oil pan heater element, and the receptacle below the driver's door, provide power to the engine block heater.

To turn on the heater, open the spring-loaded cover on the receptacle, and connect a power source to the receptacle. The element has no thermostat. Heat dissipating from the crankcase prevents oil overheating.

General Description

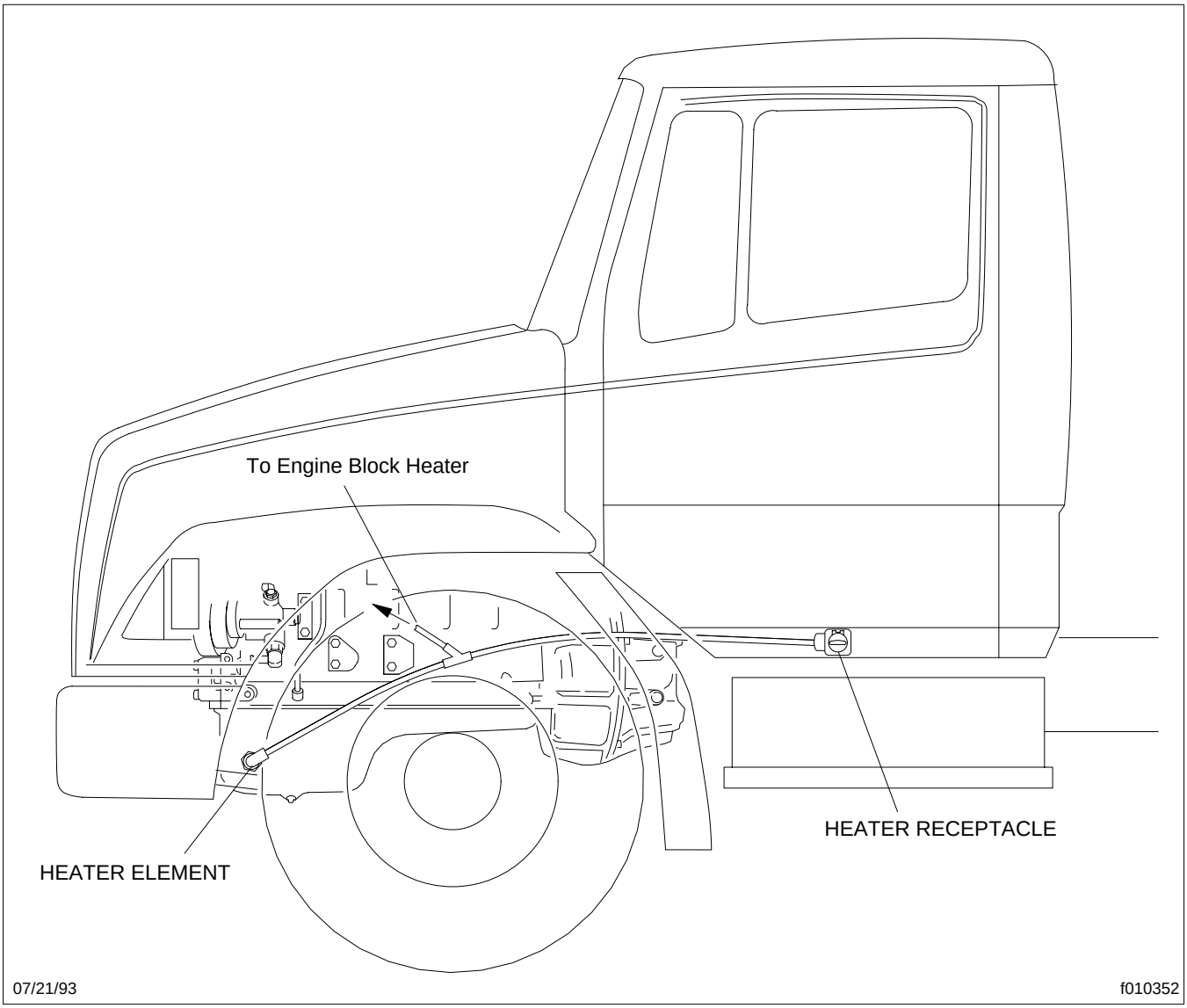


Fig. 1, Cummins B Series Engine Shown

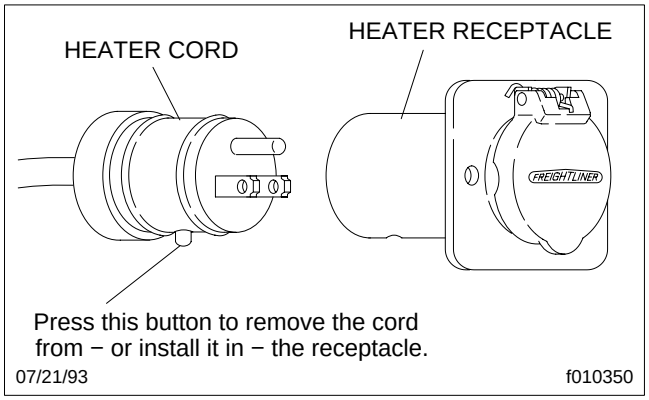

HEATER CORD
HEATER RECEPTACLE
FREIGHTLINER
Press this button to remove the cord
from − or install it in − the receptacle.
07/21/93
f010350

Fig. 2

Oil Pan Heater Element Removal and Installation

Removal

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.
3. Drain the oil.

⚠ WARNING

Drain the oil pan only when the oil and engine are cool. Draining it when they are hot could cause severe personal injury due to scalding.

   3.1 Place a suitable container under the oil pan drain plug.

   3.2 Remove the plug, and allow the oil to drain.

4. Unscrew the threaded cover that secures the cord to the element. See **Fig. 1**.
5. Pull the cord off the element.
6. Unscrew the element from the oil pan port.

Installation

1. Screw the element into the port until finger-tight. Then, use a wrench to tighten the element one more turn.
2. Plug the cord onto the element and secure it by screwing the threaded cover in place. See **Fig. 1**.
3. Install the oil drain plug in the crankcase, and fill the engine with oil. For recommended oil types and engine oil capacities, see the vehicle maintenance manual.
4. Start the engine and check for leaks. Repair any leaks as necessary.
5. To test the heater, plug a wattmeter into a power source, and connect the heater cord in the receptacle to the meter. A reading on the meter will indicate the heater is working.

Oil Pan Heater Element Removal and Installation

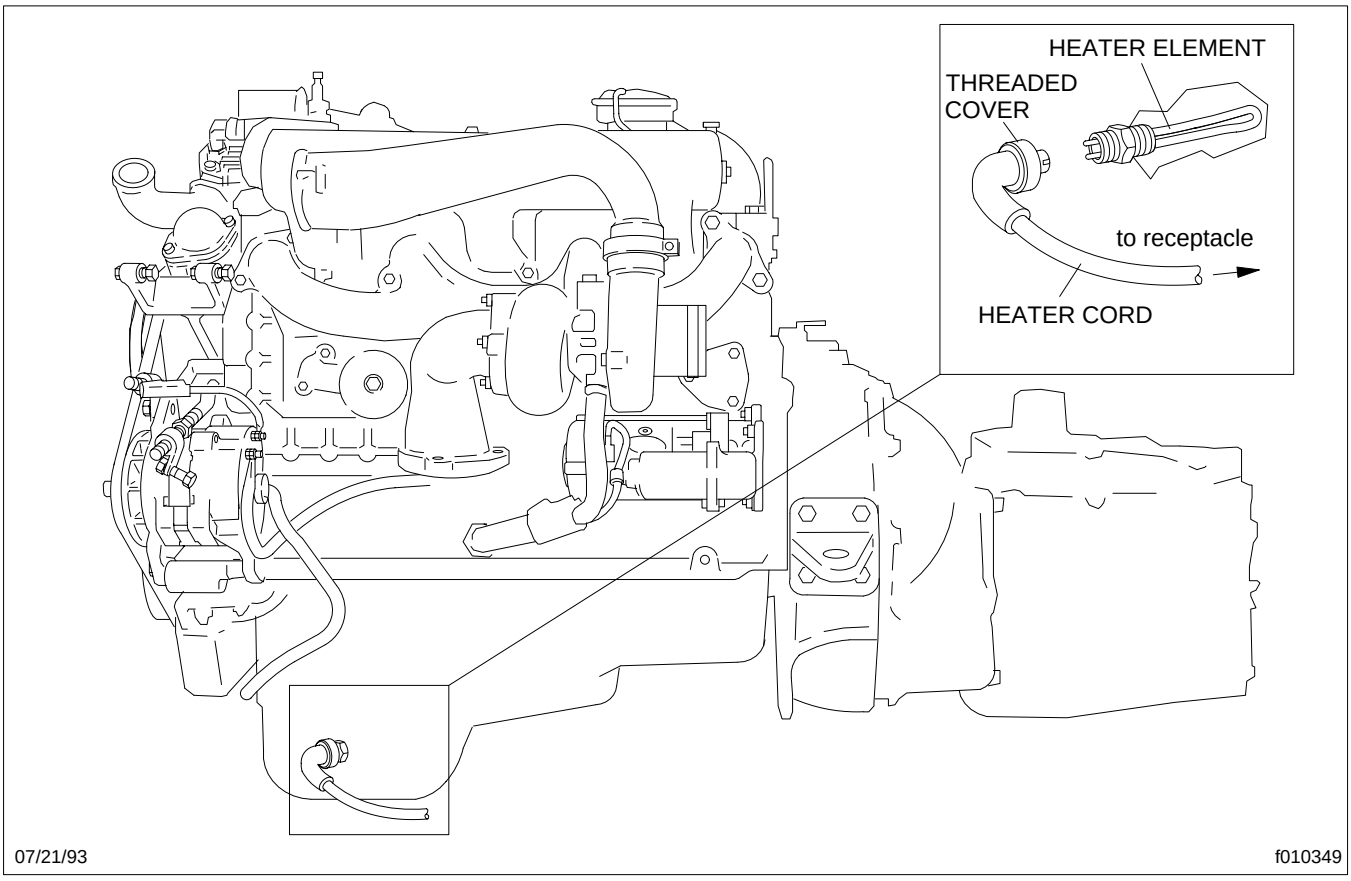


Fig. 1, Mercedes-Benz OM 366LA Engine Shown

Troubleshooting

Use the following procedures to check for the most common oil pan heater problems.

WIRING PROBLEMS

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.
3. Unscrew the threaded cover that secures the cord to the element. See **Fig. 1**. Pull the cord off the element.
4. Using an ohmmeter, check the continuity between the two poles of the element. On Cummins B Series and Mercedes-Benz OM 366LA engines, the resistance should be about 96 ohms. On Cummins C Series engines, the resistance should be about 48 ohms. If there is no reading, the element is burnt out.
5. If the element is good, check the cord. Plug the cord onto the element and secure it by screwing the cover in place. See **Fig. 1**.
6. Using an ohmmeter at the receptacle, check the continuity between the two power terminals. On Cummins B Series and Mercedes-Benz OM 366LA engines, the resistance should be about 96 ohms. On Cummins C Series engines, the resistance should be about 48 ohms. If there is no reading or a very high reading, the cord is damaged. Replace the cord.
7. Check the continuity between each power terminal and the ground terminal. There should be no ohmmeter reading. If there is a reading, replace the cord.

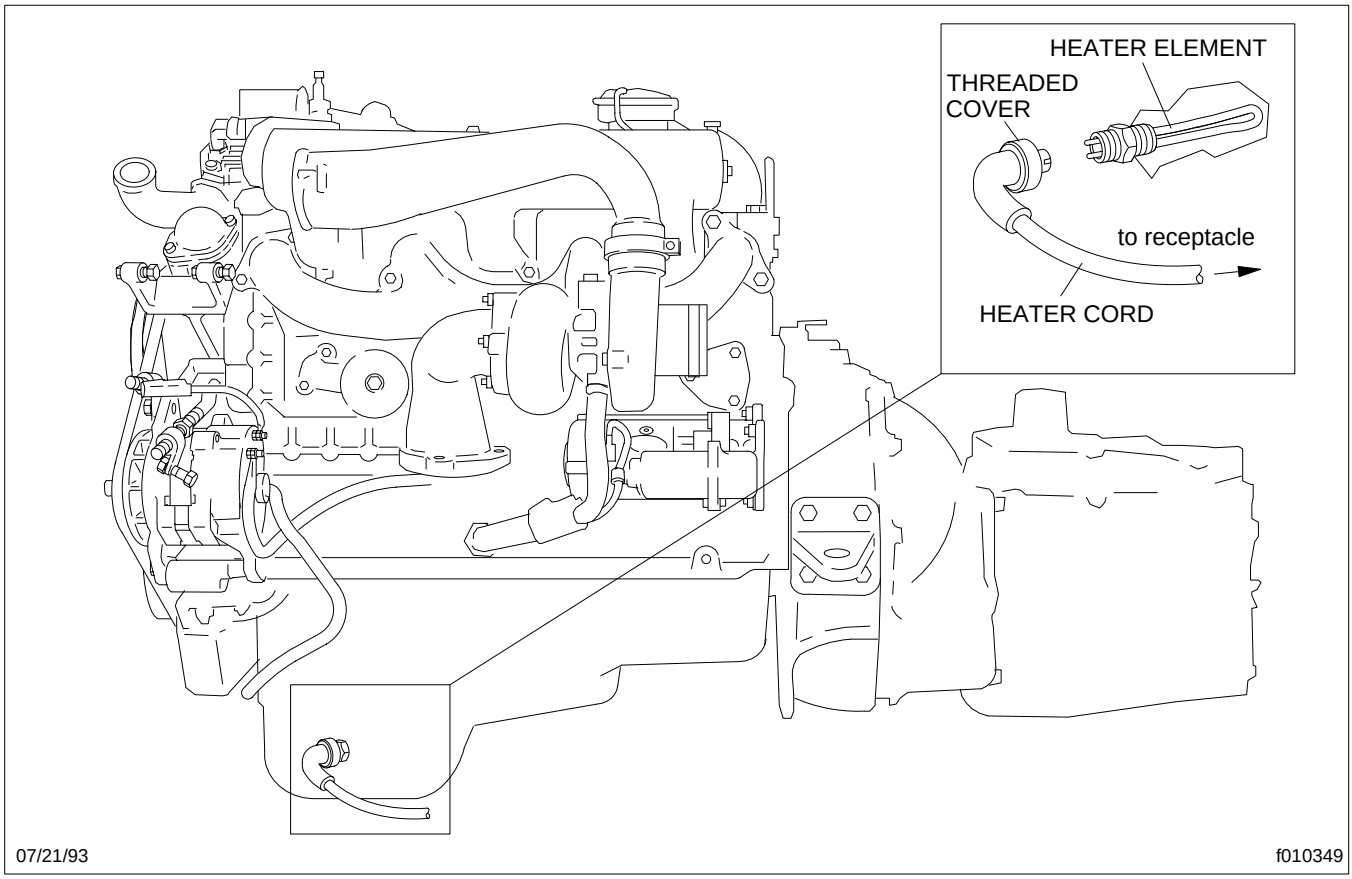


Fig. 1, Mercedes-Benz OM 366LA Engine Shown

Troubleshooting

8. Check the ohmmeter reading between the ground terminal and a good vehicle ground. The reading should be zero. If not, replace the cord.

FOULED ELEMENT

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.

⚠ WARNING

WARNING: Drain the oil pan only when the oil and engine are cool. Draining it when they are hot could cause severe personal injury due to scalding.

3. Drain the oil.
   - 3.1 Place a suitable container under the oil pan drain plug.
   - 3.2 Remove the plug, and allow the oil to drain.
4. Unscrew the threaded cover that secures the cord to the element. See **Fig. 1**. Pull the cord off the element.
5. Unscrew the element from the oil pan port.
6. Inspect the element for charred oil that may insulate it. If burnt oil is present, replace the element, and change the engine oil and oil filter.

General Description

The Phillips Temro engine block heater keeps the engine coolant about 27°C (80°F) warmer than the ambient air temperature. In cold weather, the heater helps engine starting and reduces wear on the piston walls.

When starting the engine, the diesel normally ignites on the compression stroke of each piston, when the compressed air within the cylinder reaches about 385°C (725°F). However, during cold weather starts, the heat of the compressed air dissipates into the surrounding engine block so the diesel may never reach the temperature it needs to ignite. Using the engine block heater, the engine block is already warm so heat is held in the cylinder to ignite the diesel. To reduce engine wear, the block heater warms the oil film on the piston walls and reduces piston drag caused by cold oil film.

The heater consists of an element that bolts into the side of the engine water jacket. **See Fig. 1.** A cord plugs into the outside end of the element, and the cord runs to a receptacle mounted below the driver's door. **See Fig. 2.**

NOTE: When a vehicle is also equipped with an oil pan heater, the oil pan heater is wired in tandem with the engine block heater. The cord from the engine block heater element, and the receptacle below the driver's door, provide power to the oil pan heater.

To turn on the heater, open the spring-loaded cover on the receptacle, and connect a power source to the receptacle. The element has no thermostat. Heat dissipating from the engine block prevents coolant overheating.

General Description

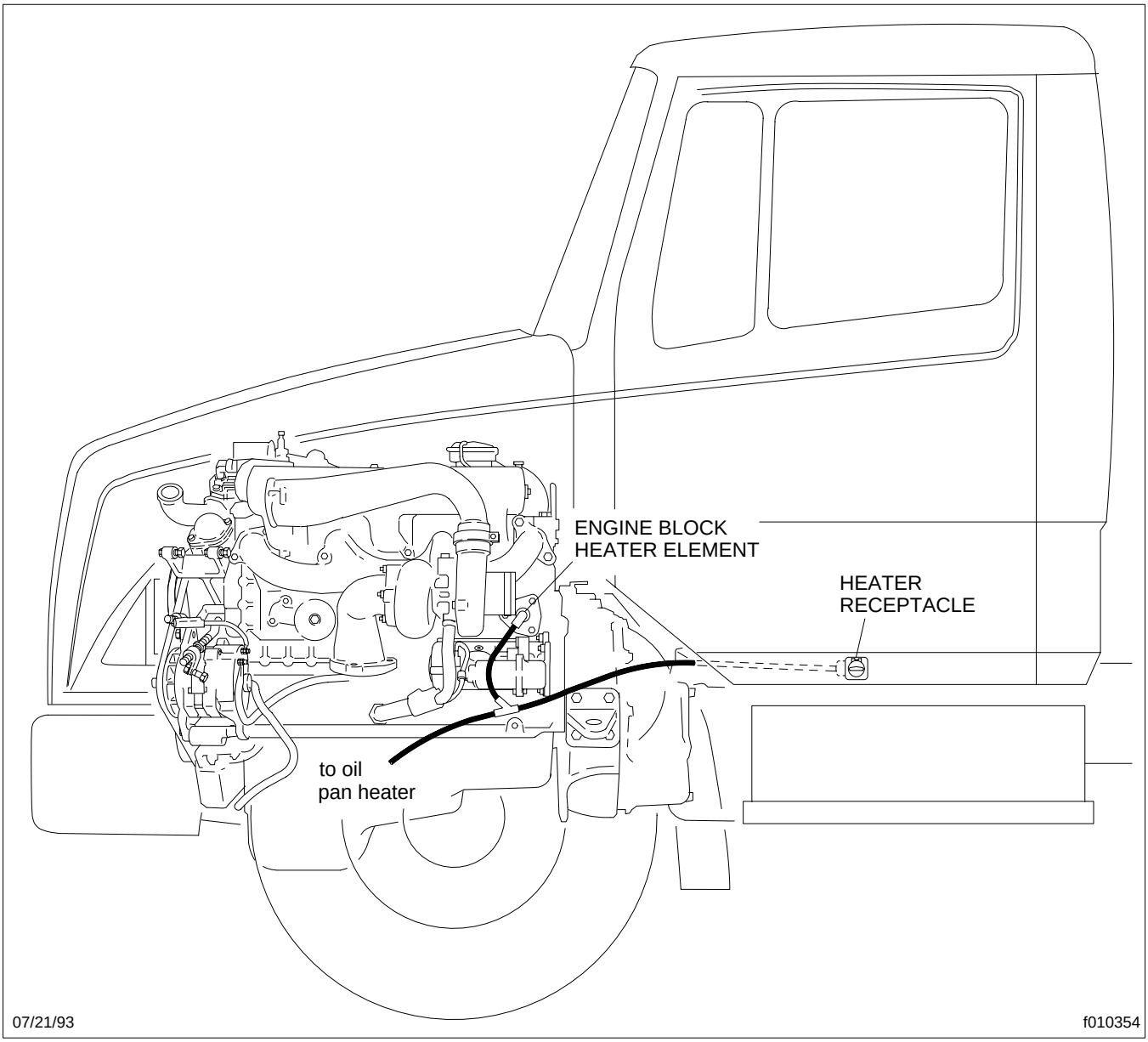


Fig. 1, Mercedes-Benz OM 366LA Engine Shown

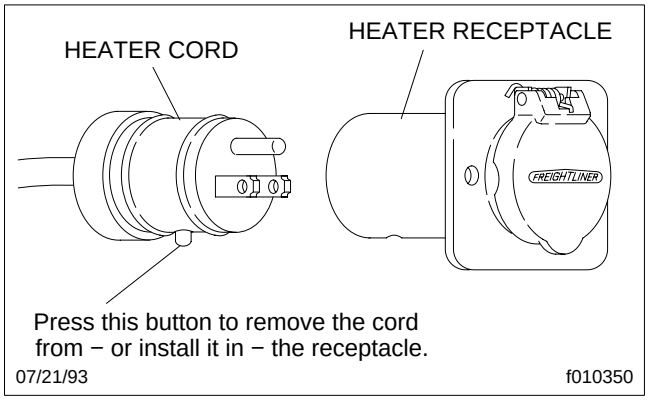

HEATER CORD
HEATER RECEPTACLE
FREIGHTLINER
Press this button to remove the cord
from − or install it in − the receptacle.
07/21/93
f010350

Fig. 2

Engine Block Heater Element Removal and Installation

Removal

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.
3. Drain the radiator.

⚠ WARNING

WARNING: Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

   3.1 Loosen the surge tank cap.

   3.2 Open the petcock at the bottom of the radiator to drain the engine coolant.

4. Unscrew the threaded cover that secures the cord to the element. **See Fig. 1.**
5. Pull the cord off the element.
6. Remove the element from the engine block.

   On Mercedes-Benz OM 366LA engines, remove the three bolts that hold the element cover to the block, and pull out the element.

   On Cummins B Series engines, loosen the capscrew in the center of the element cover, and pull out the element.

Installation

1. Install the heater element in the engine block.

   On Mercedes-Benz OM 366LA engines, secure the element in the block with three bolts. Tighten the bolts 20 N·m (15 lbf·ft).

   On Cummins B Series engines, secure the element in the block by tightening the capscrew 13 N·m (10 lbf·ft).

2. Plug the cord into the element and secure it by screwing the threaded cord cover in place. **See Fig. 1.**
3. Fill the cooling system. For recommended coolants and coolant system capacities, refer to the vehicle maintenance manual.
4. Start the engine and check for leaks. Repair any leaks as necessary. Run the engine for half an hour to purge any air from the coolant system.
5. To test the heater, plug a wattmeter into a power source, and connect the heater cord in the receptacle to the meter. A reading on the meter will indicate the heater is working.

Engine Block Heater Element Removal and Installation

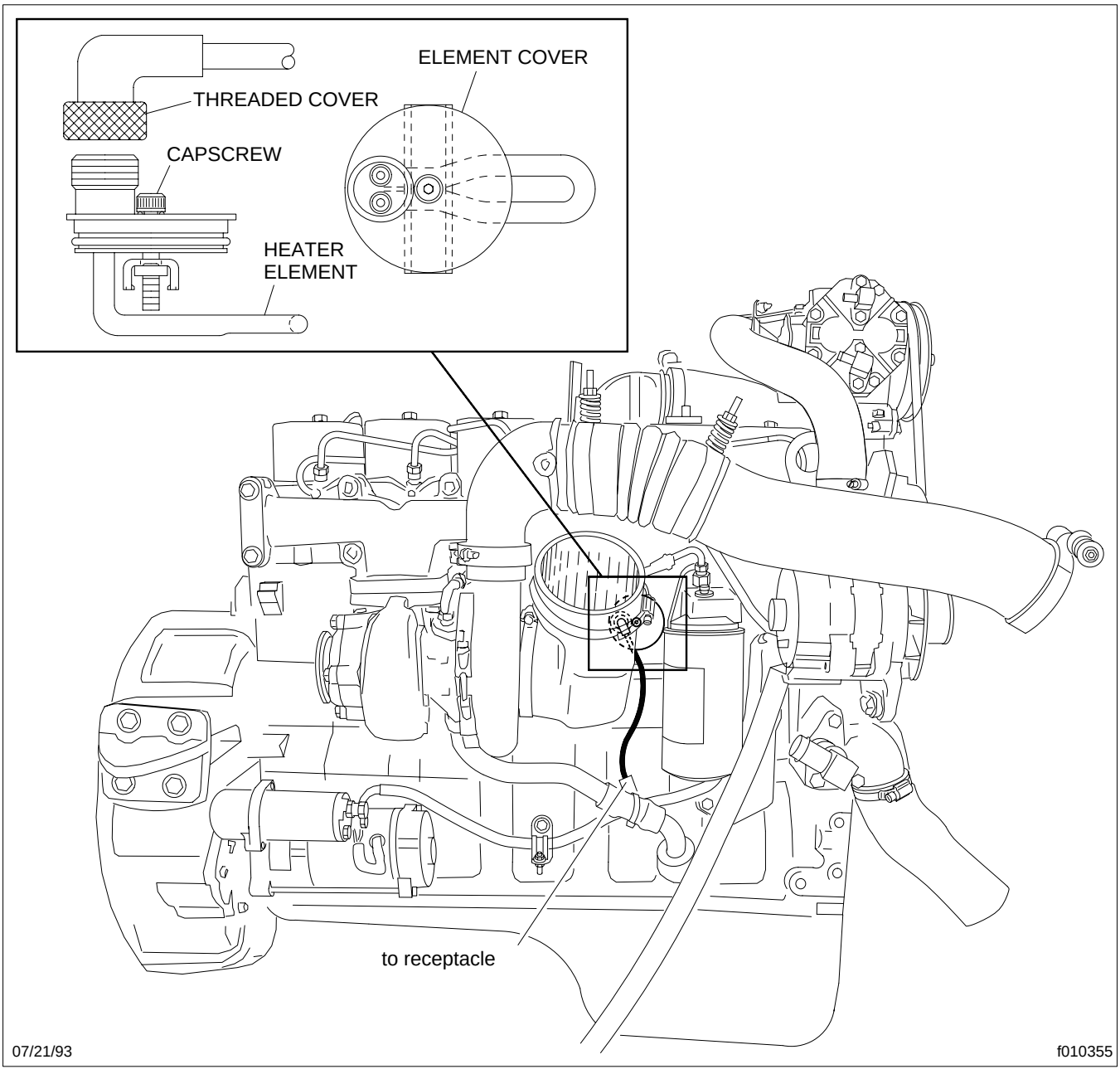


Fig. 1, Cummins B Series Engine Shown

Troubleshooting

Use the following procedures to check for the most common engine block heater problems.

WIRING PROBLEMS

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.
3. Unscrew the threaded cover that secures the cord to the element. **See Fig. 1.** Pull the cord off the element.
4. Using an ohmmeter, check the continuity between the two poles of the element. The resistance should be very low, typically between 9 and 10 ohms. If there is no reading, the element has burned out, and if the reading is very high, the element is about to burn out.
5. If the element is good, check the cord. Plug the cord into the element and secure it by screwing the threaded cover in place. **See Fig. 1.**
6. Using an ohmmeter at the receptacle, check the continuity between the two power terminals. The resistance should be low, typically between 9 and 10 ohms. If there is no reading or a very high reading, the cord is damaged. Replace the cord.
7. Check the continuity between each power terminal and the ground terminal. There should be no ohmmeter reading. If there is a reading, replace the cord.
8. Check the ohmmeter reading between the ground terminal and a good vehicle ground. The reading should be zero. If not, replace the cord.

FOULED ELEMENT

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.
3. Drain the radiator.

⚠ WARNING

WARNING: Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

   3.1 Loosen the surge tank cap.

   3.2 Open the petcock at the bottom of the radiator to drain the engine coolant.

4. Unscrew the threaded cover that secures the cord to the element. **See Fig. 1.** Pull the cord off the element.
5. Remove the element from the engine block. On Mercedes-Benz OM 366LA engines, remove the three bolts that hold the element cover to the block, and pull out the element. On Cummins B Series engines, loosen the capscrew in the center of the element cover, and pull out the element.
6. Inspect the element for residue deposits, discoloration, or damage.

   Greenish residue indicates the coolant solution contains too much antifreeze. Replace the element, and refer to the vehicle maintenance manual for the recommended antifreeze/water ratio.

   Gray or black residue indicates anti-leak coolant additives have been added to the system. Replace the element, and refer to the vehicle maintenance manual for the recommended coolant additives.

   Blue or black discoloration on the element indicates the coolant system needs more coolant. Replace the element, and fill the coolant system until coolant is visible in the surge tank sight glass.

   Holes in the element indicate the coolant solution contains too little antifreeze. The weak solution is boiling inside the engine block and causing pitting of the element and block. Replace the element, and refer to the vehicle maintenance manual for the recommended antifreeze to water concentrations.

Troubleshooting

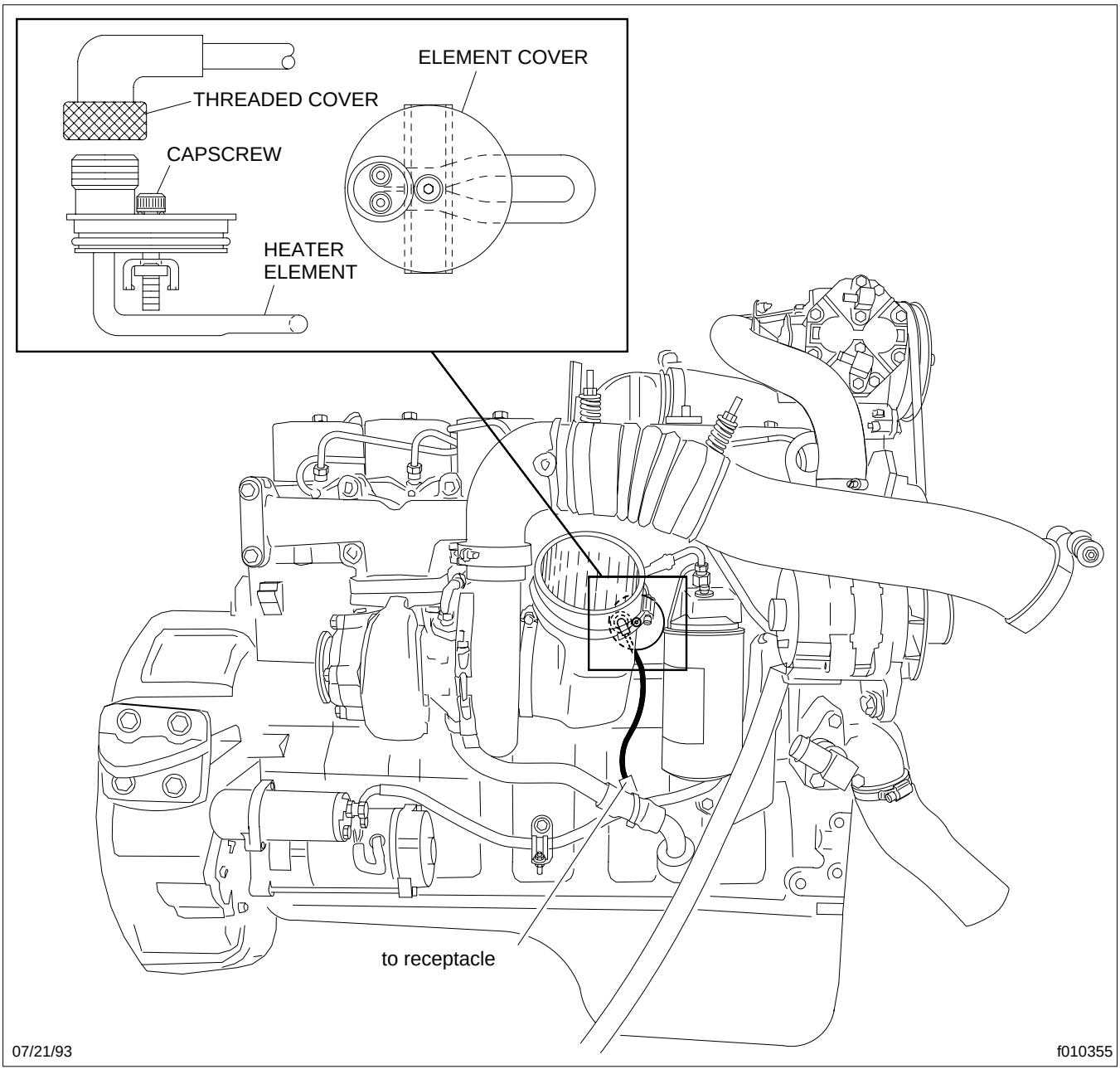


Fig. 1, Cummins B Series Engine Shown

Specifications

Description	Grade	Size	Torque N·m (lbf·ft)
Element Bolts, OM 366LA Engine	8	M8 x 1.5	20 (15)
Element Capscrew, Cummins B Series Engine	8	1/4–20	13 (10)

Table 1, Fastener Torques

General Description

During cold weather starts, the KBi starting fluid system injects vaporized ether into the engine manifold to help ignite the diesel fuel in the cylinders. The diesel normally ignites on the compression stroke of each piston, when the compressed air within the cylinder reaches about 385°C (725°F). However, during cold weather starts, the heat of the compressed air dissipates into the surrounding engine block so the diesel may never reach the temperature it needs to ignite. Ether ignites at 182°C (360°F). Therefore, ether vapor injected with the engine intake air ignites at the lower cylinder temperature, and the burning ether ignites the diesel.

Using the starting fluid system reduces the necessary cranking time in cold weather, and it prevents excessive wear on the battery and starter.

When the engine is cold, the KBi system begins injecting ether when the starter is cranked. The system continues injecting ether vapor into the manifold for a short time to prevent stalling. The system consists of the starting fluid cylinder, the ether injection nozzle in the engine manifold, and the engine temperature sensor. **See Fig. 1.**

The starting fluid cylinder **(see Fig. 2)** is mounted with the receiver-dryer against the firewall. It fits into the Dieselmatic® valve and Blockor® fitting which measure, hold, and release a controlled amount of fluid for each start attempt.

Ether travels through plastic tubing to the engine manifold where it sprays through the injection nozzle into the engine intake air. Inside the manifold, vaporized ether fills the cylinders and ignites.

If the weather is warm, or the engine is already warmed, the engine temperature sensor mounted in the engine water jacket prevents the KBi from injecting ether vapor. The system will inject ether only if the engine is cooler than about 4°C (40°F).

General Description

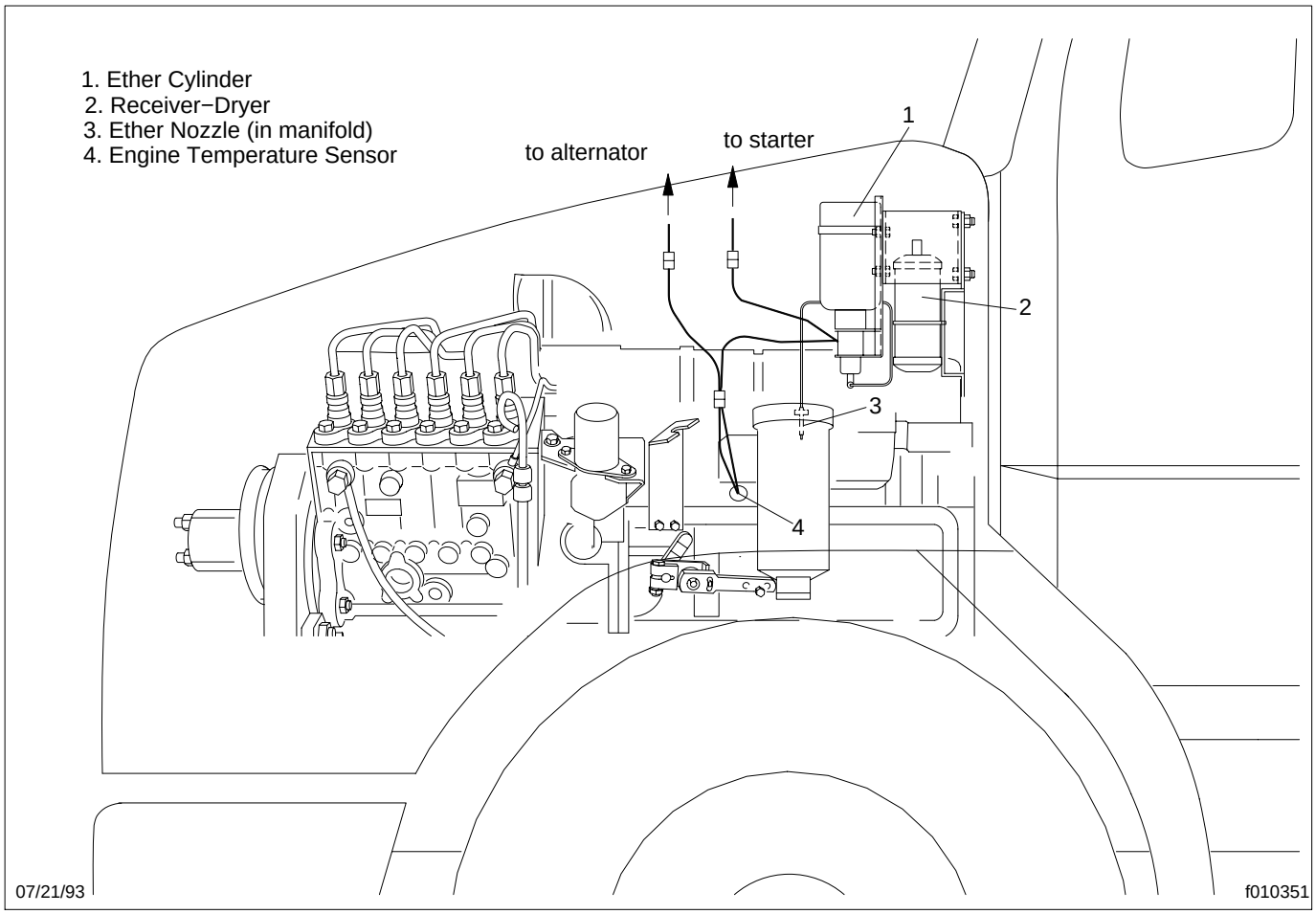


Fig. 1

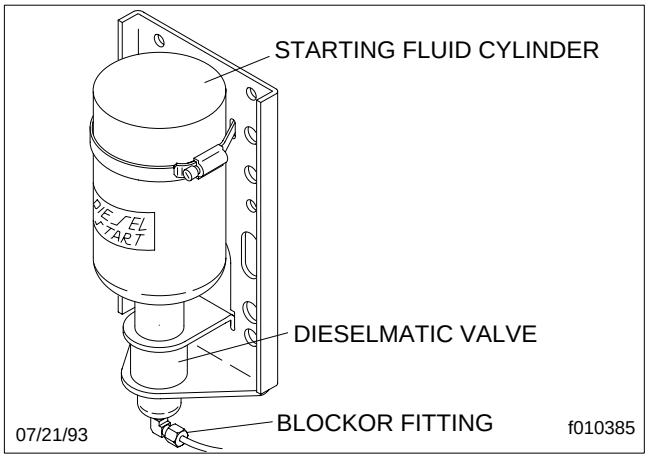
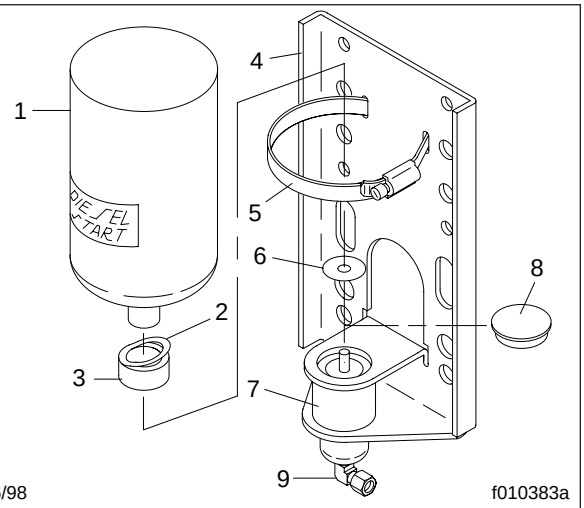


Fig. 2

Replacement (See Fig. 1)



1. Starting Fluid Cylinder
2. Paper Backing
3. Dirt Eliminator Collar
4. Mounting Plate
5. Cylinder Clamp
6. Valve Gasket
7. Dieselmatic Valve
8. Valve Cap
9. Blockor Fitting

Fig. 1, KBi Ether Start System

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.

⚠ WARNING

Service starting fluid systems only in a well-ventilated area away from sparks and open flames. The ethyl ether in these systems is flammable and toxic. Wear protective gloves and glasses, and avoid breathing ether fumes. Failure to take these precautions could result in personal injury or property damage.

3. Remove the old cylinder (Ref. 1).
   - 3.1 Clean all dirt from the neck of the cylinder and the top of the Dieselmatic® valve before removing the cylinder.
   - 3.2 Loosen the cylinder clamp.
   - 3.3 Pry the dirt eliminator collar (Ref. 3) off the neck of the cylinder.
   - 3.4 Unscrew the cylinder from the Dieselmatic valve.

NOTE: If not replacing the cylinder immediately, place the valve cap (Ref. 8) in the valve to prevent dirt or other debris from entering the system.

4. Remove the old dirt eliminator collar from the valve assembly.
5. Replace the Dieselmatic valve gasket (Ref. 6). Spread the new gasket with a light film of clean oil.
6. Place a new dirt eliminator collar, adhesive-side up, on the valve assembly. Peel off the collar's paper backing (Ref. 2) to expose the adhesive.
7. Install the new cylinder.
   - 7.1 Place the new cylinder into the Dieselmatic valve and hand tighten it firmly.
   - 7.2 Slide the dirt eliminator collar up so it sticks to the cylinder.
   - 7.3 Tighten the clamp around the cylinder 680 N·cm (60 lbf·in).
8. If the ambient temperature is below 4°C (40°F), test the starting fuel system.
9. Lower the hood, and remove the chocks from the tires.

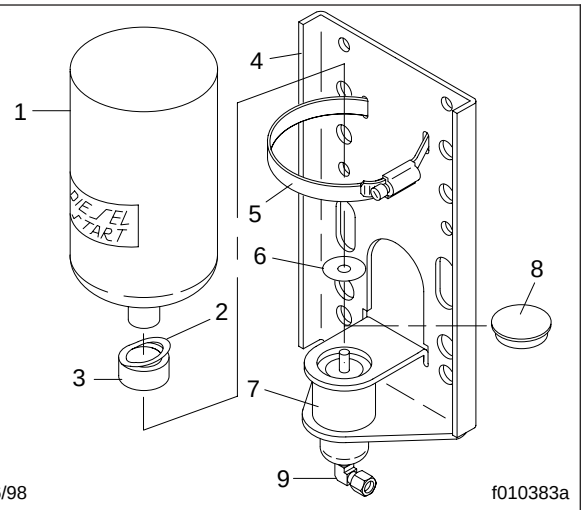
Removal

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.

⚠ WARNING

Service starting fluid systems only in a well-ventilated area away from sparks and open flames. The ethyl ether in these systems is flammable and toxic. Wear protective gloves and glasses, and avoid breathing ether fumes. Failure to take these precautions could result in personal injury or property damage.

3. Remove the starting fluid cylinder. See **Fig. 1.**



1. Starting Fluid Cylinder
2. Paper Backing
3. Dirt Eliminator Collar
4. Mounting Plate
5. Cylinder Clamp
6. Valve Gasket
7. Dieselmatic Valve
8. Valve Cap
9. Blockor Fitting

Fig. 1, KBi Ether Start System

3.1 Clean all dirt from the neck of the cylinder and the top of the Dieselmatic® valve before removing the cylinder.

3.2 Loosen the cylinder clamp.

3.3 Pry the dirt eliminator collar off the neck of the cylinder.

3.4 Unscrew the cylinder from the Dieselmatic valve.

NOTE: If not replacing the cylinder immediately, place the valve cap in the valve to prevent dirt or other debris from entering the valve.

4. Remove the old dirt eliminator collar from the valve assembly.
5. Remove the mounting plate and valve assembly. See **Fig. 2.**

   5.1 Disconnect the wires running from the assembly to the "M" terminal of the starter and to the engine temperature sensor.

   5.2 Disconnect the ether tubing from the nozzle in the engine manifold.

   5.3 Remove the four bolts that hold the mounting plate to the mounting bracket, and remove the plate and the valve assembly from the vehicle.

6. Remove the engine temperature sensor. See **Fig. 2.**

   6.1 Disconnect the sensor ground wire at the alternator ground terminal.

   6.2 Unscrew the sensor from the engine block, and seal the port with an appropriate water jacket plug.

7. Remove the ether nozzle from the engine manifold, and seal the hole in the manifold with an appropriate plug.

Installation

⚠ WARNING

Service starting fluid systems only in a well-ventilated area away from sparks and open flames. The ethyl ether in these systems is flammable and toxic. Wear protective gloves and glasses, and avoid breathing ether fumes. Failure to take these precautions could result in personal injury or property damage.

Do not install a starting fluid system on a vehicle with an air intake warmer, for example, a glow plug or a flame start system. An air intake warmer could prematurely ignite the starting fluid and cause an explosion in the air intake manifold resulting in personal injury and property damage.

Starting System Removal and Installation

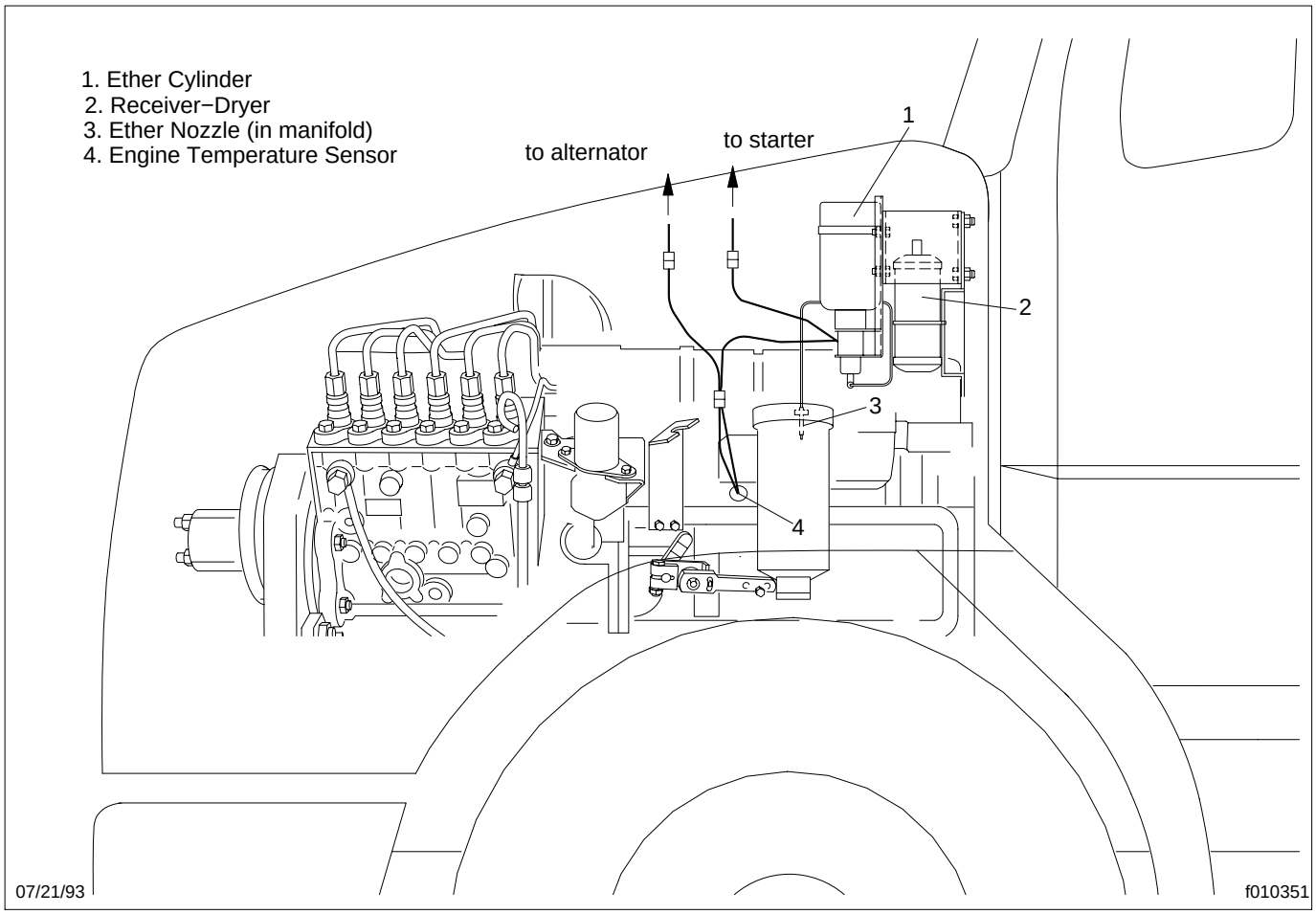


Fig. 2

1. Remove the plug in the engine intake manifold and screw the ether nozzle in place. See **Fig. 2.**
2. Install the engine temperature sensor. See **Fig. 2.**
   - 2.1 Remove the plug from the water jacket, and screw the sensor in place until finger-tight. Using a wrench, tighten the sensor one more turn.
   - 2.2 Connect the ground wire from the sensor to the alternator ground terminal.
3. Install the mounting plate and valve assembly. See **Fig. 2.**
   - 3.1 Place the mounting plate against the mounting bracket, and secure it with four bolts. Tighten the bolts 30 N·m (22 lbf·ft).
   - 3.2 Connect the ether tubing to the injection nozzle in the intake manifold. Tighten the nozzle fitting finger-tight, then, using a wrench, tighten the nozzle one more turn.
   - 3.3 Connect the black wire from the valve assembly to the engine temperature sensor.
   - 3.4 Connect the remaining wire from the assembly to the "M" terminal of the starter.
4. Install the starting fluid cylinder. See **Fig. 1.**
   - 4.1 Replace the Dieselmatic valve gasket. Spread the new gasket with a light film of clean oil.
   - 4.2 Place a new dirt eliminator collar, adhesive-side up, on the valve assembly.

Peel off the collar's paper backing to expose the adhesive.

4.3 Place the new cylinder into the Dieselmatic valve and hand-tighten it firmly.

4.4 Slide the dirt eliminator collar up so it sticks to the cylinder.

4.5 Tighten the clamp around the cylinder 680 N·cm (60 lbf·in).

5. If the ambient temperature is below 4°C (40°F), test the starting fuel system.

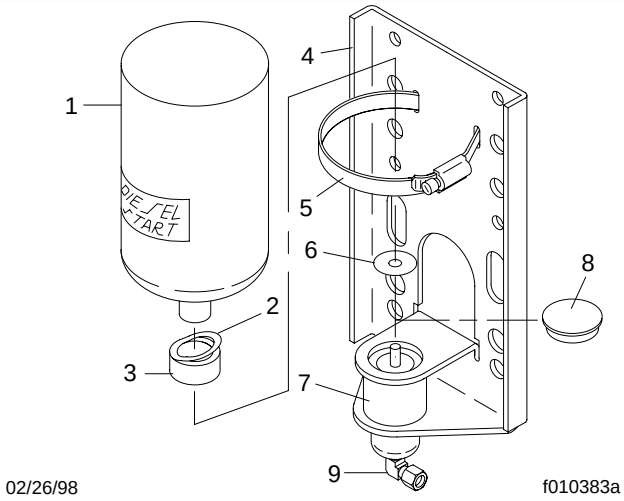
Troubleshooting

Use the following procedures to check for most common problems that may prevent starting fluid delivery.

⚠ WARNING

Service starting fluid systems only in a well-ventilated area away from sparks and open flames. The ethyl ether in these systems is flammable and toxic. Wear protective gloves and glasses, and avoid breathing ether fumes. Failure to take these precautions could result in personal injury or property damage.

EMPTY FLUID CYLINDER (See Fig. 1)



1. Starting Fluid Cylinder
2. Paper Backing
3. Dirt Eliminator Collar
4. Mounting Plate
5. Cylinder Clamp
6. Valve Gasket
7. Dieselmatic Valve
8. Valve Cap
9. Blockor Fitting

Fig. 1, KBi Ether Start System

1. Remove the old cylinder.
   - 1.1 Clean all dirt from the neck of the cylinder and the top of the Dieselmatic® valve before removing the cylinder.
   - 1.2 Loosen the cylinder clamp.
   - 1.3 Pry the dirt eliminator collar off the neck of the cylinder.
   - 1.4 Unscrew the cylinder from the Dieselmatic valve.
   - 1.5 Remove the cylinder from the mounting plate. Cover the top of the valve after the cylinder is removed.
   - 1.6 Remove the old dirt eliminator collar from the valve assembly.
2. Weigh the cylinder to see if it is empty. See **Table 1** for the weight of each cylinder size.

Cylinder Size: oz (g)	Empty Weight: oz (g)	Full Weight: oz (g)
21 (595)	16 (455)	37 (1050)
18 (510)	15 (425)	33 (935)
8 (225)	10 (285)	18 (510)

Table 1, Ether Cylinder Weights

3. Replace the Dieselmatic valve gasket. Spread the new gasket with a light film of clean oil.
4. If the cylinder is good, install it; if not, replace it.
   - 4.1 Place a new dirt eliminator collar, adhesive-side up, on the valve assembly. Peel off the collar's paper backing to expose the adhesive.
   - 4.2 Place the new cylinder into the Dieselmatic valve and hand-tighten it firmly.
   - 4.3 Slide the dirt eliminator collar up so it sticks to the cylinder.
   - 4.4 Tighten the clamp around the cylinder 680 N·cm (60 lbf·in).

CLOGGED ETHER NOZZLE

1. Disconnect the ether tubing from the nozzle, and cover the nozzle fitting. See **Fig. 2.**
2. Disconnect the black ground wire from the engine temperature sensor, and ground it.

⚠ WARNING

When testing the starting fluid system, wear protective gloves and glasses, and spray the vaporized ether into a container. Failure to do so could result in personal injury.

Troubleshooting

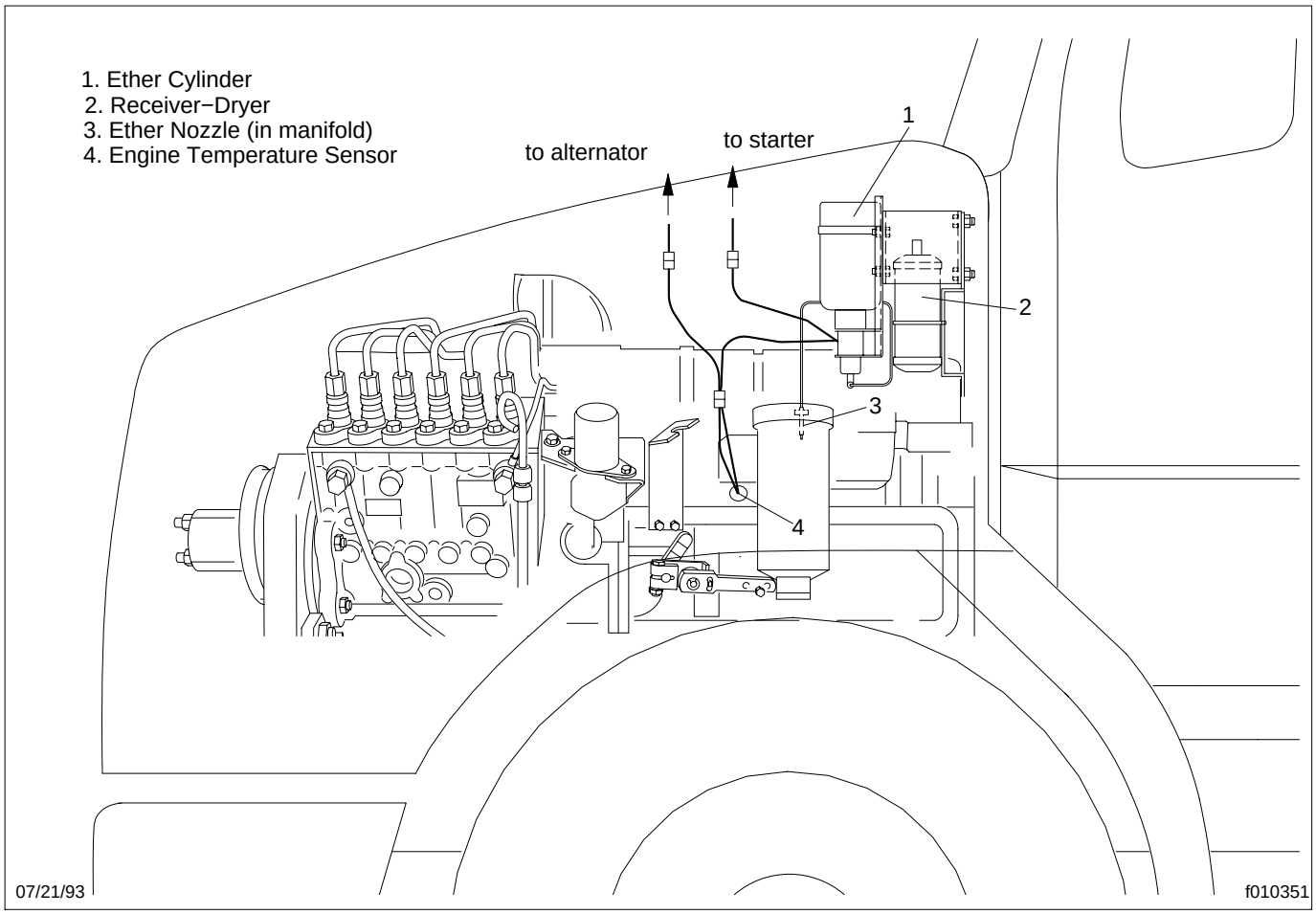


Fig. 2

3. Start the engine, and look for ether to spray from the tubing.

CAUTION

Do this test only two times. Activating the starting fluid system in this manner more than twice could result in damage to the system.

4. If no ether sprays from the tubing, disconnect the tubing at the Blockor® fitting in the base of the cylinder assembly. See **Fig. 1.**
5. Start the engine, and look for ether to spray from the Blockor fitting in the base of the cylinder assembly.

CAUTION

Do this test only two times. Activating the starting fluid system in this manner more than twice could result in damage to the system.

6. If ether sprays from the fitting, but not from the tubing, check for kinks or blockages in the ether tubing and the nozzle. Repair or replace the tubing and nozzle, as needed.

   If no ether sprays from the fitting or tubing, check the Blockor fitting for blockages. Repair or replace the fitting, as needed.

ELECTRICAL PROBLEMS

1. Check for a blown fuse, and for loose wiring connections, shorts, and broken wires.
2. Check that the black ground wire from the valve assembly is connected to the engine temperature sensor, and that the ground wire from the sensor is connected to the alternator ground terminal.
3. Check that the second wire from the valve assembly is connected to the "M" terminal of the starter.

⚠ WARNING

When testing the starting fluid system, wear protective gloves and glasses, and spray the vaporized ether into a container. Failure to do so could result in personal injury.

4. Test the valve.
   - 4.1 Remove the starting fluid cylinder.
   - 4.2 If the ambient air temperature is over 4°C (40°F), remove the black ground wire from the engine temperature sensor, and ground it.
   - 4.3 Crank the starter, and look for the valve plunger (see **Fig. 3**) to move up and stay up while the starter is cranked.

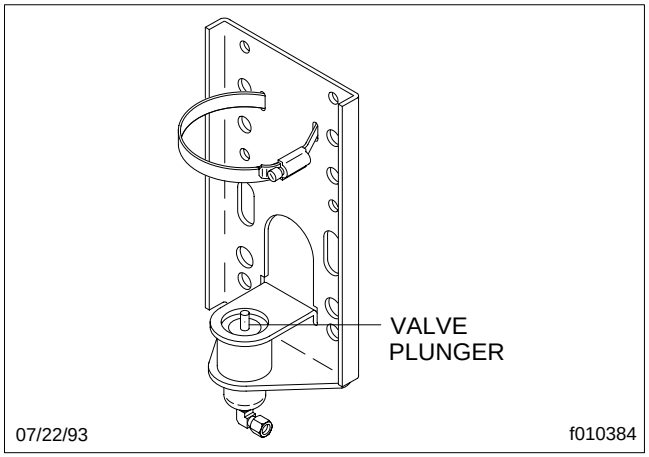


Fig. 3

⚠ CAUTION

Do this test only two times. Activating the starting fluid system in this manner more than twice could result in damage to the system.

5. If the plunger does not move, disconnect both valve assembly wires and momentarily touch the leads across battery terminals. If the valve plunger still does not move up, replace the valve.
6. If the valve operates correctly, check the engine temperature sensor.
   - 6.1 Connect the appropriate wire to the "M" terminal of the starter.
   - 6.2 Remove the sensor from the engine water jacket, and chill it to below freezing for at least ten minutes.
   - 6.3 Install the sensor, grounding it at the alternator ground terminal.
   - 6.4 Connect the black ground wire from the valve assembly to the sensor.
   - 6.5 Crank the engine, and look for the valve plunger to move up and stay up while the starter is cranked.

⚠ CAUTION

Do this test only two times. Activating the starting fluid system in this manner more than twice could result in damage to the system.

7. If the plunger does not move, replace the sensor.

Specifications

Description	Grade	Size	Torque	
			N·m (lbf·ft)	N·cm (lbf·in)
Starting Fluid Cylinder Clamp	—	—	—	680 (60)
Mounting Plate Mounting Bolts	8	5/16–18	30 (22)	—

Table 1, Fastener Torques

Cylinder Size oz (g)	Weight	
	Empty oz (g)	Full oz (g)
21 (595)	16 (455)	37 (1050)
18 (510)	15 (425)	33 (935)
8 (225)	10 (285)	18 (510)

Table 2, Starting Fluid Cylinder Weights

General Description

The Cummins C Series engine **(see Fig. 1 and Fig. 2)** is supported by three engine mounts: two mounts with a single rubber isolator apiece are at the rear of the engine— one on each side of the flywheel housing. The third mount is an underslung crossmember that supports the front of the engine with two rubber isolators.

For detailed repair procedures and other engine service not covered in this section, refer to the *Cummins C Series Operation and Maintenance Manual* , *Cummins Troubleshooting and Repair Manual C Series*, and *Cummins Workshop Manual C Series*.

General Description

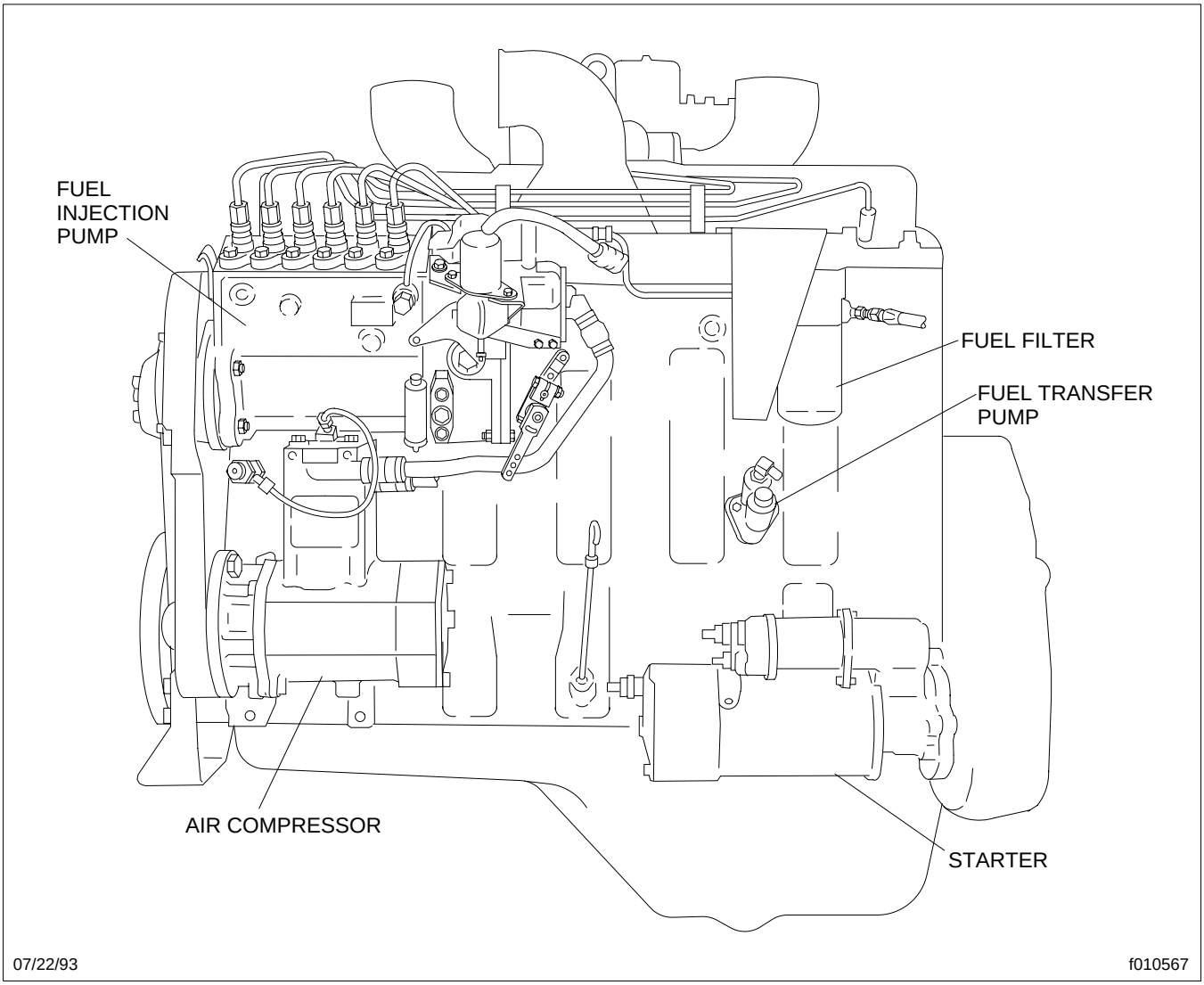


Fig. 1

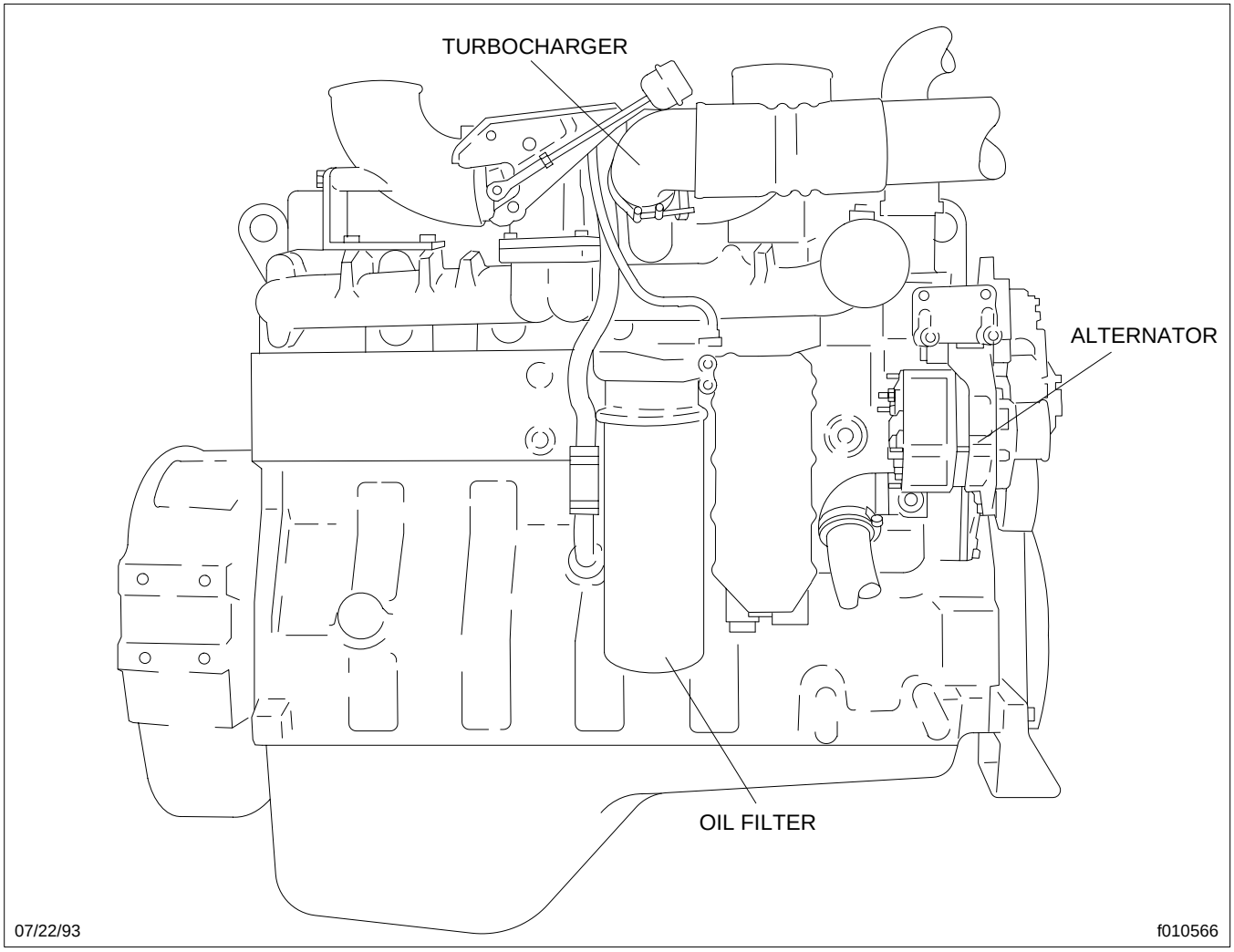


Fig. 2

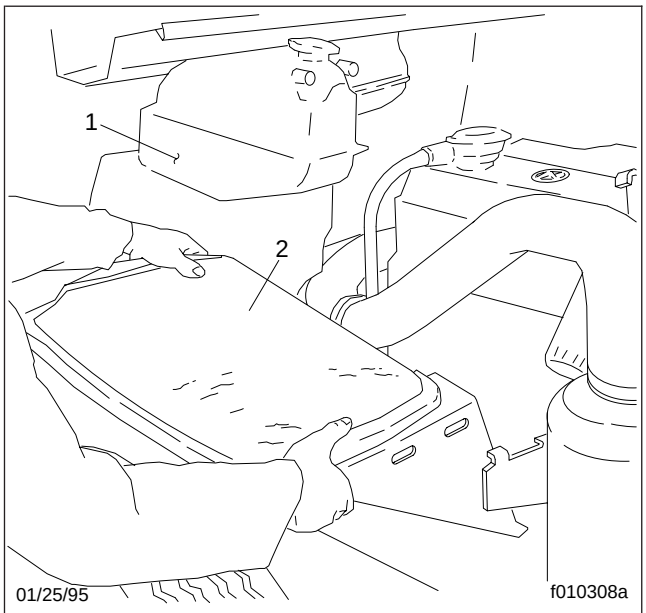
Removal

1. Apply the parking brakes, chock the tires, and (if applicable) drain the air system.
2. If the vehicle is equipped with a battery shutoff switch, turn off the switch; otherwise, disconnect the batteries.
   - 2.1 Disconnect the battery ground cable at the vehicle frame.
   - 2.2 Disconnect the positive battery cable from the batteries.
3. Remove the transmission. For instructions, see **Group 26**.
4. Remove the hood and bumper. For instructions, see **Group 88**.

⚠ WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

5. Drain the radiator.
   - 5.1 Open the petcock at the bottom of the radiator to drain the engine coolant.
   - 5.2 Loosen the surge tank cap.
6. Remove the right fender splash shield. See **Fig. 1**.
7. Remove the air cleaner. See **Fig. 2**.
   - 7.1 Remove the air intake ducting from the top of the air cleaner.
   - 7.2 Remove the four nuts (**Fig. 3**) from the inside of the air cleaner mounting bracket.
   - 7.3 Remove the air cleaner from the mounting bracket.
8. Disconnect or remove the air intake and exhaust ducting, and the air hoses.
   - 8.1 Disconnect the air restriction indicator hose (**Fig. 2**), and remove the air intake ducting between the air cleaner and the front of the turbocharger.

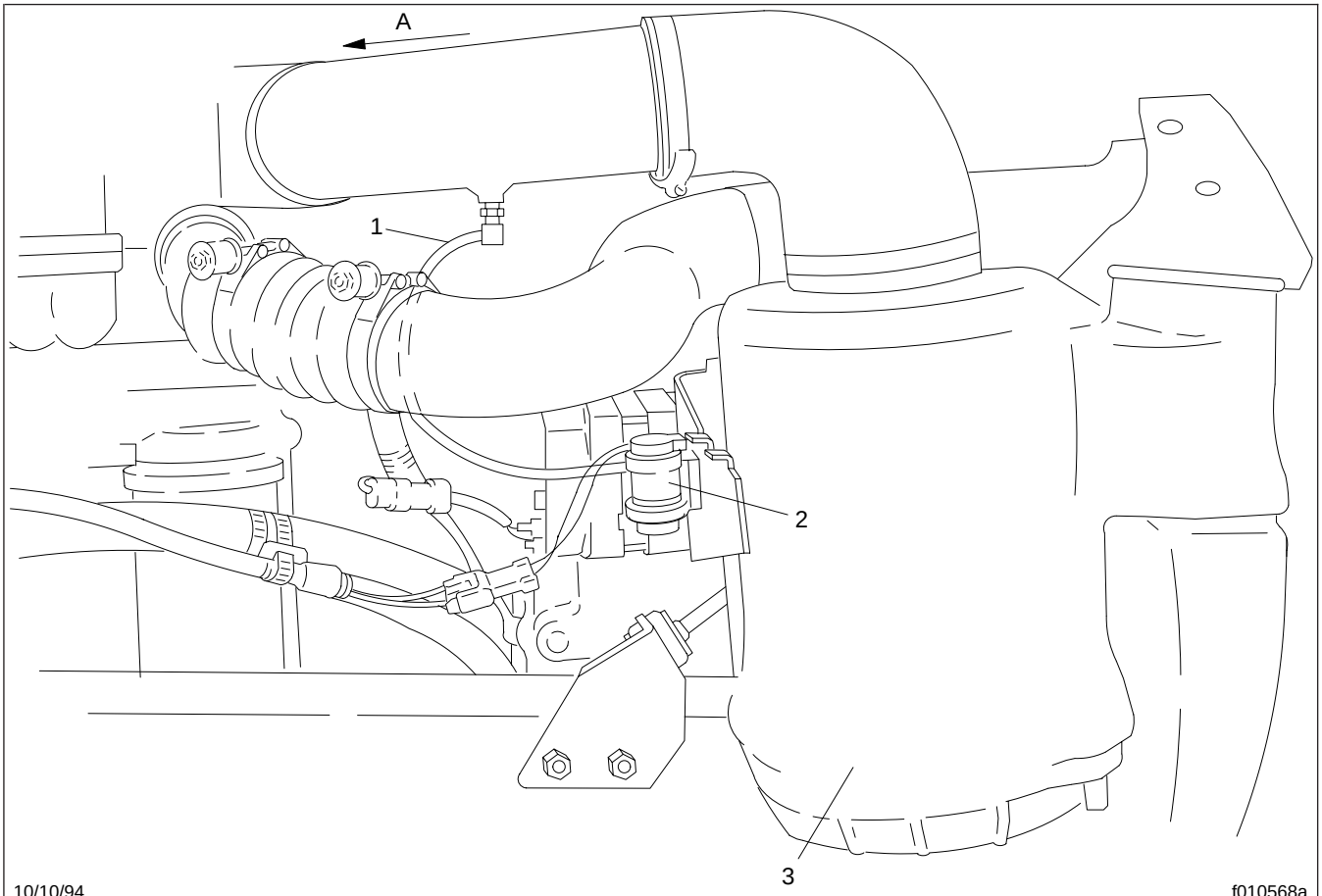


1. Surge Tank
2. Splash Shield

Fig. 1, Right Fender Splash Shield

   - 8.2 Loosen the V-band clamp (**Fig. 4**) that holds the forward end of the exhaust pipe to the rear of the turbocharger.
   - 8.3 Loosen the wide-band clamp that holds the rear end of the exhaust pipe to the flex pipe.
   - 8.4 Remove the exhaust pipe from the vehicle.
   - 8.5 Remove the air ducting between the turbocharger and the charge air cooler.
   - 8.6 Disconnect the air outlet hose from the charge air cooler.
   - 8.7 If the vehicle is equipped with air brakes, disconnect the air compressor outlet line (**Fig. 5**), and the two air signal lines (**Fig. 5**) at the air compressor and the air governor.
9. Disconnect the coolant hoses.
   - 9.1 Disconnect the coolant inlet and outlet hoses from the radiator.
   - 9.2 Disconnect the vent hoses (**Fig. 6**) from the radiator and the engine block.

Removal and Installation



A. To turbocharger.
1. Air Restriction Indicator Hose
2. Air Restriction Indicator
3. Air Cleaner

Fig. 2, Air Cleaner Removal

9.3 Disconnect the fill hose (**Fig. 7**) from the engine coolant inlet hose.

9.4 Disconnect the heater outlet hose (**Fig. 7**) from the engine coolant inlet hose.

9.5 Disconnect the heater inlet hose (**Fig. 8**) from the engine block.

10. Remove the refrigerant compressor and condenser.

10.1 Disconnect the compressor electrical connector.

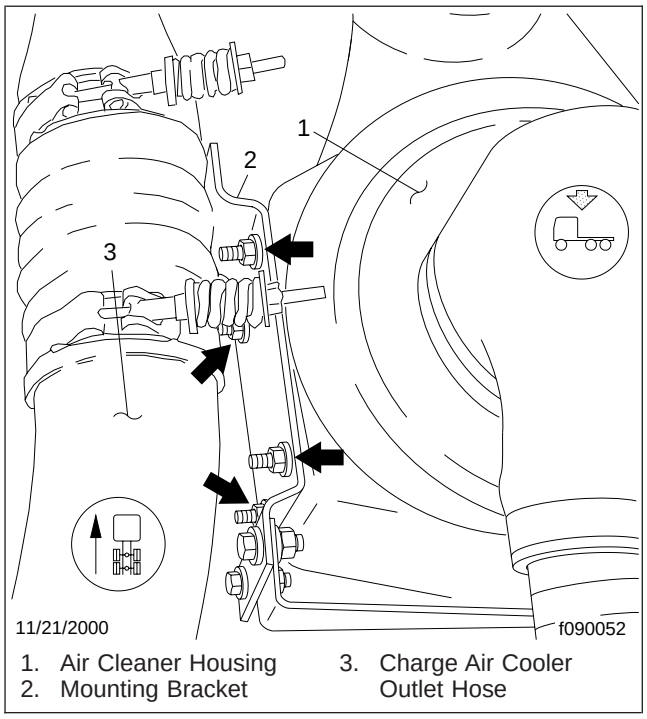
10.2 Remove the six bolts that hold the compressor in the compressor mounting bracket.

10.3 Lower the compressor and remove the belt from the refrigerant compressor pulley.

NOTE: If replacing the engine, remove the four capscrews that hold the compressor mounting bracket to the engine, and remove the bracket for installation on the new engine.

10.4 Remove the air recirculation shield (**Fig. 9**) from the left side of the charge air cooler and radiator.

10.5 Disconnect the refrigerant lines from the stand-off bracket above the power steering fluid reservoir.



1. Air Cleaner Housing
2. Mounting Bracket
3. Charge Air Cooler Outlet Hose

Fig. 3, Air Cleaner Housing Mounting Fasteners

10.6 Remove the four bolts (**Fig. 9**) that hold the condenser on the charge air cooler.

10.7 To keep the refrigerant system intact, with no leaks and no need for purging and recharging, move the refrigerant compressor and condenser to the side at the same time.

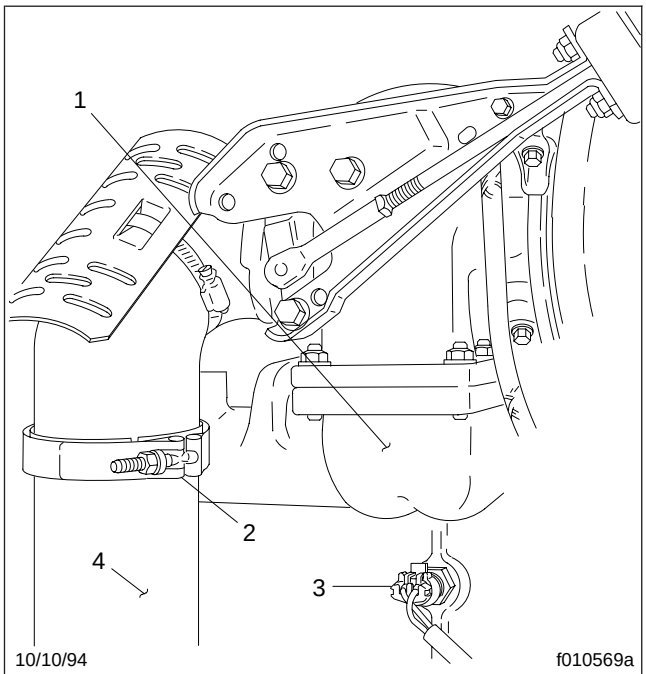
10.8 Wrap the condenser in a protective blanket, or sandwich it between two sheets of cardboard or wood to prevent damage to the condenser fins. Secure the compressor and condenser out of the way with wire.

11. Remove the radiator and charge air cooler assembly.

11.1 Hook a lifting chain to the radiator and charge air cooler assembly, and fasten the chain to a crane.

11.2 Remove the nuts, washers, and rubber isolators from the forward ends of the radiator struts. See **Fig. 10**.

11.3 Remove the nuts and washers from the radiator mounts. See **Fig. 10**.



1. Turbocharger
2. V-Band Clamp
3. Coolant Temperature Sensor
4. Exhaust Pipe

Fig. 4, V-Band Clamp Location

11.4 Lift the radiator and charge air cooler from the vehicle as a single unit. See **Fig. 11**.

12. Remove the two bolts that hold the power steering pump to the rear of the air compressor, and move the pump aside while keeping the steering fluid system intact.

13. Disconnect the engine fuel and oil system components.

13.1 Disconnect the fuel delivery line at the fuel transfer pump, below the fuel filter. See **Fig. 12**.

13.2 Disconnect the throttle cable from the throttle lever, and compress the push-snap fitting to remove the cable from the cable bracket. See **Fig. 5**.

13.3 Disconnect the fuel return line (**Fig. 5**) from the injection pump.

13.4 Disconnect the oil pressure gauge line from the fitting below the fuel filter.

Removal and Installation

14. Disconnect the engine electrical connections.

    14.1 Disconnect the engine ground strap from the starter.

    14.2 Disconnect the wires from the starter, and label them for reassembly.

    14.3 Disconnect the harness wiring connector at the coolant temperature sensor behind the oil filter. See **Fig. 4**.

    14.4 Disconnect the harness wiring connector at the coolant temperature sensor (**Fig. 13**) behind the alternator.

    14.5 Disconnect the harness from the alternator, and label the alternator connections for reassembly.

    14.6 Disconnect the harness wiring connector at the engine shutdown solenoid. See **Fig. 5**.

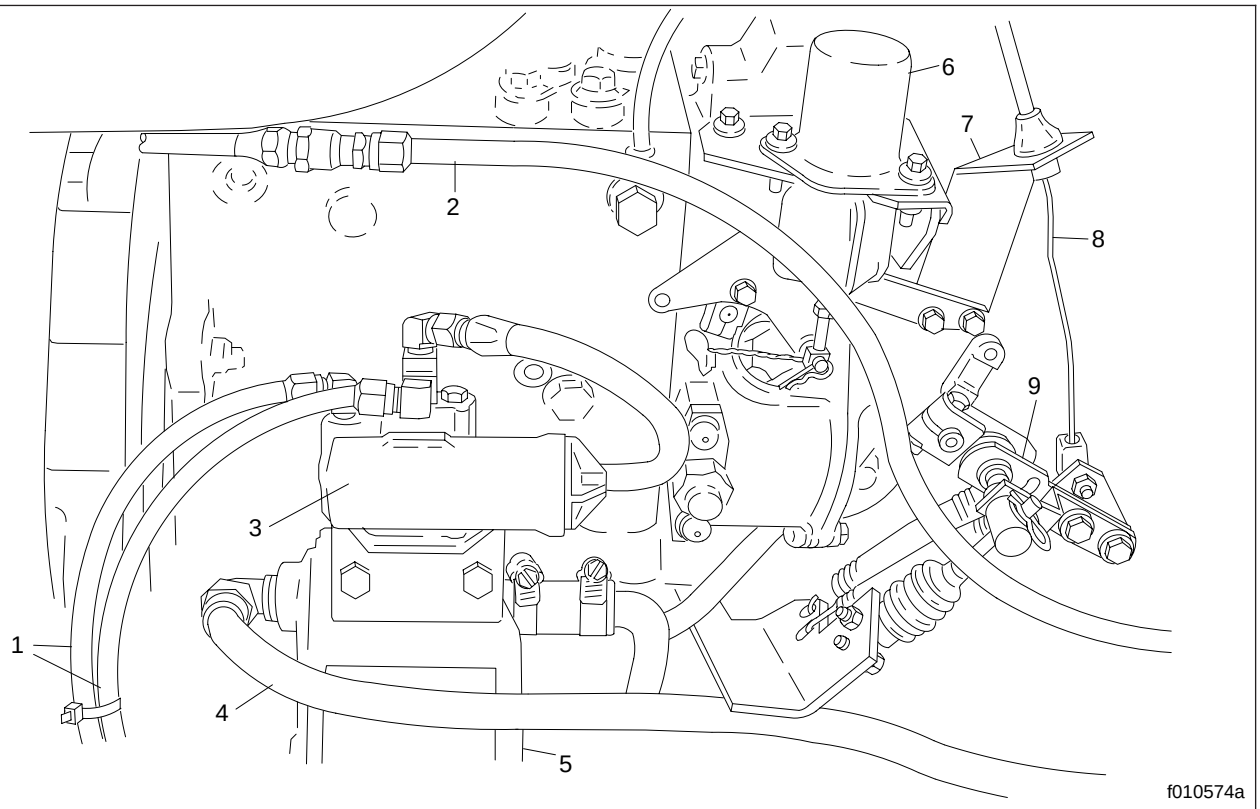
    14.7 Disconnect the wiring connector for the tachometer sensor, at the upper left side of the engine flywheel housing.

    14.8 Disconnect the engine wiring harness from any additional options, and label the wiring connectors for reassembly.

    14.9 Disconnect the harness from the stand-off bracket on the rear of the engine intake manifold.

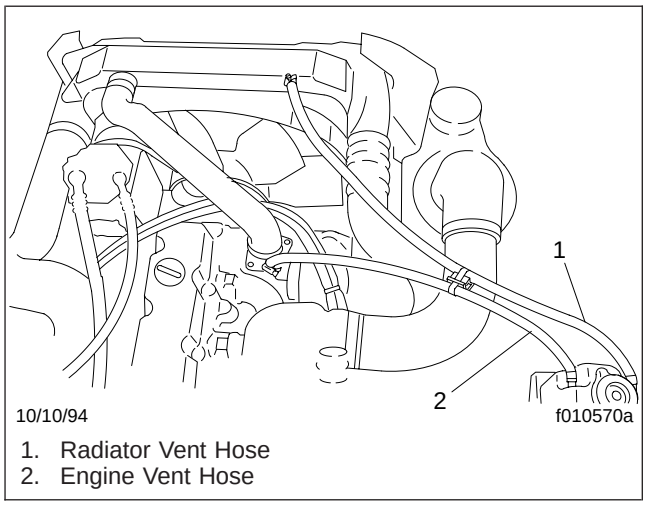
    14.10 Pull the harness off to the left side of the engine where it will be out of the way.

15. Remove the engine from the vehicle.



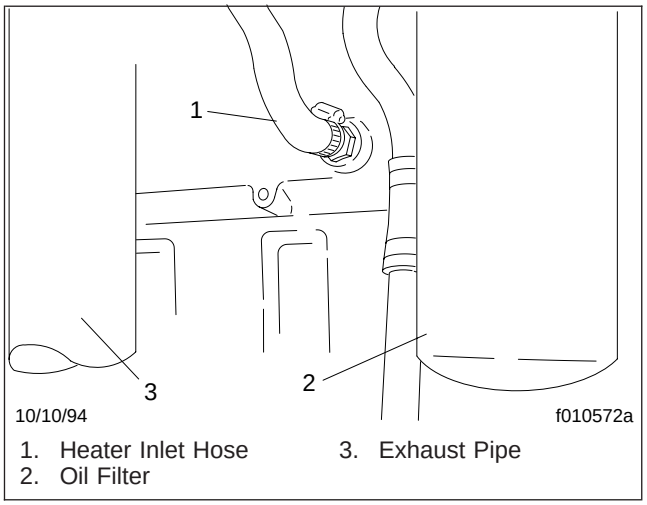
1. Signal Lines
2. Fuel Return Line
3. Air Governor
4. Air Compressor Outlet Line
5. Air Compressor
6. Engine Shutdown Solenoid
7. Throttle Cable Bracket
8. Throttle Cable
9. Throttle Lever

Fig. 5, Throttle Cable Location



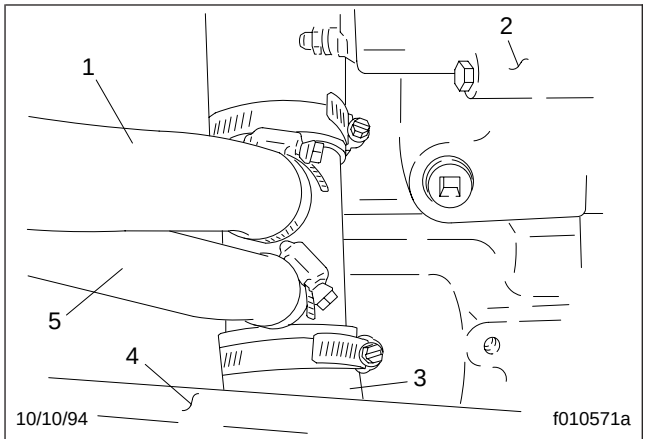
1. Radiator Vent Hose
2. Engine Vent Hose

Fig. 6, Engine and Radiator Vent Hoses



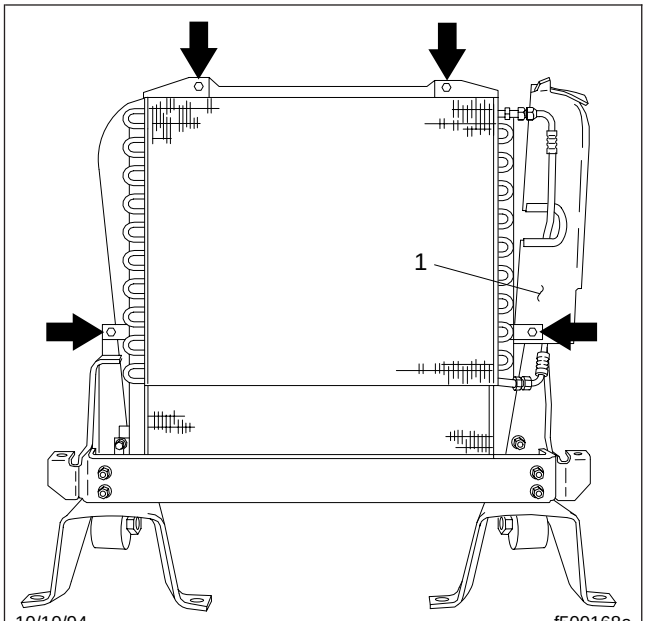
1. Heater Inlet Hose
2. Oil Filter
3. Exhaust Pipe

Fig. 8, Heater Inlet Hose Location



1. Fill Hose
2. Alternator
3. Engine Coolant Inlet Hose
4. Frame Rail
5. Heater Outlet Hose

Fig. 7, Coolant Hoses



1. Air Recirculation Shield

Fig. 9, Air Conditioning Condenser Bolts

⚠ WARNING

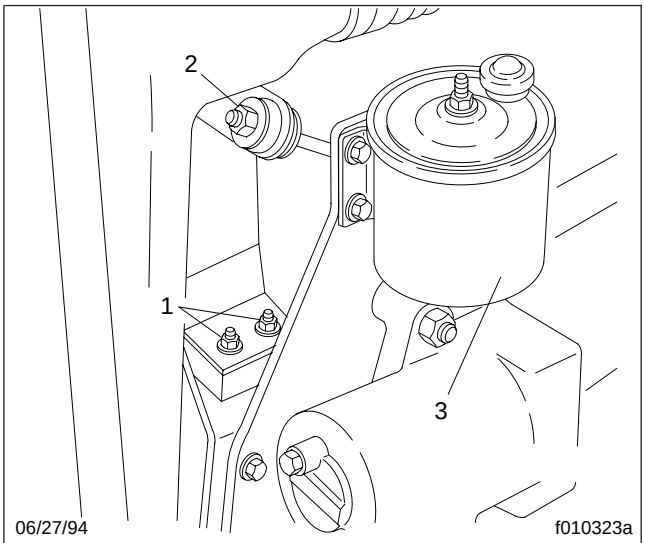
The crane and lifting chains used to remove the engine must be capable of safely lifting and supporting two metric tons. Once the engine mounts are disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

15.1 Securely attach a lifting chain to the engine. Attach the chain to a crane, and raise the chain to remove any slack.

15.2 Remove the two bolts from the front engine mount isolators.

15.3 Remove the bolt from each of the two rear engine mount isolators.

Removal and Installation



1. Left Radiator Mount Nuts
2. Left Radiator Strut Nuts
3. Power Steering Fluid Reservoir

Fig. 10, Radiator Strut and Mount Fasteners

15.4 Carefully lift the engine, and pull it forward to remove it from the engine compartment.

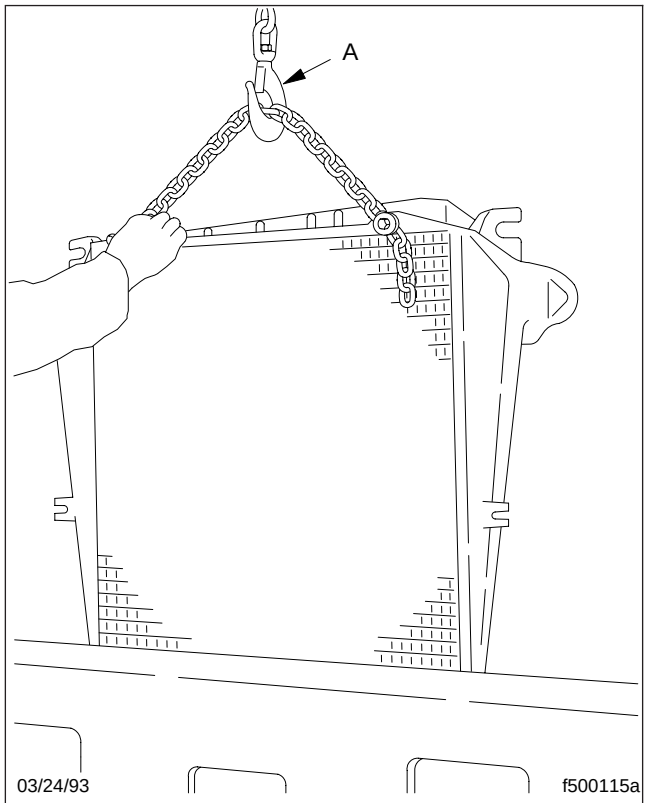
Installation

1. Examine all engine support components for damage and extreme wear. Replace components as necessary.
2. Install the engine in the vehicle.

⚠ WARNING

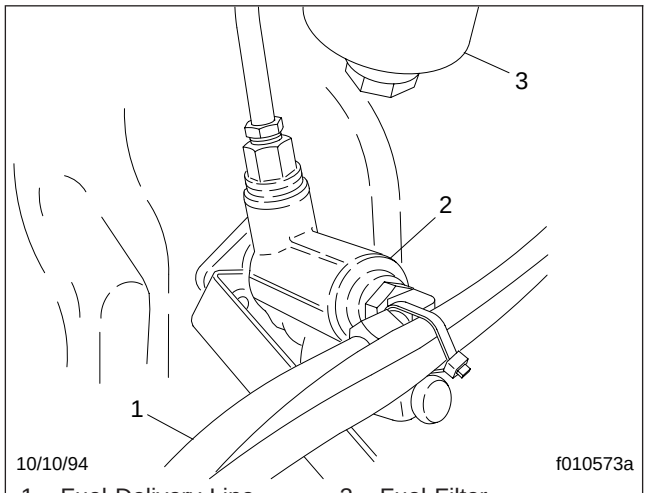
The crane and lifting chains used to install the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely installed on the engine mounts. An unsecured engine may fall, causing personal injury or death, and component damage.

2.1 Securely attach a lifting chain to the engine. Attach the chain to a crane, and raise the chain to remove any slack.



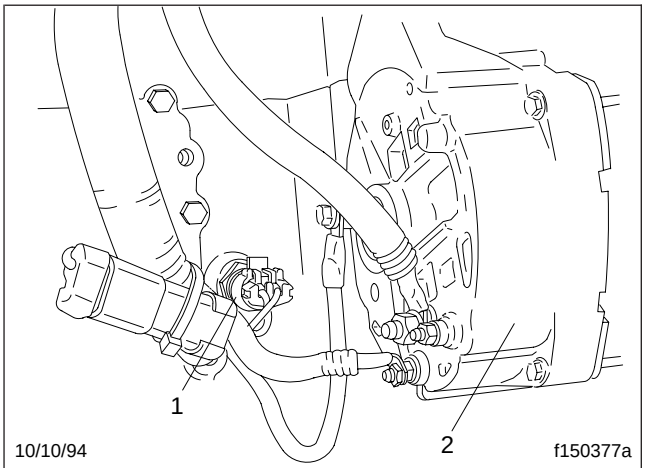
A. Use a crane to lift the radiator and charge air cooler.

Fig. 11, Lifting the Radiator and Charge Air Cooler



1. Fuel Delivery Line
2. Fuel Transfer Pump
3. Fuel Filter

Fig. 12, Fuel Lines



1. Coolant Temperature Sensor
2. Alternator

Fig. 13, Alternator Harness

2.2 Lift the engine from the engine stands, and carefully lower the engine onto the engine mounts.

2.3 Install the bolts in the two rear engine mounts, and tighten them 241 lbf·ft (327 N·m).

2.4 Install the two bolts in the front engine mount, and tighten them 150 lbf·ft (203 N·m).

2.5 Remove the lifting chain from the engine.

3. Connect the engine electrical connections.

3.1 Route the engine wiring harness across the engine from the left side and connect the harness connector to the coolant temperature sensor behind the oil filter. See **Fig. 4**.

3.2 Connect the harness connector to the coolant temperature sensor behind the alternator. See **Fig. 13**.

3.3 Connect the harness to the alternator. If the alternator wires are not labeled for reassembly, see **Group 15** for alternator wiring instructions.

3.4 Connect the harness wiring connector to the engine shutdown solenoid. See **Fig. 5**.

3.5 Connect the wiring connector to the tachometer sensor, on the left side of the engine flywheel housing.

3.6 Connect the engine wiring harness to any additional options.

3.7 Connect the harness to the wiring stand-off bracket on the rear of the engine intake manifold.

3.8 Connect the wires to the starter. If the wires are not labeled for reassembly, see **Group 15** for starter wiring instructions.

3.9 Connect the engine ground strap to the starter.

4. Connect the engine fuel and oil system components.

4.1 Connect the oil pressure gauge line to the fitting below the fuel filter.

4.2 Connect the fuel return line to the injection pump. See **Fig. 5**.

4.3 Thread the throttle cable down through the throttle cable bracket, and connect the cable to the throttle lever. Compress the push-snap fitting to install the cable in the cable bracket. See **Fig. 5**.

4.4 Connect the fuel delivery line at the fuel transfer pump, below the fuel filter. See **Fig. 12**.

5. Install the power steering pump on the rear of the air compressor, and tighten the two mounting bolts 28 lbf·ft (38 N·m).

6. Install the radiator and charge air cooler assembly.

6.1 Hook a lifting chain to the radiator and charge air cooler assembly, and fasten the chain to a crane.

6.2 Lift the assembly, and carefully lower it into place on the radiator mounts. Install the nuts and washers on the radiator mounting studs. See **Fig. 10**. Tighten the nuts 30 lbf·ft (40 N·m).

6.3 Install the washers, rubber isolators, and nuts on the radiator struts. See **Fig. 10**. Tighten the nuts 35 lbf·ft (47 N·m).

Removal and Installation

6.4 Remove the lifting chain from the assembly.

7. Install the refrigerant compressor and condenser.
   - 7.1 If it was removed, install the refrigerant compressor mounting bracket, and tighten the four capscrews 27 lbf·ft (37 N·m).
   - 7.2 Carefully move the refrigerant compressor and condenser back into place.
   - 7.3 Install the four bolts that hold the condenser to the charge air cooler. See **Fig. 9**. The lower, left bolt also holds the lower end of the left air recirculation shield. Tighten the bolts 15 lbf·ft (20 N·m).
   - 7.4 Install the bolt that holds the top of the air recirculation shield, and tighten the bolt 15 lbf·ft (20 N·m).
   - 7.5 Install the refrigerant compressor on the compressor mounting bracket. Install the belt on the compressor, and lift the compressor in its bracket to tension the belt 100 lb (45 kg). Tighten the six compressor mounting capscrews 28 lbf·ft (38 N·m).
   - 7.6 Connect the compressor electrical connector.
   - 7.7 Connect the refrigerant hoses to the stand-off bracket above the power steering fluid reservoir.
8. Connect the coolant hoses.
   - 8.1 Connect the heater inlet hose to the engine block. See **Fig. 8**.
   - 8.2 Connect the heater outlet hose to the engine coolant inlet hose. See **Fig. 7**.
   - 8.3 Connect the fill hose to the engine coolant inlet hose. See **Fig. 7**.
   - 8.4 Connect the vent hoses to the radiator and the engine block. See **Fig. 6**.
   - 8.5 Connect the coolant inlet and outlet hoses to the radiator.
9. Connect or install the air intake and exhaust ducting, air hoses, and air cleaner.
   - 9.1 Connect the air outlet hose to the charge air cooler. Tighten the charge air cooler hose clamp 60 lbf·in (680 N·cm).
   - 9.2 Install the air ducting between the turbocharger and the charge air cooler, and tighten the charge air cooler hose clamp 60 lbf·in (680 N·cm).
   - 9.3 If the vehicle is equipped with air brakes, connect the air compressor outlet line and the two air signal lines to the air compressor and the air governor. See **Fig. 5**.
   - 9.4 Connect the rear of the exhaust pipe to the flex pipe, and connect the forward end of the exhaust pipe to the rear of the turbocharger. See **Fig. 4**.
   - 9.5 Tighten the wide band clamp that holds the exhaust pipe to the flex pipe.
   - 9.6 Tighten the V-band clamp that holds the exhaust pipe to the turbocharger 85 lbf·in (940 N·cm). Tap the V-band clamp all the way around with a rubber hammer, and tighten the clamp again.
   - 9.7 Position the air cleaner on its bracket, and secure the cleaner with four nuts. See **Fig. 3**. Tighten the nuts 28 lbf·ft (38 N·m).
   - 9.8 Install the air intake ducting between the front of the turbocharger and the air cleaner.
   - 9.9 Connect the air restriction indicator hose to the air intake ducting. See **Fig. 2**.
10. Install the right fender splash shield. See **Fig. 1**.
11. Install the bumper and hood. For instructions, see **Group 88**.
12. If the vehicle is equipped with a battery shutoff switch, turn on the switch; otherwise, connect the batteries.
    - 12.1 Connect the positive battery cable to the batteries.
    - 12.2 Connect the battery ground cable to the vehicle frame.
13. Fill the engine coolant system.
    - 13.1 Close the petcock on the bottom of the radiator.
    - 13.2 Fill the system with coolant at the surge tank. For coolant specifications, see the vehicle maintenance manual.

13.3 Install and tighten the surge tank cap.

14. Start the engine and check for leaks.
15. After the engine has run for about 20 minutes, check the coolant level and add coolant if needed. If a new refrigerant compressor belt was installed, check the belt tension. All new belts will lose tension after 20 minutes of operation. If necessary, tighten the belt 45 kg (100 lb).
16. Fill and bleed the power steering system as needed. For instructions, see **Group 46**.
17. Lower the hood, and remove the chocks from the tires.

Fastener Torque

Description	Grade	Size	Torque	
			N·m (lbf·ft)	N·cm (lbf·in)
Rear Engine Mount Bolt	8	3/4 inch	327 (241)	—
Front Engine Mount Bolts	8	5/8 inch	203 (150)	—
Exhaust (Header) Pipe V-Band Clamp	—	—	81 (71)	—
Radiator Strut Nuts	2	1/2–13	47 (35)	—
Radiator Mount Nuts	5	3/8–16	40 (30)	—
Air Recirculation Shield Top Bolt	5	5/16 inch	20 (15)	—
Refrigerant Compressor Bracket Mounting Capscrews	8	3/8–16	37 (27)	—
Refrigerant Compressor Mounting Capscrews	8.8	10 mm	38 (28)	—
Condenser Mounting Bolts	5	5/16 inch	20 (15)	—
Aftercooler Hose Clamps	5	6.3 mm	—	680 (60)
Air Cleaner Mounting Nuts	5	3/8–16	38 (28)	—
Power Steering Pump Mounting Bolts	8.8	25 mm	38 (28)	—

Table 1, Fastener Torque

General Description and Principles of Operation

(See Fig. 1 and Fig. 2)

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

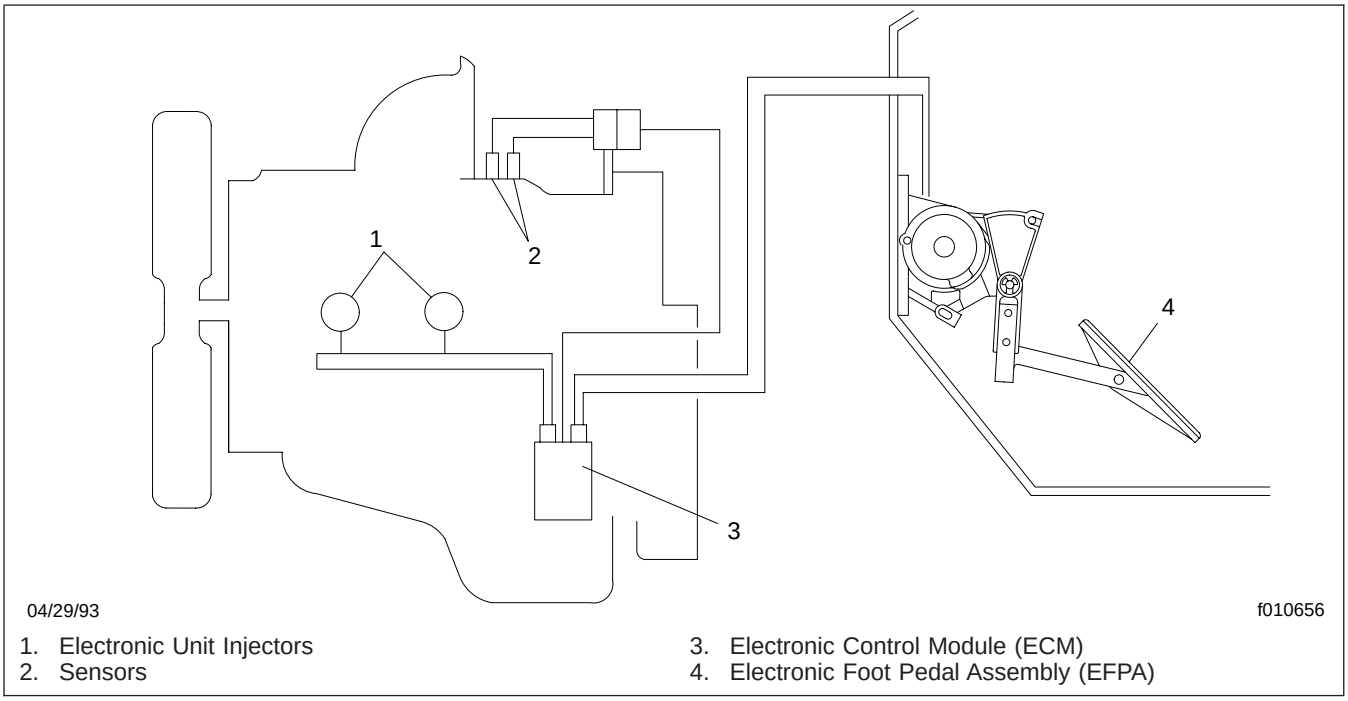
The driver controls the system by using the electronic foot pedal assembly (EFPA), which operates like a standard, mechanical accelerator pedal.

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

ELECTRONIC CONTROL MODULE (ECM)

The electronic control module **(Fig. 3)** is the center of the system. It is a microprocessor that controls and monitors the system, sending commands to the various engine components, and receiving data from them. The ECM contains an electrically eraseable, programmable read-only memory (EEPROM), which is encoded with engine performance data such as rated horsepower, torque curve, maximum engine speed, and optional protection features.

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

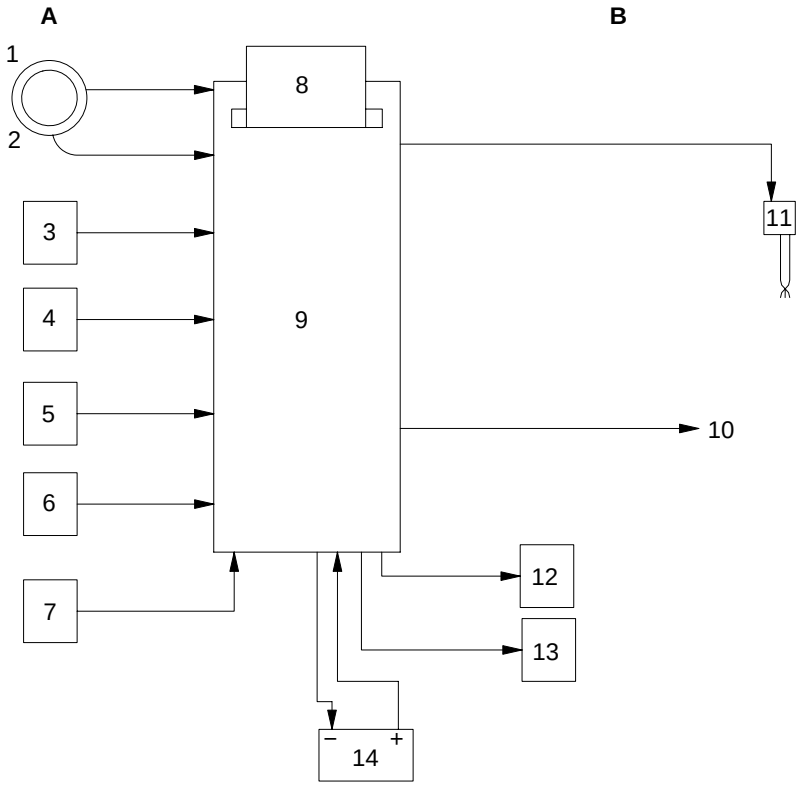


1. Electronic Unit Injectors
2. Sensors
3. Electronic Control Module (ECM)
4. Electronic Foot Pedal Assembly (EFPA)

Fig. 1, DDEC Components

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

General Description and Principles of Operation



08/13/93 f010123a

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

Fig. 2, ECM Diagram

ELECTRONIC FOOT PEDAL ASSEMBLY

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

ELECTRONIC UNIT INJECTORS

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

SYNCHRONOUS REFERENCE SENSOR

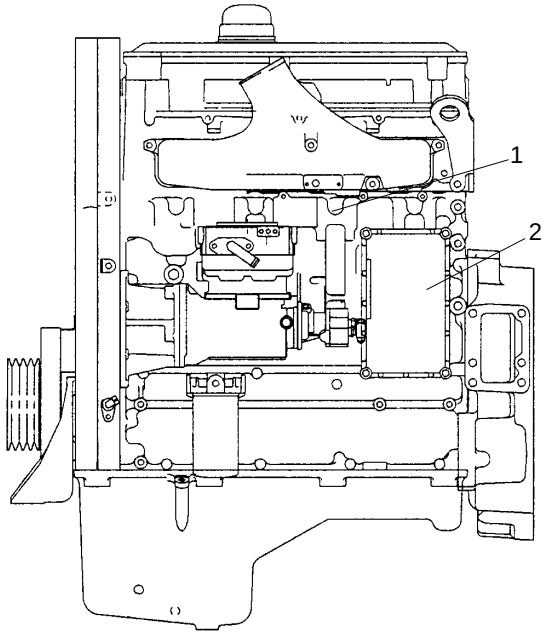
The synchronous reference sensor, located at the rear of the engine gear case, senses when the number one piston reaches about 45 degrees before top-dead-center (BTDC). This information is sent to the ECM, which uses it to determine engine speed.

TIMING REFERENCE SENSOR

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

TURBO BOOST PRESSURE SENSOR (TBS)

The turbo boost pressure sensor **(Fig. 3)** , located on the intake manifold, monitors the amount of air entering the engine, and transmits this information to the ECM. The ECM uses this information to regulate the fuel supply in order to control engine smoke.



08/13/93 f010655

1. Turbo-Boost Pressure Sensor
2. ECM

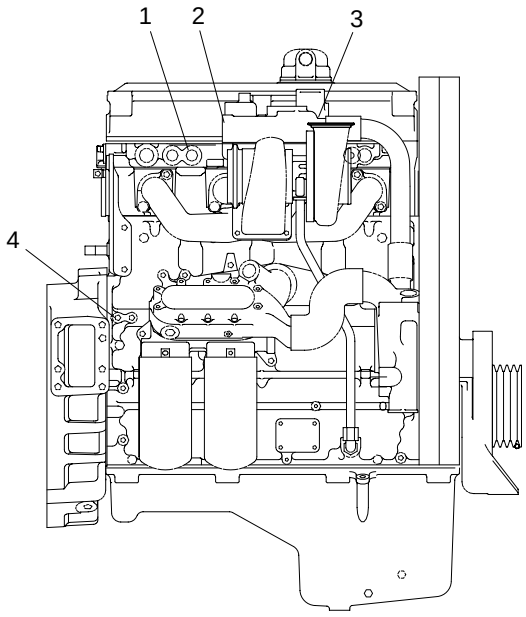
Fig. 3

OIL PRESSURE SENSOR

The oil pressure sensor (**Fig. 4**), which is connected to the main oil gallery, sends continuous electrical signals to the ECM, telling what the oil pressure is at any given speed. If a low oil pressure signal is detected by the ECM for more than seven seconds, the ECM signals the dash warning light ("Engine Down"), and if the system is so equipped, begins to shut down the engine.

OIL TEMPERATURE SENSOR

The oil temperature sensor monitors the temperature of the engine oil, and relays this information to the



01/22/96 f010658

1. Coolant Temperature Light Switch Port
2. Coolant Temperature Gauge Port
3. Fan Control Switch Port
4. Oil Pressure Gauge Port

Fig. 4

ECM. The ECM changes the engine speed according to this information, improving cold weather starts and providing faster warm-ups. If the oil temperature is too high for more than two seconds, the "Engine Down" dash light will come on, and if the vehicle is equipped with engine shutdown options, the engine will shut down.

COOLANT LEVEL SENSOR (CLS)

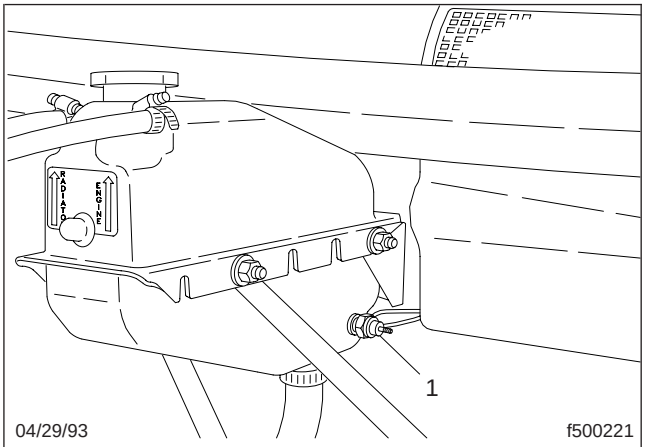
The coolant level sensor, which is located on the surge tank **(see Fig. 5)** , monitors the level and temperature of the coolant in the surge tank, and relays this information to the ECM. If the coolant level is too low, the ECM will turn

on the dash "Engine Down" light, and if the vehicle is equipped with an engine shutdown option, the engine will shut down.

DASH LIGHTS AND CONTROLS

There are two standard dash lights, the amber "Eng Chk" light and the red "Engine Down" light. Both are

General Description and Principles of Operation



1. Coolant Level Sensor

Fig. 5

located on the dashboard lightbar **(see Fig. 6)** , and both light up when the ignition is turned on. If the DDEC II system and the engine are functioning normally, both lights will go out after three to eight seconds.

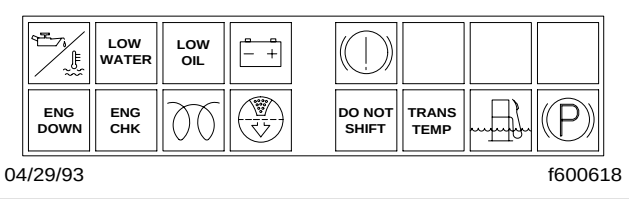
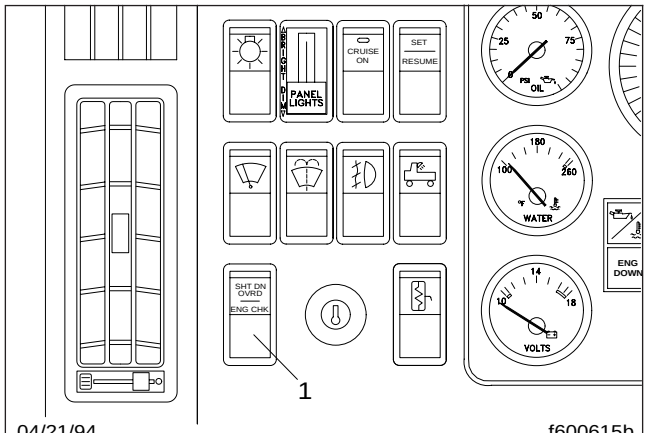


Fig. 6

If the vehicle is equipped with cruise control, the cruise control system is connected to the main DDEC II system; it doesn't operate as a separate system. **See Fig. 7** for the location of the cruise control switches on the dash.

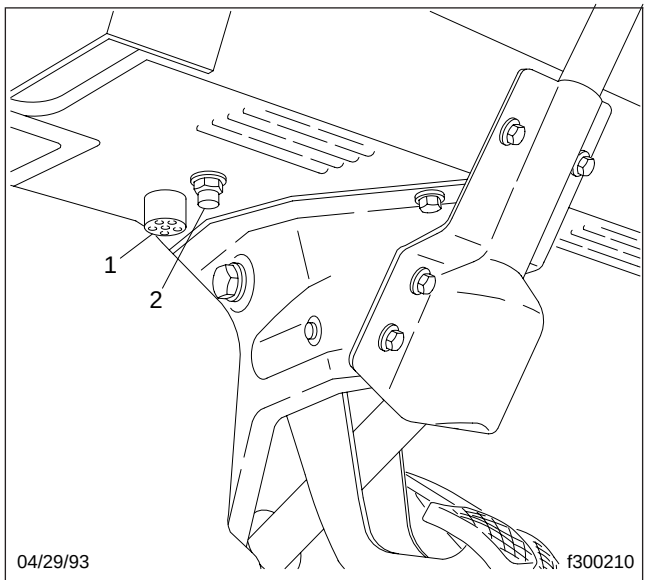
The "Eng Chk" button **(Fig. 8)** , on the bottom side of the lower left dash panel, is used to read the diagnostic codes from the "Eng Chk" light.

On vehicles with the engine shutdown option, an "Override" button allows the driver to get the vehicle off the road if the engine begins to shut down. It is on the left-side dash panel **(see Fig. 7)** .



1. Cruise Control Switch
2. Cruise Control Set/Resume Switch
3. Engine Shutdown Override Switch

Fig. 7



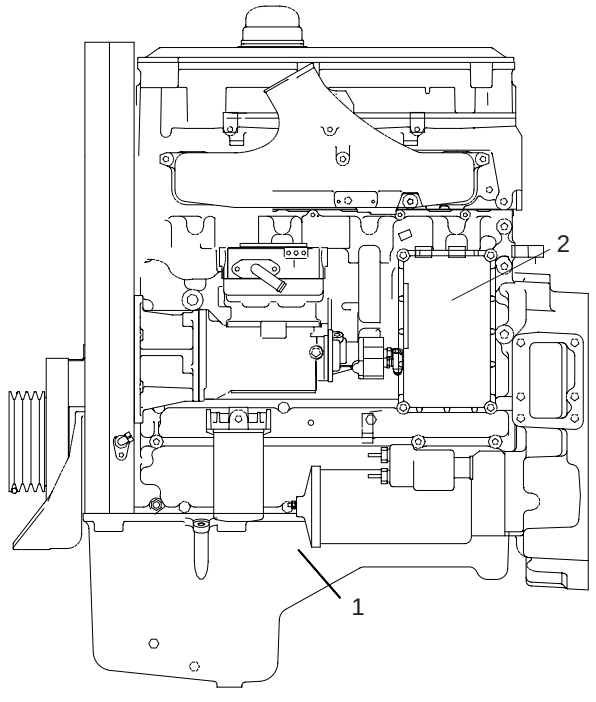
1. 6-Pin DDL Connector
2. Engine Check Button

Fig. 8

General Description

This is a general description of, first, the standard features of the Detroit Diesel Electronic Control System (DDEC III) as installed on Freightliner vehicles, and second, the components that make up DDEC III. This section has a brief description of different ways to troubleshoot the DDEC III, but doesn't have the actual troubleshooting procedures. For troubleshooting procedures and specifications, refer to the *Detroit Diesel DDEC III Troubleshooting Guide*.

To tell if an engine is equipped with DDEC II or DDEC III, find the Electronic Control Module (ECM) on the left side of the engine. **See Fig. 1.** A DDEC II Electronic Control Module has two 30-pin connectors, two 5-pin connectors, and a 6-pin connector, and all five connectors plug into *one* end of the ECM.



01/22/96 f010655a

1. Detroit Diesel Series 50 Engine
2. Electronic Control Module (ECM)

Fig. 1, Electronic Control Module Location

A DDEC III ECM has wiring harnesses plugged into *two* ends: The Detroit Diesel wiring harnesses (one 30-pin connector and two smaller connectors) plug into one end of the ECM; the Freightliner wiring harnesses (one 30-pin connector, plus a 5-pin and a 6-pin connector) plug into the opposite end of the ECM. A short, pigtail harness branches off the harness coming from the 30-pin connector on the Detroit Diesel side of the ECM. This pigtail harness wraps around the ECM and ends in a 3-pin connector near the Freightliner side. The pigtail harness connects with the Freightliner electrical engine harness.

FEATURES

The Detroit Diesel Electronic Control System (DDEC III) controls and monitors Detroit Diesel Series 50 engines installed in Freightliner vehicles. DDEC III, first offered with Detroit Diesel 1994 engines, can protect the engines from serious damage caused by:

- High Coolant Temperature
- High Oil Temperature
- Low Coolant Level
- Low Oil Pressure

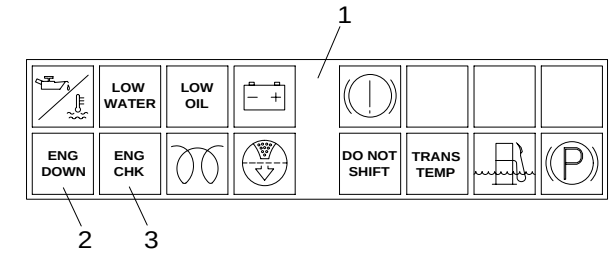
If coolant or oil temperatures rise too high, or if coolant level or oil pressure drop too low, dash warning lights will light and a buzzer will sound. If this engine condition continues, the standard DDEC III system is programmed to shut down the engine.

The brain of the DDEC III system is an electronic control module (ECM). The ECM receives information from the engine sensors provided on the engine by Detroit Diesel, and information from the electronic throttle pedal, vehicle speed sensor, and coolant level sensor provided by Freightliner. Comparing this information with the calibration tables in its memory, the ECM controls the fuel timing and quantity of fuel that the electronic unit (fuel) injectors deliver to the engine. This control improves fuel economy and lowers exhaust emissions.

The DDEC III system also provides limiting and variable speed governing. The Limiting Speed Governor fuels the engine according to the driver's use of the throttle. An optional Variable Speed Governor will hold the engine at a constant requested speed (within engine capabilities) regardless of load changes such as hills or winds. The Variable Speed Governor is usually used to provide steady, even power to a PTO (controlled with the cruise control switches while the vehicle is parked), and it will hold the engine speed constant without increased use of the hand throttle or throttle pedal.

General Description

While controlling fuel delivery to the unit injectors, the ECM also monitors sensor reports about oil temperature, fuel temperature, etc. If any of the sensors report a problem, the ECM activates first the "Engine Check" light and then the "Engine Down" light in the warning and indicator light module. **See Fig. 2.** The Engine Check light will come on if the problem is minor enough that it can be solved as soon as convenient. If the problem resolves itself, for example, if the coolant temperature drops back down into the acceptable range, the Engine Check light will go out. However, if the problem gets worse: For example, if the coolant or oil temperature continues to rise, the ECM will reduce engine power by cutting the fuel to the injectors. As the problem gets worse, the ECM will continue to cut fuel until engine power is reduced by 30 percent. At that point, (if the engine is programmed with the shutdown option) the ECM will turn on the Engine Down light. Thirty seconds after that, the ECM will shut down the engine by not delivering any fuel to the injectors.



02/10/94 f600618a

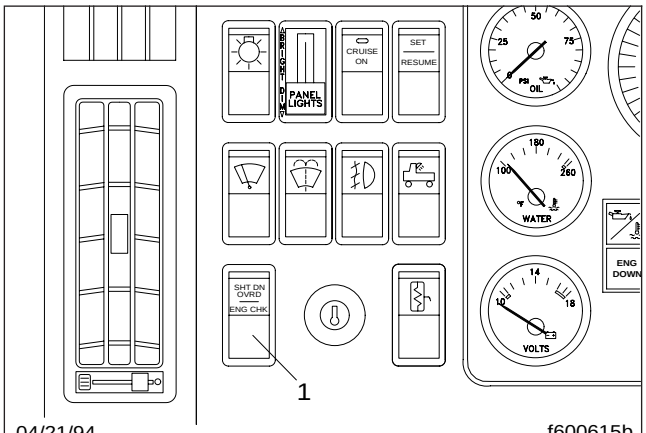
1. Warning and Indicator Light Module
2. Engine Down Light
3. Engine Check Light

Fig. 2, DDEC III Light Module

NOTE: If the driver cannot move the vehicle to safety within thirty seconds, the driver must press the Shutdown Override/Engine Check switch immediately after the Engine Down light comes on. Pressing the switch just before shutdown will keep the engine running for thirty more seconds.

If the engine is not programmed to shut down, the ECM will continue to cut fuel delivery to the injectors until the engine is running at 40 percent of original power.

After an emergency engine shutdown, the Shutdown Override/Engine Check switch allows the driver to re-start the engine for thirty seconds and move the vehicle to a new location. Turn the ignition off and then on, and press the override switch. **See Fig. 3.** For additional time, the driver must press the override switch again, every thirty seconds. Emergency engine warning, power derate, and engine shutdown are standard on engines equipped with DDEC III, but an engine can be programmed to give a warning and then cut engine power without shutting down. To reprogram engine options, contact your nearest Freightliner or Detroit Diesel dealer.



04/21/94 f600615b

1. Shutdown Override/Engine Check Switch

Fig. 3, Shutdown Override/Engine Check Switch

Diagnostics

If the DDEC III reports an engine problem, you have two ways to diagnose it:

- Press the Shutdown Override/Engine Check switch (on the left dash panel) and watch the codes flashed by the Engine Check and Engine Down light. Two types of flash codes represent engine problems. The first type, active codes, represent existing problems and keep the Engine Check or Engine Down light lighted. The second type, historical codes, represent problems that are logged in the ECM but are not active.

  If the Engine Check light and Engine Down light stay on, the engine has a problem, and the DDEC III has a flash code ready to represent that problem. To read the flash code, turn on the ignition or idle the engine, and wait for five seconds. Then press and hold the Shutdown Override/Engine Check switch. The En-

gine Down light will flash a number of times to represent the code for the problem. For example, the code 13 would be one Engine Down light flash followed by a pause, then three more flashes. If the engine has more than one problem, a code for each of the problems will flash with a pause of several seconds between them. **See Fig. 4.** After all the active codes have flashed, or if there are no active codes, the Engine Down light will flash code 25. After that, the Engine Check light will flash any historical codes for problems that are not active but are logged in the ECM. After all the historical codes have flashed, or if there are no historical codes, the Engine Check light will flash code 25. For the meaning of the flash codes, refer to the *Detroit Diesel DDEC III Troubleshooting Guide*.

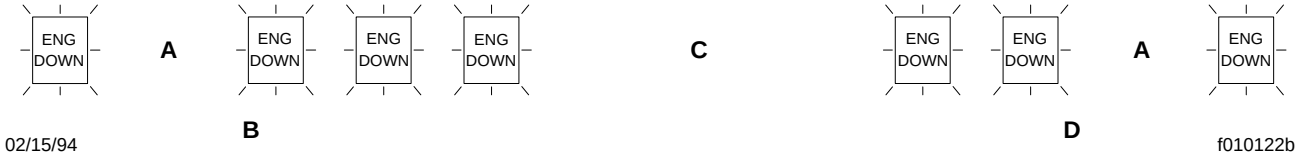
while the engine is idling and rev the engine slightly. Ninety seconds before the engine shuts down, the Engine Check light will flash. Step on the throttle pedal and rev the engine during this time, and the engine will idle indefinitely.

COMPONENTS

Electronic Control Module

The Electronic Control Module (ECM) is mounted on the lower left side of Detroit Diesel Series 50 engines. Four wiring harnesses connect to the ECM. Two Detroit Diesel harnesses plug into one end of the ECM; two Freightliner harnesses plug into the opposite end.

On the Freightliner end, the first harness, the power harness, runs from the batteries to the ECM, and



A. Short Pause (1/2 Second)
B. Flash Code 13
C. Long Pause (3 Seconds)
D. Flash Code 21

Fig. 4, DDEC III Flash Codes

- Use a hand-held Diagnostic Data Reader (DDR) equipped with a DDEC III cartridge. With the ignition turned on or the engine idling, connect the reader to the Deutsch six-pin connector under the lower, left dash panel. If using a DDR, choose reader Mode 01 to read the active codes, and choose Mode 02 to read the historical codes.

Idle Shutdown Timer

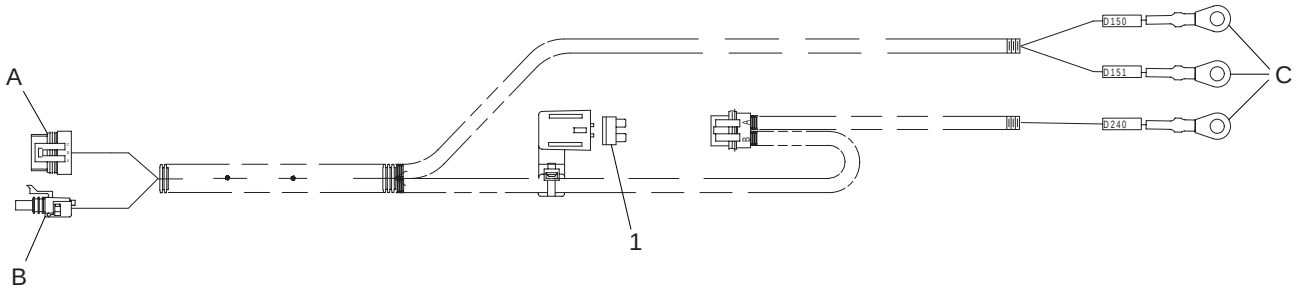
The same system that shuts down the engine during a problem also shuts down the engine if the customer requests the optional idle shutdown time. With an idle shutdown timer, the engine automatically shuts down after idling for a predetermined number of minutes. That length of time can be set anywhere between two minutes and 99 minutes. To start the engine after the idle shutdown timer has shut it down, turn the key all the way off, then turn the key on. To make the engine idle longer than the predetermined length of time, release and immediately reapply the parking brake, or press the throttle pedal

includes a single 15 amp fuse. **See Fig. 5** and **Fig. 6**. The fuse is mounted on the battery box, and if the fuse fails, the engine will not run. At the engine, the five-pin power harness connector plugs into the ECM, and the harness's single-pin connector plugs into a connector on the Freightliner electrical engine wiring harness.

NOTE: Before troubleshooting the DDEC III system, make sure the fuses and circuit breaker for the power harness and the ignition circuit are good.

The second harness, the Freightliner electrical engine wiring harness, connects the ECM and the sensors installed by Freightliner (the low coolant level sensor and the vehicle speed sensor) to the cab wiring. **See Fig. 6** and **Fig. 7**. This engine wiring harness also connects the ECM to the tachometer. Three of the wiring harness's connectors plug into the ECM. Two of these connectors, the 30-pin connector and the six-pin connector plug into the Freightliner end of the ECM; the third connector, the

General Description



02/09/94 f540714

A. Connect to the ECM.
B. Connect to the Freightliner electrical engine harness.
C. Connect to the batteries.
1. 15-Amp Fuse

Fig. 5, Freightliner Power Harness

3-pin connector, plugs into a short pigtail harness that is routed around from the opposite end of the ECM. A fourth connector near the ECM, plugs into the single-pin connector on the power harness. At the firewall, the cab interface connector plugs the harness into the cab wiring harness. The low coolant level sensor branch of the harness plugs into the sensor in the radiator surge tank. The vehicle speed sensor branch of the harness plugs into the sensor at the transmission output.

On the Detroit Diesel end of the ECM are one 30-pin connector and two smaller connectors.

The 30-pin connector is on the third wiring harness: The harness that connects the ECM to the turbo boost pressure sensor, the timing and synchronous reference sensors, the temperature sensors for the air, oil, fuel, and coolant, and pressure sensors for the fuel, oil, and coolant. **See Fig. 8.** This harness includes a smaller pigtail harness that runs from the Detroit Diesel end of the ECM and ends in a 3-pin connector near the Freightliner end. This pigtail harness connects to a 3-pin connector at the end of the Freightliner electrical engine wiring harness.

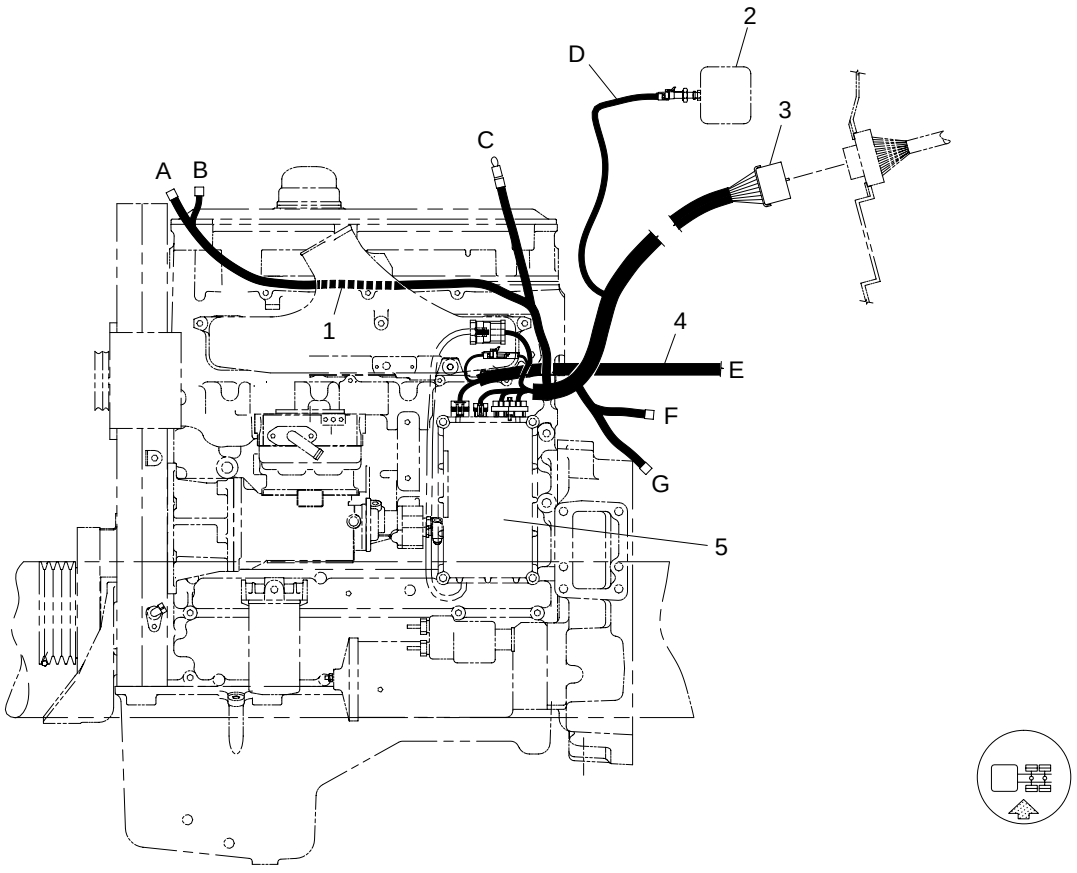
The two smaller wiring connectors plugged into the Detroit Diesel end of the ECM belong to the fourth wiring harness. This harness connects the ECM to the electronic fuel injectors.

A fifth wiring harness, the Freightliner non-electronic component wiring harness (**Fig. 9** and **Fig. 10**), connects cab and chassis wiring at the bulkhead connectors to parts within the engine compartment, including:

- The air conditioning pressure switch
- The magnetic switch
- The starter
- The back-up light and alarm switch
- The transmission oil temperature sender
- The ether start system
- The fan solenoid
- The alternator
- The ammeter shunt

The ECM makes continuous self-diagnostic checks and monitors the DDEC III system from ignition through all engine operating modes. The ECM contains an Electronically Erasable Programmable Read Only Memory (EEPROM), which controls the basic engine functions, including:

- Rated Speed and Power
- Fuel Injection Timing
- Engine Governing
- Torque Shaping
- Cold Start Logic
- Transient Fuel Delivery
- Diagnostics



02/11/94 f010768

A. Connect to the fan solenoid.
B. Connect to the Freightliner non-electronic component wiring harness.
C. Connect to the air conditioning switch.
D. Connect to the low coolant level sensor.
E. Route to the batteries.
F. Connect to the tachometer.
G. Connect to the vehicle speed sensor.
1. Freightliner Electrical Engine Harness
2. Surge Tank
3. Bulkhead Connector
4. Freightliner Power Harness
5. Electronic Control Module

Fig. 6, Freightliner Electrical Engine and Power Harnesses

- Engine Protection

For precise fuel delivery and improved fuel economy, the control logic uses calibration tables to determine the duration and timing of fuel delivery to the electronic unit injectors.

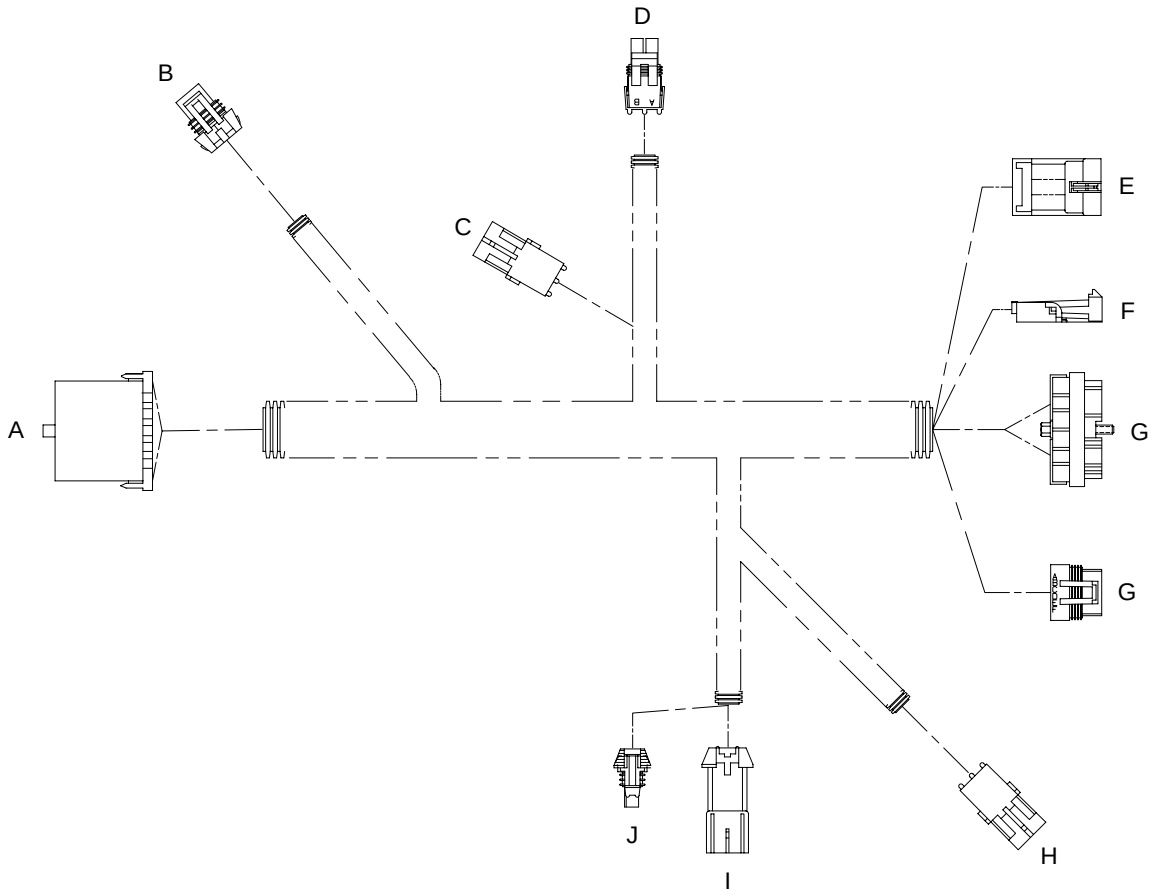
ECM Programming

In production, Freightliner programs the Electronically Erasable Programmable Read Only Memory (EEPROM) with the standard engine operating features and any options the customer has specified. Currently, the standard program includes engine shutdown, but the option is available to only cut engine power in emergency situations. To re-program the EEPROM, take the vehicle to the nearest Freightliner or Detroit Diesel dealership.

Electronic Unit Injectors

The Electronic Unit (fuel) Injectors (EUI) operate the same as Detroit Diesel mechanical unit injectors: the cam/rocker arm system powers the high fuel delivery pressure. However, on the EUI, a solenoid controlled

General Description



A. Connect to the cab interface connector.
B. Connect to the low coolant level sensor.
C. Connect to the tachometer.
D. Connect to the vehicle speed sensor.
E. Connect to the ECM (the short pigtail harness from the Detroit Diesel end of the module).
F. Connect to the power harness.
G. Connect to the ECM (Freightliner side of the module).
H. Connect to the air conditioning switch.
I. Connect to the fan solenoid.
J. Connect to the Freightliner non-electronic component wiring harness.

Fig. 7, Freightliner Electrical Engine Wiring Harness

by the ECM controls fuel injection timing and fuel quantity. When the solenoid valve closes, fuel injection begins. When the solenoid opens, fuel injection ends. As long as the ECM keeps the solenoid closed, the unit injector injects fuel into the cylinder.

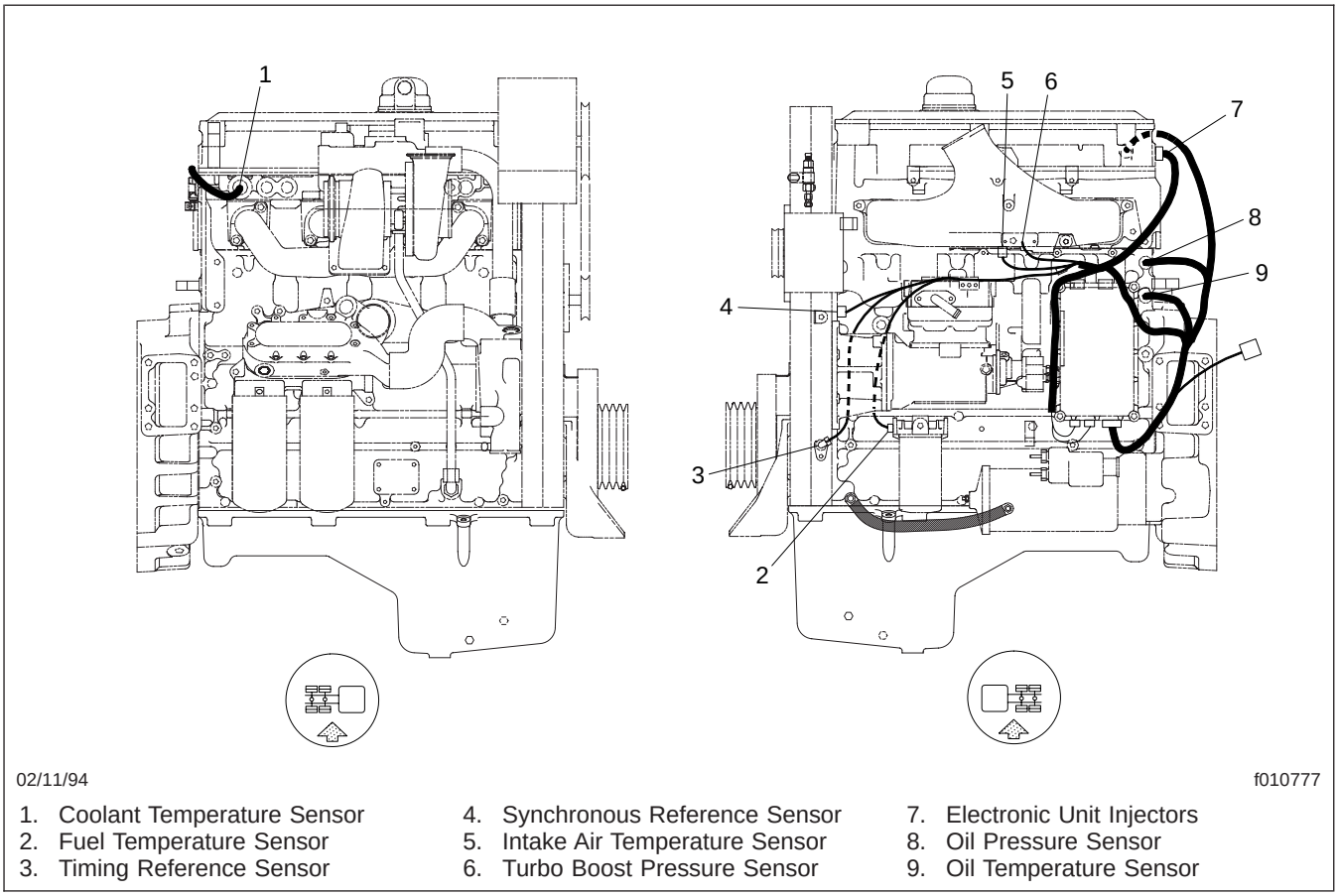
Timing and Synchronous Reference Sensors

The timing reference sensor (TRS) tells the ECM the engine rpm. This sensor is installed in front of the air compressor, below the air compressor drive.

See Fig. 8. The synchronous reference sensor (SRS) indicates a specific cylinder in the firing order. It is installed in front of the air compressor, above the air compressor drive.

Turbo Boost Pressure Sensor

The Turbo Boost Sensor (TBS) is installed in the side of the air intake manifold, and monitors the pressure of the engine intake air after it has been pressurized by the turbocharger and cooled by the aftercooler.



1. Coolant Temperature Sensor
2. Fuel Temperature Sensor
3. Timing Reference Sensor
4. Synchronous Reference Sensor
5. Intake Air Temperature Sensor
6. Turbo Boost Pressure Sensor
7. Electronic Unit Injectors
8. Oil Pressure Sensor
9. Oil Temperature Sensor

Fig. 8, Detroit Diesel Wiring Harnesses and Sensors on Series 50 Engine With DDEC III

See Fig. 8. The ECM uses information from the TBS to control engine smoke.

Oil Pressure Sensor (See Fig. 8)

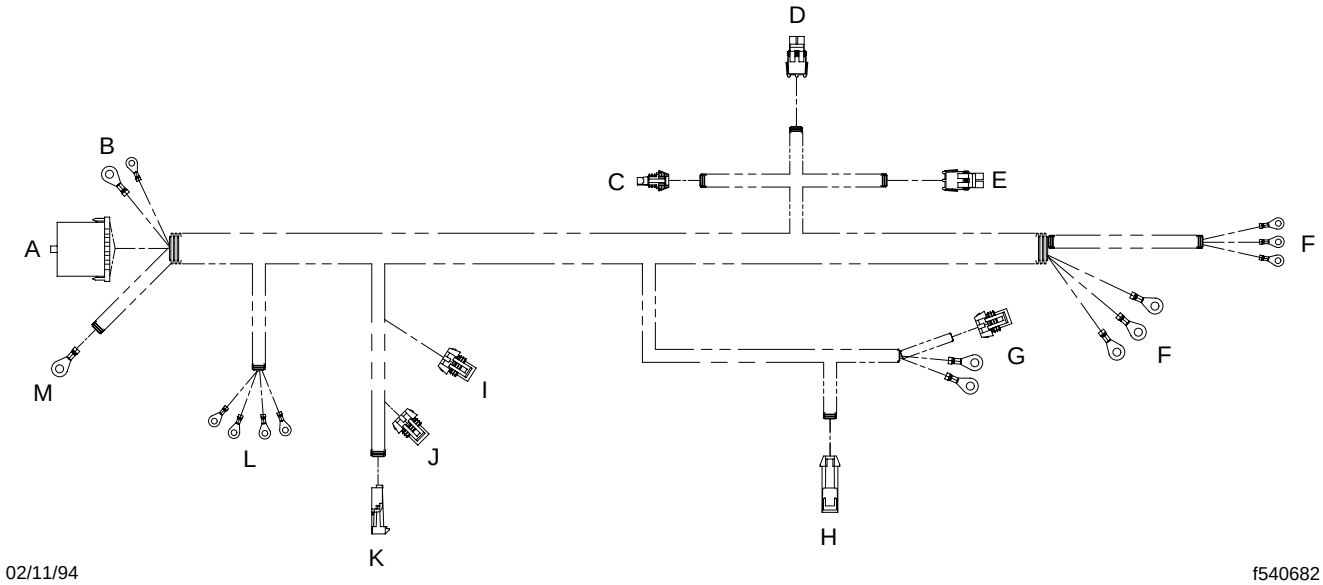
The oil pressure sensor is installed in the engine block, right below the rear end of the air intake manifold. This sensor tells the ECM the engine oil pressure in the gallery, and the ECM compares this pressure to the engine rpm. **See Fig. 11.** If oil pressure falls too low in relation to engine rpm, the ECM turns on the Engine Check light and Engine Down light, and an engine oil pressure switch turns on the low oil pressure warning light and buzzer. Thirty seconds later, the ECM shuts down the engine (if the engine is programmed with shutdown protection).

Fuel, Air, Coolant, and Oil Temperature Sensors (See Fig. 8)

The fuel temperature sensor, installed in the secondary fuel filter, measures fuel temperatures for the ECM to use when calculating fuel consumption and fuel input compensation. If the fuel temperature rises above 100°F (38°C), the ECM will increase fuel delivery to the injectors. This increase in volume compensates for the warmer, less dense fuel. If the fuel temperature rises to 140°F (60°C), the ECM will no longer increase the fuel delivery to the injectors. The ECM drops fuel delivery back to the original rate because, at this temperature, the fuel and engine are too hot.

The intake air temperature sensor, installed in the under-side of the air intake manifold, reports engine intake air temperature to the ECM so the ECM can

General Description



A. Connect to cab interface.
B. Connect to ground stud.
C. Connect to back-up light switch harness.
D. Connect to the vehicle speed sensor.
E. Connect to the tachometer.
F. Connect to the starter.
G. Connect to the alternator.
H. Connect to the electronic engine harness (fan).
I. Connect to the coolant high temperature sender.
J. Connect to the coolant high temperature switch.
K. Connect to the refrigerant compressor.
L. Connect to the magnetic switch.
M. Connect to the power stud.

Fig. 9, Freightliner Non-Electronic Component Wiring Harness, Detroit Diesel Series 50 Engine

vary the hot idle speed and injection timing for better cold starts and less white smoke.

The coolant temperature sensor, installed in the coolant jacket above the rear end of the exhaust manifold, tells the ECM if coolant temperature exceeds 217°F (103°C). At that temperature, a coolant temperature switch turns on the high coolant temperature light and buzzer, and the ECM turns on the Engine Check light and begins to cut engine power. If the coolant reaches 223°F (106°C), the ECM turns on the Engine Down light and shuts down the engine (if the engine is programmed with shutdown protection).

The oil temperature sensor is installed below the oil pressure sensor, below the rear end of the intake air manifold. **See Fig. 8.** It reports oil temperature to the ECM so the ECM can vary idle speed and injection timing for better cold starts and less white smoke. If oil temperature exceeds 250°F (121°C), the ECM activates the Engine Check light and begins to cut engine power. If the oil temperature reaches 260°F (127°C) the ECM turns on the Engine Down light and shuts down the engine (if the engine is programmed with shutdown protection).

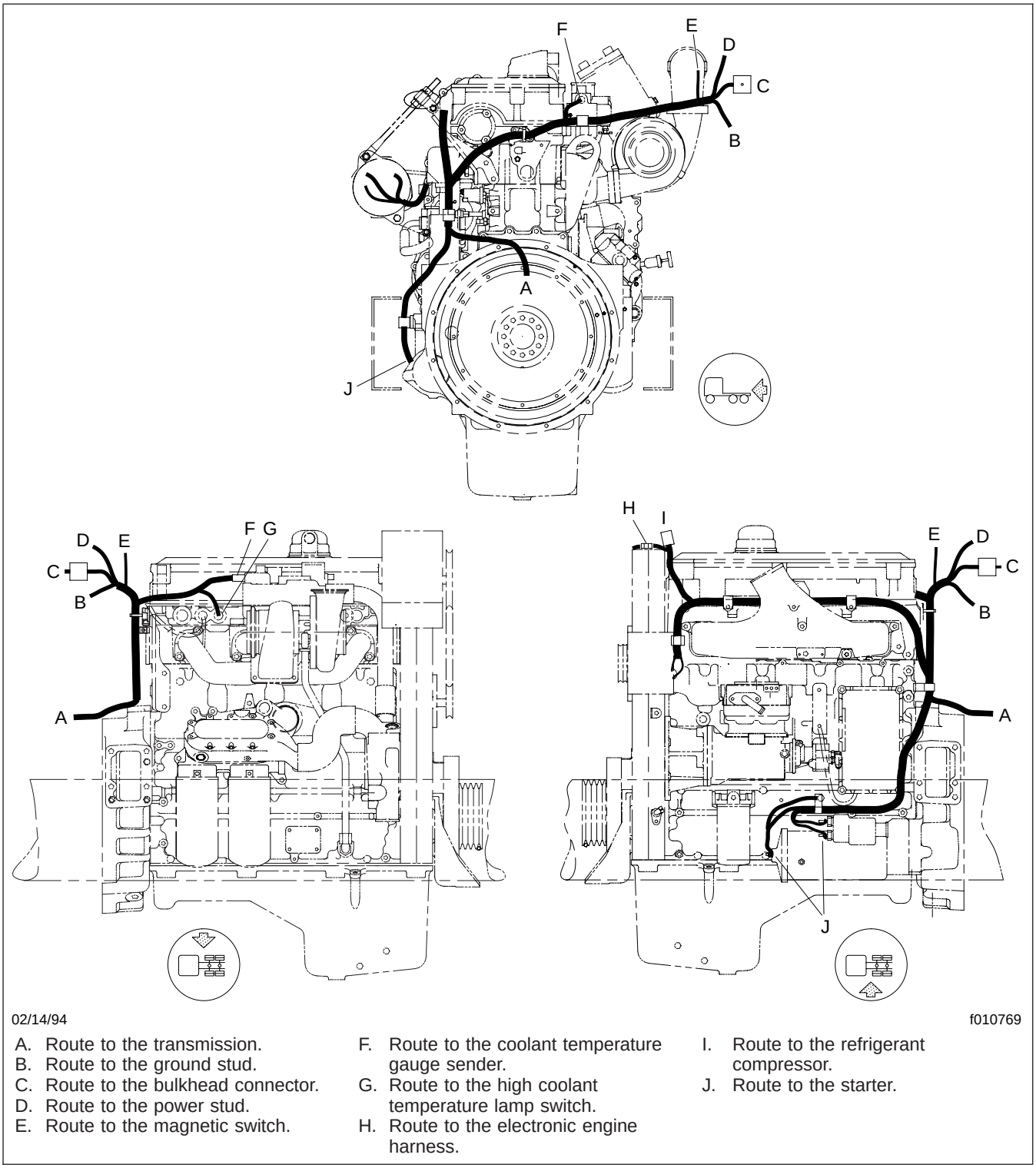
Throttle Position Sensor

The throttle position sensor is part of the electronic foot pedal assembly. Freightliner uses the Williams Electronic throttle pedal with DDEC III systems. There is no mechanical throttle linkage.

NOTE: Williams throttle pedals made to work with DDEC II will work with DDEC III, but the reverse is not true.

Coolant Level Sensor (See Fig. 12)

Freightliner installs the coolant level sensor in the radiator surge tank. The coolant grounds the sensor, so if the coolant level drops below the sensor for more than seven to ten seconds, the low coolant level warnings begin. The warning means more than 10% of the engine coolant is missing, and this early



A. Route to the transmission.
B. Route to the ground stud.
C. Route to the bulkhead connector.
D. Route to the power stud.
E. Route to the magnetic switch.
F. Route to the coolant temperature gauge sender.
G. Route to the high coolant temperature lamp switch.
H. Route to the electronic engine harness.
I. Route to the refrigerant compressor.
J. Route to the starter.

Fig. 10, Freightliner Non-Electronic Component Wiring Harness, Detroit Diesel Series 50 Engine

General Description

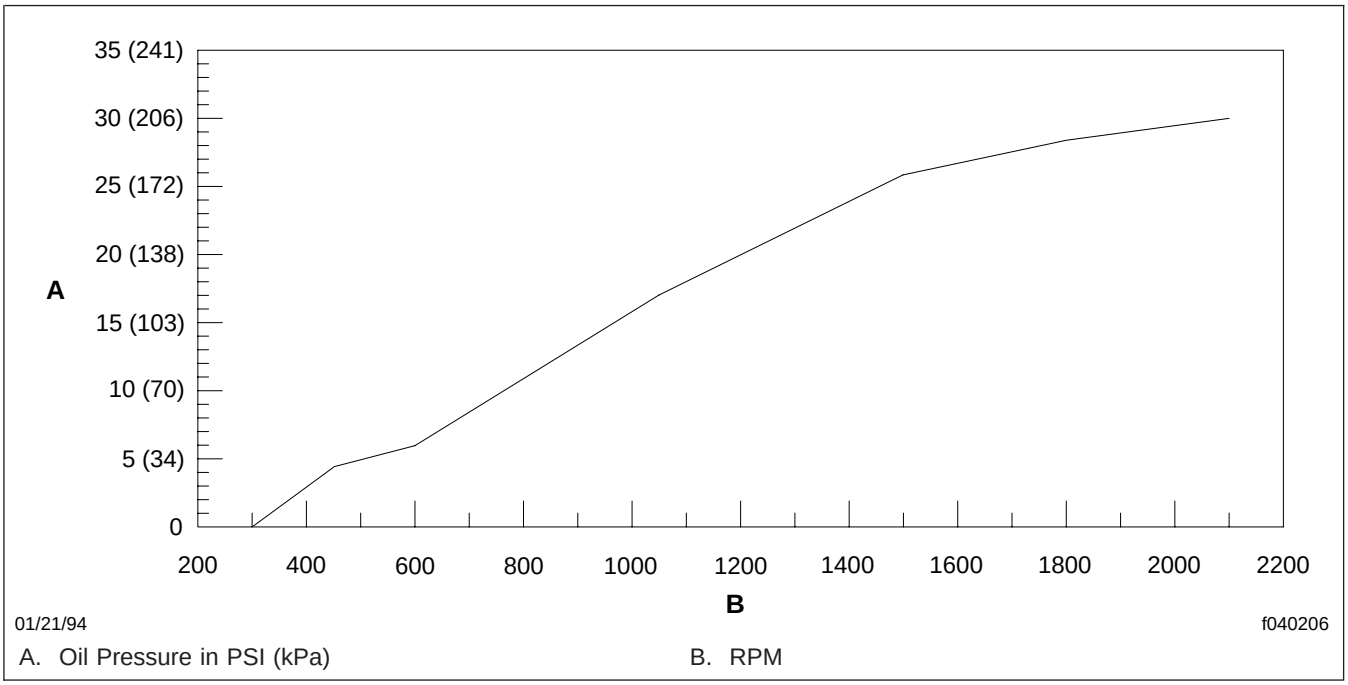


Fig. 11, Low Oil Pressure Limits, Detroit Diesel Series 50 Engines with DDEC III

warning will prevent coolant aeration and water jacket cavitation.

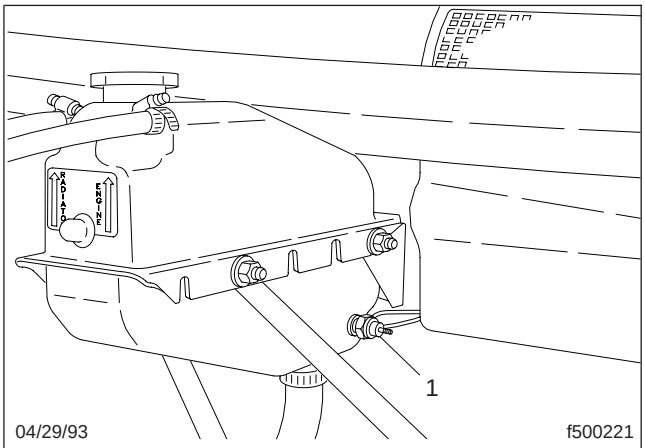


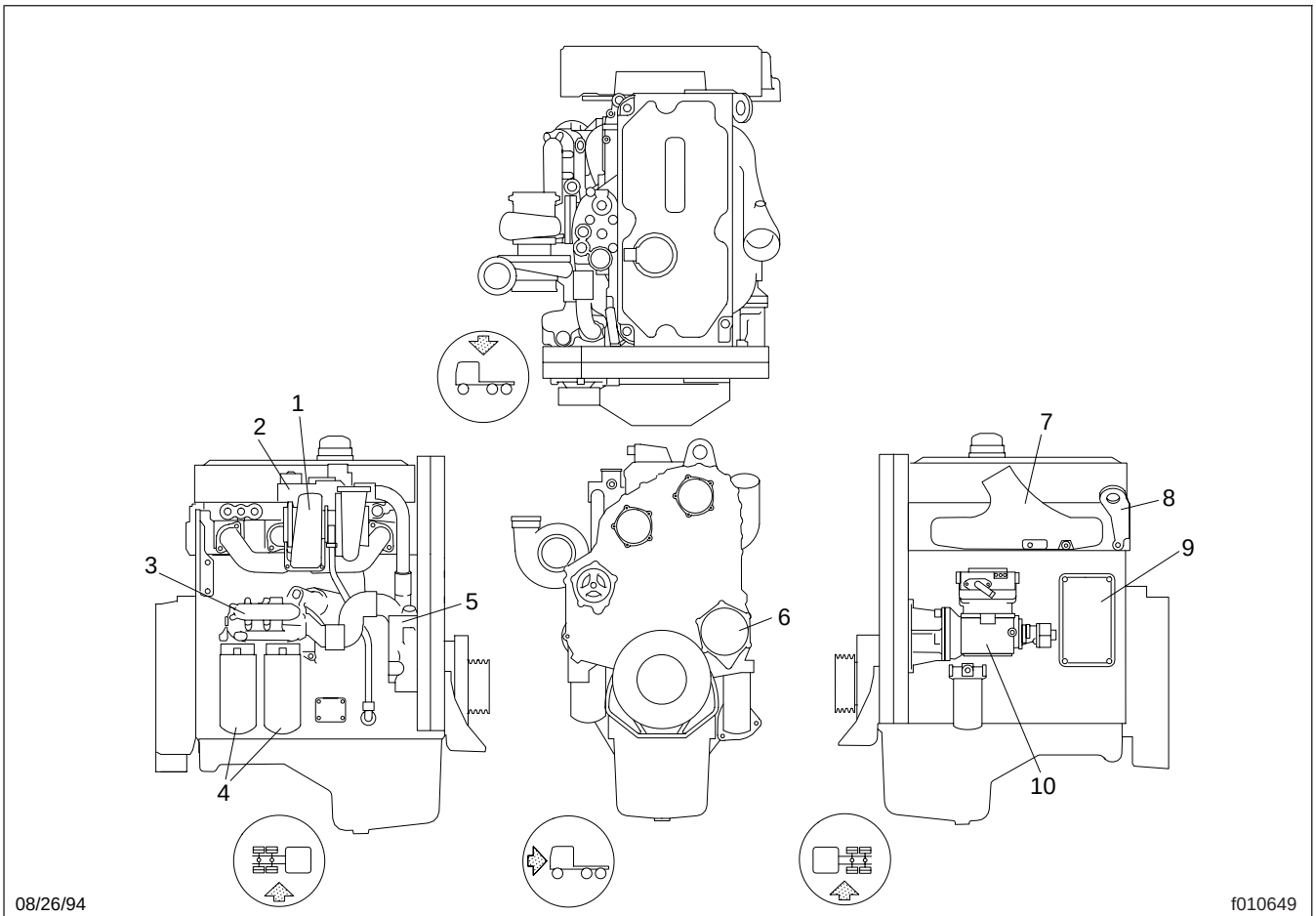
Fig. 12, Sensor Location in Surge Tank

NOTE: If a vehicle is equipped with an optional transmission retarder, and the ECM is reprogrammed by Detroit Diesel, the low coolant level warning light may come on when the transmission retarder is on. For these two functions (coolant level and transmission retarder), Freightliner uses different pin locations on the 30-pin ECM connectors than are specified by Detroit Diesel. This is not a problem because Freightliner also programs the ECM; however, if Detroit Diesel reprograms the ECM, the coolant level and transmission retarder functions will be switched back to the connector pins that Detroit Diesel specifies. If this happens, the low coolant level warning light will come on when the transmission retarder is on. If Detroit Diesel reprograms the ECM for a new exhaust brake, the low coolant level light may stay on continuously. For specific circuits and wiring schematics, refer to the DDEC section in **Group 54** of this manual.

Vehicle Speed Sensor

The vehicle speed sensor is installed in the transmission output, and sends vehicle speed signals to the speedometer and to the ECM. The ECM uses this signal for cruise control and for vehicle speed limiting.

Removal (See Fig. 1)



1. Turbocharger
2. Thermostat Housing
3. Oil Cooler
4. Oil Filters
5. Water Pump
6. Accessory Drive (Power Steering Fluid Pump)
7. Air Intake Manifold
8. Rear Engine Lifting Eye
9. Electronic Control Module
10. Air Compressor

Fig. 1, Detroit Diesel Series 50 Engine Components

1. Apply the parking brakes, chock the tires, and drain the air system.
2. If the vehicle is equipped with a battery shutoff switch, turn off the switch; otherwise, disconnect the batteries.
   - 2.1 Disconnect the battery ground cable at the vehicle frame.
   - 2.2 Disconnect the positive battery cable from the batteries.
3. Disconnect the transmission. For instructions, refer to **Group 26** in this service manual.

NOTE: To remove the transmission from a Detroit Diesel Series 50 engine in a Medium Truck, it may be necessary to remove the air regulator from the transmission and lower the transmission or raise the rear of the vehicle so that the transmission will clear the crossmember directly behind it.

Removal and Installation

4. Remove the hood, bumper and left front half-fender. For instructions, refer to the cab group in the vehicle service manual.

⚠ WARNING

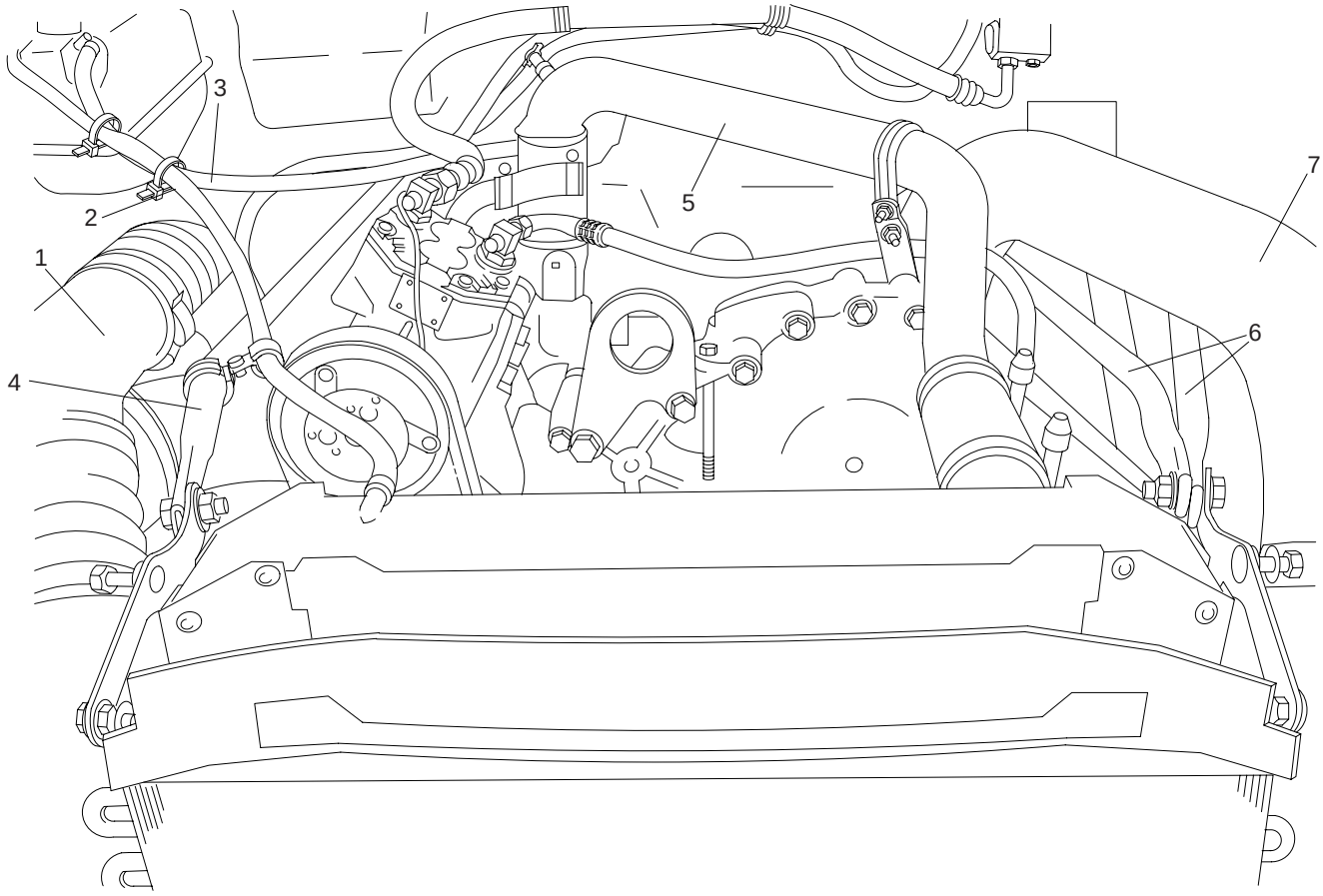
Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

5. Drain the radiator.
   - 5.1 Open the coolant drain at the bottom of the radiator.
   - 5.2 Loosen the surge tank cap.
   - 5.3 To drain the coolant from the engine block, remove the water jacket plug at the bottom of the water pump, on the inboard side of the coolant inlet from the radiator.
6. Remove the right fender splash shield.
7. Remove the air cleaner and intake air ducting. See **Fig. 2** and **Fig. 3**.
   - 7.1 Remove the hoses and convoluted tubing that run between the turbocharger and the aftercooler, and between the aftercooler and the engine intake manifold. Cover the turbocharger inlet with a clean shop rag.
   - 7.2 Remove the ducting that runs between the air cleaner and the turbocharger.
   - 7.3 Disconnect the right-side air recirculation shield from the radiator, and remove the shield with the air cleaner. See **Fig. 4**.
   - 7.4 Remove the fasteners that hold the air cleaner mounting bracket to the frame rail, and remove the bracket and the air cleaner housing, together.
8. Remove the exhaust ducting.
   - 8.1 Loosen the V-band clamp that holds the forward end of the exhaust ducting to the rear of the turbocharger. See **Fig. 3**.
   - 8.2 Loosen the clamp that holds the rear end of the exhaust ducting to the exhaust flex pipe.
   - 8.3 Remove the exhaust duct support bracket that shares mounting fasteners with the rear engine lifting eye, and remove the exhaust duct and bracket from the vehicle.

⚠ WARNING

After removing the exhaust duct support bracket, re-install all the engine lifting eye fasteners and tighten them securely. If the fasteners are not re-installed and tightened, the engine lifting eye will be unstable. Lifting the engine with an unstable lifting eye can lead to the engine falling, possibly causing personal injury and property damage.

   - 8.4 Install the rear lifting eye fasteners and tighten them securely.
9. Disconnect the coolant hoses. See **Fig. 2** and **Fig. 3**.
   - 9.1 Disconnect the coolant inlet and outlet hoses from the radiator.
   - 9.2 Disconnect the vent hoses from the radiator and the engine.
   - 9.3 Disconnect the coolant fill pipe from the top of the water pump.
   - 9.4 Disconnect the heater outlet hose from the oil cooler.
   - 9.5 Disconnect the heater inlet hose from the bottom of the water pump, near the radiator outlet hose.
10. Relocate the refrigerant compressor.
    - 10.1 Disconnect the compressor clutch electrical connector.
    - 10.2 Remove the clamps that secure the refrigerant lines within the engine compartment.
    - 10.3 Remove the two bolts that hold the refrigerant compressor mounting bracket to the engine. See **Fig. 5**.
    - 10.4 To keep the refrigerant system intact, with no leaks and no need for purging and recharging, carefully move the refrigerant compressor over the left frame rail, and secure it out of the way with tie straps. See **Fig. 6**.

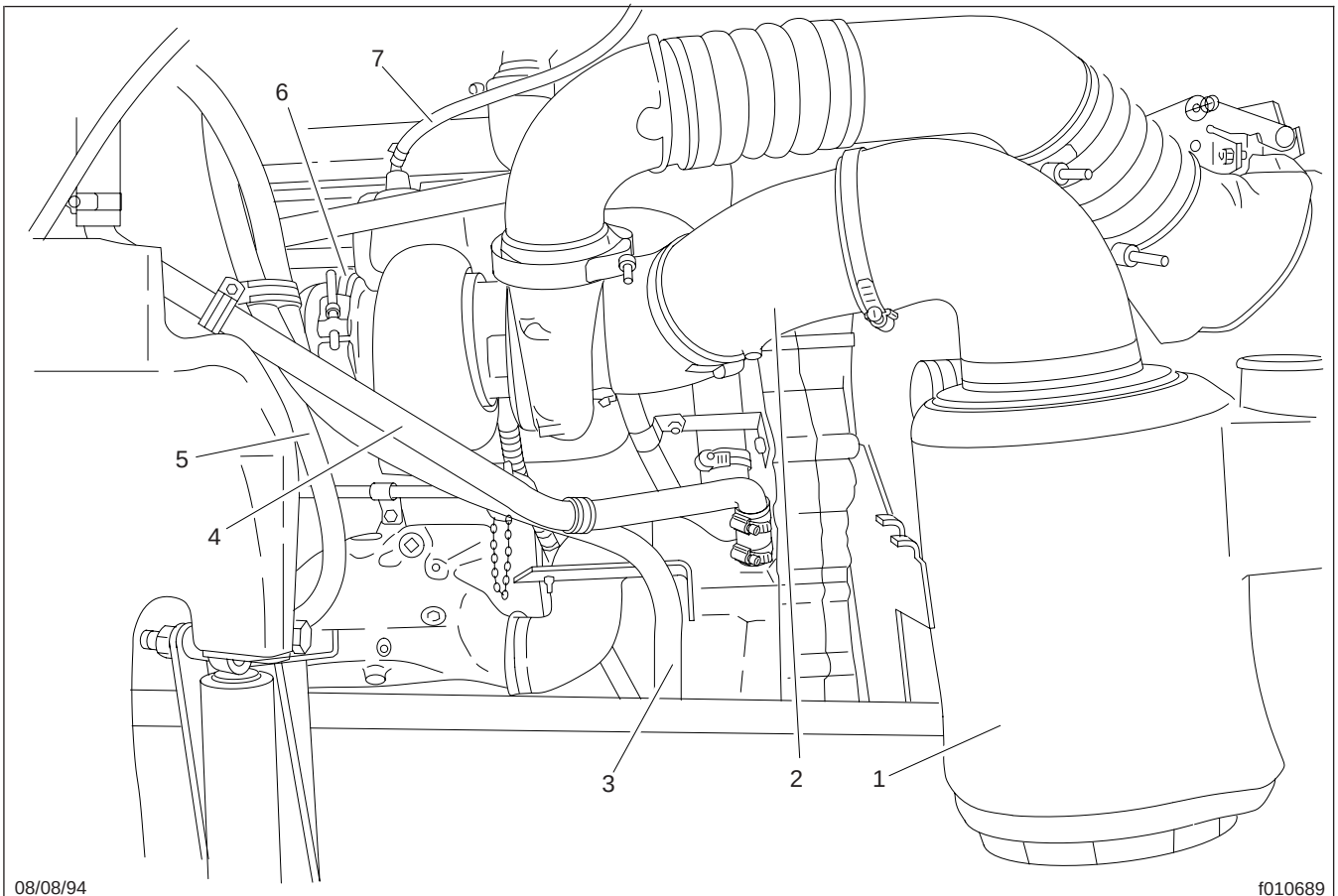


1. Intake Air Ducting, Turbocharger-to-Aftercooler
2. Radiator Vent Hose
3. Engine Vent Hose
4. Radiator Brace Rod Strut, Right-Side
5. Radiator Inlet Pipe
6. Radiator Brace Rod Struts, Left-Side
7. Intake Air Ducting, Aftercooler-to-Engine

Fig. 2, Air Cleaner and Air Ducting

11. Remove the power steering pump from the front of the engine, and (without breaking the steering fluid lines) move the pump over the left frame rail and secure it out of the way with tie straps.
12. Loosen the alternator mounting fasteners, and roll the alternator up, inboard, so that it clears the power steering reservoir when the engine is pulled forward during removal. Secure the alternator against the engine with tie straps.
13. Relocate the condenser.
    - 13.1 Remove the capscrews that hold the left-side air recirculation baffle to the radiator.
    - 13.2 Disconnect the radiator struts from the upper corners of the radiator. See **Fig. 2**.
    - 13.3 Remove the nuts and bolts that hold the condenser to the aftercooler.
    - 13.4 To keep the refrigerant system intact, with no leaks and no need for purging and recharging, carefully move the condenser over the left frame rail.
    - 13.5 Wrap the condenser in a protective blanket, or sandwich it between two sheets of cardboard to prevent damage to the con-

Removal and Installation



1. Air Cleaner Housing
2. Air Intake Ducting, Air Cleaner-to-Turbocharger
3. Heater Supply Hose
4. Coolant Fill Pipe
5. Heater Return Hose
6. V-Band Clamp
7. Engine Vent Line

Fig. 3, Coolant Hoses

denser fins. Secure the condenser out of the way with tie straps. See **Fig. 6**.

14. Disconnect the air compressor. See **Fig. 7**.

    14.1 Disconnect the air compressor outlet line from the top of the compressor.

    14.2 Disconnect the air signal lines from the air governor.

15. Remove the radiator and aftercooler assembly.

    15.1 Hook a lifting chain to the radiator and aftercooler assembly, and fasten the chain to a crane. Raise the crane until there is no slack in the chain. See **Fig. 8**.

    15.2 Remove the nut from the radiator mounting stud that passes through the underslung support bracket at the bottom of the radiator. See **Fig. 9**.

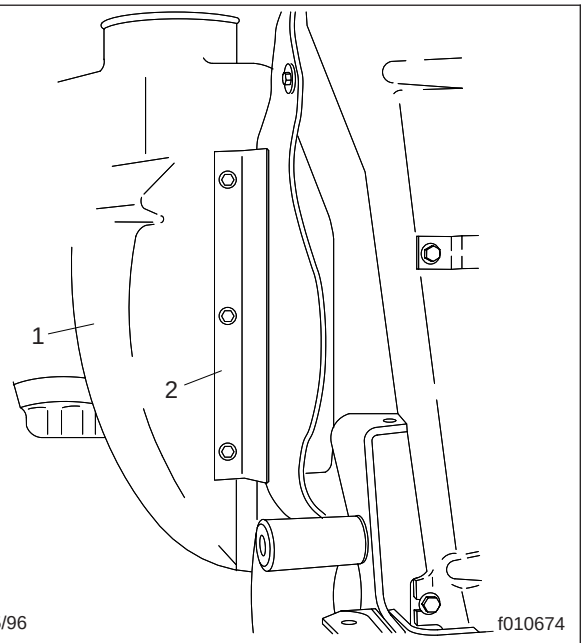
    15.3 Lift the radiator and aftercooler from the vehicle as a single unit.

    15.4 Remove the fan blades from the engine.

16. Disconnect the engine fuel and oil components.

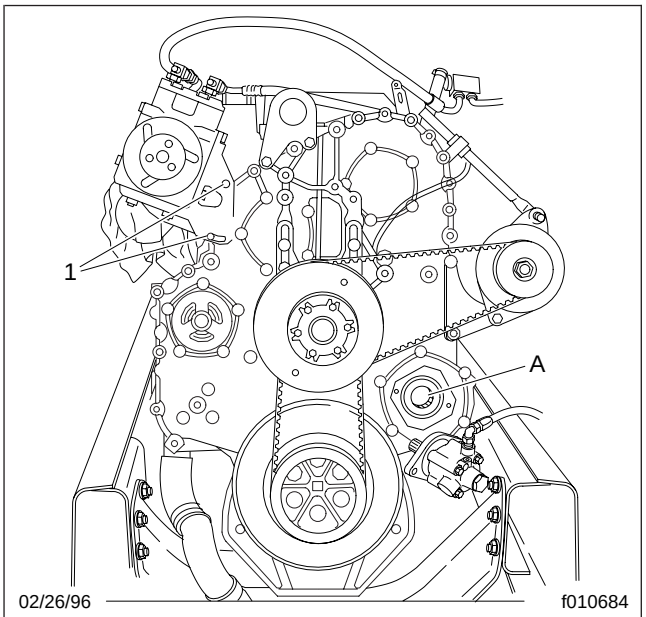
    16.1 Disconnect the fuel supply line at the fuel transfer pump. See **Fig. 10**.

    16.2 Disconnect the oil pressure gauge line behind the alternator.



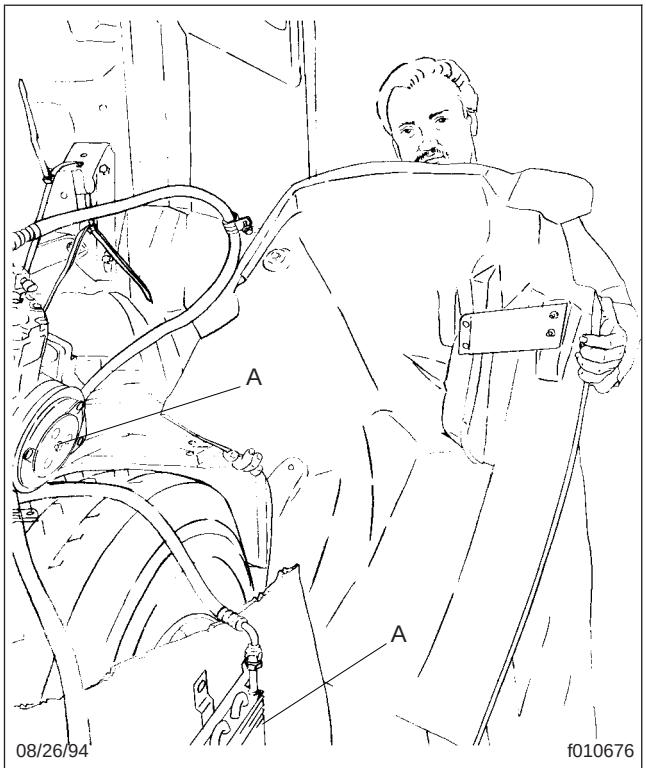
1. Air Cleaner Housing
2. Air Recirculation Shield, Right-Side

Fig. 4, Air Recirculation Shield



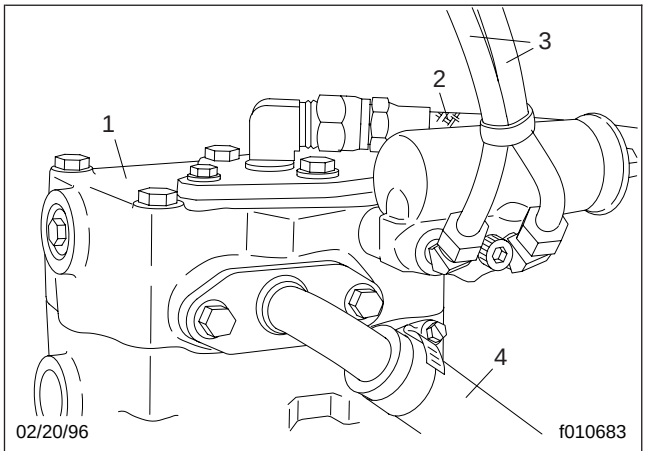
A. Remove the power steering fluid pump.
1. Refrigerant Compressor Mounting Bolts

Fig. 5, Compressor Mounting Fasteners



A. Remove the air conditioning components and move them outside of the left frame rail.

Fig. 6, Moving the Air Conditioning Components



1. Air Compressor
2. Compressor Intake Hose
3. Air Governor Signal Lines
4. Compressor Outlet Hose

Fig. 7, Disconnecting the Air Compressor

Removal and Installation

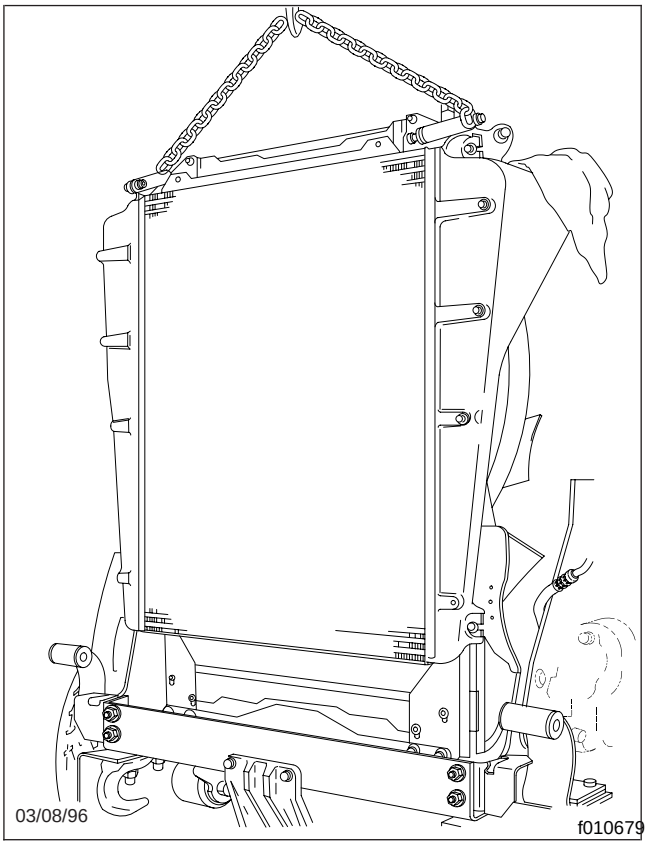


Fig. 8, Removing the Radiator

17. Disconnect the engine electrical connectors.

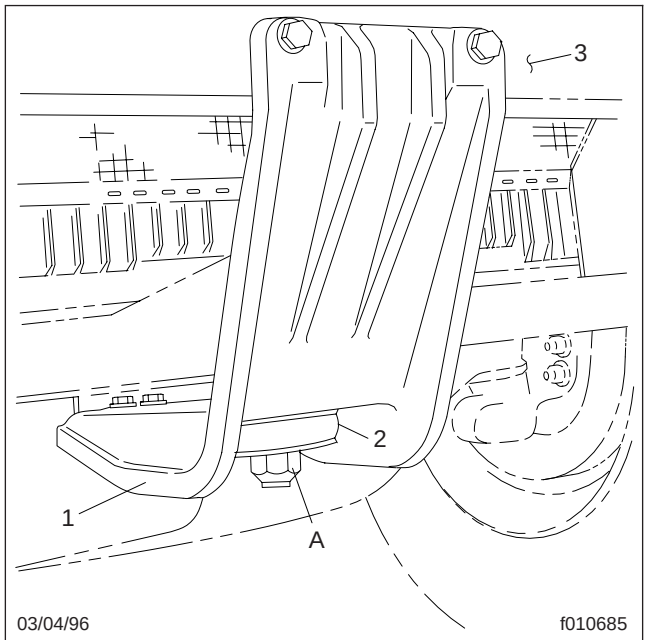
    17.1 Disconnect the horn stand-off bracket and pull the horn and its wiring harness off to the side, out of the way. See **Fig. 11**.

    17.2 Disconnect the wiring connectors from the rear of the alternator, and label the wires for reassembly. See **Fig. 12**.

    17.3 Disconnect the wiring connectors from the starter, and label the wires for reassembly.

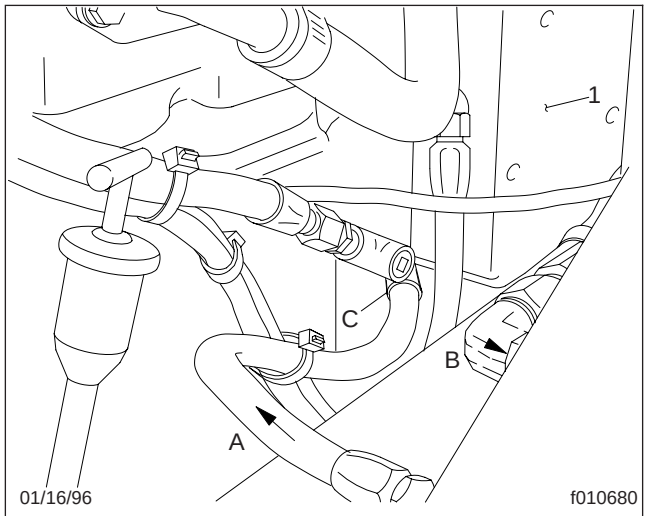
    17.4 Disconnect the wiring connectors from the electronic control module (ECM), and label the wires for reassembly. See **Fig. 13**.

    17.5 Disconnect the wiring connector from the tachometer sensor on the engine flywheel housing.



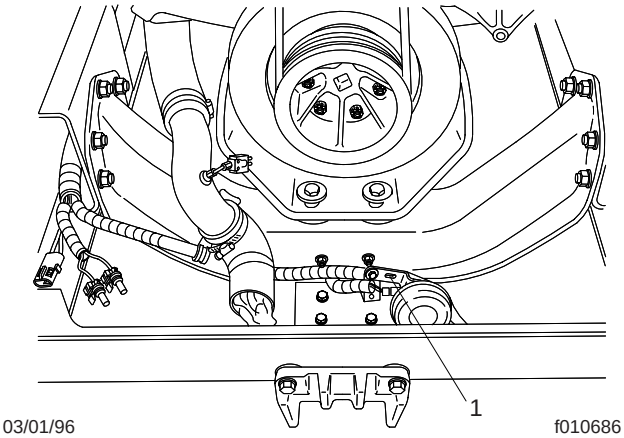
A. Remove the nut from the radiator mounting stud.
1. Radiator Underslung Support Bracket
2. Radiator Lower Isolator
3. Front Crossmember

Fig. 9, Radiator Mounting Fasteners



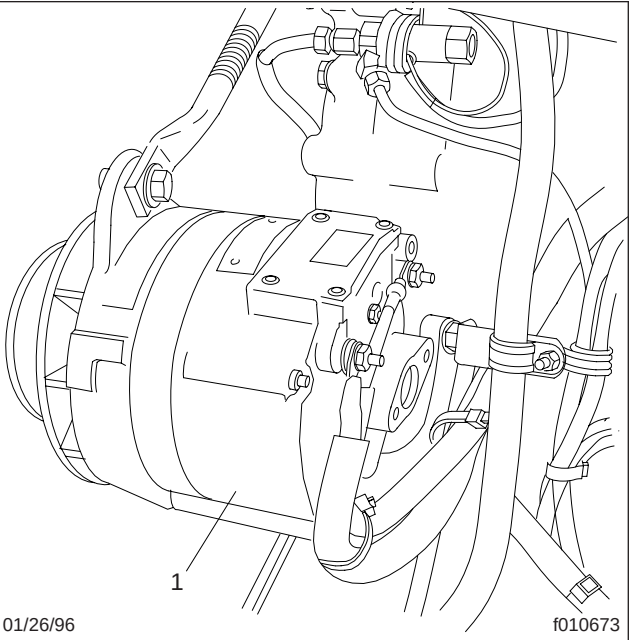
A. Fuel Flow From Filter to Pump
B. Fuel Flow From Tanks to Filter
C. Disconnect the fuel supply line at the transfer pump.
1. Electronic Control Module

Fig. 10, Fuel Lines



1. Electric Horn Bracket

Fig. 11, Disconnecting the Electric Horn



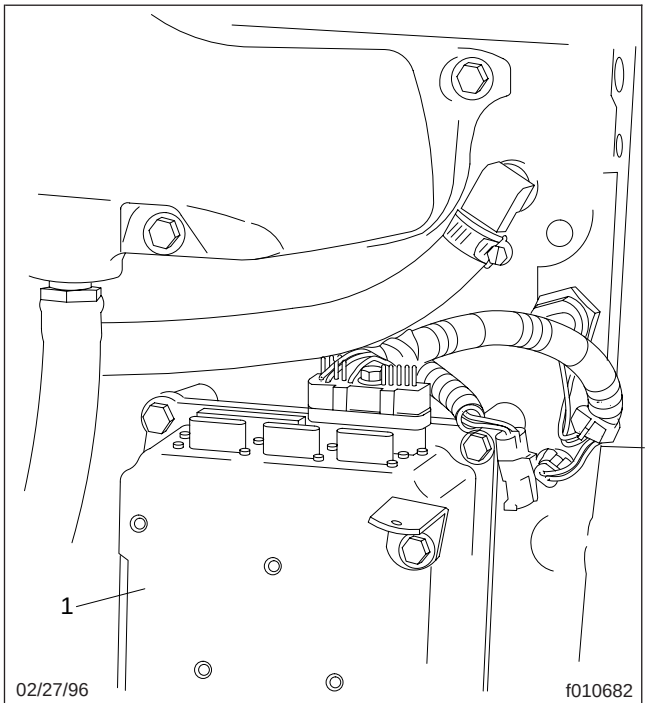
1. Alternator

Fig. 12, Alternator Wiring

17.6 Disconnect the wiring from the coolant temperature light switch port. See **Fig. 14**.

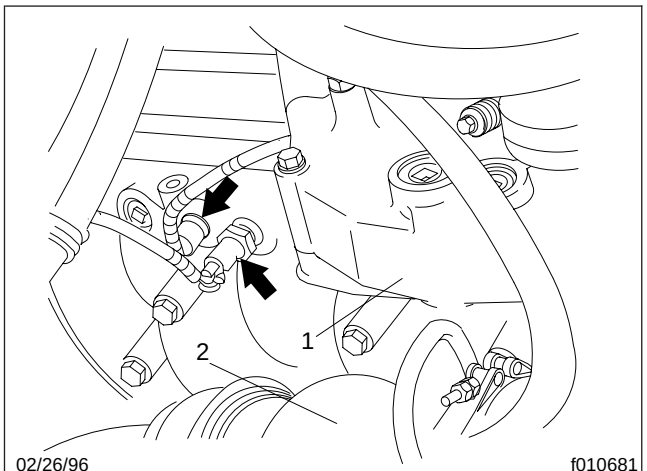
17.7 Disconnect the wiring from the coolant temperature gauge port. See **Fig. 14**.

18. Remove the windshield wiper pan. See **Fig. 15**.



1. Electronic Control Module

Fig. 13, ECM Wiring

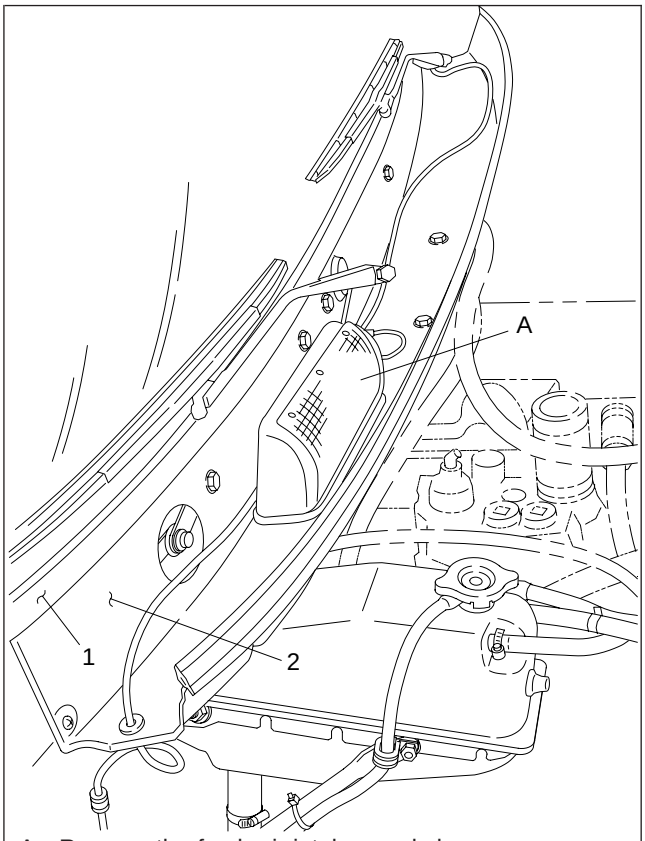


1. Thermostat Housing
2. Turbocharger

Fig. 14, Coolant Temperature Light Switch Wiring

18.1 Remove the windshield wiper arms. For instructions, refer to the cab group of this manual.

Removal and Installation



A. Remove the fresh air intake snorkel.
1. Windshield Trim
2. Windshield Wiper Pan

Fig. 15, Removing the Windshield Wiper Pan

18.2 Remove the screws that hold the wiper pan to the firewall.

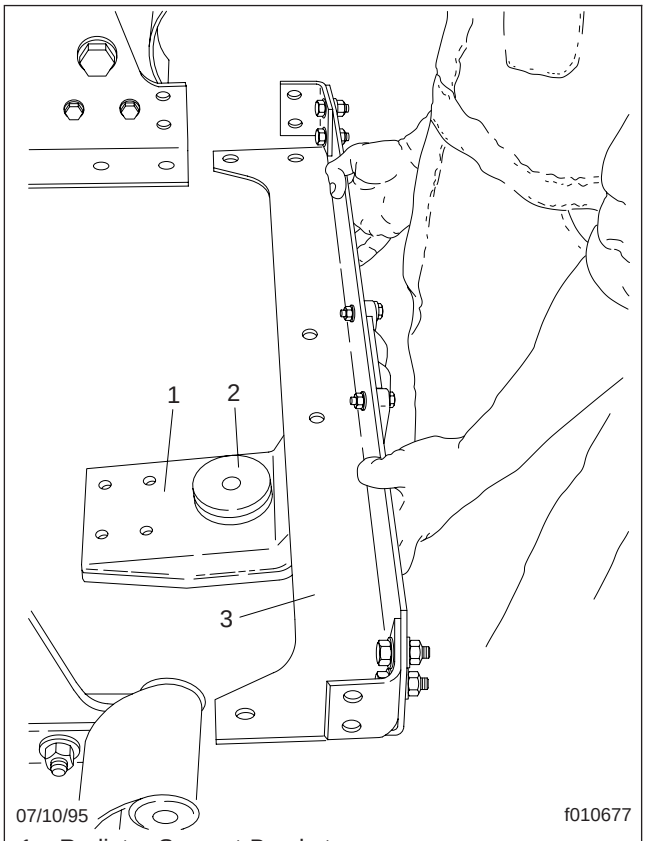
18.3 Remove the surge tank. For instructions, refer to the radiator group in this manual.

18.4 Remove the fresh air intake snorkel.

18.5 Remove the wiper pan by pulling the pan down, out from under the lower edge of the windshield trim.

19. Remove the front crossmember with the underslung radiator mounting bracket. See **Fig. 16**.

19.1 Remove the fasteners that hold the rear of the radiator support bracket to the underslung cross member that supports the front of the engine. See **Fig. 17**.



1. Radiator Support Bracket
2. Radiator Upper Isolator
3. Front Crossmember

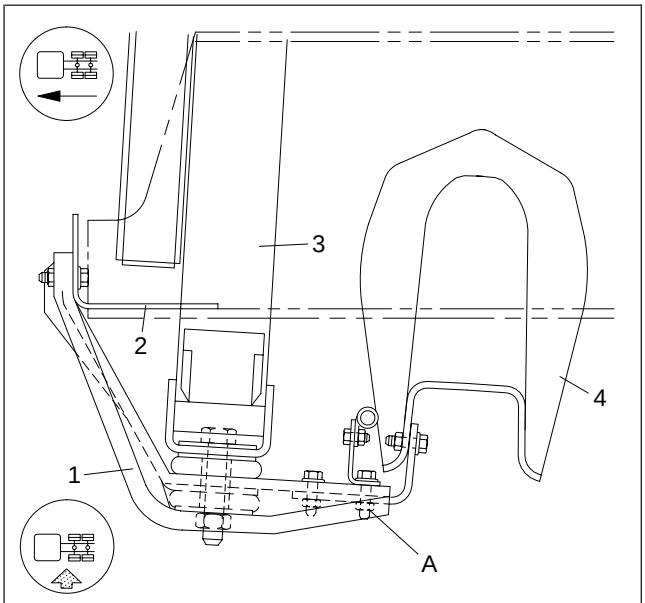
Fig. 16, Front Crossmember

19.2 Remove the fasteners that hold the front crossmember to the frame rails. See **Fig. 18**. Then, pull the crossmember forward until it's free of the frame rails.

20. Attach a three-point lifting chain to the engine, and lift the engine enough to take all weight off of the front engine mount. See **Fig. 19**.

⚠ WARNING

The crane and lifting chains used to remove the engine must be capable of safely lifting and supporting two metric tons. Once the engine mounts are disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.



A. Remove these capscrews.
1. Radiator Support Bracket
2. Front Crossmember
3. Radiator
4. Underslung Crossmember (Front Engine Mount)

Fig. 17, Radiator Support Bracket Fasteners

20.1 Attach the chain to the existing lifting hooks at the front and the rear of the engine.

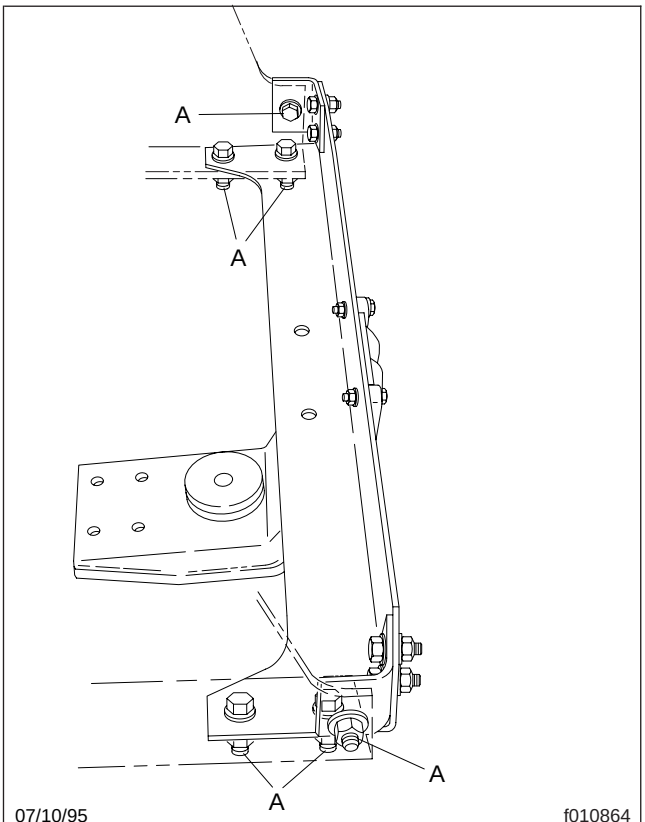
20.2 With all three engine lifting points connected by chain to the crane, raise the crane enough to tighten the chains, but not enough to lift the front of the vehicle.

21. Disconnect the engine from the rear engine mounts.

21.1 With the engine securely supported by the crane, lifting chains, and the engine stands, disconnect the rear engine legs from the engine mounts mounted on the frame rails.

21.2 On each engine leg, remove the nut from the bolt that runs down through the engine leg, rubber isolators, and engine mount. Save the fasteners and isolators.

22. Disconnect the engine from the front engine mount. See **Fig. 20**.



A. To remove or install the front crossmember, remove or install these capscrews.

Fig. 18, Front Crossmember Fasteners

22.1 Remove the nuts from the bolts that fasten the front engine bracket to the underslung crossmember.

22.2 Using the crane, lift the engine until all weight is removed from the front engine mount.

22.3 Remove the bolts and washers that hold the front engine bracket to the crossmember, and save the nuts, bolts, washers, and isolators.

23. Remove the underslung crossmember.

23.1 Remove the fasteners that hold each end of the crossmember to the frame rails. See **Fig. 21**.

23.2 Pull the crossmember forward to remove it from the vehicle.

Removal and Installation

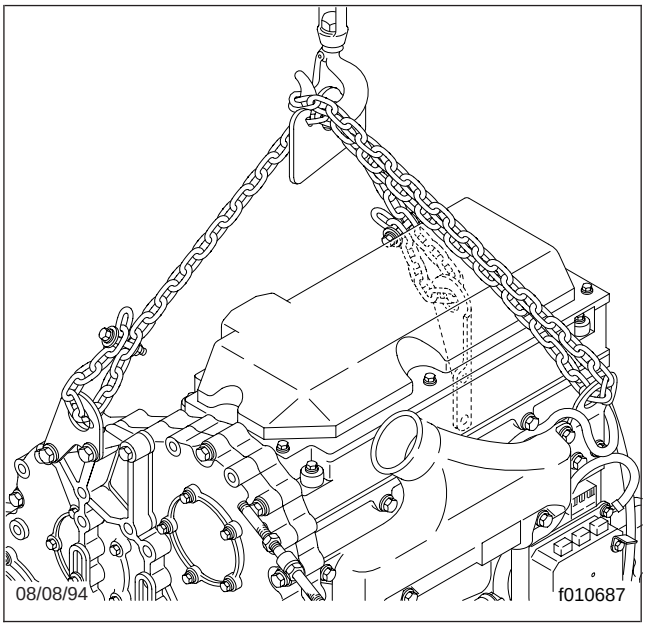


Fig. 19, Three-Point Lifting Chain

24. Remove the engine from the vehicle.

    24.1 Using the crane, lift the engine and pull it forward.

    24.2 Once the engine is clear of the vehicle, place the engine on engine stands.

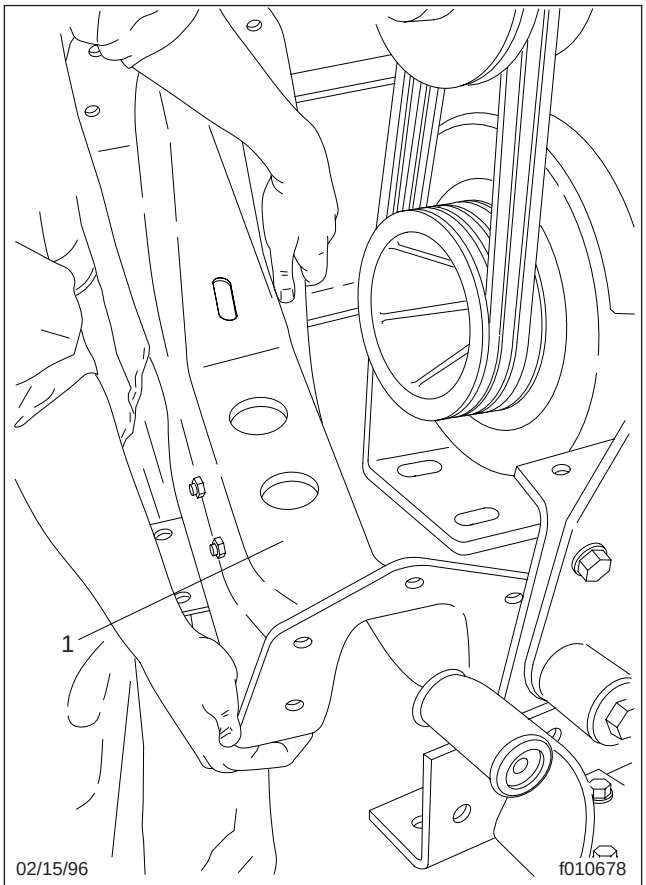
Installation

1. Install the underslung crossmember that serves as the front engine mount. See **Fig. 21**. Tighten the crossmember-to-frame rail fasteners 68 lbf·ft (92 N·m), and place the upper isolators in the engine mount holes.

⚠ WARNING

The crane and lifting chains used to install the engine must be capable of safely lifting and supporting two metric tons. Once the engine stands are removed, do not get under the engine until it is securely supported on the engine mounts. An unsecured engine may fall, causing personal injury or death, and component damage.

2. Attach a three-point lifting chain to the engine, and lift the engine off the engine stands. See **Fig. 19**.



1. Underslung Crossmember (Front Engine Mount)

Fig. 20, Front Engine Mount

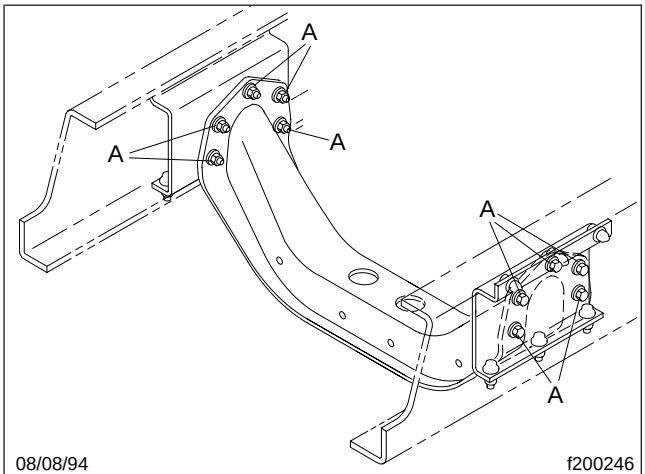
3. Install the engine in the engine compartment.

    3.1 Place the upper rubber isolators in the rear engine mounts.

    3.2 Using the crane, place the engine in the engine compartment. Keeping the front of the engine raised, slightly, push the engine back until it rests squarely on the two rear engine mounts.

    3.3 For the rear engine mounts, run a bolt down through each engine leg, the upper isolator, the engine mount, and the lower isolator. Install a nut on each bolt, and tighten each nut finger-tight.

    3.4 Using the crane, lower the engine until it rests squarely on the front engine mount.



A. To remove or install this crossmember, remove or install these capscrews.

Fig. 21, Underslung Crossmember

3.5 Run the bolts down through the front engine support bracket, the upper isolator, the engine mount, and the lower isolator. Install the nut on each bolt, and tighten each nut 241 lbf·ft (327 N·m).

3.6 Tighten the nuts on the rear engine mount bolts 241 lbf·ft (327 N·m).

3.7 With the engine securely installed on all three engine mounts, remove the crane.

4. Install the front crossmember and the underslung radiator mount. See **Fig. 17**.

4.1 Position the front crossmember between the frame rails so that it is aligned with the fastener holes. Install the capscrews, washers, and nuts removed and tighten the nuts 136 lbf·ft (184 N·m).

4.2 Use 3/8-16 1.37-inch bolts, washers and nuts to fasten the rear of the underslung radiator support bracket to the forward edge of the bracket fastened to the underslung crossmember. Tighten the nuts 28 lbf·ft (38 N·m).

5. Install the windshield wiper pan. See **Fig. 15**.

5.1 Position the pan by tucking it up under the lower edge of the windshield trim.

5.2 Install the fresh air intake snorkel.

5.3 Install the screws that hold the pan to the firewall.

5.4 Install the surge tank. For instructions, refer to the engine cooling group of this manual.

5.5 Install the wiper arms. For instructions refer to the cab group of this manual.

6. Install the power steering pump. See **Fig. 5**.

7. Remove the tie straps that hold the alternator against the engine, and adjust the alternator drive belt to the correct tension. For adjustment instructions, refer to the drive belt section in this service manual group.

8. Install the fan blades on the engine. For the applicable fastener torque, refer to **Group 20** of this service manual.

9. Connect the engine electrical connectors.

9.1 Connect the wiring harness to the coolant temperature gauge sensor. See **Fig. 14**.

9.2 Connect the wiring harness to the coolant temperature warning light switch. See **Fig. 14**.

9.3 Connect the wiring harness to the tachometer sensor on the engine flywheel housing.

9.4 Connect the wiring harness to the ECM. See **Fig. 13**.

9.5 Connect the wiring harness to the starter motor and solenoid.

9.6 Connect the wiring harness to the alternator. See **Fig. 12**.

9.7 Install the horn and horn stand-off bracket. See **Fig. 11**.

10. Connect the fuel and oil components.

10.1 Connect the oil pressure gauge sensor line behind the alternator.

10.2 Connect the fuel supply line at the fuel transfer pump. See **Fig. 10**.

11. Install the radiator and aftercooler assembly.

NOTE: Before lifting the radiator and aftercooler, be sure the upper radiator isolator is in the underslung radiator mount.

Removal and Installation

11.1 Hook a lifting chain to the top of the radiator and aftercooler assembly, and fasten the chain to a crane. Lift the radiator and aftercooler, and position the assembly on the radiator mount. See **Fig. 8**.

11.2 Install the lower radiator isolator, and install the nut on the radiator mounting stud. Tighten the nut 241 lbf·ft (327 N·m).

11.3 Install the right-side radiator brace strut.

11.4 Remove the lifting chains from the radiator and aftercooler assembly.

12. Connect the air compressor. See **Fig. 7**.

12.1 Connect the air outlet line to the top of the compressor.

12.2 Connect the two air signal lines to the air governor.

13. Install the refrigerant compressor and condenser.

13.1 Remove the tie straps and protective coverings, and carefully move the compressor and condenser back into their operating positions.

13.2 Install the fasteners that hold the condenser to the aftercooler. Tighten the fasteners 15 lbf·ft (20 N·m).

13.3 Install the fasteners that hold the compressor mounting bracket to the engine. See **Fig. 5**. Connect and adjust the compressor drive belt. For instructions, refer to the drive belt section in this manual.

13.4 Connect the radiator brace rods to the top left corner of the radiator. See **Fig. 2**. Tighten the mounting fasteners 68 lbf·ft (92 N·m).

13.5 Secure the power steering and refrigerant lines with clamps.

13.6 Install the left-side air recirculation baffle on the radiator.

14. Connect the coolant hoses. See **Fig. 2** or **Fig. 3**.

14.1 Connect the heater inlet hose to the bottom of the water pump.

14.2 Connect the heater outlet hose to the oil cooler.

14.3 Connect the coolant fill pipe to the top of the water pump.

14.4 Connect the vent hoses to the radiator and the engine.

14.5 Connect the coolant inlet and outlet hoses to the radiator.

15. Install the exhaust ducting.

15.1 Remove the lower mounting bolt from the rear engine lifting eye, and install the exhaust duct support bracket and the length of duct between the turbocharger and the exhaust flex pipe.

15.2 Connect the duct to the exhaust flex pipe, and tighten the wide band clamp.

15.3 Connect the duct to the rear of the turbocharger and tighten the V-band clamp 85 lbf·in (940 N·cm). See **Fig. 3**.

16. Install the air cleaner and air intake ducting.

16.1 Position the air cleaner on its mounting bracket, and secure it with four nuts and washers. Tighten the nuts 28 lbf·ft (38 N·m).

16.2 Fasten the right-side air recirculation shield to the air cleaner housing.

16.3 Install the hose and metal duct between the air cleaner and the turbocharger.

16.4 Install the hoses and convoluted tubing between the turbocharger and the aftercooler, and between the aftercooler and the engine intake manifold. Tighten the constant-torque hose clamps 60 lbf·in (680 N·cm).

17. Install the right fender splash shield.

18. Make sure the coolant drains in the water pump and the radiator are closed, and then fill the engine and cooling system with coolant. Refer to the vehicle maintenance manual for the correct coolant type and quantity.

19. Install the hood, bumper, and left front half-fender. For instructions, refer to the applicable group in this service manual.

20. Install the transmission on the engine. For instructions, refer to **Group 26** in this service manual.

21. Connect the batteries, or if applicable, turn on the battery shutoff switch.
22. Start the engine, and check for leaks. Repair any leaks found.
23. Test drive the vehicle.

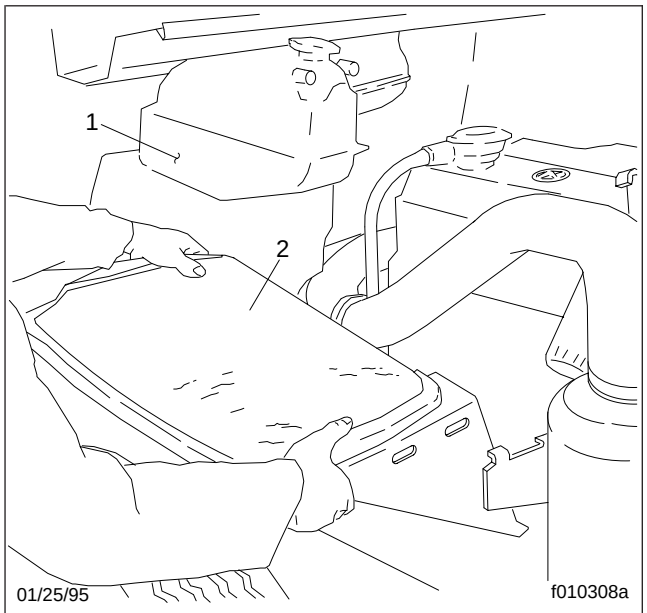
Removal

WARNING

WARNING: The fuel system is under pressure whether or not the engine is running or shut down. Always release the pressure from the fuel system before servicing any fuel supply or fuel return system component. Servicing a pressurized system could cause fuel to spray, leading to personal injury or property damage.

IMPORTANT: Before beginning this procedure, get a Chrysler fuel pressure gauge tool set 5069. You will need these tools to release the fuel system pressure.

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the hood. For instructions, see **Group 88**.
4. Remove the right fender splash shield. See **Fig. 1**.



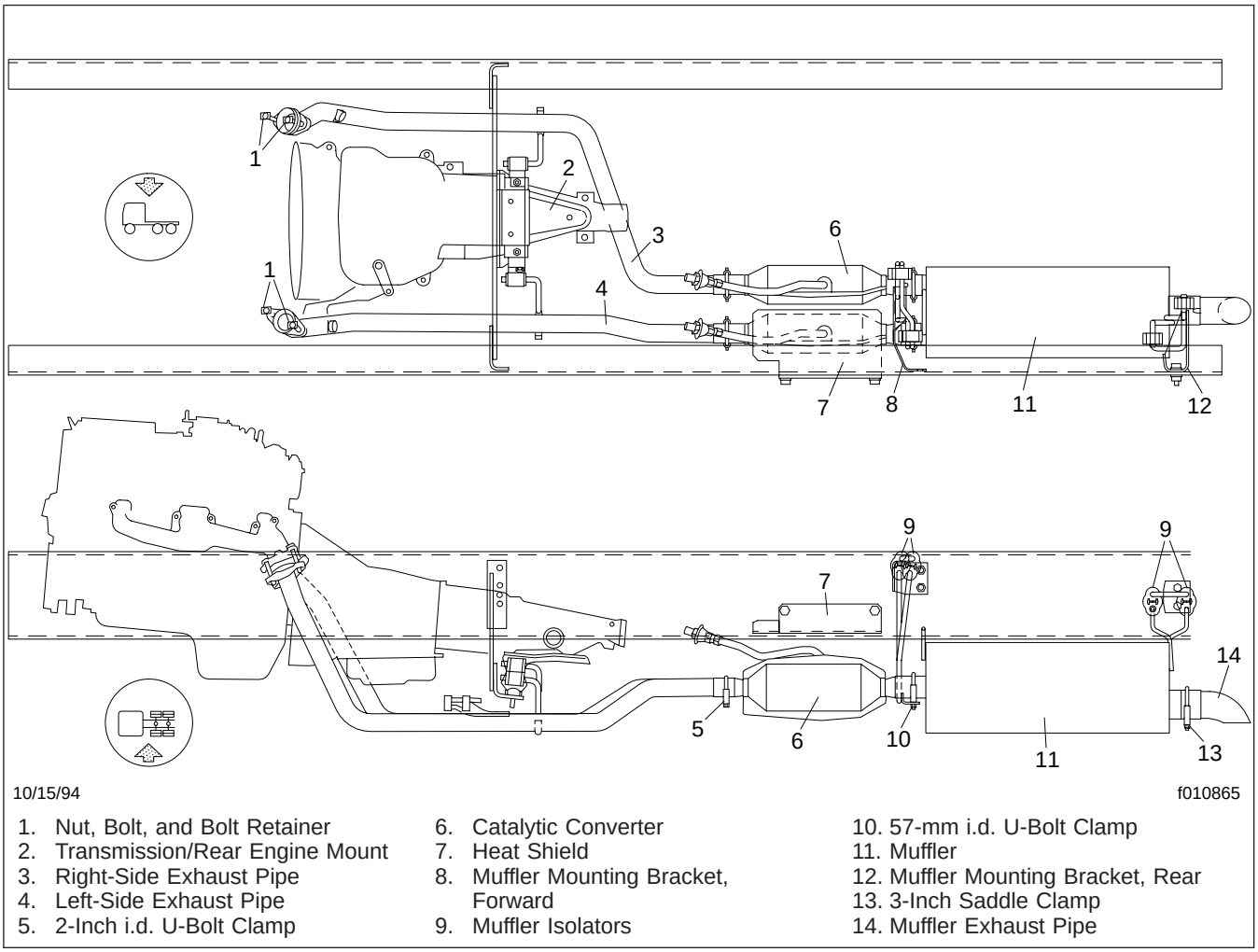
1. Surge Tank
2. Splash Shield

Fig. 1, Right Fender Splash Shield, Typical Installation

5. Remove right and left bumper extensions.
6. Use engine stands to support the rear of the engine, and remove the transmission. See **Group 26** for instructions. Removing the transmission requires removing the exhaust pipes. See **Fig. 2**.
7. Disconnect the air outlet hose from the air injection pump. See **Fig. 3**.
8. Remove the horn and bracket assembly from the right frame rail.
9. Remove the air cleaner housing. See **Fig. 4** . For complete removal instructions, see **Group 09**.
10. Disconnect the throttle cable from the throttle body cam. See **Fig. 5**.
    - 10.1 Remove the tie strap that holds the cable housing to the refrigerant line.
    - 10.2 Roll the throttle body cam, by hand, from idle to full throttle. Slip the pin on the end of the cable from the hole in the throttle body cam, and remove the cable from the cam. See **Fig. 6**.
    - 10.3 Loosen the cable clamp nuts on either side of the throttle body mounting bracket. See **Fig. 7**. Lift the cable out of the bracket, and move the cable aside.
11. Remove the fan blade and the fan shroud. See **Fig. 8**.
    - 11.1 Loosen the six self-tapping screws that hold the fan shroud to the rear of the radiator, and move the shroud back against the engine.
    - 11.2 Place a bar or screwdriver between the water pump pulley bolts to keep the pulley from turning. Then, use a wrench to turn the fan hub nut counterclockwise as viewed from the front of the vehicle.

      Unscrew the fan hub nut from the engine shaft, and remove the fan clutch from the engine.
    - 11.3 Remove the fan and the fan shroud as a unit.

Removal and Installation



1. Nut, Bolt, and Bolt Retainer
2. Transmission/Rear Engine Mount
3. Right-Side Exhaust Pipe
4. Left-Side Exhaust Pipe
5. 2-Inch i.d. U-Bolt Clamp
6. Catalytic Converter
7. Heat Shield
8. Muffler Mounting Bracket, Forward
9. Muffler Isolators
10. 57-mm i.d. U-Bolt Clamp
11. Muffler
12. Muffler Mounting Bracket, Rear
13. 3-Inch Saddle Clamp
14. Muffler Exhaust Pipe

Fig. 2, Exhaust System, Dodge Magnum Engine

⚠ WARNING

Do not drain coolant from a hot engine. Opening the cooling system when the engine and coolant are hot can cause severe personal injury due to scalding by the hot, pressurized coolant.

12. Remove the radiator. See **Fig. 9**.

12.1 Drain the radiator; then mark and disconnect the coolant hoses and vent hose from it.

12.2 Disconnect the hoses from the transmission oil cooler.

12.3 Remove the hose standoff bracket from the rear stud on the left-side radiator mount.

12.4 Support the transmission oil cooler and refrigerant condensor; then remove the four nuts that hold the cooler and condenser to the front of the radiator. Remove the transmission oil cooler, and set it aside. Keep it upright to avoid spilling any transmission fluid. Swing the condenser to the side, and out of the way.

12.5 Remove the bolts that attach the bottom of the air recirculation shields to the radia-

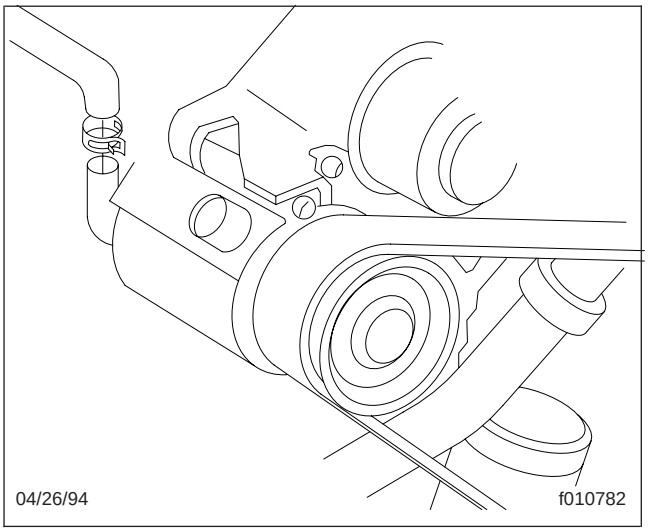


Fig. 3, Air Injection Pump Hose

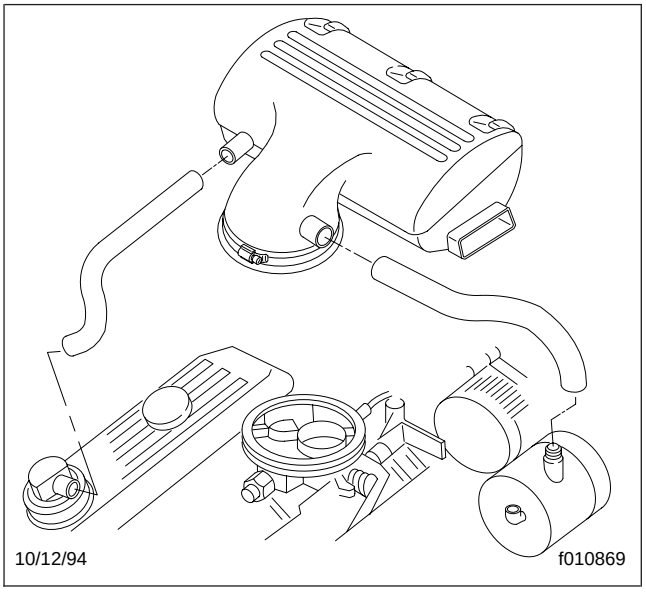


Fig. 4, Air Cleaner Installation, Dodge Magnum Engine

tor side-channels; then remove the shields. See **Fig. 10**.

12.6 Remove the hose bracket from the right-side radiator strut.

12.7 Disconnect the left-side radiator strut from the framerail bracket.

12.8 From underneath the vehicle, mark, then disconnect the coolant hoses from the engine oil cooler. See **Fig. 11**.

12.9 Remove the four nuts holding the radiator to the radiator-mount studs; then remove the radiator.

13. Disconnect the coolant hoses from the water pump. See **Fig. 12**.

14. Remove the accessory drive belt.

14.1 Place a 5/8-inch wrench over the pulley bolt on the automatic belt tensioner, and turn the wrench counterclockwise to relax the belt tensioner. See **Fig. 13**.

14.2 Remove the engine accessory drive belt.

15. Disconnect the wiring from the engine.

15.1 Disconnect the 60-pin connector from the power train control module on the bulkhead.

15.2 Mark, then disconnect the three multi-pin connectors and one single-pin connector at the rear, right side of the engine.

15.3 Disconnect the ground strap from the engine block.

15.4 Mark, then disconnect the wiring from the starter motor.

16. Disconnect the heater hoses. See **Fig. 14** .

16.1 Disconnect the heater supply hose at the rear of the engine.

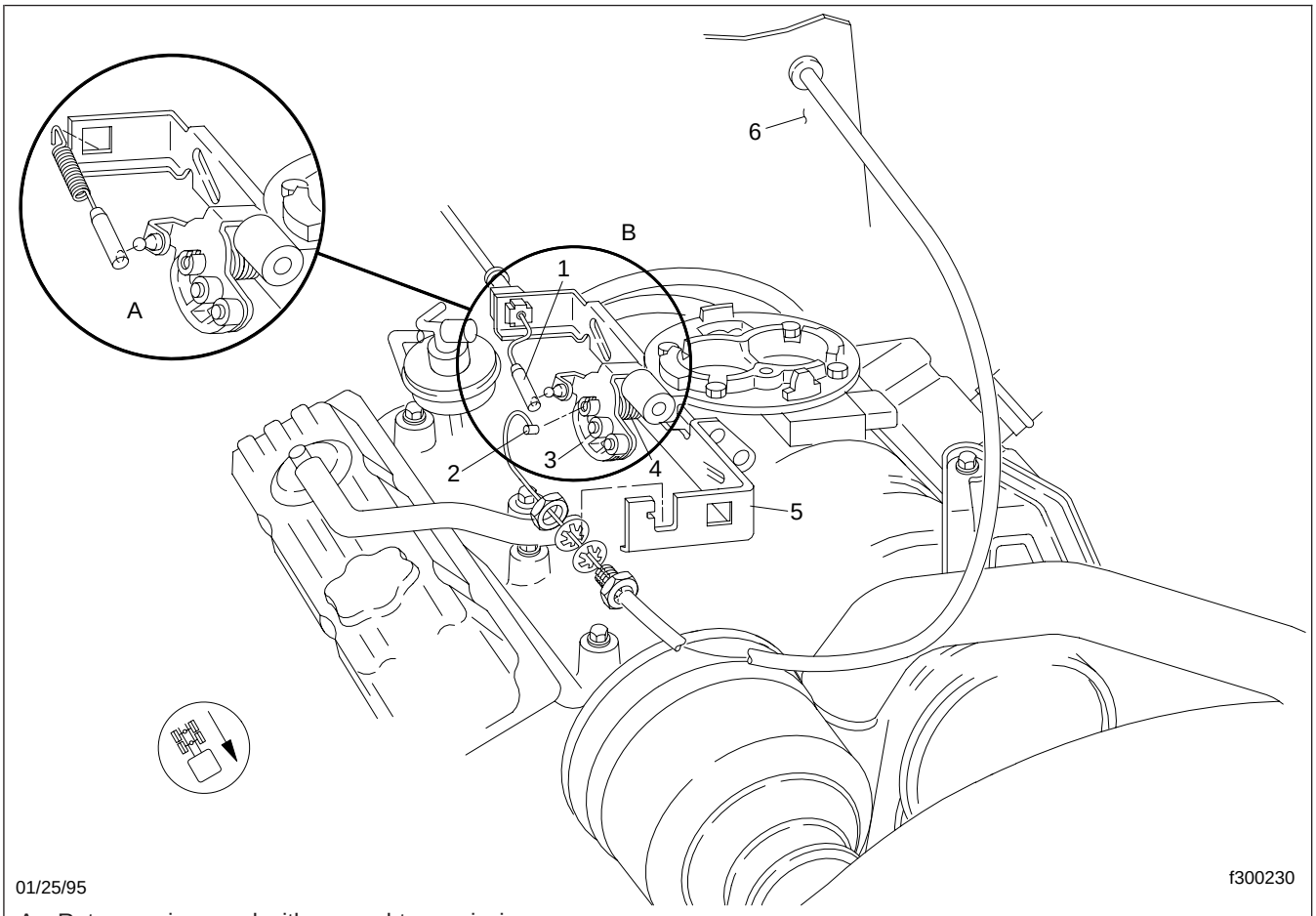
16.2 Disconnect the heater return hose from the front of the engine.

⚠ WARNING

WARNING: The fuel system is under pressure whether or not the engine is running or shut down. Always release the pressure from the fuel system before servicing any fuel supply or fuel return system component. Servicing a pressurized system could cause fuel to spray, leading to personal injury or property damage.

17. If not already done, release the pressure from the fuel system, and disconnect the fuel line at the engine.

Removal and Installation



A. Return spring used with manual transmission.
B. Transmission throttle valve cable used with automatic transmission.

1. Transmission Throttle Valve Cable (Automatic Transmissions Only)
2. Throttle Cable
3. Throttle Body Cam
4. Throttle Pedal Return Spring
5. Throttle Body Mounting Bracket
6. Firewall

Fig. 5, Throttle Cable from Firewall To Throttle Body Lever

⚠ WARNING

WARNING: Wear eye protection when releasing fuel system pressure, and do not let fuel spill onto the engine intake or exhaust manifolds. Place shop towels under and around the pressure port to absorb fuel when the pressure is released. Spilled fuel or lack of eye protection could lead to personal injury or property damage.

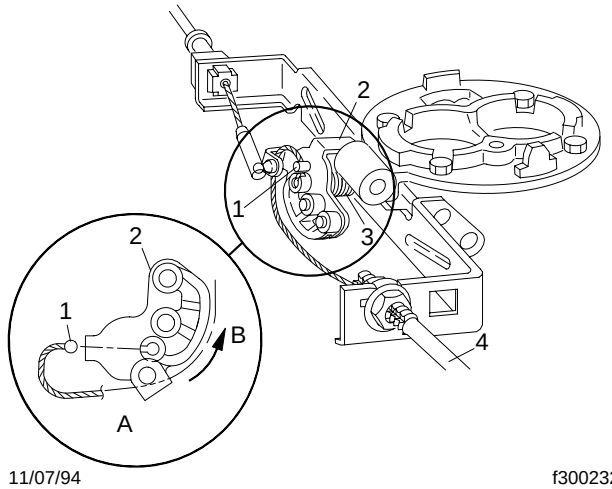
17.1 If not already done, disconnect the negative battery cable.

17.2 Remove the fuel tank caps to release fuel tank pressure.

17.3 Unscrew the protective plastic cap from the pressure test port (schrader valve) on the fuel rail. See **Fig. 15**.

17.4 Obtain the fuel pressure gauge/hose assembly from a Chrysler fuel pressure gauge tool set 5069. Remove the gauge from the hose.

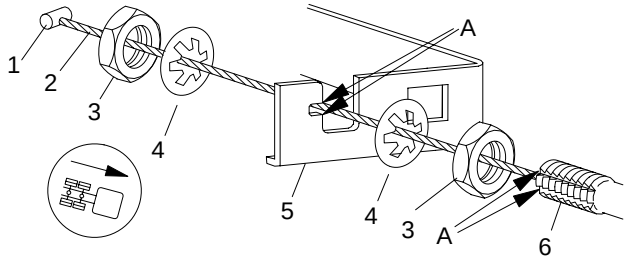
17.5 Place the gauge end of the hose into an approved gasoline storage container.



11/07/94 f300232

A. View of Wide-Open Throttle
B. Rotate to full throttle.
1. Cable Pin
2. Throttle Body Cam
3. Throttle Pedal Return Spring
4. Throttle Cable

Fig. 6, Throttle Cable Attachment to Throttle Body Cam



10/28/94 f300235

A. Turn the grooves in the cable housing outboard to align with the bracket points.
1. Throttle Cable Pin
2. Throttle Cable
3. Cable Clamp Nut
4. Toothed Lockwasher
5. Throttle Body Mounting Bracket
6. Threaded Cable Housing

Fig. 7, Throttle Cable Attachment to Throttle Body Bracket

17.6 Place a shop towel under the test port.

17.7 To release the fuel system pressure, screw the other end of the hose onto the fuel pressure test port.

17.8 After the fuel pressure has been released, remove the hose from the test port, and install the protective cap on the fuel test port.

17.9 Disconnect the fuel supply lines from the fuel racks.

18. Disconnect the power steering hoses from the power steering pump; then remove the hose bracket from the radiator strut bracket. Move the hoses and bracket out of the way.

19. Remove the refrigerant compressor. See **Fig. 16**.

19.1 Loosen the five bolts that hold the compressor to the engine.

19.2 Mark and disconnect the wiring from the compressor.

19.3 Leaving the refrigerant hoses attached to the compressor, lift it off the engine, and move it to the side.

20. From underneath the vehicle, disconnect the oil pressure sensor line from the rear of the engine. See **Fig. 17**.

21. Attach the lifting chains to the engine.

⚠ WARNING

WARNING: The crane, lifting eyes, and lifting chain used to remove the engine must be capable of safely lifting and supporting two metric tons. Once the engine mounts are disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine, or an engine lifted with unsuitable tools may fall, causing personal injury or death, and component damage.

21.1 Remove and save the upper inboard hexbolt from the power steering pump bracket; then install a 3/8-inch x 1-3/4-inch hexbolt and lifting eye in its place. Tighten the bolt firmly. See **Fig. 18**.

21.2 At the rear right-side of the engine, use a 3/8 x 1-1/4 inch hexbolt to install a second lifting eye in one of the blank holes on the engine head. See **Fig. 17**.

21.3 Attach a lifting chain to the lifting eyes.

Removal and Installation

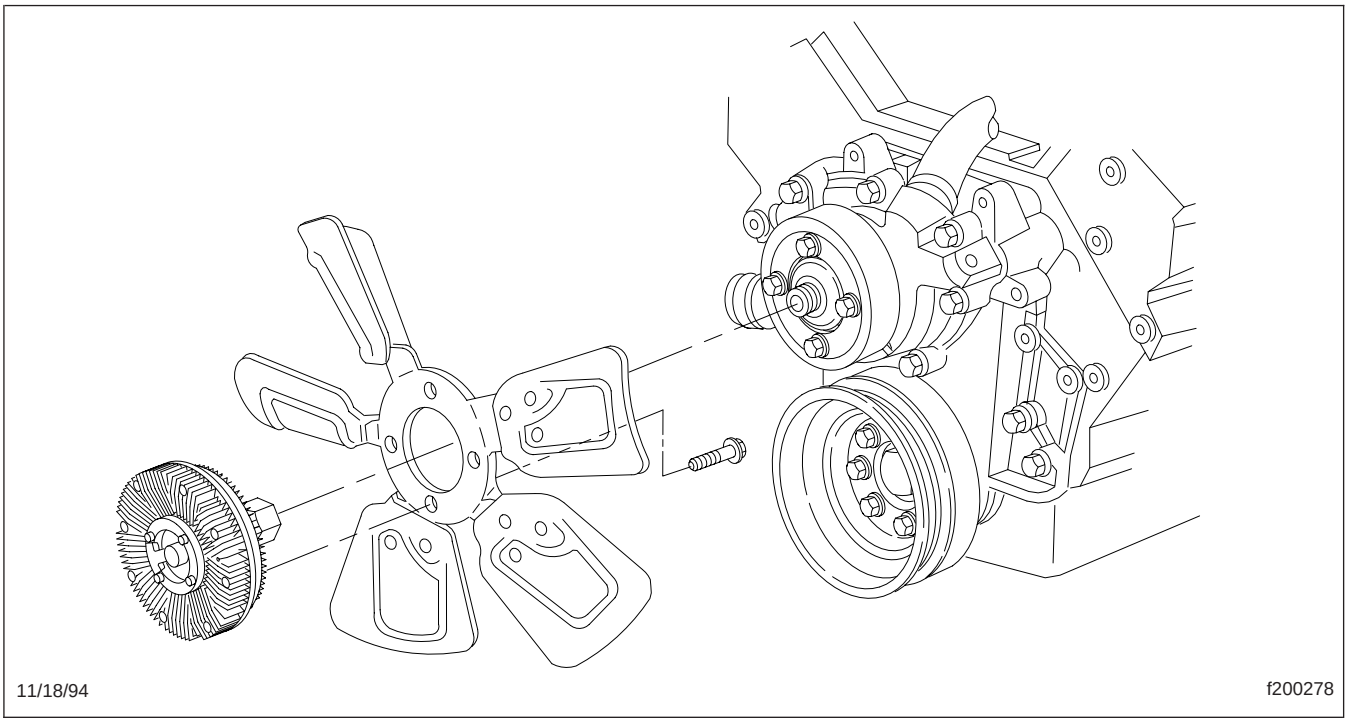


Fig. 8, Fan Clutch Mounting for Dodge Magnum V-8 Engine

21.4 Attached the chain to a suitable lifting device, and raise the chain to remove any slack.

22. Disconnect the engine from the engine mounts.

22.1 Remove the nut and washer from each of the two bolts that run through the engine legs, rubber isolators, and engine mounts.

22.2 Back out the bolts.

23. Lift the engine from the vehicle. Lower it onto suitable stands.

Installation

WARNING

WARNING: The crane, lifting eyes, and lifting chain used to remove the engine must be capable of safely lifting and supporting two metric tons. Once the engine mounts are disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine, or an engine lifted with unsuitable tools may fall, causing personal injury or death, and component damage.

1. Install the engine on the engine mounts.

1.1 With an engine stand in place to support the rear of the engine, lower the engine into the engine compartment so the engine legs align with the engine mounts.

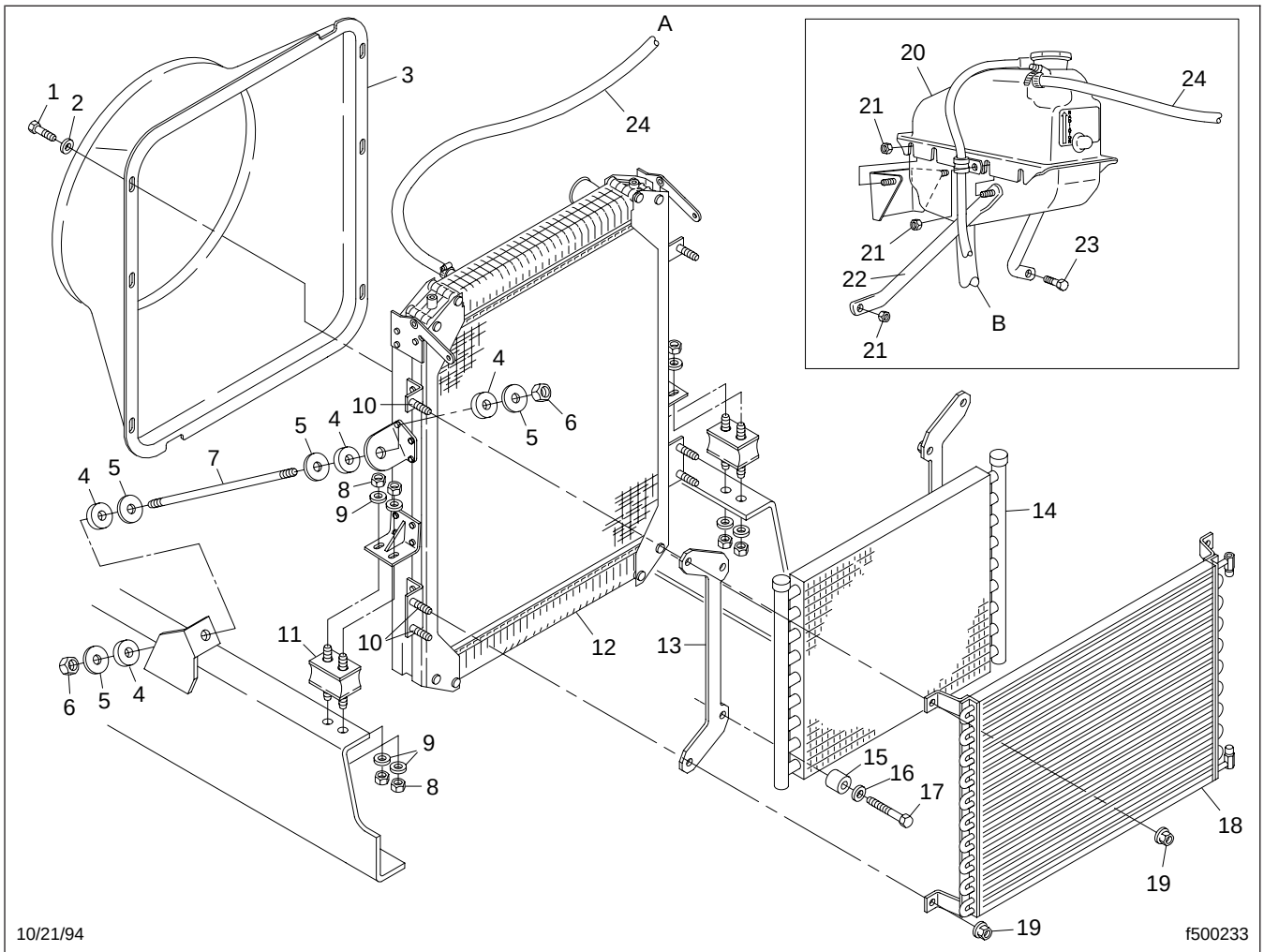
1.2 Run bolts through the engine mounts, rubber isolators, and engine legs. See **Fig. 19** and **Fig. 20**.

1.3 Secure each bolt with a flatwasher and nut, and torque each nut 54 to 68 N·m (40 to 50 lbf·ft).

1.4 Install the transmission. See **Group 26** for instructions.

1.5 Remove the lifting eyes and chains from the engine.

1.6 Install the bolt removed earlier from the power steering pump bracket on the front of the engine.



A. to surge tank
B. to water pump

1. 1/4-20 Screw
2. 1/4 Inch Washer
3. Fan Shroud
4. Radiator Strut Isolator
5. 15/32-Inch Inside Diameter Washer
6. 7/16-14 Hex Nut
7. Radiator Strut
8. 3/8-16 Hex Nut
9. 3/8 Inch Washer
10. 5/16-18 Stud
11. Radiator Mount Isolator and Studs
12. 720-Square-Inch Radiator
13. Transmission Oil Cooler Mounting Bracket
14. Transmission Oil Cooler
15. Transmission Oil Cooler Isolator
16. 5/16 Inch Washer
17. 5/16-18 Capscrew
18. Condensor
19. 5/16-18 Hex Nut
20. Surge Tank
21. M10 Nut
22. Surge Tank Brace
23. M10x20 Flanged Head Bolt
24. Radiator Vent Hose

Fig. 9, Radiator Assembly

2. Connect the air outlet hose to the air injection pump.
3. Connect the hoses to the water pump.
4. Connect the coolant lines to the oil cooler.
5. Connect the wiring to the engine.
   - 5.1 Install the ground strap to the engine block.
   - 5.2 Connect the three multi-pin connectors and the single-pin connector to the main

Removal and Installation

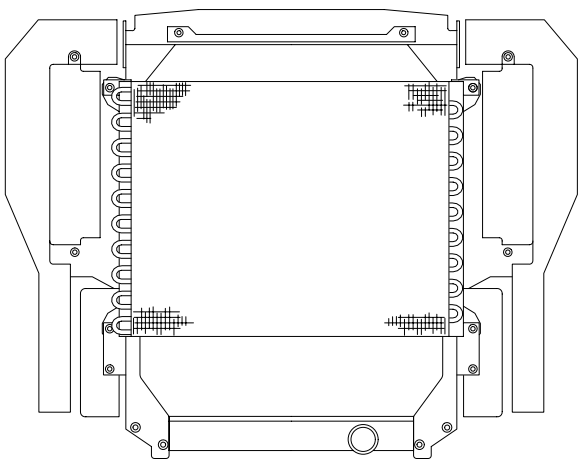
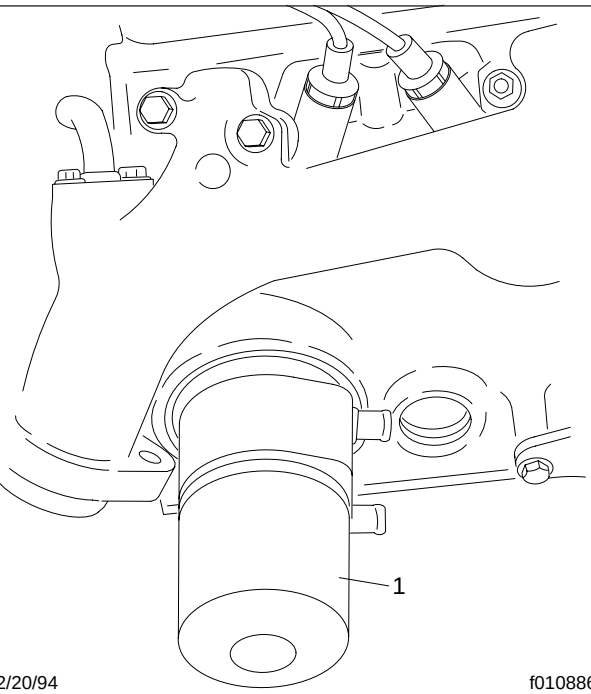


Fig. 10, Air Recirculation Shields Around the Radiator



1. Engine Oil Cooler (hoses disconnected)

Fig. 11, Engine Oil Cooler

wiring harness on the passenger side of the firewall.

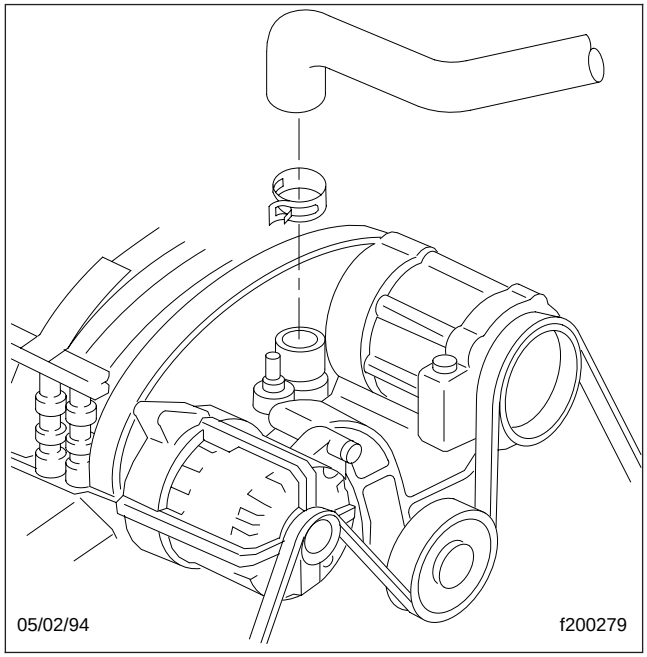
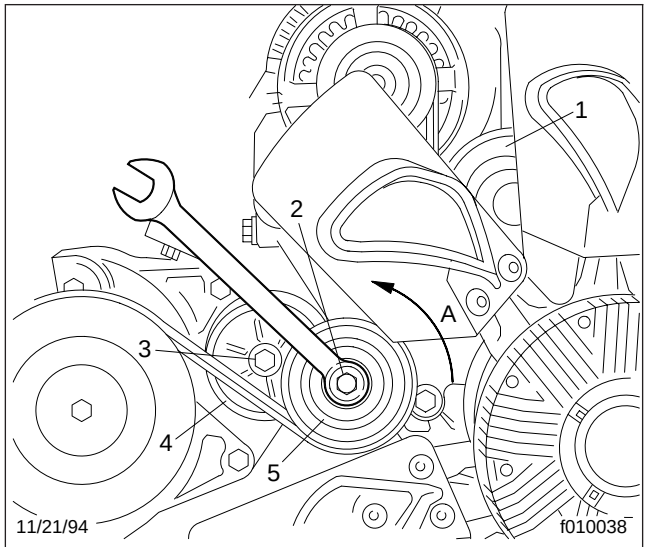
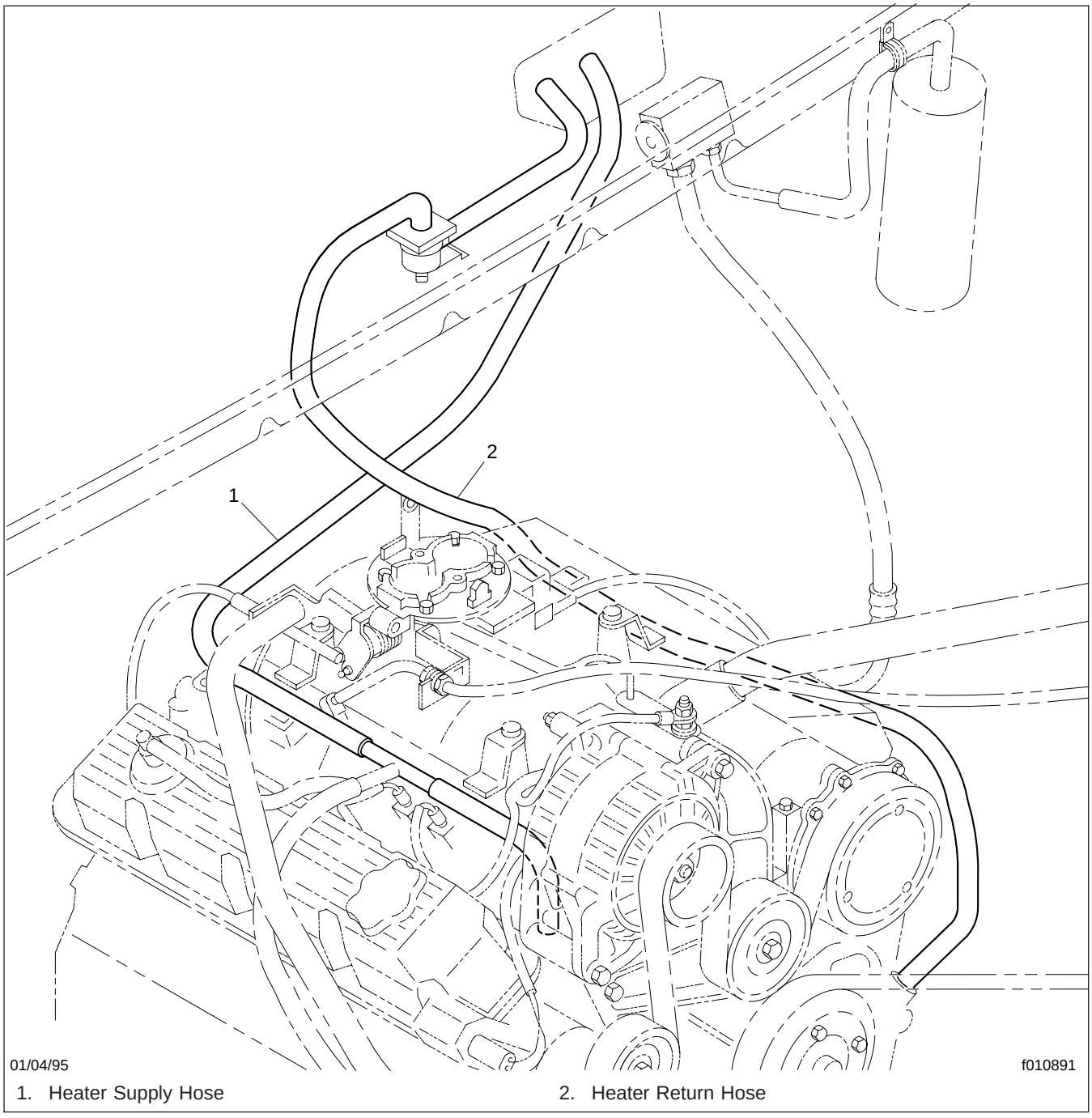


Fig. 12, Water Pump Outlet Hose, Removed



A. Turn counterclockwise to remove the belt.
1. Idler Pulley
2. Tensioner Pulley Bolt
3. Tensioner Mounting Bolt
4. Tensioner
5. Tensioner Pulley

Fig. 13, Accessory Drive Belt



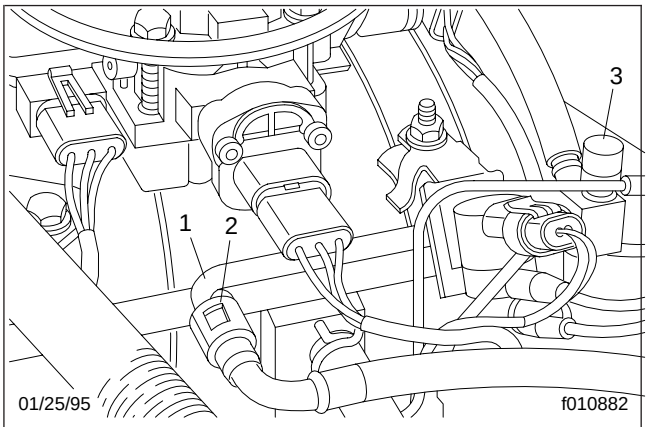
1. Heater Supply Hose
2. Heater Return Hose

Fig. 14, Heater Hoses

5.3 Connect the 60-pin connector to the powertrain control module (PTCM) on the bulkhead.

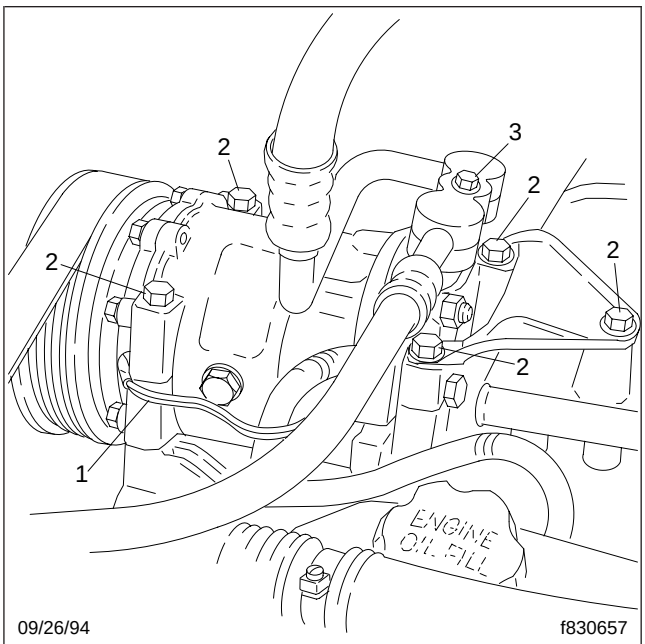
6. Install the refrigerant compressor onto the engine. Tighten the bolts 27 N·m (20 lbf·ft).
7. Connect the wiring to the refrigerant compressor.

Removal and Installation



1. Fuel Rail
2. Fuel Supply Line
3. Pressure Test Port Plastic Cap

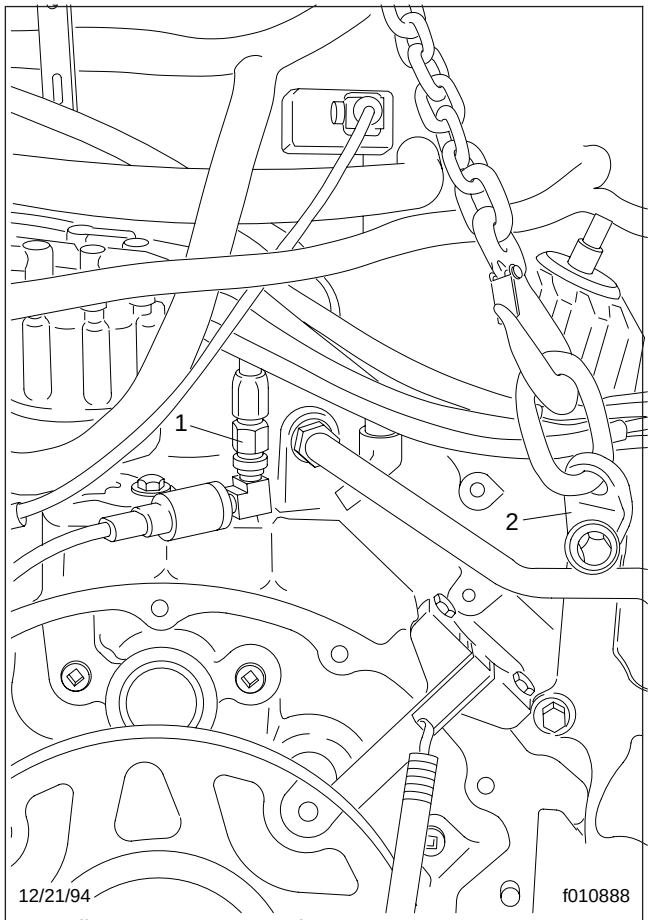
Fig. 15, Fuel Supply Line Connection



1. Clutch Electrical Wire
2. Compressor Mounting Fasteners
3. Junction Block Mounting Fastener

Fig. 16, Refrigerant Compressor Mounting

8. Connect the power steering hoses to the power steering pump.
9. Connect the throttle cable to the throttle body cam.



1. Oil Pressure Sensor Line
2. Rear Engine Lifting Eye

Fig. 17, Oil Pressure Sensor

⚠ CAUTION

CAUTION: Make sure the drive belt is installed correctly. Incorrect installation could cause the water pump pulley to rotate in the wrong direction, which could result in extensive damage to the engine from overheating.

10. Install the accessory drive belt. For belt routing instructions, see **Section 01.00**.
    - 10.1 Place a 5/8-inch wrench over the pulley bolt on the automatic belt tensioner, and turn the wrench counterclockwise to relax the belt tensioner. See **Fig. 13**.
    - 10.2 Install the belt.

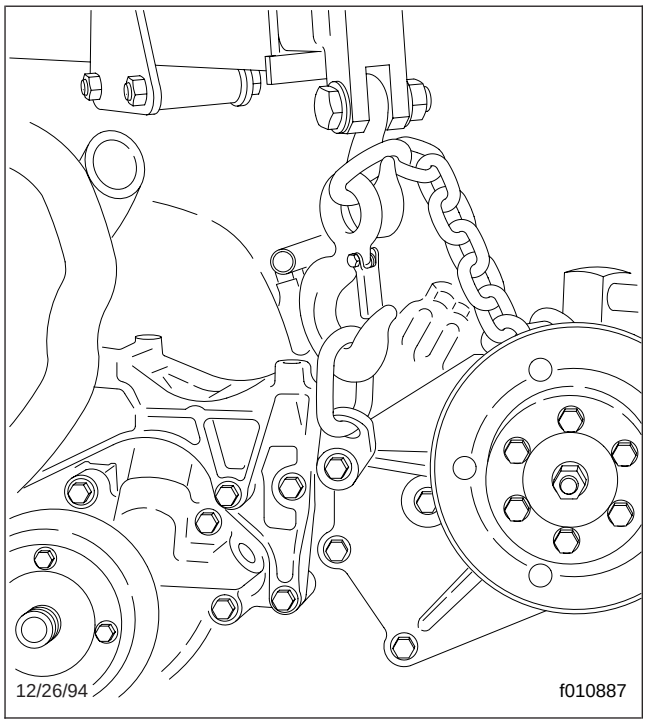


Fig. 18, Front Engine Lifting Eye

11. Connect the fuel line to the fuel rail.
12. Connect the wiring to the starter motor.
13. Connect the power lead to the alternator. See **Fig. 21**.
14. Put the fan and clutch assembly inside the fan shroud; then install the fan and clutch assembly onto the fan pulley. Tighten the nut 57 N·m (42 lbf·ft).
15. Install the radiator.
    - 15.1 Install the radiator onto the four mounting-bracket studs.
    - 15.2 Install the rear ends of the radiator support struts in the holes of the brackets on the frame rail.
    - 15.3 Install a rubber isolator, washer and nuts on the end of each strut. Tighten the nuts 47 N·m (35 lbf·ft).
    - 15.4 Install the four radiator mounting locknuts and washers, and tighten them 40 N·m (30 lbf·ft).
16. Install the fan shroud onto the radiator side channels, using the six self-tapping screws and washers
17. Install the air recirculation shields, the transmission oil cooler, and the condenser in front of the radiator. The upper mounting studs attach all three components to the radiator.
18. Connect the hoses to transmission oil cooler.
19. Install the transmission oil cooler hose stand-off bracket onto the rear stud of the driver's side radiator mounting bracket.
20. Connect the coolant hoses to the radiator. See **Fig. 22**.
21. Install the hose from the power steering reservoir to the power steering pump.
22. Connect the heater supply and return hoses.
23. Install the horn and mounting bracket assembly on the right frame rail. Make sure the nuts are facing outboard. Connect the wiring to the horn.
24. Install the air filter assembly and its gasket onto the throttle body. Make sure the stud on the intake manifold fits into the hole at the front underside of the air filter.
25. From behind the engine, connect the oil pressure sensor line to the engine. See **Fig. 17**.
26. Install the hood. See **Group 88** for instructions.
27. Install the bumper extensions.
28. Close the hood, then remove the chocks from the tires.

Removal and Installation

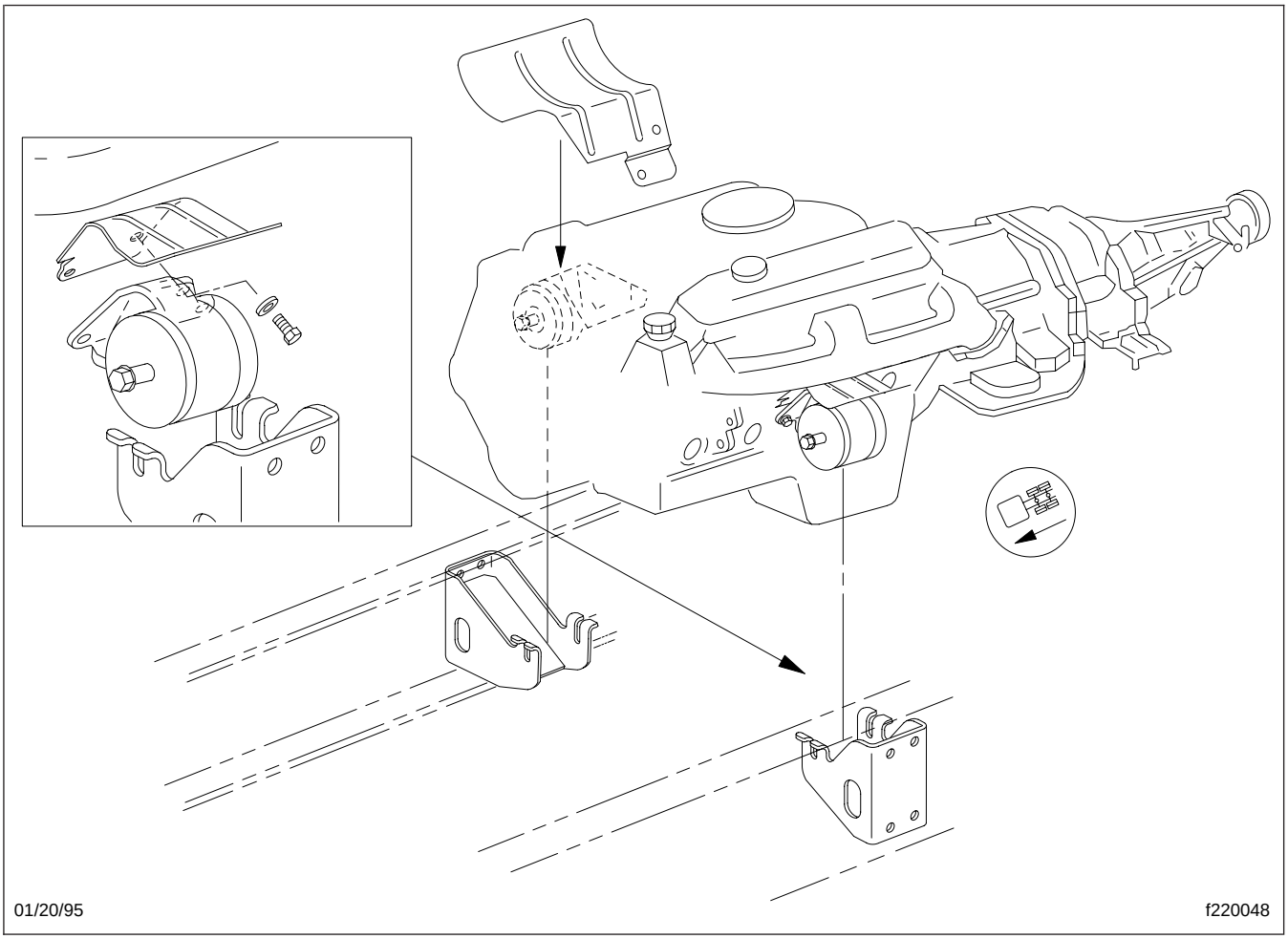
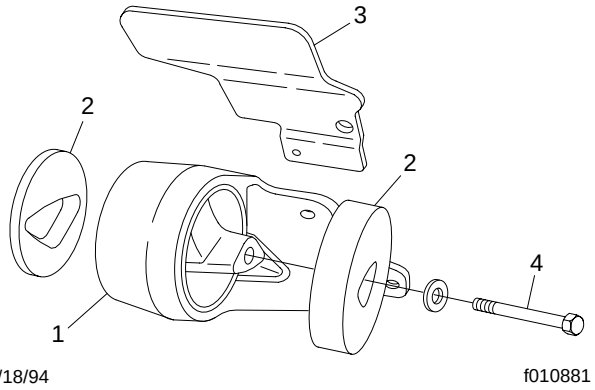
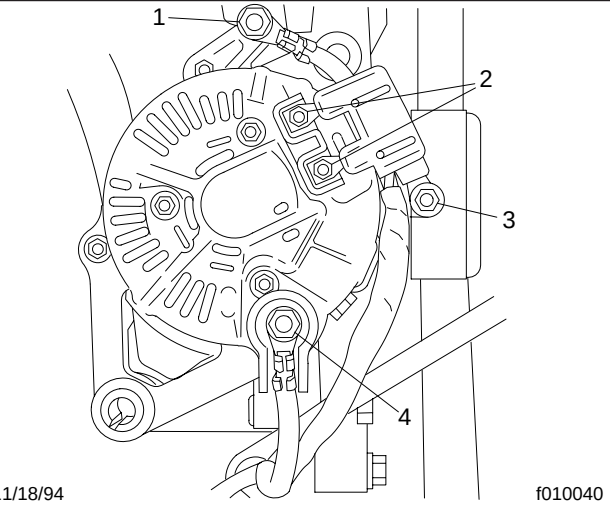


Fig. 19, Engine Placement on Front Engine Mounts



1. Engine Leg (mounted on engine)
2. Isolator
3. Heat Shield
4. 1/2-13 x 6, Grade 8 Capscrew

Fig. 20, Front Engine Mount Assembly



1. Ground Terminal
2. Field Terminals
3. Wiring Harness Holddown
4. Power Terminal

Fig. 21, Alternator Wiring Connections

Removal and Installation

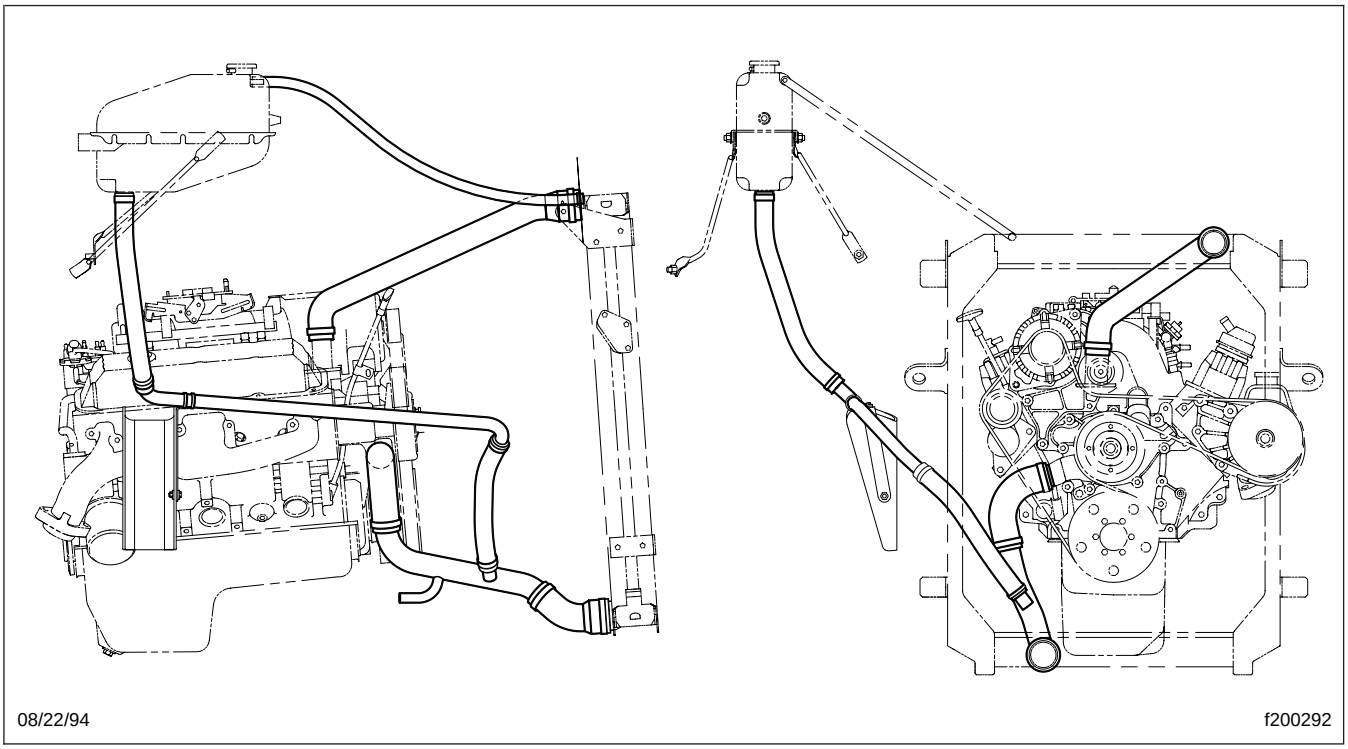


Fig. 22, Radiator Plumbing, Dodge Magnum Engine

Removal

NOTE: For engine wiring diagrams, refer to the applicable section in **Group 54**. For trouble-shooting procedures, refer to **Section 54.02** for the Kysor Warning and Engine-Shutdown System.

1. Apply the parking brakes, chock the tires, and drain the air system.
2. Disconnect the batteries.
   - 2.1 Disconnect the battery ground cable at the vehicle frame.
   - 2.2 Disconnect the positive battery cable from the batteries.
3. Remove the hood and bumper. For instructions, refer to **Group 88** in this service manual.

⚠ WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

4. Drain the radiator.
   - 4.1 Place a suitable container under the driver's side corner of the radiator. See **Fig. 1**.
   - 4.2 Remove the surge tank cap.
   - 4.3 Unscrew the plug in the bottom of the radiator.

     After the coolant has drained, screw the plug into the radiator, and tighten it firmly.
5. Remove the air cleaner housing.
   - 5.1 Remove the right fender splash shield. See **Fig. 2**.
   - 5.2 Remove the air compressor intake hose that runs from the engine air intake hose to the compressor. See **Fig. 3**.
   - 5.3 Remove the air intake hoses that run between the air cleaner housing and the turbocharger, and remove the hoses that run between the turbocharger and the charge air cooler, and between the charge air cooler and the engine.

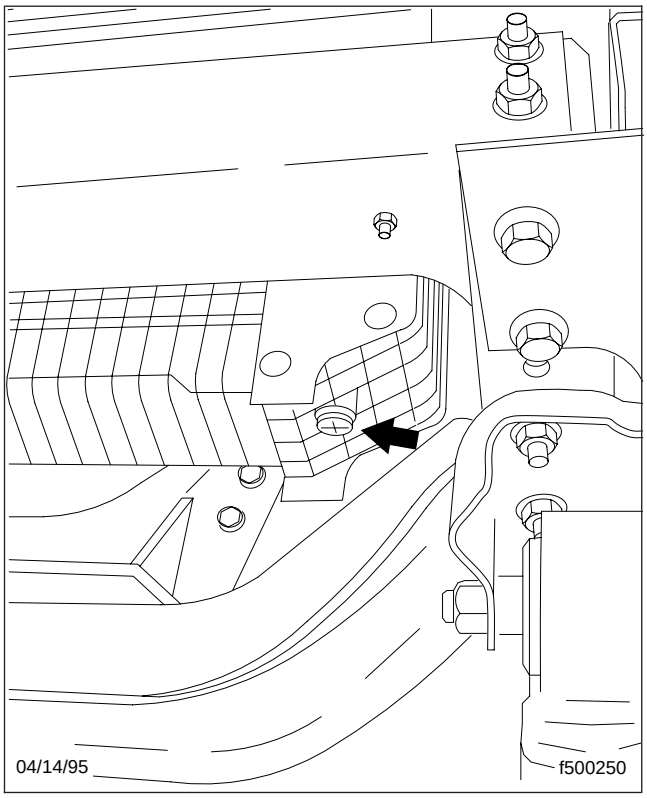
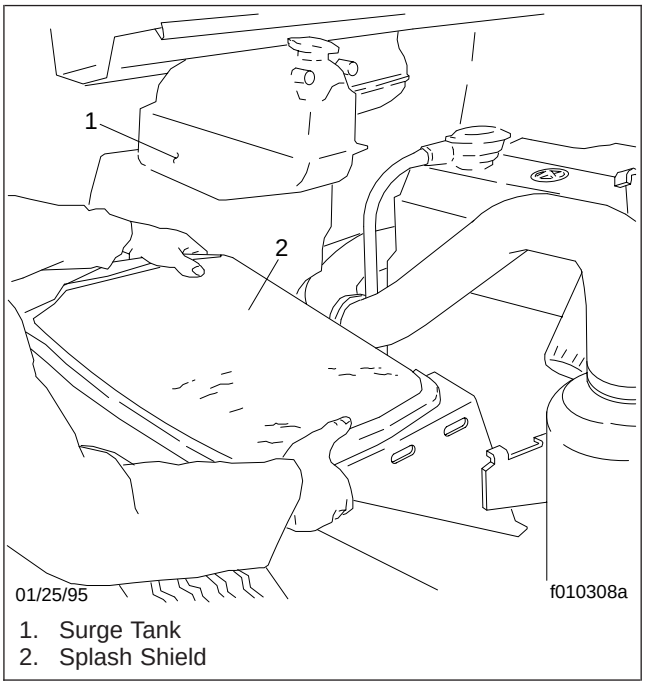


Fig. 1, Radiator Drain Plug

   Leave the A-shaped bracket that held the air intake piping to the top of the engine.
   - 5.4 Disconnect the vent lines from the radiator and the engine, and move the lines aside.
   - 5.5 Remove the radiator inlet hose from the radiator and the engine.
   - 5.6 Disconnect the radiator outlet hose from the bottom of the radiator.
   - 5.7 Disconnect the wiring to the horn.
   - 5.8 Disconnect the radiator right-hand strut from the air cleaner housing bracket.
   - 5.9 Disconnect the right-side air recirculation shield from the radiator. This includes disconnecting the two push-type fasteners that hold the shield to a bracket attached to the top of the radiator. See **Fig. 4**.

Engine Removal and Installation



1. Surge Tank
2. Splash Shield

Fig. 2, Right Fender Splash Shield, Typical Installation

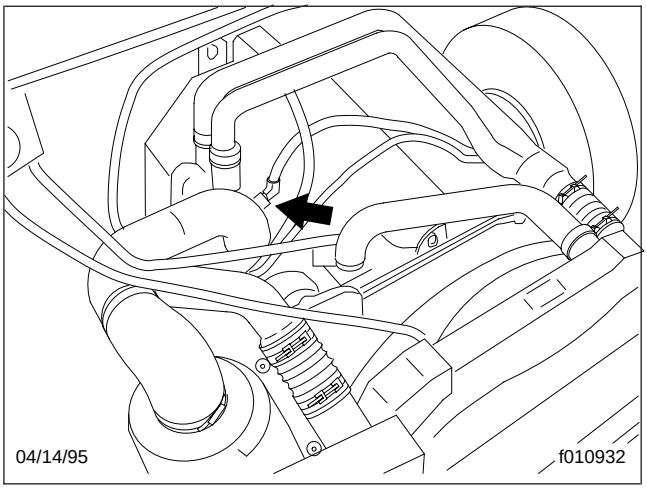


Fig. 3, Air Compressor Intake Hose

5.10 Remove the four 3/4-inch bolts that hold the air cleaner housing bracket to the frame rail.

5.11 As a unit, remove the air cleaner housing, the housing bracket, the passenger side air recirculation shield, and the horn from the vehicle.

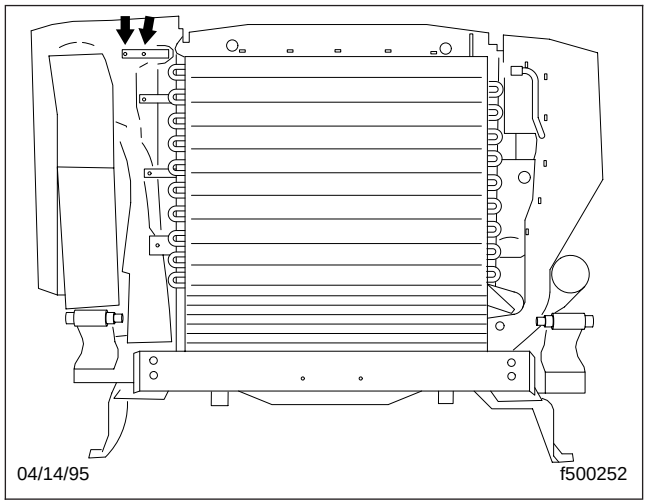


Fig. 4, Air Recirculation Shields and Fasteners

6. Remove the radiator.

6.1 Free the refrigerant lines from all routing clamps and stand-off brackets between the compressor and the condenser. See **Fig. 5**.

6.2 Remove the condenser mounting fasteners, and move the condenser aside.

6.3 Remove the left-side air recirculation shield from the radiator/charge air cooler assembly.

6.4 Disconnect the right-side radiator strut from the radiator.

6.5 Attach a lifting chain to the two rear hood attachment studs at the top of the radiator, and attach the chain to a lifting crane. See **Fig. 6**.

6.6 Disconnect the radiator/charge air cooler from its framerail mounts.

6.7 Remove the fasteners that hold the fan shroud to the radiator, and move the shroud back against the engine.

6.8 Lift the radiator/charge air cooler assembly from the vehicle.

7. Move the refrigerant compressor aside.

7.1 Disconnect the compressor wiring.

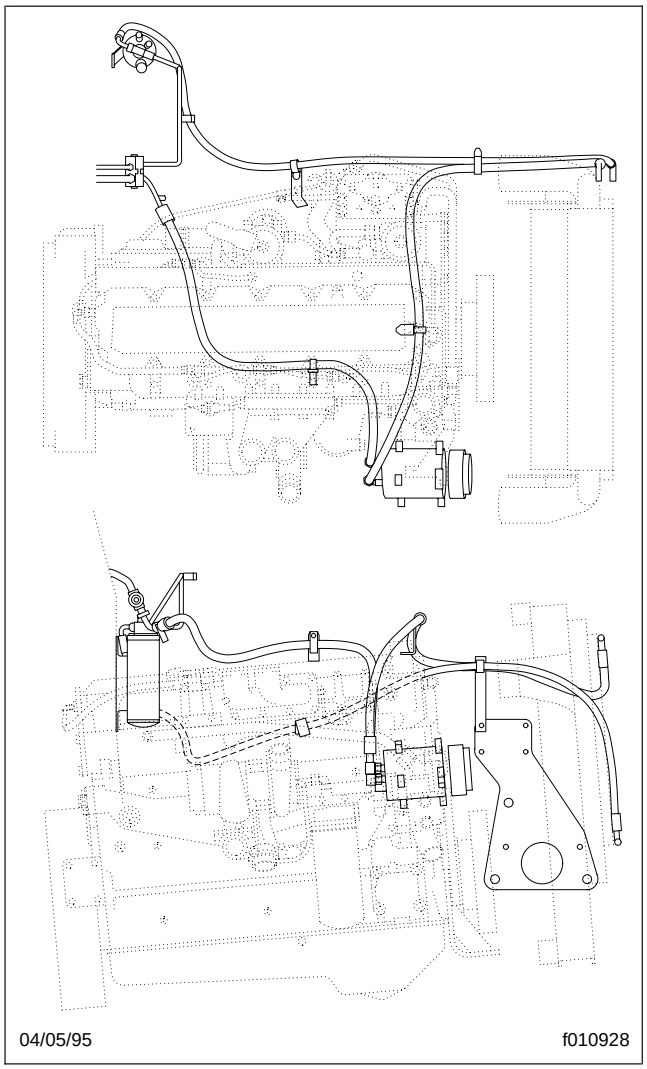


Fig. 5, Refrigerant Line Routings

7.2 Remove the accessory drive belt. For instructions, refer to **Section 01.00** in this service manual.

7.3 Remove the compressor mounting fasteners, and move the compressor aside.

7.4 Use tie straps to secure the refrigerant compressor and condenser out of the way.

8. Disconnect the heater hoses.

8.1 Disconnect the heater return hose from the water pump, and move the hose aside. See **Fig. 7**.

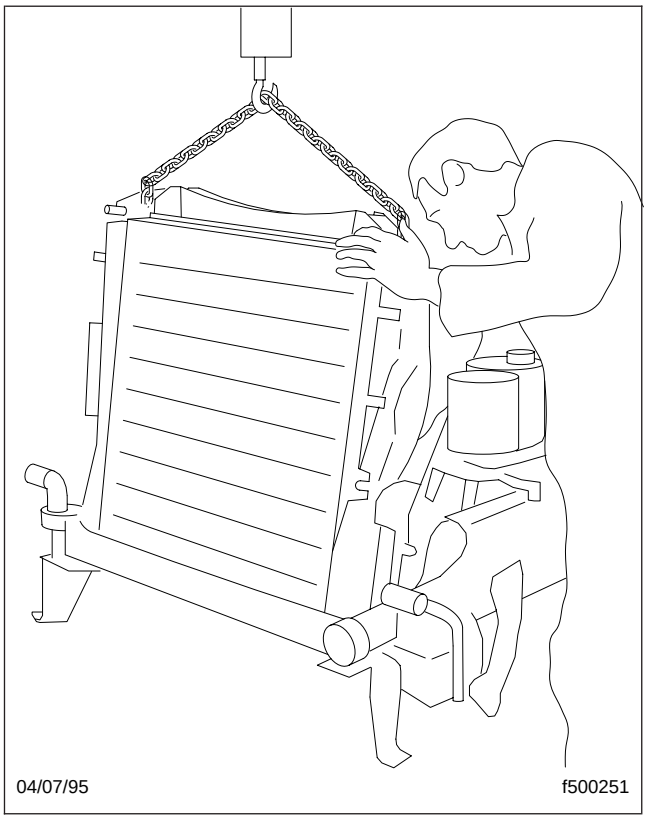


Fig. 6, Lifting the Radiator

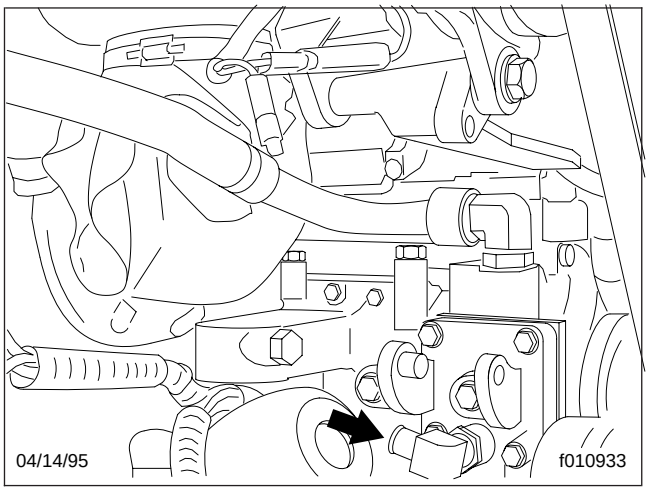
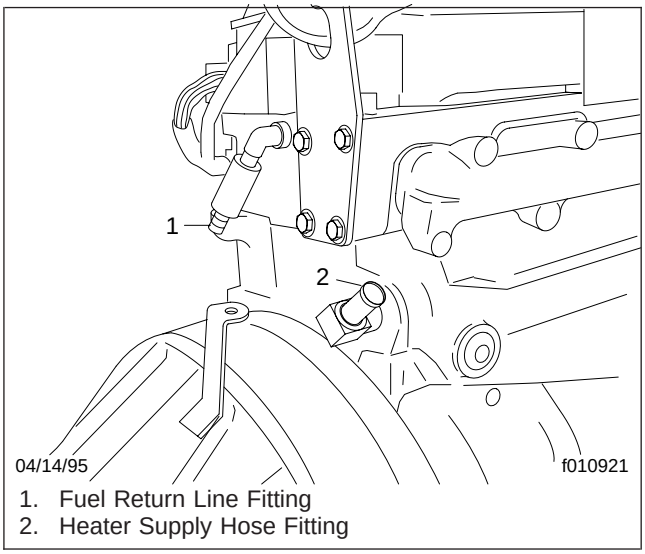


Fig. 7, Heater Return Hose Connection

8.2 Disconnect the heater supply hose from the rear of the engine block, and move the hose aside. See **Fig. 8**.

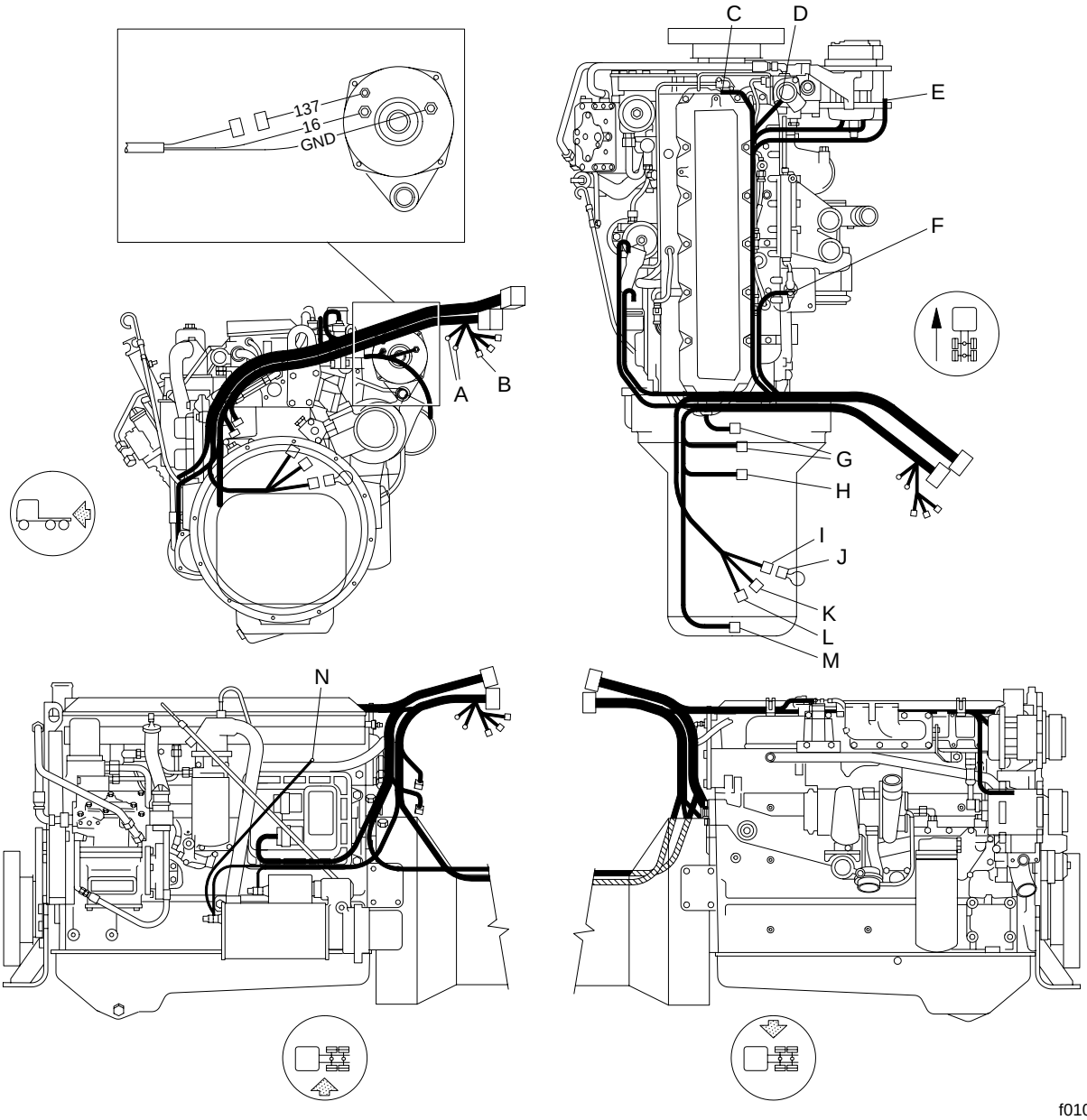
Engine Removal and Installation



1. Fuel Return Line Fitting
2. Heater Supply Hose Fitting

Fig. 8, Fuel Return and Heater Supply Connections

9. Label and disconnect the wiring. See **Fig. 9** .
   - 9.1 Disconnect the wiring from the starter. See **Fig. 10**.
   - 9.2 Disconnect the ground strap from the alternator.
   - 9.3 Disconnect the wiring from the alternator.
   - 9.4 Disconnect the wiring from the receiver-drier.
   - 9.5 Disconnect the wiring from the fan clutch.
   - 9.6 Disconnect the wiring from the coolant temperature sensors.
   - 9.7 Unplug the lower wiring harness connector from the electronic control module. See **Fig. 11**.
10. Disconnect the power steering components.
    - 10.1 Place a suitable container under the power steering fluid reservoir, and remove the hoses from the bottom of the reservoir. Allow the fluid to drain completely.
    - 10.2 At the power steering fluid pump, disconnect the hose that runs from the pump to the steering gear.
    - 10.3 Secure any loose, disconnected hoses to the engine with tie straps.
11. Disconnect the air lines from the air governor on top of the air compressor.
12. At the fuel/water separator, disconnect the fuel delivery line that runs to the engine.
13. Disconnect the forward end of the clutch rod, and tie strap the rod to the engine.
14. Remove the windshield wiper pan. See **Fig. 12**.
    - 14.1 Remove the windshield wiper arms. For instructions, refer to **Group 82** of this manual.
    - 14.2 Remove the screws that hold the wiper pan to the firewall.
    - 14.3 Remove the surge tank. For instructions, refer to **Group 20** in this manual.
    - 14.4 Remove the fresh air intake snorkel with the wiper pan.
    - 14.5 Remove the wiper pan by pulling the pan down, out from under the lower edge of the windshield trim.
15. Disconnect the air line from the fan clutch solenoid. See **Fig. 13**.
16. Remove the shift tower. For instructions, refer to **Group 26** in this service manual.
17. Remove the exhaust ducting.
    - 17.1 Loosen the V-band clamp that holds the forward end of the exhaust ducting to the rear of the turbocharger.
    - 17.2 Under the cab, disconnect the exhaust pipe from the saddle clamp mounted on the flywheel housing. See **Fig. 14**.
18. Disconnect the driveline from the transmission.
    - 18.1 Place a stand under the driveline, and disconnect the driveline from the transmission. For instructions, refer to **Group 41** in this service manual.
    - 18.2 Place a second stand under the driveline, and disconnect the driveline midship bearing bracket. See **Fig. 15**. For instructions, refer to **Group 41** in this service manual.
    - 18.3 Move the driveline out of the way.



A. To Cab Studs
B. To Mag Switch
C. To Fan Clutch Solenoid
D. To Coolant Temperature Switch
E. To Refrigerant Compressor
F. To Grid Heater (Intake Air Heater)
G. To Tachometer Sensor
H. To Back Up Switch Wiring Harness
I. To Neutral Start Switch
J. Jumper Assembly
K. To Vehicle Speed Sensor
L. To Speedometer
M. To Vehicle Speed Sensor
N. To Ground Stud

Fig. 9, Wiring Harnesses

Engine Removal and Installation

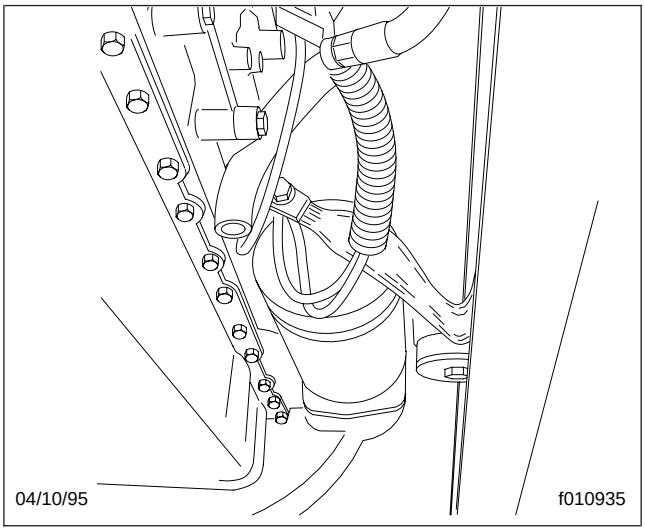


Fig. 10, Starter Wiring Connections

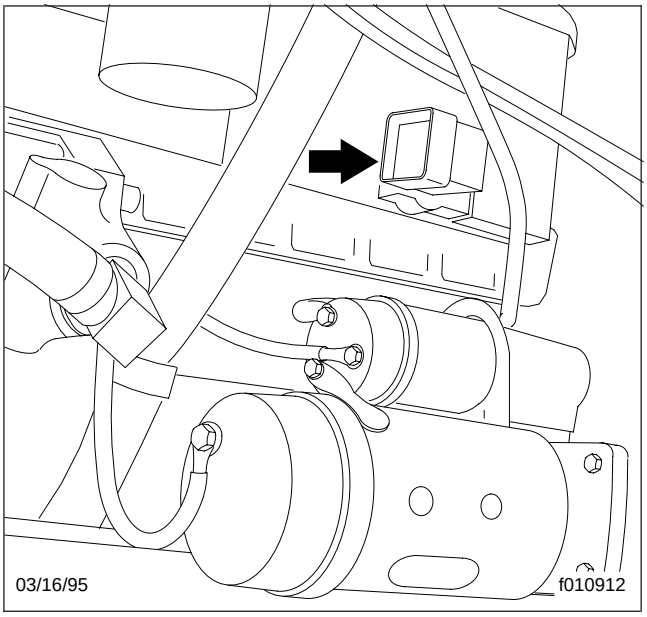


Fig. 11, Disconnect This ECM Connector

19. While under the vehicle, disconnect all other engine and transmission components.

    19.1 Disconnect the battery cable stand off bracket by the left rear engine mount.

    19.2 Disconnect the wiring from the speedometer sensor at the transmission output.

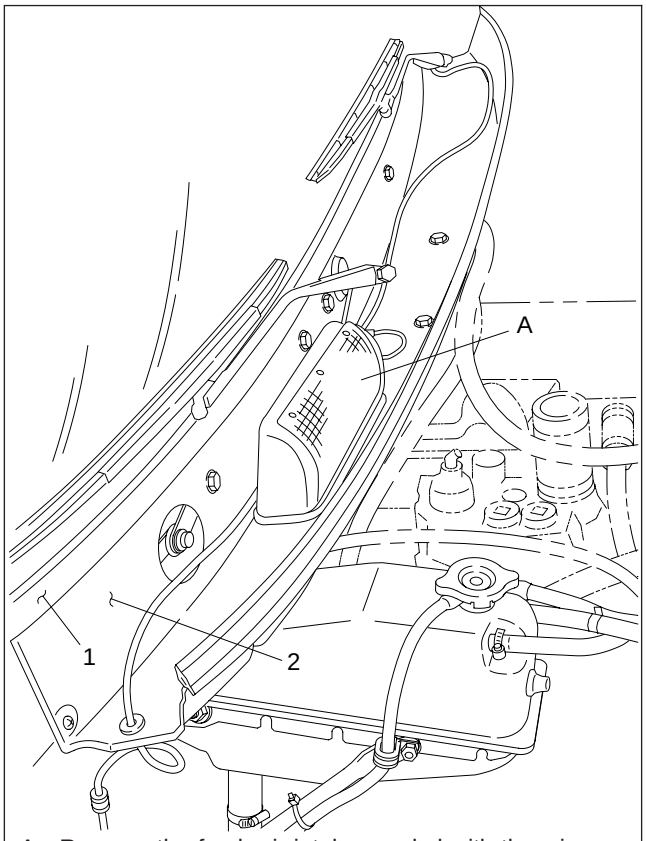
    19.3 Disconnect the wiring harness connectors from the back-up alarm switch and the neutral start switch on the transmission top cover. See **Fig. 16**.

    19.4 Remove the heat shield over the wiring harness, forward of the right, rear engine mount. See **Fig. 17**.

    19.5 Disconnect the fuel supply line from the junction plate mounted on top of the transmission.

    19.6 Disconnect the fuel return line from the back of the engine block. See **Fig. 8**.

    19.7 Disconnect the wire-braid air compressor outlet line from the chassis air supply line.



A. Remove the fresh air intake snorkel with the wiper pan.
1. Windshield Trim
2. Windshield Wiper Pan

Fig. 12, Wiper Pan Installation

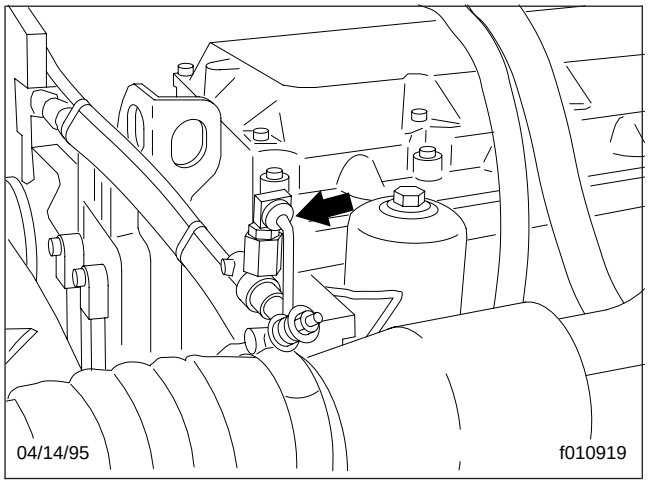


Fig. 13, Fan Clutch Solenoid

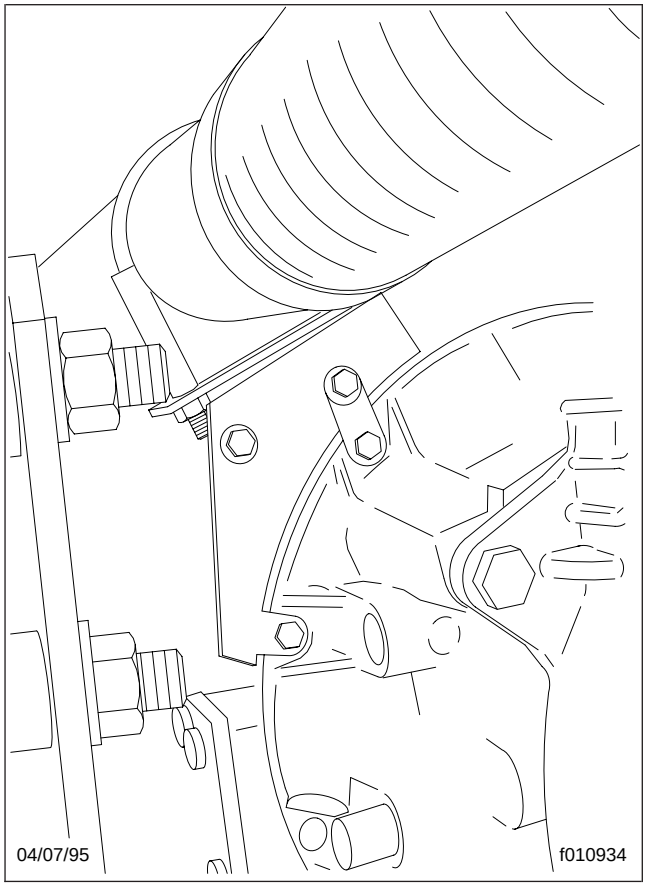


Fig. 14, Exhaust Bracket on Flywheel Housing

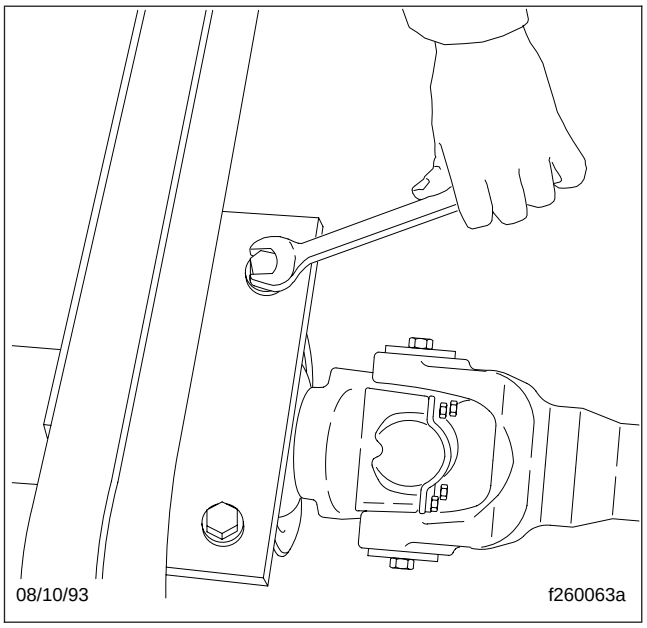


Fig. 15, Midship Bearing Bracket

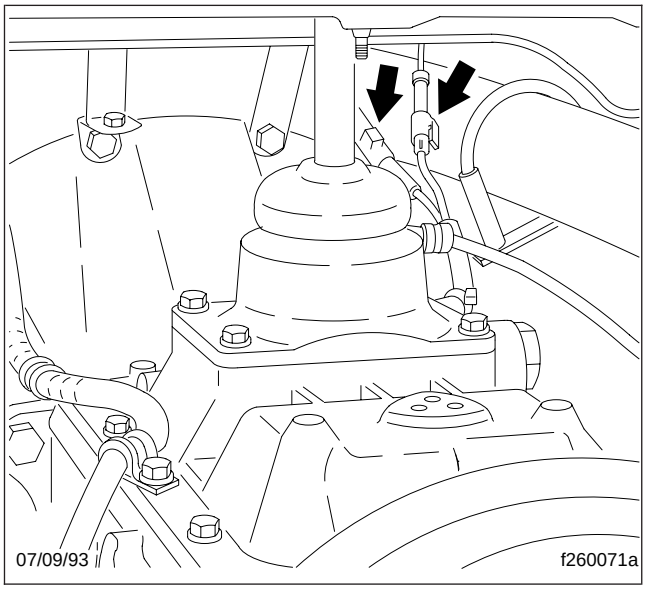


Fig. 16, Transmission Wiring Connectors

⚠ WARNING

The crane and lifting chains used to remove the engine must be capable of safely lifting and supporting two metric tons. Once the engine mounts are disconnected, do not get under the engine

Engine Removal and Installation

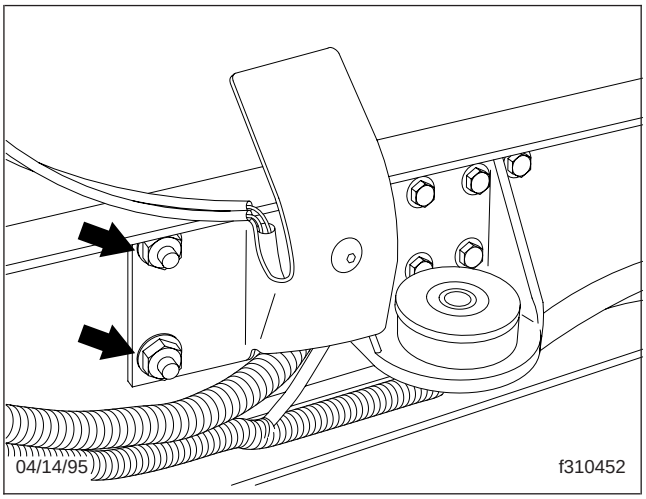


Fig. 17, Wiring Harness Heat Shield Fasteners

until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

20. Remove the engine from the vehicle.

20.1 Attach the chain to the existing lifting eyes at the front and the rear of the engine. See **Fig. 18**.

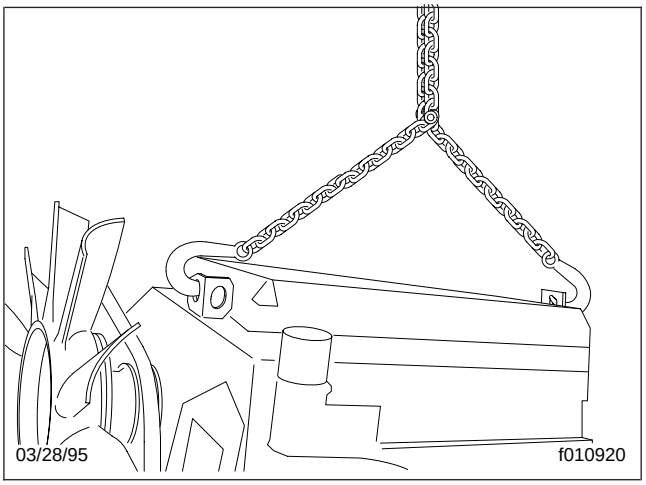


Fig. 18, Lifting Chain Installed

20.2 With the engine lifting eyes connected by chain to the crane, raise the crane enough to tighten the chains, but not enough to lift the front of the vehicle.

20.3 With the engine securely supported by the crane and lifting chains, disconnect the rear engine legs from the engine mounts on the frame rails.

On each engine leg, remove the nut from the bolt that runs down through the engine leg, rubber isolators, and engine mount. Save the fasteners and isolators.

20.4 Remove the nuts from the bolts that fasten the front engine support bracket to the underslung crossmember. See **Fig. 19**.

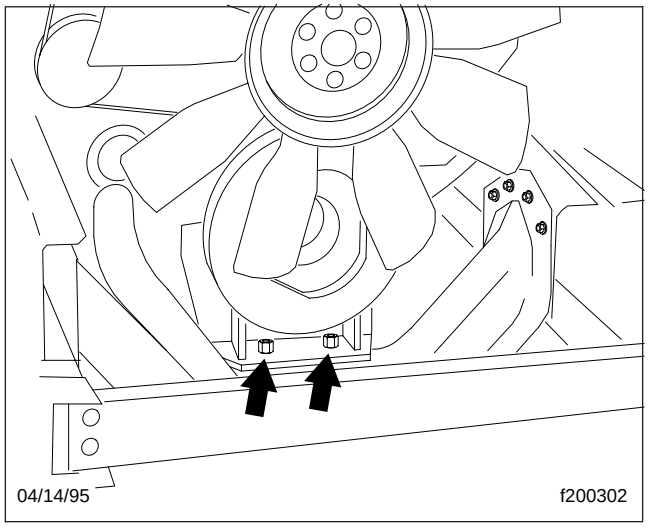


Fig. 19, Front Engine Mount Fasteners

20.5 Using the crane, lift the engine and pull it forward.

20.6 Once the engine and transmission are clear of the vehicle, place the engine on engine stands.

Installation

⚠ WARNING

The crane and lifting chains used to install the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely supported on the engine mounts. An unsecured engine may fall, causing personal injury or death, and component damage.

1. Install the engine and transmission in the vehicle.
   - 1.1 Attach the chain to the existing lifting eyes at the front and the rear of the engine.
   - 1.2 With the two engine lifting eyes connected by chain to the crane, lift the engine, and position it in the engine compartment.
   - 1.3 Connect the engine to the rear engine mounts, and tighten each bolt that runs down through the engine leg, rubber isolators, and engine mount 327 N·m (241 lbf·ft).
   - 1.4 Assemble the lower isolator under the underslung crossmember and the front engine support bracket, and secure the front engine mount with nuts and washers. Tighten the nuts 184 N·m (136 lbf·ft).
   - 1.5 Once the engine is securely installed in the vehicle, remove the lifting chains.
2. Under the engine and transmission, connect all engine and transmission components.
   - 2.1 Connect the wiring to the speedometer sensor at the transmission output.
   - 2.2 Connect the wiring harness connectors to the back-up alarm switch and the neutral start switch on the transmission top cover.
   - 2.3 Connect the fuel supply line to the junction plate mounted on top of the transmission.
   - 2.4 Connect the fuel return line to the back of the engine block.
   - 2.5 Connect the wire-braid air compressor outlet line to the chassis air supply line.
   - 2.6 Route and clamp the battery cable.
3. Connect the driveline.
   - 3.1 Connect the driveline to the transmission. For instructions, refer to **Group 41** in this manual.
   - 3.2 Connect the driveline midship bearing bracket. For instructions, refer to **Group 41** in this manual.
4. Install the exhaust ducting.
   - 4.1 Under the engine, connect the exhaust pipe to the saddle clamp mounted on the flywheel.
   - 4.2 Tighten the V-band clamp that holds the forward end of the exhaust ducting to the rear of the turbocharger 85 lbf·in (940 N·cm).
5. Install the windshield wiper pan. See **Fig. 12**.
   - 5.1 Position the pan by tucking it up under the lower edge of the windshield trim.
   - 5.2 Install the fresh air intake snorkel.
   - 5.3 Install the screws that hold the pan to the firewall.
   - 5.4 Install the surge tank. For instructions, refer to **Section 20.01** of this manual.
   - 5.5 Install the wiper arms. For instructions refer to **Group 82** of this manual.
6. Connect the air line to the fan clutch solenoid. See **Fig. 13**.
7. At the left side of the engine, connect the air lines to the air governor on top of the air compressor.
8. At the fuel/water separator, connect the fuel delivery line that runs to the engine.
9. Connect the forward end of the clutch rod, and remove any tie straps that hold the rod to the engine.
10. Connect the power steering components.
    - 10.1 Connect the hoses to the bottom of the power steering fluid reservoir.
    - 10.2 At the power steering fluid pump, connect the hose that runs from the pump to the steering gear.
    - 10.3 With all the hoses connected, fill the power steering fluid reservoir.
11. Connect the engine wiring.
    - 11.1 Connect the wiring to the starter.
    - 11.2 Connect the ground strap to the alternator.
    - 11.3 Connect the wiring to the alternator.
    - 11.4 Connect the wiring to the receiver-drier.

Engine Removal and Installation

11.5 Connect the wiring to the fan clutch.

11.6 Connect the wiring to the coolant temperature sensors.

11.7 Plug the lower wiring harness connector into the electronic control module.

12. Connect the heater hoses.

12.1 Connect the heater return hose to the water pump.

12.2 Connect the heater supply hose to the rear of the engine block.

13. Install the refrigerant compressor.

13.1 Connect the compressor wiring.

13.2 Install the compressor mounting fasteners. For instructions, refer to **Group 83** in this manual.

13.3 Install the accessory drive belt. For instructions, refer to **Section 01.00** in this manual.

14. Install the radiator.

14.1 Attach a lifting chain to the two hood attachment studs at the top of the radiator, and attach the chain to a lifting crane.

14.2 Lift the radiator/charge air cooler assembly, and position it on the radiator mounts.

14.3 Install the radiator/charge air cooler on its framerail mounts. For instructions, refer to **Section 20.01** in this manual.

14.4 Install the fan shroud on the radiator.

14.5 Connect the vent lines to the radiator and the engine.

14.6 Install the radiator inlet hose between the radiator and the engine.

14.7 Connect the radiator outlet hose to the bottom of the radiator.

14.8 Install the condenser on the radiator and charge air cooler.

14.9 Route the refrigerant lines between the compressor and the condenser, and secure the lines with clamps and stand-off brackets.

14.10 Install the driver side air recirculation shield.

15. Install the air cleaner housing.

15.1 As a unit, position the air cleaner housing, the housing bracket, the right-side air recirculation shield, and the horn on the vehicle.

15.2 Install the four 3/4-inch bolts that hold the air cleaner housing mounting bracket to the frame rail. For instructions, refer to **Group 09** in this service manual.

15.3 Connect the radiator right-hand strut to the air cleaner housing bracket.

15.4 Connect the right-side air recirculation shield to the radiator. This includes connecting the two push-type fasteners that hold the shield to a bracket attached to the top of the radiator.

15.5 Connect the air intake hoses that run between the air cleaner housing and the turbocharger, and connect the hoses that run between the turbocharger and the charge air cooler, and between the charge air cooler and the engine. Clamp the hoses to the A-shaped bracket on top of the engine.

15.6 Install the air compressor intake hose that runs from the engine air intake hose to the compressor.

15.7 Install the right fender splash shield. See **Fig. 3**.

15.8 Connect the wiring to the horn.

16. Install the shift tower.

17. Fill the radiator.

18. Install the hood and bumper. For instructions, refer to **Group 88** in this service manual.

19. Connect the batteries.

20. Remove the chocks from the tires.

21. Start the engine, and check for leaks. Repair any leaks found.

22. Test drive the vehicle.

Removal

IMPORTANT: To remove the Cummins M11 engine from a Freightliner FL112 vehicle, you'll need a special lifting bracket for the rear of the engine.

1. Apply the parking brakes, chock the tires, and drain the air system.
2. Disconnect the batteries.
3. Remove the hood, bumper, and the left-side half fender. For instructions, refer to **Group 88** in this service manual.
4. Remove the hood tilt-assist bracket mounted on the front closing crossmember. For instructions, refer to **Group 88** in this service manual.
5. Remove the transmission. For instructions, refer to the applicable section in **Group 26** in this service manual.
6. Remove the air cleaner housing and the brackets that hold the housing to the bulkhead. See **Fig. 1**. This includes removing the heat shield between the cleaner and the turbocharger. For instructions, refer to **Group 09** in this service manual.

⚠ WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

7. Drain the radiator.
   - 7.1 Place a suitable container under the left side corner of the radiator.
   - 7.2 Remove the surge tank cap.
   - 7.3 Unscrew the plug in the bottom of the radiator.

     After the coolant has drained, screw the plug into the radiator, and tighten it firmly.
8. Move the air conditioning components out of the way without breaking the refrigerant lines. See **Fig. 2**.
   - 8.1 Free the refrigerant lines from all routing clamps and stand-off brackets between the compressor and the condenser.
   - 8.2 Free the refrigerant lines from all routing clamps and stand-off brackets between the receiver- drier and the condenser.
   - 8.3 Remove the condenser mounting fasteners, and move the condenser aside.
   - 8.4 Remove the refrigerant compressor and move the compressor aside.
   - 8.5 Use tie straps to secure the refrigerant compressor and condenser out of the way.
9. Remove the air recirculation shields around the radiator and charge air cooler. For instructions, refer to **Group 09** in this service manual.
10. Remove the radiator and charge air cooler. For instructions, refer to **Group 20** in this service manual.
11. Remove the radiator mounting bracket from the front closing crossmember.
12. Disconnect or remove the remaining ducts and lines. See **Fig. 3**.
    - 12.1 If not already removed, remove the air duct between the turbocharger and the air cleaner.
    - 12.2 Disconnect the vent line from the engine, and move the line aside.
    - 12.3 Disconnect the two air signal lines from the air governor on top of the compressor.
    - 12.4 Disconnect the outlet line from the air compressor.
    - 12.5 Disconnect the air line to the fan clutch solenoid, and free the line from routing clamps.
    - 12.6 Disconnect the heater return hose from the radiator outlet pipe, and free the hose from the clamps that route it along the left frame rail. See **Fig. 4**.
    - 12.7 Disconnect the heater supply hose. See **Fig. 4**.
    - 12.8 Disconnect the oil pressure sensor line beneath the receiver-drier.

Engine Removal and Installation

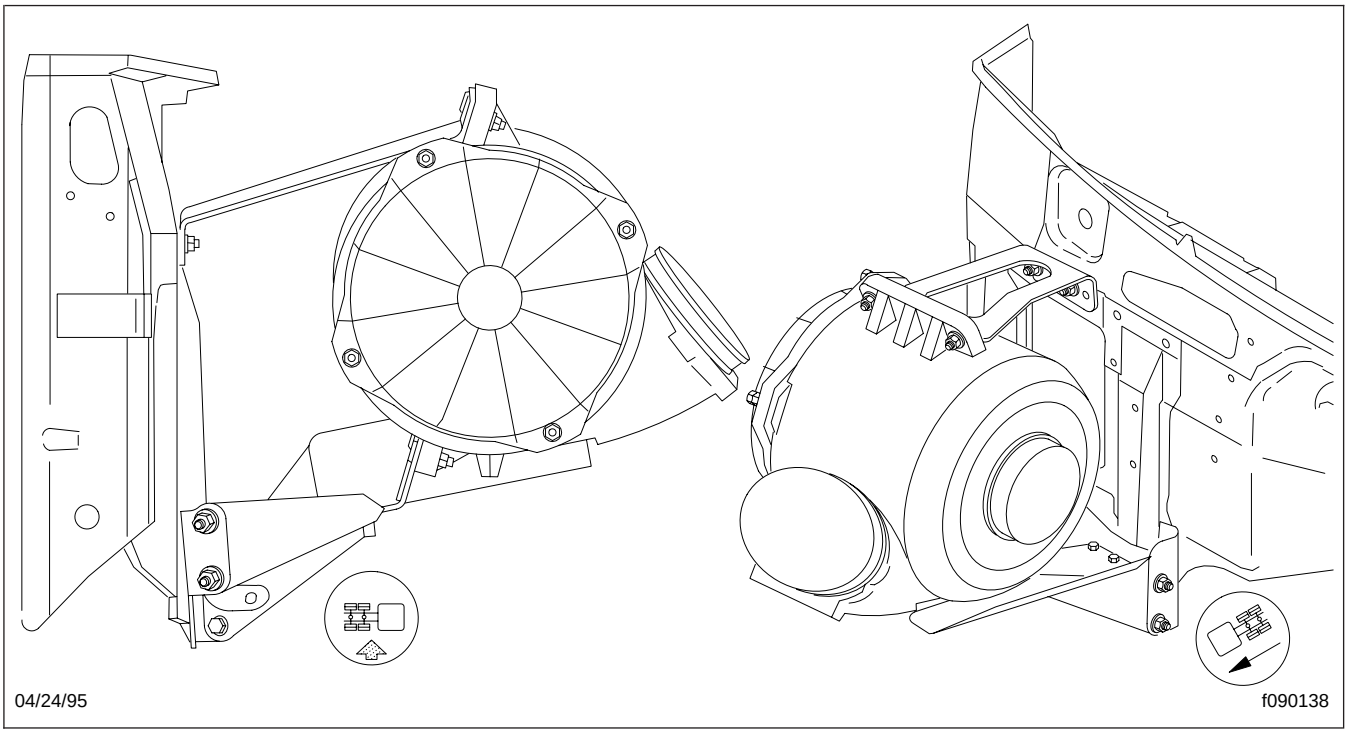
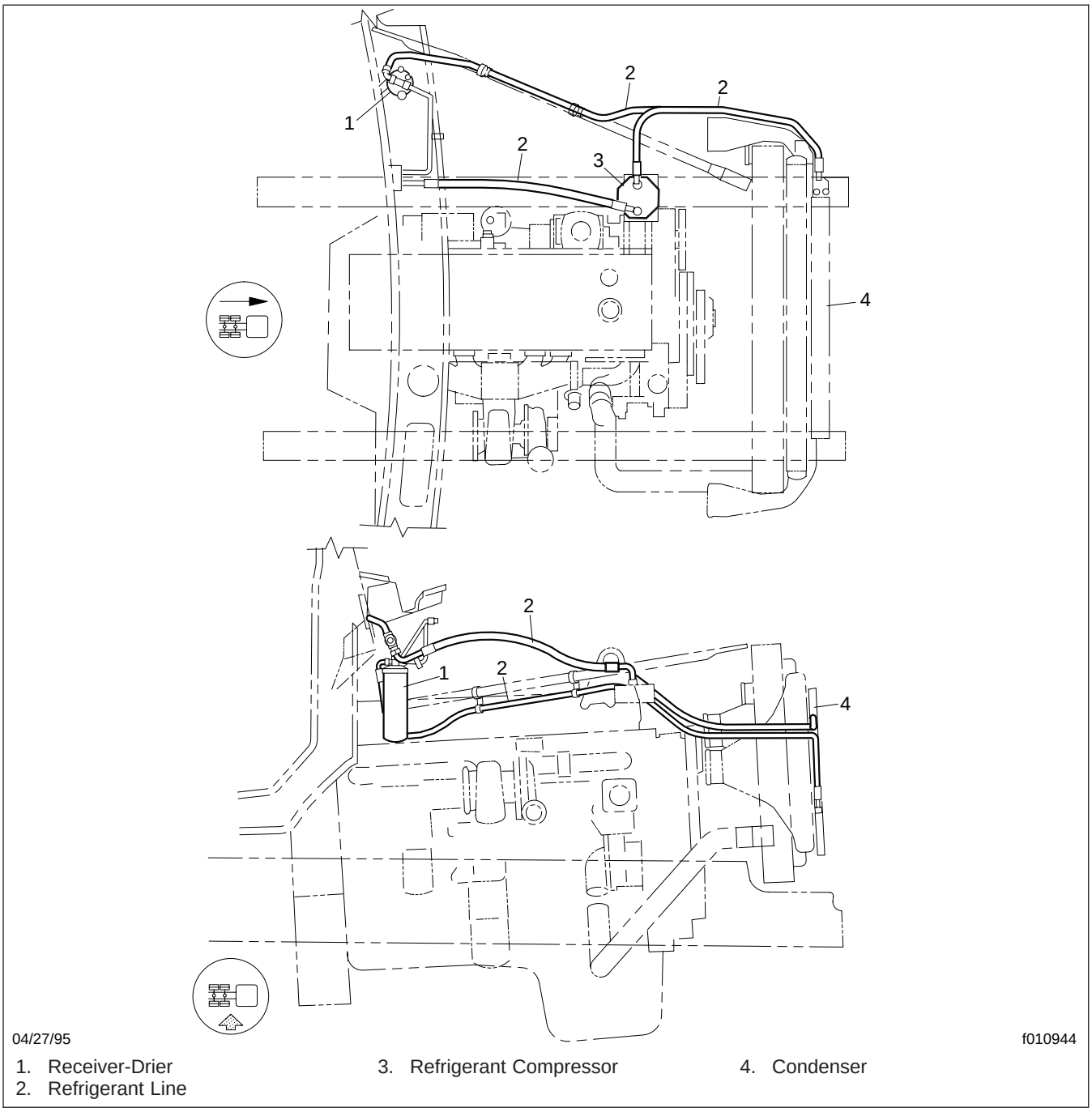


Fig. 1, Cummins M11 Engine, Air Cleaner Housing

13. Remove the windshield wiper pan. See **Fig. 5** .
    - 13.1 Remove the surge tank and mounting bracket from the bulkhead. For instructions, refer to **Group 20** in this service manual.
    - 13.2 Remove the windshield wiper arms. For instructions, refer to **Group 82** of this manual.
    - 13.3 Remove the screws that hold the wiper pan to the firewall.
    - 13.4 Remove the fresh air intake snorkel with the wiper pan.
    - 13.5 Remove the wiper pan by pulling the pan down, out from under the lower edge of the windshield trim.
14. Remove the windshield wiper linkage. For instructions, refer to **Group 82** in this service manual.
15. Label and disconnect the wiring.
    - 15.1 Disconnect the two engine harness bulkhead connectors.
    - 15.2 Disconnect the wiring from the power stud on the bulkhead.
    - 15.3 Disconnect the wiring from the ground stud on the bulkhead.
    - 15.4 Remove the two screws that hold the magnetic switch to the bulkhead, and remove the switch without disconnecting the wires from it.
    - 15.5 Disconnect the starter ground cable from the frame rail.
    - 15.6 Disconnect the power cables from the starter and the starter solenoid.
16. Without breaking the power steering fluid lines, remove the power steering pump, and move it aside. For instructions, refer to **Group 46** in this service manual.
17. Under the engine, disconnect or remove the remaining components.
    - 17.1 Remove the flex pipe section of exhaust ducting that attaches to the turbocharger.



1. Receiver-Drier
2. Refrigerant Line
3. Refrigerant Compressor
4. Condenser

Fig. 2, Cummins M11 Engine, Air Conditioning Components

17.2 Disconnect the two fuel return lines from the equiflow bracket. For instructions, refer to **Group 47** in this service manual.

17.3 Remove the bolts that hold the engine legs to the rear engine mounts.

Engine Removal and Installation

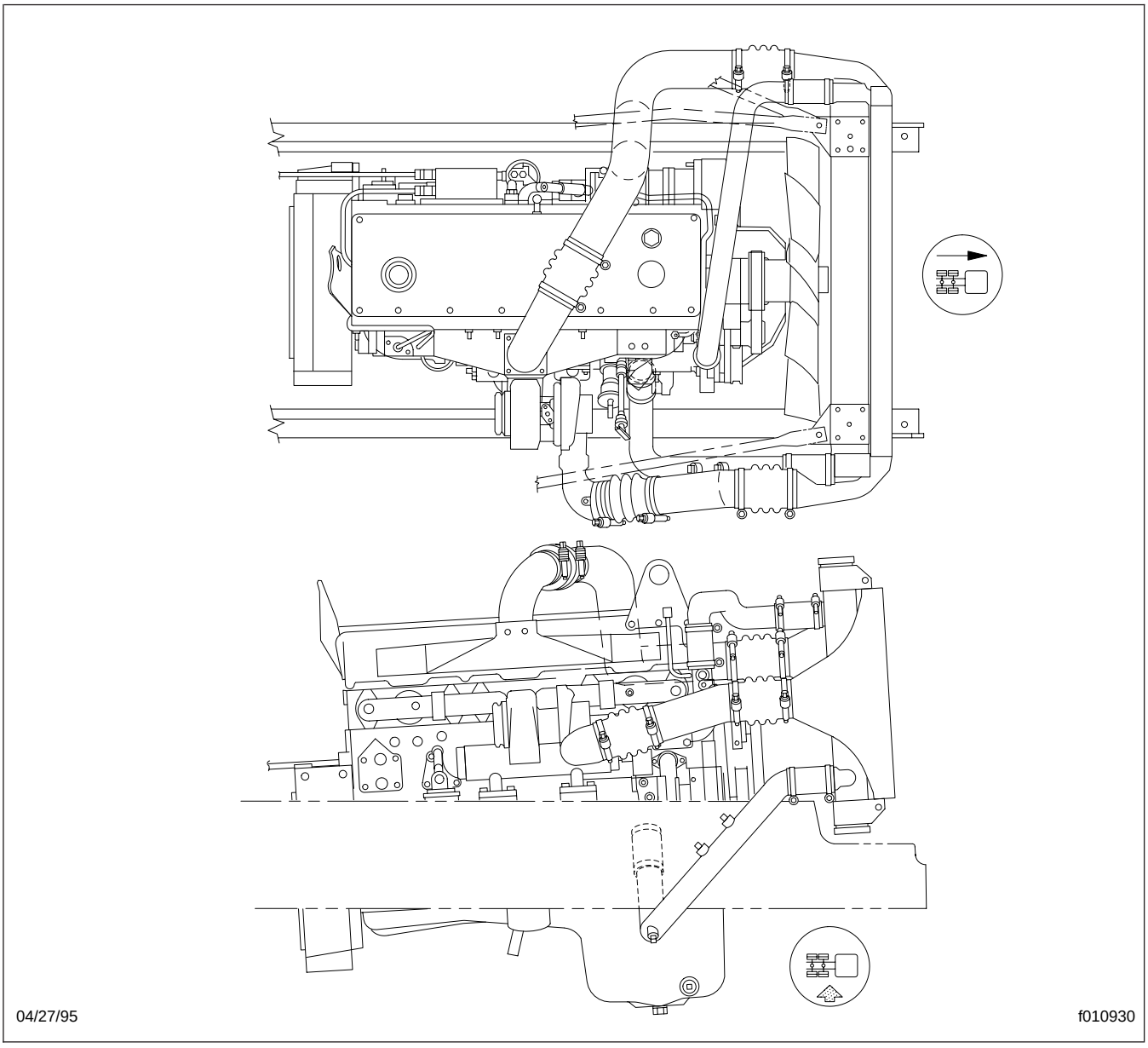


Fig. 3, Cummins M11 Engine, Radiator and Intake Air Plumbing

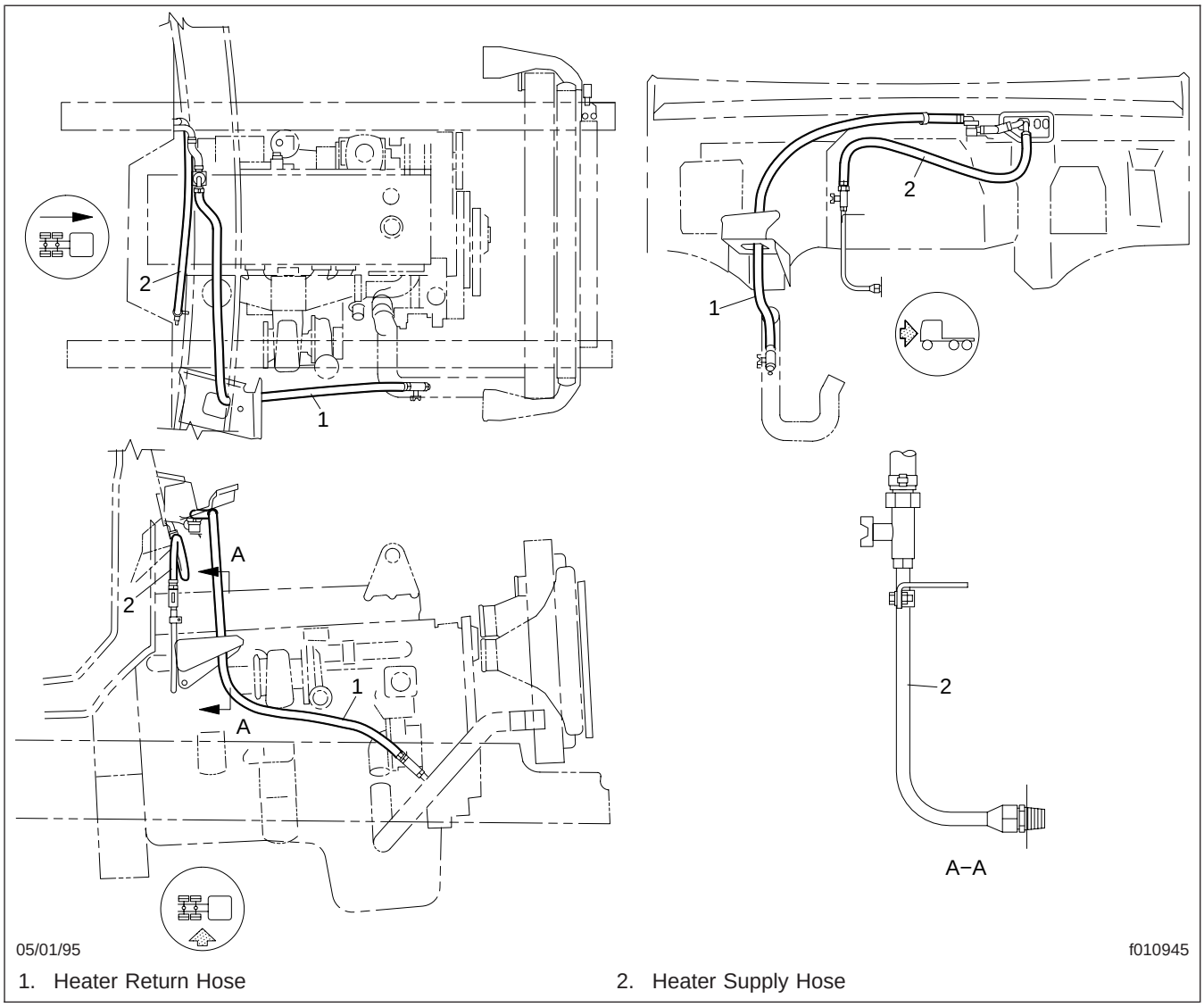
⚠ WARNING

The crane and lifting chains used to remove the engine must be capable of safely lifting and supporting two metric tons. Once the engine mounts are disconnected, do not get under the engine until it is securely supported on engine stands.

An unsecured engine may fall, causing personal injury or death, and component damage.

18. Remove the engine from the vehicle.

    NOTE: If the engine is equipped with a compression brake, remove the valve cover. For instructions, refer to the engine manufacturer's service literature.



1. Heater Return Hose
2. Heater Supply Hose

Fig. 4, Cummins M11 Engine, Heater Hoses

18.1 Attach the special lifting bracket to the rear of the engine.

18.2 Attach the chain to the existing lifting eye at the front and the special lifting bracket at the rear of the engine.

18.3 With the two engine lifting points connected by chain to the crane, raise the crane enough to tighten the chains, but not enough to lift the front of the vehicle.

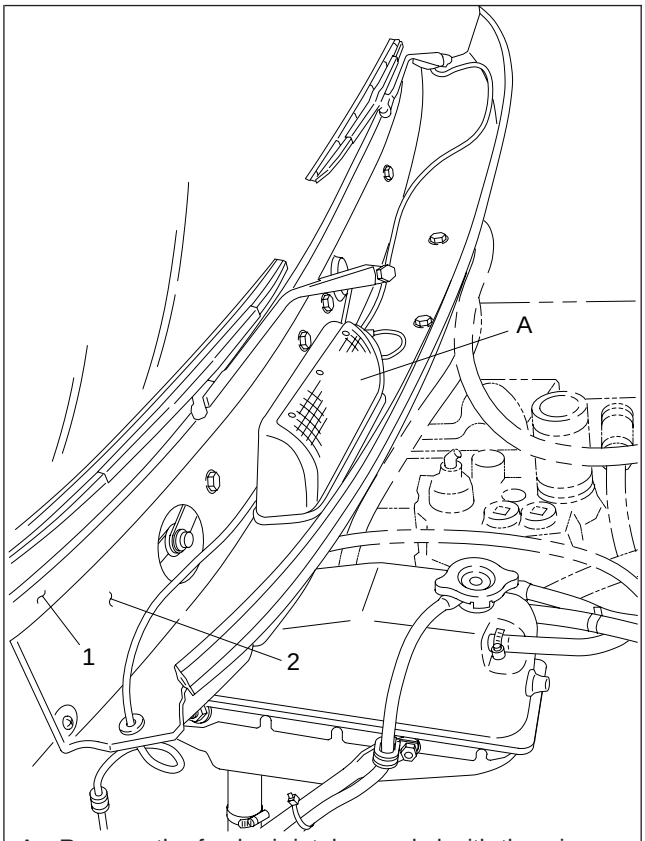
18.4 Remove the nuts from the bolts that fasten the front engine support bracket to the underslung crossmember.

18.5 Using the crane, lift the engine slightly and remove the upper isolator from the front engine mount.

18.6 Using the crane, lift the engine and pull it forward.

18.7 Once the engine is clear of the vehicle, place the engine on engine stands.

Engine Removal and Installation



A. Remove the fresh air intake snorkel with the wiper pan.
1. Windshield Trim
2. Windshield Wiper Pan

Fig. 5, Windshield Wiper Pan, Typical Installation Shown

Installation

WARNING

The crane and lifting chains used to install the engine must be capable of safely lifting and supporting two metric tons. Once the engine is removed from the engine stands, do not get under the engine until it is securely supported on the engine mounts. An unsecured engine may fall, causing personal injury or death, and component damage.

1. Install the engine in the vehicle.
   - 1.1 If not already attached. Install the special lifting bracket on the rear of the engine.
   - 1.2 Attach the chain to the existing lifting eye at the front and the special lifting bracket at the rear of the engine.
   - 1.3 With the two engine lifting points connected by chain to the crane, lift the engine, and position it in the engine compartment.
   - 1.4 Connect the engine to the rear engine mounts, and tighten the bolt that runs down through each engine leg, rubber isolators, and engine mount 327 N·m (241 lbf·ft).
   - 1.5 Assemble the lower isolator under the underslung crossmember and the front engine bracket, and secure the front engine mount with nuts and washers. Tighten the nuts 184 N·m (136 lbf·ft).
   - 1.6 Once the engine is securely installed in the vehicle, remove the lifting chains and the special lifting bracket.
   - 1.7 If the valve cover was removed, install it. For instructions, refer to the engine manufacturer's service literature.
2. Connect and install components under the engine.
   - 2.1 Connect the exhaust flex pipe to the forward end of the exhaust piping.
   - 2.2 Connect the two fuel return lines to the equiflow bracket. For instructions, refer to **Group 47** of this service manual.
3. Without breaking the power steering fluid lines, install the power steering pump. For instructions, refer to **Group 46** in this service manual.
4. Connect the wiring. For wiring harness information, refer to **Group 54** in this service manual.
   - 4.1 Connect the two engine harness bulkhead connectors.
   - 4.2 Connect the wiring to the power stud on the bulkhead.
   - 4.3 Connect the wiring to the ground stud on the bulkhead.

4.4 Install the magnetic switch on the bulkhead.

4.5 Connect the starter ground cable to the frame rail.

4.6 Connect the power cables to the starter and the starter solenoid.

5. Install the windshield wiper linkage. For instructions, refer to **Group 82** in this service manual.
6. Install the windshield wiper pan. See **Fig. 5** .
   - 6.1 Position the pan by tucking it up under the lower edge of the windshield trim.
   - 6.2 Install the fresh air intake snorkle.
   - 6.3 Install the screws that hold the pan to the firewall.
   - 6.4 Install the surge tank. For instructions, refer to **Group 20** of this service manual.
   - 6.5 Install the wiper arms. For instructions refer to **Group 82** of this manual.
7. Connect or install the ducts and lines. See **Fig. 3**.
   - 7.1 Install the V-band clamp that holds the forward end of the flex pipe exhaust ducting to the rear of the turbocharger. Tighten it 85 lbf·in (940 N·m).
   - 7.2 Install the air duct between the turbocharger and the air cleaner.
   - 7.3 Connect the vent line to the engine.
   - 7.4 Connect the two air signal lines to the air governor on top of the compressor.
   - 7.5 Connect the outlet line to the air compressor.
   - 7.6 Connect the air line to the fan clutch solenoid.
   - 7.7 Connect the heater return hose to the radiator outlet pipe. See **Fig. 4**.
   - 7.8 Connect the heater supply hose. See **Fig. 4**.
   - 7.9 Connect the oil pressure sensor line beneath the receiver-drier.
8. Install the radiator mounting bracket on the front closing crossmember.
9. Install the radiator, fan shroud, and charge air cooler. For instructions, refer to **Group 20** in this service manual.
10. Install the air recirculation shields around the radiator and charge air cooler. For instructions, refer to **Group 09** in this service manual.
11. Install the air conditioning components without breaking the refrigerant lines. See **Fig. 2**.
    - 11.1 Install the condenser. For instructions, refer to **Group 83** of this service manual.
    - 11.2 Install the refrigerant compressor. For instructions, refer to **Group 83** of this service manual. For instructions on installing the compressor drive belts, refer to **Section 01.00** in this service manual group.
    - 11.3 Route and clamp the refrigerant lines between the compressor and the condenser.
    - 11.4 Route and clamp the refrigerant lines between the receiver-drier and the condenser.
12. Install the air cleaner housing. For instructions, refer to **Group 09** in this service manual. Connect the intake air ducting to the air cleaner and the charge air cooler.
13. Install the transmission. For instructions, refer to the applicable section in **Group 26** in this service manual.
14. Install the hood tilt-assist bracket mounted on the forward closing crossmember. For instructions, refer to **Group 88** in this service manual.
15. Install the hood, bumper, and the left-side quarter fender. For instructions, refer to **Group 88** in this service manual.
16. Fill the radiator.
17. Connect the batteries.
18. Start the engine, and check for leaks. Repair any leaks found.
19. Test drive the vehicle.

General Information and Principles of Operation

This system electronically controls the two grid heating elements in the air intake manifold to assist in cold weather starts and to improve cold engine running. The electric grid heater system works in a preheat and post-heat mode. The preheat mode heats the intake air prior to starting the engine to aid in starting. The post-heat mode heats the intake air after starting to improve cold engine running. This system can be used on naturally aspirated and turbocharged engines.

The grid heater system benefits include:

- Quicker starting
- Smoother engine running after starting
- Replacement of ether as a starting aid
- Extended starter and battery life through less cranking

The grid heater starting aid will not operate unless the intake manifold temperature sensor senses a temperature below 45°F (7°C). This system is compatible with a 12-volt electrical system only, and is not compatible with a 24-volt system.

Current draw is 95 amperes per element. To prevent excessive drain on the batteries, the electric grid heater controller has incorporated a battery monitoring feature. If the battery voltage dips too low, the grid heater controller will interrupt the post-heat cycle, preventing further drain on the batteries. This battery protection feature is activated only on vehicles with weak or drained batteries.

The following is a summary of normal operations:

1. Turn the key switch to ON (intake manifold temperature sensor must read a temperature below 45°F (7°C).
2. While the wait-to-start (WTS) light is ON, the grid is in the preheat mode, see **Table 1**.
3. When the WTS light goes out, the engine is ready to start.
4. Start the engine within 10 seconds after the WTS light goes off.
5. After the engine starts, the grid is in the post-heat mode.

Intake Manifold Heater Operation

Temperature °F (°C)	Condition	Elements	Duration (seconds)	Duty Cycle % On / % Off
Below –2 (–19)	Preheat	Both	30	Continuous
	Post-Heat	Both	15	Continuous
		One	15	Continuous
		One	40	50/50
		One	106	25/75
–2 to 17 (–19 to –8)	Preheat	Both	20	Continuous
	Post-Heat	Both	20	Continuous
		One	20	Continuous
		One	40	50/50
		One	106	25/75
–17 to 46 (–8 to 8)	Preheat	Both	10	Continuous
	Post-Heat	Both	10	Continuous
		One	10	Continuous
		One	40	50/50
		One	106	25/75

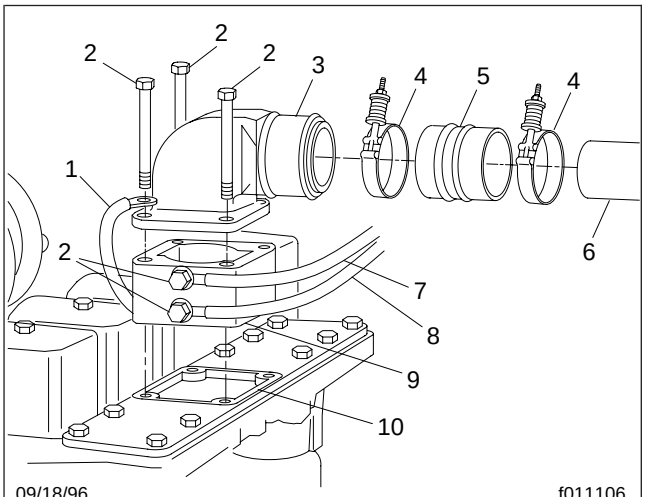
General Information and Principles of Operation

Intake Manifold Heater Operation				
Temperature °F (°C)	**Condition**	**Elements**	**Duration (seconds)**	**Duty Cycle % On / % Off**
Above 46 (8)	Preheat	None	—	—
	Post-Heat	None	—	—

Table 1, Intake Manifold Heater Operation

Grid Heater Element Replacement

Removal (See Fig. 1)



1. Ground Cable
2. Capscrew
3. Intake Elbow
4. Clamp
5. Intake Couple
6. Intake Tube
7. Positive Element Cable #1
8. Positive Element Cable #2
9. Grid Heater Block
10. Manifold Mounting Surface

Fig. 1, Intake Heater

1. Set the parking brake, shut down the engine, and chock the tires. Disconnect the batteries.
2. Remove the air intake tube from the intake elbow by loosening the clamps.
3. Disconnect all three electrical cables from the grid heater block by removing the retaining capscrews.

IMPORTANT: Note the orientation of the heater grid block before removal, to ensure correct installation.

4. Remove the four mounting capscrews; then remove the intake elbow and the grid heater block. It may be necessary to pry between the grid heater block and the manifold to break the seal between them.
5. Place a clean cloth into the intake manifold opening to prevent any contaminants from entering.
6. Clean any gasket material or sealant from the grid heater mounting surface.

Installation (See Fig. 1)

1. Remove the cloth from the intake manifold and carefully check the manifold to ensure that there are no foreign objects remaining.
2. Place a new gasket on the grid heater block mounting surface.
3. Position a new grid heater block on the mounting surface and place a gasket on the grid heater block. Place the intake elbow on the grid heater block and secure with the mounting capscrews. Be sure to secure the negative grid heater block cable (Ref. 1) under a capscrew. Torque the mounting capscrews to 18 lbf·ft (24 N·m).
4. Connect the positive electrical cables to the grid heater block.

NOTE: The electrical cables should be secured within 6 inches of any connection to avoid connector or ring terminal damage.

5. Position the intake tube on the intake elbow, with the intake couple and clamps in place. Tighten the clamps 75 lbf·in (800 N·cm).
6. Connect the batteries and remove the chocks from the tires.

Temperature Sensor Replacement

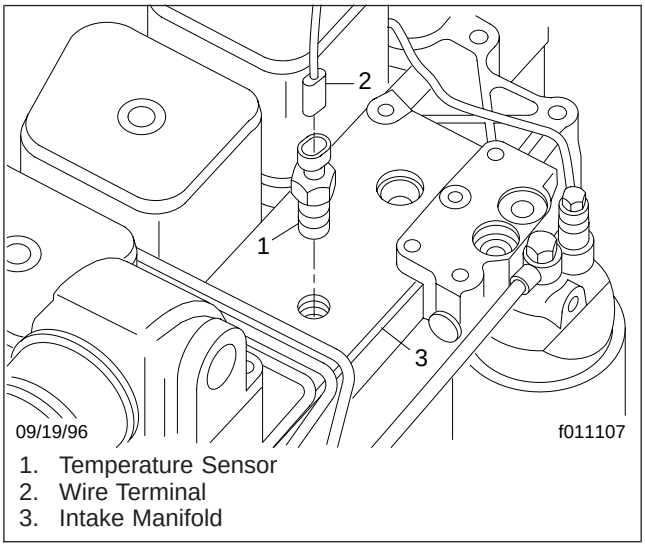
Removal (See Fig. 2)

1. Set the parking brake, shut down the engine, and chock the tires. Disconnect the batteries.
2. Disconnect the wire terminal from the sensor.
3. Remove the sensor by unscrewing it from the manifold.

Installation

1. Install the temperature sensor in the intake cover. Tighten it 25 lbf·in (35 N·m).

Component Replacement



1. Temperature Sensor
2. Wire Terminal
3. Intake Manifold

Fig. 2, Temperature Sensor

2. Connect the wire to the sensor.
3. Connect the batteries and remove the chocks from the tires.

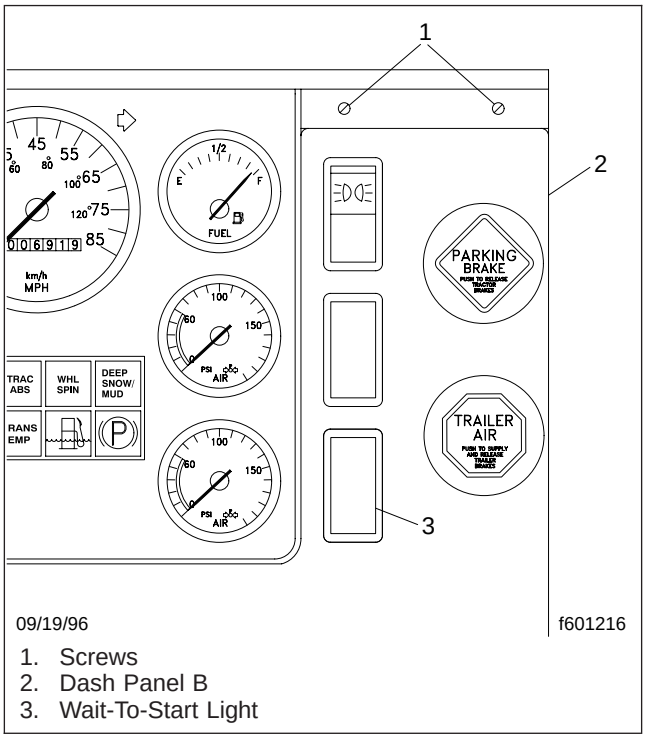
Wait-to-Start Light Assembly Replacement

Removal (See Fig. 3)

1. Set the parking brake, shut down the engine, and chock the tires. Disconnect the batteries.
2. Loosen the dashboard panel B by removing the mounting screws.
3. Being careful not to damage the connecting wires, allow the panel to come away from the dashboard.
4. Disconnect the wires at the wait-to-start light assembly.
5. Remove the light assembly by removing the mounting screws.

Installation (See Fig. 3)

1. Position a replacement wait-to-start light assembly in the dash opening and secure it with the mounting screws.
2. Connect the wire to the light assembly.



1. Screws
2. Dash Panel B
3. Wait-To-Start Light

Fig. 3, Wait-to-Start Light Replacement

3. Install the dashboard panel B and secure it with the mounting screws.
4. Connect the batteries and remove the chocks from the tires.

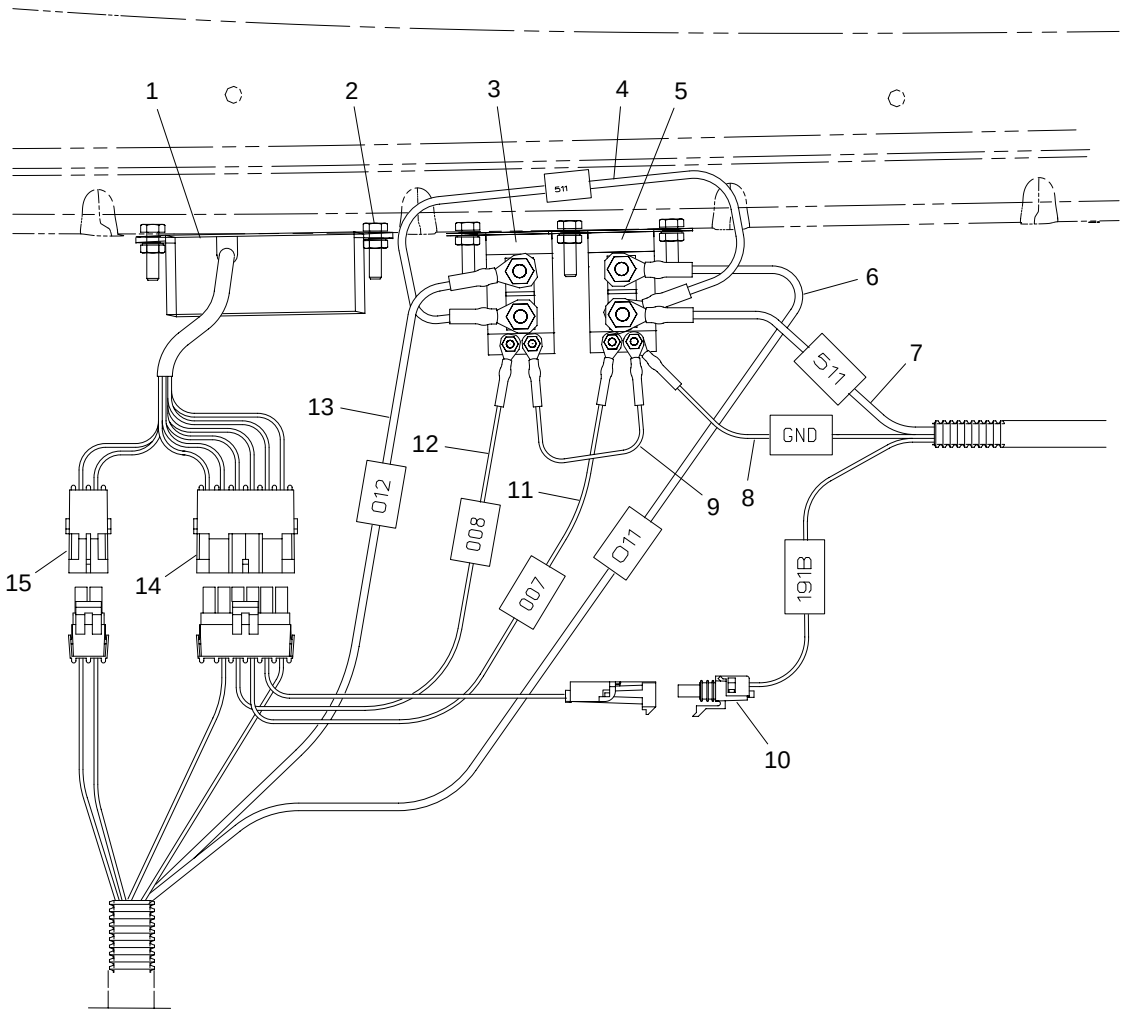
Air Intake Heater Control Module Replacement

Removal (See Fig. 4)

1. Set the parking brake, shut down the engine, and chock the tires. Disconnect the batteries.
2. Working under the hood, disconnect the main module connector and the temperature sensor connector at the intake heater module.
3. Remove the module by removing the mounting fasteners.

Installation (See Fig. 4)

1. Position the intake heater control module on the air intake tray.



09/26/96 f541399

1. Heater Control Module
2. Mounting Fastener
3. Relay #2
4. 12-Volt Power Jumper Wire
5. Relay #1
6. Grid #1 Power Cable
7. 12-Volt Power Cable
8. Heater Harness Ground Cable
9. Ground Jumper Cable
10. Wait-To-Start Light Connector
11. Controller Module to Relay #1 Wire
12. Controller Module to Relay #2 Wire
13. Grid #2 Power Cable
14. Main Module Connector
15. Temperature Sensor Connector

Fig. 4, Intake Heater Wiring Connections

2. Secure it with the mounting fasteners.
3. Connect the main module connector, and the temperature sensor connector to the module.
4. Connect the batteries and remove the chocks from the tires.

Air Intake Heater Relay #1 Replacement

Removal (See Fig. 4)

1. Set the parking brake, shut down the engine, and chock the tires. Disconnect the batteries.

Component Replacement

2. Working under the hood, disconnect the cables (Ref. 4, 6, 7, 8, and 9) and the controller module wire (Ref. 11) from the relay.
3. Remove the relay by removing the mounting fasteners.

Installation (See Fig. 4)

1. Position the relay on the air intake tray.
2. Install the fasteners.
3. Connect the cables (Ref. 4, 6, 7, 8, and 9) and the wire (Ref. 11) to the relay.
4. Connect the batteries and remove the chocks from the tires.

Air Intake Heater Relay #2 Replacement

Removal (See Fig. 4)

1. Set the parking brake, shut down the engine, and chock the tires. Disconnect the batteries.
2. Working under the hood, disconnect the cables (Ref. 4, 9 and 13) and the controller module wire (Ref. 12) from the relay.
3. Remove the relay by removing the mounting fasteners.

Installation (See Fig. 4)

1. Position the relay on the air intake tray.
2. Install the fasteners.
3. Connect the cables (Ref. 4, 9 and 13) and the wire (Ref. 12) to the relay.
4. Connect the batteries and remove the chocks from the tires.

Troubleshooting Procedures

1. Preheat Cycle—The key switch should be in the ON position. The wait-to-start (WTS) light will come on indicating that the system is in the preheat mode. When the light goes out the engine is ready to start. The engine must be cranked within 10 seconds after the WTS light goes out.

   Post-Heat Cycle—With the engine running, if white smoke is present or if the engine is running rough due to cold conditions, the operator can use the post-heat cycle. The key switch should be in the ON position. When the intake manifold heater system switch is in the ON position, the WTS light will flash indicating that the system is in the post-heat mode. See **Table 1** for operating times at given temperatures.

2. Wait-To-Start Light—Do not attempt to start the engine while the wait-to-start light is ON. When the air temperature rises above 59°F (15°C), the WTS light will go out, indicating that the engine will start. The engine must be cranked within ten seconds after the WTS light goes out, or the intake air should be warmed again. If the WTS light flashes at the rate of once per second, there is an open in the system's wiring circuit.

3. Temperature Sensor—The temperature sensor, or thermistor, is mounted in the intake manifold and sends varying resistance values to the electronic control module (ECM). The ECM in turn controls the wait-to-start light and the heater solenoids.

4. Wiring Harness—If the engine does not have a shutdown solenoid, or if it has a timer module for the shutdown solenoid, the three-pin connector "Tee" will be wired to the vehicle. The connectors on the harness have letter designations. "A" connects to the vehicle power. "B" connects to the "S" terminal on the ignition switch. "C" is the ground wire.

   If a problem is suspected in the wiring harness, check for loose connections. Also check for abrasions, and broken or worn wires. Replace or repair as necessary.

5. Contactors—The contactors, or relay coils, close the circuits to the air intake heater grid when the switch is moved to the ON position, the ignition switch is ON, and the temperature sensor senses a temperature below 59° F (17° C).

6. Fusible Links, 110A—The air intake heater system is protected by two 110 ampere fusible links—one for each of the grid heater elements. If either of the grid heater elements is suspected of not operating, both fusible links should be checked for continuity. The current draw is 95 amperes per element.

7. Controller Module—If a malfunction is suspected in the air intake heater control module, first check the wiring harness. The controller operates between 6.5 volts and 16 volts. Check the connectors for good connections. Check pin J2A for 12-volt signal.

NOTE: The controller will cancel post-heat if it senses a voltage below 9.5 volts during preheat or a delay of 10 seconds or more between the wait-to-start light going off and the start of cranking. An open in the circuit will also be detected by the controller and will also result in a cancellation of the post-heat operation.

8. Ground Circuits—Check pin J1B for ground to the controller and check the ground strap to the grid for high resistance. Repair or replace as necessary.

Intake Manifold Heater System Normal Operation		
Engine Intake Manifold Temperature °F (°C)	**Preheat Cycle Time, Ignition Key "ON", Before Crank Cycle (seconds)**	**Post-Heat Cycle Occurs, Ignition Key "ON", After Crank Cycle**
Above 59 (15)	0	No
15 to 59 (–9 to 15)	10 *	Yes
0 to 15 (–18 to –9)	15	Yes
–15 to 0 (–26 to –18)	17	Yes

Troubleshooting

Intake Manifold Heater System Normal Operation		
Engine Intake Manifold Temperature °F (°C)	**Preheat Cycle Time, Ignition Key "ON", Before Crank Cycle (seconds)**	**Post-Heat Cycle Occurs, Ignition Key "ON", After Crank Cycle**
Below –15 (–26)	20	Yes

* Heater control modules/electronic control modules with serial numbers below 0080000A will not have a preheat cycle during this cycle.

Table 1, Intake Manifold Heater System Normal Operation

Troubleshooting Table

Problem—Wait-To-Start (WTS) light will not function

Problem—Wait-To-Start (WTS) light will not function	
Possible Cause	**Remedy**
The bulb is damaged or burned out.	Replace the bulb.
There is no power to the light.	Check the voltage to the bulb socket. If there is no voltage, check the connections and wiring from the key switch to the WTS light switch and to the light socket. Check the ground circuit from the controller. Repair as necessary. The WTS light will flash once every second if the temperature sensor detects an open circuit.

Problem—Temperature Sensor Appears Inoperative

Problem—Temperature Sensor Appears Inoperative	
Possible Cause	**Remedy**
The temperature sensor has failed.	Check the resistance across the temperature sensor pins J1A and J1B at room temperature and in an ice bath, 32°F (0°C). The resistance should be approximately 800 ohms at room temperature and 2000 ohms in the ice bath. Check the resistance to ground for an open circuit. NOTE: Make resistance checks with the key switch in the ON position to make sure there are no ground problems. Replace as necessary.
The circuit is open.	Check the circuitry connections and wiring for continuity. Replace or repair as necessary.

Problem—Relays or Contactors Appear Inoperative

Problem—Relays or Contactors Appear Inoperative	
Possible Cause	**Remedy**
The relays or contactors have failed.	An audible click should be heard from the relays or contactors during operation. Replace as necessary. Check the resistance at the relay terminals and ground. If resistance is too high, replace the relay.

Problem—Insufficient Ground Connections

Problem—Insufficient Ground Connections	
Possible Cause	**Remedy**
The circuit is open.	Check pin J1B for ground to the controller, and check the ground strap to the grid for high resistance. Repair or replace the wiring as necessary.

Problem—Controller is Malfunctioning

Problem—Controller is Malfunctioning	
Possible Cause	**Remedy**
The circuit is open.	Check pin J2A for a 12-volt signal. Inspect the wiring harness for shorting, chafing, or burning. Repair or replace the wiring as necessary. NOTE: The controller operates between 6.5 volts and 16 volts.
Low or no voltage to the controller.	The controller operates between 6.5 volts and 16 volts. Check connectors for good connections. Replace the controller if necessary.
The controller is inoperative.	The controller will cancel post-heat if it senses a voltage below 9.5 volts during preheat, a ten second delay or more between the WTS light OFF and cranking, or an open temperature circuit.

Removal

1. Apply the parking brakes, chock the tires, and (if applicable) drain the air system.
2. Disconnect the battery cables at the batteries.
3. Remove the hood. For detailed instructions, see **Section 88.00**, Subject 140.
4. Drain the oil. See **Fig. 1** for the location of the oil drain plug.

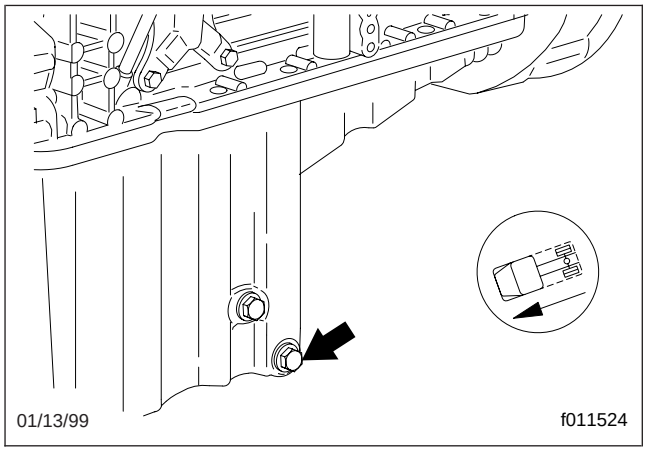


Fig. 1, Oil Drain Plug

⚠ WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

5. Drain the coolant from the radiator. See **Fig. 2**.
6. Remove the coolant hose standoff bracket.
7. When the coolant has fully drained, remove all the coolant hoses from the engine. See **Fig. 3** for the coolant delivery hoses from the surge tank, **Fig. 4** for the upper coolant hose, and **Fig. 5** for the lower coolant hose.
   - 7.1 Remove the two small-diameter hoses attached to the surge tank, one going to the engine, the other to the radiator. These are the hoses that were attached to the standoff bracket.
   - 7.2 Remove the 2-inch (50-mm) inside diameter upper coolant hose attached to the front end of the crankcase, near the cylinder head.
   - 7.3 Remove the lower coolant hose assembly.
   - 7.4 Plug the openings with a clean shop towel.
8. Remove the intake air circulation pipes and hoses. See **Fig. 5**.
   - 8.1 Remove the crossover hose from the charge air inlet pipe to the charge air cooler (cold air).

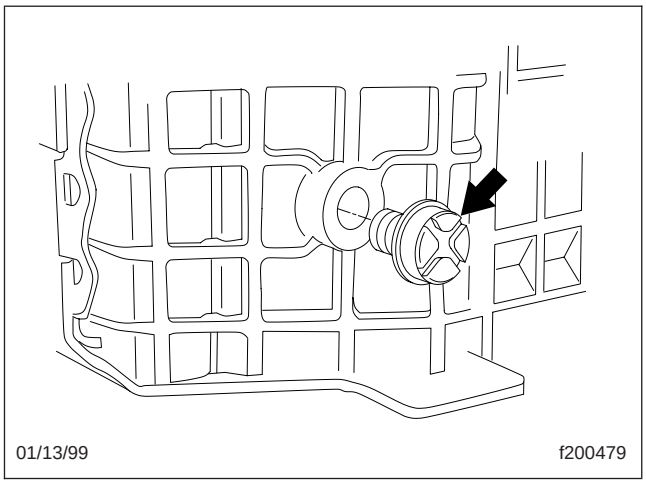
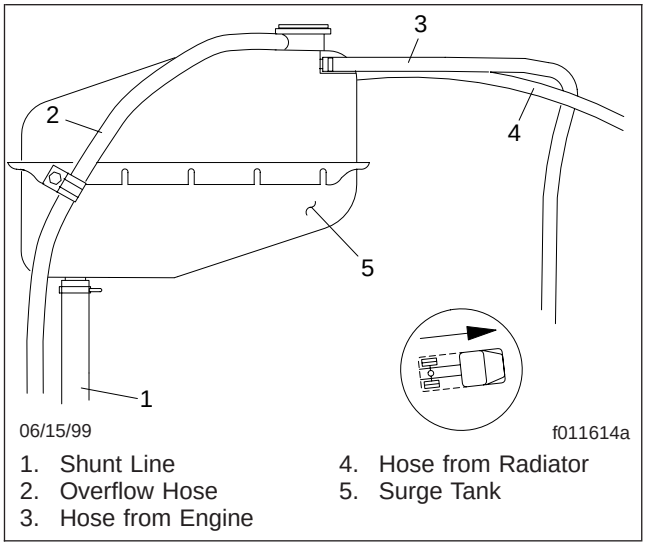


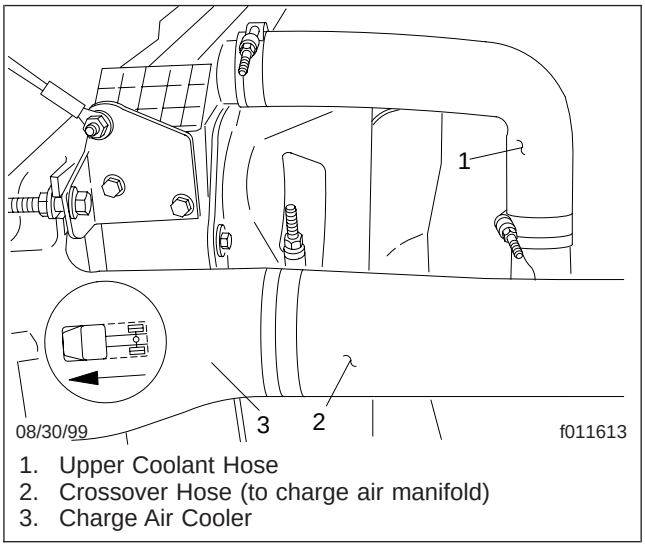
Fig. 2, Coolant Drain Plug



1. Shunt Line
2. Overflow Hose
3. Hose from Engine
4. Hose from Radiator
5. Surge Tank

Fig. 3, Coolant Hoses at the Surge Tank

Engine Removal and Installation



1. Upper Coolant Hose
2. Crossover Hose (to charge air manifold)
3. Charge Air Cooler

Fig. 4, Hoses, Left-Hand Side

8.2 Remove the convoluted hose from the turbo outlet pipe to the charge air cooler (warm air).

8.3 Remove the pipe from the air cleaner to the turbo inlet (air cleaner pipe).

8.4 Remove the crankcase breather hose from the crankcase inlet tubing.

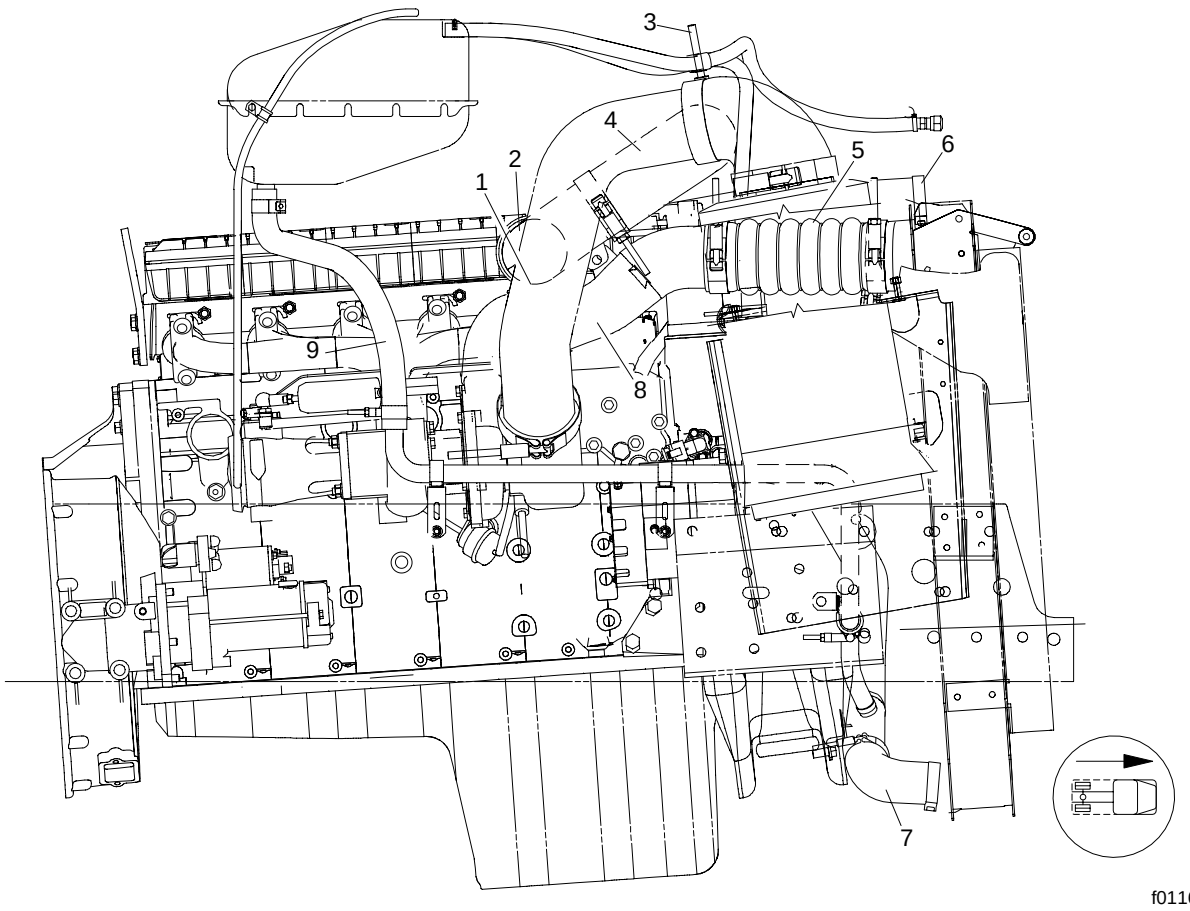
8.5 Remove the air compressor inlet hose between the air cleaner pipe and the air compressor inlet tubing.

8.6 For ease of installation, mark the outlets on each pipe with a paint pen.

8.7 Plug the openings with a clean shop towel.

IMPORTANT: Leave all air conditioning hoses attached to avoid depressurizing the A/C system.

9. Remove the air conditioning (A/C) condenser. See **Fig. 6**. Wrap the condenser, with hoses attached, in a protective blanket, and secure it out of the way.
10. Remove the charge air cooler. See **Fig. 7**. For detailed procedures, see the instructions in **Section 09.01**, Subject 100.
11. Remove the radiator assembly. See **Fig. 7**. For detailed procedures, see the instructions for frame-rail mounted radiators in **Section 20.01**, Subject 100.
12. Release the tension on the poly-V belt. See **Fig. 8**.
13. Disconnect the fuel lines from the fuel filter housing. See **Fig. 9**.
14. Remove the refrigerant compressor. See **Fig. 10**.
15. Disconnect the electrical connectors from the engine.
    - 15.1 Disconnect the engine harness connector from the PLD (engine control unit). See **Fig. 11**.
    - 15.2 Disconnect the fan solenoid connector. This connector is along the left-hand side, between the PLD and the air compressor. See **Fig. 12**.
    - 15.3 Disconnect the exhaust brake solenoid connector, if installed. This connector is on the left-hand side near the PLD. See **Fig. 12**.
16. Disconnect the power steering pump from the air compressor. Secure it, with the lines attached, up and out of the way. See **Fig. 13**.
17. Remove the air line from the exhaust brake, if installed. See **Fig. 14**.
18. Disconnect the exhaust pipe. See **Fig. 15**.
19. Remove the starter and engine ground strap. Set the starter out of the way.
    - 19.1 Remove the ground strap from the engine to the chassis.
    - 19.2 Remove the starter mounting bolts.
    - 19.3 Move the starter up and out of the way, with the cables attached. Tie the starter in place.
20. Remove the electrical leads from the back of the alternator. See **Fig. 16**.
21. Remove the transmission. For procedures, see **Group 26**.
22. Remove the hydraulic clutch line, if installed. See **Fig. 17**.
23. Remove the rain tray and wiper arms.



1. Air Cleaner Pipe
2. Charge Air Inlet Pipe (cold air)
3. Coolant Hose Standoff Bracket
4. Crossover Hose (cold air)
5. Convoluted Hose (warm air)
6. Upper Coolant Hose
7. Lower Coolant Hose
8. Turbocharger Outlet Pipe (warm air)
9. Surge Tank Shunt Line

Fig. 5, Charge Air and Coolant Pipes and Hoses

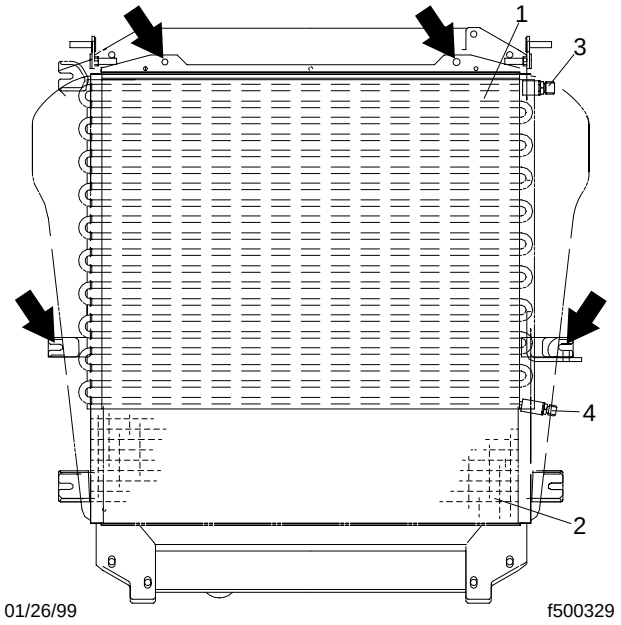
CAUTION

To avoid damage to the crankcase breather valve cover, make sure the chains on the front lifting eye provide adequate clearance.

To avoid damage to the wiper conlink, make sure the chains on the rear lifting fixture do not contact the conlink when the engine is lifted.

24. Attach a lifting hoist to the engine. Run the chains through the front lifting eye and rear lifting fixture. See **Fig. 18** for attachment to the front lifting eye and **Fig. 19** for attachment to the rear lifting fixture.
25. Loosen the engine mounts. See **Fig. 20** for the front engine mount and **Fig. 21** for the rear engine mounts.
    - 25.1 Loosen the front engine mounting bolt where it attaches to the front crossmember.
    - 25.2 Loosen the four rear engine mounting capscrews that attach the mount to the engine.

Engine Removal and Installation



Remove the four mounting bolts.

1. Air Conditioning (A/C) Condenser
2. Charge Air Cooler
3. Condenser Inlet
4. Condenser Outlet

Fig. 6, A/C Condenser

26. Support the rear of the engine with a jack.
27. Remove both rear engine mounts. For proper clearance, remove both ends of the mount.
28. Remove the front crossmember to obtain proper clearance for removal of the engine. See **Fig. 22**.

⚠ WARNING

The crane and lifting chains used to remove the engine must be capable of safely lifting and supporting two metric tons. Once the engine mounts are disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

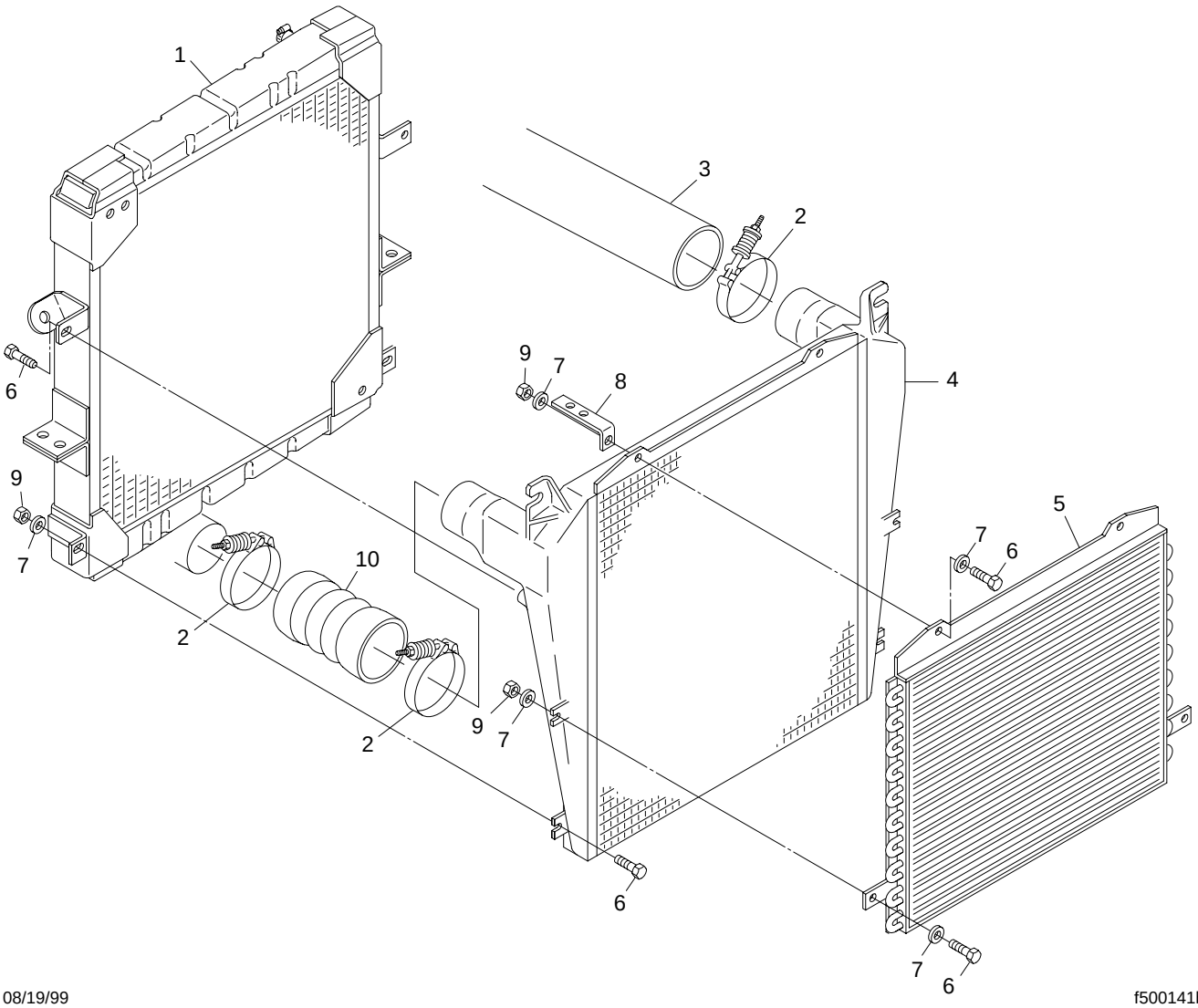
29. Remove the engine from the vehicle. See **Fig. 23**.
    - 29.1 Raise the hoist slightly until it is holding the full weight of the engine.
    - 29.2 Lower the engine just enough to allow it to move forward until it can be lifted without hitting the frontwall or wiper conlink.
    - 29.3 Pull the engine forward and up to clear the vehicle. If a new engine is to be installed, transfer all needed components from the old engine to the new engine.

Installation

⚠ WARNING

The crane and lifting chains used to remove the engine must be capable of safely lifting and supporting two metric tons. Once the engine mounts are disconnected, do not get under the engine until it is securely supported on engine stands. An unsecured engine may fall, causing personal injury or death, and component damage.

1. Using the hoist as removed, lower the engine into the engine compartment until the rear of the engine is resting on the jack used during removal. Check clearances on all sides, as removed.
2. Install the front crossmember. Tighten the locknuts on the mounting bolts 60 lbf·ft (81 N·m).
3. Install the front engine mounting bolt, isolator, and nut. Tighten the nut 136 lbf·ft (184 N·m).
    - 3.1 Position the isolator on the crossmember.
    - 3.2 Move the engine on the hoist until it rests directly on the isolator.
    - 3.3 Insert the bolt through the crossmember, isolator, and engine. Install and tighten the nut.
4. Install both rear engine mounts. See **Fig. 21** and **Fig. 24**.
    - 4.1 Install the engine mounts on the frame-mounted brackets. Tighten the mounting bolts 241 lbf·ft (347 N·m).
    - 4.2 Lower the jack under the rear of the engine slightly, until the holes in the timing case line up with the holes in the engine mounts.
    - 4.3 Insert the engine mounting capscrews and tighten them 155 lbf·ft (210 N·m).



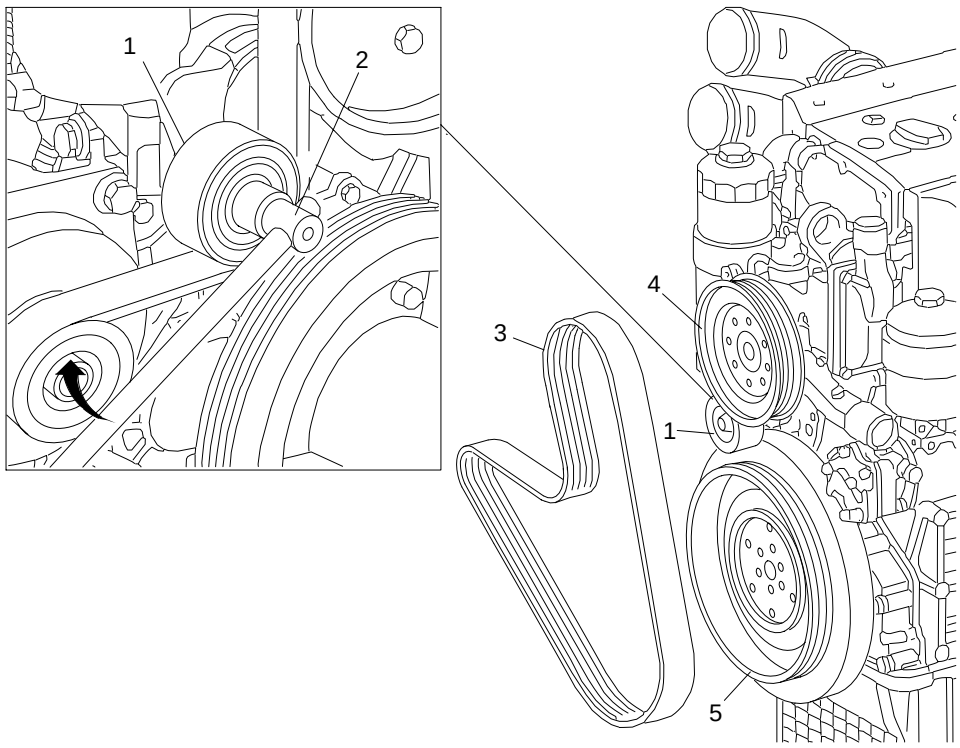
1. Radiator
2. Constant-Torque Hose Clamp
3. Charge Air Hose
4. Charge Air Cooler (CAC)
5. A/C Condenser
6. Mounting Bolt
7. Washer
8. Stand-Off Bracket
9. Nut
10. Convoluted Hose

Fig. 7, Charge Air Cooler and Radiator

4.4 Lower and remove the jack.

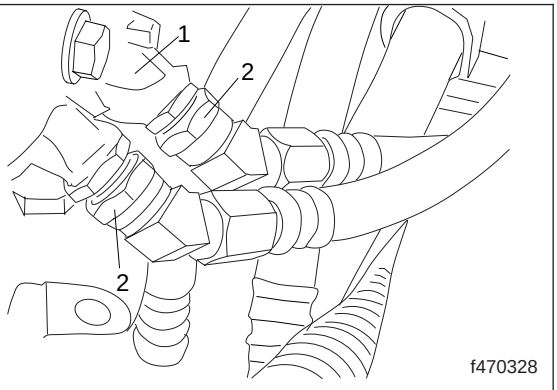
5. Remove the hoist from the front lifting eye and the rear lifting fixture.
6. Install the transmission on the engine timing case. Tighten the timing case to transmission mounting bolts 33 lbf·ft (45 N·m). For detailed procedures, see **Group 26**.
7. If removed, install the air line on the exhaust brake. See **Fig. 14**.
8. Connect the exhaust pipe. See **Fig. 15**.
9. Install the starter and engine ground strap.

Engine Removal and Installation



1. Belt Tensioner
2. Socket
3. Poly-V Belt
4. Fan Pulley
5. Vibration Damper

Fig. 8, Belt Tensioner



1. Fuel Filter
2. Fuel Line Fittings

Fig. 9, Fuel Lines

9.1 Untie the starter. Position the starter so that the starter ring gear lines up with the flywheel.

9.2 Install the starter mounting bolts and tighten them 37 lbf·ft (50 N·m).

9.3 Install the ground strap from the chassis to the engine.

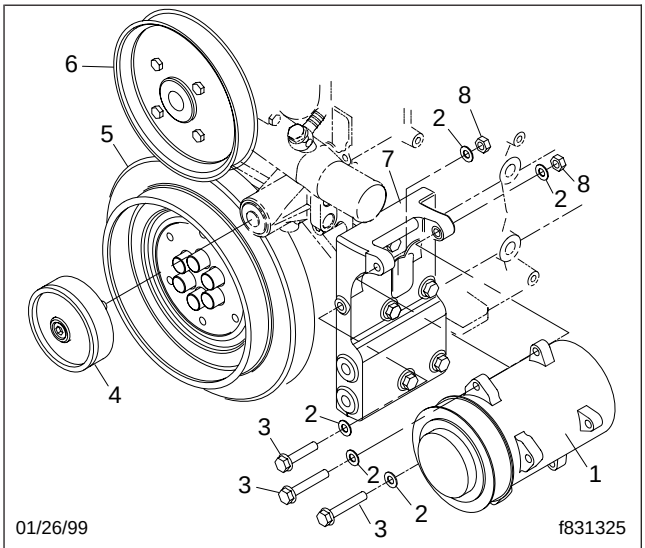
10. Install the alternator wiring on the alternator terminals. See **Fig. 16**. Tighten the output (BAT) terminal nut 100 lbf·in (1140 N·cm). Tighten the ground (G) terminal nut 65 lbf·in (740 N·cm), and the indicator light (I) terminal nut 20 lbf·in (220 N·cm).

11. Install the refrigerant compressor. See **Fig. 10**. Tighten the mounting bolts 34 lbf·ft (46 N·m).

12. Install and put tension on the poly-V belt. See **Fig. 25**.

12.1 Route the belt through and around the fan, alternator, idler, and refrigerant compressor pulleys.

12.2 Relax the tension on the belt tensioner.



1. Refrigerant Compressor
2. Hardened Flatwasher
3. Mounting Bolt, M10
4. Idler Pulley
5. Vibration Damper
6. Fan Pulley
7. Mounting Bracket
8. Locknut, M10

Fig. 10, Refrigerant Compressor

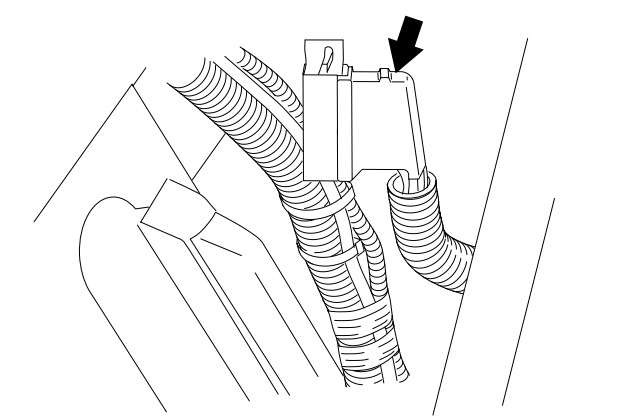
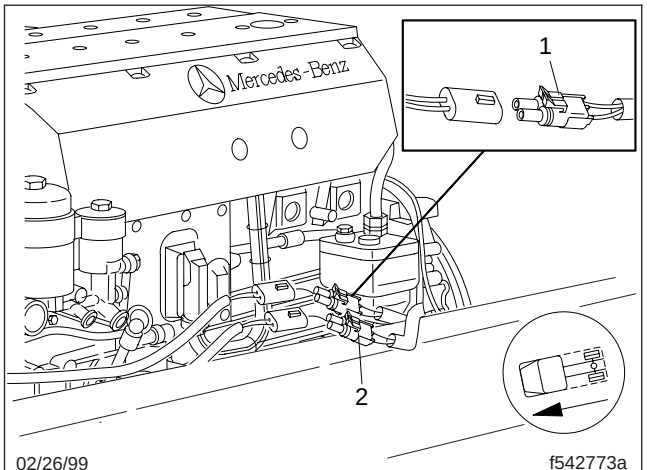


Fig. 11, Engine Harness Connector

12.3 Route the belt through the belt tensioner pulley and allow the belt tensioner to tighten the belt.

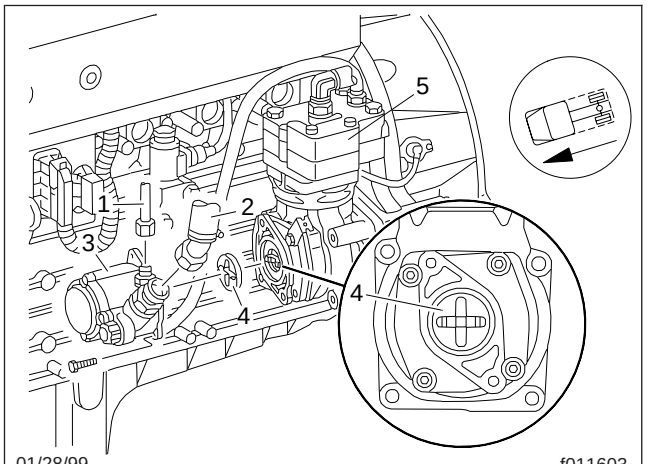
12.4 Check all the pulleys to make sure the belt is correctly installed and aligned.

13. Connect the electrical connectors to the engine.



1. Fan Solenoid Connector
2. Exhaust Brake Solenoid Connector

Fig. 12, Fan Solenoid and Exhaust Brake Solenoid Connector



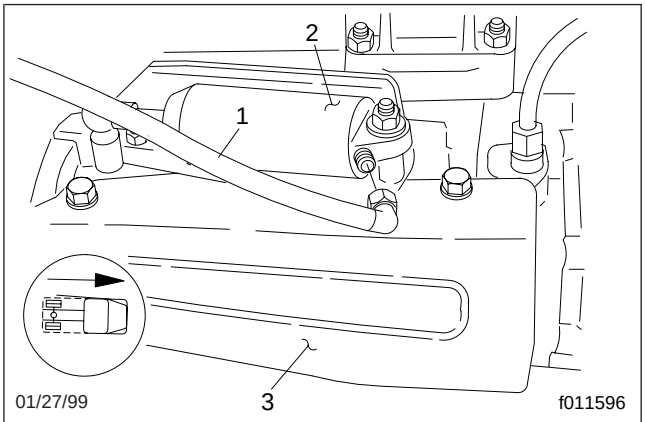
1. Pressure Line
2. Return Line
3. Power Steering Pump
4. Cross Plate
5. Air Compressor

Fig. 13, Power Steering Lines

13.1 Connect the engine harness connector to the PLD (engine) control unit. See **Fig. 11**.

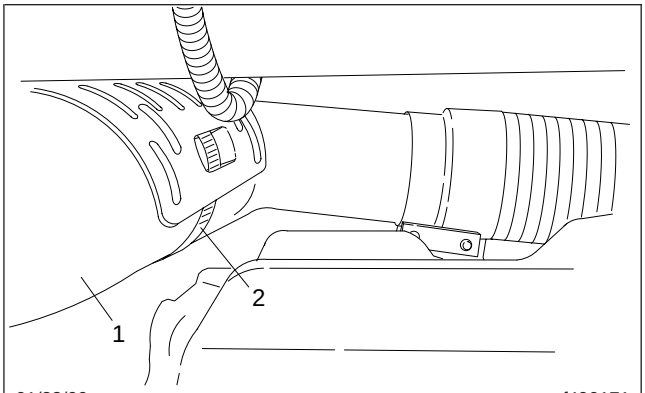
13.2 Connect the fan solenoid connector. See **Fig. 12**.

Engine Removal and Installation



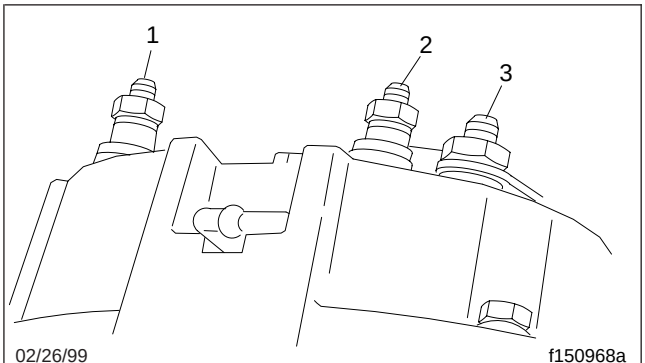
1. Compressed Air Line
2. Exhaust Brake
3. Turbocharger

Fig. 14, Exhaust Brake Air Line



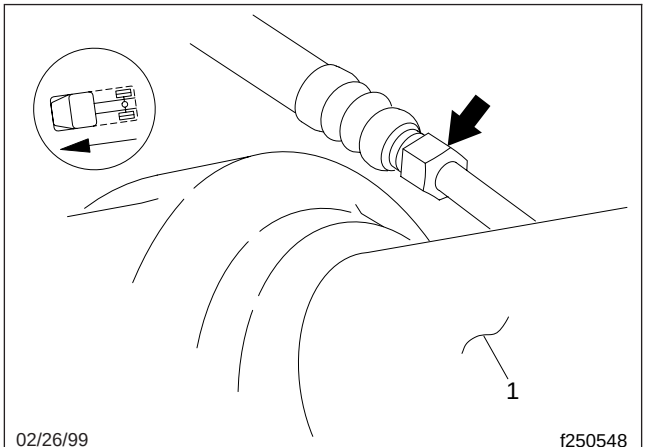
1. Exhaust Pipe
2. Clamp

Fig. 15, Exhaust Pipe



1. Ground (G)
2. Indicator Light (I)
3. Output (BAT)

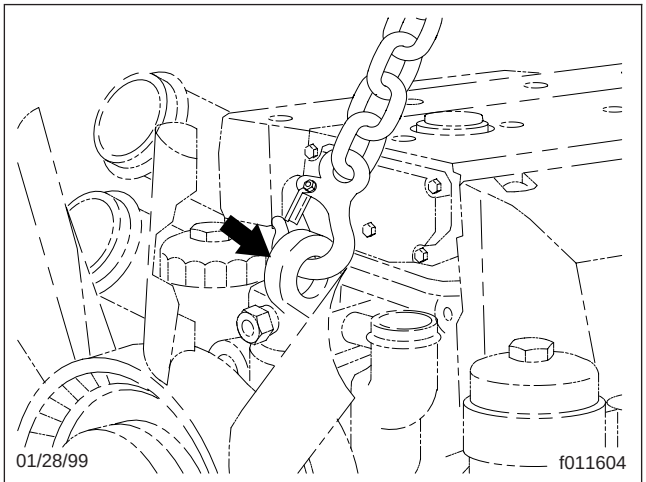
Fig. 16, Alternator Terminals



Loosen the nut on the clutch line at the arrow.

1. Clutch Slave Cylinder

Fig. 17, Hydraulic Clutch Line

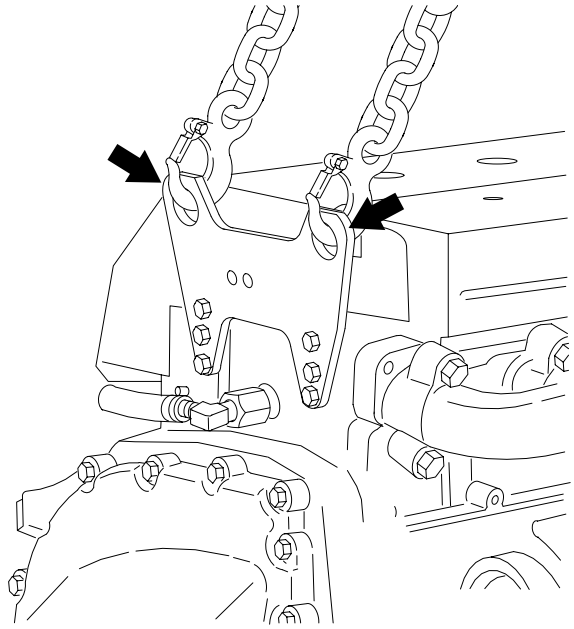


When lifting, be sure the front lifting eye is clear of the crankcase breather valve cover.

Fig. 18, Front Lifting Eye

13.3 If removed, connect the exhaust brake solenoid connector. See **Fig. 12**.

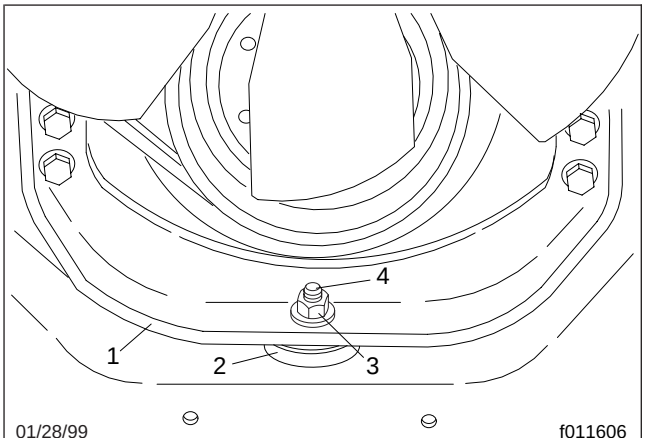
14. Connect the fuel lines to the fuel filter housing. See **Fig. 9**.
15. Connect the power steering pump to the air compressor. See **Fig. 13**.
16. Install the radiator assembly. See **Fig. 7**. For detailed instructions, see the procedures for frame-rail mounted radiators in **Section 20.01**, Subject



01/28/99 f011605

When lifting, be sure the rear lifting fixture is clear of the frontwall and the wiper conlink.

Fig. 19, Rear Lifting Fixture

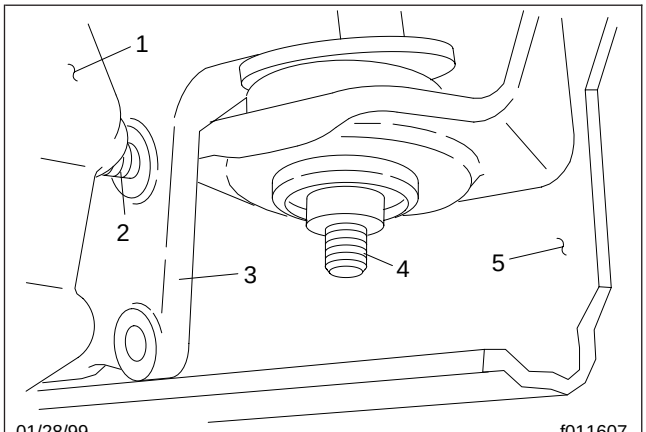


01/28/99 f011606

1. Engine Crossmember
2. Isolator
3. Hexnut, 5/8–11
4. Mounting Bolt, 5/8–11

Fig. 20, Front Engine Mount

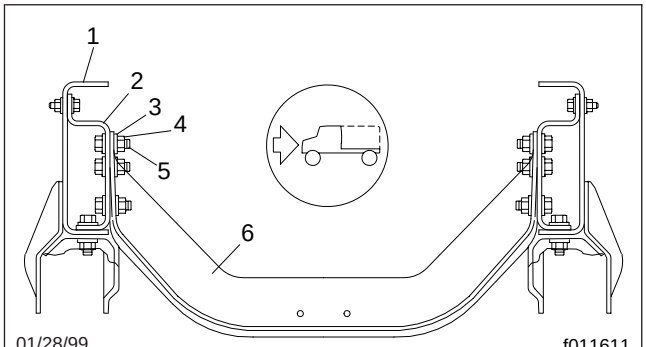
100. Tighten the nuts on the radiator brace isolators 25 lbf·ft (34 N·m).



01/28/99 f011607

1. Timing Case
2. Engine Mounting Capscrew, M16
3. Rear Mount
4. Frame-Mounted Bracket Mounting Bolt, 3/4–10
5. Frame Rail

Fig. 21, Rear Engine Mount Removal



01/28/99 f011611

1. Frame Rail
2. Mounting Bracket
3. Bearing Washer
4. Locknut, 1/2–13
5. Mounting Bolt, 1/2–13
6. Crossmember

Fig. 22, Engine Crossmember

17. Install the charge air cooler. See **Fig. 7**. For detailed instructions, see the procedures in **Section 09.01**, Subject 100. Tighten the mounting bolts 16 lbf·ft (22 N·m).
18. Install the A/C condenser and secure all hoses. See **Fig. 6**. Tighten the mounting bolts 16 lbf·ft (22 N·m).

Engine Removal and Installation

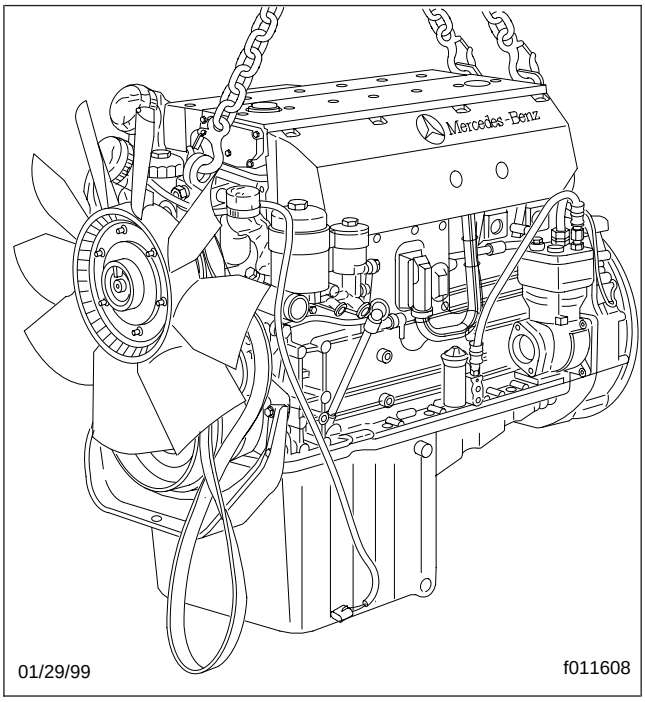
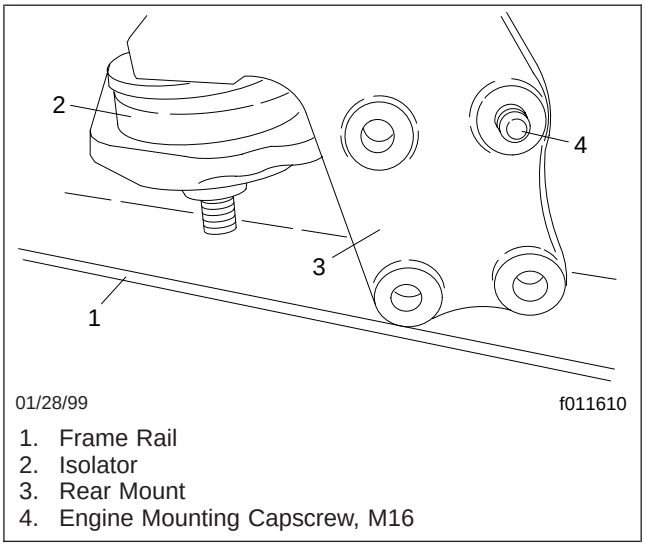


Fig. 23, Engine Removed from the Vehicle

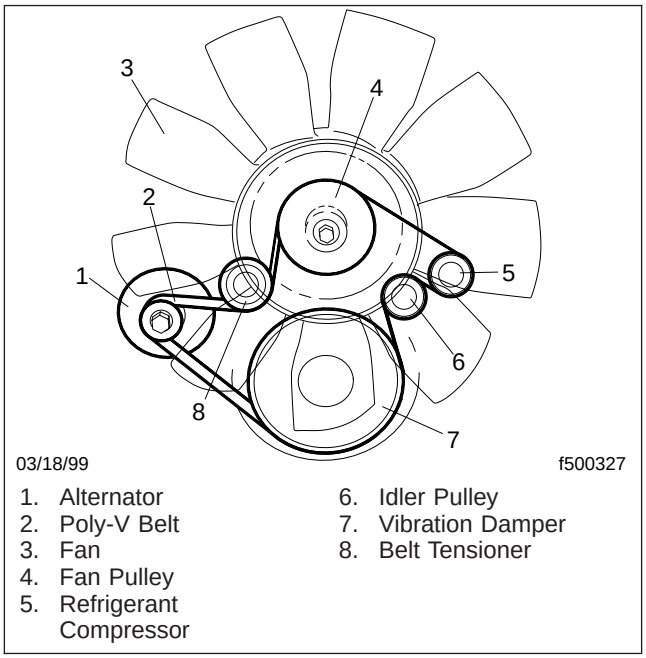


1. Frame Rail
2. Isolator
3. Rear Mount
4. Engine Mounting Capscrew, M16

Fig. 24, Rear Engine Mount Installation

19. Install the coolant hoses. See **Fig. 3**, **Fig. 4** and **Fig. 5**.

    19.1 Install the two small-diameter coolant delivery hoses attached to the surge tank.



1. Alternator
2. Poly-V Belt
3. Fan
4. Fan Pulley
5. Refrigerant Compressor
6. Idler Pulley
7. Vibration Damper
8. Belt Tensioner

Fig. 25, Belt Routing

    19.2 Install the medium-diameter upper coolant hose attached to the front end of the crankcase, near the cylinder head.

    19.3 Install the lower coolant hose assembly.

20. Install the coolant hose standoff bracket.

21. Install the charge air cooler hoses, as marked on removal. Make sure the pipes fit well and the clamps are tight. Make sure the crossover hose is oriented correctly. See **Fig. 26**.

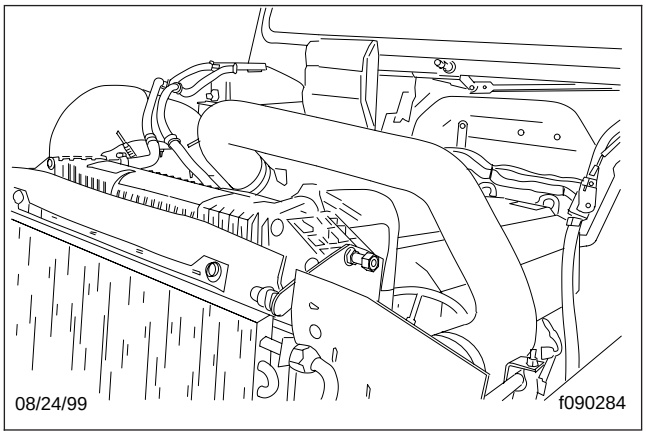
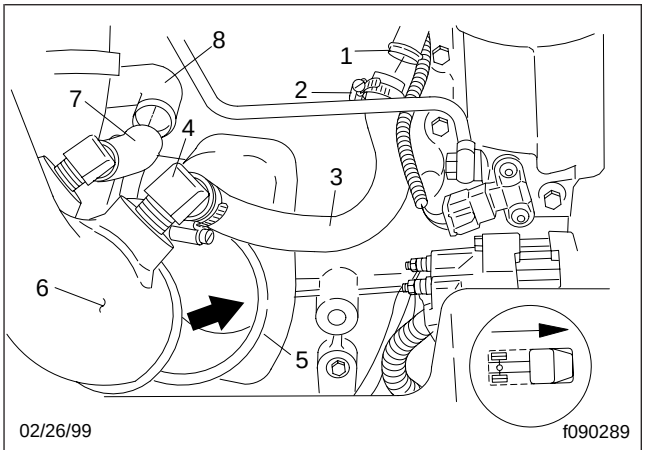


Fig. 26, Crossover Hose

21.1 Install the crossover hose leading between the charge air cooler and the charge air inlet pipe (cold air).

21.2 Install the convoluted hose between the turbo outlet pipe and the charge air cooler (warm air).

22. Install the air cleaner pipe, as marked on removal. Make sure the pipe fits well down on the inlet, is firmly connected, and the clamps are tight. See **Fig. 27** for correct fit of the air cleaner pipe to the turbo inlet.



1. Crankcase Inlet
2. Clamp
3. Crankcase Breather Hose
4. 90° Elbow
5. Turbo Inlet
6. Air Cleaner Pipe
7. Air Compressor Inlet Hose
8. Air Compressor Inlet

Fig. 27, Air Cleaner Pipe and Breather Hose

23. Install the air compressor inlet hose, as marked on removal. Make sure the hose fits well down on the air compressor inlet tubing, is firmly connected, and the clamp and elbow are tight. See **Fig. 27** for correct fit of the breather hose to the inlet tubing.

24. Install the crankcase breather hose, as marked on removal. Make sure the hose fits well down on the crankcase inlet tubing, is firmly connected, and the clamp and elbow are tight. See **Fig. 27** for correct fit of the breather hose to the inlet tubing.

25. Install the rain tray and wiper arms.

26. If removed, install the hydraulic clutch line and bleed the hydraulic clutch system. For detailed instructions, see **Section 25.03**, Subject 140.

27. Install the hood. For detailed instructions, see **Section 88.00**, Subject 140.

28. Install the coolant drain plug. Fill the radiator with coolant. Make sure the coolant drain plug is tight and is not leaking.

29. Install the oil drain plug and tighten it 48 lbf·ft (65 N·m). Fill the engine with oil. Make sure the oil drain plug is tight and is not leaking.

30. Connect the battery cables to the batteries.

31. Turn on the ignition keyswitch and test the engine for good operation. Pay attention to oil pressure, coolant temperature, warning lights, fluid leaks, and any other signs of a problem.

32. Remove the chocks from the tires.

Specifications

Torque Values, Engine Removal and Installation			
Description	**Size**	**lbf·ft (N·m)**	**lbf·in (N·cm)**
A/C Condenser to Charge Air Cooler Locknuts	5/16–18	16 (22)	—
Alternator Output (BAT) Terminal Nut	5/16–18	—	100 (1140)
Alternator Ground (G) Terminal Nut	1/4–20	—	65 (740)
Alternator Indicator Light (I) Terminal Nut	M4	—	20 (220)
Charge Air Cooler to Radiator Locknuts	5/16–18	16 (22)	—
Front Crossmember Mounting Bolts	1/2–13	60 (81)	—
Front Engine Mounting Nut, Gr. 8	5/8–11	136 (184)	—
Oil Drain Plug	—	48 (65)	
Radiator Isolator Mounting Nuts	7/16–14	25 (34)	—
Rear Engine Mounts: Engine Mounting Capscrews, Gr. 8	M16	155 (210)	—
Rear Engine Mounts: Frame-Mounted Bracket Mounting Bolts, Gr. 8	3/4–10	241 (347)	—
Refrigerant Compressor Mounting Bolts	M10	34 (46)	—
Starter Mounting Bolts	—	37 (50)	—
Timing Case to Transmission Mounting Capscrews	—	33 (45)	—

Table 1, Torque Values, Engine Removal and Installation

General Information

The Jacobs exhaust brake uses exhaust back pressure to help slow the vehicle. It supplements the vehicle's standard service brakes to supply more efficient braking action, even with heavy loads. It is virtually silent during operation, and provides retarding power proportional to the engine rpm; that is, the higher the engine rpm, the higher the retarding horsepower.

The exhaust brake is installed in the exhaust line between the turbocharger (or turbocharger exhaust pipe) and the main exhaust pipe. The major components of the exhaust brake include a butterfly valve and an air cylinder. When the air cylinder is pressurized, a pushrod rotates an actuating lever to close the butterfly plate. A solenoid valve controls the air released to the air cylinder from the secondary air tank.

When the valve restricts the flow of exhaust gas, back pressure increases inside the engine. This higher back pressure creates resistance against the pistons, which slows the crankshaft's rotation and helps control the speed of the vehicle.

The Jacobs exhaust brake has a cast-iron housing and a butterfly plate that resists extremely high temperatures. The exhaust brake requires no adjustment or maintenance because the valve's orifice is fixed and the air cylinder is sealed to prevent contamination. The unit can be deactivated by pressing a switch on the dash.

Removal

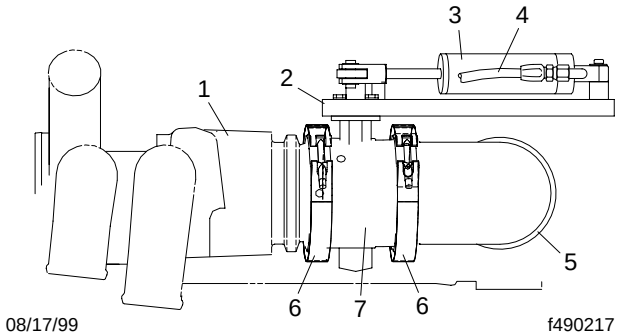
NOTE: The position of the exhaust brake and the location of the solenoid valve depend on the configuration of the vehicle. The following procedure and the illustrations are for a typical installation and may differ slightly for your application.

1. Park the vehicle, set the parking brakes, and shut down the engine. Chock the rear tires.
2. Drain the air tanks. For instructions, see **Group 42**.

⚠ WARNING

Do not work on or near the exhaust components while they are hot. To do so could result in serious personal injury from burns. Let the exhaust piping cool before you work on it.

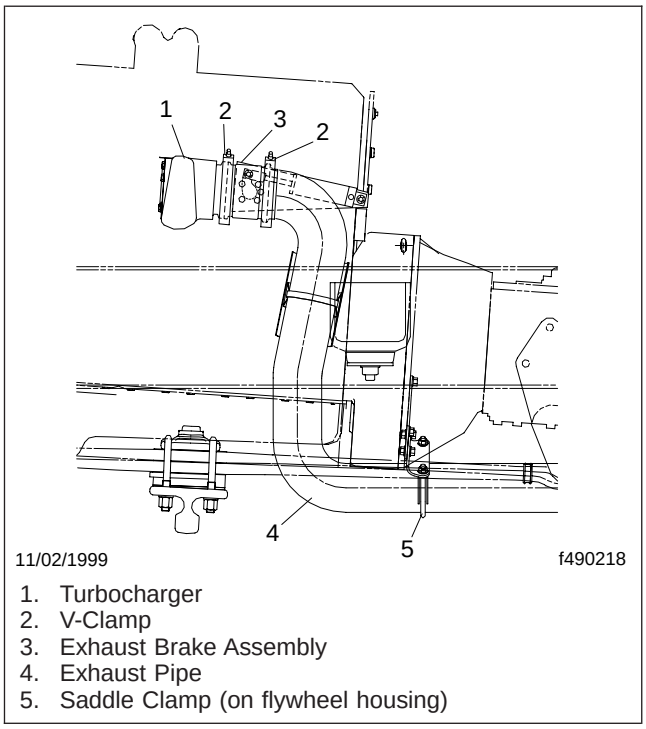
3. Disconnect the air line from the exhaust brake cylinder. See **Fig. 1**.



1. Turbocharger
2. Air Cylinder Bracket
3. Air Cylinder
4. Air Line
5. Exhaust Pipe
6. V-Clamp
7. Exhaust Brake Housing

Fig. 1, Exhaust System With Jacobs Exhaust Brake (top view)

4. Remove the exhaust brake from the exhaust pipe. See **Fig. 2**.
   - 4.1 Under the cab, remove the exhaust pipe from the saddle clamp mounted on the flywheel housing. See **Fig. 3**.
   - 4.2 Mark the exhaust brake and exhaust pipes (or turbocharger) where they are joined.



1. Turbocharger
2. V-Clamp
3. Exhaust Brake Assembly
4. Exhaust Pipe
5. Saddle Clamp (on flywheel housing)

Fig. 2, Exhaust Brake Installation (typical)

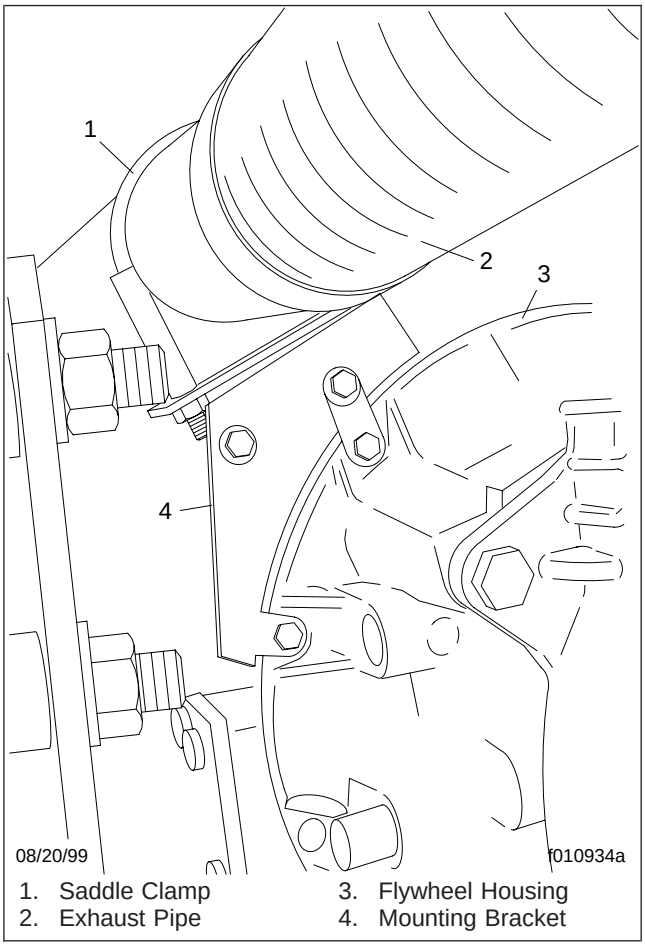
- 4.3 Loosen and remove the two V-clamps securing the exhaust piping to each side of the exhaust brake. Your vehicle may have the exhaust brake connected directly to the turbocharger without a short connecting pipe.
- 4.4 Pull the exhaust piping apart and remove the exhaust brake. Discard the gasket on the inlet side of the exhaust brake.

Installation

1. Connect the exhaust brake to the exhaust piping.
   - 1.1 Install a new gasket on the exhaust brake inlet.

     If the short turbocharger exhaust pipe was removed, install a new gasket on the inlet side of the exhaust pipe before reinstalling it.
   - 1.2 Install the exhaust brake between the turbocharger (or short turbocharger exhaust pipe) and the main exhaust pipe, aligning the marks made during removal. See

Exhaust Brake Removal and Installation



1. Saddle Clamp
2. Exhaust Pipe
3. Flywheel Housing
4. Mounting Bracket

Fig. 3, Saddle Clamp on Flywheel Housing

Fig. 2. Make sure the air cylinder bracket points downstream, away from the turbocharger.

1.3 Install the two V-clamps. Tighten each clamp 4 lbf·ft (5 N·m).

1.4 Install the saddle clamp on the exhaust pipe and secure it to the flywheel housing. Tighten the hexnuts on the saddle clamp 24 lbf·ft (33 N·m).

2. Connect the air line from the solenoid to the air cylinder. See **Fig. 1**. Tighten the connection firmly.
3. Make sure the wiring and air lines are not kinked, and are protected from abrasion and potentially hot surfaces.
4. Test the exhaust brake.
   - 4.1 Start the engine.
   - 4.2 Turn the exhaust brake switch to On.
   - 4.3 Bring the engine up to the governed rpm and release the throttle. The brake should actuate, then turn off at about 900 rpm.
5. Remove the chocks from the tires.

Replacement

NOTE: The air cylinder is the only replaceable part on the exhaust brake. Air cylinder replacement kits are available through the Caterpillar distribution system. If there is a problem with any other part, replace the entire exhaust brake assembly.

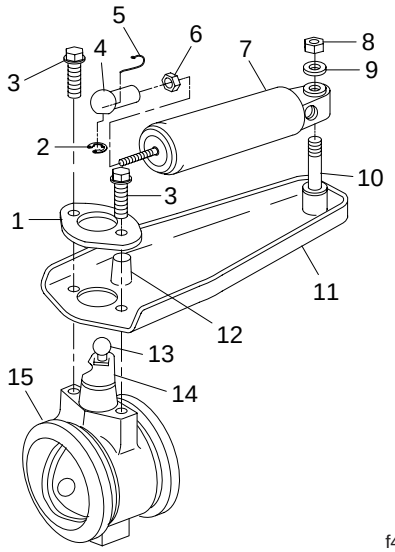
1. Park the vehicle, set the parking brakes, and shut down the engine. Chock the rear tires.
2. Drain the air tanks. For instructions, see **Group 42**.

⚠ WARNING

Do not work on or near the exhaust components while they are hot. To do so could result in serious personal injury from burns. Let the exhaust piping cool before you work on it.

3. Disconnect the air line from the exhaust brake cylinder.
4. If the configuration of your vehicle provides enough clearance to remove the air cylinder from the exhaust brake housing, go to the next step.

   If access to the air cylinder is restricted, remove the entire exhaust brake assembly from the exhaust piping. See **Subject 100** for instructions.
5. Remove the air cylinder from the exhaust brake. See **Fig. 1**.
   - 5.1 Mark the air cylinder bracket below the air supply port on the air cylinder.
   - 5.2 Loosen the jam nut between the air cylinder and the ball-and-socket joint.
   - 5.3 Remove the safety clip from the socket.
   - 5.4 Pry the socket off the ball stud on the actuating lever.
   - 5.5 Remove the locknut and washer securing the air cylinder on the pivot stud. Remove the air cylinder from the bracket.
   - 5.6 Unscrew the socket and jam nut from the threaded rod on the air cylinder.
   - 5.7 Note the orientation of the air supply fittings on the air cylinder. Remove and save the fittings. Discard the air cylinder.



1. Gasket
2. Internal Snap Ring
3. Capscrew, Hexhead
4. Socket
5. Safety Clip
6. Jam Nut, M8
7. Air Cylinder
8. Locknut, M8
9. Washer
10. Pivot Stud
11. Air Cylinder Bracket
12. Positive Stop
13. Ball Stud
14. Actuating Lever
15. Exhaust Brake Housing

Fig. 1, Jacobs Exhaust Brake

6. Install the new air cylinder on the exhaust brake.
   - 6.1 Install the air supply fittings in the same orientation on the new air cylinder.

   NOTE: The socket in the air cylinder kit has the internal snap ring already installed.
   - 6.2 Install the jam nut and socket on the threaded rod on the air cylinder, but do not tighten.
   - 6.3 Slide the air cylinder bushing onto the pivot stud on the air cylinder bracket. Make sure the air supply port is aligned with the mark you made on the bracket during disassembly.
   - 6.4 Install the washer and locknut on the pivot stud, but do not tighten.
7. Adjust the socket.
   - 7.1 Move the actuating lever clockwise until it contacts the positive stop. See **Fig. 1**. Hold the lever in this position.

Air Cylinder Replacement

7.2 Turn the socket on the threaded rod until the pocket is aligned with the ball stud on the exhaust brake housing. Then, tighten the socket one additional turn on the air cylinder threaded rod.

NOTE: The additional turn on the socket provides the required small preload on the spring in the air cylinder. If too much preload is applied (more than 1-1/2 turns), the butterfly plate will not fully close, resulting in poor exhaust brake performance.

7.3 Press the socket on the ball of the actuating lever until it snaps in place.

7.4 Make sure the spring preload in the air cylinder holds the actuating lever tightly against the positive stop. If there is any free play in the actuating lever, readjust the socket.

8. From the air cylinder side of the socket, insert the safety clip through the holes in the socket. Snap the loop on the end of the clip into the groove in the body of the socket.
9. Tighten the jam nut against the socket 13 lbf·ft (18 N·m).
10. Tighten the prevailing-torque locknut on the pivot stud until there is no free play of the cylinder on the stud.
11. Install the exhaust brake in the exhaust piping if it was removed at the start of this procedure. See **Subject 100** for instructions.
12. Connect the air line from the solenoid to the air cylinder. Tighten the connection firmly.
13. Make sure the wiring and air lines are not kinked, and are protected from abrasion and potentially hot surfaces.
14. Test the exhaust brake.
    14.1 Start the engine.
    14.2 Turn the exhaust brake switch to On.
    14.3 Bring the engine up to the governed rpm and release the throttle. The brake should actuate, then turn off at about 900 rpm.
15. Remove the chocks from the tires.

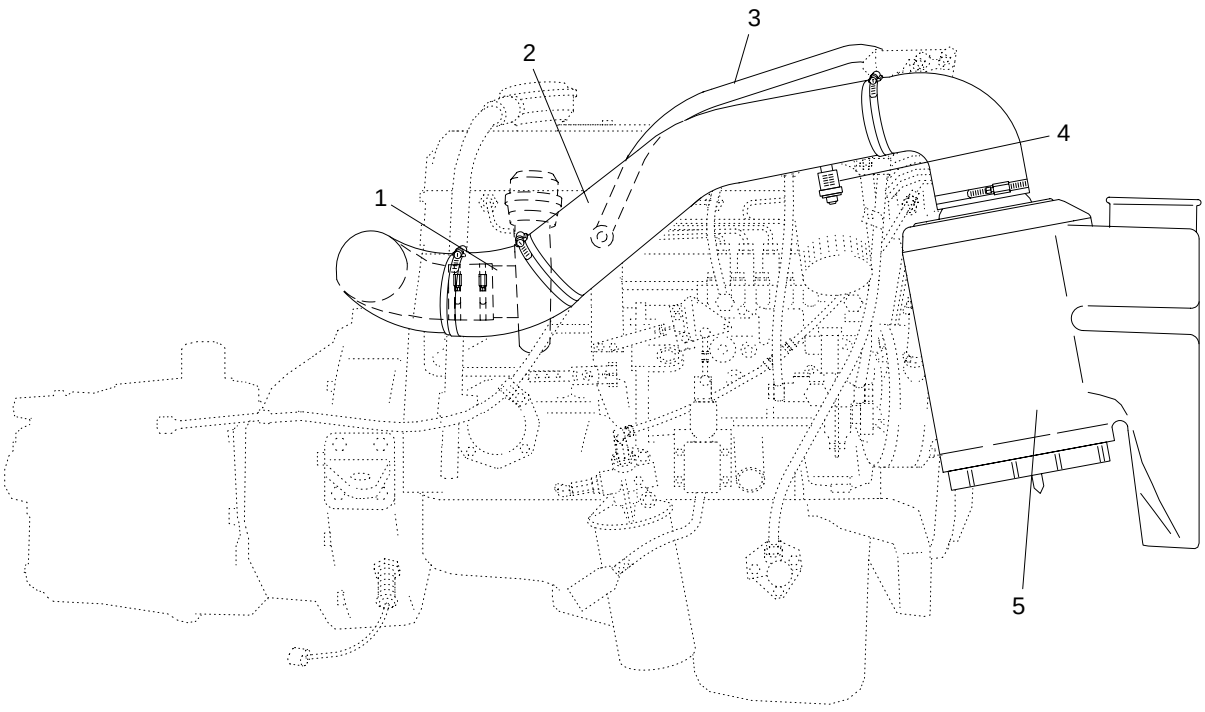
General Information

An average diesel engine needs over 10,000 gallons (38 000 liters) of clean air for each gallon (3.8 liters) of fuel burned. So complete combustion occurs in each engine cylinder, more clean air than is needed is present in each cylinder. The air intake system routes this supply of outside air through an air cleaner, which filters out dirt, dust, abrasive particles, and other foreign material from the intake air, without restricting air flow. From there, the air intake ducting routes this clean air to the engine turbocharger.

The air intake ducting consists of a high-temp plastic housing for the air cleaner, followed by aluminum tubes and neoprene hoses. Stainless steel hose clamps fasten all the components together in one of six configurations depending on which engine is used. See **Fig.1 , Fig.2 , Fig.3 , Fig.4 , Fig.5,** and **Fig.6**.

On some engines, a lock-up air restriction indicator (see **Fig.7)** is attached to the intake ducting near the air cleaner. As an option, an air restriction indicator or gauge mounts in the dashboard. Nylon tubing connects the remote-mounted indicator or gauge to the ducting. The air restriction indicator or gauge indicates when the air cleaner element needs to be replaced. The amount of allowable air restriction varies with engine type.

On vehicles equipped with a Bendix AirMaster® air compressor, the compressor air inlet hose mounts to the air intake pipe just past the air restriction indicator.

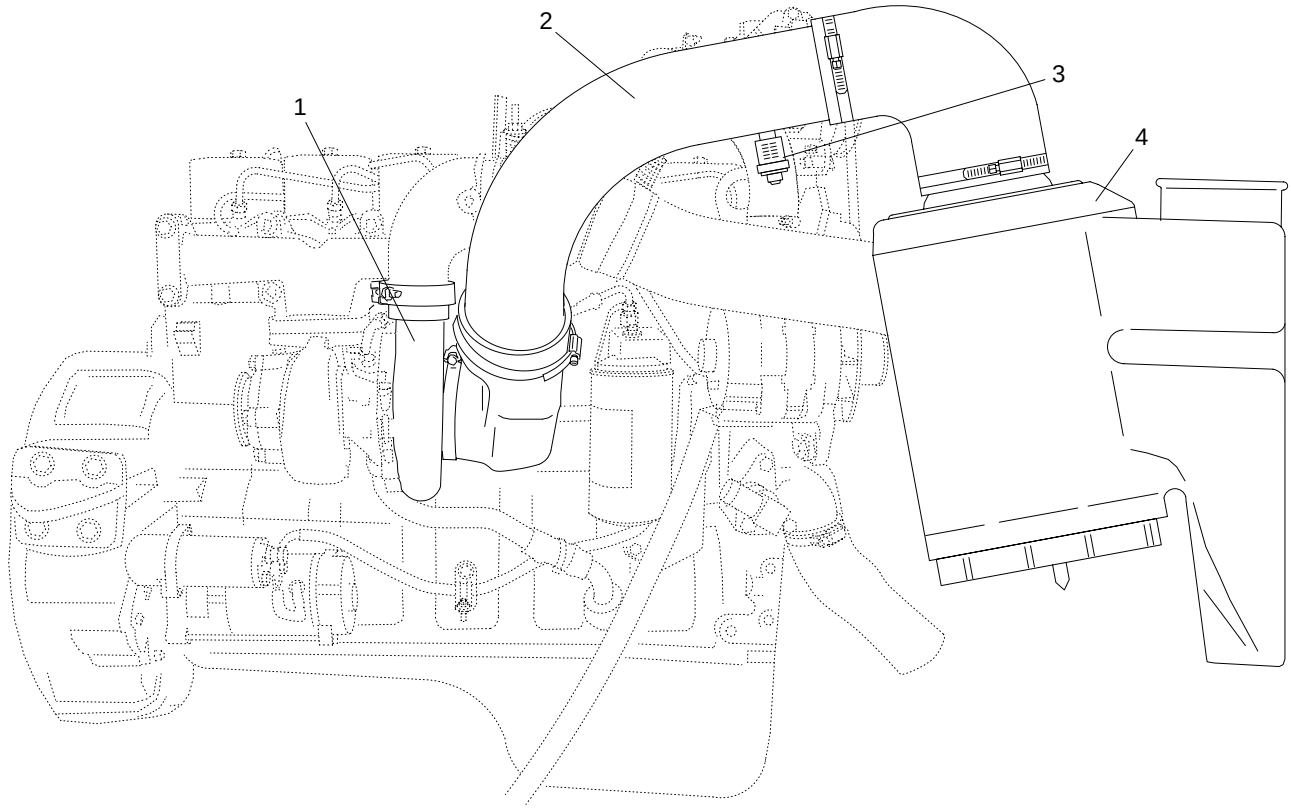


07/06/94 f010358a

1. Turbocharger
2. Air Intake Pipe
3. Air Compressor Inlet Hose
4. Air Restriction Indicator
5. Air Cleaner

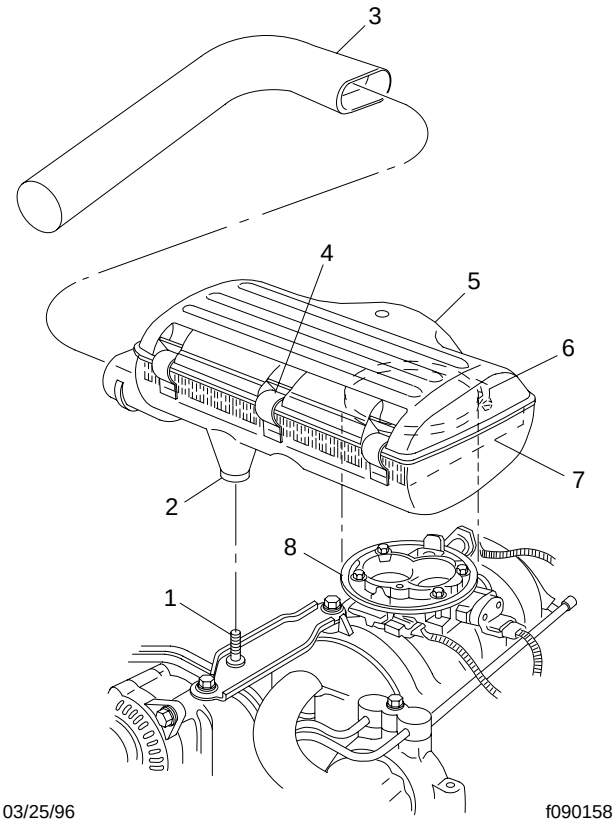
Fig. 1, Mercedes-Benz OM 366LA Engine, Air Intake Ducting

General Information



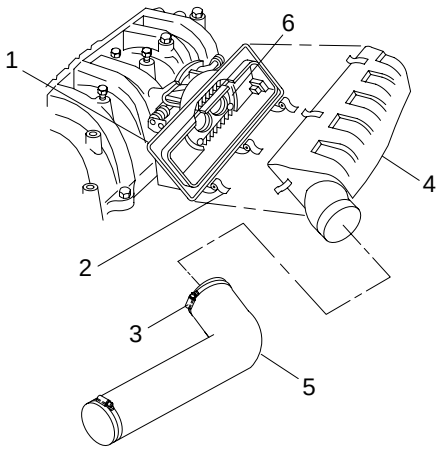
1. Turbocharger
2. Air Intake Pipe
3. Air Restriction Indicator
4. Air Cleaner

Fig. 2, Cummins B Series Engine, Air Intake Ducting



1. Mounting Stud
2. Grommet
3. Air Intake Tube
4. Spring Clip
5. Housing Cover
6. Clamp
7. Housing
8. Gasket

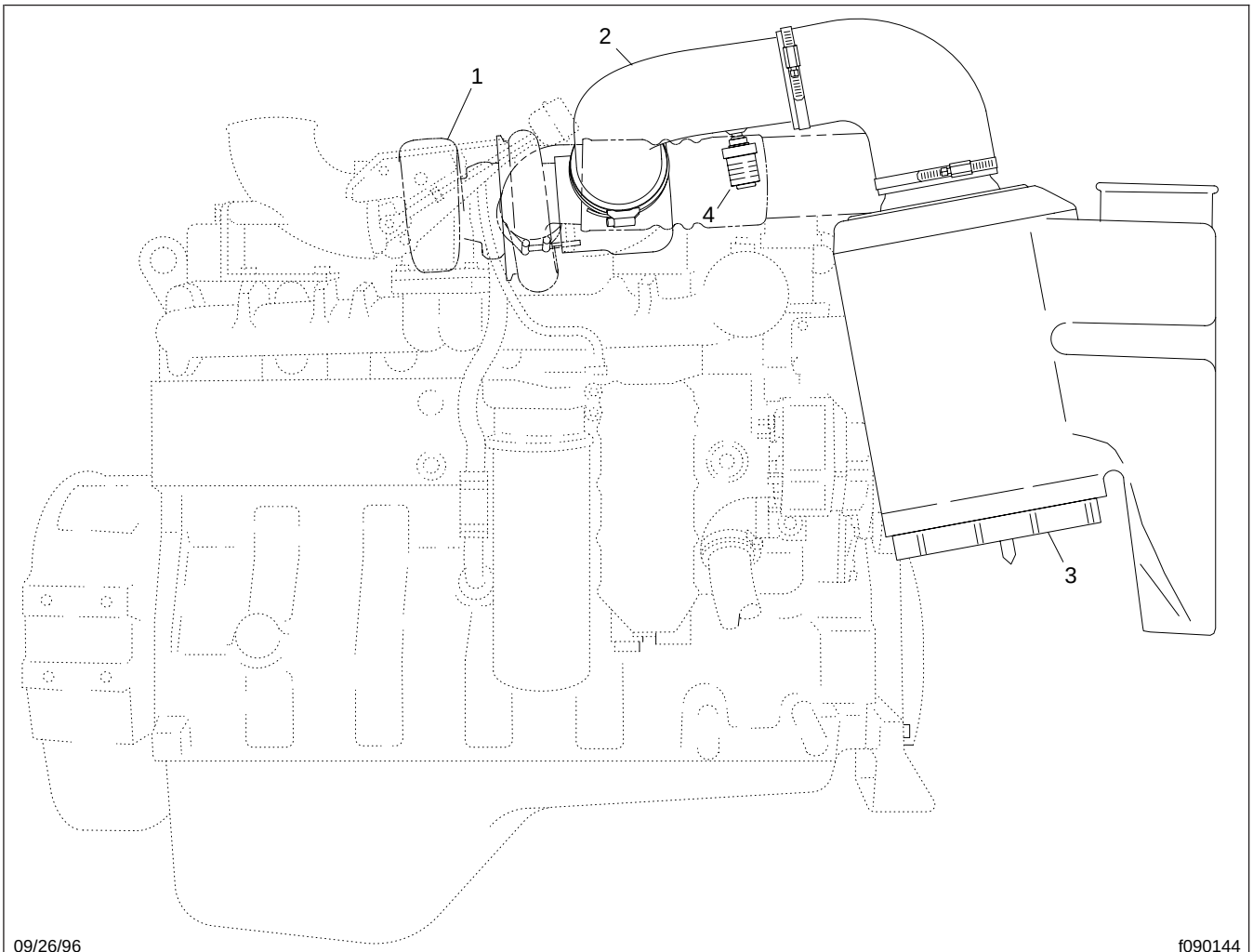
Fig. 3, Dodge Magnum V-8 Air Cleaner Installation



1. Housing
2. Spring Clip
3. Clamp
4. Housing Cover
5. Air Intake Tube
6. Gasket

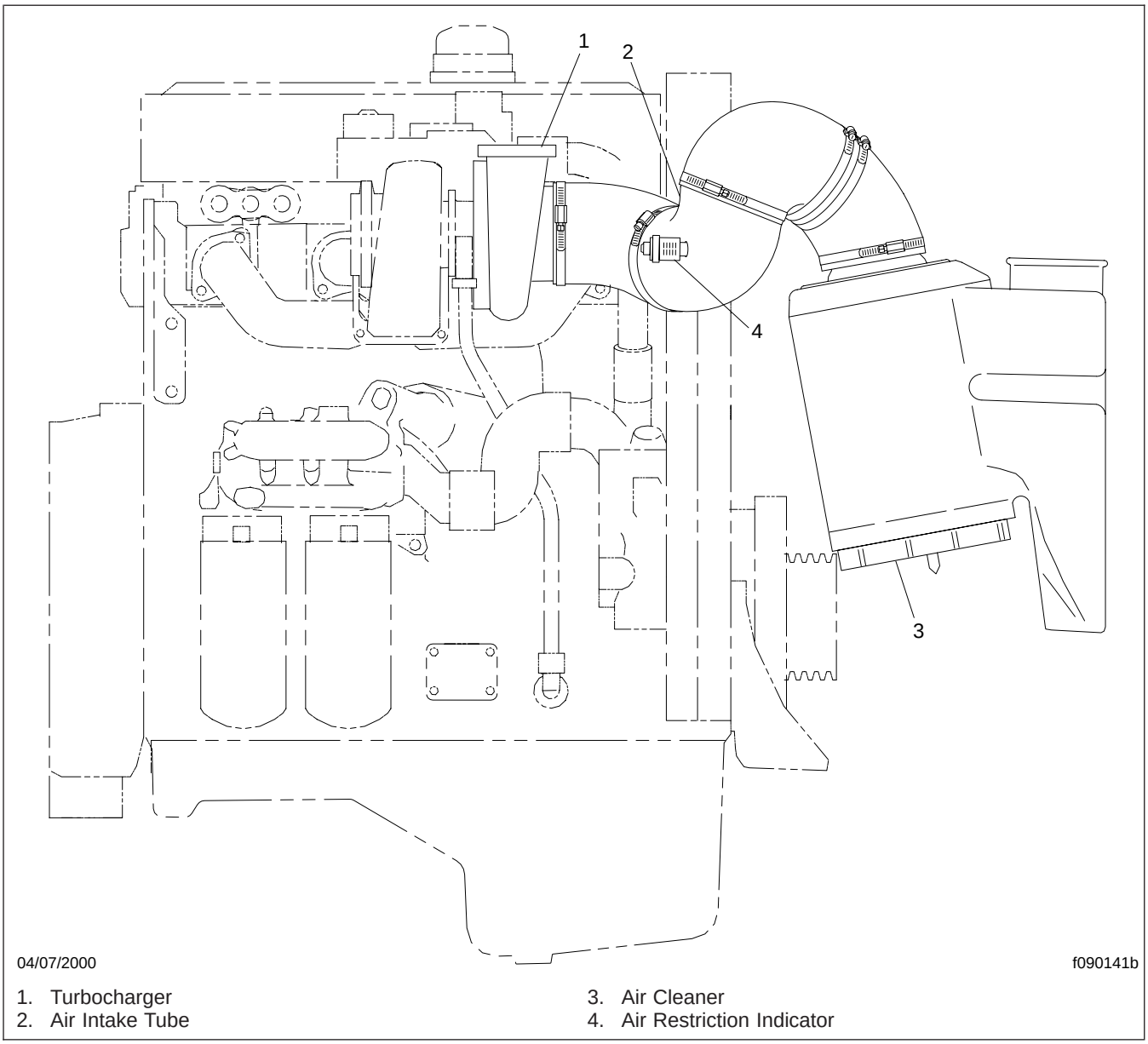
Fig. 4, Dodge Magnum V-10 Air Cleaner Installation

General Information



1. Turbocharger
2. Air Intake Pipe
3. Air Cleaner
4. Air Restriction Indicator

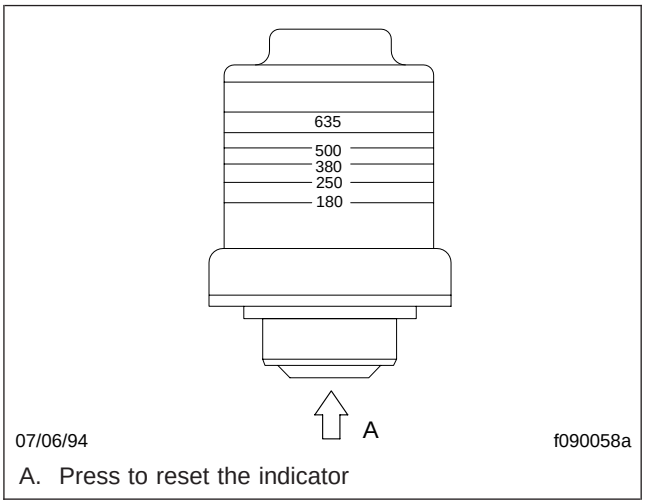
Fig. 5, Cummins C Series Engine, Air Intake Ducting



1. Turbocharger
2. Air Intake Tube
3. Air Cleaner
4. Air Restriction Indicator

Fig. 6, Detroit Diesel Series 50 Engine, Air Intake Ducting

General Information



A. Press to reset the indicator

Fig. 7, Air Restriction Indicator

Air Intake Ducting Removal and Installation, Cummins B Series Engine

General Instructions

WARNING

WARNING: Do not operate the engine with any under-hood component of the air intake system removed; serious physical injury can occur if the turbocharger impeller is touched when it is rotating.

All air intake components and connections must be air-and water-tight. Dirt or dust entering the engine can cause internal engine damage. Much of the dirt and dust are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners.

IMPORTANT: Replace damaged components with new, identical parts. Neoprene hoses and nylon ducts that have been enlarged, extended, or otherwise modified, are not acceptable for installation between the air cleaner and the engine.

To avoid chafing, air intake ducting must not contact other parts.

Removal

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.
3. Disassemble the air intake ducting. **Refer to Fig. 1.**
   - 3.1 Loosen the clamp (Ref. 8) that holds the elbow (Ref. 7) to the top of the air cleaner, and remove the elbow from the cleaner.
   - 3.2 Loosen the clamp (Ref. 6) that holds the elbow to the forward end of the air intake pipe (Ref. 5), and remove the elbow from the pipe.
   - 3.3 Loosen the clamp (Ref. 4) that holds the pipe to the elbow (Ref. 3) at the forward side of the turbocharger, and remove the pipe from the elbow.
   - 3.4 Loosen the clamp (Ref. 2) that holds the elbow to the forward side of the turbocharger, and remove the elbow from the turbocharger.

Installation

1. Replace any damaged parts with new identical parts.
2. Assemble the air intake ducting. **Refer to Fig. 1.**
   - 2.1 Install the new or undamaged elbow (Ref. 3) on the forward side of the turbocharger, and loosely install the clamp (Ref. 2).
   - 2.2 Install the new or undamaged air intake pipe (Ref. 5) in the elbow at the forward side of the turbocharger, and loosely install the clamp (Ref. 4).
   - 2.3 Install the new or undamaged elbow (Ref. 7) on the forward end of the air intake pipe, and loosely install the clamp (Ref. 6).
   - 2.4 Install the elbow on the top of the air cleaner, and tighten all hose clamps.
3. Lower the hood.
4. Remove the chocks from the tires.

Air Intake Ducting Removal and Installation, Cummins B Series Engine

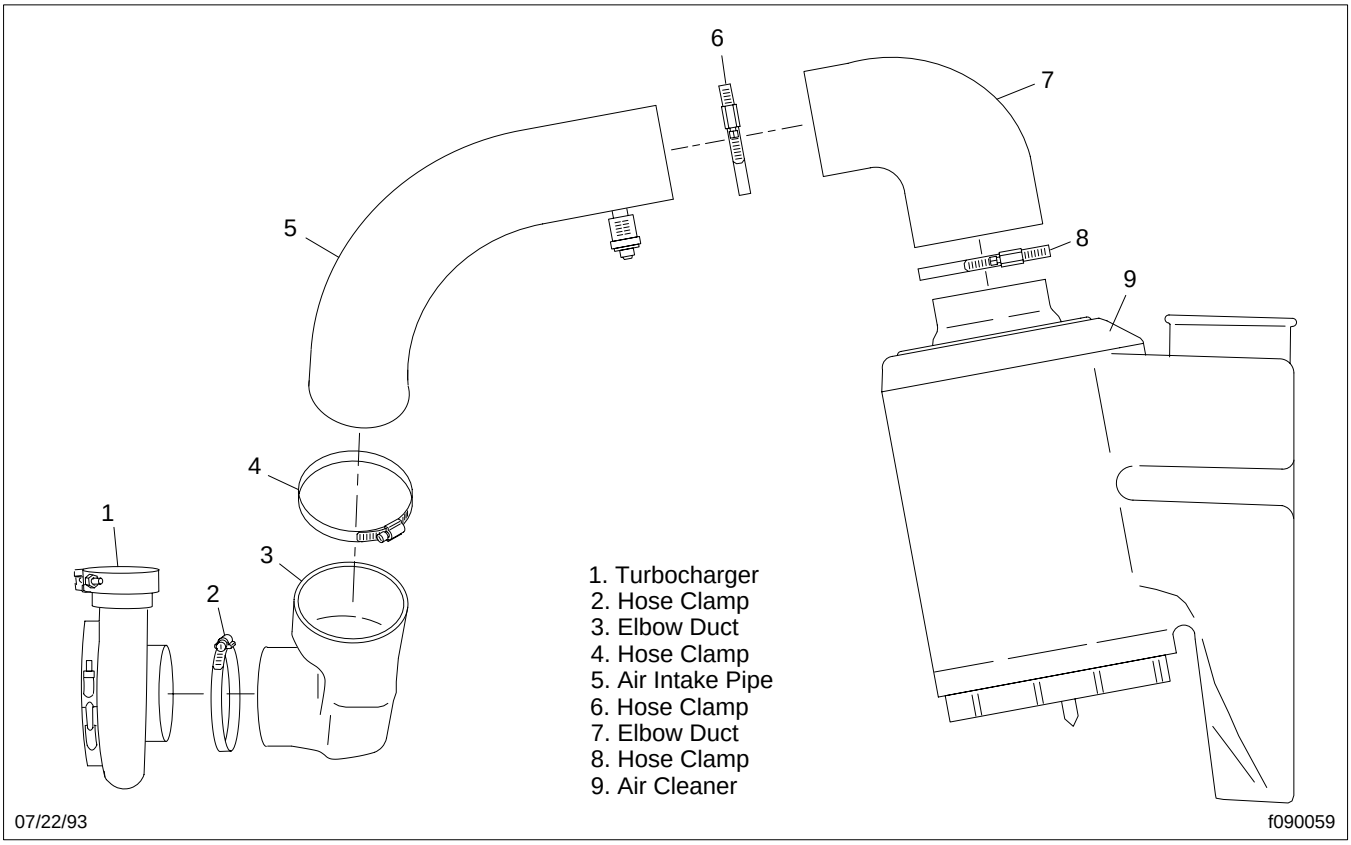


Fig. 1, Cummins B Series Engine, Air Intake Ducting

Air Intake Ducting Removal and Installation, Mercedes-Benz OM 366LA Engine

General Instructions

WARNING

WARNING: Do not operate the engine with any under-hood component of the air intake system removed; serious physical injury can occur if the turbocharger impeller is touched when it is rotating.

All air intake components and connections must be air-and water-tight. Dirt or dust entering the engine can cause internal engine damage. Much of the dirt and dust are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners.

IMPORTANT: Replace damaged components with new, identical parts. Neoprene hoses and nylon ducts that have been enlarged, extended, or otherwise modified, are not acceptable for installation between the air cleaner and the engine.

To avoid chafing, air intake ducting must not contact other parts.

Removal

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.
3. Disassemble the air intake ducting. **Refer to Fig. 1.**
   - 3.1 If applicable, disconnect the air compressor air inlet hose (Ref. 10) from the ducting air intake pipe (Ref. 9).
   - 3.2 Loosen the clamp (Ref. 13) that holds the elbow (Ref. 12) to the top of the air cleaner, and remove the elbow from the cleaner.
   - 3.3 Loosen the clamp (Ref. 11) that holds the elbow to the forward end of the air intake pipe, and remove the elbow from the pipe.
   - 3.4 Loosen the clamp (Ref. 8) that holds the air intake pipe to the junction hose (Ref. 7), and remove the pipe from the hose.
   - 3.5 Loosen the clamp (Ref. 6) that holds the junction hose to the pipe (Ref. 5) routed around the rear of the engine, and remove the hose from the pipe.
   - 3.6 Remove the two bolts that hold the pipe to the engine, and loosen the hose clamp (Ref. 4) that holds the pipe to the junction hose (Ref. 3) at the rear of the turbocharger. Remove the pipe from the engine and the turbocharger.
   - 3.7 Loosen the hose clamp (Ref. 2) that holds the junction hose (Ref. 3) to the turbocharger, and remove the hose from the turbocharger.

Installation

1. Replace any damaged parts with new identical parts.
2. Assemble the air intake ducting. **Refer to Fig. 1.**
   - 2.1 Install the new or undamaged junction hose (Ref. 3) on the rear of the turbocharger, and loosely install the hose clamp.
   - 2.2 Install the new or undamaged air intake pipe (Ref. 5) around the rear of the engine. Tighten the two bolts that hold the pipe on the engine, and loosely install the hose clamp that holds the pipe to the junction hose (Ref. 3) at the rear of the turbocharger.
   - 2.3 Install the new or undamaged junction hose (Ref. 7) on the right end of the pipe (Ref. 5), and loosely install the hose clamp.
   - 2.4 Install the new or undamaged air intake pipe (Ref. 9) in the forward end of the junction hose (Ref. 7), and loosely install the hose clamp.
   - 2.5 Install the new or undamaged elbow (Ref. 12) on the forward end of the air intake pipe, and loosely install the clamp.

Air Intake Ducting Removal and Installation, Mercedes-Benz OM 366LA Engine

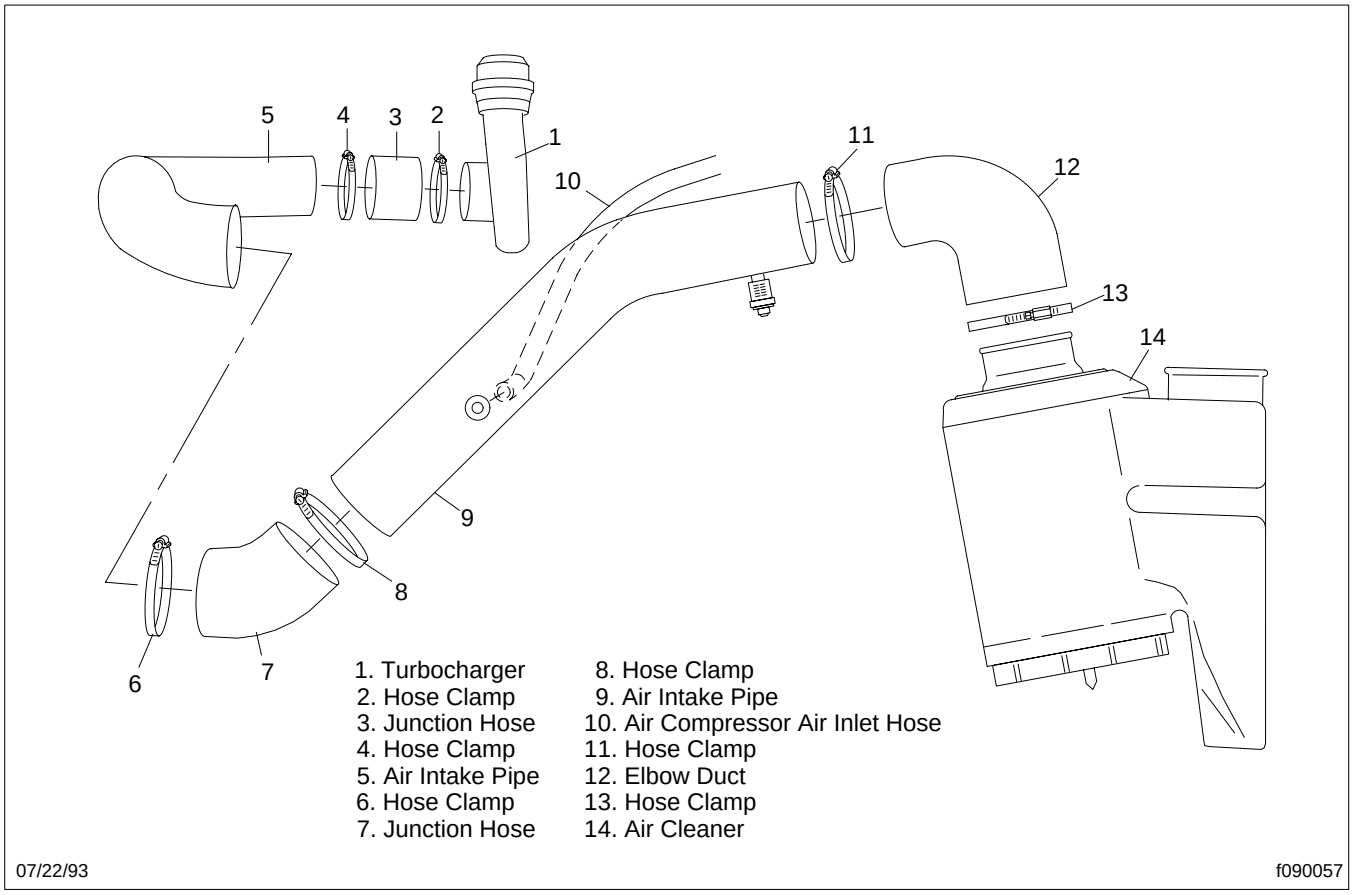


Fig. 1, Mercedes-Benz OM 366LA Engine, Air Intake Ducting

2.6 Install the elbow (Ref. 12) on the top of the air cleaner, and tighten all hose clamps.

2.7 If applicable, connect the air compressor air inlet hose (Ref. 10) to the air intake pipe.

3. Lower the hood.

4. Remove the chocks from the tires.

Air Intake Ducting, Housing, and Element Removal and Installation, Dodge Magnum Engines

General Instructions

All air intake components and connections must be air-and water-tight. Dirt or dust entering the engine can cause internal engine damage. Much of the dirt and dust are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners.

IMPORTANT: Replace damaged components with new, identical parts. Neoprene hoses and nylon ducts that have been enlarged, extended, or otherwise modified, are not acceptable for installation between the air cleaner and the engine.

To avoid chafing, air intake ducting must not contact other parts.

Removal

Dodge Magnum V-8

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.
3. Disconnect the air inlet tube at the side of the air cleaner housing. **See Fig. 1.**
4. Loosen, but do not remove the band-type screw clamp that attaches the housing to the top of the throttle body. Note the clamp positioning tabs on the air cleaner housing.
5. Disconnect the air pump hose at the air cleaner housing.

NOTE: The bottom-front of the air cleaner housing is equipped with a rubber grommet. A mounting stud is attached to the intake manifold, and is used to position the air cleaner housing into the grommet.

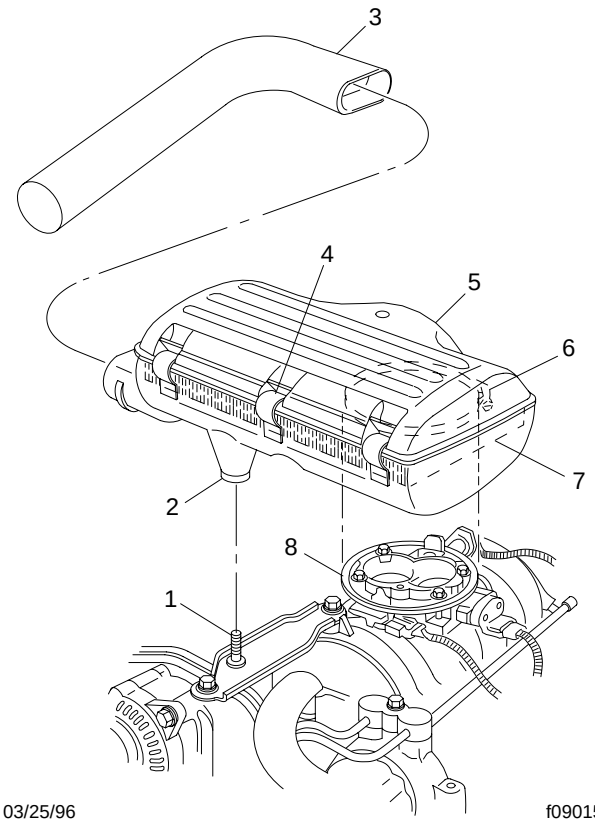
6. Lift the assembly from the throttle body while slipping the assembly from the mounting stud.
7. Check the condition of the gasket at the throttle body (and replace as necessary).
8. Unlatch the three spring clips at the top of the air cleaner housing, and tilt the housing cover up and rearward for removal of the cover.
9. Remove the air cleaner element from the air cleaner housing.

Dodge Magnum V-10

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.

NOTE: A small amount of engine oil wetting the inside of the air cleaner housing is normal. When servicing, wipe out the oil from the housing.

3. Loosen the clamp, and remove the air inlet tube at the front of the air cleaner housing cover. **See Fig. 2.**



1. Mounting Stud
2. Grommet
3. Air Intake Tube
4. Spring Clip
5. Housing Cover
6. Clamp
7. Housing
8. Gasket

Fig. 1, Dodge Magnum V-8 Air Cleaner Housing

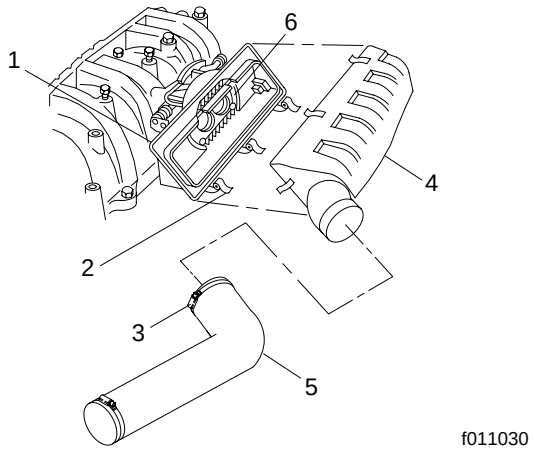
Air Intake Ducting, Housing, and Element Removal and Installation, Dodge Magnum Engines

4. Unlatch the spring clips attaching the air cleaner element cover to the air cleaner housing, and remove the cover.
5. Remove the air cleaner element from the air cleaner cover.
6. Check the condition of the gasket at the throttle body (and replace as necessary).

Installation

Dodge Magnum V-8

1. Clean inside the air cleaner housing.
2. Position the air cleaner element inside the air cleaner housing.
3. Position the air cleaner cover to the tabs on the rear of the air cleaner housing. Then, latch the three spring clips to seal the cover to the housing. **See Fig. 1.**



1. Housing
2. Spring Clip
3. Clamp
4. Housing Cover
5. Air Intake Tube
6. Gasket

Fig. 2, Dodge Magnum V-10 Air Cleaner Housing

4. Position the air cleaner housing assembly to the throttle body while guiding the rubber grommet over the mounting stud. The lower part of the screw clamp should be below the top lip of the throttle body.
5. Push down on the air cleaner housing at the rubber grommet to seat the housing at the intake manifold.
6. Tighten the throttle body-to-air cleaner housing clamp 400 N·cm (35 lbf·in).
7. Install the air inlet tube at the inlet on the air cleaner housing.
8. Close the hood.
9. Remove the chocks from the tires.

Dodge Magnum V-10

1. Clean the inside of the air cleaner housing.
2. If the removal of the housing is necessary, remove the four housing-to-throttle body nuts.
3. After re-installing the housing, tighten the four nuts to 1084 N·cm (96 lbf·in).
4. Position the air cleaner element into the air cleaner cover, and latch the spring clips to seal the cover to the housing.
5. Install the air inlet tube at the air cleaner housing.
6. Install and tighten the clamp at the air inlet tube.
7. Close the hood.
8. Remove the chocks from the tires.

Air Intake Ducting Removal and Installation, Cummins C Series Engine

General Instructions

⚠ WARNING

WARNING: Do not operate the engine with any under-hood component of the air intake system removed; serious physical injury can occur if the turbocharger impeller is touched when it is rotating.

All air intake components and connections must be air-and water-tight. Dirt or dust entering the engine can cause internal engine damage. Much of the dirt and dust are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners.

IMPORTANT: Replace damaged components with new, identical parts. Neoprene hoses and nylon ducts that have been enlarged, extended, or otherwise modified, are not acceptable for installation between the air cleaner and the engine.

To avoid chafing, air intake ducting must not contact other parts.

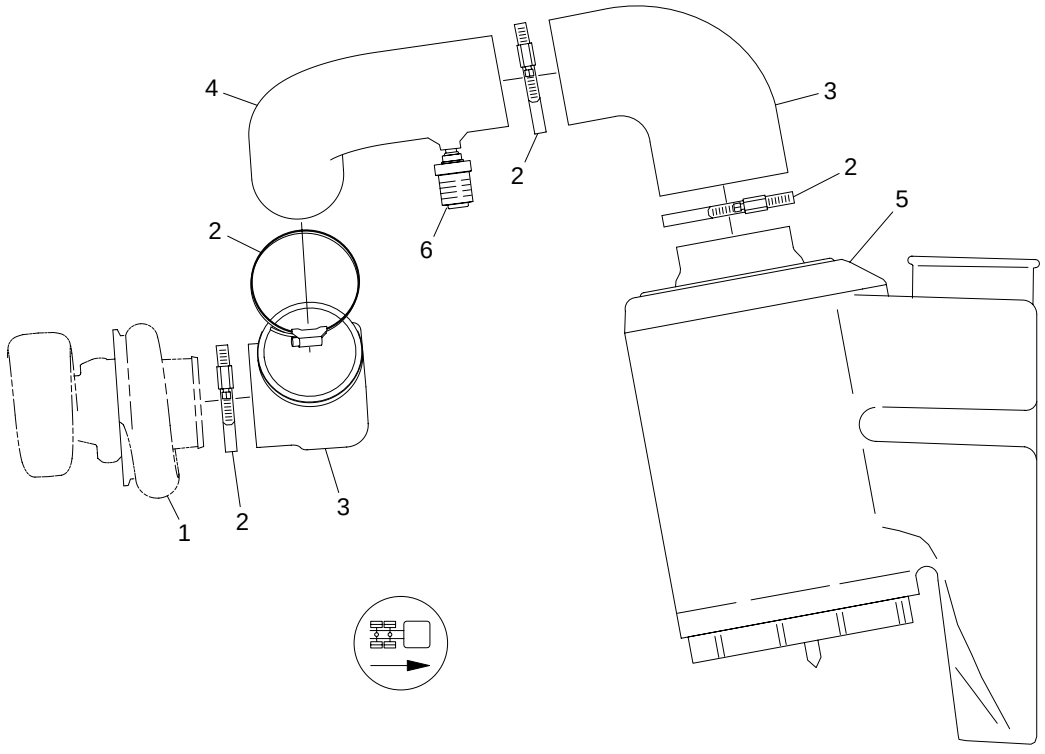
Removal (See Fig. 1)

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.
3. Disassemble the air intake ducting.
   - 3.1 Loosen the clamp that holds the elbow to the top of the air cleaner, and disconnect the elbow from the cleaner.
   - 3.2 Loosen the clamp that holds the elbow to the forward end of the air intake pipe, and remove the elbow from the pipe.
   - 3.3 Loosen the clamp that holds the pipe to the elbow at the forward side of the turbocharger, and remove the pipe from the elbow. Disconnect the restriction indicator air hose from the pipe.
   - 3.4 Loosen the clamp that holds the elbow to the forward side of the turbocharger, and remove the elbow from the turbocharger.

Installation (See Fig. 1)

1. Replace any damaged parts with new identical parts.
2. Assemble the air intake ducting.
   - 2.1 Install the new or undamaged elbow on the forward side of the turbocharger, and loosely install the clamp.
   - 2.2 Install the new or undamaged air intake pipe in the elbow at the forward side of the turbocharger, and loosely install the clamp. Connect the restriction indicator air hose to the pipe.
   - 2.3 Install the new or undamaged elbow on the forward end of the air intake pipe, and loosely install the clamp.
   - 2.4 Connect the elbow to the top of the air cleaner, and tighten all hose clamps.
3. Lower the hood.
4. Remove the chocks from the tires.

Air Intake Ducting Removal and Installation, Cummins C Series Engine



09/26/96 f090143

1. Turbocharger
2. Hose Clamp
3. Elbow Duct
4. Air Intake Pipe
5. Air Cleaner
6. Restriction Indicator

Fig. 1, Cummins C Series Engine, Air Intake Ducting

Air Intake Ducting Removal and Installation, Detroit Diesel Series 50 Engine

General Instructions

WARNING

Do not operate the engine with any under-hood component of the air intake system removed; serious physical injury can occur if the turbocharger impeller is touched when it is rotating.

All air intake components and connections must be air-and water-tight. Dirt or dust entering the engine can cause internal engine damage. Much of the dirt and dust are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners.

IMPORTANT: Replace damaged components with new, identical parts. Neoprene hoses and nylon ducts that have been enlarged, extended, or otherwise modified, are not acceptable for installation between the air cleaner and the engine.

To avoid chafing, air intake ducting must not contact other parts.

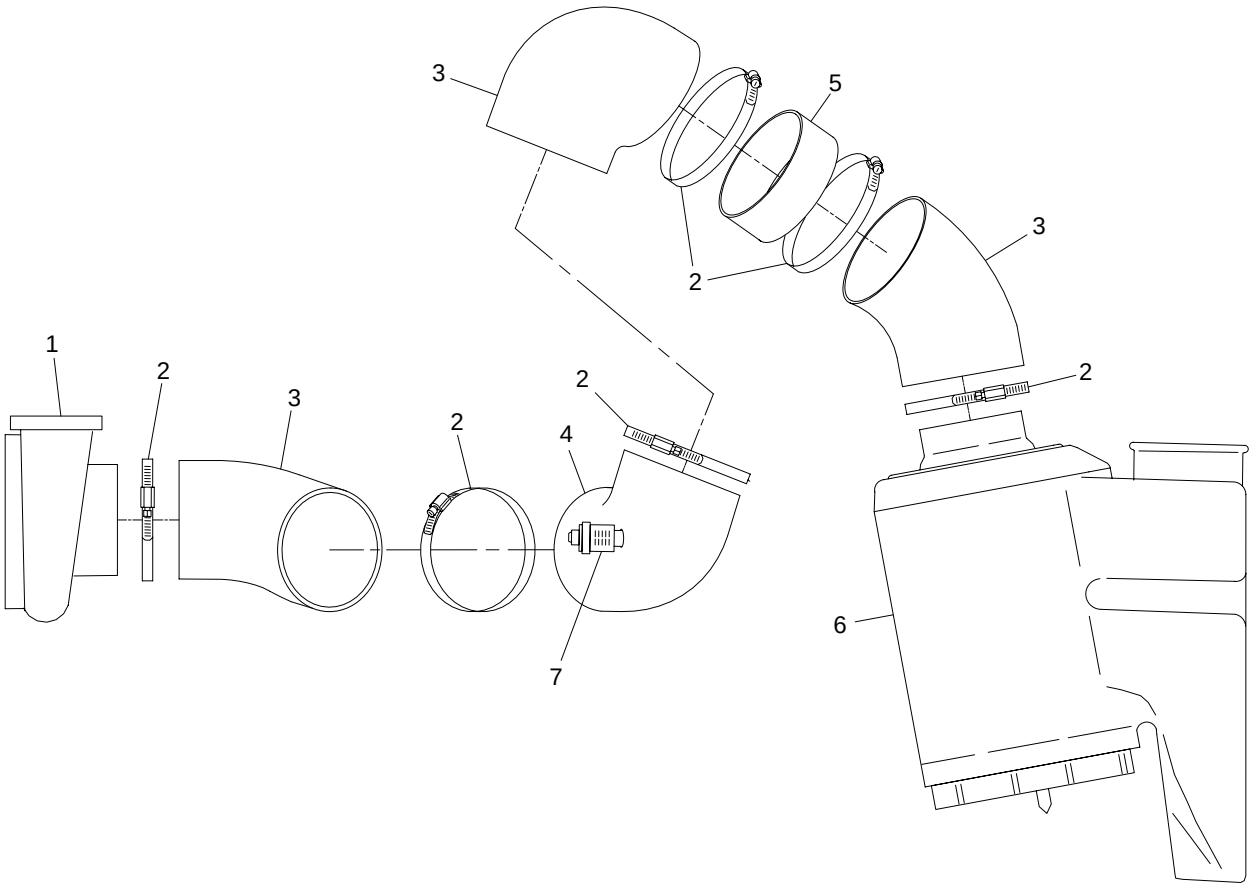
Removal (See Fig. 1)

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.
3. Disassemble the air intake ducting.
   - 3.1 Loosen the clamp that holds the elbow to the top of the air cleaner, and disconnect the elbow from the cleaner.
   - 3.2 Loosen one of the two clamps that hold the two elbows together, and disconnect the elbows. Loosen the clamp that holds the air intake pipe inside the elbow, and disconnect the pipe from the elbow.
   - 3.3 Loosen the clamp that holds the elbow to the forward end of the air intake tube, and remove the elbow from the tube.
   - 3.4 Loosen the clamp that holds the tube to the elbow at the forward side of the turbocharger, and remove the tube from the elbow.
   - 3.5 Loosen the clamp that holds the elbow to the forward side of the turbocharger, and remove the elbow from the turbocharger.

Installation (See Fig. 1)

1. Replace any damaged parts with new identical parts.
2. Assemble the air intake ducting.
   - 2.1 Install the new or undamaged elbow on the forward side of the turbocharger, and loosely install the clamp.
   - 2.2 Install the new or undamaged air intake tube in the elbow at the forward side of the turbocharger, and loosely install the clamp.
   - 2.3 Install the new or undamaged elbow on the forward end of the air intake tube, and loosely install the clamp.
   - 2.4 Install the new or undamaged air intake pipe in the elbow, and loosely install the clamp. Install the new or undamaged elbow on the intake pipe, and loosely install the clamp.
   - 2.5 Connect the elbow to the top of the air cleaner, and tighten all hose clamps.
3. Lower the hood.
4. Remove the chocks from the tires.

Air Intake Ducting Removal and Installation, Detroit Diesel Series 50 Engine



01/14/97 f090140a

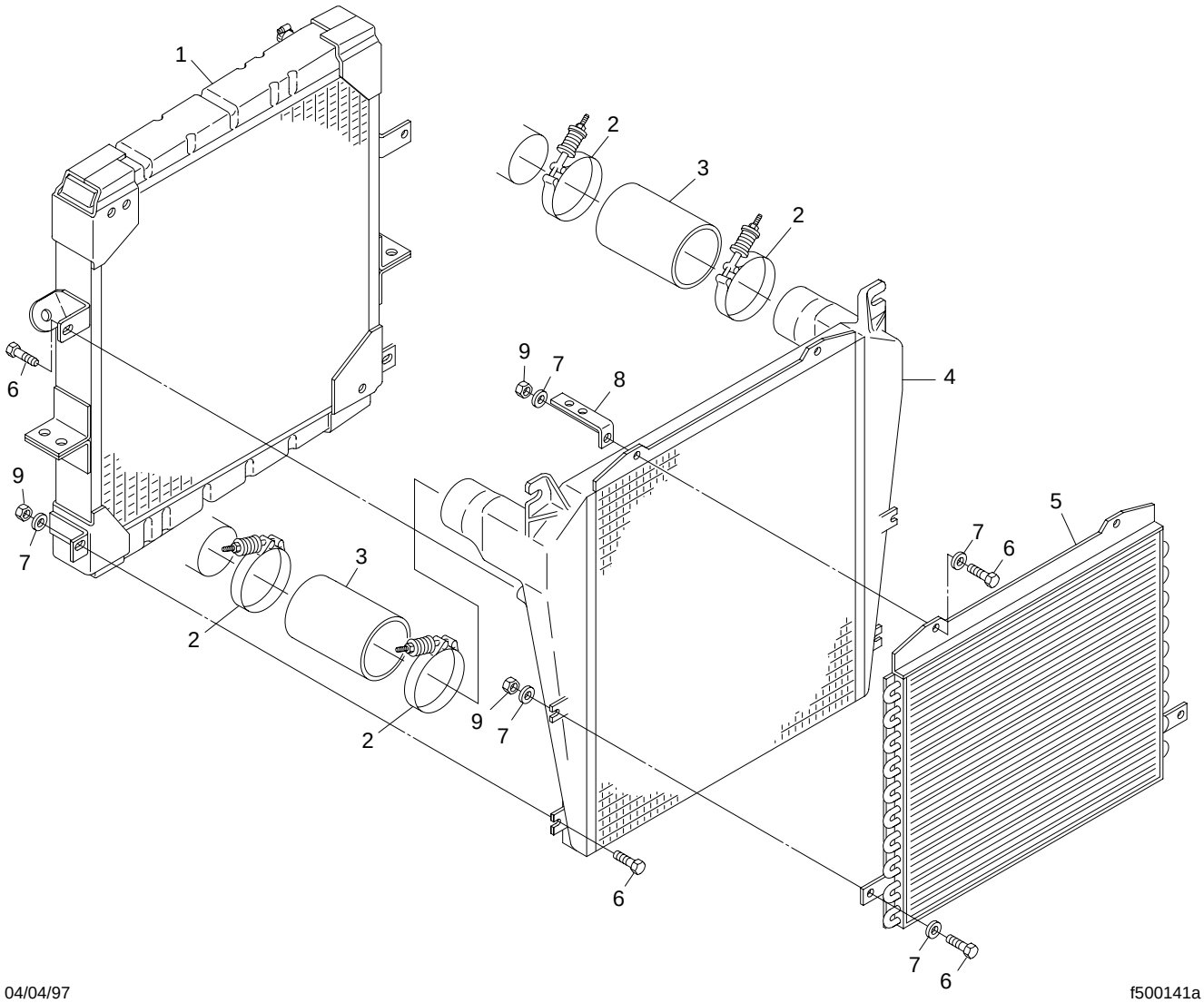
1. Turbocharger
2. Hose Clamp
3. Elbow Duct
4. Air Intake Tube
5. Air Intake Pipe
6. Air Cleaner
7. Restriction Indicator

Fig. 1, Detroit Diesel Series 50 Engine, Air Intake Ducting

General Information

The charge air cooler (CAC) is attached to the front of the radiator, behind the condenser. **See Fig. 1.** It is similar to a radiator: outside ambient air passing through the CAC core cools the engine's intake air charge.

Air leaving the turbocharger is compressed, which heats it to about 135° to 162°C (275° to 325°F), depending on the ambient temperature and boost. The CAC reduces this temperature to the engine manufacturer's specified air intake temperature before the air reaches the engine intake manifold. Lower tem-



1. Radiator
2. Constant-Torque Hose Clamp
3. Convoluted Hose
4. Charge Air Cooler (CAC)
5. Condenser
6. Bolt
7. Washer
8. Stand-Off Bracket
9. Nut

Fig. 1, Charge Air Cooler Installation (typical)

General Information

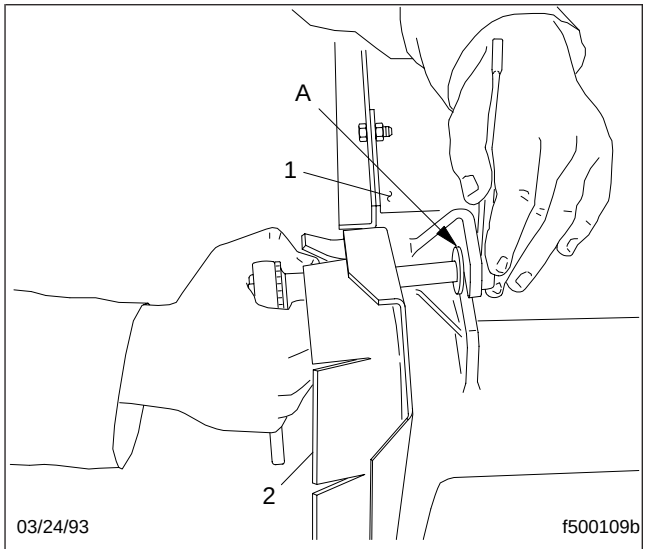
peratures reduce exhaust emissions, improve fuel economy, and increase horsepower.

Charge Air Cooler Removal and Installation

Removal

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Remove the hood; for instructions, **see Group 88**.
3. With the refrigerant hoses connected, move the condenser aside.

   3.1 Remove the air recirculation shields from either side of the condenser. **See Fig. 1.**



A. Remove air recirculation shield from mounting tab.
1. Charge Air Cooler
2. Air Recirculation Shield

Fig. 1, Air Recirculation Shield Removal/Installation

   3.2 Remove the clamp that secures the refrigerant hoses to the left radiator support strut.

   3.3 Remove the four bolts holding the condenser, and move the condenser to one side. Wrap it in a protective blanket, and secure it out of the way. **See Fig. 2.**

4. Remove the charge air cooler (CAC).

   4.1 Remove the hood cable brackets from the radiator. **See Fig. 3.**

   4.2 Disconnect the air inlet and outlet hoses from the CAC. **See Fig. 4.**

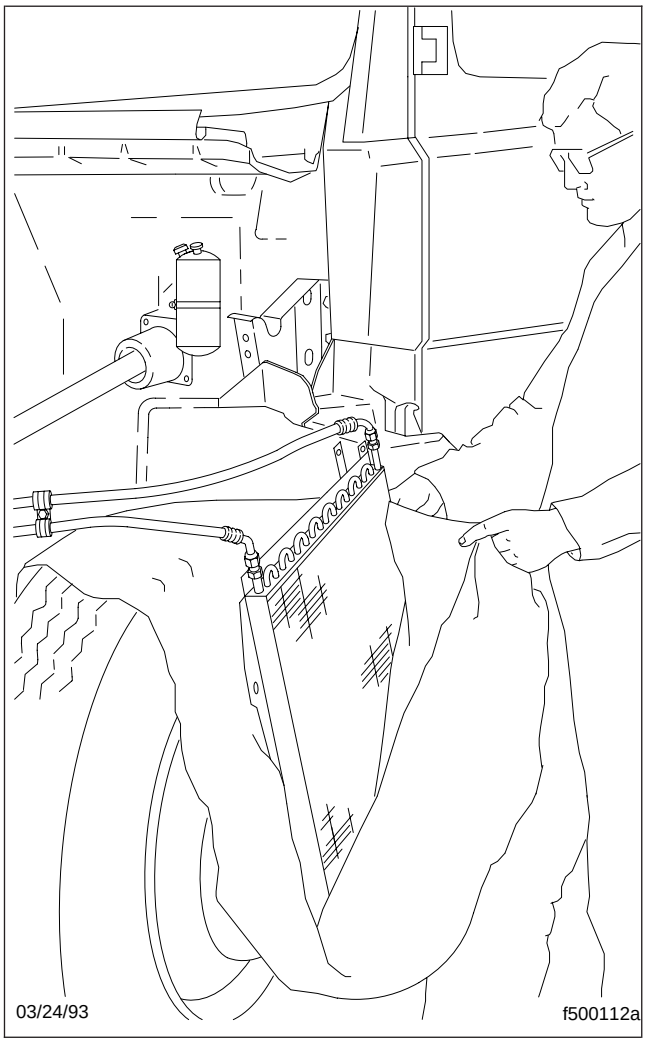


Fig. 2, Condenser Removal

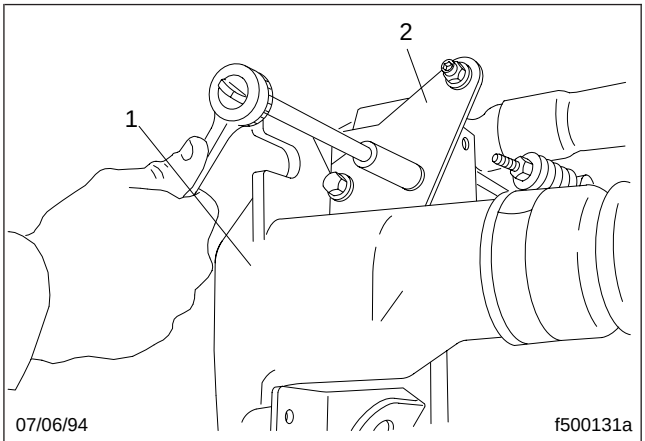
   4.3 Remove the four CAC mounting bolts. **See Fig. 5.** Then, remove the CAC from the radiator.

Installation

1. Install the charge air cooler (CAC).

   1.1 Position the CAC on the radiator, and secure it with the four mounting bolts. **See Fig. 5.** Tighten the bolts 20 N·m (15 lbf·ft).

Charge Air Cooler Removal and Installation



1. Charge Air Cooler 2. Hood Cable Bracket

Fig. 3, Hood Cable Bracket Removal/Installation

1.3 Install the hood cable brackets on the radiator. **See Fig. 3.** Tighten the bracket bolts 540 N·cm (48 lbf·in).

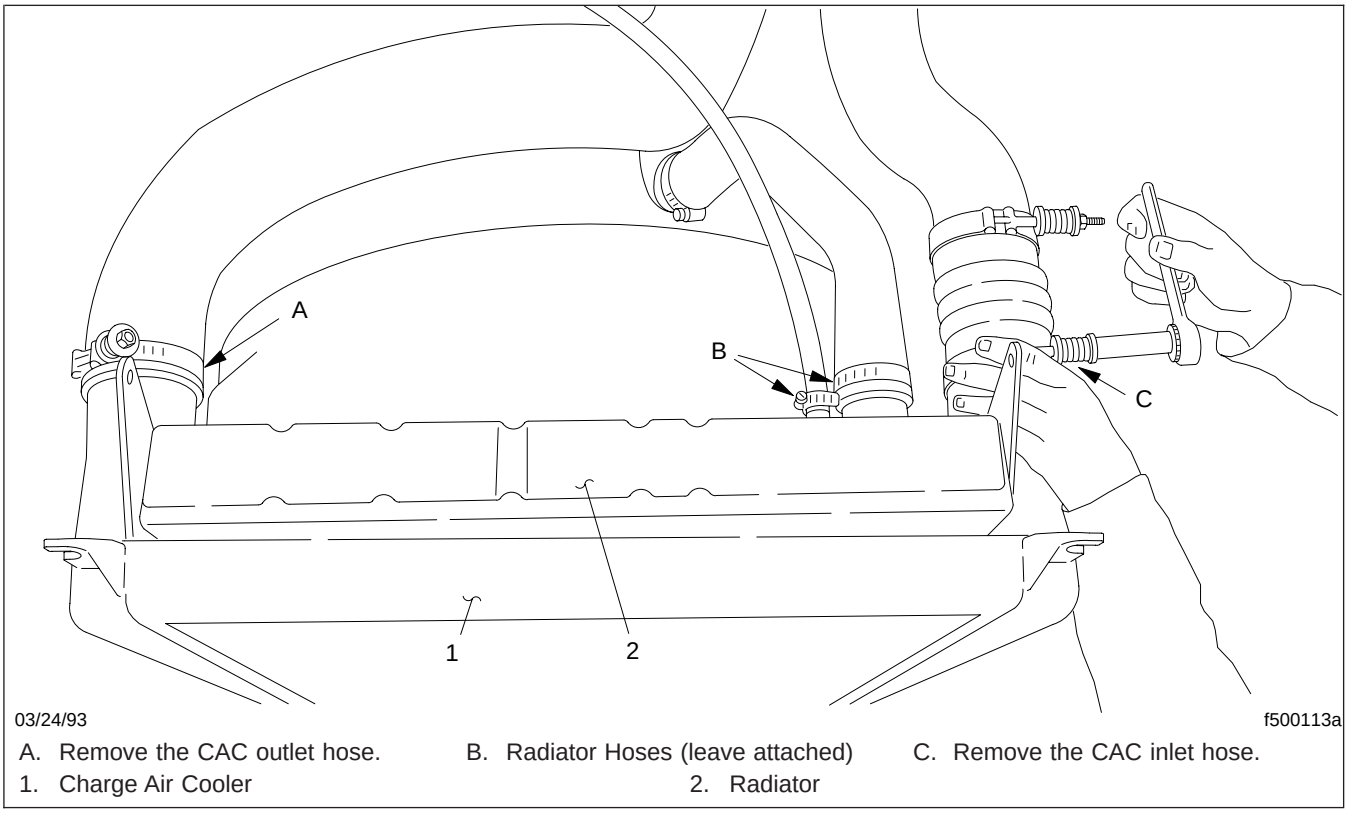
2. Install the condenser.

2.1 Position the condenser on the charge air cooler, and secure it with the four mounting screws. **See Fig. 6.** Tighten the bolts 20 N·m (15 lbf·ft).

2.2 Clamp the refrigerant hoses to the left radiator support strut.

2.3 Install the air recirculation shields on the radiator. **See Fig. 1.** Tighten the shield bolts 20 N·m (15 lbf·ft).

3. Install the hood; for instructions, **see Group 88**.



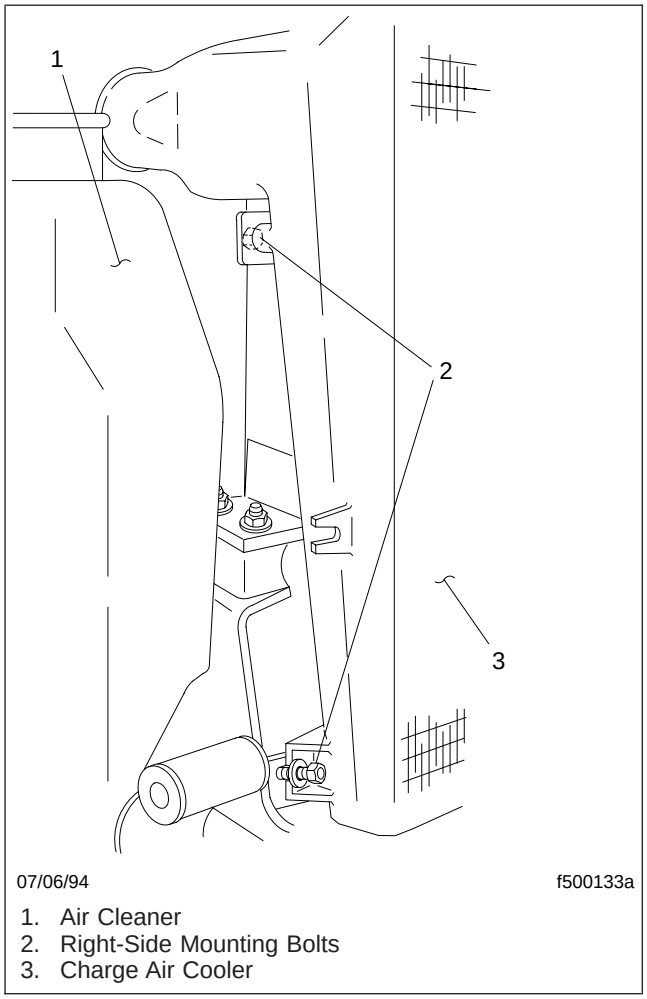
A. Remove the CAC outlet hose. B. Radiator Hoses (leave attached) C. Remove the CAC inlet hose.
1. Charge Air Cooler 2. Radiator

Fig. 4, CAC and Radiator Hose Connections (Mercedes-Benz OM 366LA engine shown)

1.2 Connect the hoses to the CAC. **See Fig. 4.** Tighten the hoses 680 N·cm (60 lbf·in).

4. Remove the chocks from the tires.

Charge Air Cooler Removal and Installation



1. Air Cleaner
2. Right-Side Mounting Bolts
3. Charge Air Cooler

Fig. 5, CAC Mounting

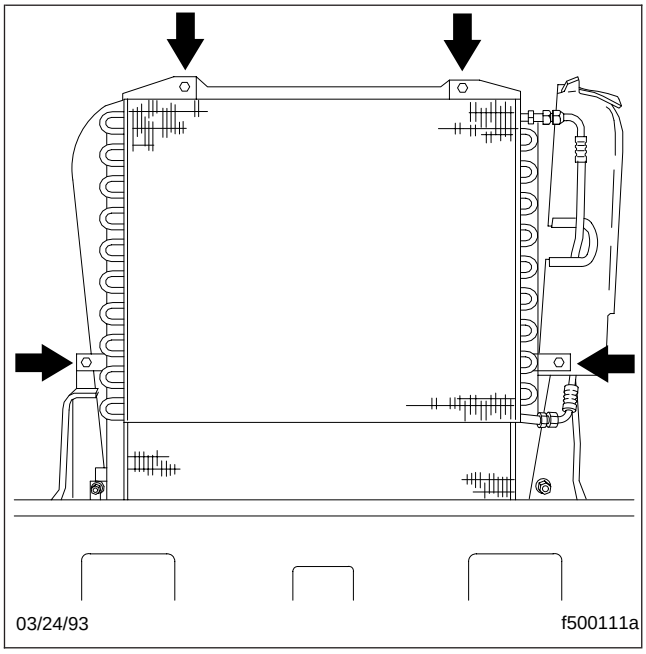


Fig. 6, Condenser Mounting Locations

Charge Air Cooler Inspection and Leakage Test

Inspection

1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Check the charge air cooler (CAC) convoluted hoses and the inlet and outlet piping for holes or other damage. Also check for loose or damaged constant-torque hose clamps. Replace damaged parts. If hose clamps are loose, turn them so their tightening screws are under the hoses or facing inboard; then tighten the screws 45 lbf·in (500 N·cm).
3. Check the CAC core fins. If the fins are bent, use a small pair of needle-nose pliers or a small screwdriver to straighten them.
4. Check the CAC core for clogged fins. Use compressed air or water to dislodge any material restricting airflow through the core.
5. Perform the "CAC Core Leakage Test."

Leakage Test

Charge air coolers are designed in such a way that they may leak an insignificant amount of air. The allowable leakage mentioned in **Table 1** represents a loss of less than 0.1 percent of charge airflow. Based on this rate, there should be no measurable loss of performance.

Leakage Rate Specifications		
Engine	**Pressure Drop in 15 Seconds psi (kPa)**	**Start Pressure psi (kPa)**
Caterpillar	5 (34)	30 (207)
Cummins	7 (48)	30 (207)
Detroit Diesel	5 (34)	25 (172)
MBE900	5 (34)	30 (207)

Table 1, Leakage Rate Specifications

The CAC core leakage test should be performed using a charge air cooler test kit, part number 5039, which can be purchased from Kent-Moore/SPX at 1.800.328.6657.

CAC CORE LEAKAGE TEST

1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Connect the test equipment to the CAC core. See **Fig. 1**.
   - 2.1 Remove the inlet and outlet air piping from the convoluted hoses that attach them to the CAC air inlet and air outlet.
   - 2.2 Slip a safety ring with thumbscrew over each convoluted hose and onto the CAC air inlet and air outlet. Turn the rings so the thumbscrews are facing outboard and the safety chains are inboard. Tighten the thumbscrews securely.
   - 2.3 Install an additional constant-torque hose clamp on each convoluted hose.
   - 2.4 Install the test plug without an adapter in the CAC air inlet and turn the plug so the safety chain is inboard. Tighten both of the rearmost constant-torque hose clamps 72 lbf·in (813 N·cm).
   - 2.5 Install the test plug with adapter in the CAC air outlet and turn the plug so the safety chain is inboard. Tighten both of the rearmost constant-torque hose clamps 72 lbf·in (813 N·cm).

⚠ WARNING

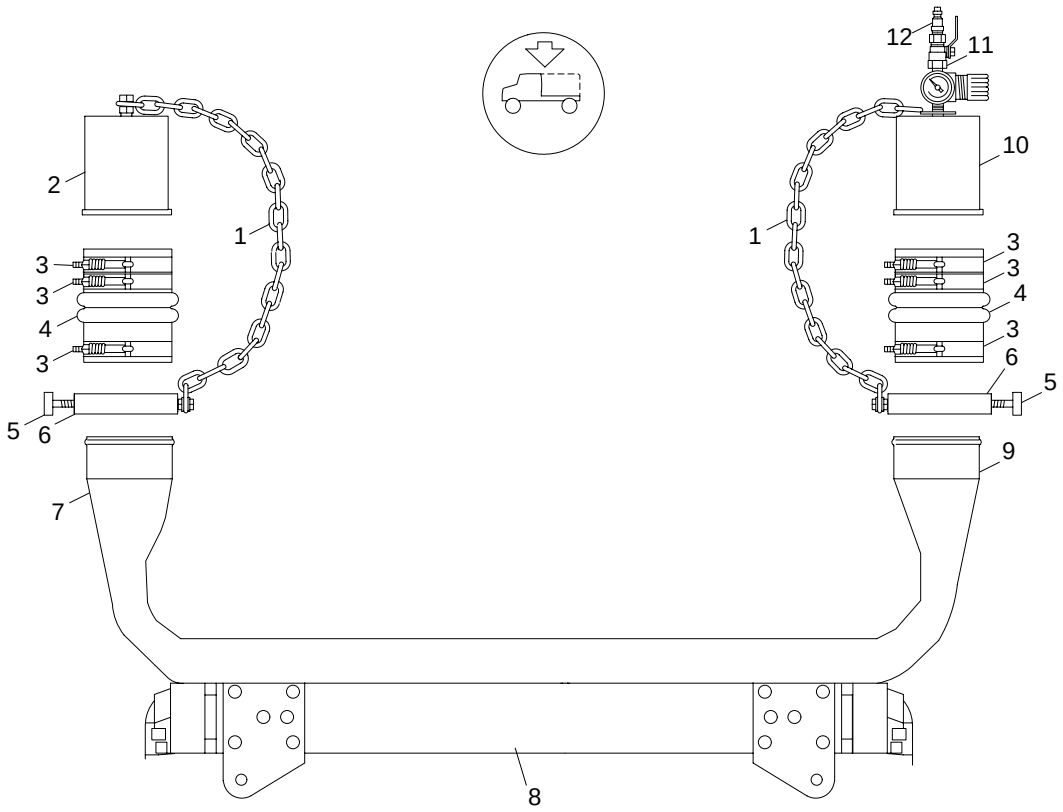
Always secure the test plugs with the safety rings. Test pressures could blow an unsecured test plug out at high speed, possibly causing eye injury or other serious personal injury.

   - 2.6 If not already installed, install a test valve/gauge assembly and air chuck in the test plug with adapter.
   - 2.7 Attach a pressurized air line to the air chuck on the pressure regulator valve.
3. Test the CAC core.

⚠ WARNING

Always wear safety glasses when doing this procedure. Do not stand in front of the test plugs while the core is pressurized. A plug could sud-

Charge Air Cooler Inspection and Leakage Test



02/25/98 f090277

1. Safety Chain
2. Test Plug
3. Constant-Torque Hose Clamp
4. Convoluted Hose
5. Thumbscrew
6. Safety Ring
7. CAC Air Inlet
8. Radiator
9. CAC Air Outlet
10. Test Plug with Adapter
11. Test Valve/Gauge Assembly
12. Air Chuck

Fig. 1, CAC Core Testing

denly release debris at high speed, possibly resulting in eye injury or other serious personal injury.

3.1 Open the test valve, then slowly open the pressure regulator valve and allow the charge air cooler system to gradually fill with air to the start pressure specified in **Table 1**.

3.2 Close the test valve and watch the gauge for 15 seconds. If there is more than the specified drop in the charge air cooler pressure in 15 seconds (see **Table 1**), replace the charge air cooler.

IMPORTANT: Do not attempt to repair the charge air cooler.

3.3 When testing is completed, reduce the pressure on the pressure regulator valve to bleed air from the charge air cooler.

4. Remove the test equipment (and the additional constant-torque hose clamps) from the convoluted hoses.
5. Pull the convoluted hoses and constant-torque hose clamps rearward until the hoses cover about 1-1/2 inches (38 mm) of the CAC air inlet and air outlet piping.
6. Turn the clamps so their tightening screws are under the hoses or facing inboard. Tighten the screws 45 lbf·in (500 N·cm).

7. Lower the hood and remove the chocks from the tires.

Charge Air Cooler Flushing

If the charge air cooler is suspected of being contaminated, flush the charge air cooler.

1. Turn off the engine, apply the brakes, and chock the tires.
2. Remove the charge air cooler. For instructions, see **Subject 100**.
3. Set the charge air cooler in a horizontal position with the inlet and outlet ports facing up.

⚠ CAUTION

Use only naphtha or mineral spirits to clean the charge air cooler. Do not use caustic solutions such as those that are commonly used in radiator shops. Do not use steam or high-temperature cleaning operations. Caustic solutions, steam, and high-temperature cleaning operations will damage the RTV that seals the charge air cooler tubes to the headers, which may result in leaking.

4. Pour a filtered naphtha or mineral spirits solution into the charge air cooler until it is 40 percent full.
5. Cap the inlet and outlet ports on the charge air cooler.
6. Rock the charge air cooler back and forth so that the solvent travels from one tank, through the tubes, to the other tank and back. Repeat this process ten times.

NOTE: Do not leave the solvent in the charge air cooler for more than ten minutes.

7. Remove the caps from the inlet and outlet ports
8. Drain the charge air cooler and properly dispose of the solvent.
9. Leave the caps off and allow the residual solvent to evaporate.
10. Install the charge air cooler. For instructions, see **Subject 100**.
11. Remove the chocks from the tires.

Restriction Test

After flushing the charge air cooler because of turbocharger or engine damage, test the pressure drop across the charge air cooler and air piping, as follows:

1. Remove the pipe plug from the tapped hole in the turbocharger air outlet elbow.

   Remove the pipe plug, or the nylon tube and atomizer for the ether start system (if so equipped), or the air line to the turbocharger air-pressure gauge (if so equipped), from the tapped hole in the rear left-hand side of the intake manifold.

   Install an air pressure gauge in each tapped hole.

2. Operate the engine at rated speed and horsepower; there is no need to operate the engine at its peak torque rating. While operating the engine, read both air pressure gauges.

   Because of air turbulence at the turbocharger outlet, subtract 0.3 inHg (1 kPa) from the pressure measurement taken at this point, to make it a true reading.

   From that reading, subtract the reading taken at the intake manifold. This is the pressure drop of the charge air cooler.

   If the pressure drop is more than 4 inHg (14 kPa), flush or replace the charge air cooler as needed.

Specifications

Description	Grade	Size	Torque	
			N·m (lbf·ft)	N·cm (lbf·in)
Charge Air Cooler to Radiator Mounting Bolt	5	5/16"	20 (15)	—
Hood Cable Bracket Bolts	8.8	10 mm	—	540 (48)
Charge Air Cooler Constant-Torque Hose Clamps	5	6.3 mm	—	680 (60)
Condenser Mounting Bolts	5	5/16"	20 (15)	—
Air Recirculation Shield Bolt	5	5/16"	20 (15)	—

Table 1, Fastener Torques

General Information

The air cleaner is vertically mounted on the outside of the right frame rail, directly behind the bumper. **See Fig. 1.** Air enters through the grill and is diverted into the air cleaner housing where it passes from the outside to the inside of a replaceable, moisture-resistant, fine-mesh paper filter element **(Fig. 2).** Filtered air exits the air cleaner through an outlet port at the top of the housing.

A lock-up air restriction indicator is mounted on the underside of the air intake pipe. **See Fig. 3.** The indicator shows when the air filter element needs to be replaced. As an optional location, the air restriction indicator can be mounted in the dashboard. Nylon tubing connects the remote-mounted indicator or gauge to the air intake piping.

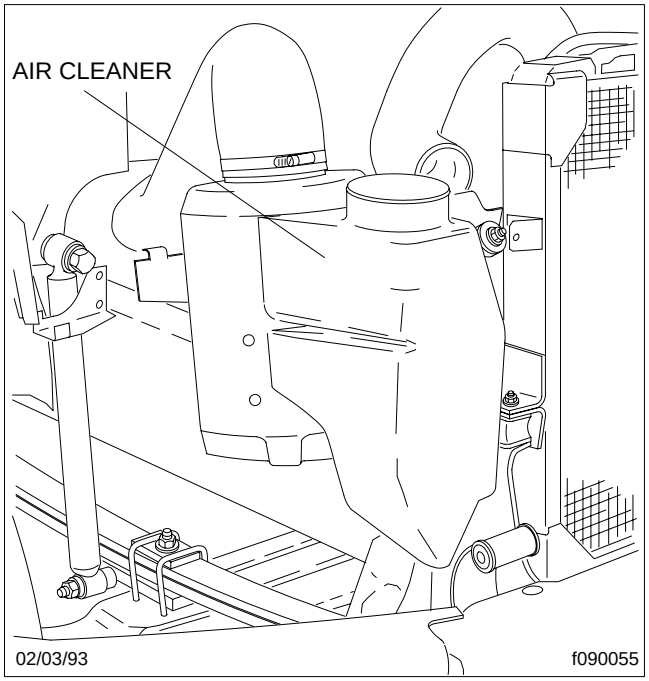


Fig. 1

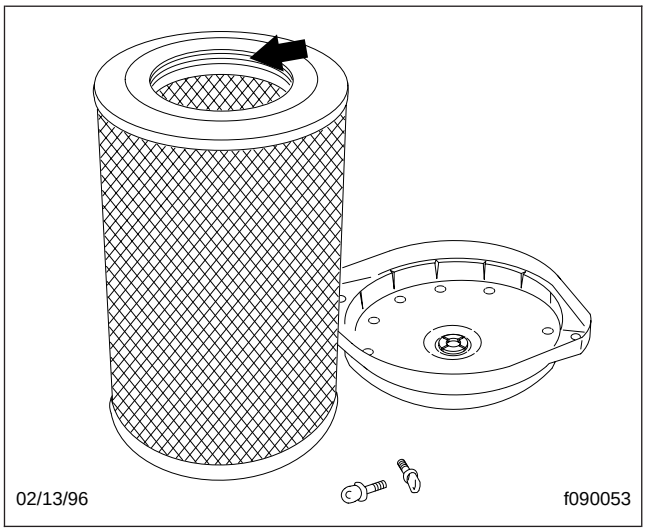


Fig. 2

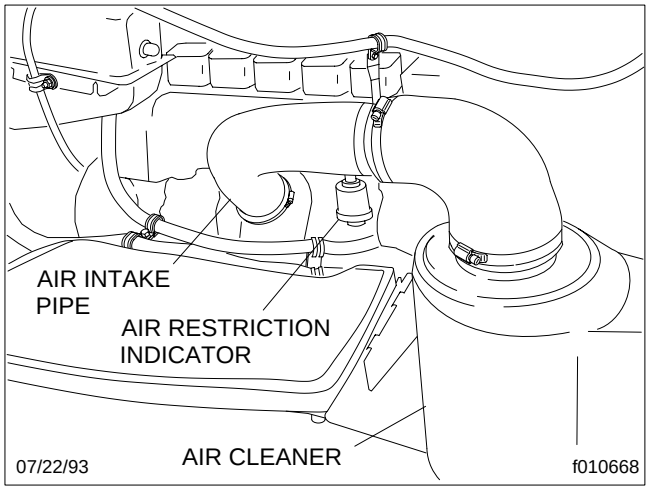


Fig. 3

Element Replacement

NOTE: Replace the air cleaner element only when it reaches the maximum restriction level allowed by the engine manufacturer; **see Subject 120**.

⚠ CAUTION

CAUTION: Do not operate the engine with the air filter element or any intake component removed — damage to the engine could occur.

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.
3. Check the seams around the air cleaner inlet and outlet ports. **See Fig. 1.** Check the outer surface of the cleaner housing for cracks, dents, or damage. If there are signs of leaks or damage, repair or replace the parts.

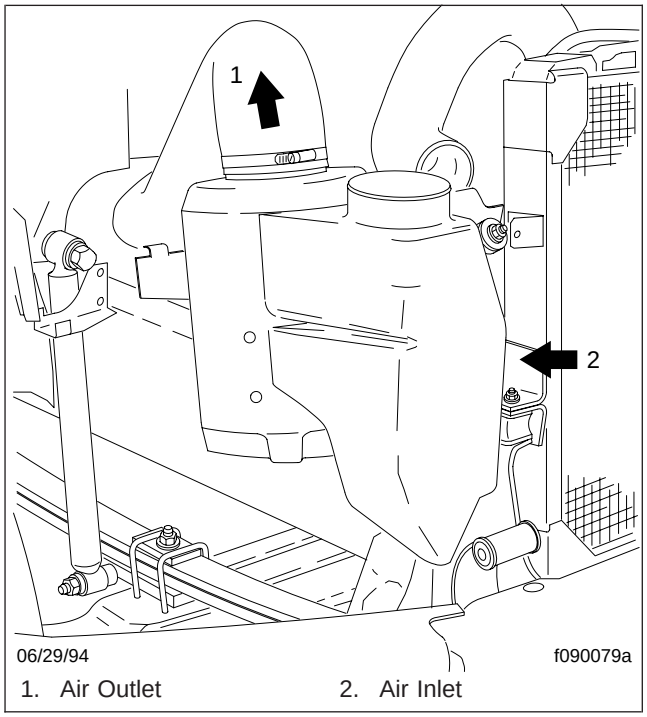


Fig. 1, Air Cleaner Housing Ports

4. Remove the two thumb screws from the bottom of the housing. **See Fig. 2.** Remove the cover.

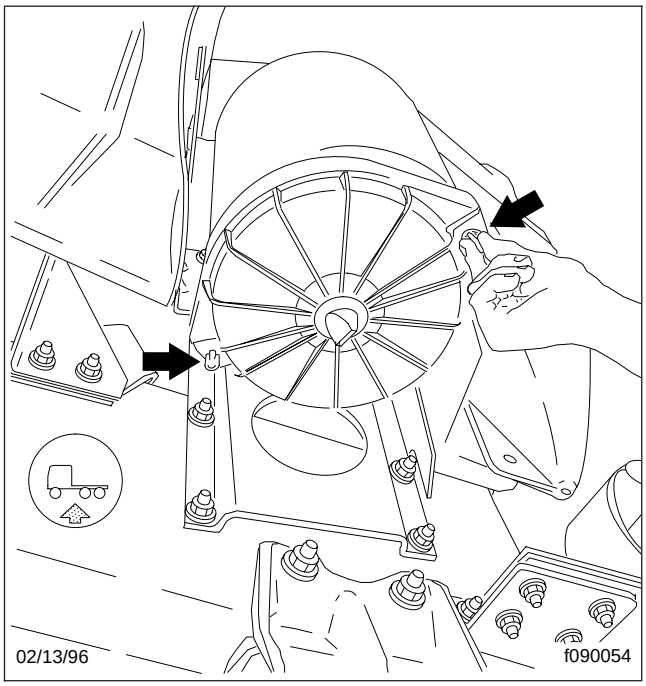


Fig. 2, Air Cleaner Housing Thumb Screws

5. Grip the base of the filter element firmly. **See Fig. 3.** Gently twist and pull the filter element down and out of the housing.
6. Inspect the element and clean the housing.
   - 6.1 Check the filter element for soot or oil. If soot is present, check for leaks in the engine exhaust system, and for exhaust from other equipment. If the element is oily, check for fumes escaping from the engine crankcase breather. Excessive oil mist shortens the life of any dry-type filter; correct the cause.
   - 6.2 Inspect the filter element radial seal surface for dust trails (from gasket leakage) **(see Fig. 4)**. Check the cleaner housing for damage or dirt build-up that may cause sealing problems. If there is leakage or damage, repair or replace the parts.
   - 6.3 Wipe the inside of the cleaner housing with a clean damp cloth.

Air Cleaner Element Replacement

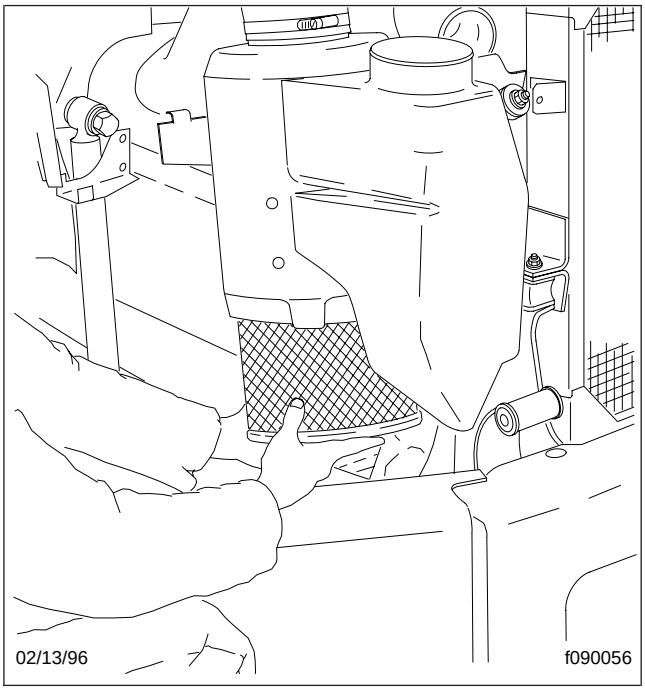


Fig. 3, Filter Element Removal/Installation

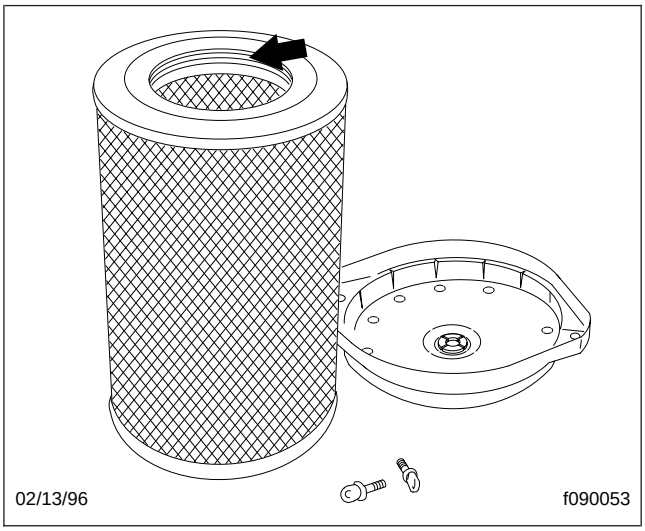


Fig. 4, Radial Seal Surface of Filter Element

⚠ CAUTION

CAUTION: Any dirt in the cleaner housing, on the clean side of the element gaskets, could be drawn into the engine, causing damage.

7. Inspect the new filter element **(see Fig. 4)** before installing it.
   - 7.1 Inspect the element for radial seal surface damage and dented metal parts. If the radial seal surface is damaged to the extent that dust might bypass it, do not use the element.
   - 7.2 Place a bright light inside the element, and rotate the element while looking through it from the outside. The light will reveal, by a bright spot, any hole or rupture. Any hole in the element will allow dust to enter the engine; do not use the element if it is damaged.
8. Position the filter element in the air cleaner housing. **See Fig. 3.** Push the element up into place until only about 2.5 cm (1 inch) still extends below the bottom of the housing.
9. Place the cover over the bottom of the element, and secure the cover with the two thumb screws.
10. Check all clamps for tightness, and all ducting and hoses for leaks; repair as necessary.
11. Lower the hood, and remove the chocks from the tires.

Replacement

CAUTION

CAUTION: All air intake components and connections must be air-and water-tight. Dirt or dust entering the engine can cause internal engine damage. Much of the dirt and dust are silicates, which fuse into abrasive glass-like particles during engine combustion. These particles can grind piston rings, pistons, and cylinder liners. Do not operate the engine with the air filter element or any air intake component removed.

IMPORTANT: Do not modify air cleaners or air intake ducting.

If the air cleaner housing has been dented or damaged, immediately check all ducting and connections to the air cleaner for leakage. Adjust or replace parts as necessary. If needed, replace the air cleaner as follows:

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.
3. Remove the air cleaner.
   - 3.1 Remove the two thumb screws securing the housing cover, and remove the cover. **See Fig. 1.**
   - 3.2 Remove the filter element from the housing; **see Subject 100**.
   - 3.3 Loosen the hose clamp connecting the air intake pipe to the elbow at the top of the air cleaner housing. **See Fig. 2.** Remove the pipe from the elbow, and cover the open end of the pipe.
   - 3.4 Remove the elbow from the top of the housing.
   - 3.5 Remove the four nuts that secure the housing to its mounting bracket. **See Fig. 3.**
   - 3.6 Take the air cleaner off its mounting bracket.
4. Install the new air cleaner.
   - 4.1 Position the air cleaner housing on its mounting bracket. Secure the housing with the four nuts, and tighten them 38 N·m (28 lbf·ft).
   - 4.2 Connect the elbow to the top of the new housing.

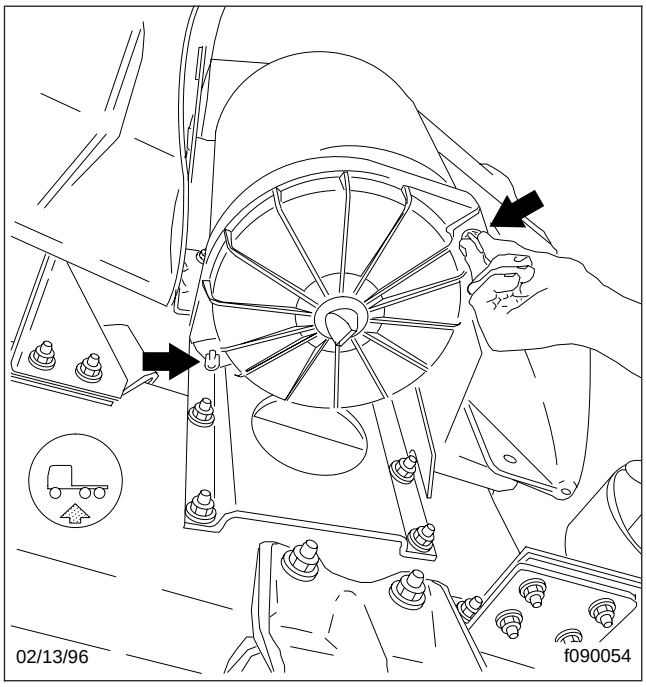
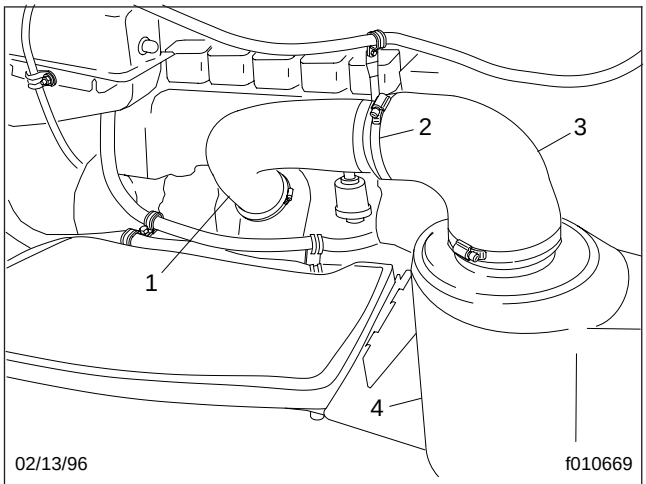


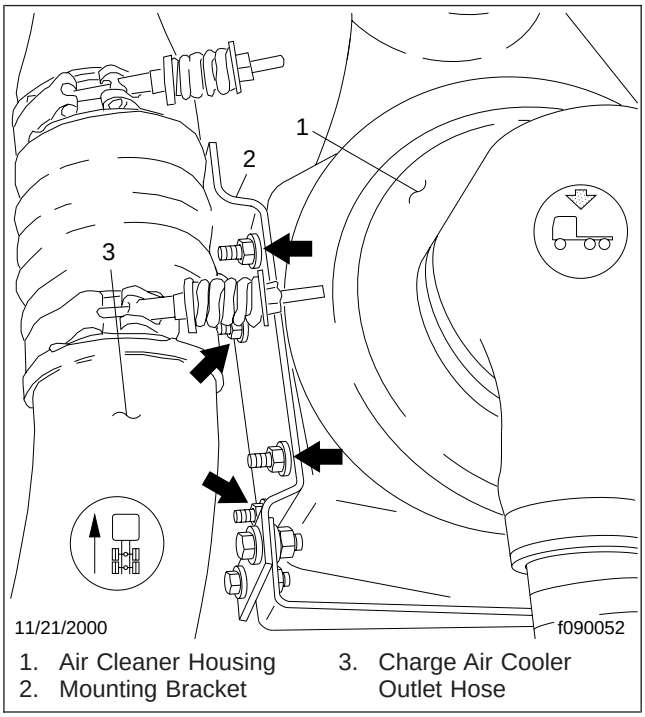
Fig. 1, Air Cleaner Housing Thumb Screws



1. Air Intake Pipe
2. Hose Clamp
3. Elbow
4. Air Cleaner Housing

Fig. 2, Elbow to Intake Pipe Connection

Air Cleaner Replacement



1. Air Cleaner Housing
2. Mounting Bracket
3. Charge Air Cooler Outlet Hose

Fig. 3, Air Cleaner Housing Mounting Fasteners

4.3 Uncover the air intake pipe, and connect it to the elbow. Tighten the hose clamp.

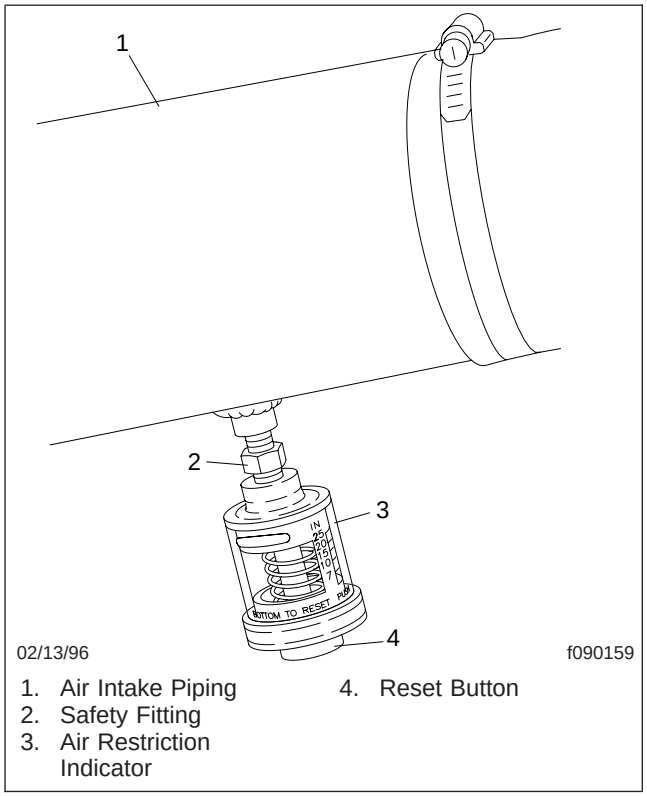
4.4 Check all clamps for tightness, and all ducting and hoses for leaks; repair as necessary.

5. Inspect a new filter element and install it in the new air cleaner; **see Subject 100**.

Element Restriction Checking

The restriction of air flow through the air cleaner element is measured at the tap in the air transfer tube joined to the cleaner outlet.

On vehicles with an intake-duct-mounted restriction indicator (manual- or automatic-reset), the indicator is mounted in a safety fitting in the air intake piping. **See Fig. 1.**



1. Air Intake Piping
2. Safety Fitting
3. Air Restriction Indicator
4. Reset Button

Fig. 1, Standard Intake-Duct-Mounted Manual-Reset Air Restriction Indicator

On vehicles with a dash-mounted restriction indicator (manual-reset) (**Fig. 2**) or air restriction gauge (automatic-reset) (**Fig. 3**), a hose connects the indicator or gauge to the safety fitting in the air intake piping.

On vehicles *without* an indicator or gauge, a water manometer or a service gauge must be connected to the air intake ducting to check element restriction.

- For a vehicle with a manual-reset air restriction indicator, check the indicator with the engine off to see if air restriction equals or exceeds the value shown in **Table 1** for maximum air restriction at *full load* and governed rpm. If air restriction is at or above the maximum, push the reset button on the dash-mounted or intake-duct-mounted indicator, then operate the engine at *no-load* and governed rpm, and compare the indicator reading with the value shown in **Table 1** for maximum air restriction at *no-load* and governed rpm.

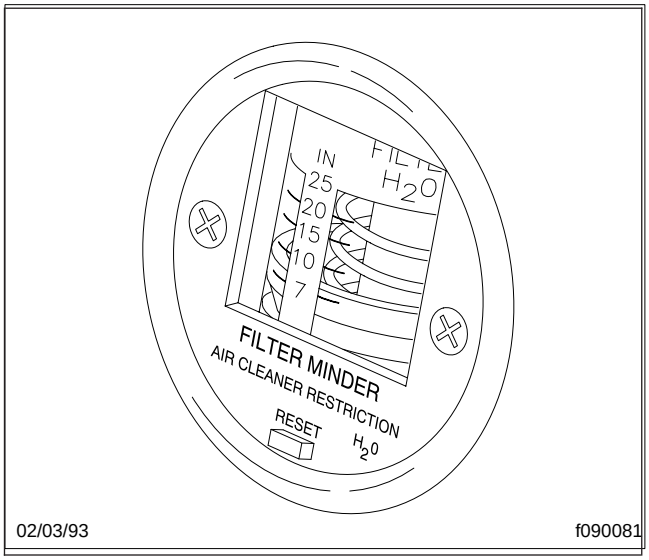


Fig. 2, Optional Dash-Mounted Manual-Reset Air Restriction Indicator

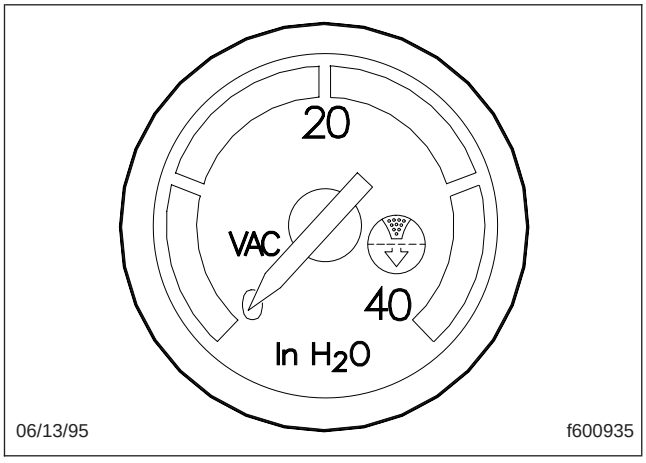


Fig. 3, Optional Dash-Mounted Automatic-Reset Air Restriction Gauge

- For a vehicle with an air restriction gauge, or a restriction indicator that resets automatically

Air Cleaner Element Restriction Checking

when the engine is shut down, operate the engine at *no-load* and governed rpm, and compare the gauge/indicator reading with the value shown in **Table 1** for maximum air restriction at *no-load* and governed rpm.

- For a vehicle without a gauge or indicator, test restriction with a water manometer or a service gauge. Refer to the test equipment manufacturer's literature for test procedures. Operate the engine at *no-load* and governed rpm, and compare the reading with the value shown in **Table 1** for maximum air restriction at *no-load* and governed rpm.

If air restriction equals or exceeds the value shown in **Table 1** for maximum air restriction at *no-load* and governed rpm, replace the air cleaner element; **see Subject 100**.

Engine	At Full Load and Governed RPM	At No-Load and Governed RPM
Cummins	25	12
Detroit Diesel	20	10
Mercedes-Benz	20	10

Table 1, Maximum Air Restriction in Inches of Water (inH_2O)

Specifications

Description	Grade	Size	Torque N·m (lbf·ft)
Air Cleaner Mounting Nuts	5	3/8–16	38 (28)

Table 1, Fastener Torques

General Description

The Bendix AirMaster air compressor is an engine-driven, single-piston compressor which supplies compressed air to the vehicle air system.

The compressor draws air from the air intake pipe, compresses the air, and delivers it to the air system supply reservoir. The compressor runs continuously but has "loaded" and "unloaded" modes, which are regulated by the air governor and the compressor loading assembly. When the air system reaches 825 kPa (120 psi), the governor sends an air signal to the unloader assembly. The unloader assembly then holds the compressor air intake valve open so that no more compressed air is forced into the air system. As air in the system is used, its pressure drops, and at 620 kPa (90 psi), the air governor stops the signal to the compressor. Without the signal, the unloader assembly automatically closes the compressor air intake valve to force more air into the system.

On vehicles with air dryers, when the system reaches the cut-out pressure of 825 kPa (120 psi), the air governor also sends an air signal to open the sludge ejector in the air dryer.

Removal and Installation, Mercedes-Benz OM 366LA Engine

Removal (Refer to Fig. 1)

1. Apply the parking brakes, chock the tires, and drain the air system.
2. Tilt the hood.
3. Disconnect the air and oil lines from the air compressor.
   - 3.1 Disconnect the air inlet hose (Ref. 5) from the rear of the compressor head.
   - 3.2 Disconnect the air outlet pipe (Ref. 6) from the fitting at the top of the compressor.
   - 3.3 Disconnect the air signal lines (Refs. 11 and 14) from the air governor.
   - 3.4 Disconnect the oil supply line (Ref. 16) from the air compressor.
4. Remove the drive belts from the air compressor.
   - 4.1 Remove the clamp bolt (Ref. 25).
   - 4.2 Loosen the bolt (Ref. 27) in the threaded block (Ref. 31).
   - 4.3 Turn the nut at the top of the clamp (Ref. 24) to raise the adjusting assembly (Ref. 26) off the drive belts.
   - 4.4 Loop the drive belts off the adjusting assembly pulleys. Then, loop the belts off the air compressor pulleys.
5. Remove the air compressor from the engine.
   - 5.1 Remove the four air compressor mounting bolts (Ref. 17).
   - 5.2 Lift the compressor (Ref. 1) from its mounting bracket (Ref. 32).

Installation (Refer to Fig. 1)

1. Install the air compressor on the engine.
   - 1.1 Position the air compressor (Ref. 1) on its mounting bracket (Ref. 32). If necessary, hold the O-ring (Ref. 22) in place over the oil return port with white grease or petroleum jelly.
   - 1.2 Install the four air compressor mounting bolts (Ref. 17), and tighten the bolts 16 N·m (12 lbf·ft).
2. Install the drive belts on the air compressor.
   - 2.1 Loop the drive belts around the air compressor pulleys and the adjusting assembly (Ref. 26) pulleys.
   - 2.2 Turn the nut at the top of the clamp (Ref. 24) to lower the adjusting assembly (Ref. 26) onto the belts. Lower the assembly until the belts are tightened to 23 kg (50 lbs).
   - 2.3 Tighten the clamp bolt 85 N·m (63 lbf·ft).
   - 2.4 Tighten the bolt (Ref. 27) into the threaded block (Ref. 31) 100 N·m (74 lbf·ft).
3. Connect the air and oil lines to the air compressor.
   - 3.1 Connect the air signal lines (Refs. 11 and 14) to the air governor.
   - 3.2 Connect the air outlet pipe (Ref. 6) to the air compressor.
   - 3.3 Connect the air inlet hose (Ref. 5) to the air compressor.
   - 3.4 Connect the oil supply line (Ref. 16) to the air compressor.
4. Start the engine and check for leaks. Repair any leaks.
5. Lower the hood, and remove the chocks from the tires.

Removal and Installation, Mercedes-Benz OM 366LA Engine

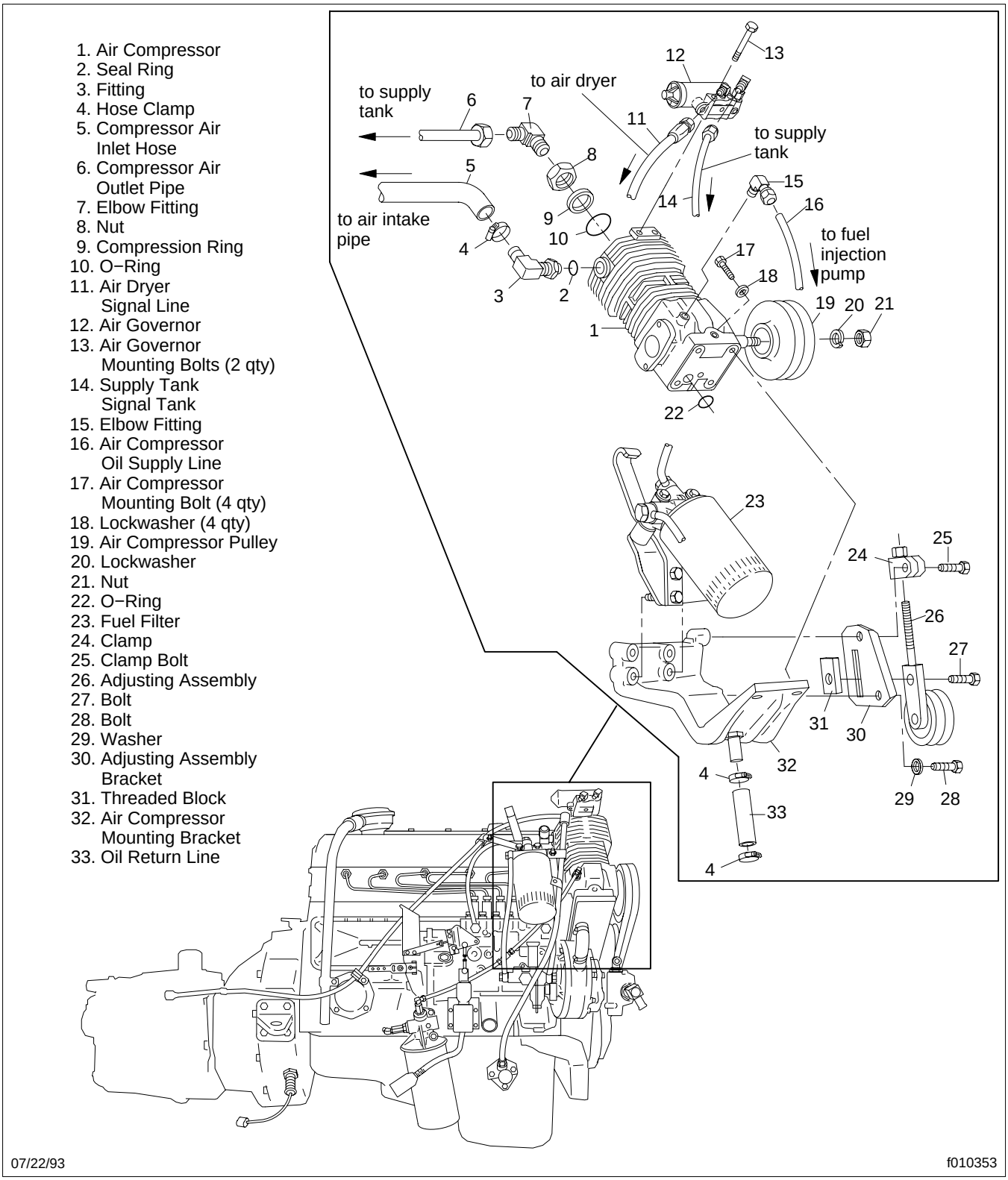


Fig. 1

Cylinder Head Disassembly, Inspection and Cleaning, and Assembly

Disassembly (Refer to Fig.1)

1. Remove the compressor from the vehicle, and place it on a suitable work surface. For instructions, **refer to "Removal and Installation from Mercedes-Benz OM 366LA Engine, 100."**
2. Remove the air governor.
3. Remove the cylinder head cover (Ref. 2).
4. Remove and discard the gasket (Ref. 9). Note the position of the gasket ear. **See Fig.2.**
5. Remove the cylinder head (Ref. 10) from the valve plate (Ref. 17).
6. Note the position of the gasket ear. **See Fig.2.** Then, remove and discard the gasket (Ref. 16).
7. Note the position of the gasket ears. **See Fig.2.** Then, remove and discard the gaskets (Ref. 18).
8. If present, remove the unloader cap (Ref. 3) from the cylinder head cover.
9. Remove the unloader piston (Ref. 4), and remove the four O-rings (Refs. 5 through 8) from the piston. Discard the O-rings.
10. Depress the spring guide (Ref. 12), and remove the C-clip (Ref. 11) from the unloader valve (Ref. 15). Discard the C-clip.
11. Remove and discard the spring guide (Ref. 12), unloader spring (Ref. 13), and unloader valve (Ref. 15) from the cylinder head.

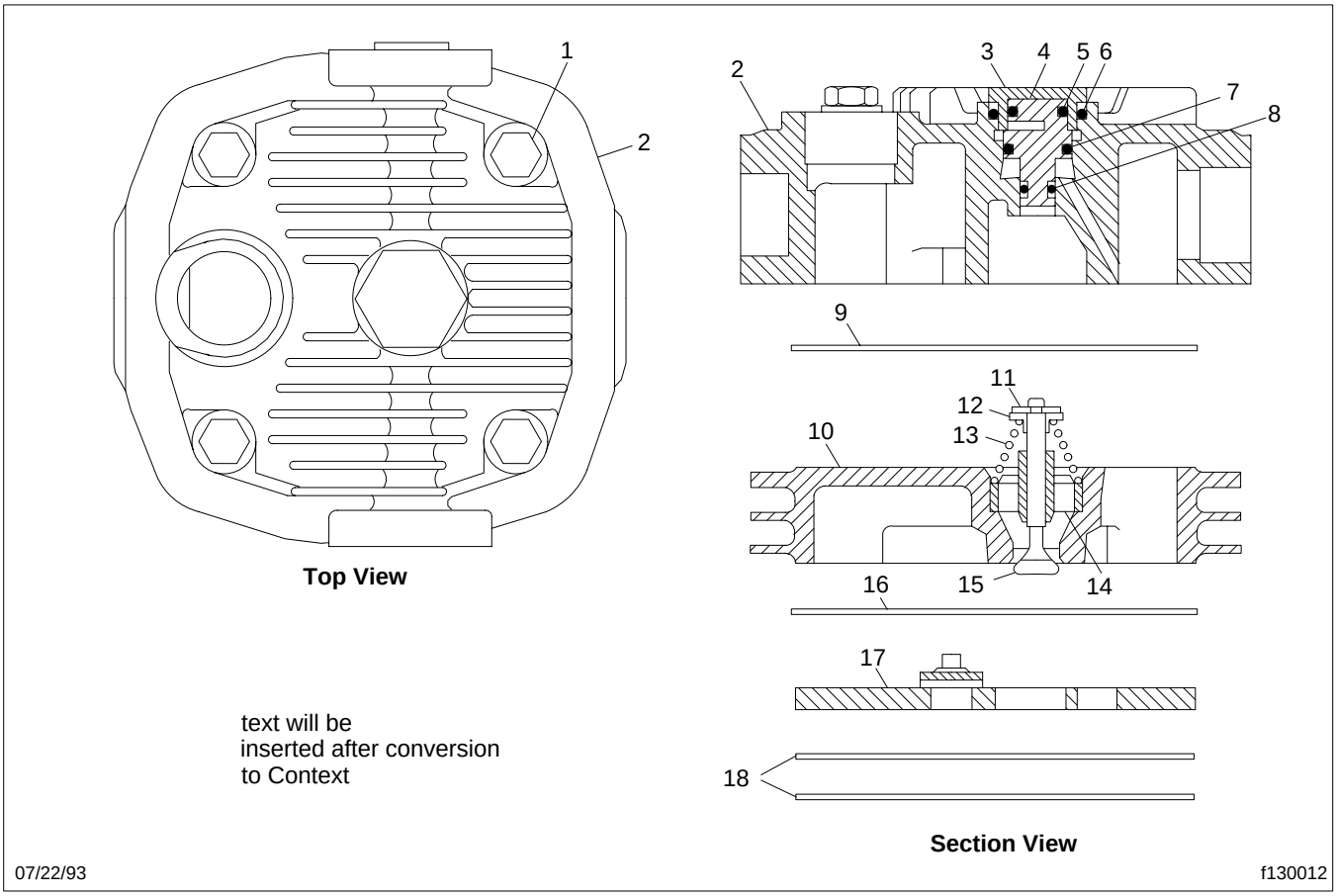


Fig. 1, Compressor Head Assembly

Cylinder Head Disassembly, Inspection and Cleaning, and Assembly

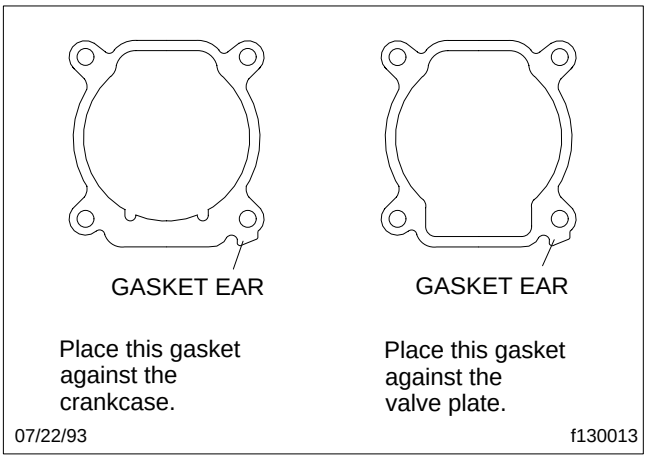


Fig. 2

Inspection and Cleaning

WARNING

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

1. Using a solvent, thoroughly clean all metal parts removed from the compressor.
2. Check that all air passages are clear, including the small drilling in the unloader piston. **See Fig.1**, Ref. 4.
3. Check that all mating surfaces are clean of old gasket material. Remove any old material.
4. With the piston at the top of its stroke, clean any carbon from the piston crown and the crankcase head face.

Assembly **(Refer to Fig.1)**

1. Using silicon fluid grease, lubricate the unloader piston (Ref. 4) and the O-rings (Refs. 5, 7, and 8). Fit the O-rings around the piston.
2. Lubricate the unloader cap O-ring (Ref. 6), and fit it around the cap. Lubricate the unloader bore in the cylinder head cover, and assemble the unloader piston and the unloader cap into the cover. Tighten the cap 27 N·m (20 lbf·ft).
3. Place a new unloader valve (Ref. 15) into the cylinder head (Ref. 10), and carefully thread the valve guide (Ref. 14)— with the small, tapered end down— over the unloader valve stem.
4. Place a new unloader spring (Ref. 13) and spring guide (Ref. 12) onto the valve guide. Depress the spring guide and place a new C-clip (Ref. 11) on the unloader valve stem. Release the spring and ensure the clip is securely in place.
5. Assemble the valve plate, cylinder head, cylinder head cover, and gaskets (Refs. 9 and 16), **as shown in Fig.1.**
6. Install the cylinder head assembly on the crankcase with the two gaskets (Ref. 18). For the correct placement of the gaskets, **refer to Fig.2.**
7. Install the four cylinder head bolts. Tighten the bolts diagonally, 27 N·m (20 lbf·ft).
8. Install the compressor on the engine. For instructions, **refer to "Removal and Installation from Mercedes-Benz OM 366LA Engine, 100."**
9. Install the air governor.
10. Start the engine, and check the compressor for air and oil leaks.

Specifications

Description	Class/Grade	Size	Torque N·m (lbf·ft)
Bolt to Threaded Block	8.8	M10 x 40	100 (74)
Air Compressor Tensioning Assembly Clamp Bolt	8	1/2–12	85 (63)
Air Compressor Mounting Bolts	10.9	8 mm	16 (12)
Compressor Cylinder Head Bolts	10.9	8 mm	27 (20)

Table 1, Fastener Torques

Description	Tension kg (lbs)
Air Compressor Belts	23 (50)

Table 2, Drive Belt Tension

General Description

Cummins B Series engines use the Holset SS191B air-cooled air compressor, an engine-driven, single-piston compressor which supplies compressed air to the vehicle air system. The compressor draws turbo-charged, aftercooled air from the engine manifold. It compresses the air further, and delivers it to the air system supply reservoir.

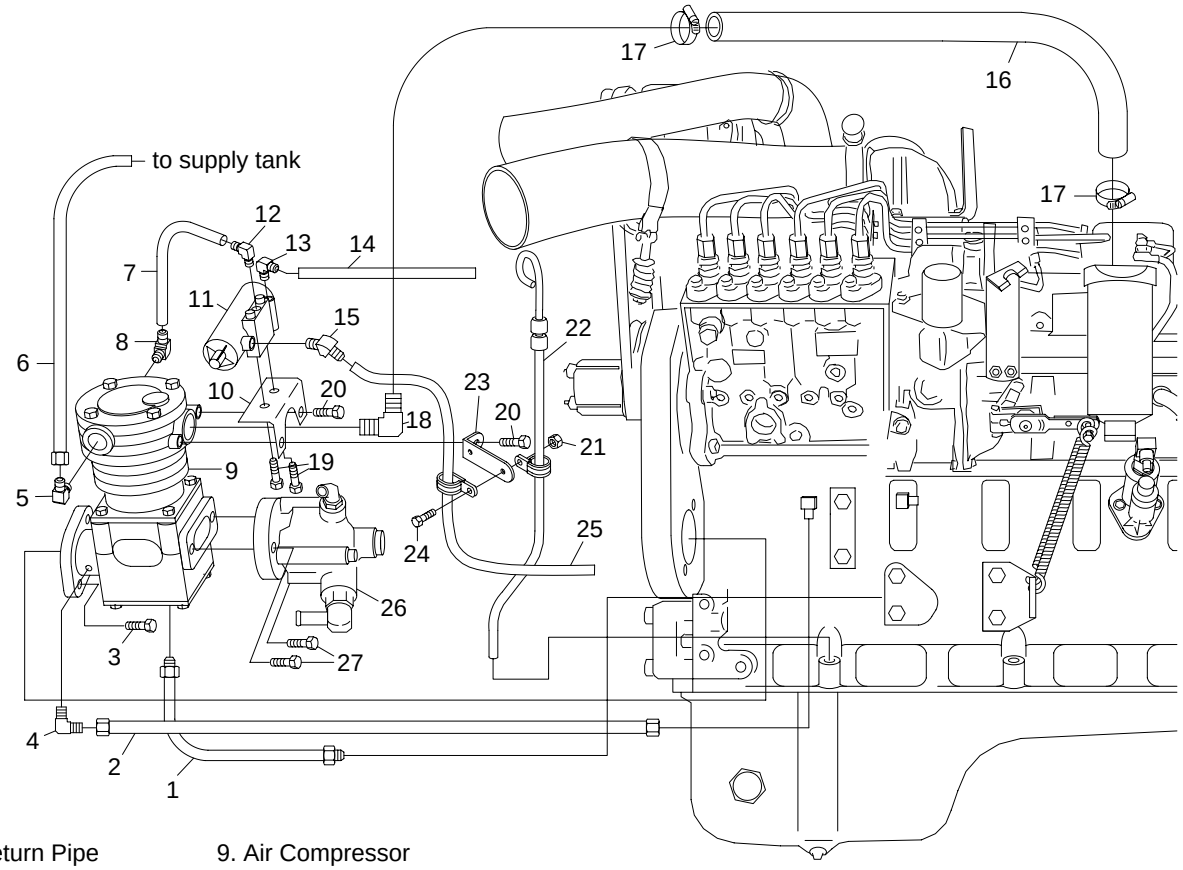
The compressor runs continuously but has "loaded" and "unloaded" modes, which are regulated by the air governor and the compressor loading assembly. When the air system reaches 825 kPa (120 psi), the governor sends an air signal to the unloader assembly. The unloader assembly then holds the compressor air intake valve open so that no more compressed air is forced into the air system. As air in the system is used, its pressure drops, and at 620 kPa (90 psi), the air governor stops the signal to the compressor. Without the signal, the unloader assembly automatically closes the compressor air intake valve to force more air into the system.

On vehicles with air dryers, when the system reaches the cut-out pressure of 825 kPa (120 psi), the air governor also sends an air signal to open the sludge ejector in the air dryer.

For detailed repair procedures and other engine service not covered in this section, refer to the *Cummins SS191B Air Compressor Shop Manual* or *Cummins Single Cylinder Air Compressor Shop Manual.*

Removal (Refer to Fig. 1)

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Drain the air reservoirs.
3. Tilt the hood.
4. Carefully disconnect the air lines.
   - 4.1 Disconnect the air inlet line (Ref. 16) at the rear of the compressor head.
   - 4.2 Disconnect the air outlet line (Ref. 6) from the side of the compressor head.



1. Oil Return Pipe
2. Oil Supply Line
3. Air Compressor Mounting Bolt
4. Elbow Fitting
5. Elbow Fitting
6. Air Compressor Outlet Line
7. Air Compressor Signal Line
8. Elbow Fitting
9. Air Compressor
10. Air Governor Bracket
11. Air Governor
12. Elbow Fitting
13. Elbow Fitting
14. Air Governor Signal Line
15. Elbow Fitting
16. Air Compressor Input Line
17. Hose Clamp
18. Elbow Fitting
19. Air Governor Mounting Bolt
20. Air Governor Bracket Bolt
21. Nut
22. Dipstick
23. Stand−Off Bracket
24. Bolt
25. Air Governor Signal Line
26. Power Steering Pump
27. Power Steering Pump Mounting Bolt

07/22/93 f010356

Fig. 1

Removal and Installation

4.3 Disconnect the air signal line (Ref. 7) between the compressor and the air governor.

4.4 Disconnect the air signal lines (Refs. 14 and 25) between the air governor and the chassis air system.

5. Remove the power steering pump.

5.1 Remove the butterfly clamps holding the power steering lines together.

5.2 Remove the power steering pump mounting bolts (Ref. 27).

5.3 Remove the pump from the compressor.

6. Remove the dipstick (Ref. 22) and air signal line (Ref. 25) clamps from the stand-off bracket (Ref. 23) at the rear of the air governor.

7. Remove the left air governor bracket bolt (Ref. 20) to free the stand-off bracket. Remove the bracket.

8. Disconnect the oil lines.

8.1 Disconnect the compressor oil return pipe (Ref. 1) from the engine.

8.2 Disconnect the compressor oil supply line (Ref. 2) from the air compressor.

8.3 Remove the two compressor mounting bolts (Ref. 3), then lift the compressor from the engine.

Installation (Refer to Fig. 1)

1. Install the air compressor.

1.1 Position the compressor on the engine, and secure it with the air compressor mounting bolts (Ref. 3). Tighten the bolts 73 N·m (54 lbf·ft).

1.2 If removed, install the air governor on the compressor. Install the stand-off (Ref. 23) with the left bracket bolt, and tighten both bolts 20 N·m (15 lbf·ft).

2. Connect the air compressor oil lines.

2.1 Connect the oil supply line (Ref. 2) to the compressor.

2.2 Connect the oil return pipe (Ref. 1) to the engine.

3. Install the power steering pump.

3.1 Position the pump on the air compressor, and secure it with the power steering pump mounting bolts (Ref. 27). Tighten the bolts 38 N·m (28 lbf·ft).

3.2 Clamp the power steering pump inlet and outlet lines together.

4. Connect the air compressor and air governor air lines.

4.1 Connect the air signal lines (Refs. 14 and 25) between the air governor and the chassis air system.

4.2 Connect the air signal line (Ref. 7) between the compressor and the air governor.

4.3 Connect the air outlet line (Ref. 6) to the side of the compressor head.

4.4 Connect the air inlet line (Ref. 16) at the rear of the compressor head.

5. Clamp the air signal line (Ref. 25) and the dipstick (Ref. 22) to the stand-off bracket (Ref. 23).

6. Start the engine, and check for leaks in the compressor mounting. Repair any leaks as necessary.

7. Lower the hood, and remove the chocks from the tires.

Specifications

This subject contains the following table: •Fastener Torques

Description	Grade	Size	Torque N·m (lbf·ft)
Air Governor Bracket Bolts	5	5/16–18	20 (15)
Air Compressor Mounting Bolts	8.8	M12 x 1.75	73 (54)
Power Steering Pump Mounting Bolts	5	3/8–16	38 (28)

Table 1, Fastener Torques

General Description

Cummins C Series engines use the Holset SS296 water-cooled air compressor, an engine-driven, piston-type compressor which supplies

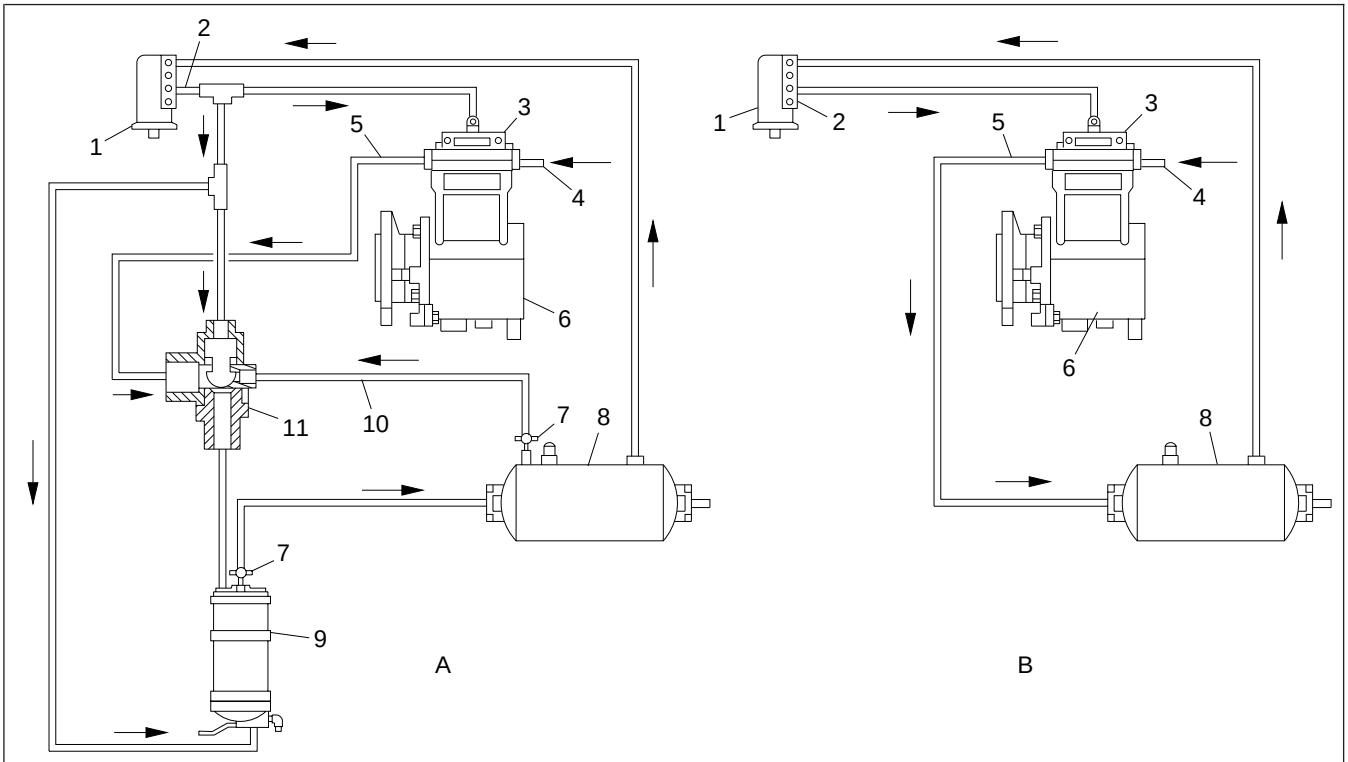
compressed air to the vehicle air system. See **Fig. 1**. The compressor draws turbocharged, aftercooled air from the engine intake manifold. It compresses the air further and delivers it to the air system supply reservoir.

The compressor runs continuously but has loaded and unloaded modes, which are regulated by the air governor and the compressor loading assembly. The compressor also uses an Economy (E-type) unloader system to reduce pumping and engine boost pressure losses through the compressor intake valve while operating in the unloaded mode. If equipped with an air dryer, an Econ valve must be installed to prevent excessive oil consumption. When the air system reaches 120 psi (825 kPa), the governor sends an air signal to the unloader assembly. The unloader assembly then seals off incoming air at the intake valve so that no more compressed air enters the air system. As air in the system is used, its pressure drops and at 90 psi (620 kPa), the air governor stops the signal to the compressor. Without the signal, the compressor again pumps more compressed air into the system.

When the system reaches the cut-out pressure of 120 psi (825 kPa) on vehicles with air dryers, the air governor also sends an air signal to open the sludge ejector in the air dryer.

For detailed repair procedures and other engine service not covered in this section, refer to the *Cummins SS296 Air Compressor Shop Manual* or the *Cummins Troubleshooting and Repair Manual C Series Engines*.

General Description



A. With Air Dryer
1. Air Governor
2. Unloader Port
3. E-Type Unloader Valve
4. Air Inlet Line
5. Air Outlet Line
6. Compressor
7. Check Valve
8. Air Reservoir (wet tank)

B. Without Air Dryer
9. Air Dryer
10. Secondary Pressure Line
11. Econ Valve

Fig. 1, Air System Diagram

Removal

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.

⚠ WARNING

WARNING: Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

3. Drain the coolant and the air reservoirs.
4. Carefully disconnect the air lines, coolant lines, and the oil supply line.
   - 4.1 Disconnect the air inlet line **(Fig. 1)** at the rear of the compressor head and at the engine.
   - 4.2 Disconnect the air outlet line **(Fig. 1)** from the front of the compressor head.
   - 4.3 Disconnect the coolant lines **(Fig. 2)** at the rear of the compressor head and at the cylinder head and engine block.
   - 4.4 Disconnect the two air signal lines between the air governor and the chassis air system.
   - 4.5 Disconnect the compressor oil supply line **(Fig. 3)** from the air compressor.

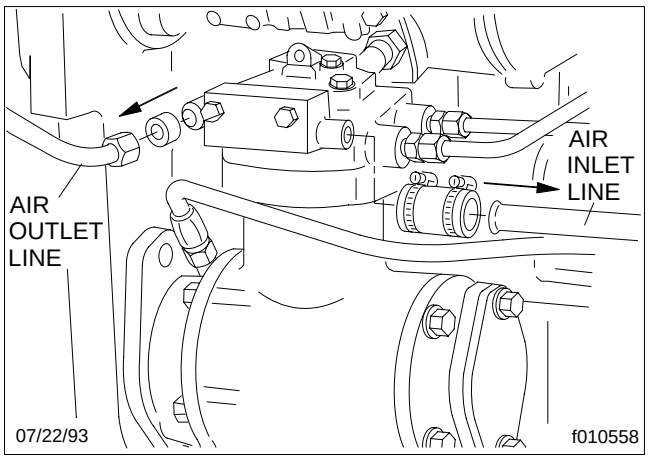


Fig. 1

5. Remove the power steering pump.
   - 5.1 Remove the power steering pump mounting bolts.
   - 5.2 Remove the pump from the compressor.
6. Remove the air compressor. **Refer to Fig. 4.**
   - 6.1 Remove the compressor support-bracket capscrews, then remove the bracket.
   - 6.2 Remove the compressor mounting nuts, then lift or lower the compressor out of the engine compartment.

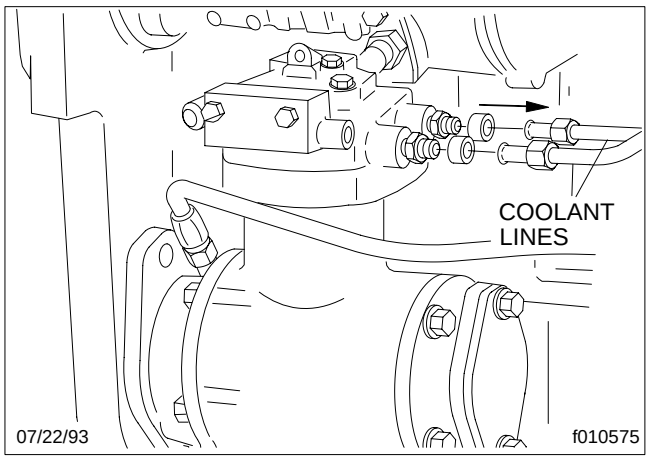


Fig. 2

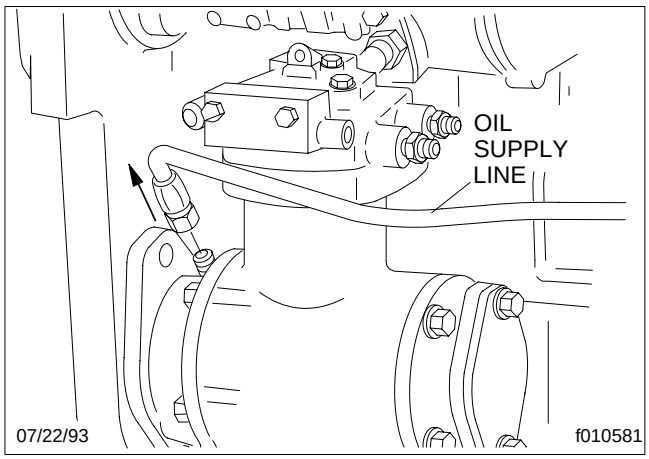
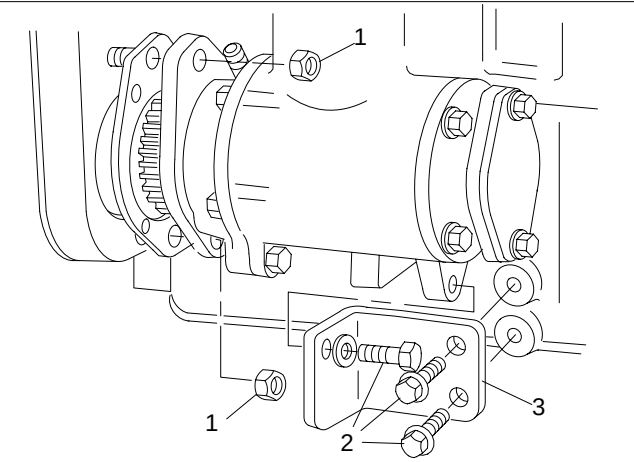


Fig. 3

Installation

1. Install the compressor.

Removal and Installation



1. Compressor Mounting Nuts
2. Support−Bracket Capscrews
3. Mounting Bracket

07/22/93 f010557

Fig. 4

1.1 Position the compressor and a new gasket on the engine.

1.2 Install the mounting nuts and tighten them 77 N·m (57 lbf·ft).

1.3 Install the compressor support bracket and tighten the capscrews 47 N·m (35 lbf·ft).

2. Install the power steering pump.

   Position the pump on the air compressor, and secure it with the power steering pump mounting bolts. Tighten the bolts 47 N·m (35 lbf·ft).

3. Connect the air lines, coolant lines, and the oil supply line.

   3.1 Connect the air inlet line **(Fig. 1)** to the rear of the compressor head and to the engine.

   3.2 Connect the air outlet line **(Fig. 1)** to the front of the compressor head.

   3.3 Connect the coolant lines **(Fig. 2)** to the rear of the compressor head and to the cylinder head and engine block.

   3.4 Connect the two air signal lines between the air governor and the chassis air system.

   3.5 Connect the compressor oil supply line **(Fig. 3)** to the air compressor.

4. Fill the cooling system with approved coolant. Refer to the vehicle maintenance manual.

5. Start the engine, and check for leaks in the air lines, coolant lines, and the oil supply line. Repair any leaks as necessary.

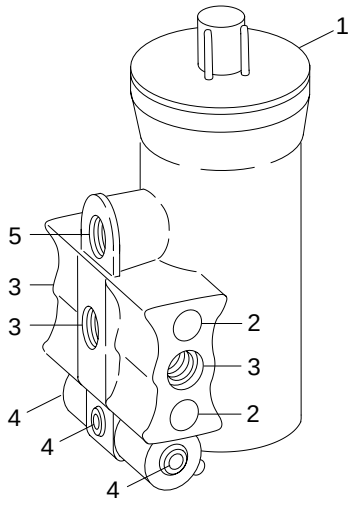
6. Lower the hood, and remove the chocks from the tires.

General Description

The governor **(see Fig. 1),** together with the compressor unloading mechanism, automatically controls air pressure in the air brake system. It keeps the pressure between 655 and 862 kPa (95 to 125 psi), which is a preset range for all Freightliner vehicles.

The compressor runs continuously while the engine runs, but actual air compression is controlled by the D–2 governor, working with the compressor unloading mechanism.

The D–2 governor is mounted on the compressor. There are three reservoir ports, three unloader ports, and one exhaust port (all 1/8-inch NPT) on the governor.



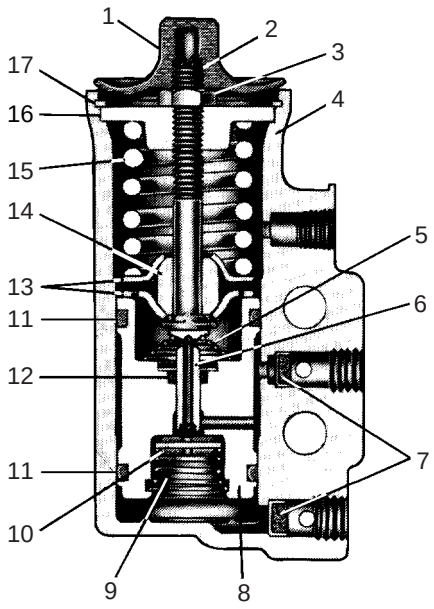
01/11/94 f420038a

1. Top Cover
2. Mounting Hole
3. Unloader Port
4. Reservoir Port
5. Exhaust Port

Fig. 1

Principles of Operation

Pressurized air enters the D–2 governor at one of its reservoir ports, and acts on the area of the piston and beneath the inlet and exhaust valve. **See Fig. 2.** As air pressure builds up, the piston moves against the resistance of the pressure-setting spring. The piston and inlet and exhaust valve move up when the reservoir air pressure reaches the cut-out setting of the governor. The exhaust stem seats on the inlet and exhaust valve, and then the inlet passage opens. Reservoir air then flows by the open inlet valve, through the passage in the piston, and out the unloader port to the compressor unloading mechanism. Air also flows around the piston, and acts upon the additional area of the piston. This added force, which results from a larger area on the piston, ensures a positive action and fully opens the inlet valve.



09/28/94 f420301a

1. Cover
2. Adjusting Screw
3. Adjusting Screw Locknut
4. Body
5. Exhaust Stem Spring
6. Exhaust Stem
7. Filters
8. Piston
9. Inlet and Exhaust Valve Spring
10. Inlet and Exhaust Valve
11. O-Rings
12. Lower Spring Seats
13. Spring Guide
14. Pressure-Setting Spring
15. Upper Spring Seat
16. Retaining Ring

Fig. 2

As the system reservoir air pressure drops to the cut-in setting of the governor, the force exerted on the piston is reduced so that the pressure-setting spring moves the piston down. The inlet valve closes and the exhaust opens. With the exhaust open, the air in the unloader line escapes back through the piston, through the exhaust stem and out the exhaust port.

Tests

The following test should be done whenever the vehicle air pressure is incorrect and the causes are unknown.

If the air governor doesn't work correctly or if leakage is excessive, replace it with a new or rebuilt unit, or repair it using genuine Bendix parts and the instructions in this section.

1. Apply the parking brakes and chock the tires. Tilt the hood.
2. Start the engine and build up air pressure in the air brake system.

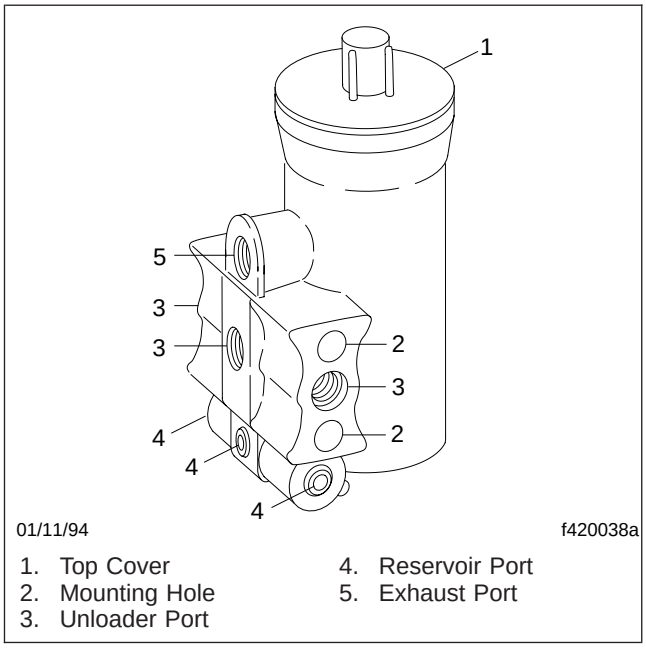
IMPORTANT: Make sure the test gauge is registering accurately before using it to check or adjust the air governor.

3. Using a test gauge attached to the supply reservoir, check the pressure at the time the air governor cuts out. The cut-out pressure should be 120 to 130 psi (827 to 896 kPa).
4. With the engine still running, apply the brakes a few times to reduce the air pressure and observe at what pressure the air governor cuts in the compressor. The minimum cut-in pressure should be 100 psi (689 kPa).
5. If either the cut-out or cut-in pressure is incorrect, proceed to **Subject 130**.
6. Test the leakage on the air governor in both the cut-in and cut-out positions.

   6.1 With the compressor in the cut-in position, apply a soap solution to the air governor exhaust port. See **Fig. 1**. A slight bubble leakage is permitted. More leakage indicates that the inlet valve or lower piston O-ring is worn out.

   6.2 With the compressor in the cut-out position, apply a soap solution to the air governor exhaust port. See **Fig. 1**. A slight bubble leakage is permitted. More leakage indicates that the exhaust valve seat, stem, O-ring, or upper piston O-ring is worn out.

7. Lower the hood and remove the chocks from the tires.



1. Top Cover
2. Mounting Hole
3. Unloader Port
4. Reservoir Port
5. Exhaust Port

Fig. 1, Air Governor

Removal (See Fig. 1)

1. Chock the tires, then drain the air brake system. Tilt the hood.

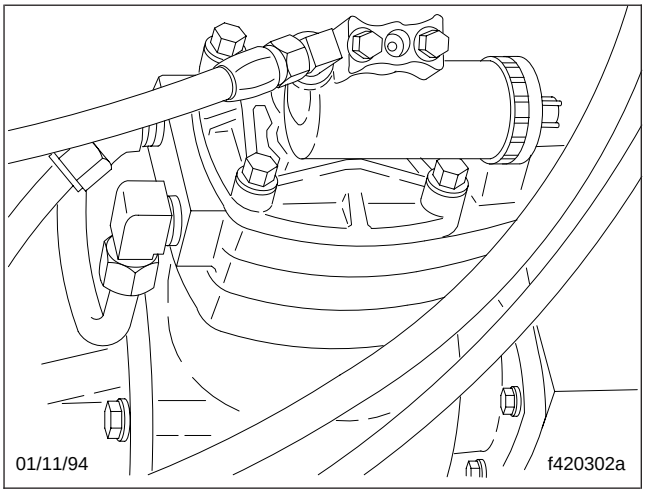


Fig. 1

2. Disconnect the reservoir and unloader port air lines. Mark the lines for later reference. Cap the air lines tightly to keep out dirt and moisture.
3. Remove the governor mounting bolts, then remove the governor.

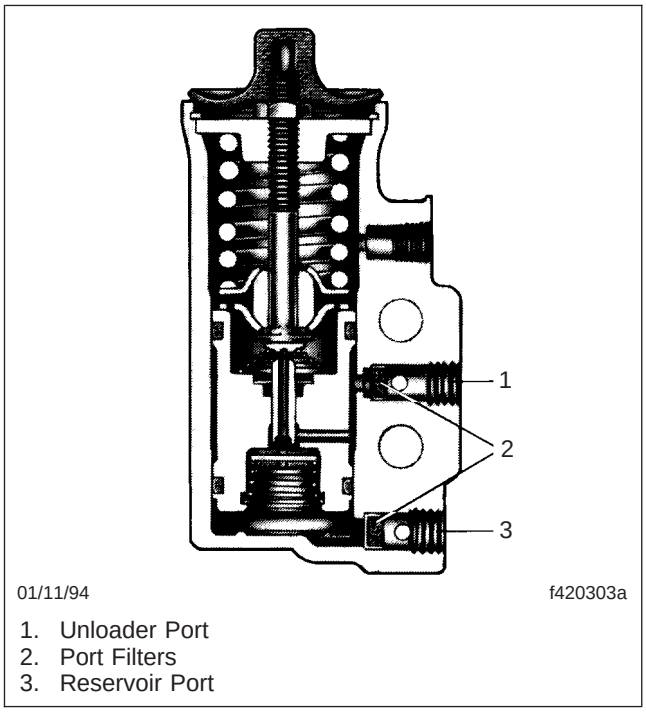
Installation

1. Clean the mounting pad on both the compressor and the governor block, and be sure the compressor unloading port is clear and clean.
2. Using a new governor mounting gasket, install the governor and its mounting bolts. Tighten the bolts 15 to 20 N·m (11 to 15 lbf·ft).
3. Clean the connecting lines after removing the caps, and apply Loctite® 242, or equivalent sealant in small quantities, to the reservoir and unloader fittings.

⚠ CAUTION

CAUTION: Make sure sealant doesn't get inside the fittings. Loose material inside the plumbing may clog the governor or other components, causing damage.

4. Connect the reservoir and unloader port air lines as referenced earlier. Tighten the fittings 15 to 18 N·m (11 to 13 lbf·ft).
5. Do the operating and leakage tests under **Subject 100**.
6. After the tests have been completed and the governor is operating correctly, screw the top cover on tightly until it seals the body, preventing the entry of any foreign matter.
7. If necessary, install new filters **(see Fig. 2)** in the reservoir and unloader ports. These cup-shaped filters can be installed with the head of a pencil.
8. Lower the hood. Then remove the chocks from the tires.



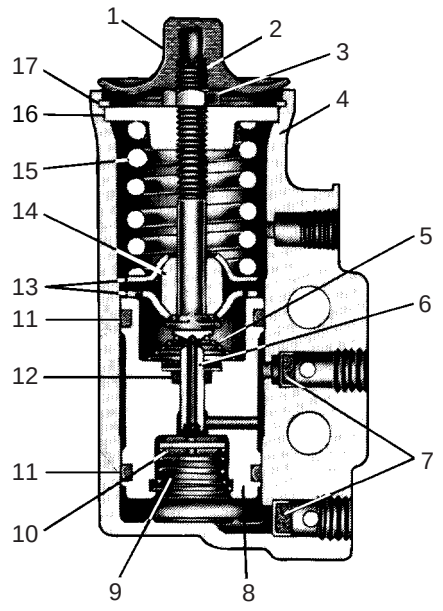
1. Unloader Port
2. Port Filters
3. Reservoir Port

Fig. 2

Disassembly, Cleaning and Inspection, and Assembly

Disassembly (See Fig. 1)

1. Remove the governor from the vehicle, using the instructions under **Subject 110**.



09/28/94 f420301a

1. Cover
2. Adjusting Screw
3. Adjusting Screw Locknut
4. Body
5. Exhaust Stem Spring
6. Exhaust Stem
7. Filters
8. Piston
9. Inlet and Exhaust Valve Spring
10. Inlet and Exhaust Valve
11. O-Rings
12. Lower Spring Seats
13. Spring Guide
14. Pressure-Setting Spring
15. Upper Spring Seat
16. Retaining Ring

Fig. 1

2. Clean the governor exterior of road dirt and grease.
3. Unscrew the top cover (Ref. 1).
4. Using a pair of retaining ring pliers, remove the spring assembly retaining ring (Ref. 16).
5. Remove the adjusting screw (Ref. 2) and spring assembly.
6. Remove the locknut (Ref. 3), then the hex-shaped upper spring seat (Ref. 15) from the adjusting screw.
7. Remove the pressure-setting spring (Ref. 14), lower spring seat (Ref. 12), spring guide (Ref. 13), and the other lower spring seat (Ref. 12) from the adjusting screw.
8. Remove the exhaust stem and its spring from the top of the piston. With the body in the inverted position, tap lightly and remove the piston.
9. Remove the inlet and exhaust valve spring (Ref. 9) and the valve (Ref. 10) from the piston.
10. Remove the two piston O-rings (Ref. 11), and with a hooked wire, remove the exhaust stem O-ring.
11. Clean or remove the unloader and reservoir port filters (Ref. 7).

Cleaning and Inspecting

WARNING

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

1. Clean all metal parts in mineral spirits.
2. Wipe all rubber parts dry, using a clean cloth.
3. Inspect the governor body for cracks or other damage. Be particularly careful that all air passages in the body, filters, exhaust stem, and piston are not obstructed.
4. Check the springs for cracks, distortion, or corrosion.
5. Replace all worn or damaged parts.

Assembly (See Fig. 1)

Before assembly, lubricate the lower body bore, the top of the piston, the piston grooves, piston O-rings, and the spring guide and adjusting screw with Dow Corning 55-M pneumatic grease, or equivalent.

Disassembly, Cleaning and Inspection, and Assembly

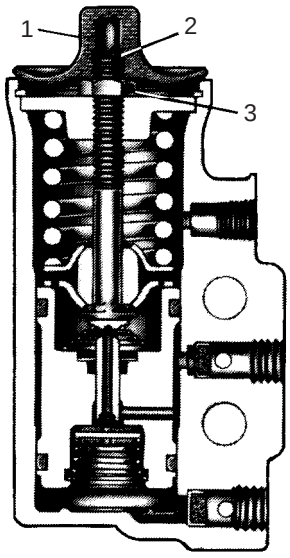
1. Install the exhaust stem O-ring (Ref. 11) in its groove in the stem bore of the piston.
2. Install the upper and lower piston O-rings (Ref. 11).
3. Drop the inlet and exhaust valve (Ref. 10) into place at the bottom of the piston.
4. Install the inlet and exhaust valve spring (Ref. 9) with the small end against the valve. Press the spring down until the larger coiled end snaps into the groove inside the piston.
5. Place the exhaust stem spring (Ref. 5) over the exhaust stem. Carefully press the stem into the stem bore of the piston.
6. Install the piston in the body.
7. Install one lower spring seat (Ref. 12), spring guide (Ref. 13), the other lower spring seat (Ref. 12), pressure-setting spring (Ref. 14), and the hex-shaped upper spring seat (Ref. 15) on the adjusting screw, in that order. Screw the upper spring seat (Ref. 15) down until the distance from the top of the seat to the bottom of the stem head is about 48 mm (1-7/8 inches).
8. Install the locknut (Ref. 3).
9. Before placing the adjusting screw and stem assembly in the governor body, check that the exhaust stem (Ref. 6) and its spring are in place in the piston.
10. Install the adjusting screw (Ref. 2) and spring assembly, and the retaining ring (Ref. 16).
11. Install the governor on the vehicle, following the instructions under **Subject 110**.

Adjustment

NOTE: An air governor with a dryer reservoir module (DRM) is not adjustable.

If the pressure settings of the governor are inaccurate or if they need to be changed, do the following:

1. Apply the parking brakes and chock the tires. Tilt the hood.
2. Remove the top cover from the governor and loosen the adjusting screw locknut. See **Fig. 1.**



01/11/94 f420305a

1. Top Cover
2. Adjusting Screw
3. Adjusting Screw Locknut

Fig. 1, Air Governor

3. To raise the pressure settings, turn the adjusting screw counterclockwise. To lower the pressure setting, turn the adjusting screw clockwise.

NOTE: The pressure range between cut in and cut out is not adjustable.

If these adjustments do not correct the pressure settings, repair or replace the governor using the instructions in this section.

4. Tighten the adjusting screw locknut and install the top cover.
5. Lower the hood, then remove the chocks from the tires.

General Information

The Cummins 15.2 cfm compressor is used on the ISB engine. The 18.7 cfm compressor is used on the ISC engine. Both compressors are single cylinder engine-driven, piston-type compressors which supply compressed air to operate air powered actuators on vehicles. These compressors are geared directly to the engine which serves to operate the compressor and any accessory that is connected on the rear flange. These compressors will deliver air out of the exhaust port when the unloader port is at atmospheric pressure and will stop air delivery when the unloader port is pressurized to the system pressure between 100 to 125 psi (689 to 862 kPa). A governor determines the "cut-in" (start of pumping) and "cut-out" (termination of pumping) of the compressor by supplying the proper control signal to the unloader port. The governor is sensing the pressure in the air supply tank or "wet tank." If the output air pressure is inadvertently blocked or required to exceed 250 psi (1724 kPa), the compressor will stop air delivery. The air will be recycled within the compressor and no mechanical harm will be done.

Air Compressor Removal and Installation

Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Tilt the hood.
3. Drain the air reservoirs.
4. Drain the radiator coolant below the level of the air compressor. See **Group 20** in this manual for instructions.

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

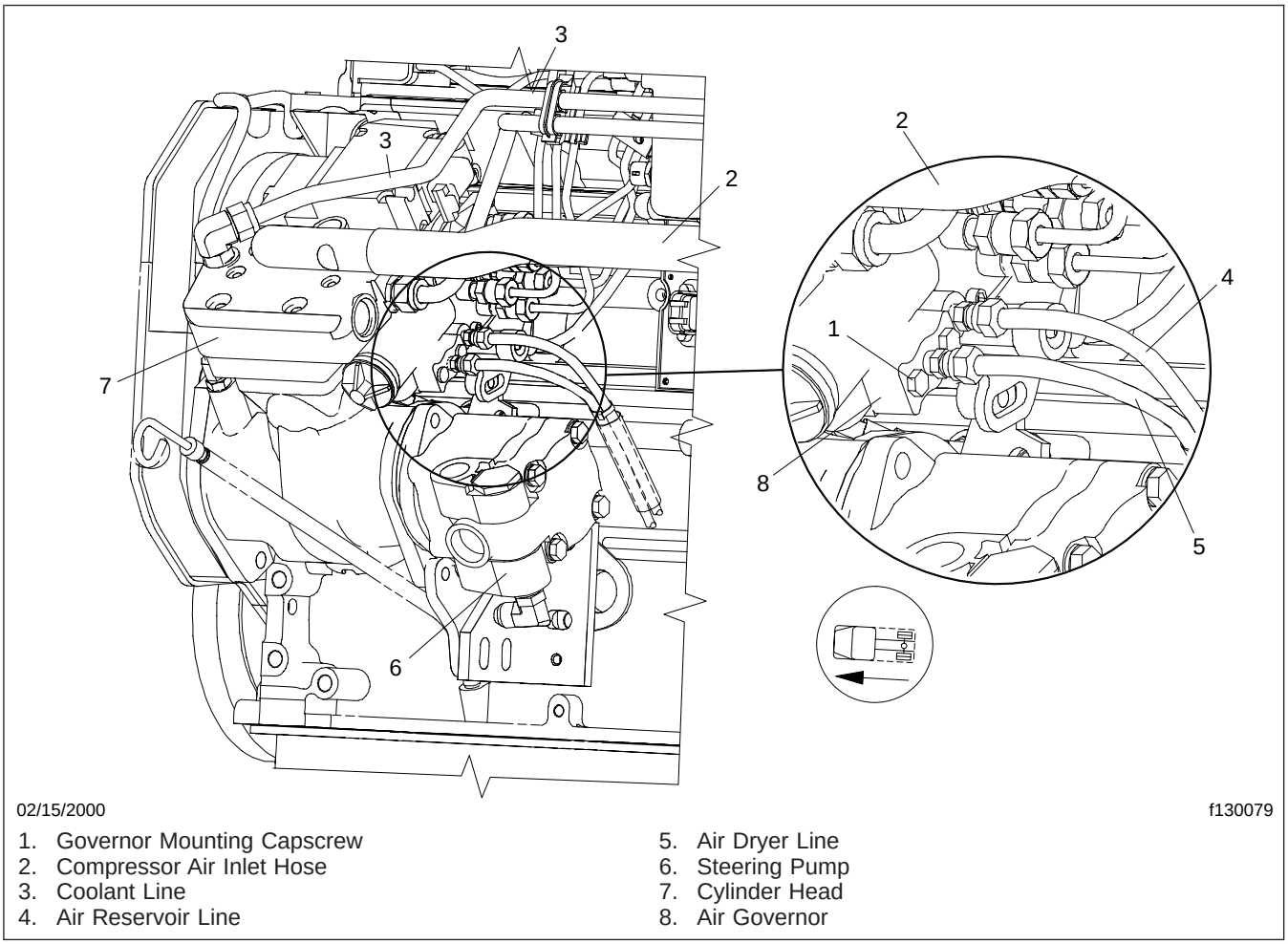
5. Using a cleaning solvent, remove road dirt and grease from the outside of the air compressor, then dry the air compressor with compressed air.
6. Marking their locations and positions, disconnect all air, coolant, and oil lines attached to the air compressor and governor. Remove cushion clamps and tie straps as needed to move the lines out of the way. See **Fig. 1** and **Fig. 2**.
7. Remove the power steering pump.
   - 7.1 Remove the power steering pump mounting capscrews.
   - 7.2 Remove the power steering pump from the air compressor.
8. Remove the air compressor.
   - 8.1 Remove the air compressor support bracket. See **Fig. 3** and **Fig. 4**.
   - 8.2 Support the air compressor, and remove the nuts and washers from the front gear cover studs.
   - 8.3 Lift or lower the air compressor out of the engine compartment.
   - 8.4 Remove and discard the air compressor mounting gasket, and clean the mating surfaces.

Installation

IMPORTANT: Be sure the gasket surfaces are cleaned and not damaged.

1. Install the air compressor.
   - 1.1 Install a new gasket on the front gear cover.
   - 1.2 Position the air compressor on the front gear cover studs while aligning the compressor drive gear.
   - 1.3 Install the washers and nuts to the mounting studs and tighten 57 lbf·ft (77 N·m).
   - 1.4 Install the compressor support bracket and tighten the capscrews 35 lbf·ft (47 N·m).
2. Position the steering pump on the air compressor, and secure it with the mounting capscrews. Tighten the capscrews 35 lbf·ft (47 N·m).
3. Identify and connect all air, coolant, and oil lines to the compressor and governor. Secure the lines as needed with cushion clamps and tie straps.
4. Fill the engine cooling system. See **Group 20** for instructions.
5. Operate the engine and check for leaks.
6. Remove the chocks from the rear tires and close the hood.

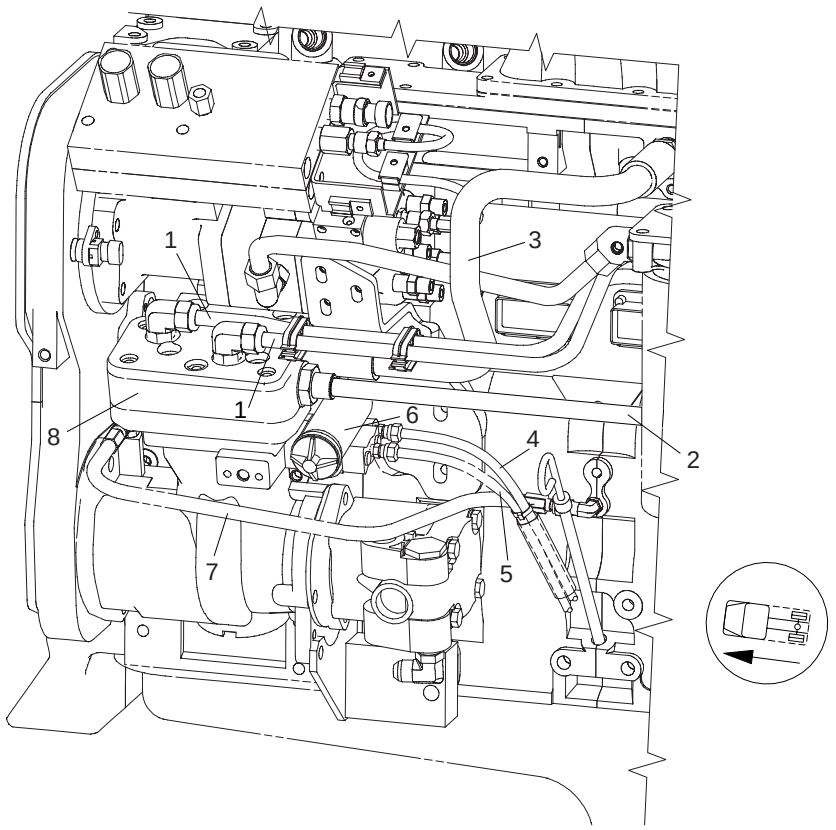
Air Compressor Removal and Installation



1. Governor Mounting Capscrew
2. Compressor Air Inlet Hose
3. Coolant Line
4. Air Reservoir Line
5. Air Dryer Line
6. Steering Pump
7. Cylinder Head
8. Air Governor

Fig. 1, Air Compressor Removal, ISB

Air Compressor Removal and Installation

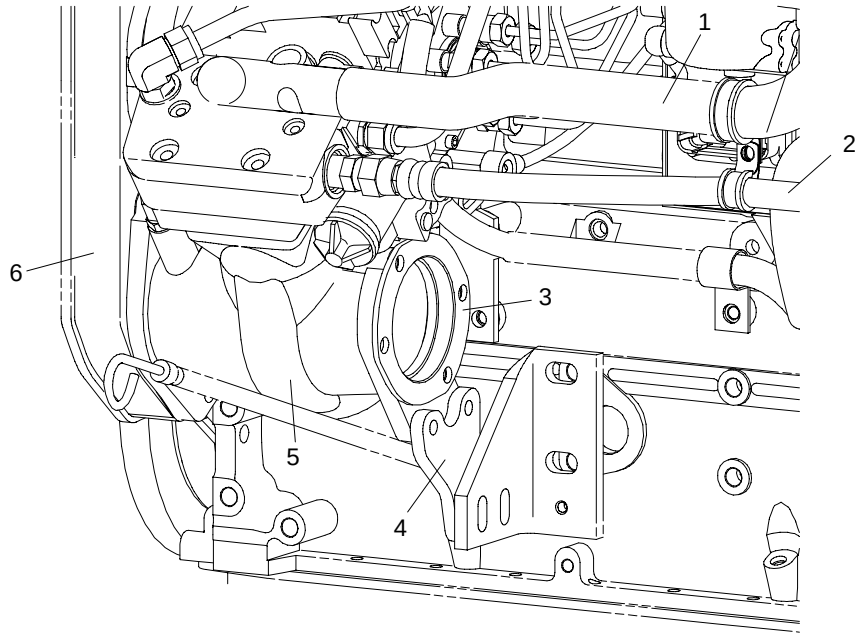


02/15/2000 f130078

1. Coolant Line
2. Air Dryer/Wet Tank Line
3. Compressor Air Inlet Hose
4. Air Reservoir Line
5. Air Dryer Line
6. Air Governor
7. Oil Feed Line
8. Cylinder Head

Fig. 2, Air Compressor Removal, ISC

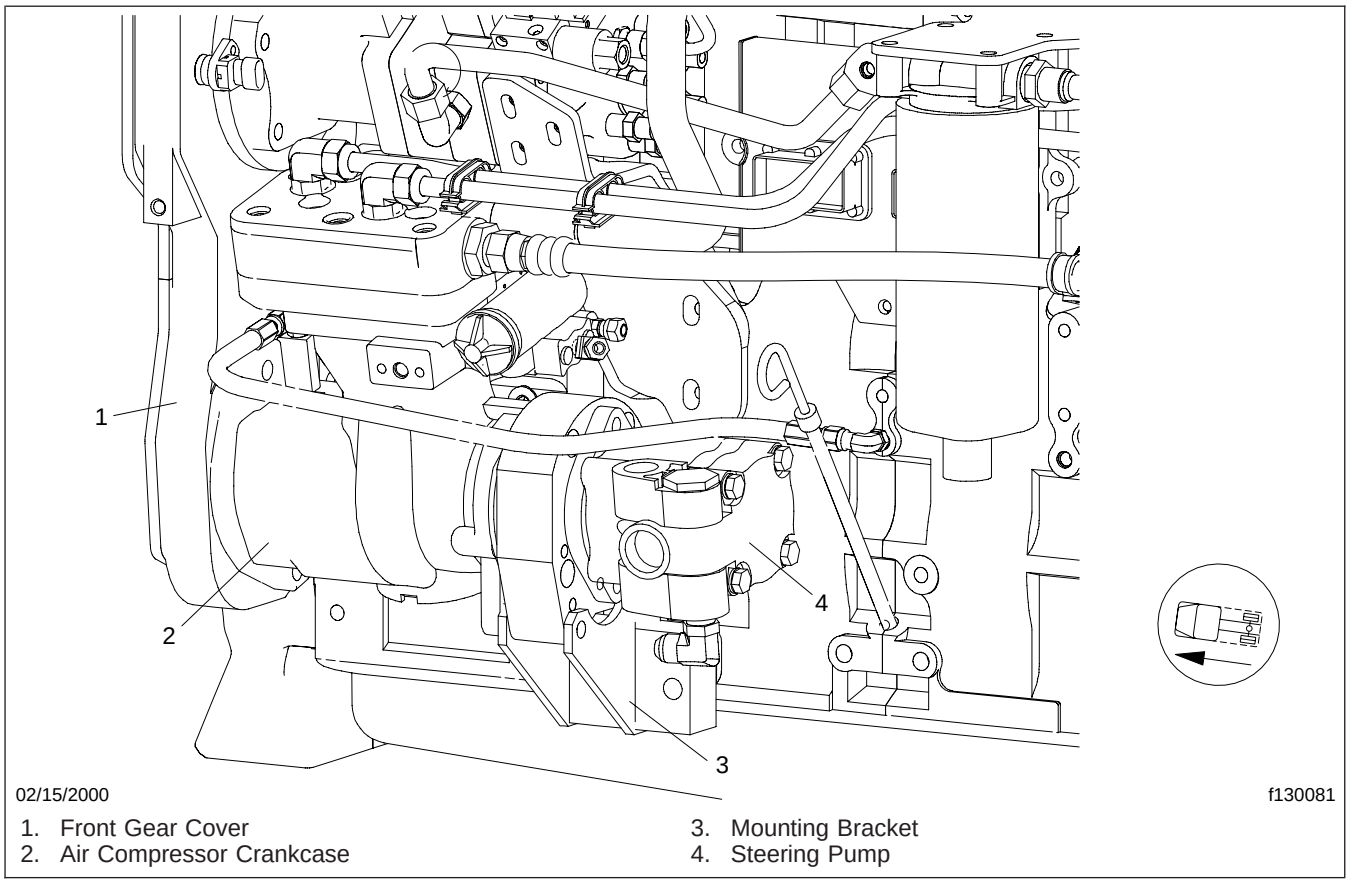
Air Compressor Removal and Installation



02/28/2000 f130080

1. Compressor Air Inlet Hose
2. Air Dryer/Wet Tank Line
3. Rear Flange
4. Mounting Bracket
5. Compressor Crankcase
6. Front Gear Cover

Fig. 3, Air Compressor Rear Support, ISB



1. Front Gear Cover
2. Air Compressor Crankcase
3. Mounting Bracket
4. Steering Pump

Fig. 4, Air Compressor Rear Support, ISC

Cylinder Head Replacement, 15.4 Compressor

Replacement

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Drain the air from all air reservoirs.
3. Remove the compressor from the vehicle. See **Subject 100** for instructions.
4. Mount the compressor on a suitable holding fixture.

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

5. Using a cleaning solvent, remove road dirt and grease from the outside of the compressor, then dry the compressor with compressed air.
6. Remove the cylinder head assembly, from the crankcase.

   6.1 Scribe an alignment mark across the cylinder head and upper crankcase, for assembly alignment.

   IMPORTANT: Do not use a marking method, such as chalk, that can be wiped off during assembling.

   NOTE: There is no need to remove the smaller screws.

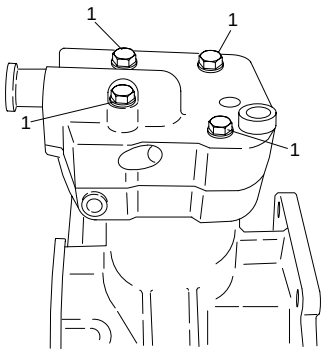
   6.2 Note the positions of any attached components, then remove the four M8 cylinder head capscrews. Discard the capscrews. See **Fig. 1**.

   6.3 Tap the cylinder head with a soft mallet to break the gasket seal. Remove the cylinder head assembly and discard the gasket. See **Fig. 2**. Note the position of the ports with respect to the crankcase for reassembly.

   6.4 Remove the coolant and air fittings for reuse.

7. Clean the upper crankcase.

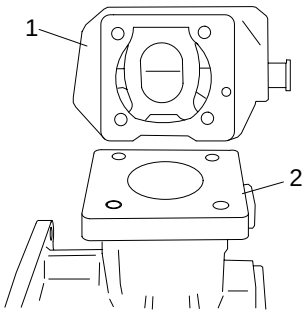
   7.1 Rotate the crankshaft until the piston is at the top of the cylinder bore.



02/22/2000 f130085

1. Cylinder Head Capscrew

Fig. 1, Cylinder Head Capscrews



02/22/2000 f130083

1. Cylinder Head Assembly
2. Upper Crankcase

Fig. 2, Cylinder Head Removal

NOTE: Avoid the use of abrasive products similar to Scotch Brite® because of damage and abrasive grit left behind.

7.2 Remove any accumulated carbon and varnish by carefully scraping, and light application of solvents. Avoid getting debris and solvents into the clearance between the piston and bore. Avoid the use of abrasive products similar to Scotch Brite because of damage and abrasive grit left behind.

Cylinder Head Replacement, 15.4 Compressor

WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

7.3 Using compressed air, blow dirt particles or gasket material from all cylinder cavities.

8. Inspect the top crankcase surface. It should be smooth and free of scratches to enable resealing on assembly.
9. Transfer the original cylinder head alignment marks to the replacement cylinder head.
10. Install the coolant and air fittings on the replacement cylinder head assembly.
11. Install the cylinder head assembly on the compressor upper crankcase.

    11.1 Position the sliding valve and the guide pins in the correct direction to enter the larger diameters in the valve body and crankcase.

    11.2 Align the marks on the cylinder head and crankcase.

    11.3 Using a new cylinder head gasket, position the gasket and head assembly on the crankcase.

    Note: You should find two cover bolts loosely holding the head assembly together.

    11.4 Install new capscrews.

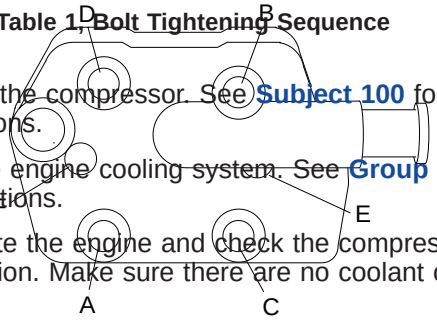
CAUTION

A torque angle gauge and inch pound torque wrench must be used to perform the torque-turn capscrew tightening sequence. The tightening sequence listed in Table 1 must be followed to prevent damage to the cylinder head assembly.

12. Tighten the capscrews using the bolt tightening sequence in **Table 1**.

Bolt Tightening Sequence			
Step	Bolt	Torque: lbf·in (N·cm)	Rotation Degrees
1	A	119 to 145 (1350 to 1650)	—
2	B	119 to 145 (1350 to 1650)	—
3	C	119 to 145 (1350 to 1650)	—
4	D	119 to 145 (1350 to 1650)	—
5	A	203 to 239 (2300 to 2700)	—
6	B	203 to 239 (2300 to 2700)	—
7	C	203 to 239 (2300 to 2700)	—
8	D	203 to 239 (2300 to 2700)	—
9	A	—	170 to 190
10	B	—	260 to 280
11	C	—	170 to 190
12	D	—	170 to 190
13	E	48 to 58 (540 to 660)	—
14	F	48 to 58 (540 to 660)	—
15	E	—	85 to 105
16	F	—	85 to 105

Table 1, Bolt Tightening Sequence



13. Install the compressor. See **Subject 100** for instructions.
14. Fill the engine cooling system. See **Group 20** for instructions.
15. Operate the engine and check the compressor operation. Make sure there are no coolant or air leaks.
16. Remove the chocks from the rear tires.

Cylinder Head Replacement, 18.7 CFM Compressor

Replacement

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Drain the air from all air reservoirs.
3. Remove the compressor from the vehicle. See **Subject 100** for instructions.
4. Mount the compressor on a suitable holding fixture.

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

5. Using a cleaning solvent, remove road dirt and grease from the outside of the compressor, then dry the compressor with compressed air.
6. Remove the cylinder head assembly, from the crankcase.

   6.1 Scribe an alignment mark across the cylinder head and upper crankcase, for assembly alignment.

   IMPORTANT: Do not use a marking method, such as chalk, that can be wiped off during assembling.

   NOTE: There is no need to remove the smaller screws.

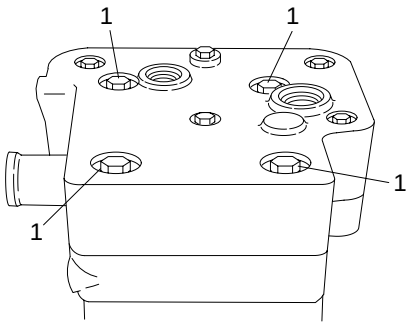
   6.2 Note the positions of any attached components, then remove the four M8 cylinder head capscrews. Discard the capscrews. See **Fig. 1** .

   6.3 Tap the cylinder head with a soft mallet to break the gasket seal. Remove the cylinder head valve assembly and gasket. See **Fig. 2**. Note the position of the ports with respect to the crankcase for reassembly.

   6.4 Remove the coolant and air fittings for reuse. Discard the original cylinder head.

7. Clean the upper crankcase.

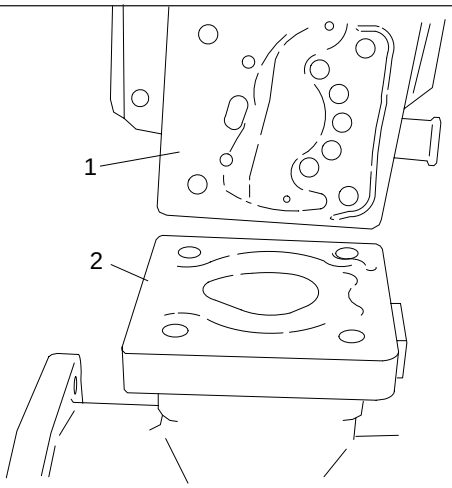
   7.1 Rotate the crankshaft until the piston is at the top of the cylinder bore.



03/06/2000 f130088

1. Cylinder Head Capscrew

Fig. 1, Cylinder Head Capscrews



03/06/2000 f130084

1. Cylinder Head Assembly
2. Upper Crankcase

Fig. 2, Cylinder Head Removal

NOTE: Avoid the use of abrasive products similar to Scotch Brite® because of damage and abrasive grit left behind.

7.2 Remove any accumulated carbon and varnish by carefully scraping and light application of solvents. Avoid getting debris and solvents into the clearance between the piston and bore. Avoid the use of abrasive products similar to Scotch Brite because of damage and abrasive grit left behind.

Cylinder Head Replacement, 18.7 CFM Compressor

WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

7.3 Using compressed air, blow dirt particles or gasket material from all cylinder cavities.

8. Inspect the top crankcase surface. It should be smooth and free of scratches to enable resealing on assembly.
9. Transfer the alignment marks from the original cylinder head to the replacement cylinder head.
10. Install the coolant and air fittings on the new cylinder head assembly.
11. Install the cylinder head on the compressor crankcase.

    11.1 Position the sliding valve and the guide pins in the correct direction to enter the larger diameters in the valve body and crankcase.

    11.2 Align the marks on the cylinder head and crankcase.

    11.3 Using a new cylinder head gasket, position the gasket and head assembly on the crankcase.

    NOTE: You should find five cover bolts loosely holding the head assembly together.

    11.4 Install new capscrews.

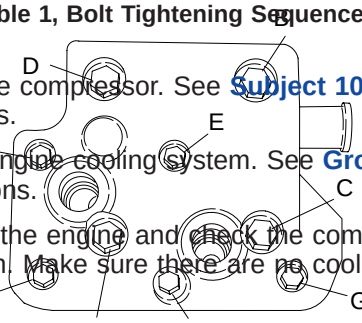
CAUTION

A torque angle gauge and inch pound torque wrench must be used to perform the torque-turn capscrew tightening sequence. The tightening sequence listed in Table 1 must be followed to prevent damage to the cylinder head assembly.

11.5 Tighten the capscrews using the bolt tightening sequence in **Table 1**.

Bolt Tightening Sequence			
Step	Bolt	Torque: lbf·in (N·cm)	Rotation Degrees
1	A	177 to 221 (2000 to 2500)	—
2	B	177 to 221 (2000 to 2500)	—
3	C	177 to 221 (2000 to 2500)	—
4	D	177 to 221 (2000 to 2500)	—
5	A	—	85 to 105
6	B	—	85 to 105
7	C	—	85 to 105
8	D	—	55 to 75
9	E	48 to 58 (540 to 660)	—
10	F	48 to 58 (540 to 660)	—
11	G	48 to 58 (540 to 660)	—
12	H	48 to 58 (540 to 660)	—
13	I	48 to 58 (540 to 660)	—
14	E	—	85 to 105
15	F	—	85 to 105
16	G	—	85 to 105
17	H	—	85 to 105
18	I	—	85 to 105

Table 1, Bolt Tightening Sequence



12. Install the compressor. See **Subject 100** for instructions.
13. Fill the engine cooling system. See **Group 20** for instructions.
14. Operate the engine and check the compressor operation. Make sure there are no coolant or air leaks.
15. Remove the chocks from the rear tires.

03/06/2000 f130087

Troubleshooting Tables

Problem—Excessive Oil Passage

Problem—Excessive Oil Passage	
Possible Cause	**Remedy**
Restricted air intake.	Check engine air filter and replace if necessary. Check compressor air inlet for kinks and excessive bends. Repair as needed.
Restricted oil return hole in front of compressor.	Remove compressor and check the oil return hole for restrictions. Repair as needed.
Defective or worn seal in the rear bearing cap.	Replace seal.
Compressor runs loaded an excessive amount of time.	Check air lines and connections for leakage. Check for a defective governor or restricted line. Replace the governor if necessary. Repair or replace lines and connections until leakage is eliminated.
Back pressure from the engine crankcase.	Check for excessive engine crankcase pressure. Repair or replace ventilation components as necessary. NOTE: An indication of crankcase pressure is a loose or partially lifted dipstick.
Excessive engine oil pressure.	Check the engine oil pressure with a test gauge, and compare the reading to the engine specification. Do not restrict the compressor oil supply line.
Malfunctioning compressor.	Replace the compressor after making certain none of the preceding conditions exist.

Problem—Noisy Compressor Operation

Problem—Noisy Compressor Operation	
Possible Cause	**Remedy**
Loose drive coupling or gear (as indicated).	Inspect the fit of the drive coupling and gear on the compressor crankshaft. Tighten or replace the components. If the crankshaft keyway is damaged, replace the compressor.
Compressor cylinder head or discharge line restrictions.	Inspect the compressor discharge port and discharge line for carbon build-up. If carbon is detected, remove the carbon and check for proper coolant flow to the compressor. Inspect the discharge line for kinks and restrictions. Replace the discharge line as necessary.
Compressor internal engine components damaged or worn.	Replace the compressor.

Problem—Excessive Build-Up and Recovery Time

Problem—Excessive Build-Up and Recovery Time	
Possible Cause	**Remedy**
Restricted air intake.	Check engine air filter and replace if necessary. Check compressor air inlet for kinks and excessive bends. Repair as needed.

Troubleshooting

Problem—Excessive Build-Up and Recovery Time	
Possible Cause	**Remedy**
Restricted discharge or compressor discharge cavity.	Inspect the compressor discharge port and line for restrictions and carbon build-up. If carbon is detected, remove the carbon. Check for proper cooling to the compressor. Inspect the discharge line for kinks and restrictions. Replace the discharge line as necessary.
Slipping drive components.	Check for faulty drive gears and coupling, and replace as necessary.
Excessive air system leakage (not including the air compressor).	Check all valves, air lines, and connections for leakage. Repair or replace valves and lines until leakage is eliminated.
Unloader piston seized.	Check the operation of the unloading mechanism. Check for corrosion and contamination of unloader pistons. Check for correct operation of the compressor air governor. If the governor is operating properly, replace the compressor.
Damaged compressor rings, valves, and gaskets.	Replace the compressor.

Problem—Compressor Fails to Unload

Problem—Compressor Fails to Unload	
Possible Cause	**Remedy**
Malfunctioning governor.	Check the setting with an accurate test gauge. Repair or replace the air governor.
Unloader air lines from governor damaged.	Inspect the air lines to and from the governor for kinks or restrictions. Repair or replace the air lines.
Faulty or worn unloader piston or bore.	Replace the compressor.

Problem—Air in Water System/Water in Air System

Problem—Air in Water System/Water in Air System	
Possible Cause	**Remedy**
Internal gasket leakage.	Replace the compressor.
Internal casting porosity.	Replace the compressor.

General Information

The CS-130 alternator features a high ampere output per pound of weight, and a totally new and different regulator. A diode trio is not used. A delta stator, a rectifier bridge, and a rotor with slip rings and brushes are electrically similar to earlier models of alternators (**Fig. 1** and **Fig. 2**).

The CS stands for Charging System, and 130 denotes the outside diameter in millimeters of the stator laminations. The CS-130 features sealed bearings with lifetime lubrication in both end frames. A conventional fan mounted next to the pulley pulls air through the assembly for cooling. An internal fan mounted on the rotor pulls air through the slip ring end frame to cool the rectifier bridge and regulator. The air is expelled through openings in the end frame. No periodic maintenance on the alternator is required.

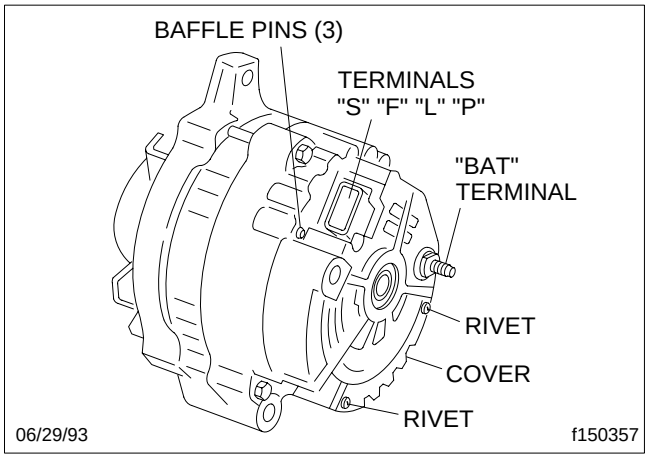


Fig. 1

Principles of Operation

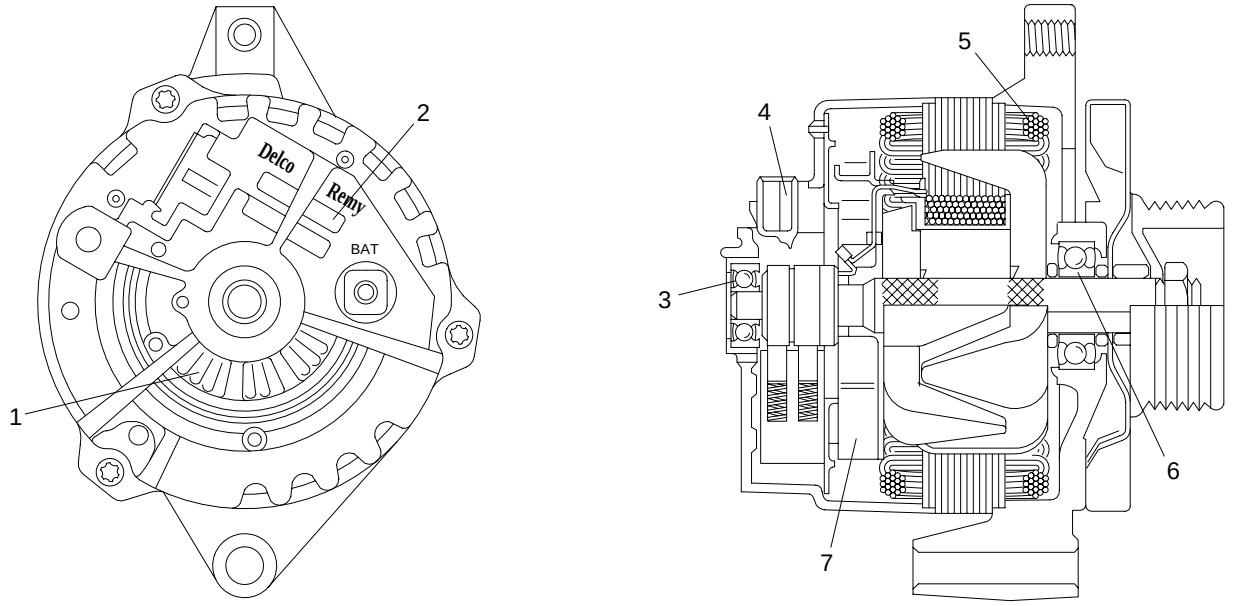
The CS-130 used on Freightliner trucks is wired with three wires connected to the alternator. The charge indicator works in much the same way as on other charging systems— the indicator light comes on when the switch is closed, and then goes out when the engine is running. If the charge indicator is on with the engine running, a charging system problem is indicated. Regardless of the problem, the indicator will glow at full brilliance. A new feature of this regulator is that it will cause the charge indicator to be on with the engine running if the system voltage is too high or too low. The regulator is temperature-compensated; that is, its voltage setting varies with temperature.

As in other alternators, the regulator limits the system voltage by controlling the rotor field current. Unlike other regulators, this regulator switches the field current on and off at a fixed frequency of about 400 cycles per second. By varying the on-off time, the correct average field current for proper system voltage control is obtained. At high speeds, the on-time may be 10%, and the off-time 90%. At low speeds with high electrical loads the on-off time may be 90% and 10% respectively.

The use of the "P" and "S" terminals is optional. The "P" terminal is connected to the stator, and may be connected externally to a tachometer or other device. The "S" terminal may be connected externally to a voltage, such as battery voltage, to sense the voltage to be controlled. For the complete circuit, see the wiring diagrams.

Where the regulator is identified with an "I" marking on the regulator case, the circuit in **Fig. 3** applies. In this circuit, both the "L" and "I" terminals serve to turn on the regulator and allow field current to flow when the switch is closed. The "I" terminal may be connected directly to the switch, or through a resistor. Both are illustrated. The "I" circuit may be used with or without the "L" circuit; that is, with or without anything connected to the "L" circuit.

General Information and Principles of Operation



1. Rectifier Bridge
2. Multi−Function Integrated Circuit Regulator
3. Double Sealed Ball Bearing
4. Protected Terminals
5. High Temperature Insulation
6. Double Sealed Ball Bearing
7. Internal Fan

07/09/93 f150364

Fig. 2, Typical Cross-Sectional View

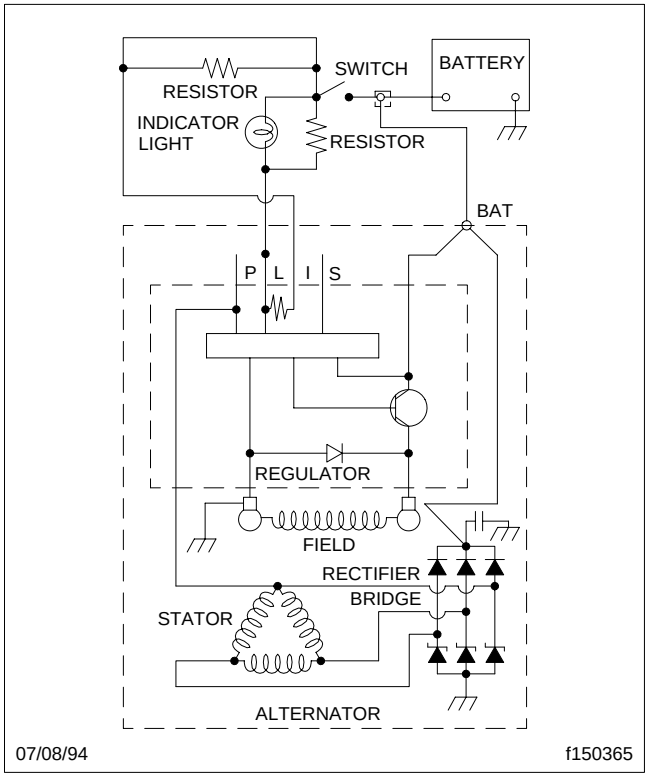


Fig. 3, Basic Circuit Using L and I Terminals, I Terminal Connected to Switch Either Directly or Through Resistor

Alternator Removal and Installation, Cummins B Series Engines

Removal

1. Disconnect the batteries, negative lead.
2. Disconnect and mark the battery lead wire on the alternator.
3. Disconnect the alternator wiring harness.
4. Gripping the wrench handle firmly, lift the tensioner arm and pulley; then remove the belt from the alternator pulley. **See Fig. 1.**

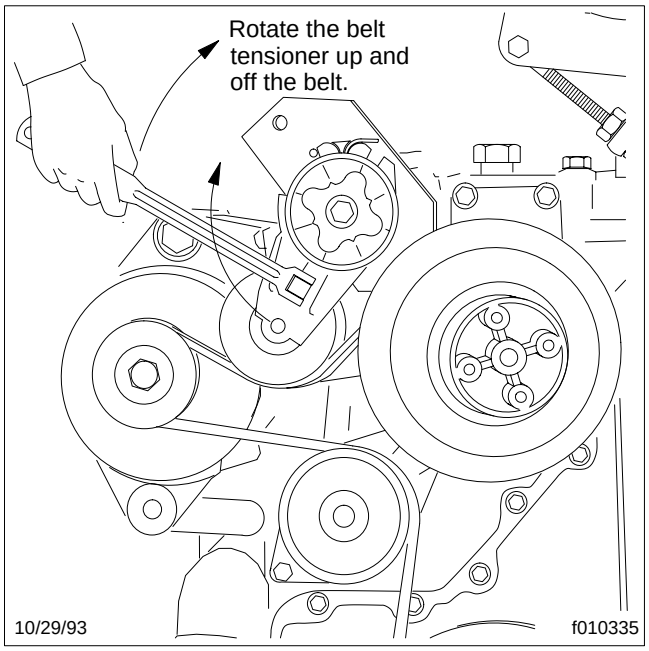


Fig. 1

5. Remove the alternator mounting bolts. Remove the alternator.

Installation

1. Check the tightness of the alternator-bracket fasteners **(Fig. 2**, Ref. 1). Tighten them 24 N·m (18 lbf·ft).
2. Position the alternator on the mounting bracket, then install the mounting bolts finger-tight.
3. Connect the alternator link **(Fig. 2**, Ref. 4) to the alternator, finger-tight.

NOTE: Make sure the alternator link is properly positioned for correct belt alignment.

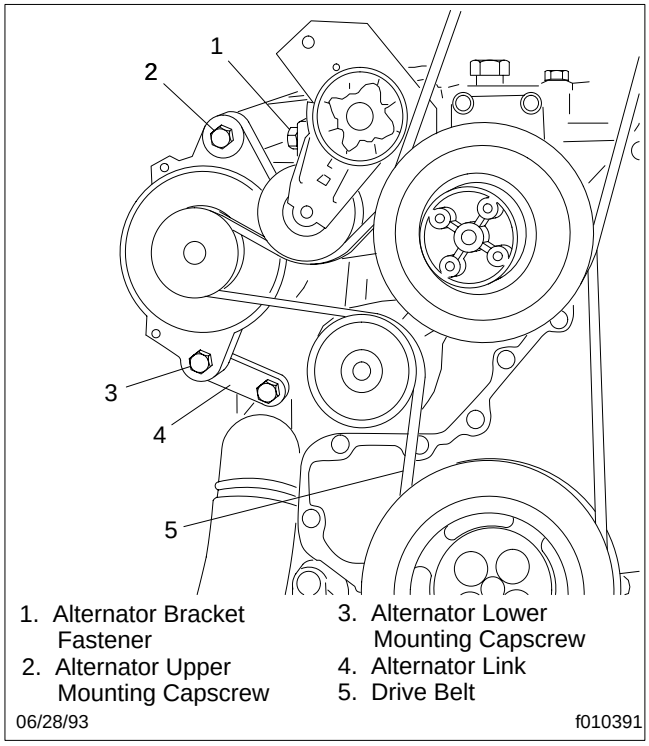


Fig. 2, Alternator and Drive Belt Installation

4. Tighten the alternator mounting capscrews as follows:
   - 8 mm: 16 N·m (12 lbf·ft)
   - 3/8-inch: 38 N·m (28 lbf·ft)
5. Lift the tensioner arm; then install the drive belt on the pulleys **(see Fig. 2).**
6. Connect the alternator wiring harness.
7. Connect the battery lead wire to the back of the alternator as previously marked. Tighten the output terminal nut maximum 8 N·m (6 lbf·ft) when attaching the cable.
8. Connect the batteries.

Disassembly (Refer to Fig. 1)

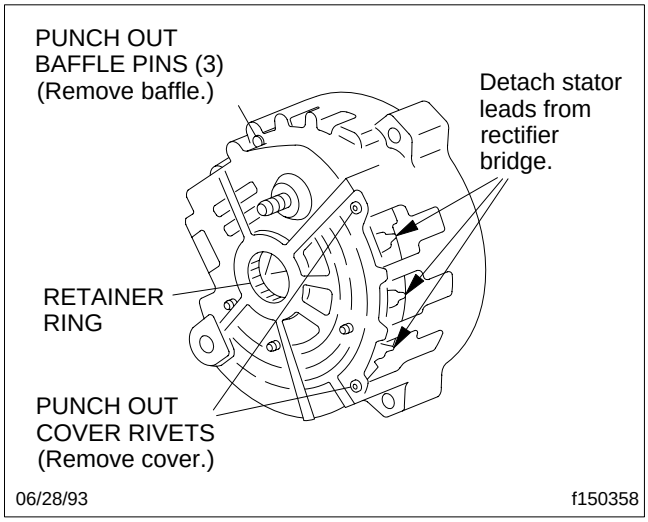


Fig. 1, Slip Ring End Frame Partially Disassembled, Bearing Removed

NOTE: If spare parts are not available, malfunctioning alternators must be replaced.

1. Remove the alternator from the vehicle. For instructions, **refer to "Removal and Installation, 100."**
2. Remove the long frame assembly bolts, and separate the drive-end frame assembly from the slip-ring end frame assembly.
3. Remove the drive-end frame from the rotor: place the rotor in a vise tightened only enough to permit removal of the shaft nut, or hold the rotor with a hex wrench in the end of the shaft when removing the nut.
4. Disassemble the slip ring end frame **(Fig. 1)** as follows:

   4.1 Punch out the cover rivets or pins and discard the cover.

   4.2 Separate the stator from the end frame assembly by cutting off the stator leads at the rectifier bridge terminals just long enough to leave adequate wire for connecting these parts if they are to be reused.

   4.3 Remove the stator.

   4.4 Punch out the baffle pins and remove the baffle.

   NOTE: To ensure correct assembly, carefully note the arrangement of parts; crimped, soldered, or welded connections; and location of mechanical fasteners. **See Fig. 2.**

   4.5 Remove the fasteners; then lift the brush holder, regulator, and rectifier bridge from the end frame.

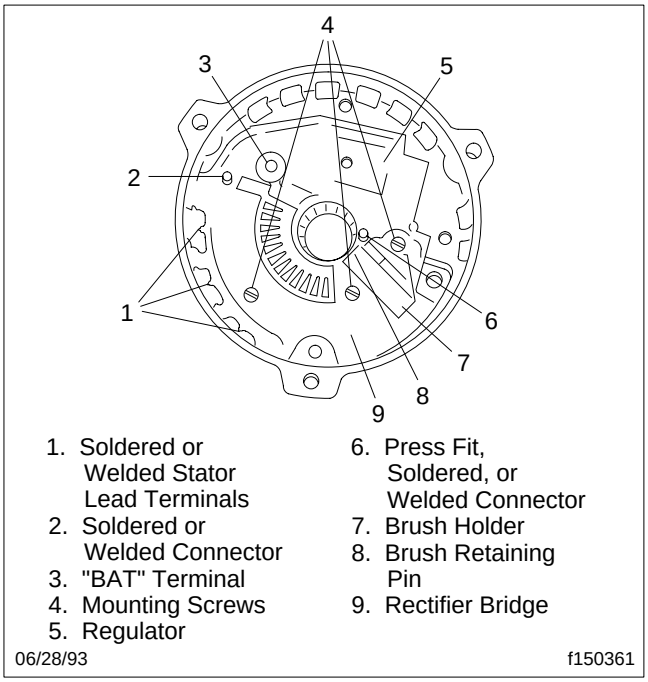


Fig. 2, View Inside the Slip Ring End Frame

   4.6 Unsolder and uncrimp the connector to disconnect the regulator from the rectifier bridge and from the brush holder.

Checking

ROTOR FIELD WINDING CHECKS

1. Connect an ohmmeter between one slip ring and the rotor. If the reading is less than one ohm, the rotor is grounded. **See Fig. 3.**
2. Check for opens by connecting the ohmmeter between the two slip rings. If the ohmmeter reading is high (infinite), the winding is open.

Disassembly, Checking, and Assembly

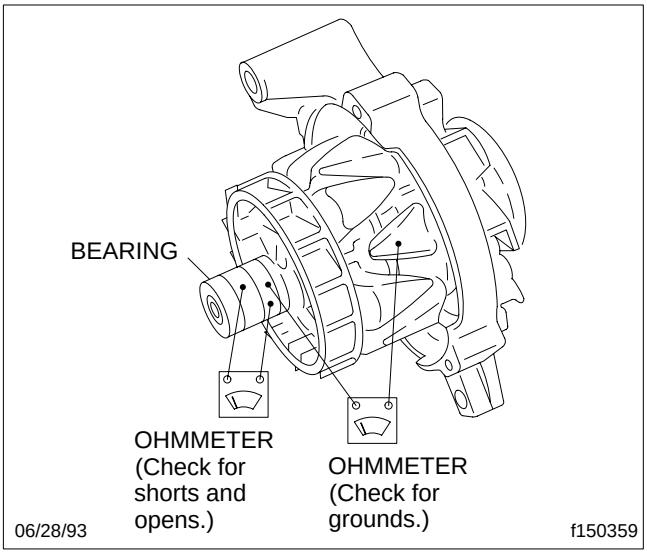


Fig. 3, Checking the Rotor

3. Check the winding for short circuits or excessive resistance by connecting a battery and ammeter in series between the two slip rings. Note the ammeter reading and refer to Delco Remy Service Bulletin 1G-188 for specifications. An ammeter reading above the specified value indicates shorted windings.

   An alternate method is to check the resistance of the field by connecting an ohmmeter between the two slip rings. If the resistance reading is below the specified value, the winding is shorted; if it is above the specified value, the winding has excessive resistance.

NOTE: The winding resistance or ammeter readings will vary slightly with winding temperature changes. If the rotor checks out okay, but the alternator fails to supply rated output, the problem is in the rectifier bridge, stator, or regulator.

STATOR CHECKS

Connect an ohmmeter between each of the stator leads and bare metal on the stator laminations. If any reading is less than 1000 ohms, the stator is grounded. **See Fig. 4.**

NOTE: An ohmmeter cannot be used to test the delta stator for shorts or opens. However, noticeable discoloration any place on the assembly usually indicates damaged stator windings.

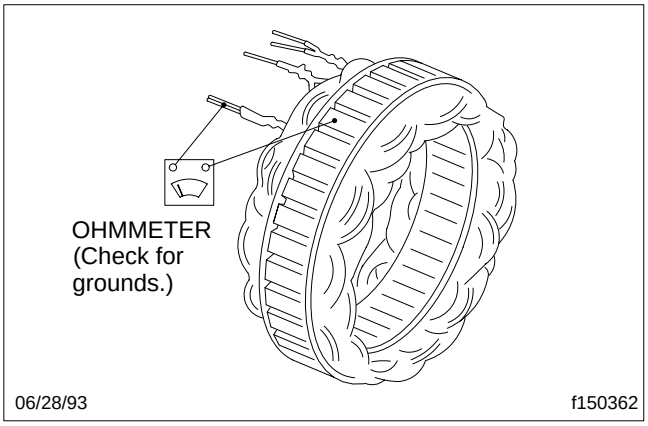


Fig. 4, Checking the Stator

RECTIFIER BRIDGE CHECK

(See Fig. 5)

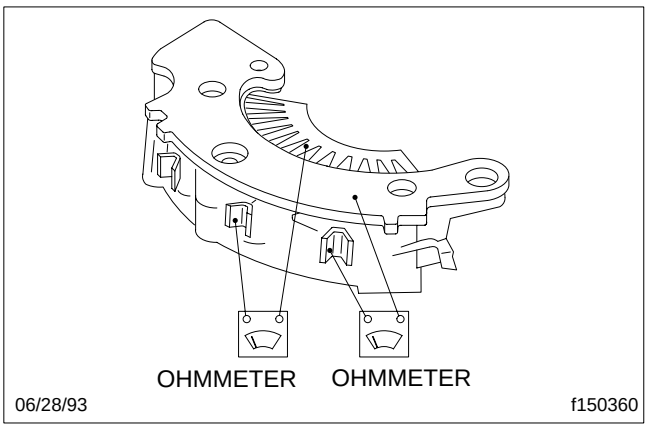


Fig. 5, Checking the Rectifier Bridge

1. To check the rectifier bridge, connect an ohmmeter (using a low scale) from the bridge terminal to the heat sink; then reverse the connections. If both readings are the same, replace the rectifier bridge.
2. Connect the ohmmeter between each of the other two terminals to the heat sink in the same manner, in order to check the other two diodes.
3. Connect the ohmmeter between each of the other three terminals and the base plate, in order to check the remaining three diodes in the rectifier bridge.

NOTE: Some digital ohmmeters cannot be used to check the diodes in the rectifier bridge. Consult the ohmmeter manufacturer's instructions to determine the ohmmeter's capabilities.

REGULATOR

The regulator cannot be checked with an ohmmeter. Use only an approved tester to test regulators of this type.

BRUSH HOLDER

If the brushes are to be re-used, clean them with a soft, dry cloth. Replace the brush holder assembly if the brushes are excessively worn.

SLIP RING SERVICING

1. If the slip rings are rough or out-of-round, turn them on a lathe to 0.05 mm (0.002 inch) maximum indicator reading. Remove only enough material to make the rings smooth and round.
2. After the slip rings are trued, or if they are only dirty, they may be cleaned and finished with 400 grain or finer polishing cloth. Spin the rotor, and hold the polishing cloth against the slip rings until they are clean. Blow away all the dust.

IMPORTANT: Turn the rotor in order to clean the slip rings evenly. Cleaning the slip rings by hand without spinning the rotor may result in flat spots on the slip rings, causing brush noise.

Assembly

1. Discard the bearing retainer ring. **See Fig. 1.**
2. Install a new ring.
3. Install a new bearing outer race; push on it until the bearing bottoms in the end frame.

NOTE: This procedure is not yet completed: See the step for installing the inner and outer races after the alternator is completely assembled.

4. Position the regulator, rectifier bridge, and brush holder on the work bench flat surface; then solder or crimp the connectors as in the original assembly. Hold the brushes in the holder with a pin.
5. To improve heat dissipation, place silicone grease 1974984 on the end frame casting under the rectifier bridge.
6. Position the assembly in the slip ring end frame; then assemble the fasteners.
7. Assemble the baffle, using a punch to drive the pins down flush with the baffle.
8. Seat the stator securely against the end frame; then solder the three stator leads to the rectifier bridge terminals.
9. Install the cover; then use a punch to drive the pins flush with the cover.
10. Push on both the inner and outer races of the slip ring end bearing to assemble the end frames together.
11. Install the long frame assembly bolts. Remove the brush holder pin.
12. With the alternator assembled, push on both the inner and outer races so the slip ring end bearing outer race is recessed 1.9 to 2.2 mm (0.07 to 0.09 inch) into the casting. **See Fig. 6.**

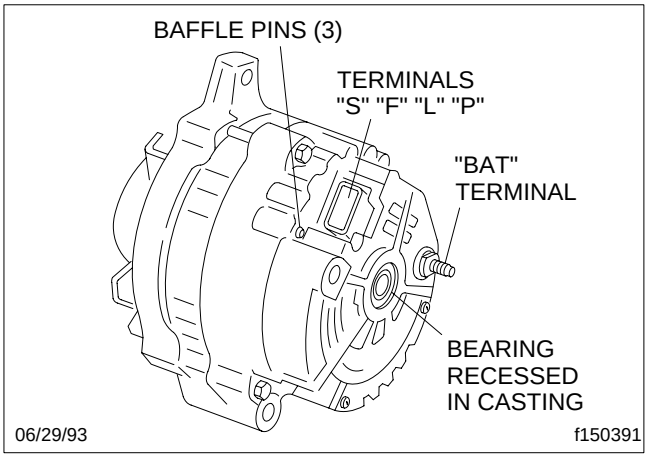


Fig. 6, Slip Ring End Bearing Assembled in the End Frame

Troubleshooting

Many alternators have been replaced that later investigation reveals were working properly. This may be due to incorrectly diagnosing the problem.

IMPORTANT: Before testing, make sure:

- All belts are correctly tightened;
- The wiring and terminals are clean and in good condition;
- All terminal nuts are torqued and properly protected.

Delco Remy has an alternator testing tool called the Intelli-Check Alternator Analyzer. See **Fig. 1**. This tool (DR 10457848, a single tester, or DR 10457865, a four-pack of testers) is to be used as a quick check of the alternator to see if it is working correctly.

NOTE: If you do not have the Delco Intelli-Check Tester, or if the alternator rated output is above 145 amps, or if a total vehicle charging system analysis is required, see "Alternator/Charging System Testing."

Intelli-Check Alternator Analyzer

The following information includes a pre-test procedure and operating instructions for the Delco Intelli-Check Tester, and is similar to the procedures provided by Delco with the Intelli-Check Tester.

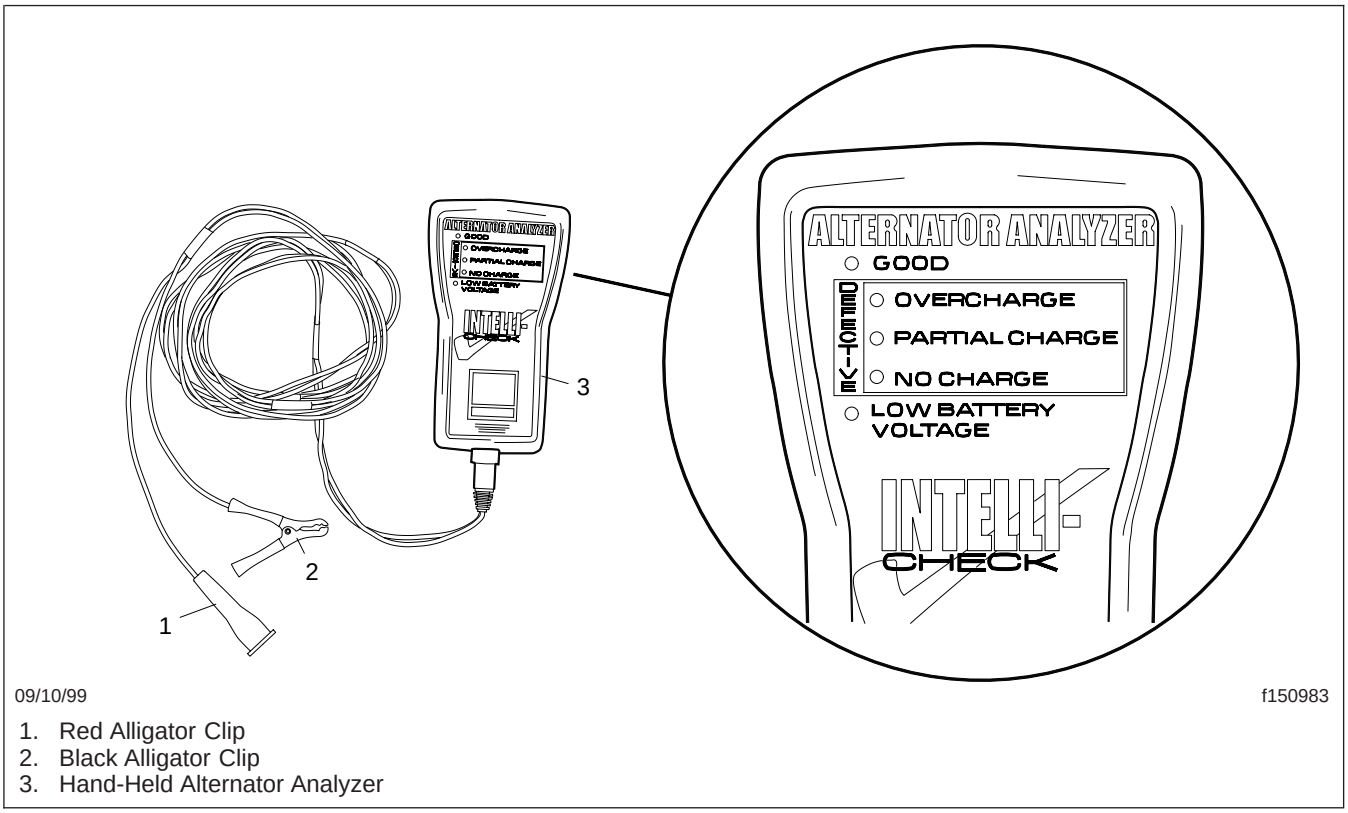
Pre-Test Procedure (Engine Off)

1. Inspect the alternator connections to verify that all terminals are secured and tight. Verify that the sense wire is connected to the sense terminal on vehicles equipped with remote-sense alternators.
2. With the engine off, connect the red alligator clip to the output terminal of the alternator. Connect the black alligator clip to the alternator ground. An optional ground connection is to the body of the alternator. The tester LEDs will illuminate and then go off as it performs a self-test.
3. After 4 seconds the tester will activate. The following LEDs may illuminate depending on the condition of the batteries:
    - **GOOD** (green) LED indicates the battery voltage is above 12.8 and has a surface charge. The surface charge must be removed before proceeding with the alternator test. To remove the surface charge, do the following:
        A. Turn on the headlights and blower motor for 2 minutes without restarting the engine.
        B. Reset the tester by disconnecting, then reconnecting the tester alligator clips. The analyzer will again perform its self-test.
        C. Repeat the applicable steps of the Pre-Test Procedure.
    - **NO CHARGE** (red) LED indicates the battery voltage is below 12.8. This LED should illuminate for most tests. Proceed with the alternator test.
    - **LOW BATTERY VOLTAGE** (blue) LED indicates the battery voltage is below 12.35. If the batteries will start the vehicle, proceed with the alternator test. However, after completing the Intelli-Check alternator test, perform the procedures under "Alternator/Charging System Testing" to determine the condition of the rest of the charging system.

Tester Operating Instructions (Engine Running)

1. Start the engine using onboard batteries only. If the batteries will not start the engine, they must be charged for 2 hours. Start the test again after charging the batteries.
2. Verify the engine is at idle and all electrical loads are off.
3. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
    - If the **GOOD** (green) LED illuminates, proceed to the next step.
    - If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
    - If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging

Troubleshooting



1. Red Alligator Clip
2. Black Alligator Clip
3. Hand-Held Alternator Analyzer

Fig. 1, Delco Remy Intelli-Check Alternator Analyzer

system using the instructions in "Alternator/Charging System Testing."

4. With the engine running, turn on all electrical loads.
5. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
6. If the **GOOD** (green) LED illuminates, the alternator is OK and the test is complete.

NOTE: If the alternator tests OK in the above tests, and the customer's complaint is reduced battery or headlight life, see "Alternator/ Charging System Testing" to completely analyze the charging system.

7. If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
8. If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing".

Alternator/Charging System Testing

Battery Open Circuit Voltage Test, Alternator Output Voltage Test and Alternator Amperage Output Test

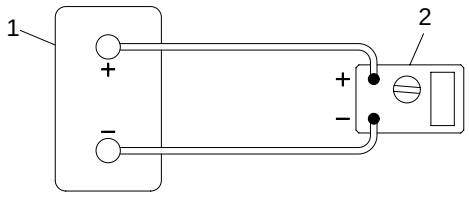
1. Use a digital volt-ohmmeter (VOM) set on the 2-20VDC (or similar) scale to test the battery open circuit voltage (OCV). With the engine shut down and the voltmeter set up as shown in **Fig. 2**, check for voltage of 12.4 volts or more.

   If the OCV is 12.4 volts or more, turn on the vehicle headlights for approximately 3 minutes.

   If the OCV is less than 12.4 volts, charge the batteries properly. For instructions, see **Group 54**.

IMPORTANT: Be sure to disconnect the batteries or remove them from the vehicle before charging.

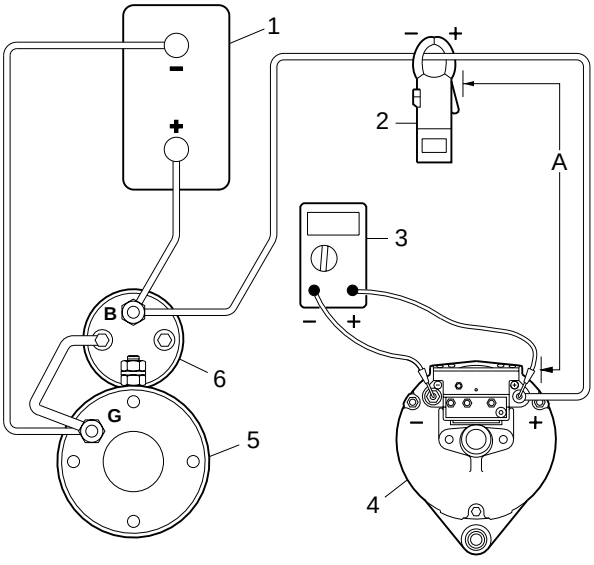
2. Check the alternator output without a load. See **Fig. 3**.



02/26/97 f150607

1. Battery
2. Digital Voltmeter

Fig. 2, Setup 1: Battery Open Circuit Voltage (and alternator amperage output)



02/11/98 f150938

A. Locate the ammeter at least 6 inches (15 cm) away from the alternator.

1. Battery
2. Ammeter
3. Digital Voltmeter
4. Alternator
5. Cranking Motor
6. Solenoid

Fig. 3, Setup 2: Alternator Output Test

2.1 Start the engine and run it at 1500 rpm for 3 to 5 minutes to stabilize the system before proceeding to the next step.

2.2 Connect the positive (+) lead of the digital voltmeter (still set on the 2-20VDC or similar scale) to the alternator (battery) terminal. Connect the negative (–) lead of the voltmeter to the alternator negative (–) ground terminal. See **Fig. 3**.

2.3 If the voltmeter reads from 13.8 to 14.2 volts, record this reading (V1) and go to the next step. If the alternator reads less than 13.8 volts and is adjustable, try to adjust the voltage regulator to 13.8 to 14.2 volts. If unable to obtain acceptable output, replace the alternator.

3. Check the alternator output under load. See **Fig. 3**.

3.1 Attach a clamp-on induction ammeter around the positive (+) wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

3.2 With the engine still running at 1500 rpm, turn on the following electrical accessories to load the alternator until the ammeter reads 60 to 75 amps.

- Both front and rear heater blowers (on HIGH)
- Headlights (high beams)
- Road lights
- Interior lights

NOTE: As an alternate method of putting load on the alternator, connect a carbon pile tester and set it to 60 to 75 amps.

3.3 Keep the voltmeter connected as in the previous step; positive (+) lead connected to the alternator positive (+) terminal; negative (–) lead connected to the alternator negative (–) terminal.

3.4 If the voltmeter reads from 13.6 to 14.2 volts, record this reading (V2) and go to the next step.

If the voltmeter reads less than 13.6 volts, replace the alternator.

4. Perform an alternator amperage output test.

4.1 Connect a carbon pile tester across the vehicle batteries as shown in **Fig. 2**.

Troubleshooting

NOTE: **Figure 2** shows a voltmeter, but the connections for the carbon pile tester are the same.

4.2 Attach a clamp-on induction ammeter around the alternator output wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

4.3 Start the engine and make sure all vehicle electrical accessories are turned off. Run it at fast speed and adjust the tester to the alternator maximum current output. Record this output value.

NOTE: Ensure that the alternator is turning at maximum available rpms and keep adjusting the tester dial until the ammeter reads its highest value.

4.4 Turn off the tester and shut down the engine.

4.5 If the output value recorded is less than 85 percent of the rated amperage output, repeat the test. If the output value recorded is still less than 85 percent of the rated amperage output, replace the alternator.

4.6 Make sure that all test instruments are removed and that the vehicle wiring is returned to its operational state.

5. To identify other problem areas within the vehicle, check the operation of the charging system. Set up the voltmeter as shown in **Fig. 2** and **Fig. 3**.

NOTE: For any load at 1500 rpm or more, battery voltage must be within 0.5 volts of the alternator voltage.

5.1 If readings at the batteries are within 0.5 volts of the readings at the alternator, the charging system is working correctly. Check other areas of the vehicle to locate the problem.

5.2 If the reading at the batteries is more than 0.5 volts lower than the reading at the alternator, do the next step.

6. Check charging system connections, cables and terminals.

6.1 Check all connections between the battery, starter and alternator for tightness and signs of corrosion. Tighten and clean as necessary.

6.2 Check all cables for breaks or partial breaks. Repair or replace as necessary.

6.3 Check each ring terminal for breakage at the point where it attaches to its wire or cable.

See **Fig. 1** for a schematic of the charging system.

Description	Size	Torque	
		lbf·in (N·cm)	lbf·ft (N·m)
Alternator Bracket Fasteners	—	—	18 (24)
Alternator Mounting Capscrews:			
Lower	M8	—	12 (16)
Upper	3/8	—	28 (38)
Alternator Output Terminal Bolt	—	72 (810)	—
Alternator Adjustment Outer Jam Nut	—	—	155 (210)
Alternator Shaft Nut	—	—	60–80 (80–110)

Table 1

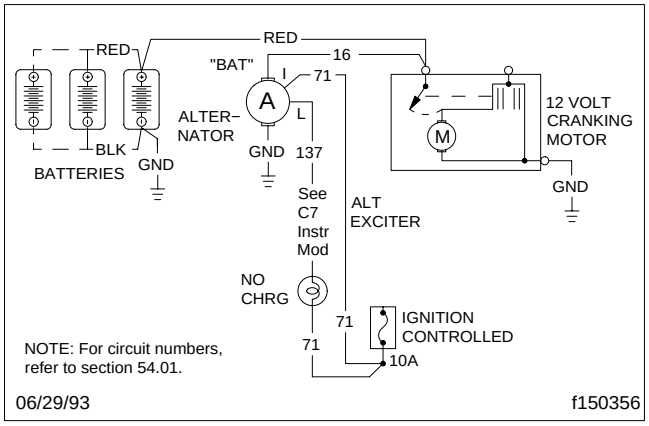


Fig. 1, Charging System

General Description

The Delco Remy 21–SI series alternator (see **Fig. 1**) features a solid-state regulator that is mounted inside the end frame. The only moving part in the assembly is the rotor, which is mounted on a ball bearing at the drive end, and a roller bearing at the rectifier end. See **Fig. 2**.

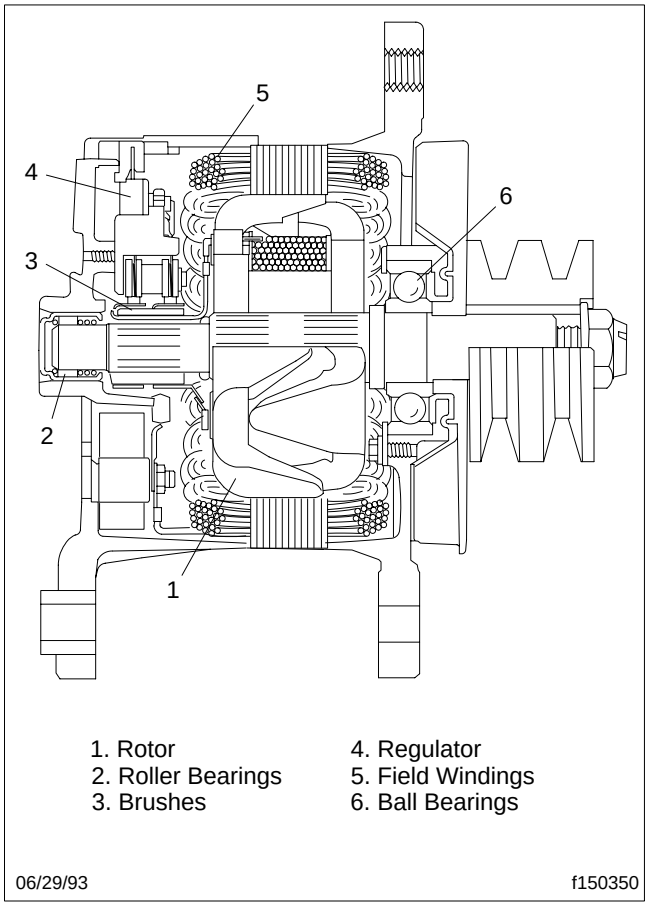


Fig. 1, 21-SI Alternator Components

All bearings are sealed so that no periodic maintenance is required. All current-carrying conductors are stationary, as are the field-winding stator components. The regulator and diodes are enclosed in a sealed compartment. A fan located on the drive end provides air flow for cooling.

Only one wire connects the alternator to the battery at the starter, along with a ground return. Since the vehicle's system is a negative ground, the output terminal connects to the starter's positive terminal.

As the rotor begins to turn, the permanent magnetism within it induces voltages in the stator windings. The voltages across the diodes cause current to flow, charging the battery.

General Description

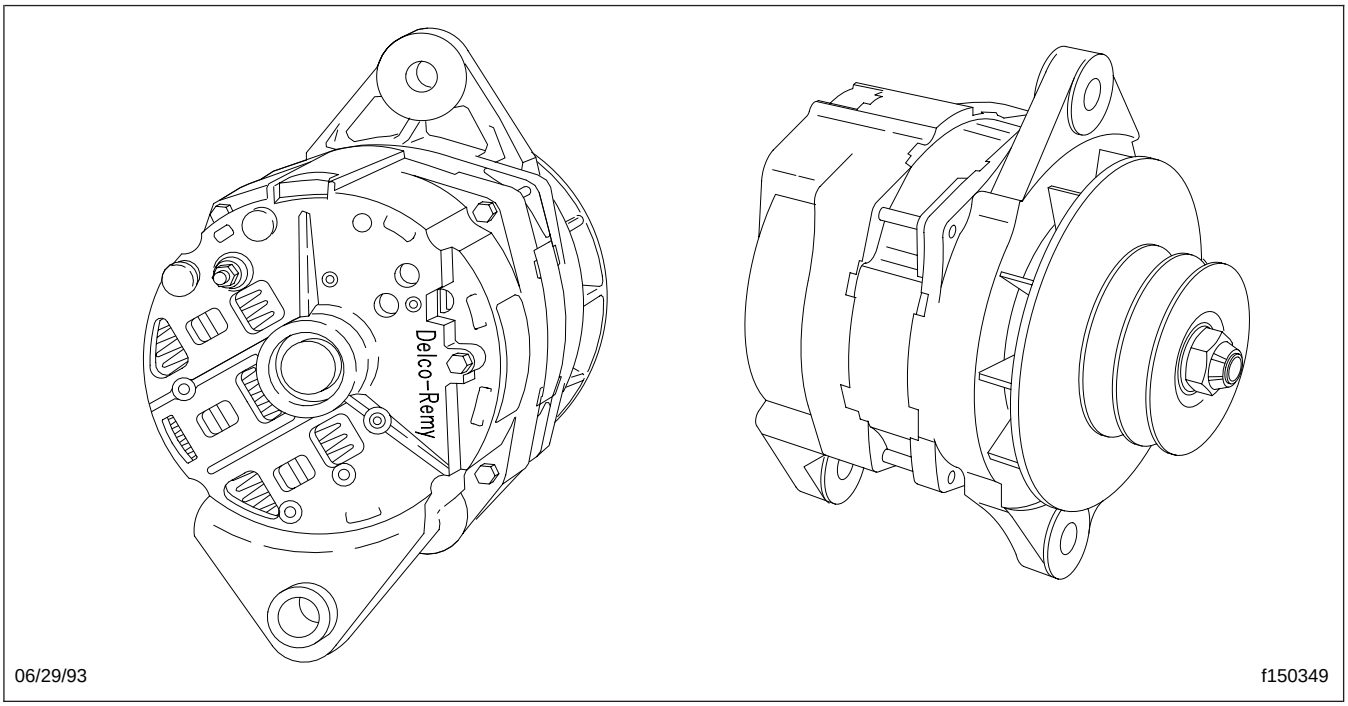


Fig. 2, Delco Remy 21-SI Alternator

Removal and Installation from Cummins B Series Engine

Removal

1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Disconnect the batteries or, if equipped, turn off the battery shutoff switch.
3. Disconnect the wires from the alternator terminals, and label them for reassembly.
4. Remove the alternator belt.
   - 4.1 Insert a 3/8-inch breaker bar in the belt tensioner **(see Fig. 1),** and rotate the tensioner up and off the belt.
   - 4.2 Holding the tensioner up, remove the belt from the alternator pulley.
   - 4.3 Slowly release the belt tensioner, and remove the breaker bar.
5. Remove the alternator. **Refer to Fig. 2.**

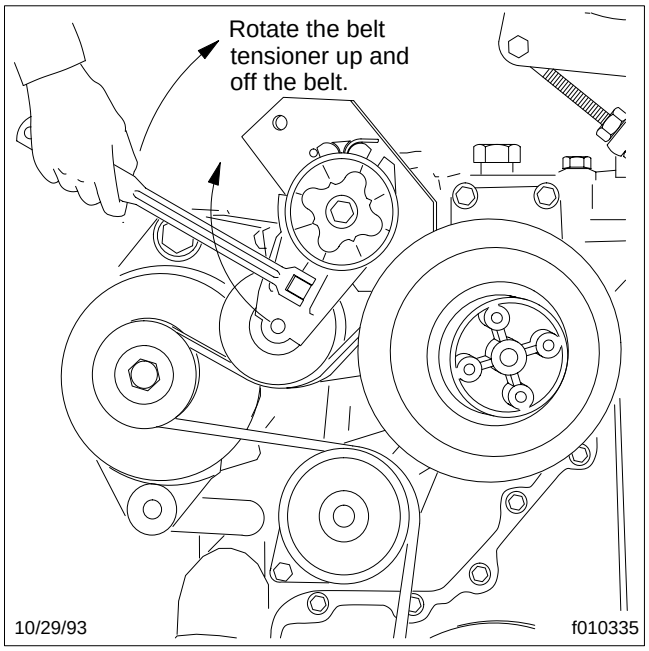


Fig. 1

   - 5.1 Remove the capscrew (Ref. 8) that secures the lower alternator mount to the link (Ref. 7).
   - 5.2 Remove the nut and washer (Refs. 5 and 4) from the pivot bolt (Ref. 1).
   - 5.3 Securely hold the alternator to prevent it from falling, and remove the pivot bolt.
   - 5.4 Remove the alternator from the vehicle.

Installation

1. Install the alternator on the alternator mount. **Refer to Fig. 2.**
   - 1.1 Position the alternator on the mount.
   - 1.2 Insert the pivot bolt (Ref. 1) through the alternator and mount.
   - 1.3 Install the washer and nut (Refs. 4 and 5) on the end of the pivot bolt.
2. Install the capscrew **(Fig. 2**, Ref. 8) to secure the lower alternator mount to the alternator link **(Fig. 2,** Ref. 7), and tighten it 21 N·m (16 lbf·ft). Tighten the nut on the end of the pivot bolt 54 N·m (40 lbf·ft).
3. Install the belt on the alternator.
   - 3.1 Insert a 3/8-inch breaker bar in the belt tensioner **(see Fig. 1),** and rotate the tensioner up while installing the belt on the alternator pulley. Make sure the belt is aligned on all pulleys.
   - 3.2 Slowly release the tensioner assembly onto the belt. The tensioner automatically tightens the belt to the correct tension.
   - 3.3 Remove the breaker bar from the tensioner.
4. Connect the wires to the alternator terminals. If the wires are not labeled, refer to the wiring diagram in **"Specifications, 400."**
5. Connect the batteries or, if equipped, turn on the battery shutoff switch.
6. Lower the hood, and remove the chocks from the tires.

Removal and Installation from Cummins B Series Engine

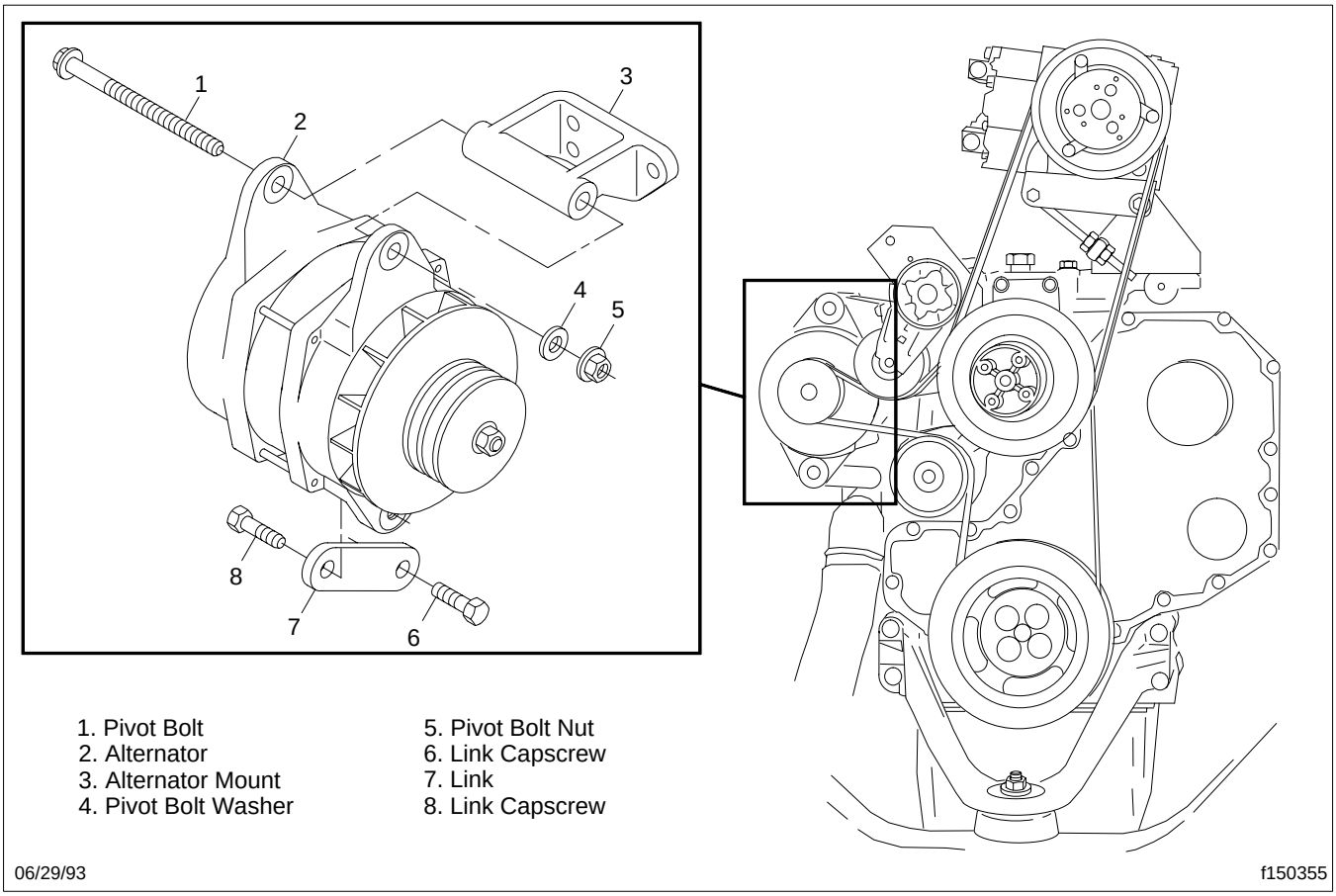


Fig. 2, Alternator Installation, Cummins B Series Engine

Removal and Installation from Mercedes-Benz OM 366LA Engine

Removal (Refer to Fig. 1)

1. Apply the parking brakes, chock the tires, and tilt the hood.

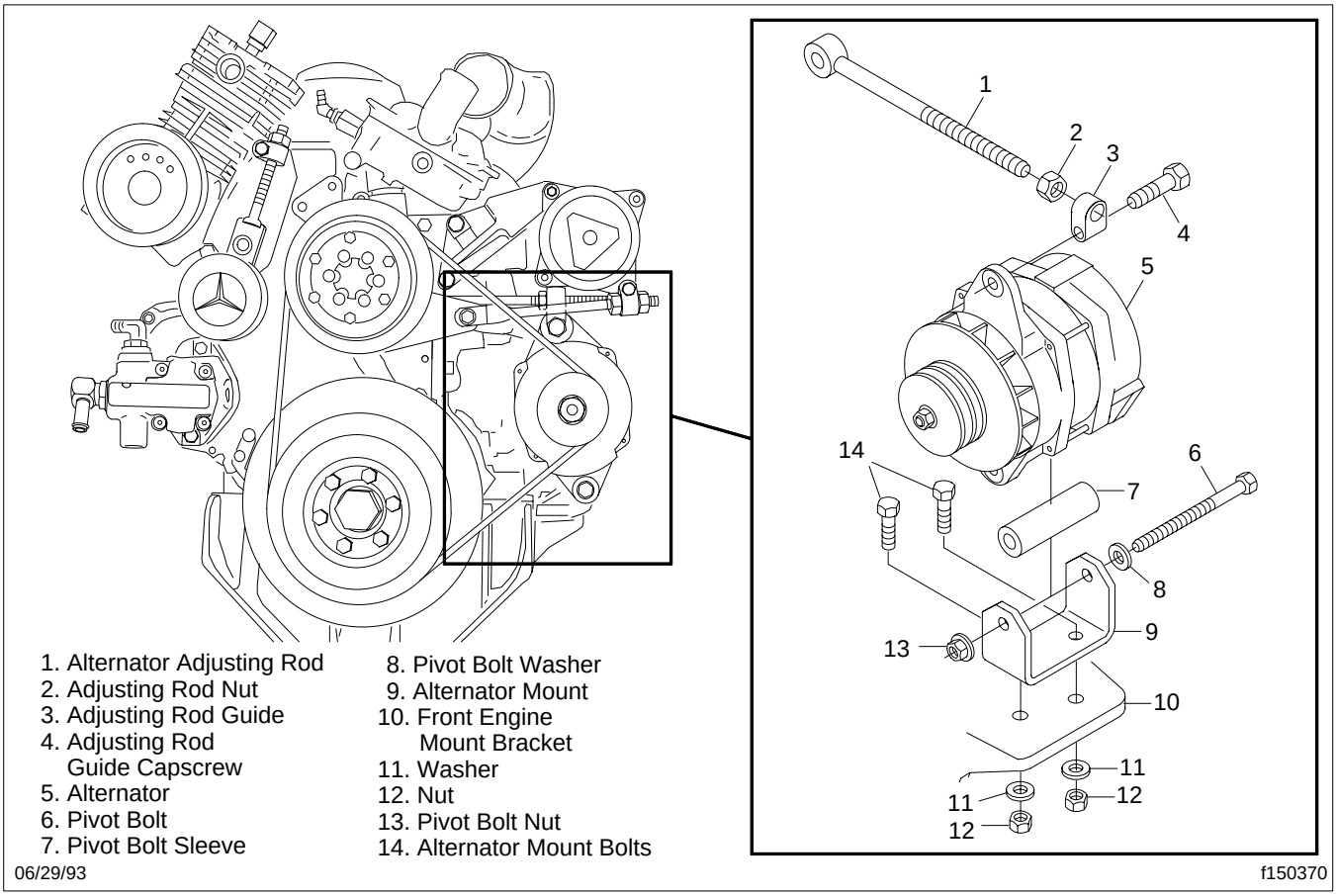


Fig. 1, Alternator Installation, Mercedes-Benz OM 366LA Engine

2. Disconnect the batteries or, if equipped, turn off the battery shutoff switch.
3. Disconnect the wires from the alternator terminals, and label them for reassembly.
4. Remove the alternator belt.
   - 4.1 Turn the adjusting rod nut (Ref. 2) clockwise to allow the adjusting rod guide (Ref. 3) to slide inward along the adjusting rod (Ref. 1).
   - 4.2 Loosen the capscrew (Ref. 4) in the adjusting rod guide.
   - 4.3 Loosen the nut (Ref. 13) on the pivot bolt (Ref. 6).
   - 4.4 Rotate the alternator inward along the adjusting rod, and remove the belt.
5. Remove the alternator.
   - 5.1 Rotate the alternator outward until the adjusting rod guide (Ref. 3) is off the adjusting rod.
   - 5.2 Remove the nut (Ref. 13) from the pivot bolt.
   - 5.3 Securely hold the alternator to prevent it from falling, and remove the pivot bolt.
   - 5.4 Remove the alternator from the vehicle.

Removal and Installation from Mercedes-Benz OM 366LA Engine

Installation (Refer to Fig. 1)

1. Install the alternator on the alternator mount (Ref. 9).
   - 1.1 Position the alternator on the mount.
   - 1.2 Hold the pivot bolt sleeve (Ref. 7) in place between the two flanges of the mount, and insert the pivot bolt (Ref. 6) through the alternator, mount, and sleeve.
   - 1.3 Install the nut (Ref. 13) on the end of the pivot bolt, and tighten the nut finger-tight.
2. Install the belt on the alternator.
   - 2.1 Rotate the alternator upward, and insert the adjusting rod (Ref. 1) through the adjusting rod guide (Ref. 3).
   - 2.2 Loop the belt on the alternator pulley, and make sure it is still aligned on the fan and vibration damper pulleys.
   - 2.3 Tighten the belt by turning the adjusting rod nut (Ref. 2) counterclockwise until the alternator rotates outward against the belt.

     Check the tension while turning the nut, use your thumb to apply about 11 kg (25 lbs) of force at the center of the longest belt free-span until the belt deflection equals one belt thickness per 305 mm (1 ft) of pulley center distance.
   - 2.4 Install a belt tension gauge at the center of the belt's longest free-span.
   - 2.5 Turn the adjusting rod nut against the adjusting rod guide to move the alternator outward until the belt tension is 75 kg (160 lbs).

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

3. Tighten the capscrew on the adjusting rod guide (Ref. 3) 81 N·m (60 lbf·ft).
4. Tighten the nut (Ref. 13) on the pivot bolt 81 N·m (60 lbf·ft).
5. Check the belt tension again, and adjust if needed.
6. If installing a new belt, operate the engine for about 20 minutes, then check the belt tension. All new belts will lose tension after 20 minutes of operation.

   If necessary, adjust the belt to 75 kg (160 lbs).
7. Connect the wires to the alternator terminals. If the wires are not labeled, refer to the wiring diagram in **"Specifications, 400".**
8. Connect the batteries or, if equipped, turn on the battery shutoff switch.
9. Lower the hood, and remove the chocks from the tires.

Troubleshooting

Many alternators have been replaced that later investigation reveals were working properly. This may be due to incorrectly diagnosing the problem.

IMPORTANT: Before testing, make sure:

- All belts are correctly tightened;
- The wiring and terminals are clean and in good condition;
- All terminal nuts are torqued and properly protected.

Delco Remy has an alternator testing tool called the Intelli-Check Alternator Analyzer. See **Fig. 1**. This tool (DR 10457848, a single tester, or DR 10457865, a four-pack of testers) is to be used as a quick check of the alternator to see if it is working correctly.

NOTE: If you do not have the Delco Intelli-Check Tester, or if the alternator rated output is above 145 amps, or if a total vehicle charging system analysis is required, see "Alternator/Charging System Testing."

Intelli-Check Alternator Analyzer

The following information includes a pre-test procedure and operating instructions for the Delco Intelli-Check Tester, and is similar to the procedures provided by Delco with the Intelli-Check Tester.

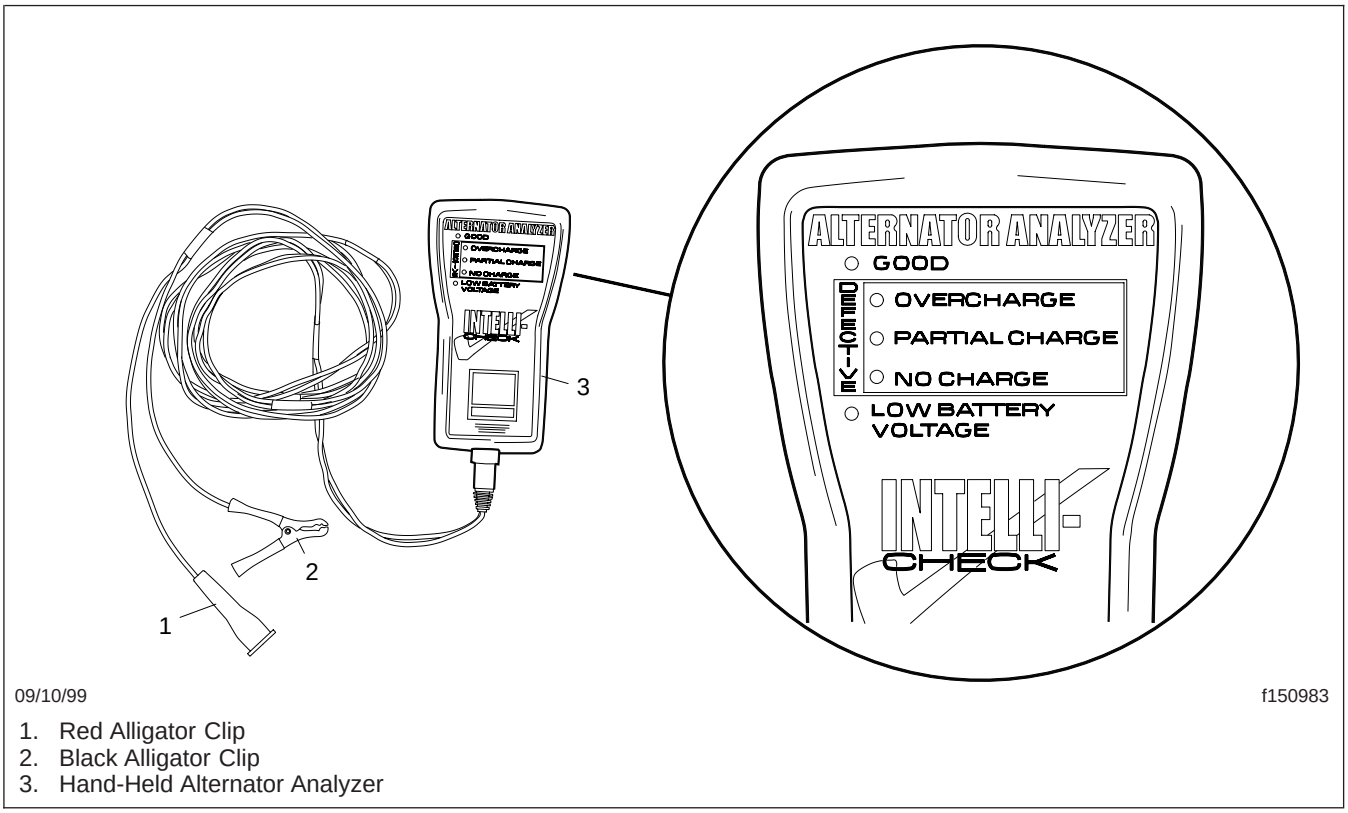
Pre-Test Procedure (Engine Off)

1. Inspect the alternator connections to verify that all terminals are secured and tight. Verify that the sense wire is connected to the sense terminal on vehicles equipped with remote-sense alternators.
2. With the engine off, connect the red alligator clip to the output terminal of the alternator. Connect the black alligator clip to the alternator ground. An optional ground connection is to the body of the alternator. The tester LEDs will illuminate and then go off as it performs a self-test.
3. After 4 seconds the tester will activate. The following LEDs may illuminate depending on the condition of the batteries:
    - **GOOD** (green) LED indicates the battery voltage is above 12.8 and has a surface charge. The surface charge must be removed before proceeding with the alternator test. To remove the surface charge, do the following:
        A. Turn on the headlights and blower motor for 2 minutes without restarting the engine.
        B. Reset the tester by disconnecting, then reconnecting the tester alligator clips. The analyzer will again perform its self-test.
        C. Repeat the applicable steps of the Pre-Test Procedure.
    - **NO CHARGE** (red) LED indicates the battery voltage is below 12.8. This LED should illuminate for most tests. Proceed with the alternator test.
    - **LOW BATTERY VOLTAGE** (blue) LED indicates the battery voltage is below 12.35. If the batteries will start the vehicle, proceed with the alternator test. However, after completing the Intelli-Check alternator test, perform the procedures under "Alternator/Charging System Testing" to determine the condition of the rest of the charging system.

Tester Operating Instructions (Engine Running)

1. Start the engine using onboard batteries only. If the batteries will not start the engine, they must be charged for 2 hours. Start the test again after charging the batteries.
2. Verify the engine is at idle and all electrical loads are off.
3. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
    - If the **GOOD** (green) LED illuminates, proceed to the next step.
    - If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
    - If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging

Troubleshooting



1. Red Alligator Clip
2. Black Alligator Clip
3. Hand-Held Alternator Analyzer

Fig. 1, Delco Remy Intelli-Check Alternator Analyzer

system using the instructions in "Alternator/Charging System Testing."

4. With the engine running, turn on all electrical loads.
5. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
6. If the **GOOD** (green) LED illuminates, the alternator is OK and the test is complete.

NOTE: If the alternator tests OK in the above tests, and the customer's complaint is reduced battery or headlight life, see "Alternator/ Charging System Testing" to completely analyze the charging system.

7. If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
8. If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing".

Alternator/Charging System Testing

Battery Open Circuit Voltage Test, Alternator Output Voltage Test and Alternator Amperage Output Test

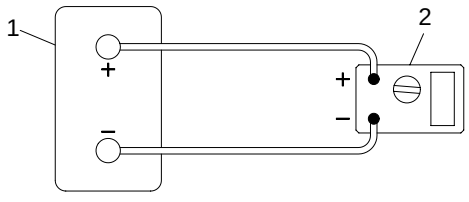
1. Use a digital volt-ohmmeter (VOM) set on the 2-20VDC (or similar) scale to test the battery open circuit voltage (OCV). With the engine shut down and the voltmeter set up as shown in **Fig. 2**, check for voltage of 12.4 volts or more.

   If the OCV is 12.4 volts or more, turn on the vehicle headlights for approximately 3 minutes.

   If the OCV is less than 12.4 volts, charge the batteries properly. For instructions, see **Group 54**.

IMPORTANT: Be sure to disconnect the batteries or remove them from the vehicle before charging.

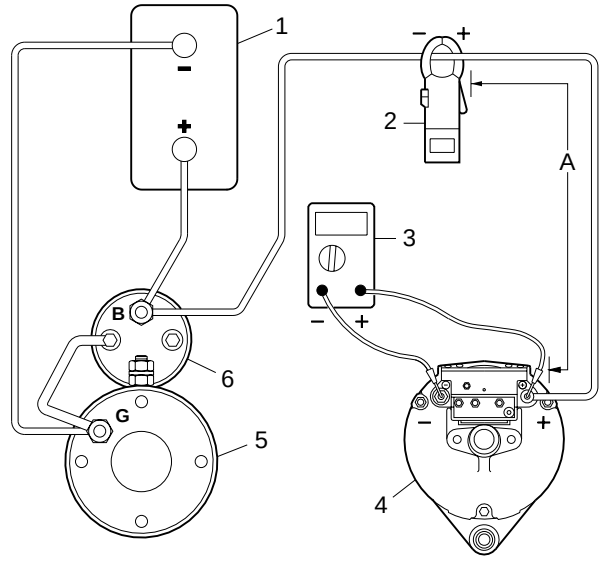
2. Check the alternator output without a load. See **Fig. 3**.



02/26/97 f150607

1. Battery
2. Digital Voltmeter

Fig. 2, Setup 1: Battery Open Circuit Voltage (and alternator amperage output)



02/11/98 f150938

A. Locate the ammeter at least 6 inches (15 cm) away from the alternator.

1. Battery
2. Ammeter
3. Digital Voltmeter
4. Alternator
5. Cranking Motor
6. Solenoid

Fig. 3, Setup 2: Alternator Output Test

2.1 Start the engine and run it at 1500 rpm for 3 to 5 minutes to stabilize the system before proceeding to the next step.

2.2 Connect the positive (+) lead of the digital voltmeter (still set on the 2-20VDC or similar scale) to the alternator (battery) terminal. Connect the negative (–) lead of the voltmeter to the alternator negative (–) ground terminal. See **Fig. 3**.

2.3 If the voltmeter reads from 13.8 to 14.2 volts, record this reading (V1) and go to the next step. If the alternator reads less than 13.8 volts and is adjustable, try to adjust the voltage regulator to 13.8 to 14.2 volts. If unable to obtain acceptable output, replace the alternator.

3. Check the alternator output under load. See **Fig. 3**.

3.1 Attach a clamp-on induction ammeter around the positive (+) wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

3.2 With the engine still running at 1500 rpm, turn on the following electrical accessories to load the alternator until the ammeter reads 60 to 75 amps.

- Both front and rear heater blowers (on HIGH)
- Headlights (high beams)
- Road lights
- Interior lights

NOTE: As an alternate method of putting load on the alternator, connect a carbon pile tester and set it to 60 to 75 amps.

3.3 Keep the voltmeter connected as in the previous step; positive (+) lead connected to the alternator positive (+) terminal; negative (–) lead connected to the alternator negative (–) terminal.

3.4 If the voltmeter reads from 13.6 to 14.2 volts, record this reading (V2) and go to the next step.

If the voltmeter reads less than 13.6 volts, replace the alternator.

4. Perform an alternator amperage output test.

4.1 Connect a carbon pile tester across the vehicle batteries as shown in **Fig. 2**.

Troubleshooting

NOTE: **Figure 2** shows a voltmeter, but the connections for the carbon pile tester are the same.

4.2 Attach a clamp-on induction ammeter around the alternator output wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

4.3 Start the engine and make sure all vehicle electrical accessories are turned off. Run it at fast speed and adjust the tester to the alternator maximum current output. Record this output value.

NOTE: Ensure that the alternator is turning at maximum available rpms and keep adjusting the tester dial until the ammeter reads its highest value.

4.4 Turn off the tester and shut down the engine.

4.5 If the output value recorded is less than 85 percent of the rated amperage output, repeat the test. If the output value recorded is still less than 85 percent of the rated amperage output, replace the alternator.

4.6 Make sure that all test instruments are removed and that the vehicle wiring is returned to its operational state.

5. To identify other problem areas within the vehicle, check the operation of the charging system. Set up the voltmeter as shown in **Fig. 2** and **Fig. 3**.

NOTE: For any load at 1500 rpm or more, battery voltage must be within 0.5 volts of the alternator voltage.

5.1 If readings at the batteries are within 0.5 volts of the readings at the alternator, the charging system is working correctly. Check other areas of the vehicle to locate the problem.

5.2 If the reading at the batteries is more than 0.5 volts lower than the reading at the alternator, do the next step.

6. Check charging system connections, cables and terminals.

6.1 Check all connections between the battery, starter and alternator for tightness and signs of corrosion. Tighten and clean as necessary.

6.2 Check all cables for breaks or partial breaks. Repair or replace as necessary.

6.3 Check each ring terminal for breakage at the point where it attaches to its wire or cable.

Specifications

This subject contains the following tables:

- Fastener Torques
- Drive Belt Tension, Mercedes-Benz OM 366LA Engine

See Fig. 1 for a Delco Remy 21-SI Alternator wiring diagram.

Fastener Torque			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Mercedes-Benz OM 366LA Engine			
Alternator Pivot Bolt Nut	8	1/2–13	60 (81)
Cummins B Series Engine			
Alternator Adjusting Rod Guide Capscrew	8	3/8–16	40 (54)
Alternator Link Capscrew	8.8	M8	16 (21)

Table 1, Fastener Torque

Description	Tension kg (lbs)
Fan/Alternator Belt	75 (160)

Table 2, Drive Belt Tension, Mercedes-Benz OM 366LA Engine

Specifications

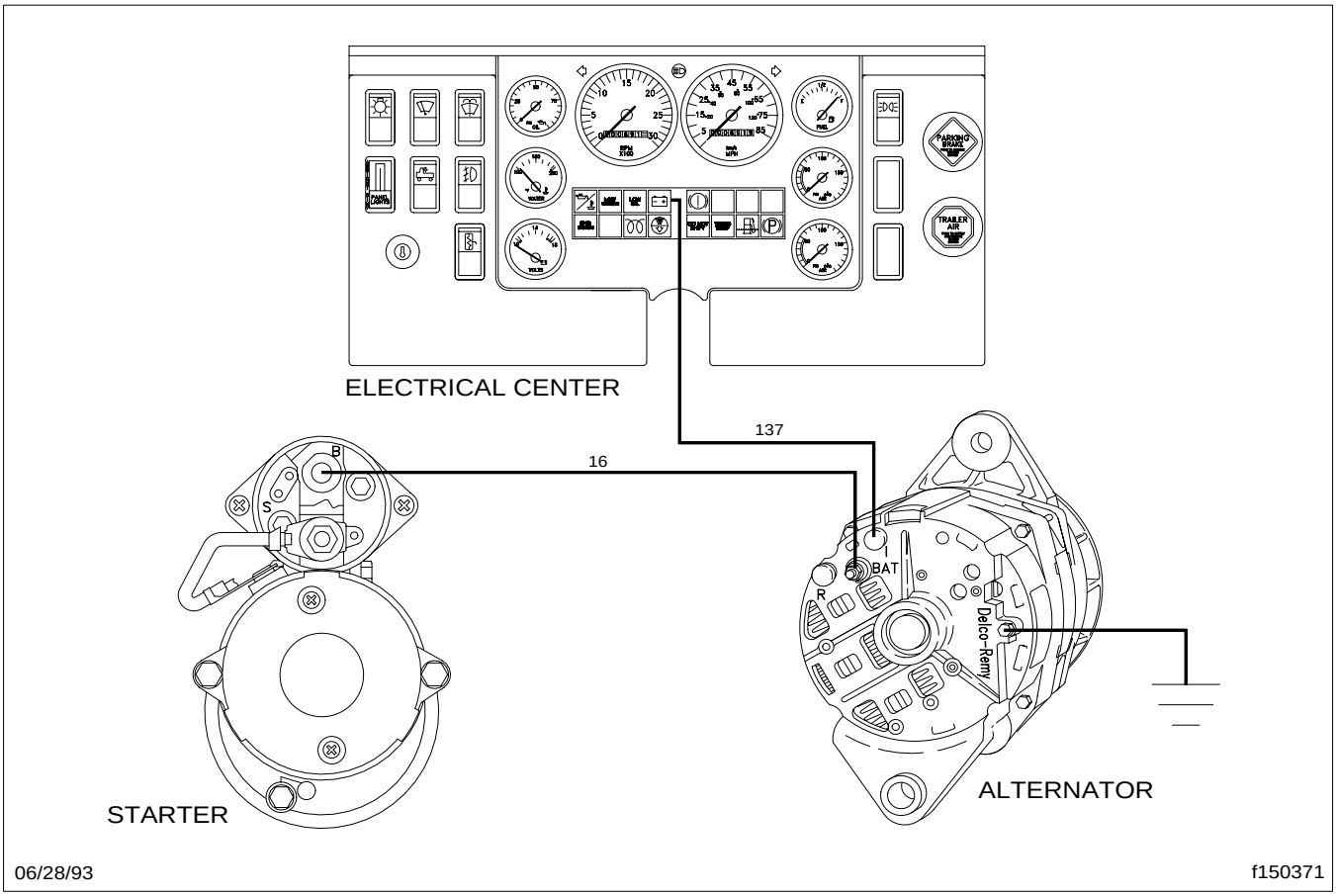


Fig. 1, Delco Remy Alternator 21-SI Wiring Diagram

General Information

The Delco Remy 28-MT starter **(Fig. 1)** mounts at the forward face of the flywheel bell housing. On Cummins B Series engines, the starter mounts on the right side of the engine. On Mercedes-Benz OM 366LA engines, it mounts on the left.

The starter assembly **(Fig. 2)** consists of two basic parts: the solenoid and the starter motor. The shift lever and wiring connect the two parts, and the lever, motor, and solenoid are completely enclosed for protection from dirt, ice, and splash. The 28-MT starter features sealed bearings with lifetime lubrication.

The solenoid is wired to the starter relay, the alternator, and the batteries. Turning the key switch to start supplies power to the starter relay, and the relay activates the solenoid. Once activated, the solenoid plunger slides forward, moving the shift lever to engage the starter drive gear with the engine flywheel ring gear, and connecting the solenoid's battery terminal to the motor terminal.

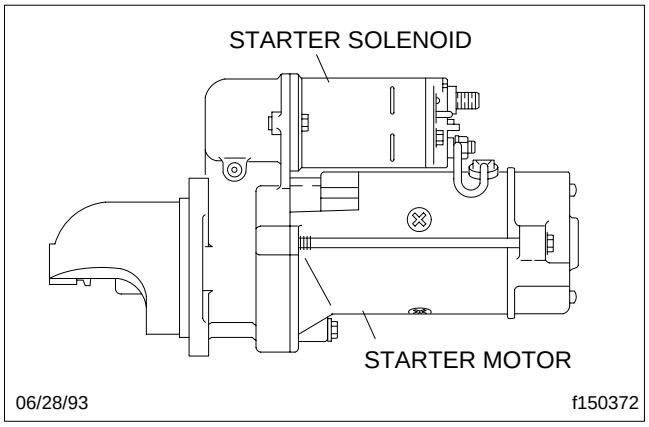


Fig. 1, Delco Remy 28-MT Starter

The motor terminal is wired to the starter motor so power from the batteries activates the starter motor after the starter drive gear engages the engine flywheel.

Once the engine starts, and the ignition stops supplying power to the starter relay, the solenoid plunger retracts, disengaging the starter motor from the engine flywheel, and cutting battery power to the starter motor.

General Information

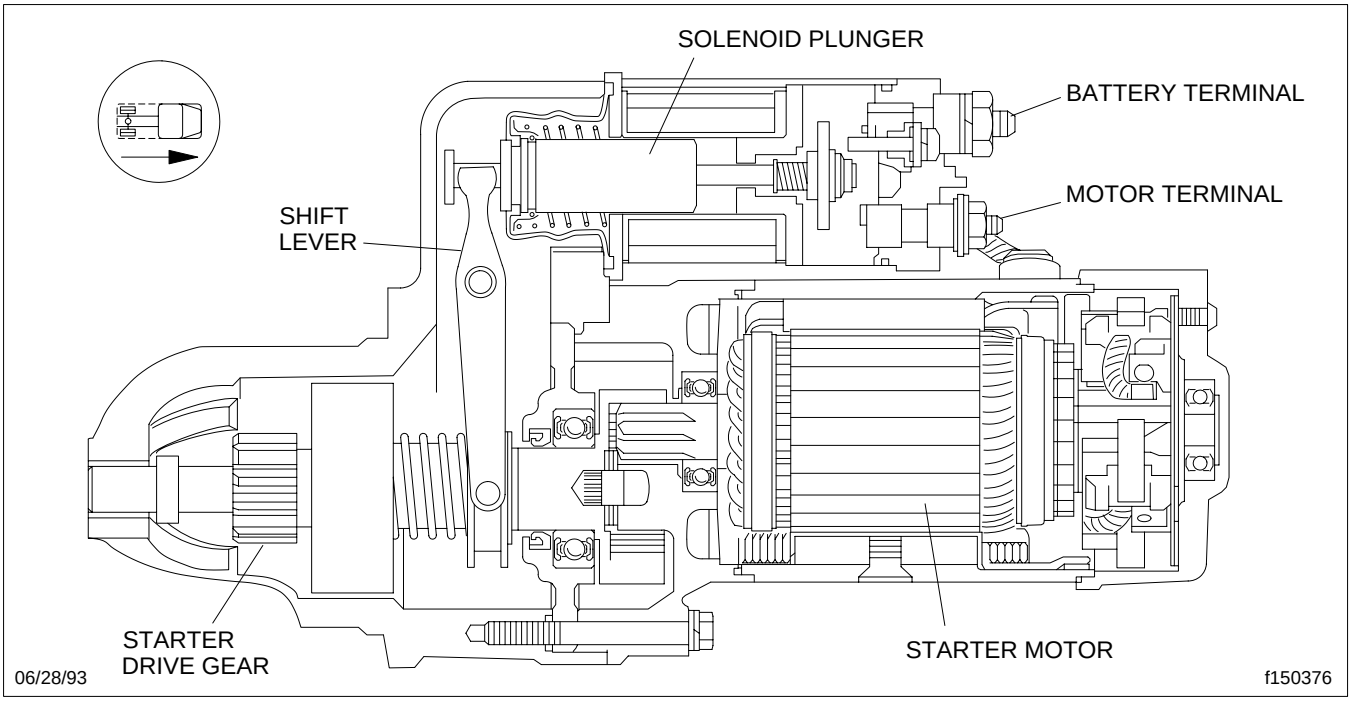


Fig. 2, Starter Components

Removal

1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Disconnect the batteries or, if equipped, turn off the battery shutoff switch.
   - 2.1 Disconnect the battery ground cable at the vehicle frame.
   - 2.2 Disconnect the positive battery cable from the batteries.
3. Disconnect the wires from the starter solenoid terminals, and label them for reassembly.
4. Remove the starter from the engine.

   On Cummins B Series engines, remove the three capscrews that secure the starter to the engine. **Refer to Fig. 1.**

   On Mercedes-Benz OM 366LA engines, remove the oil return pipe from the bottom of the turbo-charger by removing the two bolts that hold the top of the pipe and the
5. pipe clamp that holds the base. **Refer to Fig. 2.** Remove the three nuts that secure the starter to the engine.

Installation

1. Install the starter on the engine.

   On Cummins B Series engines, position the starter and secure it with the three capscrews. **Refer to Fig. 1.** Tighten the capscrews 43 N·m (32 lbf·ft).

   On Mercedes-Benz OM 366LA engines, position the starter and secure it with the three nuts. **Refer to Fig. 2.** Tighten the nuts 43 N·m (32 lbf·ft). To install the oil return pipe on the bottom of the turbocharger, tighten the bolts at the top of the pipe 40 N·m (30 lbf·ft), and tighten the clamp at the base of the pipe.
2. Connect the wires to the starter terminals. If the wires were not labeled for reassembly, refer to the starter wiring diagram in **"Specifications, 400."**
3. Connect the batteries or, if equipped, turn on the battery shutoff switch.
   - 3.1 Connect the positive battery cable to the batteries.
   - 3.2 Connect the battery ground cable to the vehicle frame.
4. Lower the hood, and remove the chocks from the tires.
5. Start the engine to test the starter.

Removal and Installation

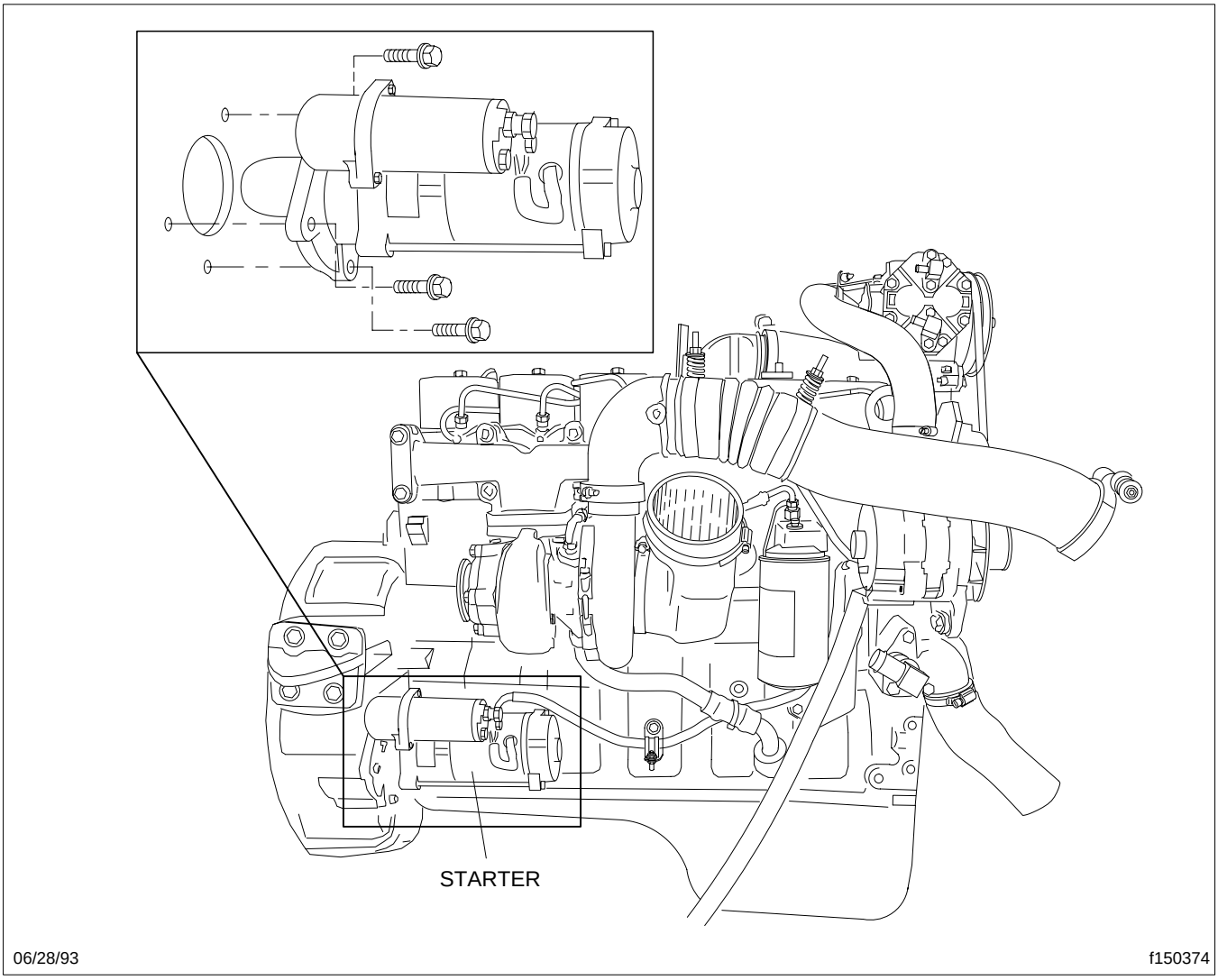


Fig. 1, Cummins B Series Engine

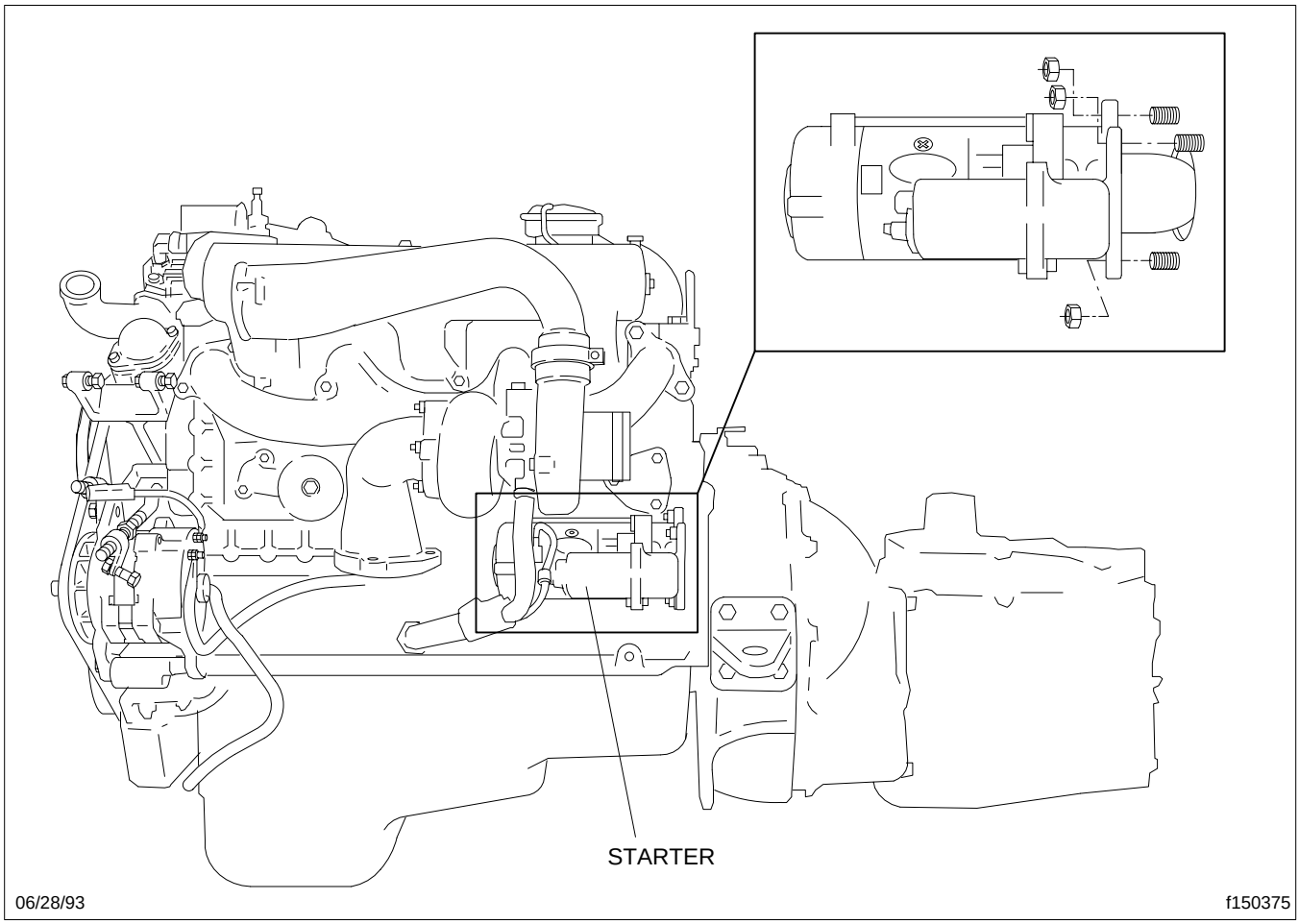


Fig. 2, Mercedes-Benz OM 366LA Engine

Specifications

This subject contains the following table:

See Fig. 1 for a starter wiring diagram.

•Fastener Torques

Description	Grade	Size	Torque N·m (lbf·ft)
Starter Mounting Capscrews, Cummins B Series Engines	8.8	M10 x 1.5	43 (32)
Starter Mounting Nuts, Mercedes-Benz OM 366LA Engine	10.9	M10 x 1.5	43 (32)
Turbocharger Oil Return Pipe Mounting Bolts	10.9	M8 x 1.25	40 (30)

Table 1, Fastener Torques

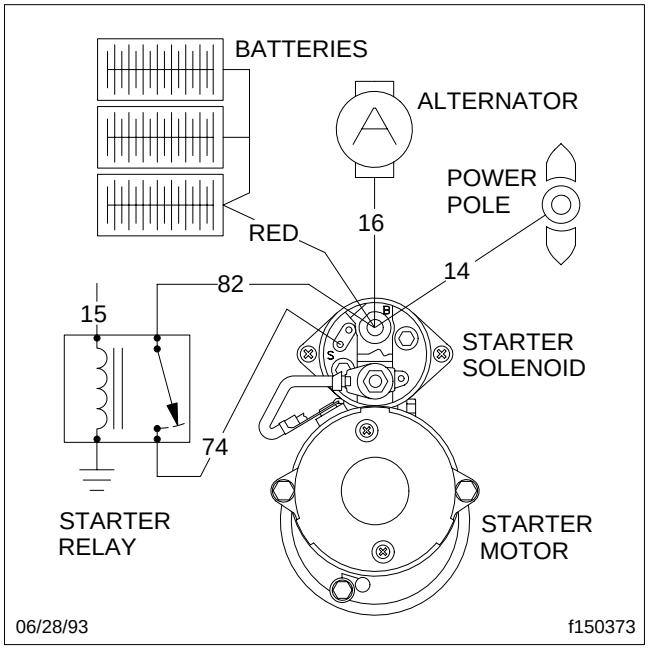


Fig. 1, Starter Wiring Diagram

General Information

The Nippondenso starter mounts on the left-hand side of the engine directly into the transmission, through a hole in the torque converter access cover.

The starter motor incorporates a planetary gear system between the electric motor and pinion gear. This feature allows the armature to rotate at a higher speed and delivers increased torque to the drive plate ring gear or flywheel. At the same time, it reduces the size and weight of the starter.

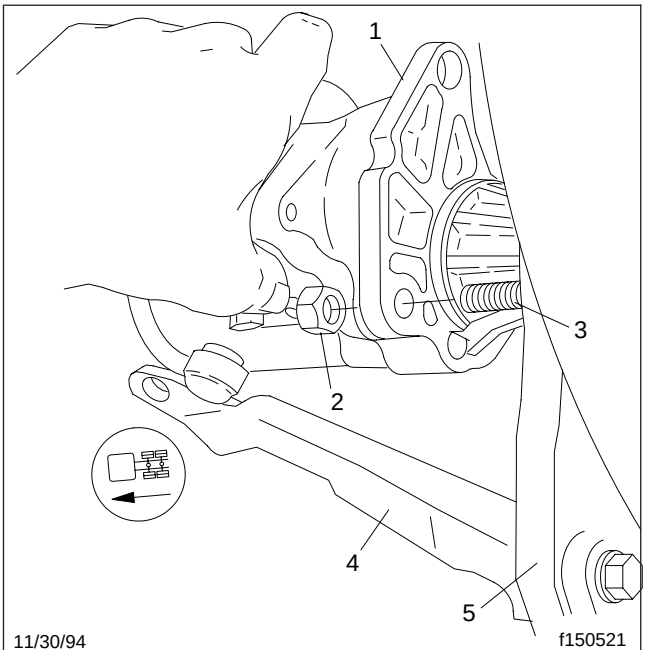
The starter motor is activated by a solenoid mounted to the overrunning clutch housing. The starter motor and solenoid are serviced as a complete unit only. If either component fails, replace the entire assembly.

Removal

1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Disconnect the batteries.
3. Raise and support the vehicle.
4. Remove the starter from the bell housing.
   - 4.1 Remove the battery cable standoff bracket. Remove the battery cable bolt and bracket. Do not remove the clamp from the battery cable.
   - 4.2 Mark and disconnect the battery and solenoid cable leads. Remove the two starter mounting bolts and the mounting stud nut.
   - 4.3 Move the starter forward until the nose of the starter gear housing clears the hole in the torque converter access cover and the mounting flange clears the mounting stud. **See Fig. 1.**

Installation

1. Install the starter. **See Fig. 1.**
   - 1.1 Attach the battery cable leads to the starter, as previously marked. Tighten the connector on the battery lead 800 to 1240 N·cm (70 to 110 lbf·in). Tighten the connector on the solenoid lead 500 to 740 N·cm (45 to 65 lbf·in).
   - 1.2 Insert the starter gear housing into the hole in the torque converter access cover. Slip the starter into place over the starter mounting stud.
   - 1.3 Install the two starter mounting bolts and tighten them 68 N·m (50 lbf·ft). Install the starter mounting nut on the stud and tighten it 27 N·m (20 lbf·ft).
   - 1.4 Install the battery cable standoff bracket.
2. Connect the batteries.
3. Lower the vehicle and remove the supports.
4. Lower the hood and remove the chocks from the tires.
5. Start the engine to test the starter.



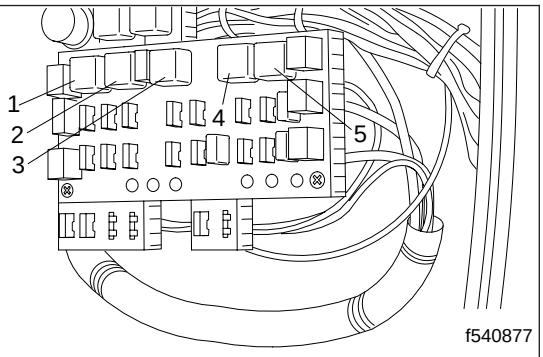
1. Starter
2. Mounting Stud Nut
3. Mounting Stud
4. Engine-to-Transmission Strut
5. Bell Housing

Fig. 1, Starter Removal and Installation

Replacement

The starter relay is located inside the Electrical Power Center (EPC). The EPC is underneath the dash panel on the passenger side.

1. Disconnect the batteries.
2. Remove the starter relay from the EPC.
   2.1 Remove the fasteners holding the EPC cover. Look for the starter relay on the top row of the EPC. For a typical installation, **see Fig. 1**. The exact location of the starter relay will vary depending on options installed.



This is a typical installation. The exact location of the starter relay will vary depending on options installed.

1. Fuel Pump Relay
2. Engine Shutdown Relay
3. Starter Relay
4. Stop Lamp Relay
5. Air Conditioning Ground Signal Relay

Fig. 1, Electrical Power Center (EPC)

   2.2 Unplug the old starter relay unit from the EPC.
3. Plug in the new starter relay. Make sure the relay is firmly seated on its mounting plate and that the electrical connections behind the panel are tight.
4. Replace the EPC cover and install the fasteners.
5. Connect the batteries.
6. Start the engine to test the starter relay.

Specifications

Description	Torque N·m (lbf·ft)	Torque N·cm (lbf·in)
Starter Mounting Bolts	68 (50)	—
Starter Mounting Nut	27 (20)	—
Starter Battery Lead Connector	—	800–1240 (70–110)
Starter Solenoid Lead Connector	—	500–740 (45–65)

Table 1, Fastener Torques

General Information

The Nippondenso alternator is driven by the engine through the serpentine accessory drive belt. It mounts directly onto the engine, on the right-hand side.

The alternator is serviced as a complete unit only. If the alternator fails for any reason, replace the entire unit.

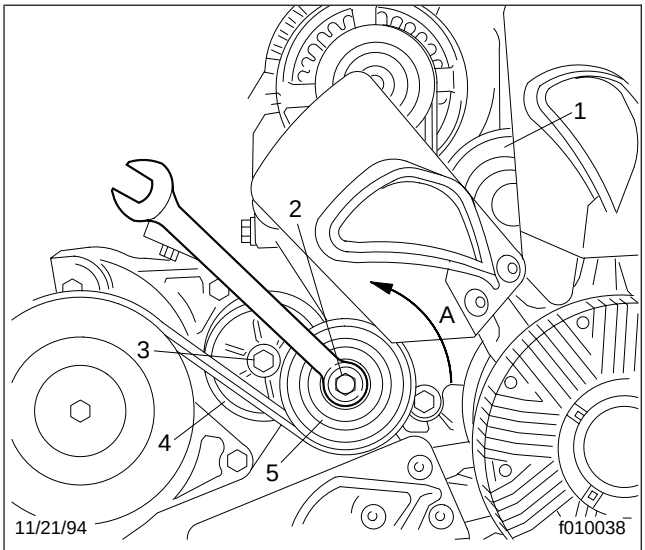
Removal

1. Apply the parking brakes, chock the tires, and tilt the hood.

⚠ WARNING

WARNING: Disconnect the negative cable from the batteries before removing the battery output wire from the alternator. Failure to do so could cause personal injury.

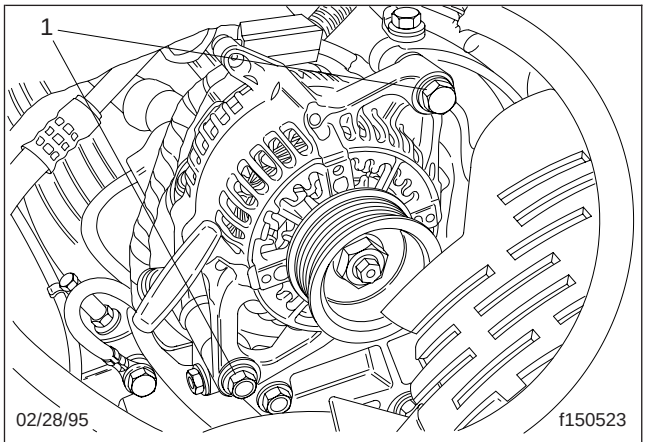
2. Disconnect the batteries.
3. Remove the engine accessory drive belt.
   - 3.1 Place a 5/8-inch wrench over the pulley bolt on the automatic belt tensioner, and turn the wrench counterclockwise to relax the belt tensioner. **See Fig. 1.**



A. Turn counterclockwise to remove the belt.
1. Idler Pulley
2. Tensioner Pulley Bolt
3. Tensioner Mounting Bolt
4. Belt Tensioner
5. Tensioner Pulley

Fig. 1, Relaxing the Belt Tension

   - 3.2 When the belt tension is fully relaxed, remove the engine accessory drive belt. Remove the belt first from the belt tensioner, then from the other pulleys.
4. Remove the alternator from the vehicle.
   - 4.1 Remove the alternator mounting bolts. **See Fig. 2.**



1. Alternator Mounting Bolts

Fig. 2, Alternator Mounting Bolts

   - 4.2 From the rear (rectifier) end of the alternator, remove the nuts from the battery (positive) terminal, ground (negative) terminal, the wire harness hold-down, and the two field terminals. **See Fig. 3.**
   - 4.3 Remove the alternator.

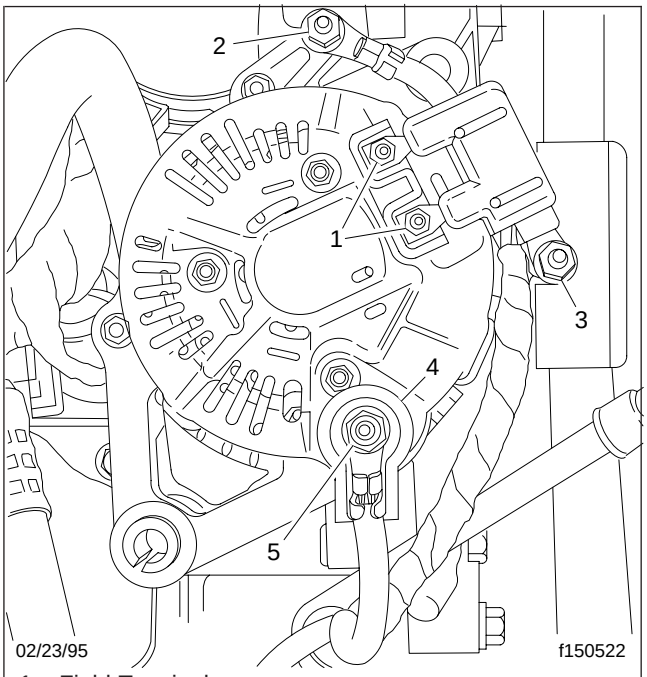
Installation

1. Install the alternator.
   - 1.1 Attach the alternator electrical connectors to the alternator. Tighten the nuts on the field terminals 280 N·cm (25 lbf·in). Tighten all the other nuts 840 N·cm (75 lbf·in). **See Fig. 3.**
   - 1.2 Install the alternator mounting bolts. Tighten each one 41 N·m (30 lbf·ft).
2. Install the engine accessory drive belt.

⚠ CAUTION

CAUTION: When installing the serpentine accessory drive belt, route the belt correctly. If the belt is not routed correctly, the water pump pulley may rotate in the wrong direction, allowing the engine to overheat.

Removal and Installation



1. Field Terminals
2. Ground (–) Terminal
3. Wire Harness Hold-Down
4. Battery Terminal Insulator
5. Battery (B+) Terminal

Fig. 3, Alternator Electrical Connectors

NOTE: If the pulley must be removed from the automatic belt tensioner, note that the pulley bolt has left-hand threads.

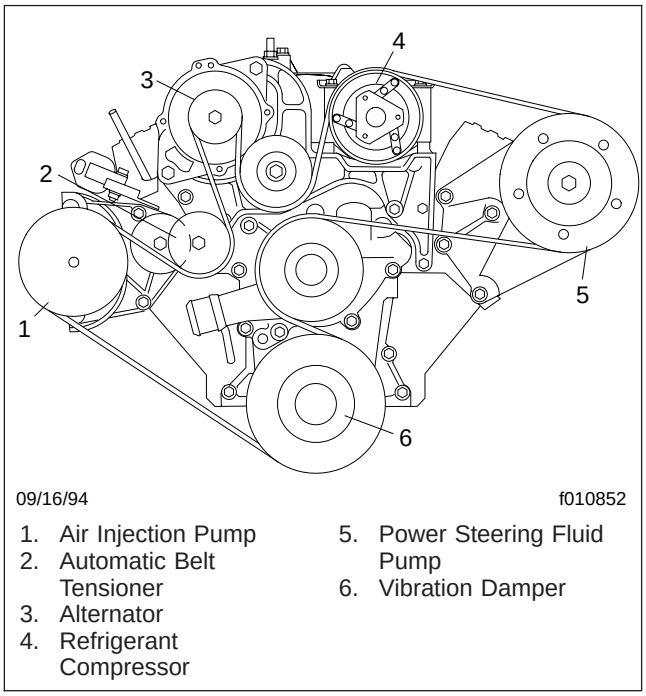
2.1 Position the drive belt over all the pulleys *except the drive belt tensioner*. For the correct belt routing, **see Fig. 4** or **Fig. 5**.

2.2 Place a 5/8-inch wrench over the pulley bolt on the automatic belt tensioner, and turn the wrench counterclockwise to relax the belt tensioner. **See Fig. 1.**

⚠ CAUTION

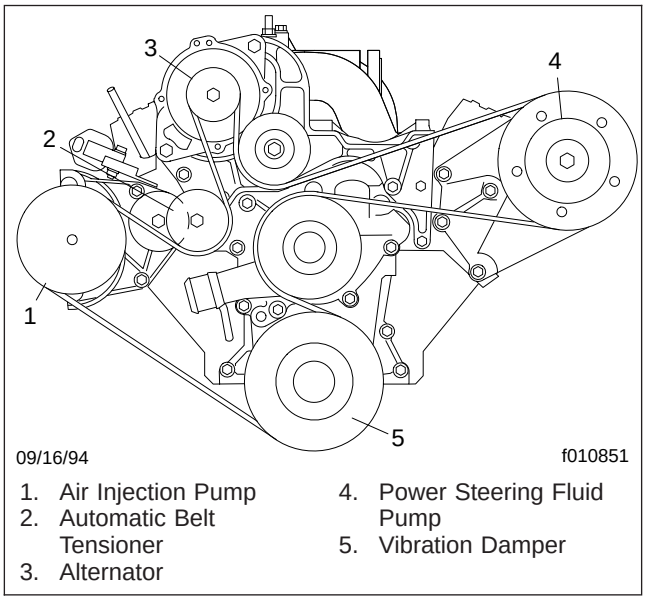
CAUTION: Never use a screwdriver to force the belt over a pulley rim. This can damage the synthetic fiber of the belt.

2.3 When the belt tension is fully relaxed, install the belt over the tensioner pulley. Allow the tensioner to move the belt back into place.



1. Air Injection Pump
2. Automatic Belt Tensioner
3. Alternator
4. Refrigerant Compressor
5. Power Steering Fluid Pump
6. Vibration Damper

Fig. 4, Drive Belt Routing (with a Refrigerant Compressor)



1. Air Injection Pump
2. Automatic Belt Tensioner
3. Alternator
4. Power Steering Fluid Pump
5. Vibration Damper

Fig. 5, Drive Belt Routing (without a Refrigerant Compressor)

2.4 Remove the wrench and be sure the belt is correctly seated on each pulley.

3. Connect the batteries.
4. Lower the hood and remove the chocks from the tires.

Troubleshooting

Many alternators have been replaced that later investigation reveals were working properly. This may be due to incorrectly diagnosing the problem.

IMPORTANT: Before testing, make sure:

- All belts are correctly tightened;
- The wiring and terminals are clean and in good condition;
- All terminal nuts are torqued and properly protected.

Delco Remy has an alternator testing tool called the Intelli-Check Alternator Analyzer. See **Fig. 1**. This tool (DR 10457848, a single tester, or DR 10457865, a four-pack of testers) is to be used as a quick check of the alternator to see if it is working correctly.

NOTE: If you do not have the Delco Intelli-Check Tester, or if the alternator rated output is above 145 amps, or if a total vehicle charging system analysis is required, see "Alternator/Charging System Testing."

Intelli-Check Alternator Analyzer

The following information includes a pre-test procedure and operating instructions for the Delco Intelli-Check Tester, and is similar to the procedures provided by Delco with the Intelli-Check Tester.

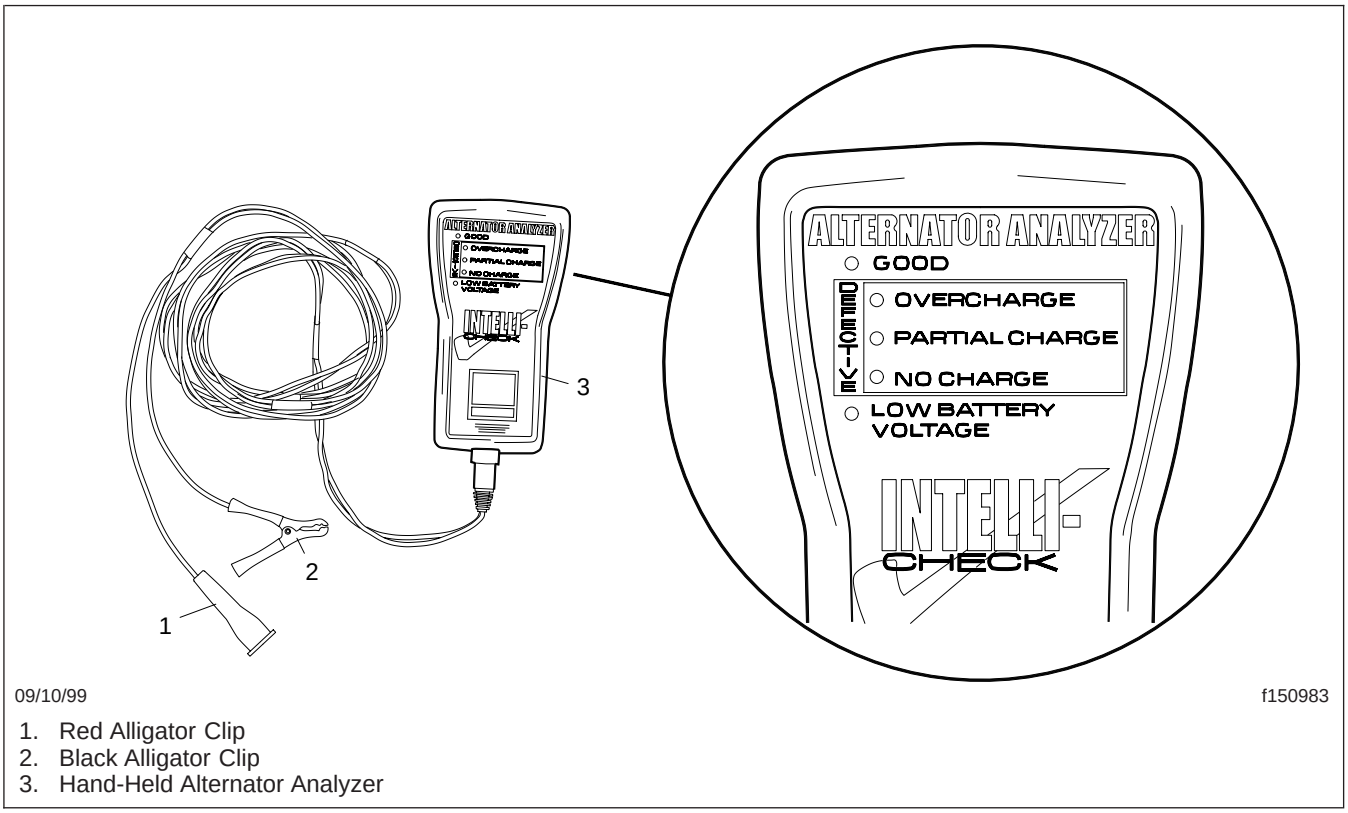
Pre-Test Procedure (Engine Off)

1. Inspect the alternator connections to verify that all terminals are secured and tight. Verify that the sense wire is connected to the sense terminal on vehicles equipped with remote-sense alternators.
2. With the engine off, connect the red alligator clip to the output terminal of the alternator. Connect the black alligator clip to the alternator ground. An optional ground connection is to the body of the alternator. The tester LEDs will illuminate and then go off as it performs a self-test.
3. After 4 seconds the tester will activate. The following LEDs may illuminate depending on the condition of the batteries:
    - **GOOD** (green) LED indicates the battery voltage is above 12.8 and has a surface charge. The surface charge must be removed before proceeding with the alternator test. To remove the surface charge, do the following:
        A. Turn on the headlights and blower motor for 2 minutes without restarting the engine.
        B. Reset the tester by disconnecting, then reconnecting the tester alligator clips. The analyzer will again perform its self-test.
        C. Repeat the applicable steps of the Pre-Test Procedure.
    - **NO CHARGE** (red) LED indicates the battery voltage is below 12.8. This LED should illuminate for most tests. Proceed with the alternator test.
    - **LOW BATTERY VOLTAGE** (blue) LED indicates the battery voltage is below 12.35. If the batteries will start the vehicle, proceed with the alternator test. However, after completing the Intelli-Check alternator test, perform the procedures under "Alternator/Charging System Testing" to determine the condition of the rest of the charging system.

Tester Operating Instructions (Engine Running)

1. Start the engine using onboard batteries only. If the batteries will not start the engine, they must be charged for 2 hours. Start the test again after charging the batteries.
2. Verify the engine is at idle and all electrical loads are off.
3. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
    - If the **GOOD** (green) LED illuminates, proceed to the next step.
    - If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
    - If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging

Troubleshooting



1. Red Alligator Clip
2. Black Alligator Clip
3. Hand-Held Alternator Analyzer

Fig. 1, Delco Remy Intelli-Check Alternator Analyzer

system using the instructions in "Alternator/Charging System Testing."

4. With the engine running, turn on all electrical loads.
5. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
6. If the **GOOD** (green) LED illuminates, the alternator is OK and the test is complete.

NOTE: If the alternator tests OK in the above tests, and the customer's complaint is reduced battery or headlight life, see "Alternator/ Charging System Testing" to completely analyze the charging system.

7. If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
8. If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing".

Alternator/Charging System Testing

Battery Open Circuit Voltage Test, Alternator Output Voltage Test and Alternator Amperage Output Test

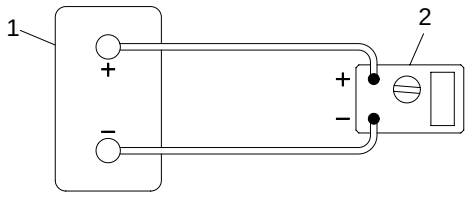
1. Use a digital volt-ohmmeter (VOM) set on the 2-20VDC (or similar) scale to test the battery open circuit voltage (OCV). With the engine shut down and the voltmeter set up as shown in **Fig. 2**, check for voltage of 12.4 volts or more.

   If the OCV is 12.4 volts or more, turn on the vehicle headlights for approximately 3 minutes.

   If the OCV is less than 12.4 volts, charge the batteries properly. For instructions, see **Group 54**.

IMPORTANT: Be sure to disconnect the batteries or remove them from the vehicle before charging.

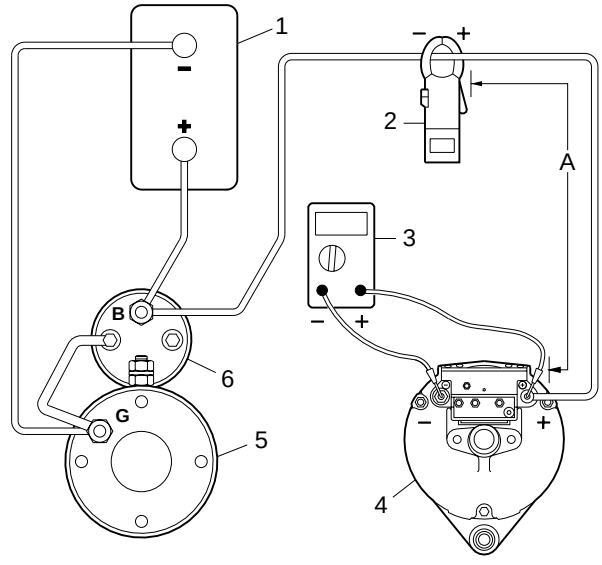
2. Check the alternator output without a load. See **Fig. 3**.



02/26/97 f150607

1. Battery
2. Digital Voltmeter

Fig. 2, Setup 1: Battery Open Circuit Voltage (and alternator amperage output)



02/11/98 f150938

A. Locate the ammeter at least 6 inches (15 cm) away from the alternator.

1. Battery
2. Ammeter
3. Digital Voltmeter
4. Alternator
5. Cranking Motor
6. Solenoid

Fig. 3, Setup 2: Alternator Output Test

2.1 Start the engine and run it at 1500 rpm for 3 to 5 minutes to stabilize the system before proceeding to the next step.

2.2 Connect the positive (+) lead of the digital voltmeter (still set on the 2-20VDC or similar scale) to the alternator (battery) terminal. Connect the negative (–) lead of the voltmeter to the alternator negative (–) ground terminal. See **Fig. 3**.

2.3 If the voltmeter reads from 13.8 to 14.2 volts, record this reading (V1) and go to the next step. If the alternator reads less than 13.8 volts and is adjustable, try to adjust the voltage regulator to 13.8 to 14.2 volts. If unable to obtain acceptable output, replace the alternator.

3. Check the alternator output under load. See **Fig. 3**.

3.1 Attach a clamp-on induction ammeter around the positive (+) wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

3.2 With the engine still running at 1500 rpm, turn on the following electrical accessories to load the alternator until the ammeter reads 60 to 75 amps.

- Both front and rear heater blowers (on HIGH)
- Headlights (high beams)
- Road lights
- Interior lights

NOTE: As an alternate method of putting load on the alternator, connect a carbon pile tester and set it to 60 to 75 amps.

3.3 Keep the voltmeter connected as in the previous step; positive (+) lead connected to the alternator positive (+) terminal; negative (–) lead connected to the alternator negative (–) terminal.

3.4 If the voltmeter reads from 13.6 to 14.2 volts, record this reading (V2) and go to the next step.

If the voltmeter reads less than 13.6 volts, replace the alternator.

4. Perform an alternator amperage output test.

4.1 Connect a carbon pile tester across the vehicle batteries as shown in **Fig. 2**.

Troubleshooting

NOTE: **Figure 2** shows a voltmeter, but the connections for the carbon pile tester are the same.

4.2 Attach a clamp-on induction ammeter around the alternator output wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

4.3 Start the engine and make sure all vehicle electrical accessories are turned off. Run it at fast speed and adjust the tester to the alternator maximum current output. Record this output value.

NOTE: Ensure that the alternator is turning at maximum available rpms and keep adjusting the tester dial until the ammeter reads its highest value.

4.4 Turn off the tester and shut down the engine.

4.5 If the output value recorded is less than 85 percent of the rated amperage output, repeat the test. If the output value recorded is still less than 85 percent of the rated amperage output, replace the alternator.

4.6 Make sure that all test instruments are removed and that the vehicle wiring is returned to its operational state.

5. To identify other problem areas within the vehicle, check the operation of the charging system. Set up the voltmeter as shown in **Fig. 2** and **Fig. 3**.

NOTE: For any load at 1500 rpm or more, battery voltage must be within 0.5 volts of the alternator voltage.

5.1 If readings at the batteries are within 0.5 volts of the readings at the alternator, the charging system is working correctly. Check other areas of the vehicle to locate the problem.

5.2 If the reading at the batteries is more than 0.5 volts lower than the reading at the alternator, do the next step.

6. Check charging system connections, cables and terminals.

6.1 Check all connections between the battery, starter and alternator for tightness and signs of corrosion. Tighten and clean as necessary.

6.2 Check all cables for breaks or partial breaks. Repair or replace as necessary.

6.3 Check each ring terminal for breakage at the point where it attaches to its wire or cable.

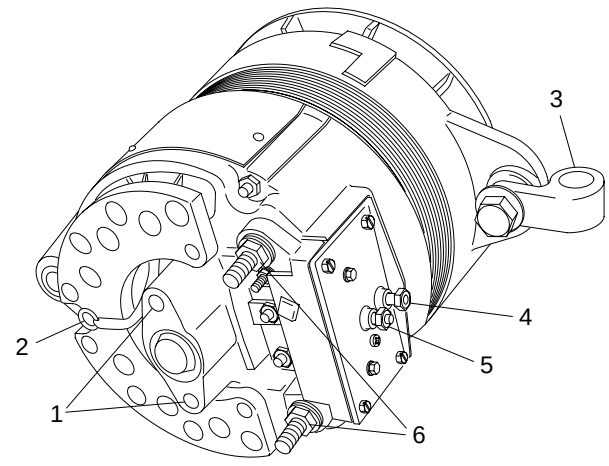
Specifications

Description	Torque N·m (lbf·ft)	Torque N·cm (lbf·in)
Alternator Mounting Bolts	41 (30)	—
Battery Terminal Nut	—	840 (75)
Ground Terminal Nut	—	840 (75)
Harness Hold-Down Nut	—	840 (75)
Field Terminal Nuts	—	280 (25)

Table 1, Fastener Torques

General Information

The Lestek alternator is an electromechanical device that converts mechanical force from the engine crankshaft or accessory drive, into pulsed DC electrical energy. See **Fig. 1**. A multi-poled magnet, referred to as a rotor, is spun inside a multiphased coil called a stator, that induces AC current flow in the stator coils. This AC current is then rectified using positive and negative diodes, producing a pulsed DC output which can then be used to drive electrical devices, motors, lights, etc., and charge the system batteries.



06/02/98 f150952

1. Optional Negative Ground
2. Negative Ground
3. End Link
4. Field to Regulator
5. Ground to Regulator
6. Positive Terminals

Fig. 1, Lestek Brute 190 (and 200) Alternator

The Lestek Brute 190 alternator is rated for 150 amps at engine idle and the Lestek Brute 200 is rated at 140 at engine idle. They contain a patented hand-wound Dual Delta stator. Eighteen 50-amp press-fit diodes combine for a 450-amp rectifier manufactured of high grade milled aluminum. The rotors utilize special high-flux density coils that are precision balanced for long bearing life. They use an SAE standard J180 mount, and an external regulator.

Removal

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Tilt the hood.

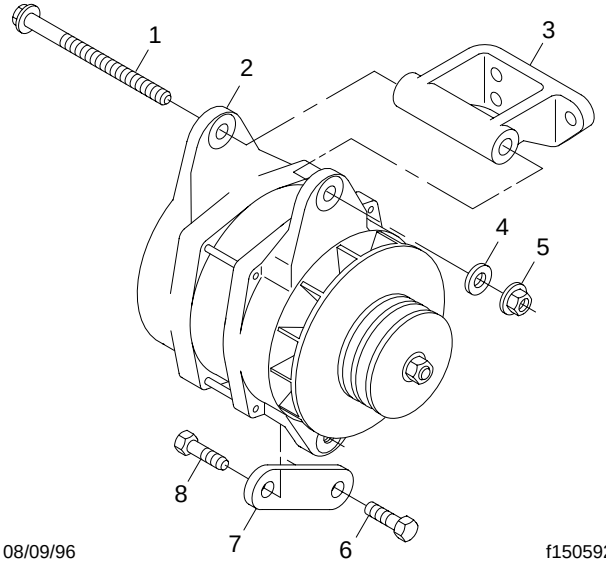
⚠ WARNING

Before disconnecting the batteries, read the instructions and Danger and Warning notices in Section 54.02. Keep sparks, flames, burning cigarettes, etc. away from batteries. Batteries generate explosive gases, which could cause a battery to explode, causing serious personal injury, including blindness.

3. Disconnect the batteries.
4. Mark all electrical leads and disconnect them from the alternator.
5. Remove the drive belts and note the routing. For instructions, see **Section 01.00**.
6. Remove the alternator. See **Fig. 1**.
   - 6.1 Remove the alternator mounting capscrew (Ref. 8) from the link (Ref. 7).
   - 6.2 Remove the nut and washer (Refs. 5 and 4) from the pivot bolt (Ref. 1).
   - 6.3 Securely hold the alternator to prevent it from falling, and remove the pivot bolt.
   - 6.4 Remove the alternator from the vehicle.
7. Inspect the drive belts. For instructions, see **Section 01.00**.

Installation

1. Install a new pulley, if applicable, and tighten the shaft nut to 75 lbf·ft (102 N·m).
2. Install the alternator on the pivot bracket. See **Fig. 1**.
   - 2.1 Position the alternator on the bracket.
   - 2.2 Insert the pivot bolt (Ref. 1) through the alternator and the bracket.
   - 2.3 Install the washer and nut (Refs. 4 and 5) on the end of the pivot bolt.



1. Pivot Capscrew
2. Mounting Lug
3. Pivot Bracket
4. Washer
5. Pivot Nut
6. Alternator Link Fastener
7. Alternator Link
8. Alternator Mounting Capscrew

Fig. 1, Mounting Hardware (Cummins engine mounting shown)

3. Check the torque of the alternator bracket fasteners. If necessary, tighten, see **Specifications 400**.
4. Install the alternator mounting capscrew, and tighten it 65 lbf·ft (88 N·m). Tighten the pivot nut 65 lbf·ft (88 N·m).
5. Install the drive belt on the pulley as removed. For instructions, see **Section 01.00**.

NOTE: The belt tensioner automatically adjusts the drive belt to the correct tension. If the belt slips, repair or replace the tensioner. For instructions, see the engine manufacturer's service literature.

6. Connect all leads to the back of the alternator as previously marked and tighten. See **Specifications 400**.
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1** for approved brands.

Alternator Removal and Installation

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Section 15.09, Troubleshooting 300**.
10. Lower the hood.
11. Remove the tire chocks.

Troubleshooting

Many alternators have been replaced that later investigation reveals were working properly. This may be due to incorrectly diagnosing the problem.

IMPORTANT: Before testing, make sure:

- All belts are correctly tightened;
- The wiring and terminals are clean and in good condition;
- All terminal nuts are torqued and properly protected.

Delco Remy has an alternator testing tool called the Intelli-Check Alternator Analyzer. See **Fig. 1**. This tool (DR 10457848, a single tester, or DR 10457865, a four-pack of testers) is to be used as a quick check of the alternator to see if it is working correctly.

NOTE: If you do not have the Delco Intelli-Check Tester, or if the alternator rated output is above 145 amps, or if a total vehicle charging system analysis is required, see "Alternator/Charging System Testing."

Intelli-Check Alternator Analyzer

The following information includes a pre-test procedure and operating instructions for the Delco Intelli-Check Tester, and is similar to the procedures provided by Delco with the Intelli-Check Tester.

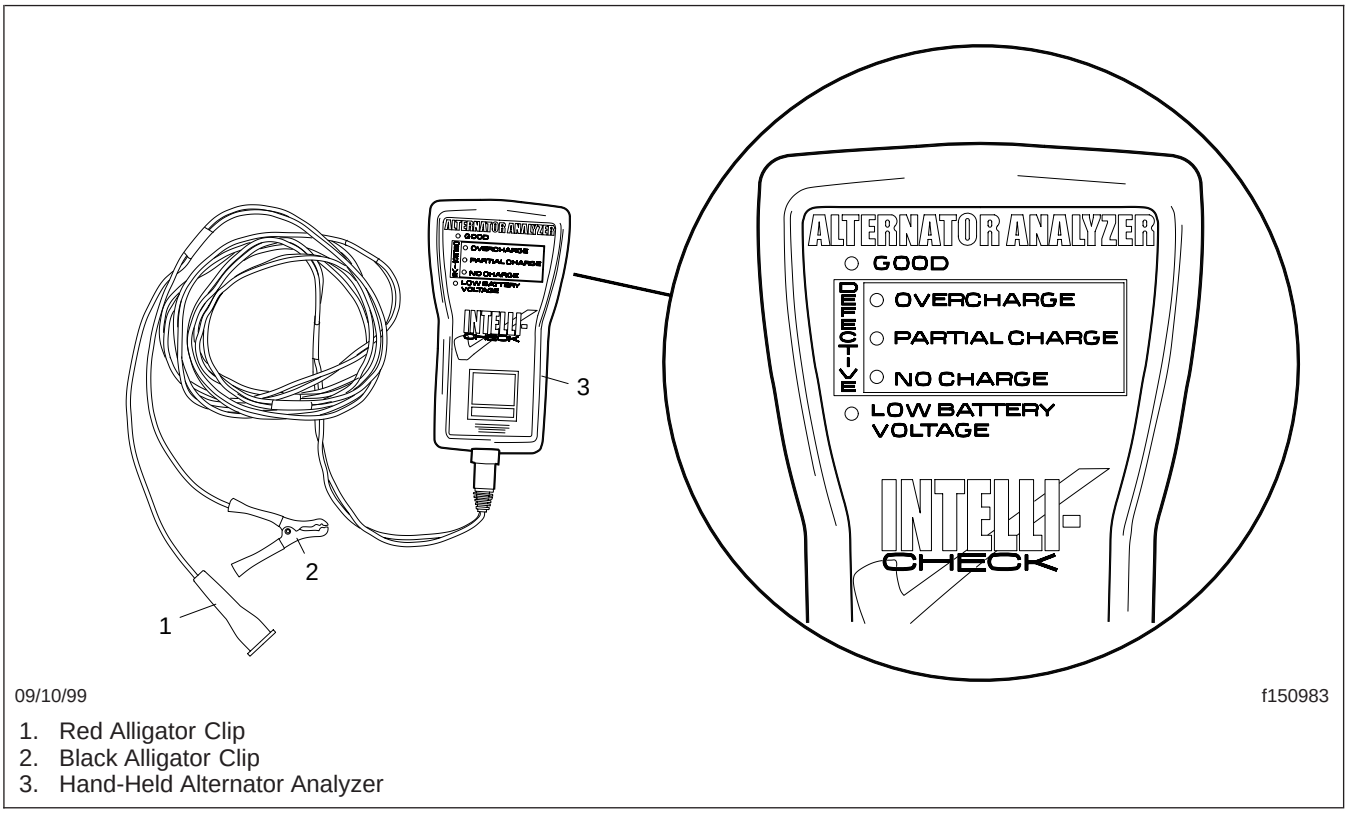
Pre-Test Procedure (Engine Off)

1. Inspect the alternator connections to verify that all terminals are secured and tight. Verify that the sense wire is connected to the sense terminal on vehicles equipped with remote-sense alternators.
2. With the engine off, connect the red alligator clip to the output terminal of the alternator. Connect the black alligator clip to the alternator ground. An optional ground connection is to the body of the alternator. The tester LEDs will illuminate and then go off as it performs a self-test.
3. After 4 seconds the tester will activate. The following LEDs may illuminate depending on the condition of the batteries:
    - **GOOD** (green) LED indicates the battery voltage is above 12.8 and has a surface charge. The surface charge must be removed before proceeding with the alternator test. To remove the surface charge, do the following:
        A. Turn on the headlights and blower motor for 2 minutes without restarting the engine.
        B. Reset the tester by disconnecting, then reconnecting the tester alligator clips. The analyzer will again perform its self-test.
        C. Repeat the applicable steps of the Pre-Test Procedure.
    - **NO CHARGE** (red) LED indicates the battery voltage is below 12.8. This LED should illuminate for most tests. Proceed with the alternator test.
    - **LOW BATTERY VOLTAGE** (blue) LED indicates the battery voltage is below 12.35. If the batteries will start the vehicle, proceed with the alternator test. However, after completing the Intelli-Check alternator test, perform the procedures under "Alternator/Charging System Testing" to determine the condition of the rest of the charging system.

Tester Operating Instructions (Engine Running)

1. Start the engine using onboard batteries only. If the batteries will not start the engine, they must be charged for 2 hours. Start the test again after charging the batteries.
2. Verify the engine is at idle and all electrical loads are off.
3. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
    - If the **GOOD** (green) LED illuminates, proceed to the next step.
    - If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
    - If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging

Troubleshooting



1. Red Alligator Clip
2. Black Alligator Clip
3. Hand-Held Alternator Analyzer

Fig. 1, Delco Remy Intelli-Check Alternator Analyzer

system using the instructions in "Alternator/Charging System Testing."

4. With the engine running, turn on all electrical loads.
5. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
6. If the **GOOD** (green) LED illuminates, the alternator is OK and the test is complete.

NOTE: If the alternator tests OK in the above tests, and the customer's complaint is reduced battery or headlight life, see "Alternator/ Charging System Testing" to completely analyze the charging system.

7. If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
8. If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing".

Alternator/Charging System Testing

Battery Open Circuit Voltage Test, Alternator Output Voltage Test and Alternator Amperage Output Test

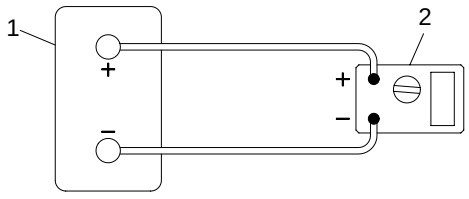
1. Use a digital volt-ohmmeter (VOM) set on the 2-20VDC (or similar) scale to test the battery open circuit voltage (OCV). With the engine shut down and the voltmeter set up as shown in **Fig. 2**, check for voltage of 12.4 volts or more.

   If the OCV is 12.4 volts or more, turn on the vehicle headlights for approximately 3 minutes.

   If the OCV is less than 12.4 volts, charge the batteries properly. For instructions, see **Group 54**.

IMPORTANT: Be sure to disconnect the batteries or remove them from the vehicle before charging.

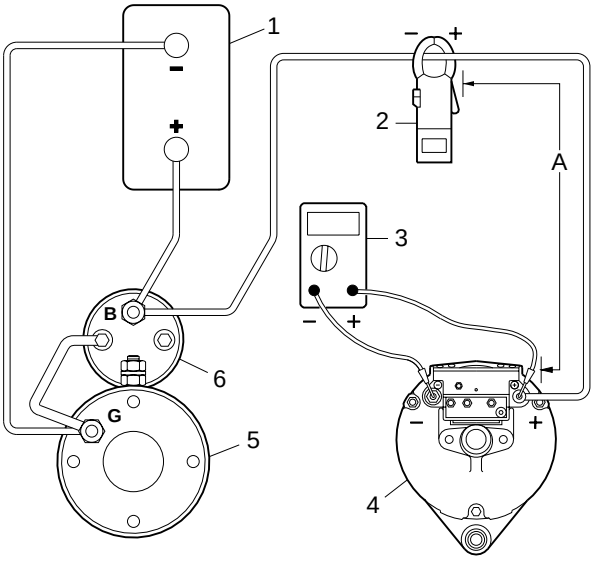
2. Check the alternator output without a load. See **Fig. 3**.



02/26/97 f150607

1. Battery
2. Digital Voltmeter

Fig. 2, Setup 1: Battery Open Circuit Voltage (and alternator amperage output)



02/11/98 f150938

A. Locate the ammeter at least 6 inches (15 cm) away from the alternator.

1. Battery
2. Ammeter
3. Digital Voltmeter
4. Alternator
5. Cranking Motor
6. Solenoid

Fig. 3, Setup 2: Alternator Output Test

2.1 Start the engine and run it at 1500 rpm for 3 to 5 minutes to stabilize the system before proceeding to the next step.

2.2 Connect the positive (+) lead of the digital voltmeter (still set on the 2-20VDC or similar scale) to the alternator (battery) terminal. Connect the negative (–) lead of the voltmeter to the alternator negative (–) ground terminal. See **Fig. 3**.

2.3 If the voltmeter reads from 13.8 to 14.2 volts, record this reading (V1) and go to the next step. If the alternator reads less than 13.8 volts and is adjustable, try to adjust the voltage regulator to 13.8 to 14.2 volts. If unable to obtain acceptable output, replace the alternator.

3. Check the alternator output under load. See **Fig. 3**.

3.1 Attach a clamp-on induction ammeter around the positive (+) wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

3.2 With the engine still running at 1500 rpm, turn on the following electrical accessories to load the alternator until the ammeter reads 60 to 75 amps.

- Both front and rear heater blowers (on HIGH)
- Headlights (high beams)
- Road lights
- Interior lights

NOTE: As an alternate method of putting load on the alternator, connect a carbon pile tester and set it to 60 to 75 amps.

3.3 Keep the voltmeter connected as in the previous step; positive (+) lead connected to the alternator positive (+) terminal; negative (–) lead connected to the alternator negative (–) terminal.

3.4 If the voltmeter reads from 13.6 to 14.2 volts, record this reading (V2) and go to the next step.

If the voltmeter reads less than 13.6 volts, replace the alternator.

4. Perform an alternator amperage output test.

4.1 Connect a carbon pile tester across the vehicle batteries as shown in **Fig. 2**.

Troubleshooting

NOTE: **Figure 2** shows a voltmeter, but the connections for the carbon pile tester are the same.

4.2 Attach a clamp-on induction ammeter around the alternator output wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

4.3 Start the engine and make sure all vehicle electrical accessories are turned off. Run it at fast speed and adjust the tester to the alternator maximum current output. Record this output value.

NOTE: Ensure that the alternator is turning at maximum available rpms and keep adjusting the tester dial until the ammeter reads its highest value.

4.4 Turn off the tester and shut down the engine.

4.5 If the output value recorded is less than 85 percent of the rated amperage output, repeat the test. If the output value recorded is still less than 85 percent of the rated amperage output, replace the alternator.

4.6 Make sure that all test instruments are removed and that the vehicle wiring is returned to its operational state.

5. To identify other problem areas within the vehicle, check the operation of the charging system. Set up the voltmeter as shown in **Fig. 2** and **Fig. 3**.

NOTE: For any load at 1500 rpm or more, battery voltage must be within 0.5 volts of the alternator voltage.

5.1 If readings at the batteries are within 0.5 volts of the readings at the alternator, the charging system is working correctly. Check other areas of the vehicle to locate the problem.

5.2 If the reading at the batteries is more than 0.5 volts lower than the reading at the alternator, do the next step.

6. Check charging system connections, cables and terminals.

6.1 Check all connections between the battery, starter and alternator for tightness and signs of corrosion. Tighten and clean as necessary.

6.2 Check all cables for breaks or partial breaks. Repair or replace as necessary.

6.3 Check each ring terminal for breakage at the point where it attaches to its wire or cable.

Specifications

Mounting Fastener Torques, Caterpillar Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
End Link Mounting Capscrew	8PO	1/2–13	68 (92)
Alternator Mounting Capscrew	8PO	1/2–13	68 (92)
Adjusting Rod Mounting Capscrew	8PO	1/2–13	68 (92)
Adjusting Rod Jam Nut	5	5/8	95 (130)
Alternator Bracket Fasteners	5PO	3/8–16	34 (46)

Table 1, Mounting Fastener Torques, Caterpillar Engines

Mounting Fastener Torques			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Alternator Mounting Capscrews	8PO	1/2–13	65 (88)
Adjusting Strap Mounting Capscrew	8PO	1/2–13	65 (88)

Table 2, Mounting Fastener Torques, Cummins Engines

Terminal Fastener Torques			
Description	**Grade**	**Size**	**Torque: lbf·in (N·cm)**
Alternator Output ("BAT") Terminal Nut	5	5/16–18	100 (1140)
Alternator Ground ("G") Terminal Nut	5	1/4–20	65 (740)
Alternator Instrument ("I") Terminal Nut	8.8	#10, M4	20 (220)

Table 3, Terminal Fastener Torques

Pulley Nut Torque			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Pulley Nut	8PO	5/8	75 (102)

Table 4, Pulley Nut Torque

General Description

The main function of a cooling system is to keep the engine at its optimum operating temperature. This results in the most efficient use of fuel and allows the engine oil to provide a good lubricating film. For the coolant plumbing for your vehicle, refer to the applicable figure from the list below:

- For a Cummins B Series engine, **see Fig. 1** .
- For a Mercedes-Benz OM 366LA engine, **see Fig. 2**.
- For a Detroit Diesel Series 50 engine, **see Fig. 3**.
- For a Dodge Magnum V-8 engine, **see Fig. 4**.
- For a Caterpillar CFE Series engine, **see Fig. 5**.
- For a Cummins M11 engine, **see Fig. 6**.

The cooling system is a high-flow design, where most of the coolant in a warm engine moves relatively quickly across the radiator in a single pass.

Coolant flows from the radiator to the water pump, which forces the coolant into the engine block. Inside the block, the coolant flows around and between the cylinders, then up into the cylinder head. From the head, it flows to the temperature regulator (thermostat) housing. If the engine is cool, the thermostat directs the coolant back to the water pump, and the water pump forces the coolant back into the engine. As the engine warms, the thermostat directs the coolant to the radiator. The thermostat keeps the engine temperature in the optimum range by controlling the two flows.

To prevent air and vapor from being trapped in the radiator or engine, vent lines rise from the high points where air and vapor would collect in those components. The vent lines carry any collected air to the surge tank.

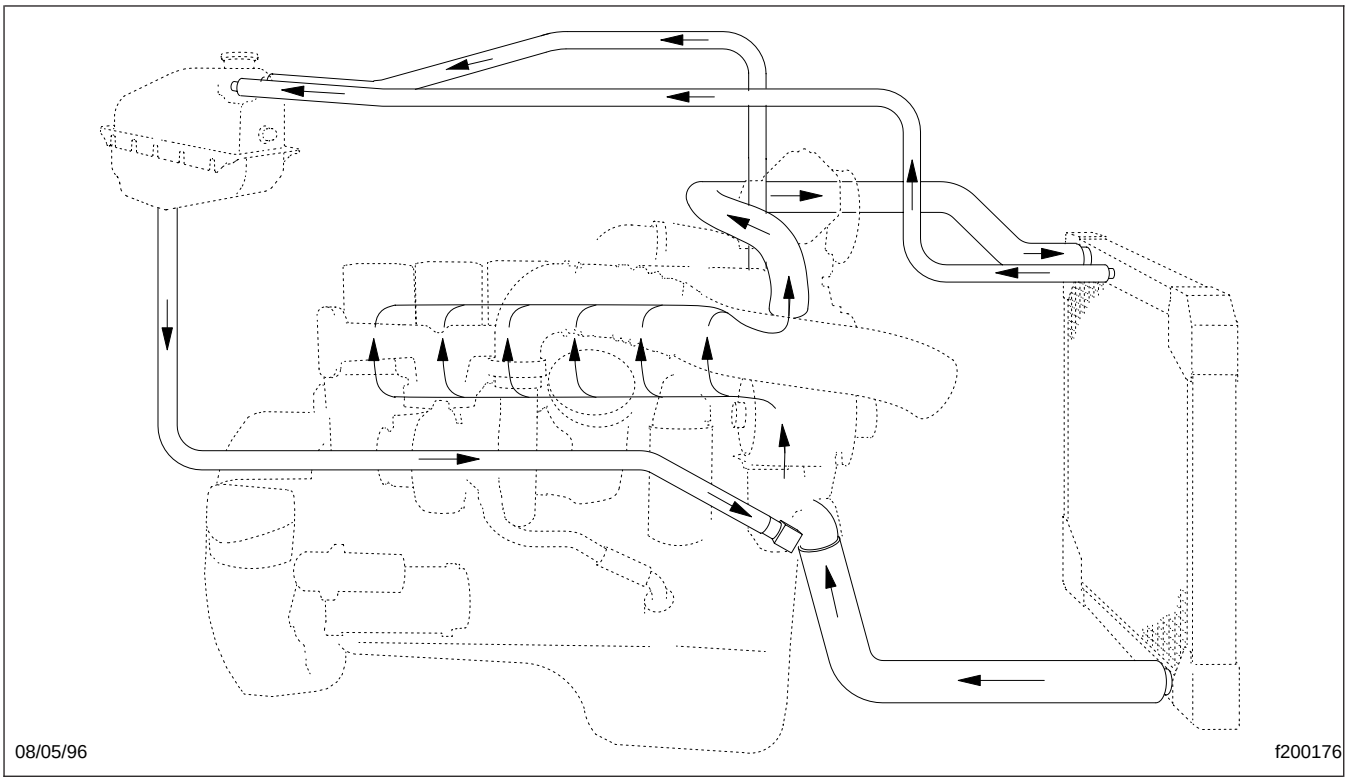


Fig. 1, Coolant Plumbing for a Cummins B Series Engine

General Description

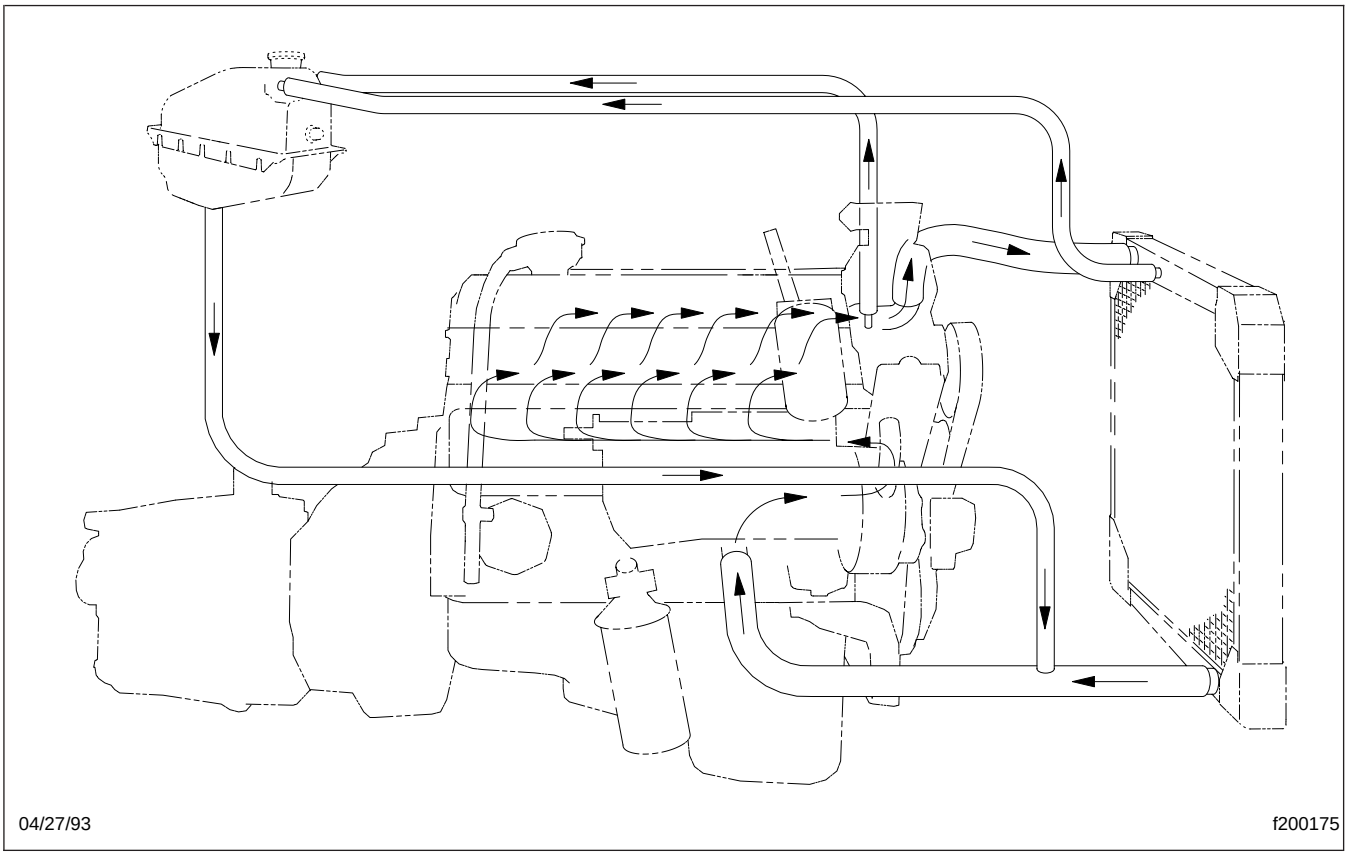


Fig. 2, Coolant Plumbing for a Mercedes-Benz OM 366LA Engine

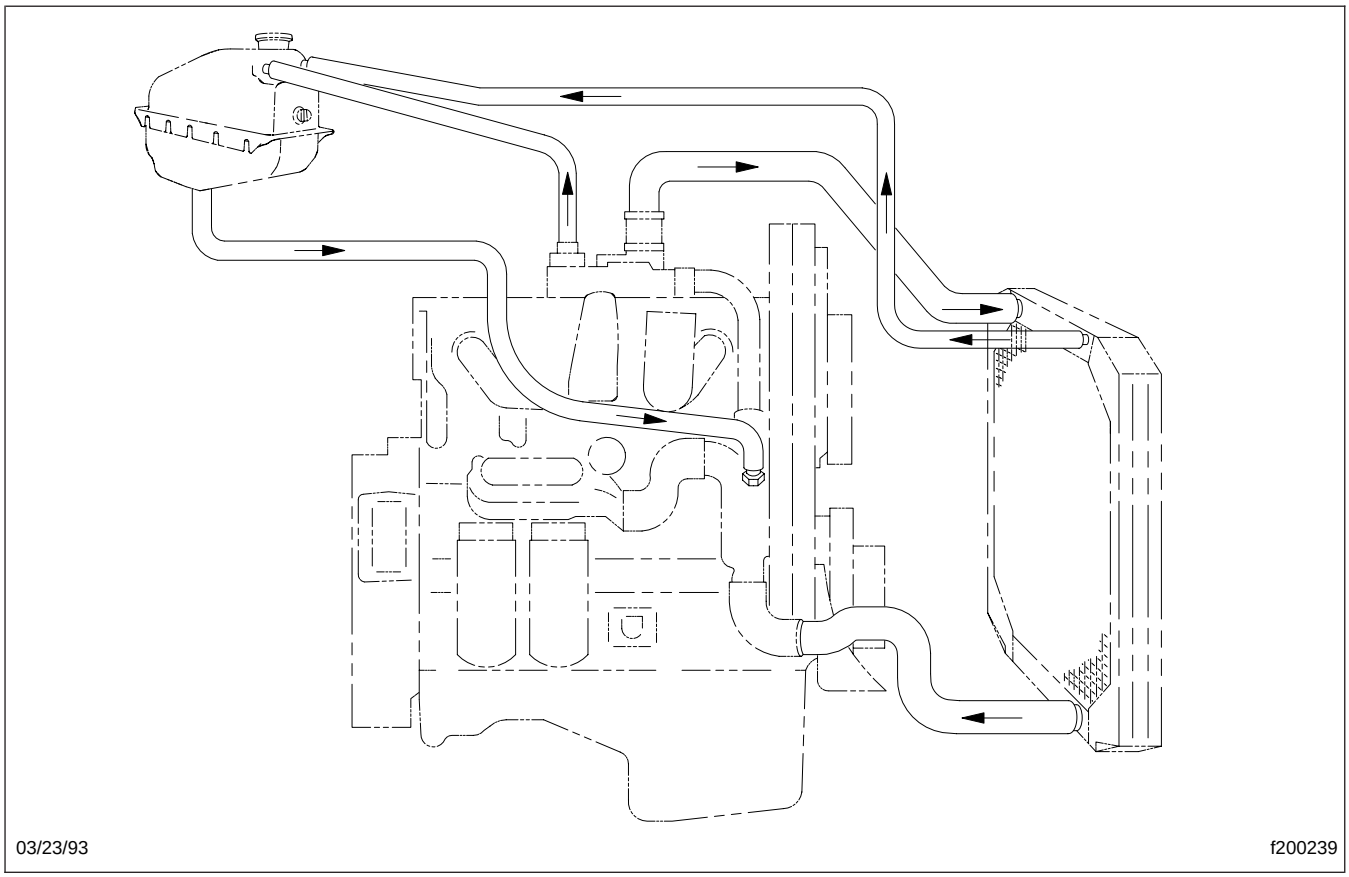
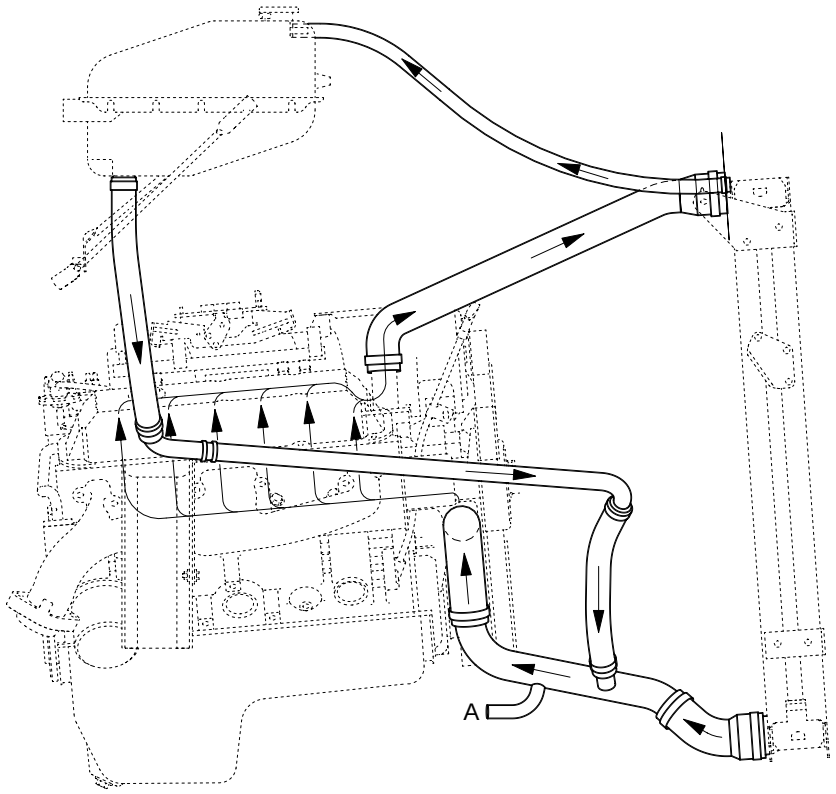


Fig. 3, Coolant Plumbing for a Detroit Diesel Series 50 Engine

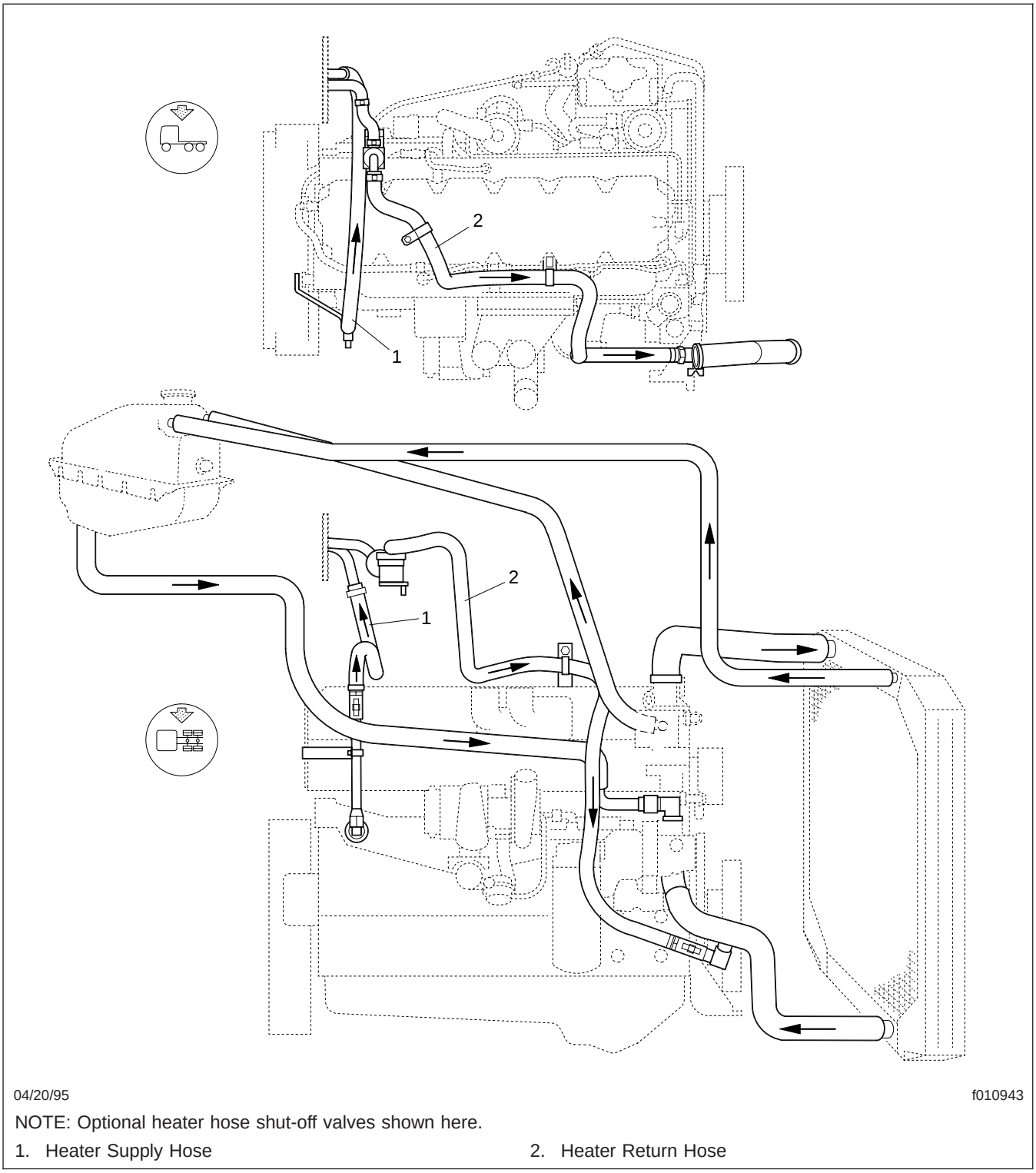
General Description



09/28/94 f200295

A. To the optional engine oil cooler.

Fig. 4, Coolant Plumbing for a Dodge Magnum Engine

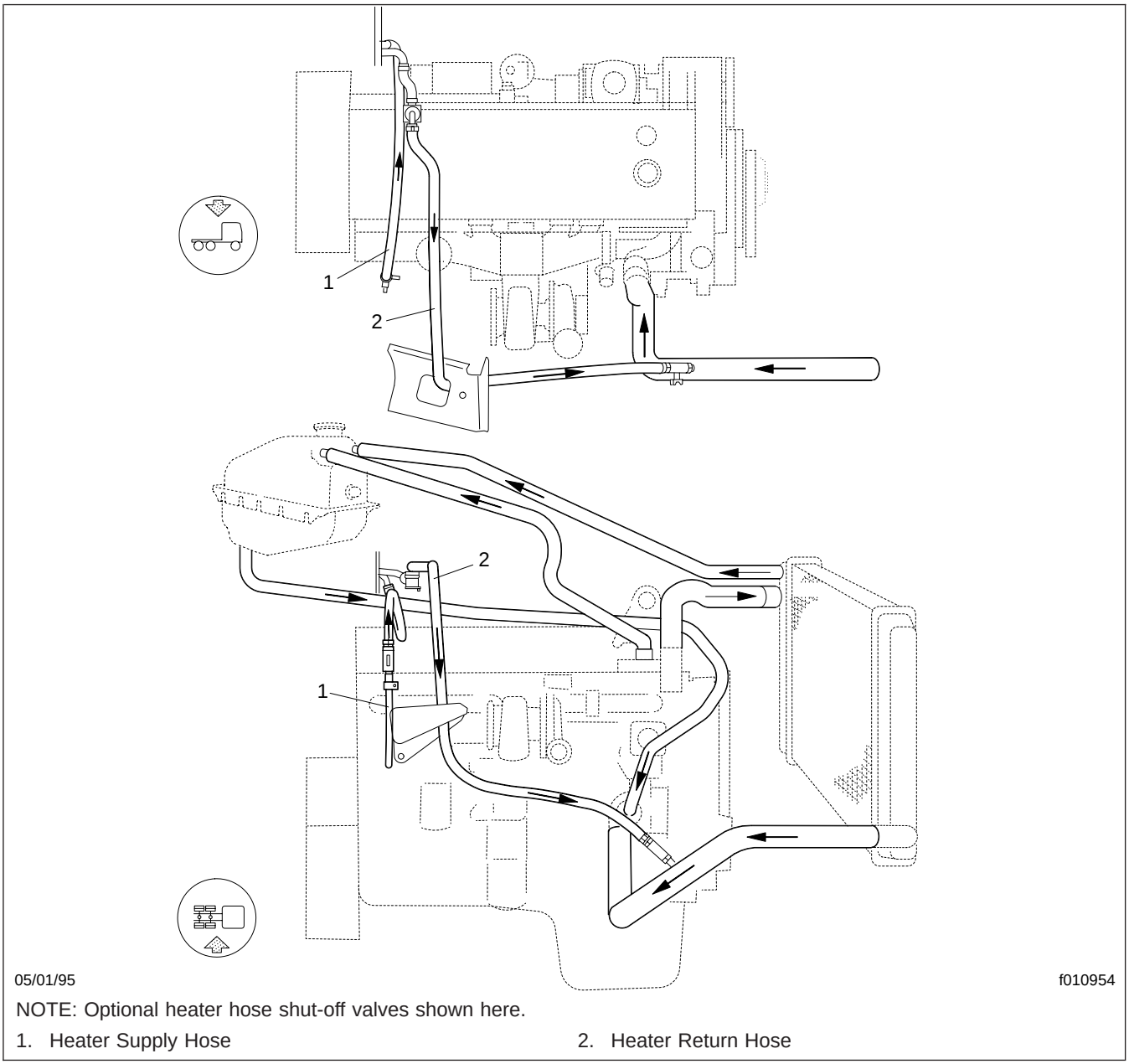


NOTE: Optional heater hose shut-off valves shown here.

1. Heater Supply Hose
2. Heater Return Hose

Fig. 5, Coolant Plumbing for a Caterpillar CFE Series Engine

General Description



NOTE: Optional heater hose shut-off valves shown here.

1. Heater Supply Hose
2. Heater Return Hose

Fig. 6, Coolant Plumbing for a Cummins M11 Engine

Possible causes of abnormally high or low coolant temperatures are listed below. For repairs, refer to other sections of this manual or to the engine and component manufacturer's service publications.

This subject contains the following troubleshooting tables:

- Coolant Temperature Above Normal
- Coolant Temperature Below Normal

Problem—Coolant Temperature Above Normal

Possible Cause	Remedy
Coolant leakage (see possible sources below) is causing a low coolant level. External Leakage: hoses and hose connections radiator seams, core, petcock and cap block core and drain plugs water pump thermostat housing surge tank heater hoses and core temperature sending unit(s) cylinder head(s) mating (gasket) surfaces coolant filter oil cooler Internal Leakage: cylinder head gasket warped head or block surfaces cracked cylinder head or block cylinder head capscrews loose, missing, or tightened unevenly oil cooler aftercooler	Do the repairs necessary to stop the leaks. Fill to the surge tank sight glass with the correct mixture of antifreeze and water. Refer to the vehicle maintenance manual for coolant specifications.
The temperature gauge is not working.	Check the gauge wiring, circuit breaker, and sending unit. If the gauge circuit is okay, replace the temperature gauge. If the gauge circuit is broken, repair it and then check the temperature gauge operation.
The radiator, aftercooler, or condenser fins are clogged.	Clean the outside of the core and the condenser with compressed air directed from the fan side, or with water and a mild laundry soap. Straighten bent fins.
A radiator hose is collapsed or plugged.	Replace the hose(s).
A fan belt or water pump belt is loose.	Adjust belt tension.
The cooling fan shroud is damaged.	Repair or replace the shroud.
The radiator cap is incorrect or malfunctioning.	Make sure the correct radiator cap is installed. If the cap does not hold the correct pressure, replace it.
The viscous fan drive is not operating to specifications.	Check for unobstructed airflow through the radiator core, aftercooler, and condenser to the fan clutch sensor. Check that the radiator core is getting hot in front of the fan clutch (core is not internally clogged in that area) so that the sensor is getting a correct reading. If no radiator problems exist, refer to the viscous fan clutch section in this group for fan clutch inspection procedures and operation tests.
The engine oil level is incorrect.	Fill to the high (H) mark on the dipstick.
There is too much antifreeze in the system.	Clean and flush the cooling system. Refill the system with the correct mixture of antifreeze and water.
The thermostat is incorrect or inoperative.	Make sure the correct thermostat is installed in the temperature regulator housing. Test the thermostat according to the engine manufacturer's instructions. Replace it if it does not operate correctly.
The water pump is not working correctly.	Repair or replace the water pump.

Troubleshooting

Possible Cause	Remedy
The radiator core is internally plugged or damaged.	To check for blockages, warm the engine to normal operating temperature. Turn off the engine, and run your hand over the finned surface of the radiator. If there is a blockage in the radiator, it should cause an obvious temperature difference from one area of the core to another. An obvious difference between inlet and outlet temperatures is normal. If blockage is suspected, clean and flush the cooling system. Repair or replace a damaged core.
Air or combustion gases are entering the cooling system.	Check the cylinder heads, head gaskets, cylinder liners, and aftercooler for leaks. Repair or replace parts, as necessary.
The aftercooler is internally plugged or damaged.	Repair or replace the aftercooler.
The oil cooler is internally plugged or damaged.	Repair or replace the oil cooler.
The engine is receiving too much fuel.	Refer to the engine manufacturer's fuel delivery system adjustment procedures.
The wrong replacement fan was installed.	Install the correct fan.
There is exhaust blockage.	Remove the blockage.
Coolant is frozen in the radiator due to subfreezing temperatures.	Use the proper antifreeze-to-water ratio needed for winter temperatures.

Problem—Coolant Temperature Below Normal

Possible Cause	Remedy
The temperature gauge is not working.	Check the gauge circuit wires, circuit breaker, and sending unit. If the gauge circuit is okay, replace the temperature gauge. If the gauge circuit is broken, repair it and then check the temperature gauge operation.
The viscous fan drive operates continuously.	Refer to the viscous fan clutch section in this group for fan clutch inspection procedures and operation tests. Replace the fan drive if necessary.
The thermostat is incorrect or inoperative.	Make sure the correct thermostat is installed. Test the thermostat according to the engine manufacturer's instructions. Replace it if it does not operate correctly.

General Description

The main function of a cooling system is to keep the engine at its optimum operating temperature. This results in the most efficient use of fuel and allows the engine oil to provide a good lubricating film.

The central component of the cooling system, the radiator assembly, includes the surge tank (remote mounted on the firewall), the radiator, and the surge tank cap. **See Fig. 1**, **Fig. 2**, **Fig. 3**, or **Fig. 4.**

The surge tank provides extra reserve coolant, expansion space for heated coolant, and deaeration space. When coolant in the radiator runs low, reserve coolant stored in the surge tank flows from the tank, through the fill hose, to the water pump. As the coolant heats and expands beyond radiator capacity, excess coolant travels back through the fill hose from the water pump to the extra space in the surge tank. Any air trapped in the engine block or radiator rises to the top of the engine or radiator and escapes through the vent hoses to the surge tank.

Freightliner Medium Trucks use full-flow (or high-flow) radiators. With full-flow radiators, the coolant flows into the radiator at the left of the top tank and flows out of the radiator at the right of the bottom tank. Most of the engine coolant is routed through the radiator, and it moves relatively quickly in a single pass.

There are five sizes of two-row radiators in use:

- 695 square inches
- 720 square inches
- 850 square inches
- 1000 square inches
- 1200 square inches

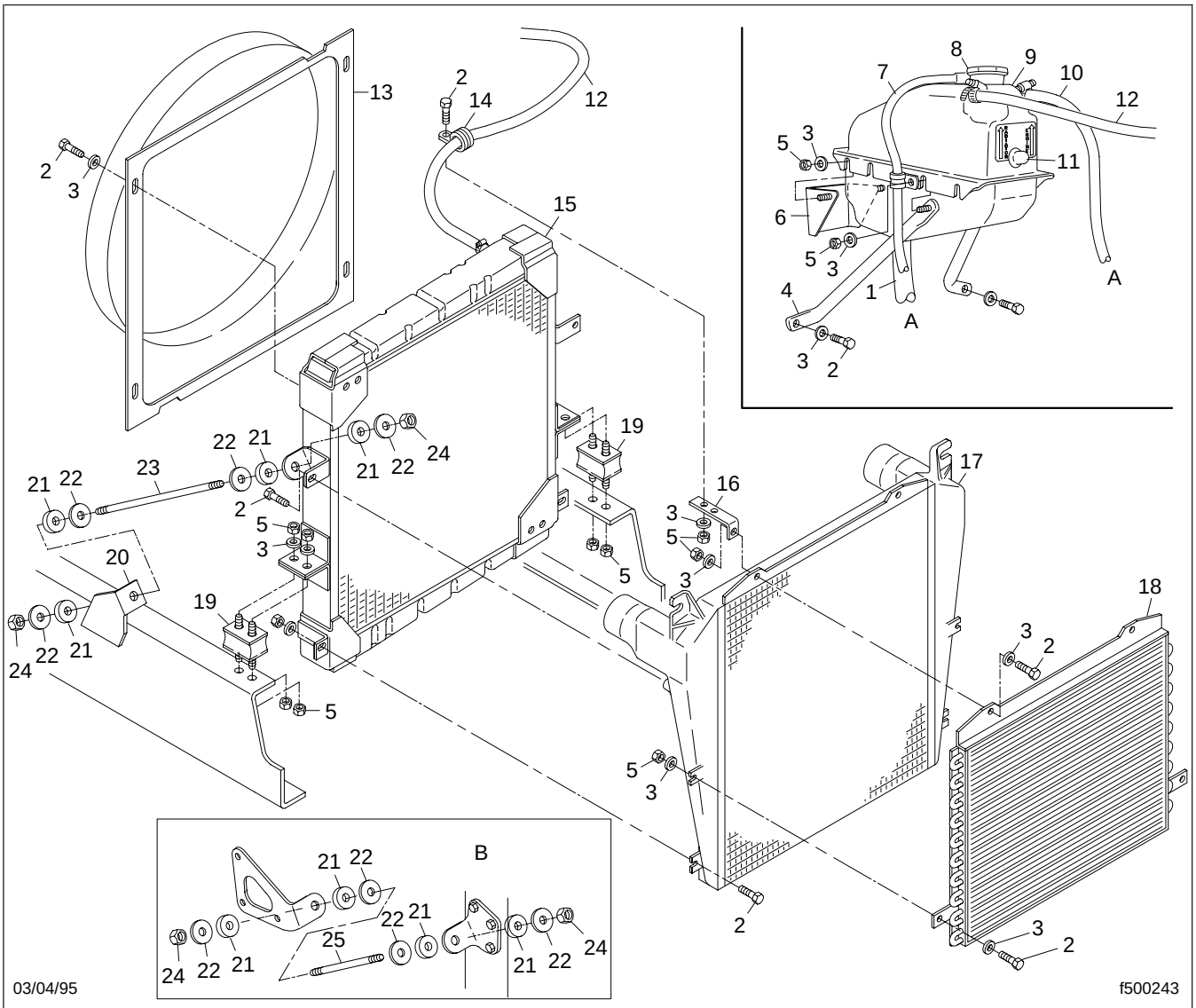
The core of the smallest radiator is soldered to brass top and bottom tanks, and the tanks and radiator core are held in steel side channels that mount on the frame rails. **See Fig. 5.**

The larger radiators use glass-filled nylon top and bottom or side tanks. The edges of the radiator core header are compressed in a "dimple wave lock" crimp (**see Fig. 6**) that holds the tanks on the radiator core, and the tanks and core are held in steel channels that mount on the frame rails. On the largest radiators, with 850, 1000, or 1200 square inches of front area, the radiator is also secured by brace rods that run between the top of the radiator and the firewall. The fins of the radiator core are reinforced along their forward edge to resist damage from road debris and pressure washing.

Because crimping holds the nylon top and bottom tanks in place, the larger radiators can be disassembled and assembled.

The surge tank cap (**Fig. 1**, **Fig. 2** , **Fig. 3** , or **Fig. 4**) limits system pressure to about 9 kPa (62 psi), which raises the boiling point of the coolant. If the cooling system overheats, excess coolant is released through the overflow tube.

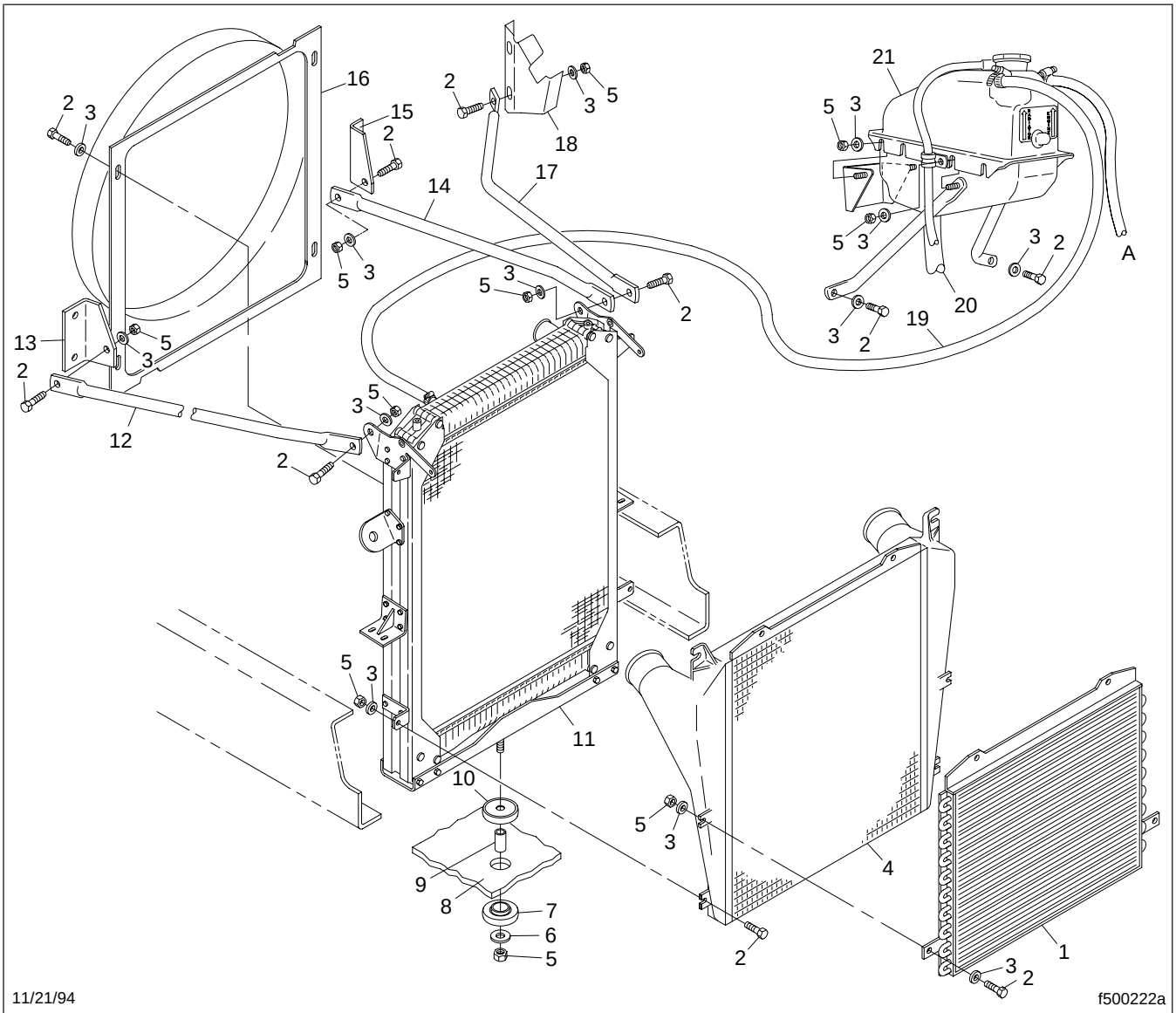
General Description



A. to engine
B. Right-Side Strut Installation, Caterpillar CFE Engines

1. Fill Hose
2. Bolt
3. Washer
4. Surge Tank Strut
5. Nut
6. Surge Tank Mounting Bracket
7. Surge Tank Overflow Tube
8. Surge Tank Cap
9. Surge Tank
10. Engine Vent Hose
11. Surge Tank Sight Glass
12. Radiator Vent Hose
13. Fan Shroud
14. Hose Cushion Clamp
15. Radiator
16. Stand-off Bracket
17. Aftercooler
18. Condensor
19. Radiator Mounting Stud
20. Radiator Strut Bracket
21. Radiator Strut Isolator
22. Hardened Washer
23. Radiator Strut
24. Radiator Strut Nut
25. Shortened Right-Side Strut, Used with Caterpillar CFE Engines

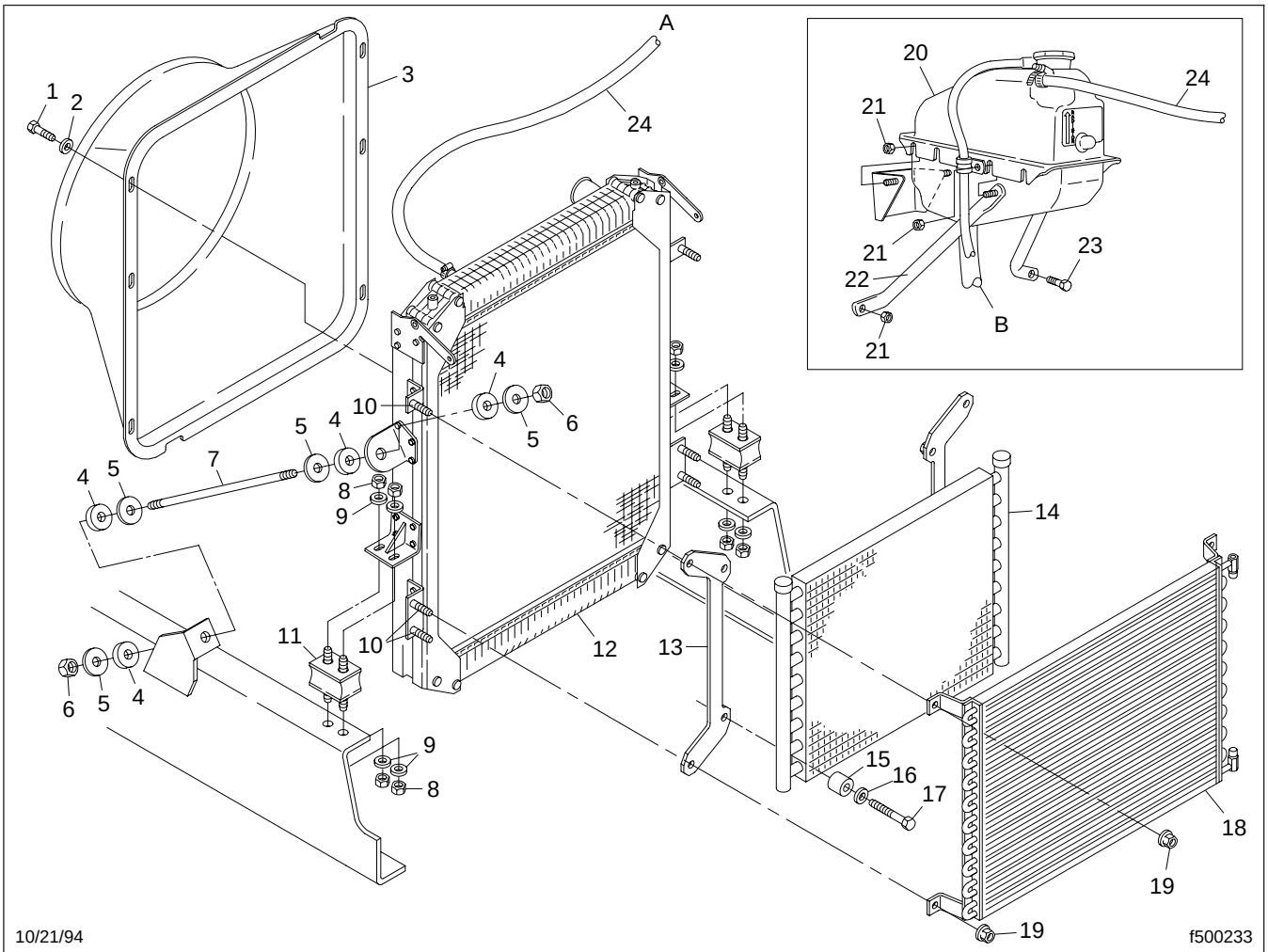
Fig. 1, Radiator Installation for Caterpillar, Cummins B and C series, and Mercedes-Benz Engines



A. to engine
1. Condensor
2. Bolt
3. Washer
4. Aftercooler
5. Nut
6. Washer
7. Lower Radiator Isolator
8. Radiator Underslung Support
9. Spacer Tube
10. Radiator Upper Isolator
11. Radiator
12. Radiator Left Brace Rod
13. Left Brace Rod Bracket
14. Radiator Center Brace Rod
15. Center Brace Rod Bracket
16. Fan Shroud
17. Radiator Right Brace Rod
18. Right Brace Rod Bracket
19. Radiator Vent Hose
20. Fill Hose
21. Surge Tank

Fig. 2, Radiator Installation for Detroit Diesel Engines

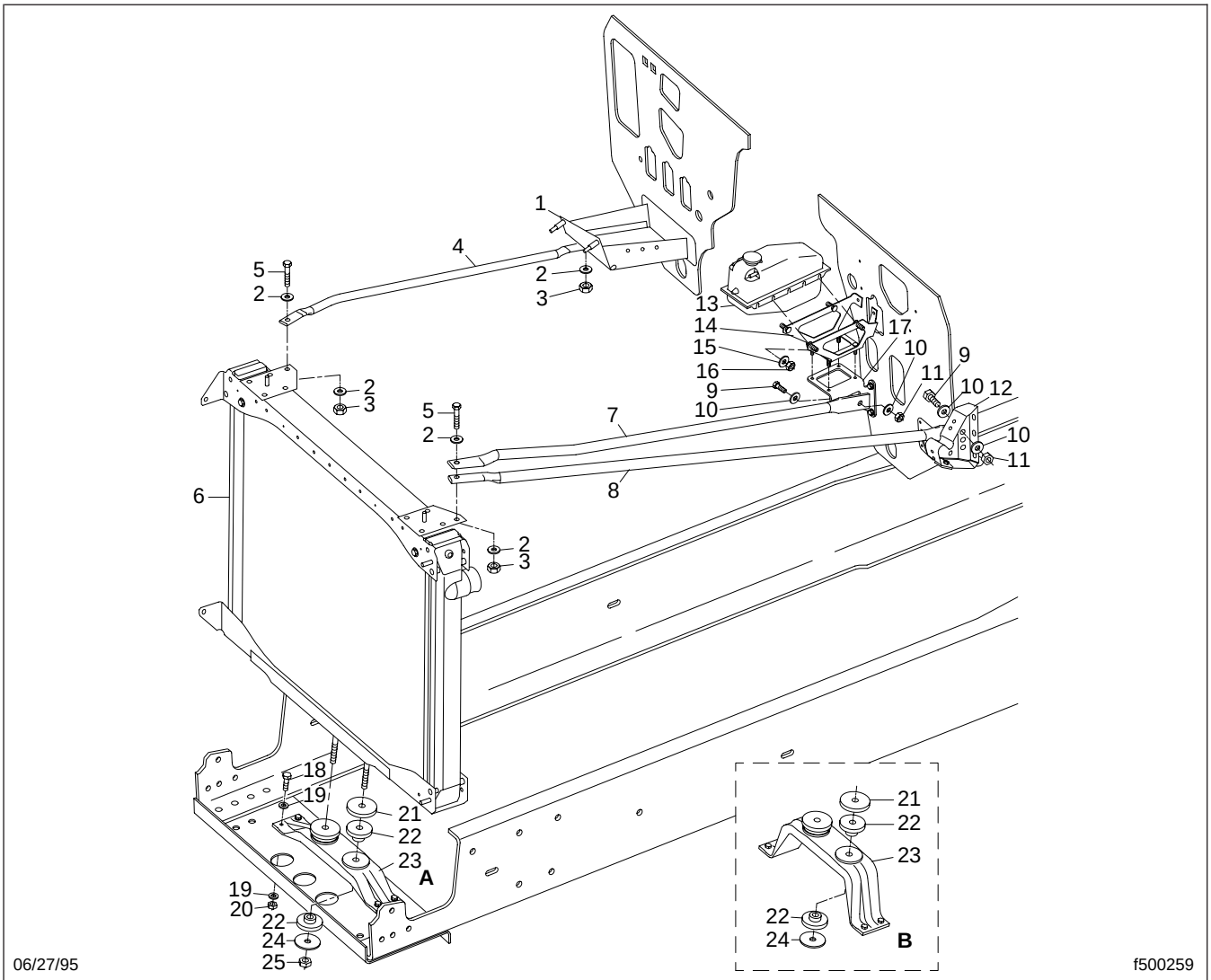
General Description



A. to surge tank
B. to water pump

1. 1/4-20 Screw
2. 1/4 Inch Washer
3. Fan Shroud
4. Radiator Strut Isolator
5. 15/32-Inch Inside Diameter Washer
6. 7/16-14 Hex Nut
7. Radiator Strut
8. 3/8-16 Hex Nut
9. 3/8 Inch Washer
10. 5/16-18 Stud
11. Radiator Mount Isolator and Studs
12. 720-Square-Inch Radiator
13. Transmission Oil Cooler Mounting Bracket
14. Transmission Oil Cooler
15. Transmission Oil Cooler Isolator
16. 5/16 Inch Washer
17. 5/16-18 Capscrew
18. Condensor
19. 5/16-18 Hex Nut
20. Surge Tank
21. M10 Nut
22. Surge Tank Brace
23. M10x20 Flanged Head Bolt
24. Radiator Vent Hose

Fig. 3, Radiator Installation for Dodge Magnum Engines

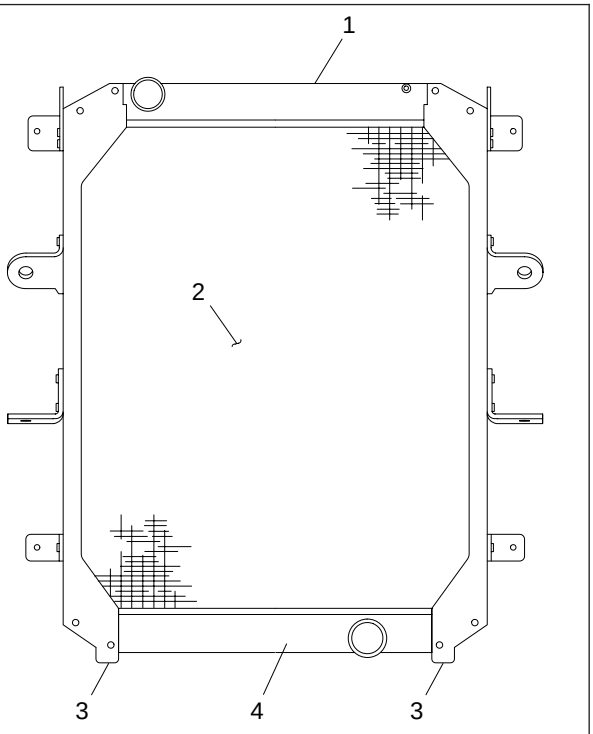


A. Support Bracket for a 1200-Square-Inch Radiator
B. Support Bracket for a 1000-Square-Inch Radiator

1. Air Cleaner Mounting Bracket
2. Washer, 1/2 Inch
3. Nut 1/2–13, Grade 8
4. Right-Hand Radiator Strut Rod
5. Capscrew, 1/2–13x2 Inches, Grade 8
6. Radiator
7. Left-Hand Radiator Strut Rod, Inboard
8. Left-Hand Radiator Strut Rod, Outboard
9. Capscrew, 5/8–11x1.5 Inches, Grade 8
10. Washer
11. Nut, 5/8–11, Grade 8
12. Hood Support Bracket
13. Surge Tank
14. Surge Tank Bracket, Upper
15. Washer
16. Locknut, M8
17. Surge Tank Bracket, Lower
18. Capscrew, 3/8–16x1.25 Inch, Grade 8
19. Washer
20. Nut, 3/8–16, Grade 8
21. Spacer (used only with 11-inch frame rails)
22. Isolator
23. Radiator Support Bracket
24. Washer
25. Nut, 58–11, Grade 8

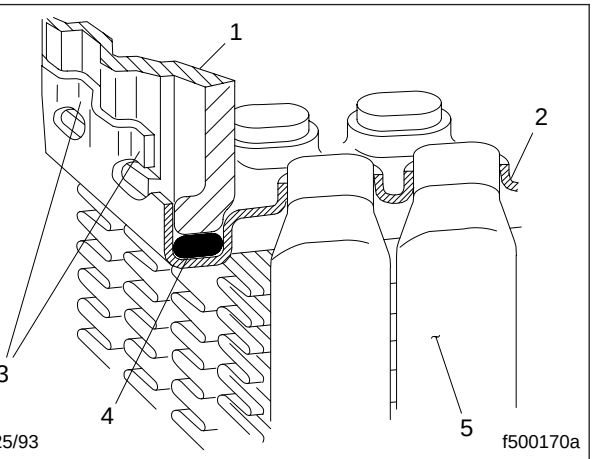
Fig. 4, Radiator Installation for Cummins M11 Engines

General Description



1. Top Tank
2. Radiator Core
3. Side Channels
4. Bottom Tank

Fig. 5, Radiator Components



1. Nylon Tank
2. Radiator Header
3. Dimple Wave Lock Crimp
4. Sealing Gasket
5. Radiator Core

Fig. 6, Radiator Crimping

NOTE: There are three types of radiator installations for Medium Trucks:

- *For Caterpillar, Cummins B and C series, Dodge, and Mercedes-Benz engines using the 695- or 720-square-inch radiators,* the radiators are mounted to the frame rails.
- *For Detroit Diesel engines using the 850-square-inch radiator,* the bottom of the radiator is mounted to an underslung support. Brace rods run from the top of the radiator to the firewall to brace the radiator.
- *For Cummins M11 engines using the 1000- or 1200-square-inch radiator,* the bottom of the radiator is mounted to a bracket on the front, closing crossmember. Brace rods run from the top of the radiator to the firewall to brace the radiator.

Use the removal and installation procedures applicable to the vehicle.

Removal

Framerail-Mounted 695- or 720-Square-Inch Radiators

1. Park the vehicle, apply the parking brakes, and chock the tires.

   Tilt the hood.

⚠ WARNING

Do not drain coolant from a hot engine. Opening the cooling system when the engine and coolant are hot can cause severe personal injury due to scalding by the hot, pressurized coolant.

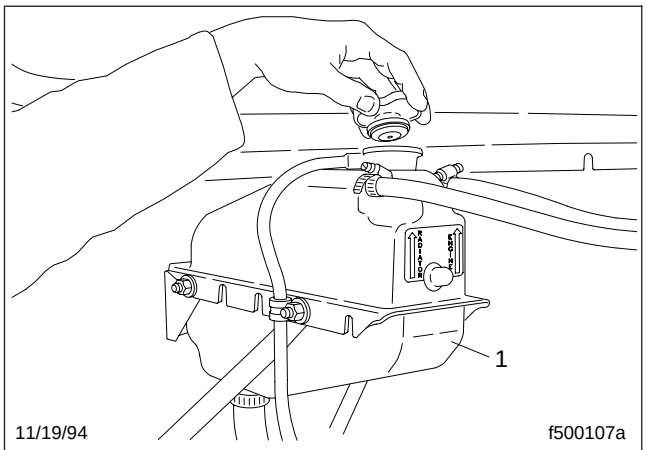
2. Drain the radiator.

   2.1 Remove the radiator surge tank cap. See **Fig. 1**.

   2.2 Open the petcock at the bottom of the radiator to drain the engine coolant. See **Fig. 2.**

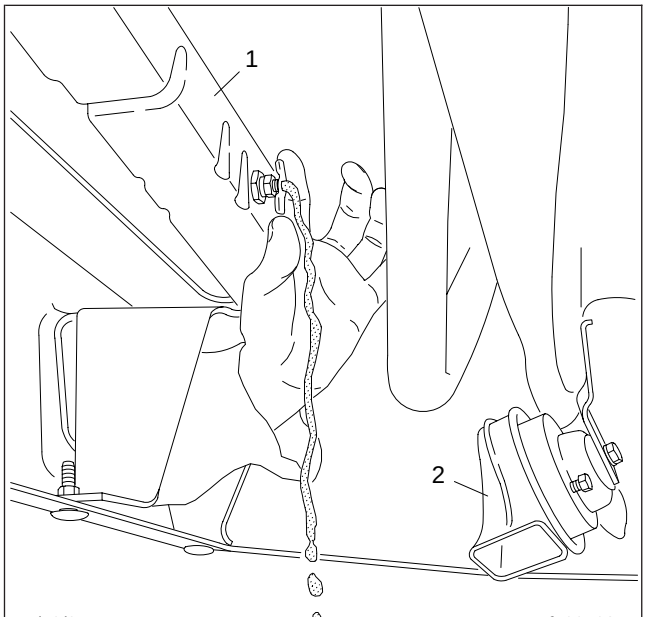
3. Remove the hood. For instructions, refer to **Group 88** in the vehicle service manual.

4. Move the condensor aside.



1. Surge Tank

Fig. 1, Remove the Surge Tank Cap



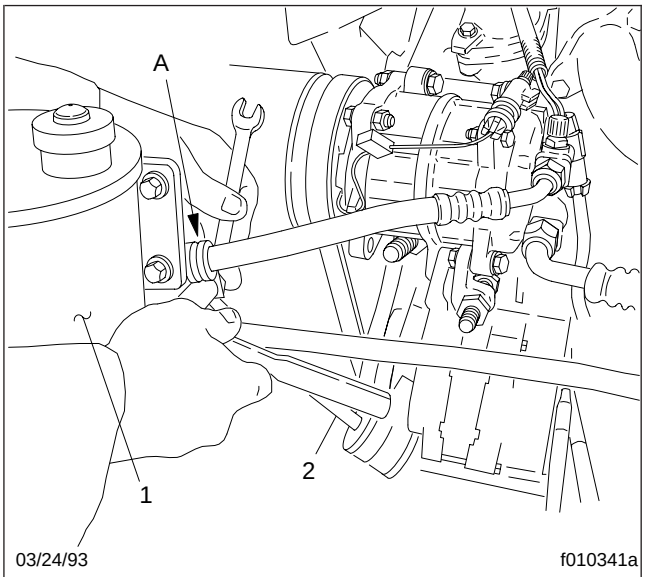
1. Radiator
2. Horn

Fig. 2, Drain the Radiator

   4.1 Remove the clamp securing the refrigerant lines to the left radiator support strut. See **Fig. 3.**

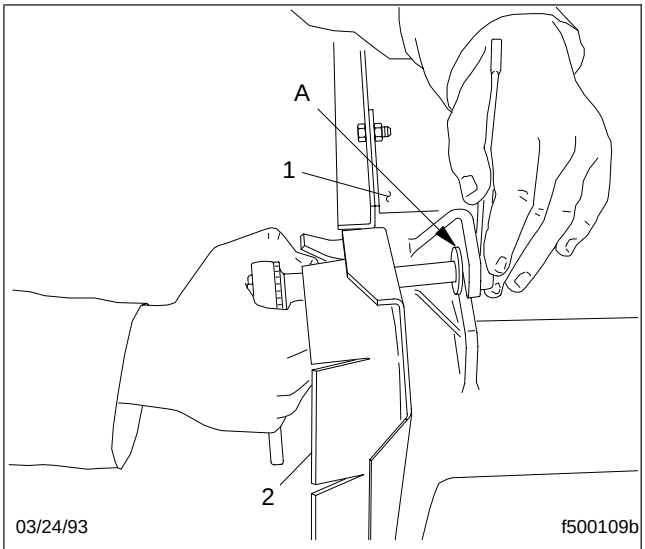
   4.2 Remove the air recirculation shield from the charge air cooler left mounting tab. See **Fig. 4.**

Radiator Removal and Installation



A. Remove the hose clamp from the strut.
1. Power Steering Fluid Reservoir
2. Left Radiator Strut

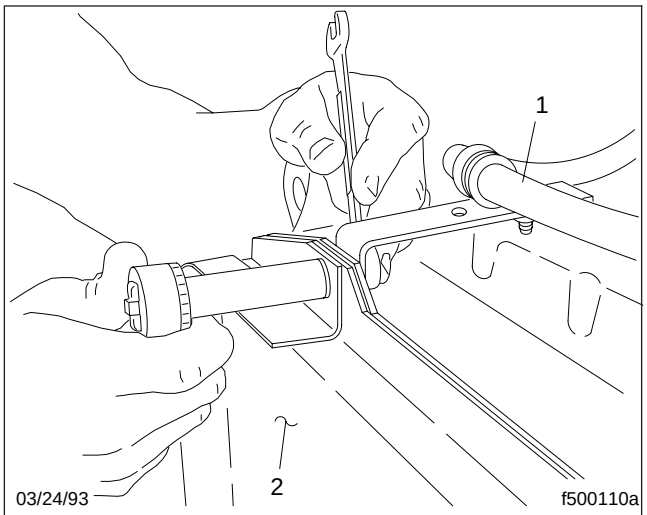
Fig. 3, Hose Clamp Location



A. Remove the air recirculation shield from the mounting tab.
1. Charge Air Cooler
2. Air Recirculation Shield

Fig. 4, Shield Mounting Tab

4.3 Remove the four bolts securing the condensor and the radiator vent hose bracket. See **Fig. 5** and **Fig. 6.**



1. Radiator Vent Hose
2. Condensor

Fig. 5, Vent Hose Bracket

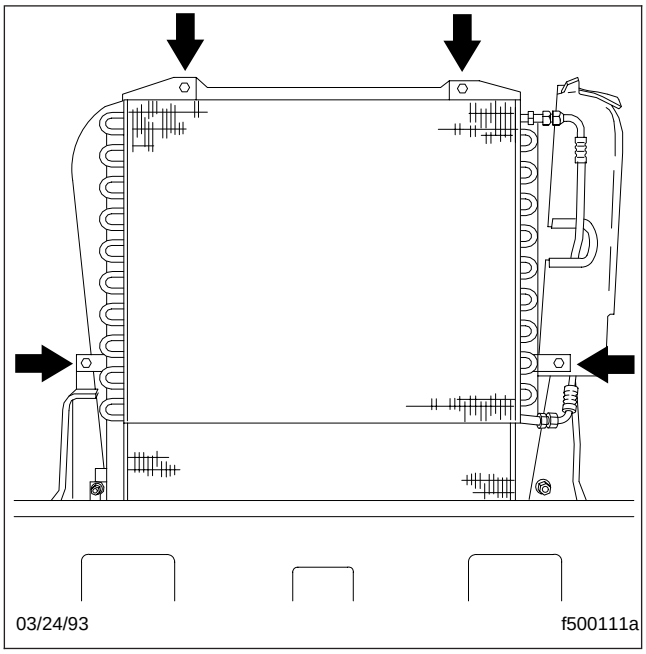


Fig. 6, Condensor Mounting Bolts

5. Remove the condensor, wrap it in a protective blanket, and secure it out of the way. See **Fig. 7**.

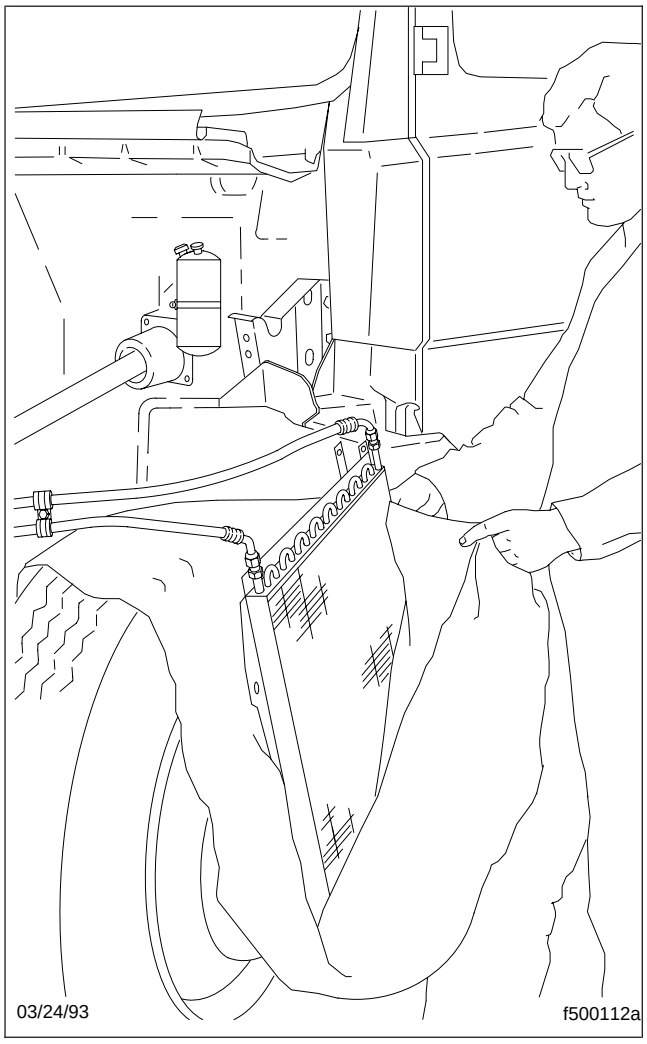


Fig. 7, Condensor Moved Aside

6. Remove the radiator and charge air cooler assembly.
   - 6.1 Remove the air hoses from the charge air cooler. See **Fig. 8.**
   - 6.2 Remove the radiator vent hose and coolant inlet hose from the radiator. See **Fig. 8.**
   - 6.3 Remove the coolant outlet hose from the bottom of the radiator.
   - 6.4 Using lifting chains, secure the radiator and charge air cooler assembly to a crane.
   - 6.5 Remove the radiator mount nuts and washers. See **Fig. 9.**
   - 6.6 Remove the radiator strut nuts, washers, and rubber isolators. See **Fig. 9.**
   - 6.7 Using the crane, lift the radiator and charge air cooler assembly from the vehicle. See **Fig. 10.** Place the assembly charge air cooler-down on a work bench.
7. Disassemble the radiator and charge air cooler assembly.
   - 7.1 Remove the four sheet metal bolts that secure the fan shroud to the radiator. See **Fig. 11.** Remove the fan shroud.
   - 7.2 Remove the four bolts holding the radiator to the charge air cooler. See **Fig. 12.**
   - 7.3 Remove the hood cable brackets from the radiator. See **Fig. 13.**
   - 7.4 Remove the radiator from the charge air cooler. See **Fig. 14.**

Crossmember-Mounted 850- to 1200-Square-Inch Radiators

(See Fig. 15 or Fig. 16)

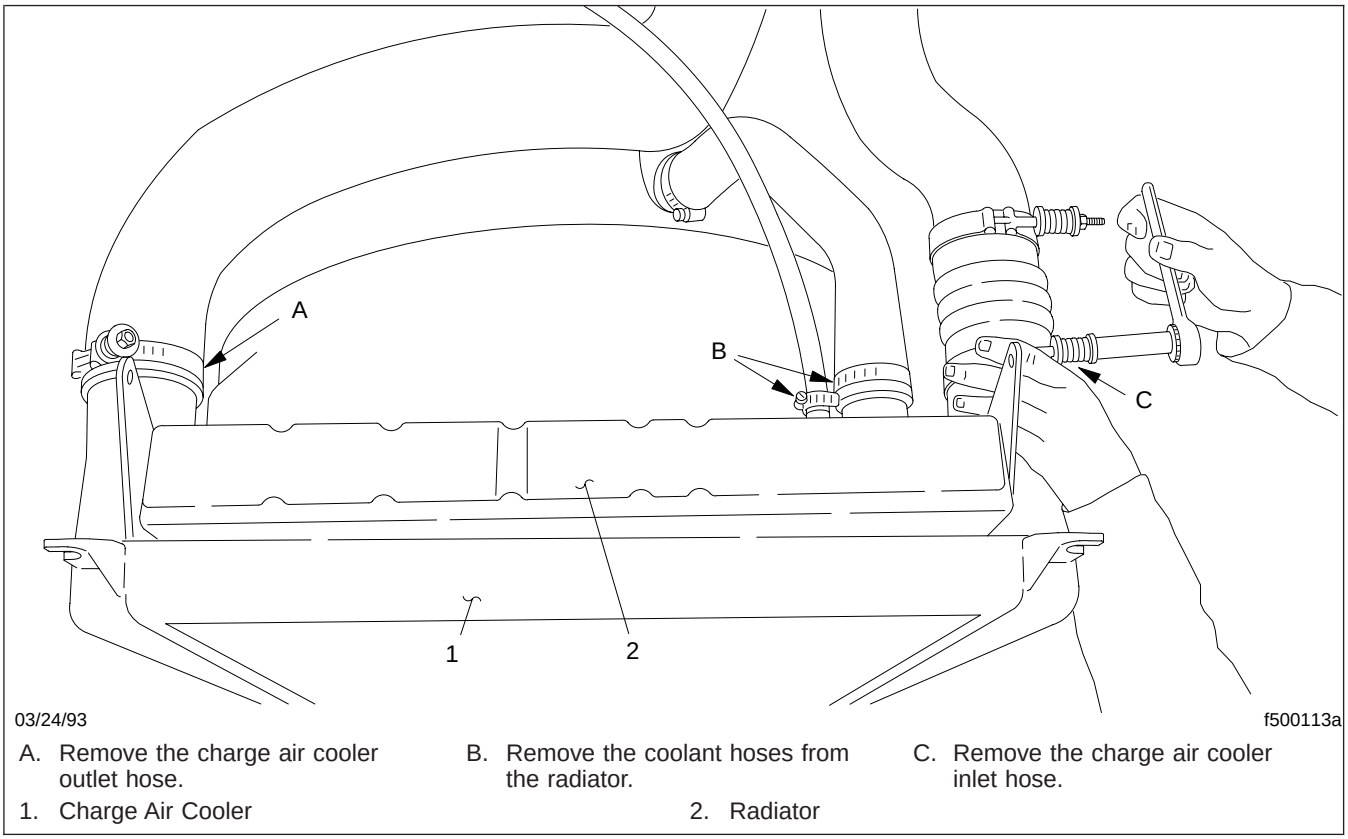
1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.

⚠ WARNING

Do not drain coolant from a hot engine. Opening the cooling system when the engine and coolant are hot can cause severe personal injury due to scalding by the hot, pressurized coolant.

3. Drain the radiator.
   - 3.1 Remove the radiator surge tank cap.
   - 3.2 Open the petcock at the bottom of the radiator to drain the engine coolant.
4. Remove the hood. For instructions, refer to **Group 88** in this service manual.
5. Move the condensor aside.
   - 5.1 Free the refrigerant lines from any routing clamps between the compressor and the

Radiator Removal and Installation



A. Remove the charge air cooler outlet hose.
B. Remove the coolant hoses from the radiator.
C. Remove the charge air cooler inlet hose.
1. Charge Air Cooler
2. Radiator

Fig. 8, Radiator and Charge Air Cooler Hoses

condensor and between the condensor and the receiver dryer.

5.2 Remove the four bolts securing the condensor.

5.3 Move the condensor aside, wrap it in a protective blanket, and use tie straps to secure it out of the way.

6. Remove the radiator and charge air cooler assembly.

6.1 Remove the air recirculation shields from the radiator. For instructions, refer to **Group 09** in this service manual.

6.2 Remove the air hoses from the charge air cooler.

6.3 Disconnect the radiator inlet and outlet lines and the radiator vent line.

6.4 Remove the screws that hold the fan shroud to the radiator, and move the shroud back against the engine.

6.5 Attach the radiator and charge air cooler assembly to a crane with lifting chains.

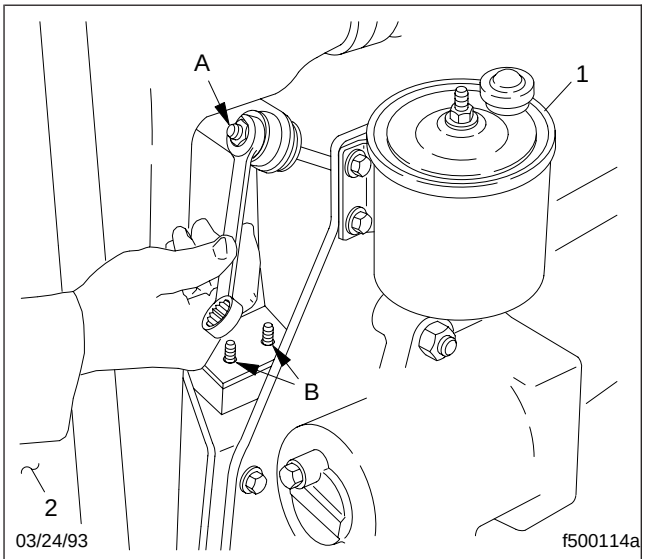
6.6 Remove the nuts that hold the bottom of the radiator to the support bracket.

6.7 Remove the nuts and bolts that hold the brace rods to the top of the radiator.

6.8 Use the crane to lift the radiator and charge air cooler assembly from the vehicle. Place the assembly, charge air cooler up, on a work bench.

7. Disassemble the radiator and charge air cooler assembly.

7.1 Remove the four bolts holding the charge air cooler to the radiator.



A. Remove radiator strut nuts.
B. Remove radiator mount nuts.
1. Power Steering Fluid Reservoir
2. Charge Air Cooler

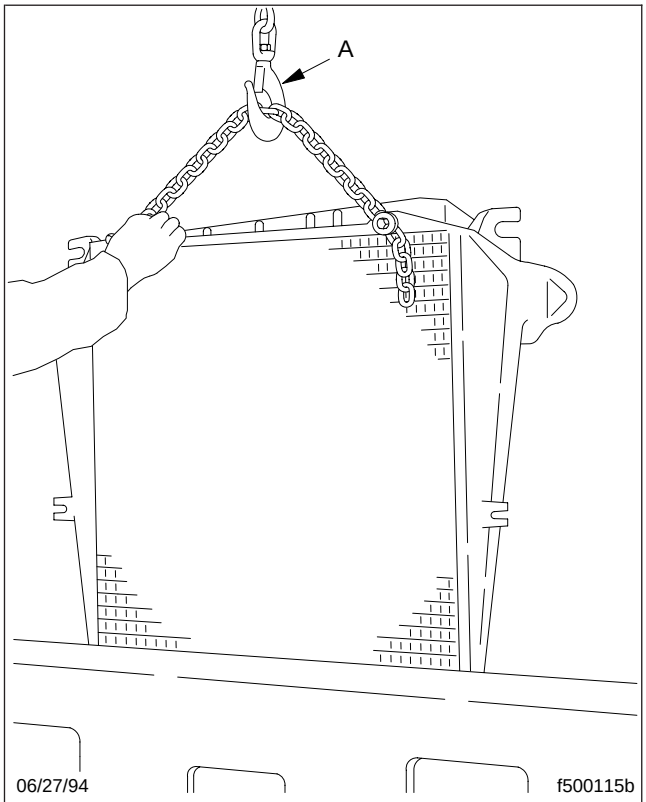
Fig. 9, Radiator Mounts (left side)

7.2 Remove the charge air cooler from the radiator.

Installation

Framerail-Mounted 695- OR 720-Square-Inch Radiators

1. Assemble the radiator and charge air cooler assembly.
   - 1.1 On a work bench, place the radiator on the charge air cooler (**Fig. 14**), and secure it with four bolts and washers. Tighten the bolts 20 N·m (15 lbf·ft). See **Fig. 12**.
   - 1.2 Install the hood cable brackets on the radiator, and tighten the bracket bolts 540 N·cm (48 lbf·in).
   - 1.3 Install the fan shroud with the four sheet metal bolts and washers. Do not tighten the bolts.
2. Install the radiator and charge air cooler assembly.



A. Use a crane to lift the radiator and charge air cooler.

Fig. 10, Lifting the Radiator

- 2.1 Secure a lifting chain to the charge air cooler, and lift the assembly with a crane.
- 2.2 Position the radiator and charge air cooler assembly on the radiator mounting studs. Secure the assembly to the mounts with nuts and washers, and tighten the nuts 40 N·m (30 lbf·ft). See **Fig. 9.**
- 2.3 Secure the radiator support struts with rubber isolators, washers, and nuts, and tighten the nuts 47 N·m (35 lbf·ft). See **Fig. 9.**
- 2.4 Remove the lifting chain from the radiator assembly.
- 2.5 Connect the coolant outlet hose at the bottom of the radiator.
- 2.6 Connect the radiator vent hose and coolant inlet hose to the radiator. See **Fig. 8.**

Radiator Removal and Installation

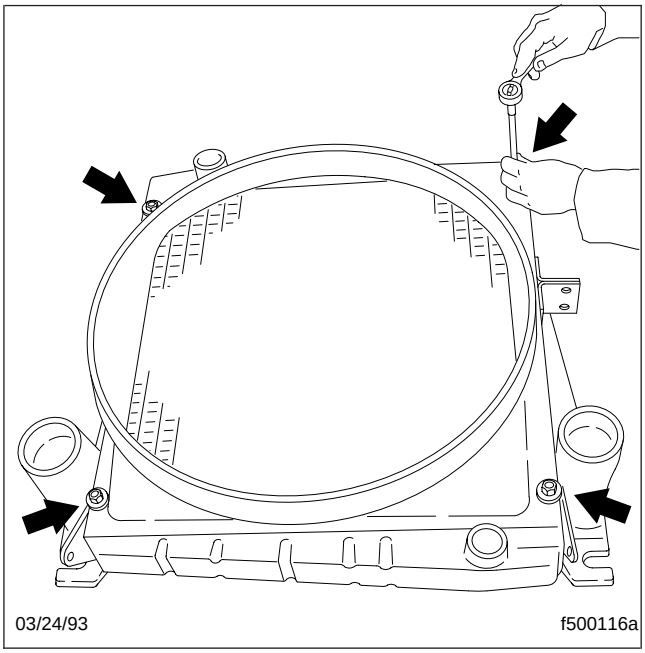
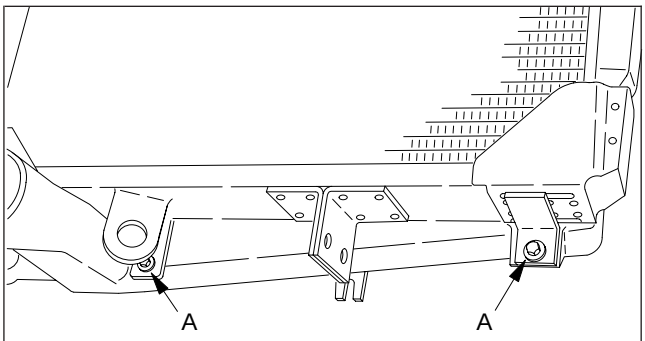
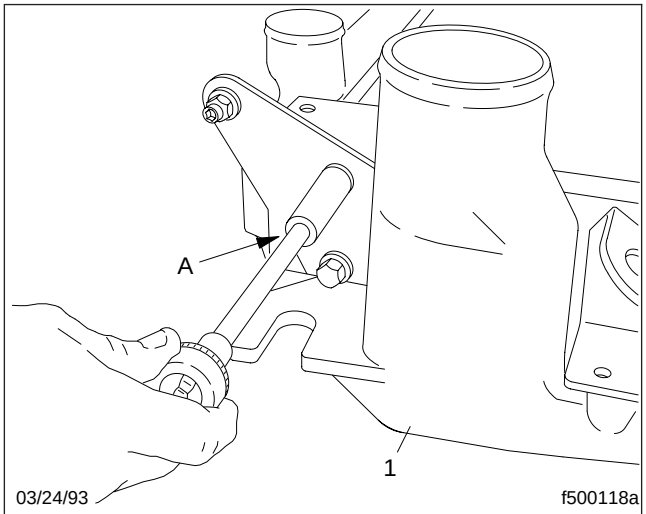


Fig. 11, Removing the Fan Shroud



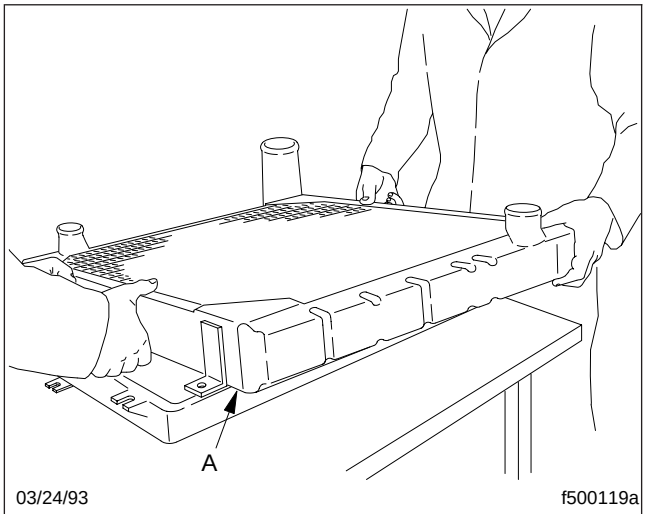
A. Remove the bolts securing the charge air cooler to the radiator.

Fig. 12, Removing the Charge Air Cooler



A. Remove the hood cable brackets.
1. Charge Air Cooler

Fig. 13, Hood Cable Brackets



A. Remove the radiator from the charge air cooler.

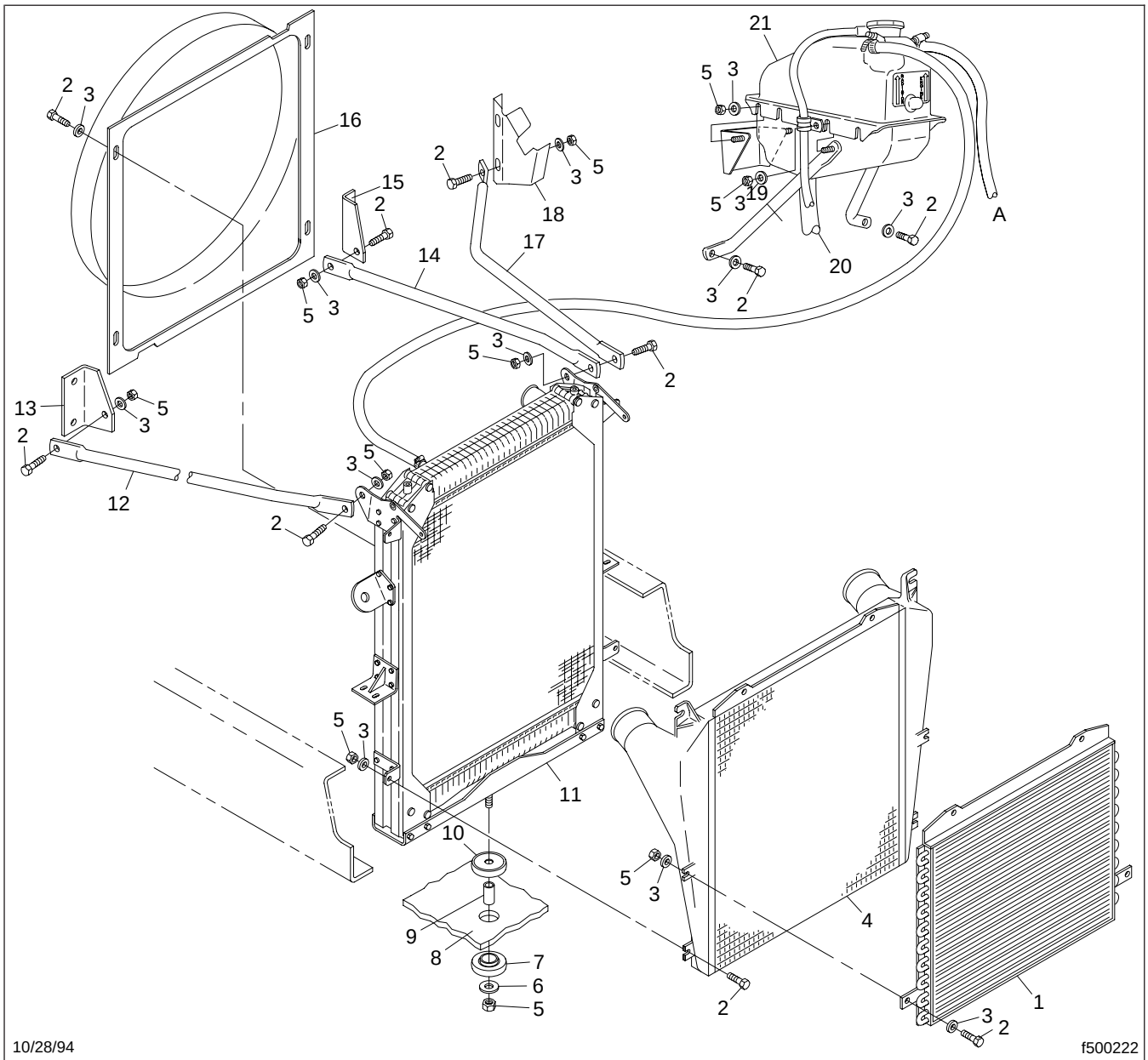
Fig. 14, Radiator Loose from Charge Air Cooler

2.7 Remove the seals from the coolant hose ends, and connect the hoses. Your hose clamps may be T-bolt clamps, (**Fig. 17**), Breeze Constant-Torque clamps, (**Fig. 18**) or ABA radial worm-drive clamps, (**Fig. 19**).

When working with T-bolt type hose clamps, tighten the clamps 620 N·cm (55 lbf·in). These clamps are now standard on hoses with an inside diameter greater than 51 mm (2 inches).

Breeze Constant-Torque hose clamps must be tightened to the correct torque. Properly tightened, the screw tip of the clamp should extend about 6 mm (1/4 inch) from the clamp housing, and the Belleville washer stacks must be collapsed

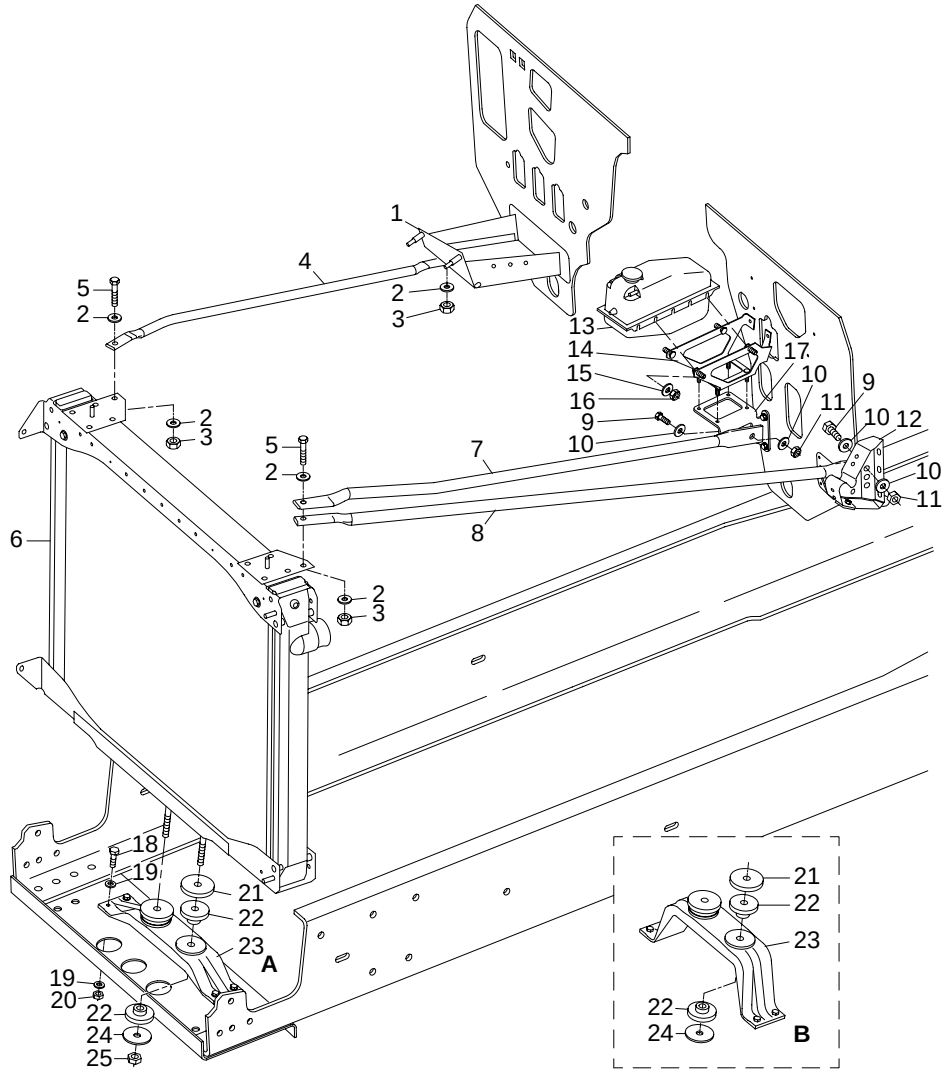
Radiator Removal and Installation



A. to engine
1. Condensor
2. Bolt
3. Washer
4. Charge Air Cooler
5. Nut
6. Washer
7. Lower Radiator Isolator
8. Radiator Underslung Support
9. Spacer Tube
10. Radiator Upper Isolator
11. Radiator
12. Radiator Left Strut
13. Left Strut Bracket
14. Radiator Center Strut
15. Center Strut Bracket
16. Fan Shroud
17. Radiator Right Strut
18. Right Strut Bracket
19. Radiator Vent Hose
20. Fill Hose
21. Surge Tank

Fig. 15, Radiator Installation for Detroit Diesel Engines

Radiator Removal and Installation



06/27/95 f500259

A. Support Bracket for a 1200-Square-Inch Radiator
B. Support Bracket for a 1000-Square-Inch Radiator

1. Air Cleaner Mounting Bracket
2. Washer, 1/2 Inch
3. Nut 1/2–13, Grade 8
4. Right-Hand Radiator Strut Rod
5. Capscrew, 1/2–13x2 Inches, Grade 8
6. Radiator
7. Left-Hand Radiator Strut Rod, Inboard
8. Left-Hand Radiator Strut Rod, Outboard
9. Capscrew, 5/8–11x1.5 Inches, Grade 8
10. Washer
11. Nut, 5/8–11, Grade 8
12. Hood Support Bracket
13. Surge Tank
14. Surge Tank Bracket, Upper
15. Washer
16. Locknut, M8
17. Surge Tank Bracket, Lower
18. Capscrew, 3/8–16x1.25 Inch, Grade 8
19. Washer
20. Nut, 3/8–16, Grade 8
21. Spacer (used only with 11-inch frame rails)
22. Isolator
23. Radiator Support Bracket
24. Washer
25. Nut, 58–11, Grade 8

Fig. 16, Radiator Installation for Cummins M11 Engines

almost flat. Use a torque wrench to install these hose clamps correctly. The correct

installation torque for Breeze Constant-Torque hose clamps is as follows:

For Breeze Constant-Torque hose clamps with a 5/16-inch tightening screw hex: 620 N·cm (55 lbf·in).

For Breeze Constant-Torque hose clamps with a 3/8-inch tightening screw hex: 1020 N·cm (90 lbf·in).

NOTE: All hose clamp adjusters lose torque after installation, due to cold-flow of the hose material from under the clamp. Breeze Constant Torque clamps typically show a 30 percent loss of torque shortly after installation; a 50 percent loss after heat-cycling, and up to 80 percent loss after time and repeated heat cycles. However, when correctly installed, Breeze Constant-Torque clamps adjust automatically, holding enough torque to keep consistent sealing pressure. During vehicle operation and shutdown, the screw tip may adjust in and out, according to temperature and pressure changes. The torque may need to be adjusted for individual applications.

ABA Radial worm-drive hose clamps may lose 30 percent of their torque at the screw adjuster, shortly after being correctly tightened. This is due to cold-flow of the hose material, not an actual loosening of the clamp. This is the way they are designed to work, they should not be tightened further. To check the torque of an ABA clamp, it must be loosened completely, then torqued to the proper value listed in **Table 1**. Overtightening an ABA Radial worm-drive hose clamp can result in coolant leaks.

2.8 Connect the air hoses to the charge air cooler.

3. Secure the fan shroud.

3.1 Adjust the vertical clearance between the top of the fan blade and the fan shroud opening. It should be equal within 1/8 inch (3 mm) to the clearance between the bottom of the blade and the shroud opening.

3.2 Tighten the screws 1220 N·cm (108 lbf·in).

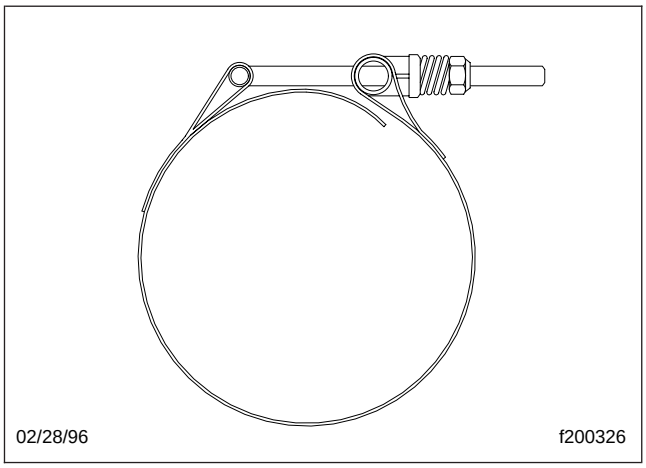
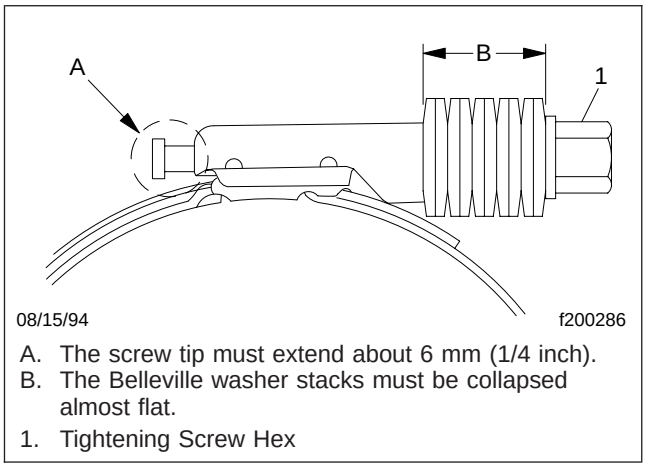


Fig. 17, T-bolt Type Hose Clamp



A. The screw tip must extend about 6 mm (1/4 inch).
B. The Belleville washer stacks must be collapsed almost flat.
1. Tightening Screw Hex

Fig. 18, Breeze Constant-Torque Hose Clamp Installation

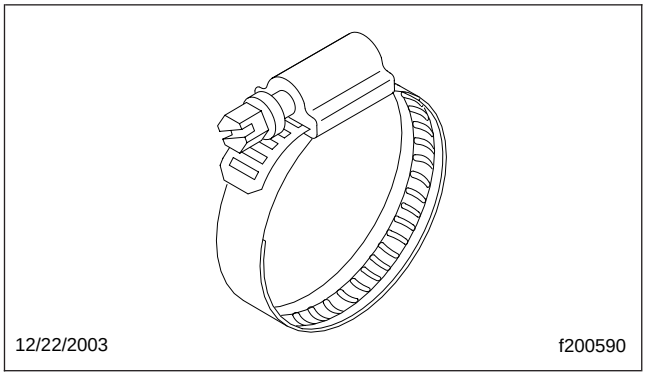


Fig. 19, ABA Radial Worm-Drive Hose Clamp(typical)

4. Install the condensor.

Radiator Removal and Installation

4.1 Install the condensor on the charge air cooler, and secure it with the four mounting bolts. Install the radiator vent hose bracket with the top, right mounting bolt. See **Fig. 5** and **Fig. 6.** Tighten the bolts 20 N·m (15 lbf·ft).

4.2 Install the air recirculation shield on the charge air cooler left mounting tab. See **Fig. 4.** Tighten the bolt 20 N·m (15 lbf·ft).

4.3 Clamp the refrigerant lines to the left radiator support strut. See **Fig. 3.**

5. Install the hood. For instructions, refer to **Group 88** in the vehicle service manual.
6. Fill the coolant system, and install the surge tank cap.
7. Start the engine and check for coolant leaks. Repair any leaks. After idling the engine for 15 to 20 minutes, add more coolant if necessary.
8. Lower the hood, and remove the chocks from the tires.

Crossmember-Mounted 850- TO 1000-Square-Inch Radiators

(See Fig. 15)

1. Assemble the radiator and charge air cooler assembly.
   1.1 On a work bench, place the radiator on the charge air cooler, and secure it with four bolts and washers.
   1.2 Tighten the bolts 20 N·m (15 lbf·ft).
2. Install the radiator and charge air cooler assembly.
   2.1 Place the fan shroud in position around the fan.
   2.2 Secure a lifting chain to the charge air cooler, and lift the assembly with a crane.
   2.3 Place the upper radiator isolator and washer on the hole in the support bracket, and position the radiator and charge air cooler assembly on the support. Hold the lower radiator isolator and washer in position, and secure the assembly to the support with locknuts.

   For 850-square-inch radiators: tighten the locknuts 327 N·m (241 lbf·ft).

   For 1000-square-inch radiators: tighten the locknuts 122 N·m (90 lbf·ft).

   2.4 Secure the radiator brace rods to the top of the radiator with bolts, washers, and locknuts.

   For 850-square-inch radiators, tighten the locknuts 92 N·m (68 lbf·ft).

   For 1000-square-inch radiators, tighten the locknuts 122 N·m (90 lbf·ft).

   2.5 Remove the lifting chain from the radiator assembly.
   2.6 Connect the coolant inlet and outlet hoses and the vent hose to the radiator.
   2.7 Connect the radiator vent hose and coolant inlet hose to the radiator.
   2.8 Remove the seals from the coolant hose ends, connect the hoses to the radiator, and tighten the hose clamps.
   2.9 Connect the air hoses to the charge air cooler. Tighten the constant torque hose clamps 680 N·cm (60 lbf·in).
3. Secure the fan shroud.
   3.1 Adjust the vertical clearance between the top of the fan blade and the fan shroud opening. It should be equal within 1/8 inch (3 mm) of the clearance between the bottom of the blade and the shroud opening.
   3.2 Tighten the screws 1220 N·cm (108 lbf·in).
4. Install the condensor on the charge air cooler, and secure it with the four mounting bolts. Tighten the bolts 20 N·m (15 lbf·ft).
5. Route and clamp the refrigerant lines.
6. Install the hood. For instructions, refer to **Group 88** in the vehicle service manual.
7. Fill the coolant system, and install the surge tank cap.
8. Start the engine and check for coolant leaks. Repair any leaks. After idling the engine for 15 to 20 minutes, add more coolant if necessary.

9. Lower the hood, and remove the chocks from the tires.

Hose Clamp Torque Values		
Clamp Type	**Size**	**Torque: lbf·in (N·cm)**
T-Bolt	All	55 (620)
Breeze Constant-Torque	5/16-inch tightening screw hex	90 (1020)
	3/8-inch tightening screw hex	90 (1020)
ABA	1.26-inch Diameter	31 (360)
	1.50-inch Diameter	35 (400)
	1.73-inch Diameter	35 (400)
	1.97-inch Diameter	35 (400)
	2.28-inch Diameter	35 (400)
	2.68-inch Diameter	40 (460)
	3.03-inch Diameter	40 (460)

Table 1, Hose Clamp Torque Values

Radiator Disassembly and Assembly

IMPORTANT: Disassembling and assembling nylon top- and bottom-tank radiators requires the special tools listed in **Table 1 :**

Description	Quantity
Plastech II® Tanking Machine With Five 2-Inch Cylinders	1
T-Bar	1
Hooked-End Bar	1
Wave Form Bar	1

Table 1

Order these tools from:

RAD PAL
2381 17 St.
Detroit, , MI 48216

(313) 963–3194

Disassembly

Before disassembling the radiator, pressure flush it and check the surge tank, following the instructions in the radiator group of the vehicle maintenance manual. Clean and check the exterior of the radiator, following the instructions in the vehicle driver's manual.

1. Remove the radiator from the vehicle; for instructions, refer to **Subject 100** .

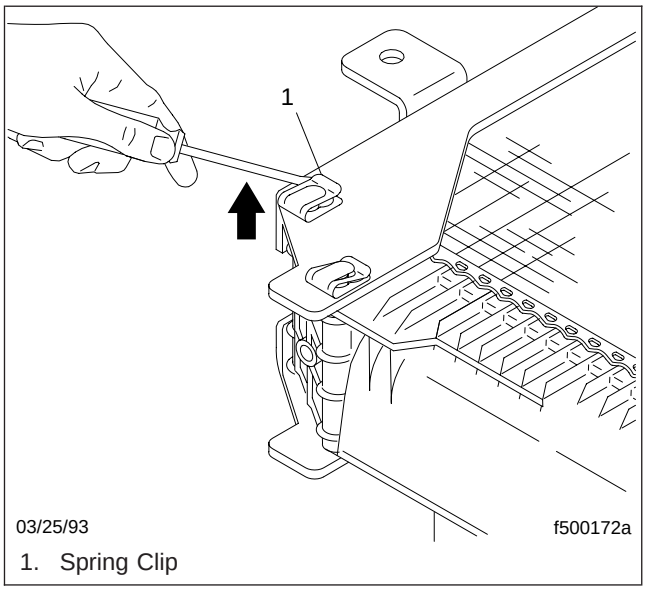
⚠ CAUTION

CAUTION: Use care when handling or supporting the nylon top and bottom tanks. Failure to do so could damage the tanks.

2. Remove the side channels from the radiator assembly.

   2.1 Remove the eight spring clips that hold the side channel mounting pins in position. **See Fig. 1.** Insert a screwdriver blade in the open end of each clip, and pry the clip open until it clears the edge of the mounting pin. Then, slip the clip off the pin.

   2.2 Use a rubber mallet and a punch to tap out the eight mounting pins. **See Fig. 2.**



1. Spring Clip

Fig. 1

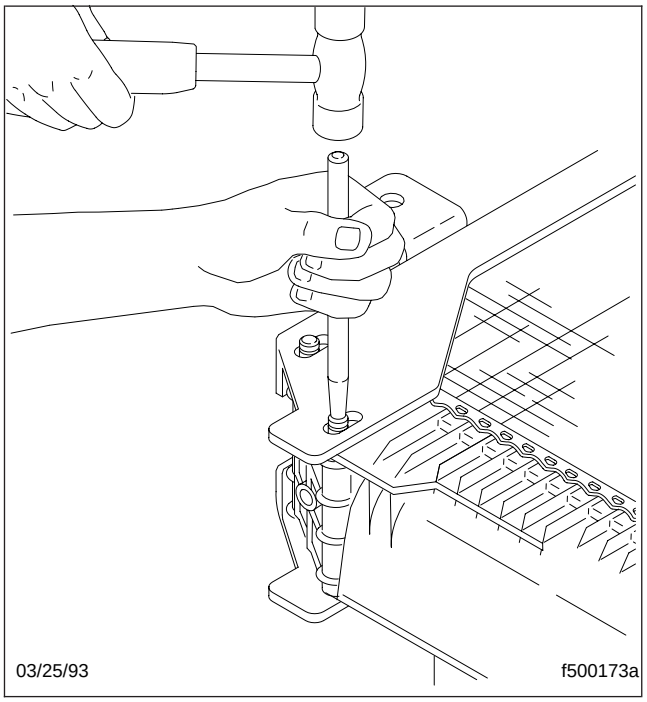
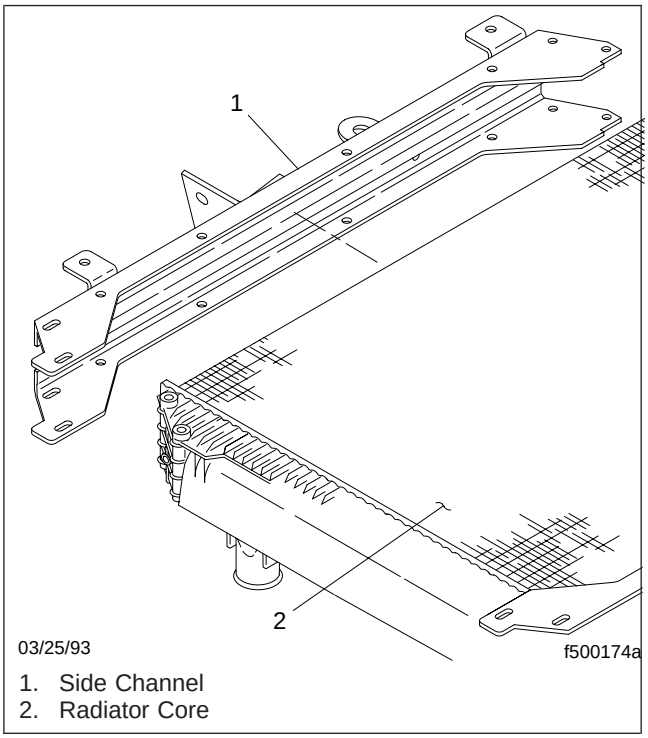


Fig. 2

   2.3 Slip the side channels off the radiator core and tank assembly. **See Fig. 3.**

3. Leak test the radiator core and tank assembly.

Radiator Disassembly and Assembly



1. Side Channel
2. Radiator Core

Fig. 3

3.1 Securely plug all tank ports.

CAUTION

CAUTION: Don't apply a higher amount of pressure than specified below; too much pressure will damage the radiator core.

3.2 At one tank port, install a pressure regulator and gauge. Using a hand pump, apply 138 kPa (20 psi) air pressure through the port.

3.3 Submerge the radiator in a tank of water and check it for leaks. Mark any leaks for repair. If a leak is between the radiator core header and a tank, remove the tank and inspect the tank flange, the header sealing surface, and the sealing gasket. If the leak is in the core, but within 7.5 cm (3 inches) of the tank, remove the tank before repairing the leak. If the leak is in the tank, replace the tank.

4. Remove the top and bottom tanks.

4.1 Place the radiator core and tank assembly in the disassembly/assembly fixture, and clamp the assembly securely in place. **See Fig. 4**

4.2 Position the tank clamping cylinders evenly across the top of the tank. Make sure the cylinders' rubber plungers will not press against breakable fittings, such as vent tube ports.

CAUTION

CAUTION: Apply only enough pressure to compress the sealing gasket. Too much pressure will crack the nylon tank.

4.3 Apply pressure evenly across the top of the tank until the tank-to-core sealing gasket is compressed enough to show a small gap between the bottom of the dimple wave lock crimp and the tank sealing flange.

CAUTION

CAUTION: In some places, especially around the tank ports, the wave lock crimps may have to be unlocked with a screwdriver. When using a screwdriver, use care not to crack or gouge the nylon tank.

4.4 Place the T-bar into the T-bar groove in the disassembly/assembly fixture. **See Fig. 5.**

4.5 Slide the hooked-end bar over the T-bar. Place the hook over the top of the wave crimp and pull the T-bar back to unlock the crimp. **See Fig. 5 .**

4.6 Slide the hooked-end bar and the T-bar down the T-bar groove to the next wave crimp, and repeat the previous step until all the wave crimps are unlocked.

5. Once the wave crimps are unlocked, remove the tank.

5.1 Release the pressure from the tank, and move the clamping cylinders off the radiator core and tank assembly.

Radiator Disassembly and Assembly

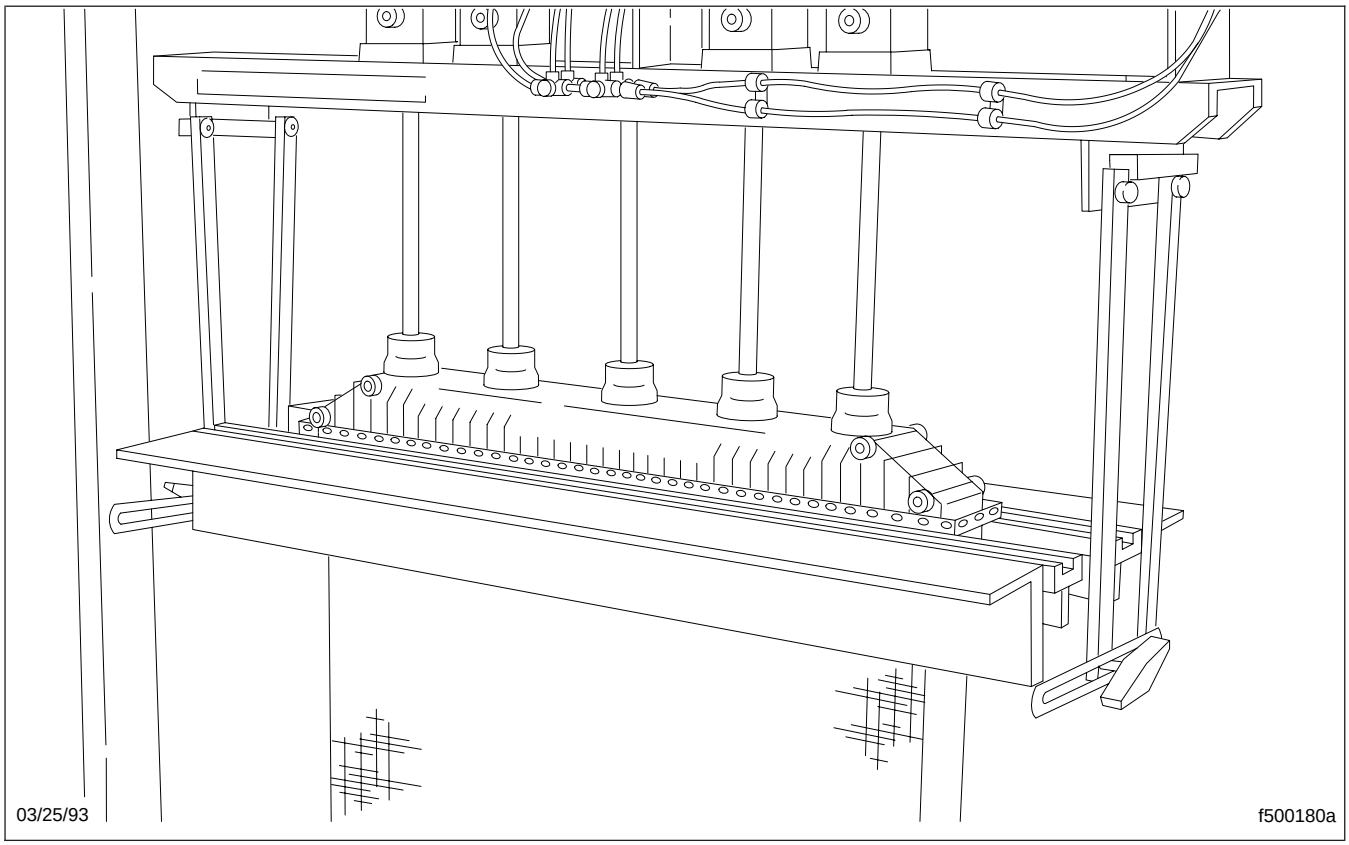


Fig. 4

CAUTION

CAUTION: If needed, use a rubber mallet or the heel of your hand and tap the side of the tank to loosen it. Do not use a screwdriver against the tank sealing flange. A screwdriver blade may damage the flange and prevent a good seal after the tank is installed.

5.2 Lift the tank from the forward side, the side opposite the tank ports. Remove the nylon tank from the radiator core. **See Fig. 6.**

5.3 Remove the sealing gasket from the sealing surface of the radiator core header. **See Fig. 7 .**

5.4 Clean the sealing surface of the radiator core header.

5.5 Repair any leaks marked during leak testing, step 3.

5.6 Repeat steps 4 and 5 to remove the opposite tank.

IMPORTANT: Check the tubes of the radiator core for scale deposits. If the radiator has been pressure-flushed, and the tubes are still clogged, the radiator should be rodded or boiled out with acid by an experienced radiator shop. Otherwise, replace the core.

Assembly

1. Install the nylon top and bottom tanks on the radiator core.

1.1 With the radiator securely clamped in the disassembly/assembly fixture, header sealing surface up, make sure the bottom of the radiator core and tank assembly is completely supported, and that the

Radiator Disassembly and Assembly

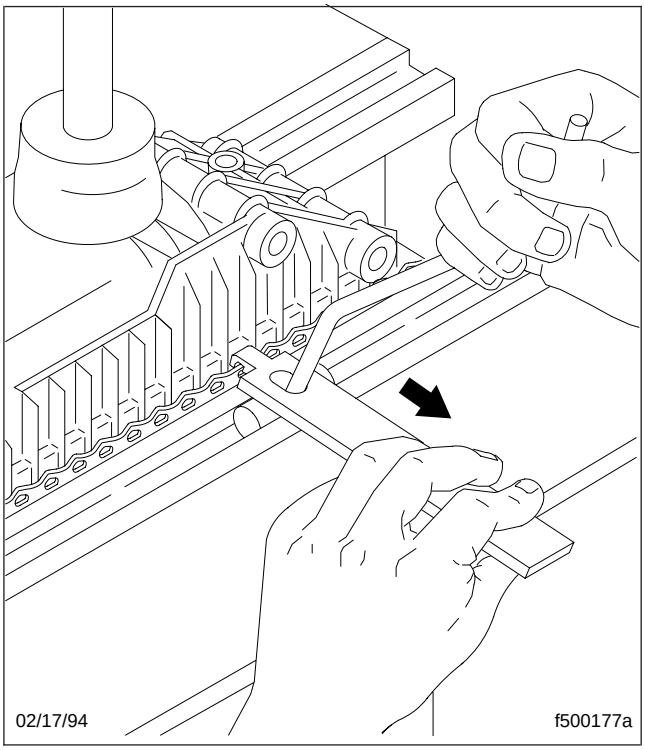


Fig. 5

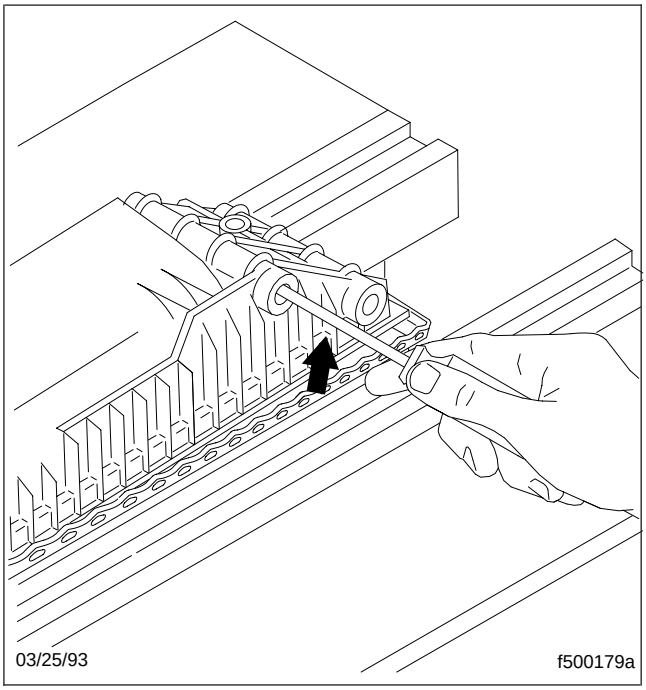
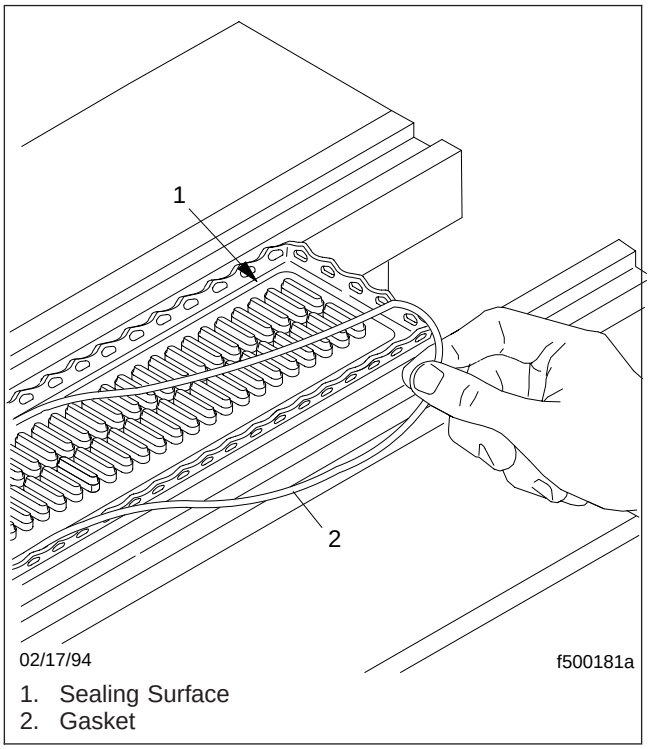


Fig. 6



1. Sealing Surface
2. Gasket

Fig. 7

header sealing surface is free of any dents, tool marks, or foreign particles.

1.2 Lubricate a new sealing gasket with a soap and water solution, and position the gasket on the header sealing surface. **See Fig. 7.** To make sure the gasket is not twisted, run a finger along the gasket as it lies on the sealing surface. The mold lines of the gasket should be on the outside and inside diameters of the gasket; if you can feel a mold line cross over the top of the gasket, the gasket is twisted.

1.3 Inspect the tank sealing flange. The flange must be clean and free of defects. If the sealing flange is damaged, replace the tank.

1.4 Place the tank on the gasket, and tap the tank with a rubber mallet or the heel of your hand to seat the tank. Make sure the tank ports are facing the correct direction.

1.5 Position the tank clamping cylinders evenly across the top of the tank. Make sure the cylinders' rubber plungers will

not press against breakable fittings, such as vent tube ports. **See Fig. 4.**

CAUTION

CAUTION: Apply only enough pressure to compress the sealing gasket. Too much pressure will crack the nylon tank.

1.6 Apply pressure evenly across the top of the tank until the tank-to-core sealing gasket is compressed enough to show a small gap between the bottom of the dimple wave lock crimp and the tank sealing flange.

1.7 Place the T-bar into the T-bar groove in the disassembly/assembly fixture.

1.8 Slide the wave form bar over the T-bar, and center the bar in front of the wave crimp slot.

CAUTION

CAUTION: Do not push the wave crimp until it touches the side of the nylon tank, or the tank may crack.

1.9 Push the T-bar forward to crimp the header's edge until it almost touches the tank's side. **See Fig. 8.**

1.10 Slide the tools down the T-bar groove to the next wave crimp slot, and repeat steps 1.8 and 1.9 until all the wave crimps are crimped.

CAUTION

CAUTION: In some places, especially around the tank ports, the wave crimps may have to be crimped with a screwdriver. When using a screwdriver, use care not to crack or gouge the nylon tank.

1.11 Release the pressure from the tank, and move the clamping cylinders off the radiator core and tank assembly.

1.12 Repeat step 1 to install the opposite tank.

2. Leak test the radiator core and tank assembly. For instructions, refer to "Disassembly."

3. Install the radiator side channels.

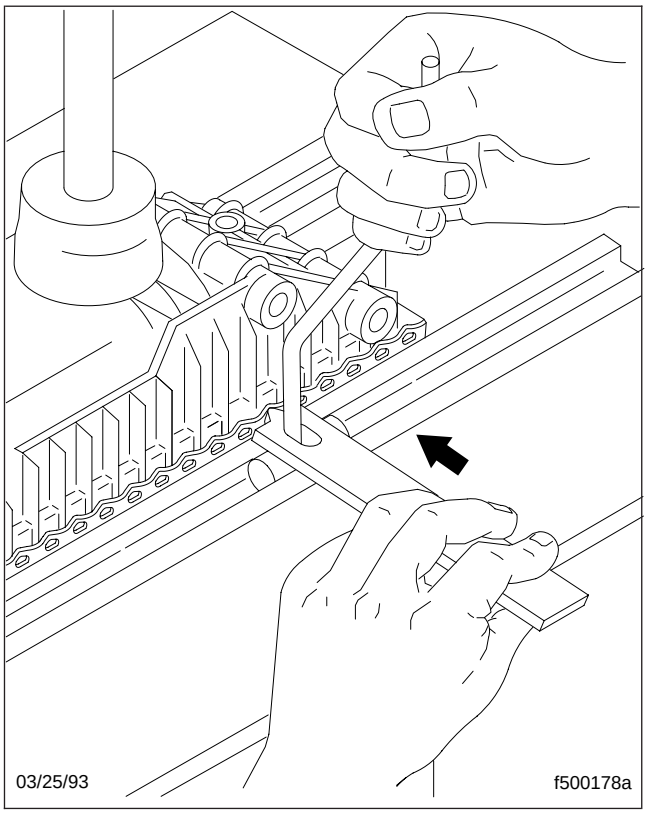


Fig. 8

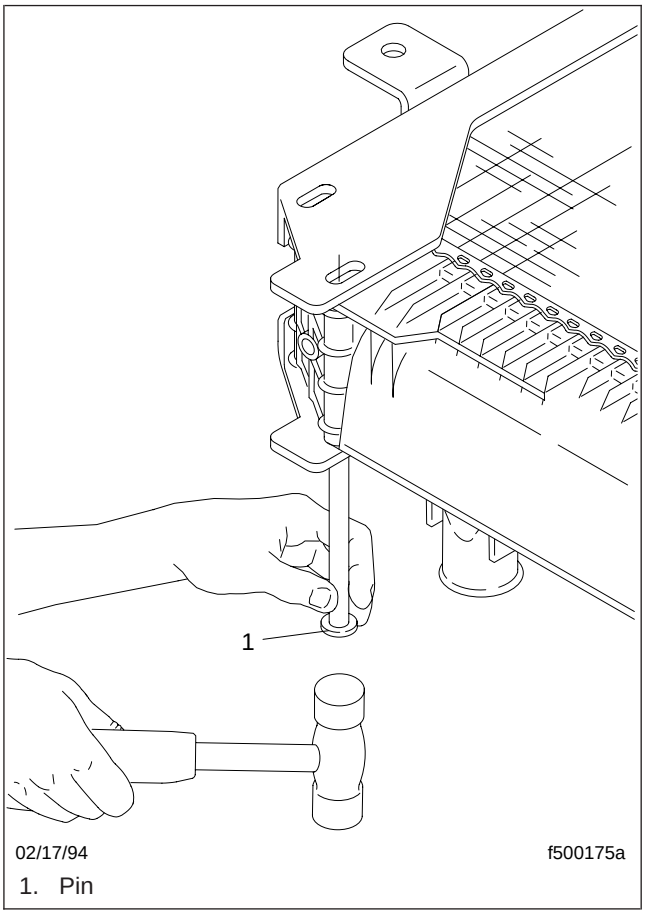
3.1 Slide the side channels onto the radiator core and tank assembly.

3.2 Using a rubber mallet and a punch, install the eight mounting pins through the side channel holes and tank bosses. **See Fig. 9.**

3.3 Install the eight spring clips to secure the mounting pins in position. **See Fig. 10.** To install each clip, place the clip over the end of the mounting pin, and slide the clip until it engages the groove in the pin and the open end of the clips snaps over the edge of the pin. If necessary, use a clamp to compress the side channel while installing the clips.

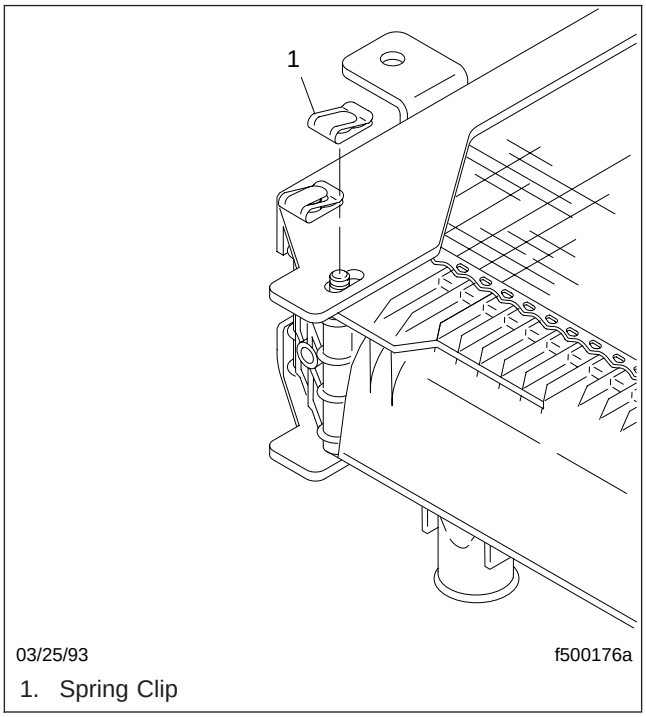
4. Install the radiator in the vehicle. For instructions, **refer to Subject 100.**

Radiator Disassembly and Assembly



1. Pin

Fig. 9



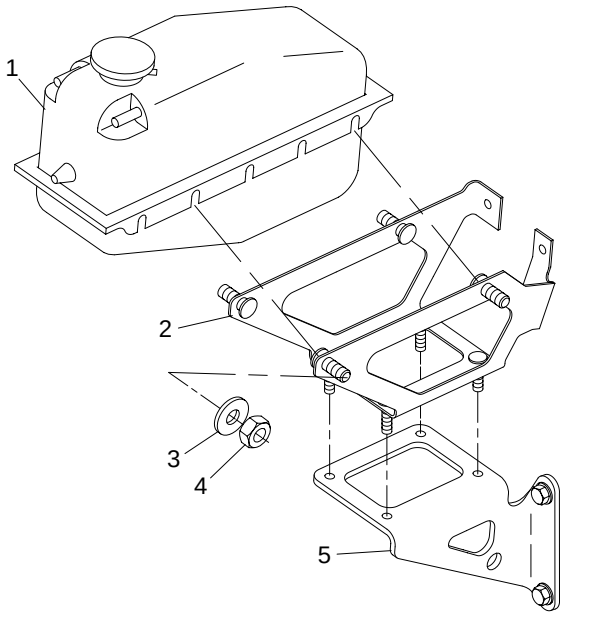
1. Spring Clip

Fig. 10

Surge Tank Removal and Installation

Removal

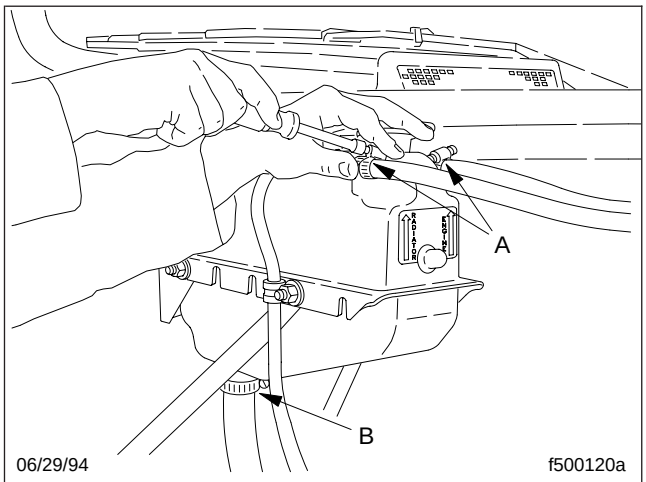
NOTE: In Business Class vehicles, Freightliner mounts the remote surge tank in two ways. In vehicles equipped with Cummins M11 or Detroit Diesel Series 55 engines, the surge tank is mounted on the driver's side of the bulkhead. **See Fig. 1.** In vehicles equipped with other engines, the surge tank is mounted on the passenger's side of the bulkhead. **See Fig. 2.**



1. Surge Tank
2. Surge Tank Bracket, Upper
3. Washer
4. Locknut, M8
5. Surge Tank Bracket, Lower

Fig. 1, Surge Tank Mounting for a Cummins M11 or a Detroit Diesel Series 55 Engine

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.



A. Disconnect the engine and radiator vent hoses.
B. Disconnect the fill hose.

Fig. 2, Surge Tank Mounting for All Engines Except a Cummins M11 or a Detroit Diesel Series 55 Engine

⚠ WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

3. Drain the radiator.
   - 3.1 Remove the surge tank cap.
   - 3.2 Open the petcock or remove the drain plug on the bottom of the radiator to drain the engine coolant. Drain only enough coolant to empty the surge tank.
4. Remove the surge tank.

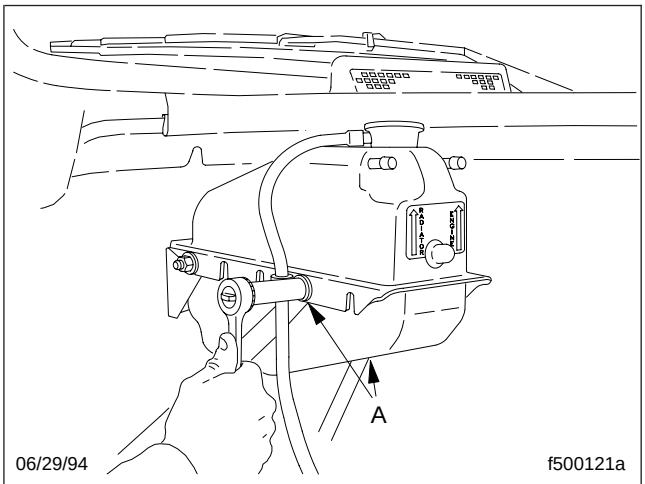
   NOTE: Cap all the disconnected hoses to prevent the remaining coolant from spilling.

   - 4.1 Disconnect the engine and radiator vent line from the front of the surge tank.
   - 4.2 Disconnect the fill hose from the bottom of the surge tank.
   - 4.3 *On M11 and Detroit Diesel Series 55 engines,* remove the nuts that hold the tank to the bracket. **See Fig. 1.** Then, lift the tank out of the bracket.

     On other engines, remove the two surge tank support struts. **See Fig. 3.**

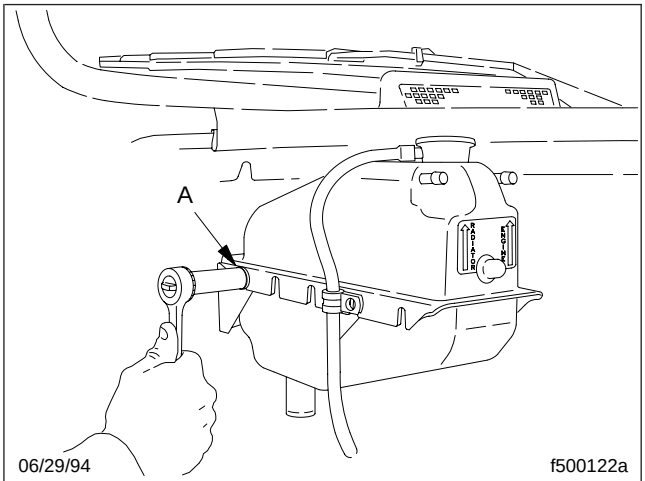
Surge Tank Removal and Installation

Then, loosen the surge tank mounting nuts (**see Fig. 4**), and remove the tank by lowering the front end first. **See Fig. 5.** Lift the rear end off the mounting bracket, and remove the tank.



A. Remove the surge tank struts.

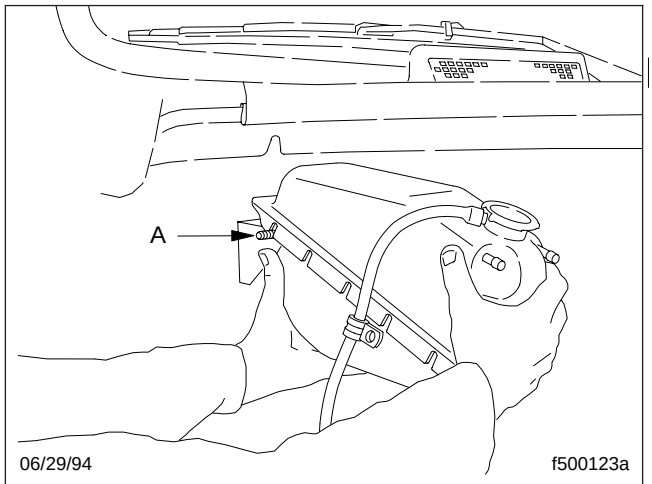
Fig. 3, Surge Tank Struts



A. Loosen the mounting nuts.

Fig. 4, Surge Tank Mounting Nuts

5. Turn the sight glass counterclockwise to remove it.



A. Lift the tank off the mounting bracket.

Fig. 5, Removing the Surge Tank

Installation

1. If the surge tank sight glass has been removed, replace it by twisting it into the sight glass hole clockwise. Make sure the rubber seal ring is in place on the sight glass.
2. Install the surge tank.
   - 2.1 *On M11 and Detroit Diesel Series 55 engines,* place the surge tank in the bracket. **See Fig. 1.** Then, secure the tank with nuts, and tighten the nuts 30 lbf·ft (40 N·m).
   - 2.2 *On other engines,* install the surge tank on its mounting bracket by placing the two rear mounting studs in the bracket notches and installing the mounting nuts. **See Fig. 4.** Tighten the nuts 30 lbf·ft (40 N·m).
   - 2.3 Install the two support struts. **See Fig. 3.** Tighten the strut nuts 30 lbf·ft (40 N·m).
3. Connect the hoses to the tank.
   - 3.1 Connect the surge tank fill hose. **See Fig. 2.**
   - 3.2 Connect the engine and radiator vent hoses to the front of the tank.
4. Fill the coolant system, and install the surge tank cap.

5. Start the engine and check for coolant leaks. Repair any leaks.
6. Lower the hood, and remove the chocks from the tires.

Pressure Testing

1. Remove the radiator. For instructions, **refer to "Radiator Removal and Installation, 100."**
2. Pressure test the radiator as follows:
   - 2.1 Leaving the coolant inlet port open, plug the outlet, and all other ports on the radiator.
   - 2.2 Using the necessary adaptor, connect a pressure regulator and a gauge on the coolant inlet port. Use a hand pump to apply 138 kPa (20 psi) air pressure through the inlet port.

⚠ CAUTION

CAUTION: Don't apply a higher amount of air pressure; too much pressure will damage the radiator core.

   - 2.3 Submerge the radiator in a tank of water and check it for leaks. Remove the radiator from the water.
   - 2.4 Remove the plugs and testing gauge. Repair the radiator, if necessary.
3. Install the radiator. For instructions, **refer to "Radiator Removal and Installation, 100."**

NOTE: For additional troubleshooting information, refer to Section 20.00.

Visual Check

It's a sound service practice to give the cooling system a quick visual check whenever you tilt the hood. Look for signs of visible leaks (or the stains they leave), especially on the engine block. A final check is to look at the inside of the oil breather cap for signs of a milky substance —which means that coolant is leaking into the oil.

Air Conditioner Condensor and Air-to-Air Aftercooler

Since the condensor and aftercooler are right in front of the radiator, air must pass through them to get to the radiator. For the heat transfer process to take place, the fins of the radiator , the condensor, and the aftercooler must be free of blockages and deposits such as dirt or bugs. Clean the surfaces with compressed air or water and a mild laundry soap.

Also remember that because the three heat-transfer parts are so close to each other, heat will pass between them. A blocked condensor will transfer its heat to the aftercooler and a hot aftercooler will transfer its heat to the radiator.

Radiator Cap

The radiator cap is the most often ignored part in the cooling system. If it's suspect, replace it. An inspection means checking the cap with a pressure tester. A radiator cap in good condition will not open below 62 kPa (9 psi). A visual check is also in order: look for signs of deterioration on the inner gasket. Also look for cracks or breaks in the spring retainer in the cap and for corrosion or deposits on the spring itself. If the spring is not in perfect condition, it has probably lost tension; replace it.

Engine Coolant

Check the level of the coolant at the surge tank. It should be up to the sight glass.

If the engine coolant is dirty or its color is beginning to fade, change it. It should also be replaced if it has a dead fish smell.

Be sure that the mixture is correct. Refer to the maintenance manual for specifications.

Radiator

Radiator problems are limited to external leaks, which can be spotted visually, and internal blockages, assuming that there is good airflow and that the radiator is large enough to do the job.

To check for blockages, warm the engine to normal operating temperature. Shut down the engine, and pass your hand in front of the finned surface of the radiator. If there is a blockage in the radiator it should cause an obvious temperature difference from one area of the core to another. An obvious difference between inlet and outlet temperatures, however, is to be expected.

Fan

Refer to the applicable section in this group for fan and fan clutch checks.

Specifications

Description	Grade	Size	Torque	
			N·m (lbf·ft)	N·cm (lbf·in)
Aftercooler-to-Radiator Mounting Bolts	5	5/16 inch	20 (15)	—
Hood Cable Bracket Bolts	8.8	10 mm	—	540 (48)
Fan Shroud Mounting Bolts	8	1/4 inch	—	1220 (108)
Radiator Mount Nuts	5	3/8-16	40 (30)	—
Radiator Strut Nuts	2	1/2-13	47 (35)	—
Aftercooler Hose Clamps	5	6.3 mm	—	680 (60)
Condensor Mounting Bolts	5	5/16 inch	20 (15)	—
Air Recirculation Shield Bolts	5	5/16 inch	20 (15)	—
Surge Tank Mounting Bolts	5	10 mm	40 (30)	—
Surge Tank Strut Nuts	5	10 mm	40 (30)	—
Radiator Isolator Bolt Locknut	8	3/4 inch	327 (241)	—
Radiator Brace Rod Locknuts	8	1/2 inch	92 (68)	—

Table 1, Fastener Torques

General Description (See Fig. 1)

The fan drive senses the air temperature behind the radiator core, and engages or disengages the fan depending on that temperature. An increase or decrease in the amount of heat from the radiator coolant causes a change in the air temperature behind the radiator core. A coiled metal heat sensor (Ref. 1) on the fan drive detects the temperature change; it engages the fan clutch when more cooling (airflow) is needed, and disengages it when the engine is sufficiently cooled.

The fan clutch consists of two basic parts: the input plate and shaft (Refs. 2 and 3), and the output plate (Ref. 6). The input shaft is mounted to the fan hub so it and the input plate are constantly turning as the engine runs. The output plate carries the fan blades (Ref. 7) but engages with the input plate only when extra engine cooling is needed.

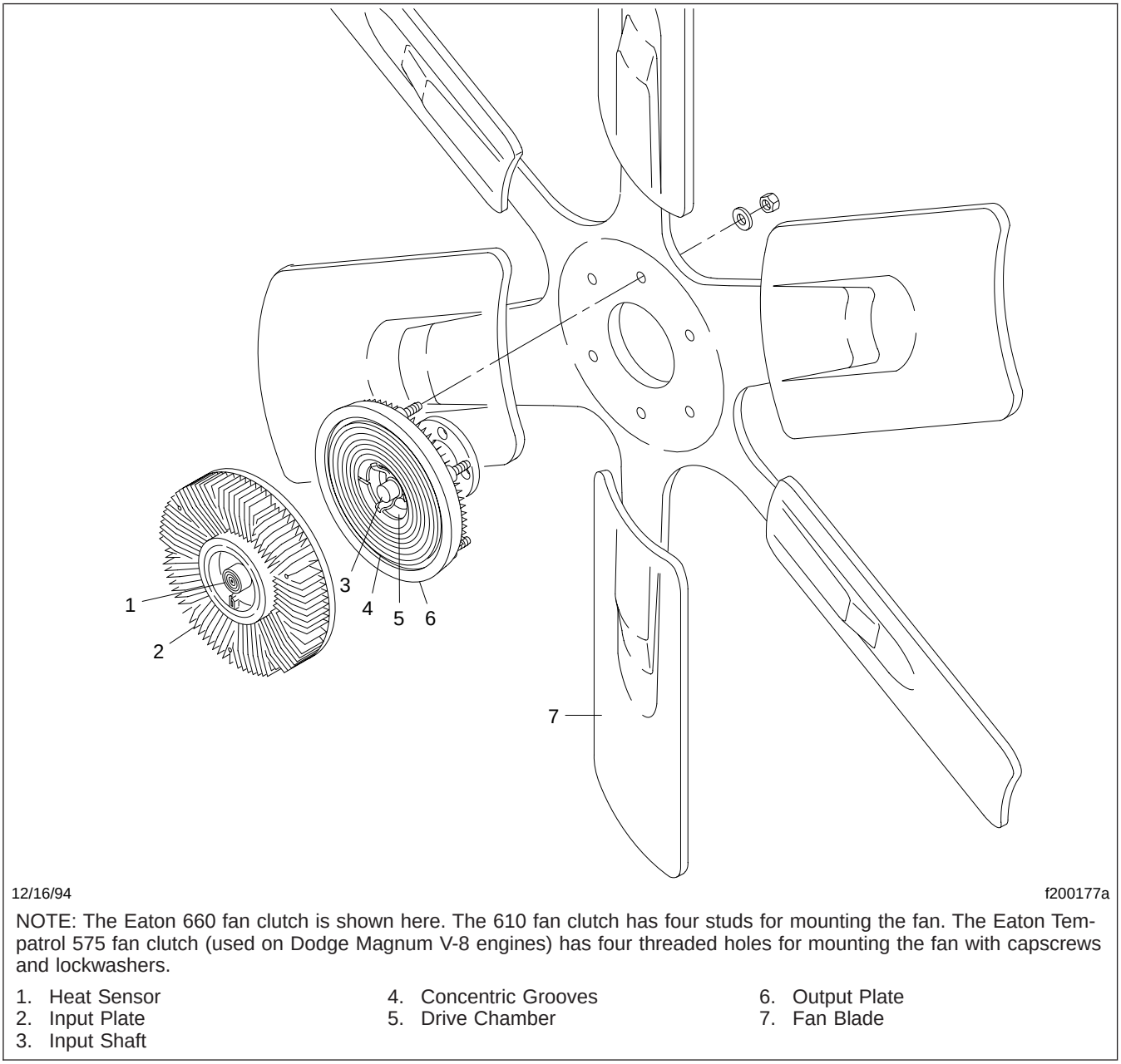
When the fan is disengaged, a single bearing allows the output plate and fan to free-wheel in relation to the input shaft and plate. Both the output and input plates are lined with concentric grooves (Ref. 4) which intermesh with very close tolerance.

To engage the fan, the heat sensor on the front of the clutch opens a valve in the clutch's drive chamber (Ref. 5). The centrifugal force of the turning input plate forces the viscous (thick) silicone fluid stored in the drive chamber to flow out. The fluid flows between the concentric grooves of the input and output plates, creating friction between the two plates. As that friction increases, the output plate and fan begin to turn with the input plate. The fluid continues to spread out between more grooves, increasing the friction between the plates until they spin at about the same speed.

When air passing through the radiator is cool enough, the heat sensor disengages the fan clutch. It does this by closing the valve in the drive chamber, which stops the flow of silicone fluid to the input and output plates. For the fluid already between the plates, centrifugal force continues to push it outward until it's beyond the grooves. There, at the outer edge of the clutch, it returns through a passage in the input plate to the drive chamber.

Again, without the fluid to create friction between the two plates, the output plate and fan free-wheel in relation to the input plate and input shaft.

General Description



12/16/94 f200177a

NOTE: The Eaton 660 fan clutch is shown here. The 610 fan clutch has four studs for mounting the fan. The Eaton Temptrol 575 fan clutch (used on Dodge Magnum V-8 engines) has four threaded holes for mounting the fan with capscrews and lockwashers.

1. Heat Sensor
2. Input Plate
3. Input Shaft
4. Concentric Grooves
5. Drive Chamber
6. Output Plate
7. Fan Blade

Fig. 1

Fan Clutch Inspection and Operation Checking

Inspection

CAUTION

CAUTION: If the fan drive assembly is damaged, promptly replace the unit. Operating a vehicle with a seized or otherwise damaged clutch reduces fuel economy, and could cause serious engine damage.

The fan drive is only one part of the cooling system and will function well only if all other parts of the system are working right. All parts of the system should be checked if there is a cooling problem. Do all the checks in the cooling system troubleshooting section in this group, and pay special attention to the fuel flow rate and exhaust temperature. Over-fueling can cause engine overheating and high exhaust temperatures.

1. With the engine off, rotate the fan at least one full turn by hand. It should have a smooth, steady drag. If it doesn't, replace the fan clutch.
2. Check for physical damage to the fan or fan shroud.
3. Inspect the fan clutch mounting.
   - 3.1 Check the torque of the nuts holding the fan input shaft to the fan hub or mounting adapter (diesel engines), or the torque of the internally threaded fan hub nut to the engine shaft (gasoline engines). They should be tightened as follows:
     - Fan clutch input shaft to fan hub, Cummins B Series engine: 61 N·m (45 lbf·ft);
     - Fan clutch input shaft to fan hub, Cummins C Series engine: 46 N·m (34 lbf·ft);
     - Fan clutch input shaft to adapter, Mercedes-Benz OM 366LA engine: 61 N·m (45 lbf·ft);
     - Fan clutch mounting adapter to fan hub, Mercedes-Benz OM 366LA engine: 35 N·m (25 lbf·ft);
     - Internally threaded fan hub nut to engine shaft, Dodge Magnum V-8 engine: 50 to 62 N·m (37 to 46 lbf·ft).
   - 3.2 Check for wear of the fan clutch bearings. There should be no side-to-side or in-and-out movement of the fan clutch.

Operation Checking

Use the following procedure to check for correct engagement and disengagement of the fan clutch.

1. Coolant temperature in the radiator should be below 60°C (140°F) before the start of the test; the outside temperature should be above 10°C (50°F). Ideally, a temperature probe placed about 13 mm (1/2 inch) from the fan clutch sensor is needed to see if the fan clutch engages at the right temperature.
2. Disconnect any hydraulic pumps (such as the power steering pump) to prevent oil overheating.
3. Get a piece of cardboard that is large enough to block the entire front of the radiator. Cut a round 18-centimeter (7-inch) hole in the cardboard; locate the hole so that it lines up with the fan clutch. Don't put the cardboard in front of the radiator yet.

WARNING

Before starting the engine, make sure people's hands and all other objects are away from the fan blades. It is extremely dangerous to get too close to the fan blades when the engine is on, because the fan could start operating without warning. Do not try to restrict the fan blade rotation when the engine is on.

4. Turn off the air conditioner, if so equipped. Start the engine, and let it idle until the oil pressure is normal.
5. As soon as there is normal oil pressure, bring the engine up to high idle (about 80 percent of governed engine speed) and lock the throttle at this speed.

   If the engine has been idle for more than eight hours, the fan clutch may engage as soon as the engine is started. If this happens, the usual noise from the fan will be heard; the noise will stop after five minutes or less, when the fan clutch disengages.
6. After the fan clutch disengages, put the cardboard in front of the radiator.

Fan Clutch Inspection and Operation Checking

7. Look at the temperature gauge and note at what point the engine thermostat opens. As the engine warms up, the coolant temperature will rise steadily and then seem to level off after the thermostat opens. It will then start rising again, before the fan clutch engages.
8. Keep watching the coolant temperature and, if possible, the temperature of the air in front of the fan clutch, until the clutch engages. Note the temperature(s) at which the clutch engages. The fan should be fully engaged when the air at the fan clutch sensor rises to about:

   Diesel Engines: 68° to 74°C (155°to 165°F).

   Gasoline Engines: 74° to 80°C (165°to 180°F).

   With the clutch engaged, the coolant temperature will keep rising, at a slower rate, as long as the radiator is blocked with cardboard.
9. Remove the cardboard from in front of the radiator. Keep watching the coolant temperature while the clutch is engaged; you should notice a decrease after the cardboard is removed.
10. The fan should disengage when the air temperature at the fan clutch sensor drops to about:

    Diesel Engines: 49° to 54°C (120°to 130°F).

    Gasoline Engines 57° to 79°C (135°to 175°F).

    If the coolant temperature keeps rising, even though the fan is engaged and the cardboard has been removed, the fan clutch may be working okay; the problem is probably in another part of the cooling system.

IMPORTANT: If the air temperature in front of the clutch is being tested, and it does not rise as the coolant temperature rises, then the problem could be a clogged radiator or a stuck engine thermostat.

If the engine still overheats during operation, even though everything described above checks out okay, use a stroboscope to check peak fan speed. The fan speed should be at least 93 percent of the fan pulley speed when the clutch is fully engaged.

Example:

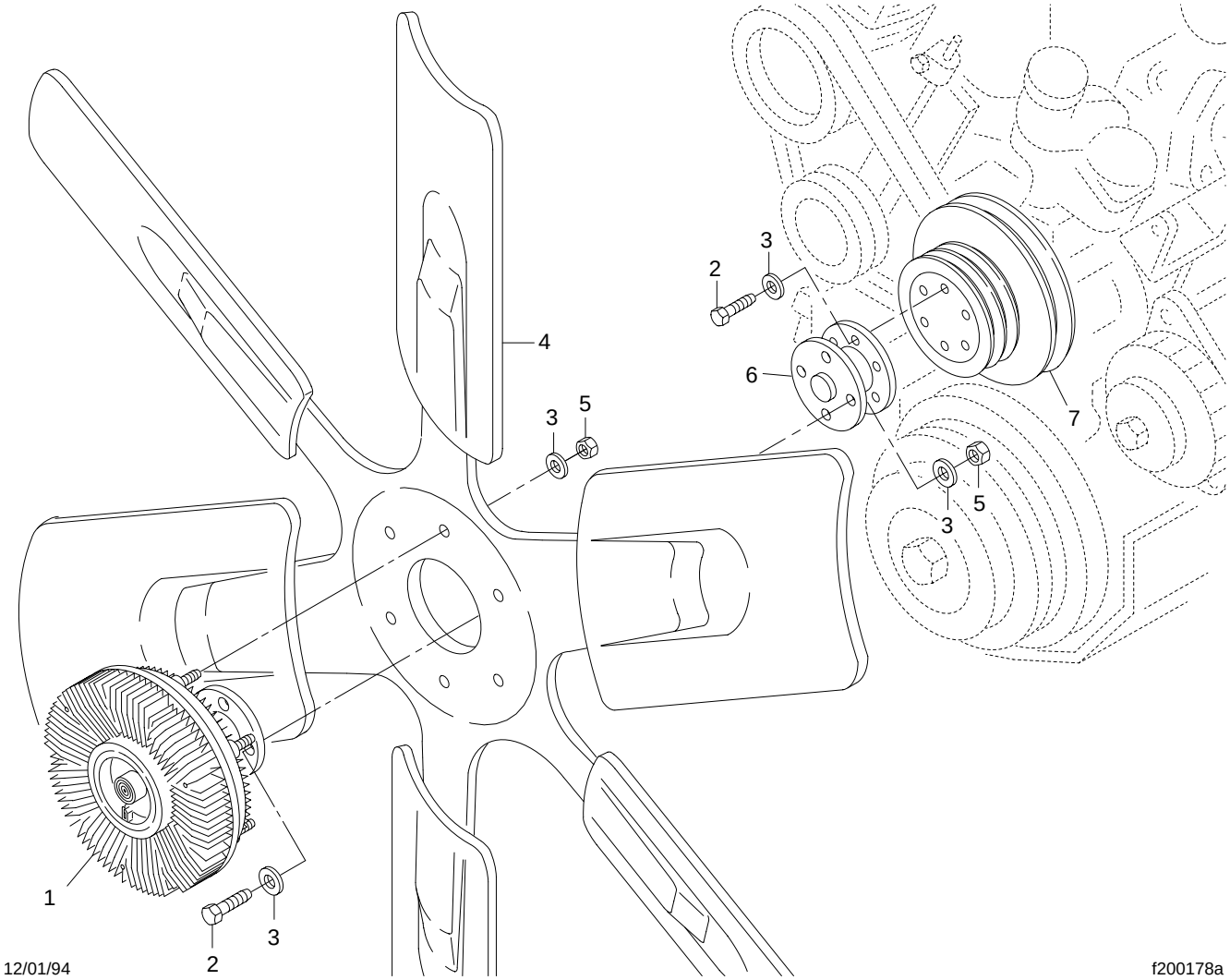
2160 = Fan pulley speed x .93 = 2009 = 93 percent of fan pulley speed

Fan speed must be at least 2009 rpm when the fan clutch is fully engaged.

Removal (See Fig. 1, Fig. 2 , or Fig. 3)

1. Shut down the vehicle, apply the parking brakes, chock the tires, and (if applicable) drain the air system.

   Disconnect the battery ground cable at the vehicle frame.
3. Tilt the hood.
4. *On diesel engines:* remove the capscrews and



NOTE: The Eaton 660 viscous fan clutch is shown here.

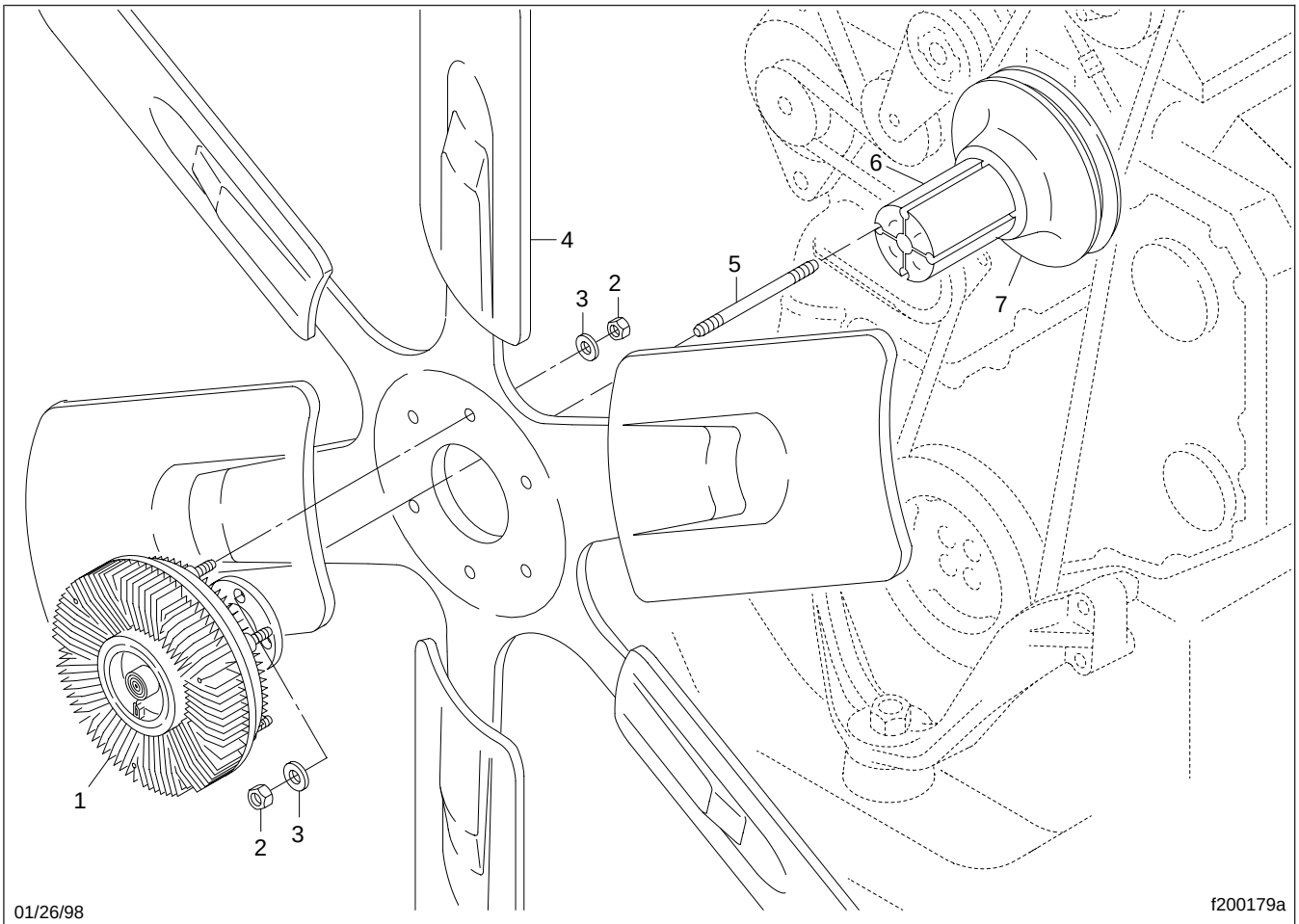
1. Fan Clutch Assembly
2. Capscrew
3. Lockwasher
4. Fan Blade
5. Locknut
6. Fan Clutch Adapter
7. Fan Hub

Fig. 1, Fan Clutch Mounting for Mercedes-Benz OM 366LA Engine

2. Disconnect the batteries or, if the vehicle is equipped with a battery shutoff switch, turn off the switch.

   lockwashers (**Fig. 1**, Refs. 2 and 3), or locknuts and lockwashers (**Fig. 2**, Refs. 2 and 3) that

Fan Clutch Removal and Installation



NOTE: The Eaton 660 viscous fan clutch is shown here.

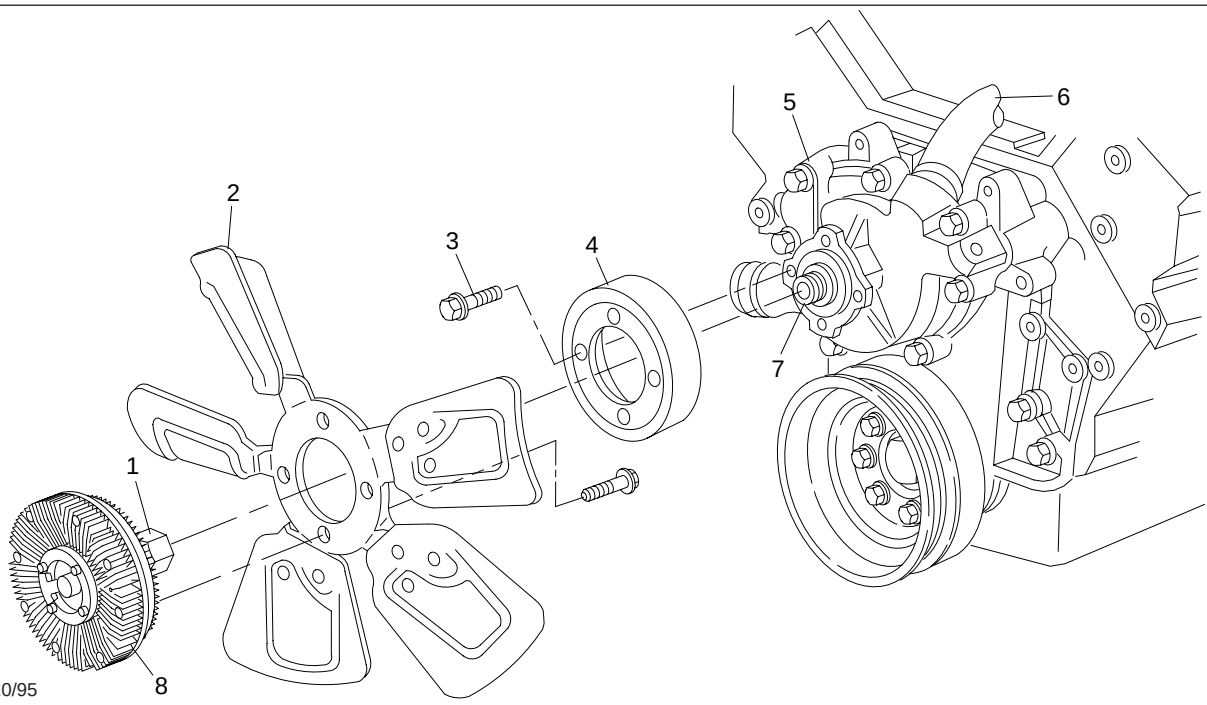
1. Fan Clutch Assembly
2. Locknut
3. Lockwasher
4. Fan Blade
5. Stud
6. Spacer
7. Fan Hub

Fig. 2, Fan Clutch Mounting for Cummins B Series Engine

hold the clutch to the fan hub. Remove the clutch from the engine.

If necessary, on Mercedes-Benz OM 366LA engines, remove the capscrews and lockwashers (**Fig. 1**, Refs. 2 and 3) that secure the fan clutch adapter (Ref. 6) to the fan hub. Remove the adapter from the fan hub.

5. *On gasoline engines:* place a bar or screwdriver between the water pump pulley bolts to keep the pulley from turning. Then, use a wrench to turn the fan hub nut counterclockwise as viewed from the front of the vehicle. Unscrew the fan hub nut from the engine shaft, and remove the fan clutch from the engine.
6. Remove the nuts and lockwashers (diesel engines), or capscrews and lockwashers (gasoline engines) that hold the fan blade to the clutch. Remove the blade.



NOTE: The Eaton 575 viscous fan clutch is shown here.

1. Fan Hub Nut
2. Fan Blade
3. Pulley Bolts
4. Water Pump Pulley
5. Water Pump
6. Coolant Bypass Hose
7. Threaded Engine Shaft (Water Pump Hub)
8. Viscous Fan Clutch Assembly

Fig. 3, Fan Clutch Mounting for Dodge Magnum V-8 Engine

Installation (See Fig. 1, Fig. 2 , or Fig. 3)

1. Install the fan blade on the fan clutch. Tighten the fan mounting locknuts as follows:
   - Model 610: 54 N·m (40 lbf·ft);
   - Model 660: 30 N·m (22 lbf·ft);
   - Model 575: 20 to 27 N·m (15 to 20 lbf·ft).

NOTE: Use only approved fans, as specified in the *Freightliner Parts Technical Information Manual.* Never go over the maximum input speeds, and do not make changes to the engine that will raise the operating speed of the fan.

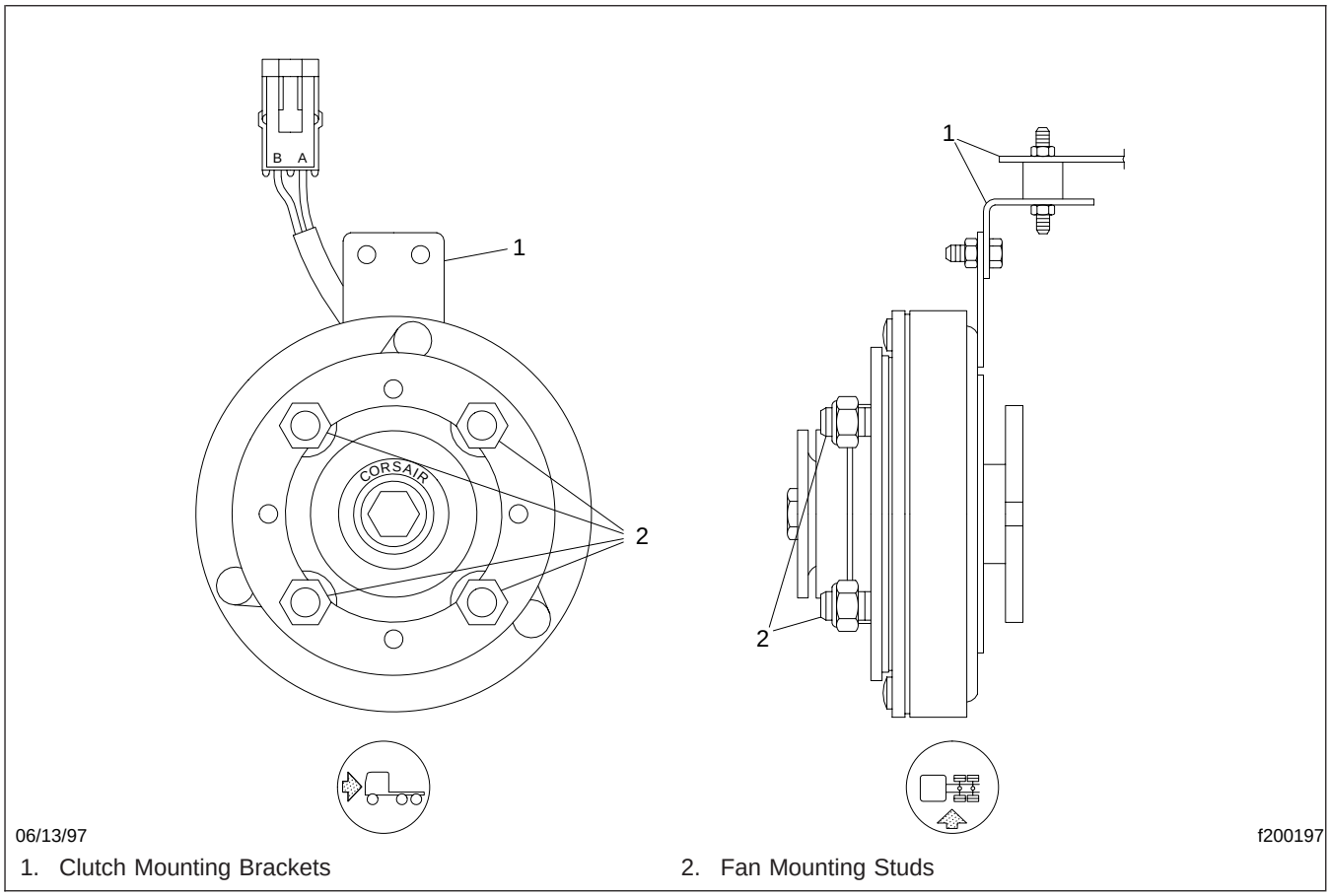
2. On Mercedes-Benz OM 366LA engines (**see Fig. 1**), if the fan clutch adapter (Ref. 6) was removed, mount it on the fan hub. Tighten the mounting capscrews 35 N·m (25 lbf·ft).
3. Install the fan clutch assembly. Tighten the fasteners as follows:
   - Mercedes-Benz OM 366LA engines (**Fig. 1**, Ref. 2): 61 N·m (45 lbf·ft);
   - Cummins B Series engines (**Fig. 2**, Ref. 2): 61 N·m (45 lbf·ft);
   - Cummins C Series engines: 46 N·m (34 lbf·ft);
   - Dodge Magnum V-8 engines (**Fig. 3**, Ref. 1): 50 to 62 N·m (37 to 46 lbf·ft).
4. Lower the hood, connect the batteries, and remove the chocks from the tires.

Specifications

Description	Grade	Size	Torque: lbf·ft (N·m)
Fan Mounting Locknuts: Model 610 Clutch	8	3/8	40 (54)
Model 660 Clutch	8	5/16	22 (30)
Model 575 Clutch	—	—	15–20 (20–27)
Fan Clutch Input Shaft to Fan Hub Locknut, Cummins B Series Engine	10.9	M10	45 (61)
Fan Clutch Input Shaft to Fan Hub Locknut, Cummins C Series Engine	10	M10	34 (46)
Fan Clutch Input Shaft to Adapter Capscrew, Mercedes-Benz OM 366LA Engine	10.9	M10	45 (61)
Fan Clutch Mounting Adapter to Fan Hub Capscrew, Mercedes-Benz OM 366LA Engine	10.9	M8	25 (35)
Fan Hub Nut to Engine Shaft, Chrysler V-8 Engine	5	5/16–18	37–46 (50–62)

Table 1, Fastener Torques

General Information (See Fig. 1)



1. Clutch Mounting Brackets
2. Fan Mounting Studs

Fig. 1, Horton EC450 Electromagnetic Fan Clutch

The Horton EC450 fan clutch (previously marketed as the Corsair fan clutch) is an electromagnetic on/off-style engine cooling fan clutch. The fan clutch is electrically operated, and is not connected to the vehicle's air system.

When vehicle motion (ram air effect) provides enough airflow through the radiator to keep engine coolant temperature within operating limits, the fan is disengaged by de-energizing the fan clutch. Disengaging the fan saves fuel, lowers power consumption and engine noise, and—for cold starts—allows the engine and the cab to warm up faster.

When the vehicle is stationary, or whenever extra air flow through the radiator is necessary, the fan clutch is engaged to connect the fan with the fan drive pulley and provide extra engine cooling. On most vehicles, this extra cooling is seldom needed—the clutch is deactivated and the fan is not turning 90 to 95 percent of the time.

There are several different methods of fan control depending on whether or not the vehicle is equipped with air conditioning, and whether or not it is equipped with an engine protection system.

WITHOUT AIR CONDITIONING OR ENGINE PROTECTION SYSTEM

If the vehicle isn't equipped with air conditioning or an engine protection system, a single switch (see **Fig. 2**) in the engine water jacket controls the fan clutch. The switch is "open" until engine coolant temperature rises above a preset limit, usually 200°F (93°C) or 205°F (96°C). Then, the switch closes, en-

General Information

ergizing the electromagnetic clutch, which engages the fan. When coolant temperature drops below a preset point, usually about seven degrees below the switch closing point, the switch again "opens" to deactivate the fan.

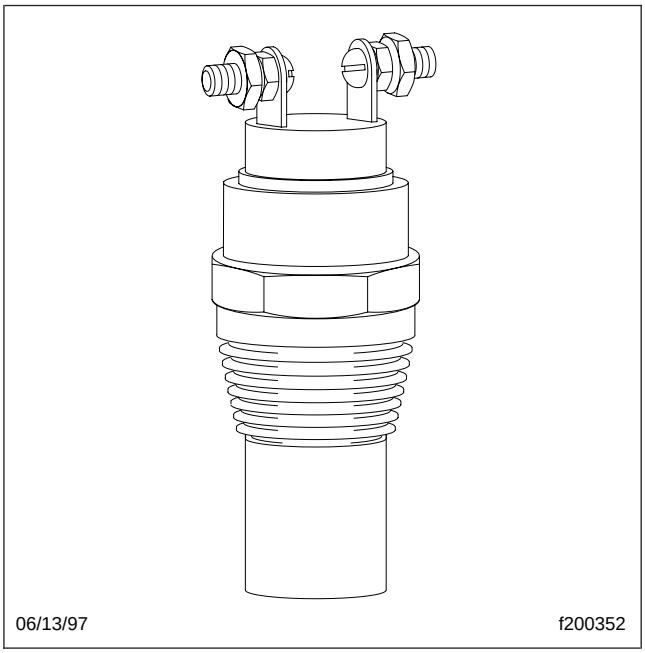


Fig. 2, Coolant Temperature Switch

WITH AIR CONDITIONING, WITHOUT ENGINE PROTECTION SYSTEM

When the vehicle is equipped with air conditioning, but not an engine protection system, coolant temperature on/off control of the fan is the same as mentioned above. With air conditioning added, however, a normally-open refrigerant pressure switch (an "override" switch), is installed on the receiver-drier. See **Fig. 3**. When refrigerant system high-side pressure rises above a preset limit, usually about 275 psi (1896 kPa) the switch closes and activates the fan, regardless of engine coolant temperature. When pressure drops to about 225 psi (1551 kPa), the switch "opens" to deactivate the fan.

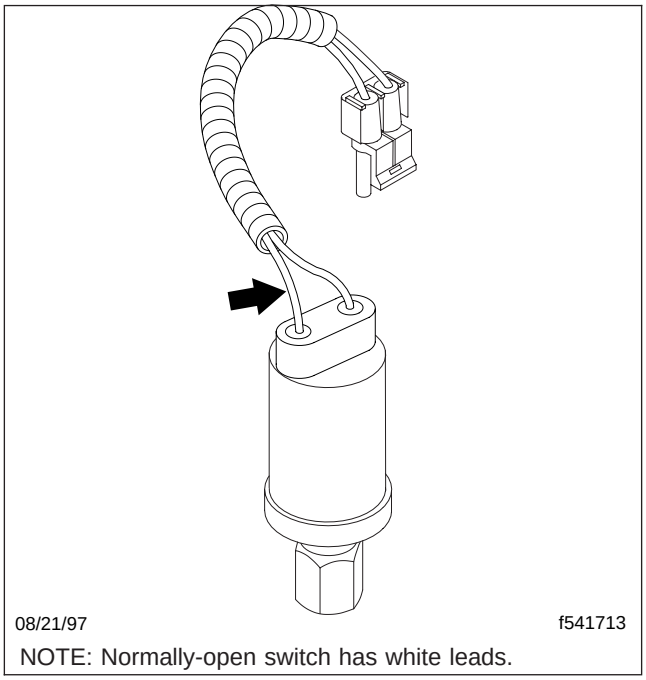


Fig. 3, A/C Override Switch, Without Engine Protection System

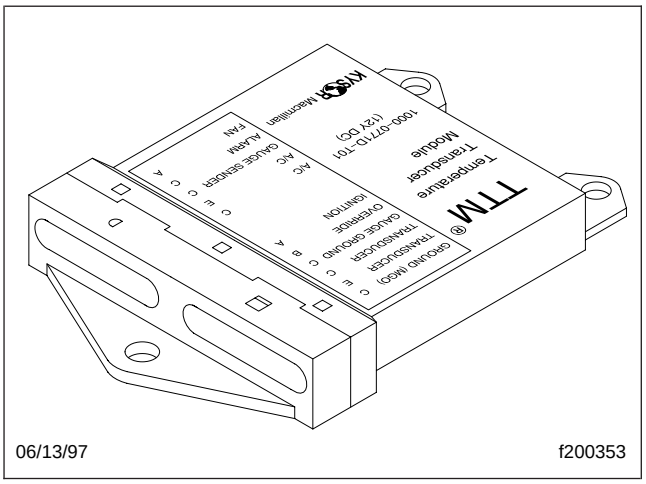
WITHOUT AIR CONDITIONING, WITH ENGINE PROTECTION SYSTEM

If the vehicle is equipped with an engine protection system, the coolant temperature sensor is installed in the engine water jacket port that would otherwise be used for the fan clutch control. Instead of finding another location for the fan switch, the method of controlling the fan (and other functions) is changed.

A Kysor Temperature Transducer Module (TTM), installed behind the instrument panel, is used to control the fan clutch, the engine protection system, and the coolant temperature gauge. See **Fig. 4**. The TTM controls all three of these functions using a single coolant temperature transducer, which is installed in the standard coolant temperature gauge sender port.

NOTE: While all TTMs look the same, they are programmed differently and are not interchangeable. Identify a particular TTM using the part number that appears on the module top surface.

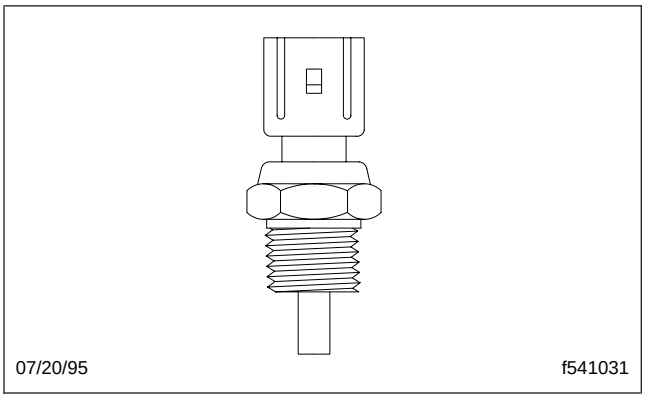
The temperature transducer (**Fig. 5**) is a positive temperature coefficient (PTC) thermistor; as coolant temperature increases, transducer resistance in-



06/13/97 f200353

Fig. 4, Temperature Transducer Module (TTM)

creases. Conversely, as coolant temperature decreases, transducer resistance decreases.



07/20/95 f541031

Fig. 5, Coolant Temperature Transducer

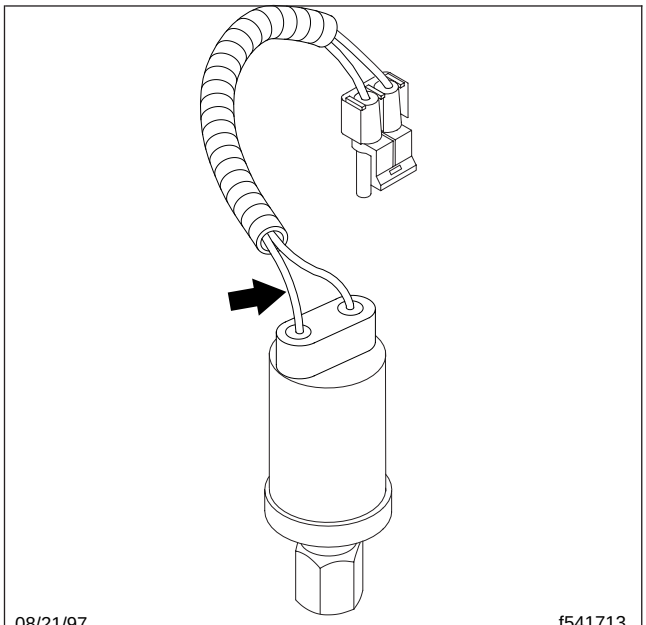
While the TTM drives the coolant temperature gauge and the engine protection system warning lamp and/or buzzer directly, fan clutch current draw is high enough to require use of a fan clutch relay. This relay is mounted behind the instrument panel, in the fuse/relay/circuit breaker panel.

The fan circuit is wired so that the relay, when *de-energized*, is directing power to the fan clutch. When energized by the TTM, the relay interrupts power to the fan clutch.

WITH AIR CONDITIONING AND ENGINE PROTECTION SYSTEM

Fan control circuitry for a vehicle equipped with both an engine protection system and air conditioning is almost the same as fan control circuitry for a vehicle with only an engine protection system. A Kysor Temperature Transducer Module (TTM) is still installed behind the instrument panel (but in a slightly different location), and used to control the fan clutch, the engine protection system, and the coolant temperature gauge as described previously.

An A/C override switch (**Fig. 6**) also provides information to the TTM, but the switch is a *normally closed* switch. The switch contacts "open" when the refrigerant system high-side pressure rises above a preset limit, usually about 275 psi (1896 kPa). The TTM then engages the fan. When pressure drops to about 225 psi (1551 kPa), the switch closes again, but the TTM does not immediately disengage the fan. Instead, it keeps it engaged for about 36 seconds more to ensure adequate fan run time, and reduce fan cycling.



08/21/97 f541713

NOTE: Normally-closed switch has yellow leads.

Fig. 6, A/C Override Switch, With Engine Protection System

Additional circuitry in the TTM is used to provide override switch monitoring. If the TTM detects an in-

General Information

termittent "open" in the override switch circuit while the fan is operating, it assumes that a fault is present in the circuit. The TTM will then keep the fan engaged for about 5 minutes to alert the driver that there is a fault in the fan control circuit.

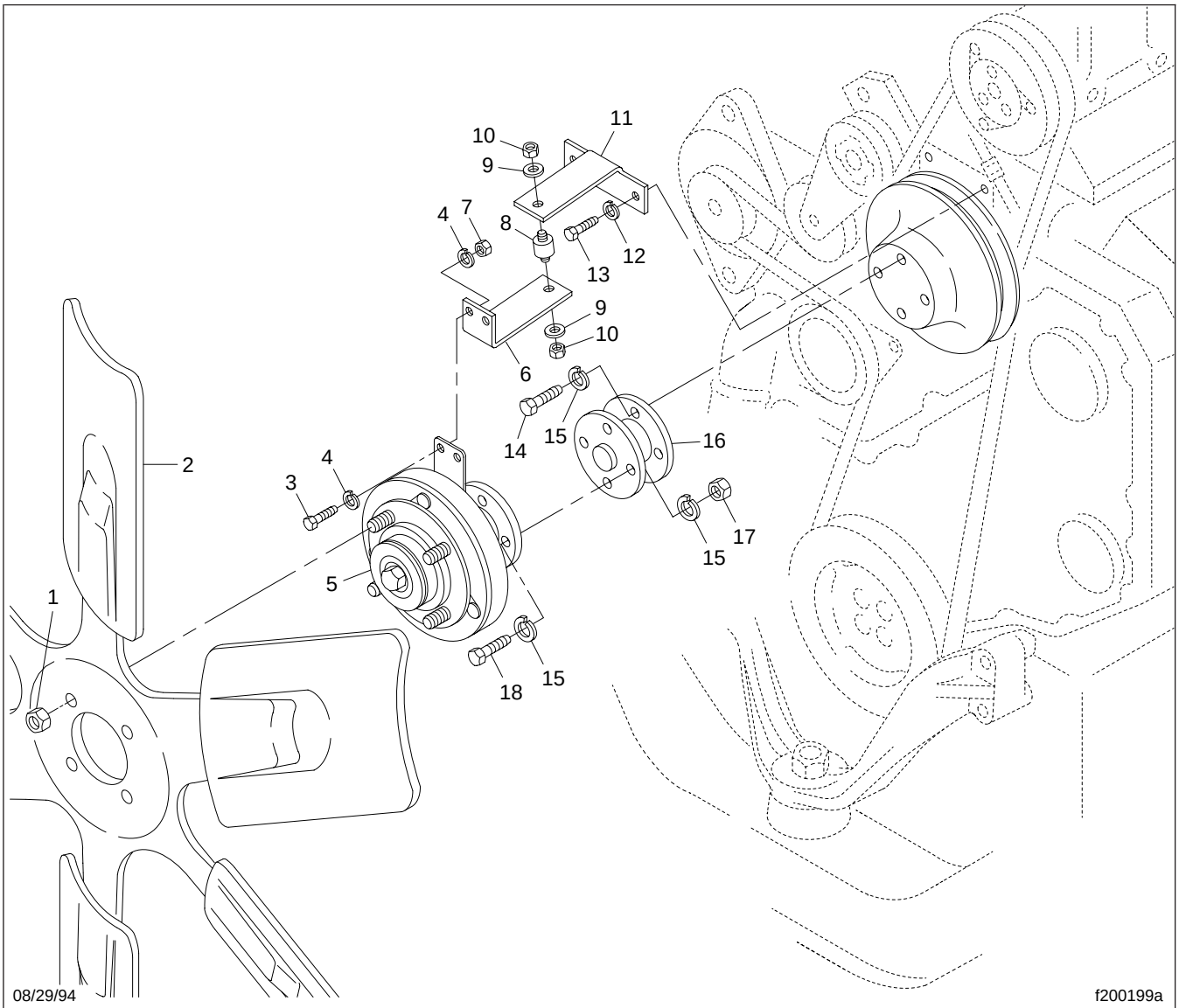
Replacement (See Fig.1 or Fig.2)

1. Apply the parking brakes, chock the tires, and (if applicable) drain the air system.
2. Disconnect the battery ground cable at the vehicle frame, or if the vehicle is equipped with a battery shutoff switch, turn off the switch.
3. Tilt the hood.
4. Remove the fan clutch.
   - 4.1 Disconnect the fan clutch field coil connector.
   - 4.2 Remove the locknuts from the fan clutch studs.
   - 4.3 Remove the fan from the fan clutch.
   - 4.4 Remove the two capscrews, lockwashers, and hexnuts that hold the clutch-side clutch mounting bracket to the fan clutch.
   - 4.5 Remove the four capscrews that hold the fan clutch to the fan clutch adaptor or the fan hub.
   - 4.6 Remove the fan clutch from the vehicle.
5. Install the new fan clutch.
   - 5.1 Position the fan clutch on the fan clutch adaptor or the fan hub.
   - 5.2 Secure the fan clutch with four capscrews. For Cummins B Series engines, use new split lockwashers. Tighten the capscrews 34 lbf·ft (46 N·m).
   - 5.3 Secure the clutch-side clutch mounting bracket to the fan clutch with two capscrews. Use new split lockwashers, and tighten the capscrews 62 lbf·in (700 N·cm).
   - 5.4 Position the fan on the fan clutch, and secure it with new locknuts.

     For a Cummins C Series engine, tighten the locknuts 16 lbf·ft (22 N·m).

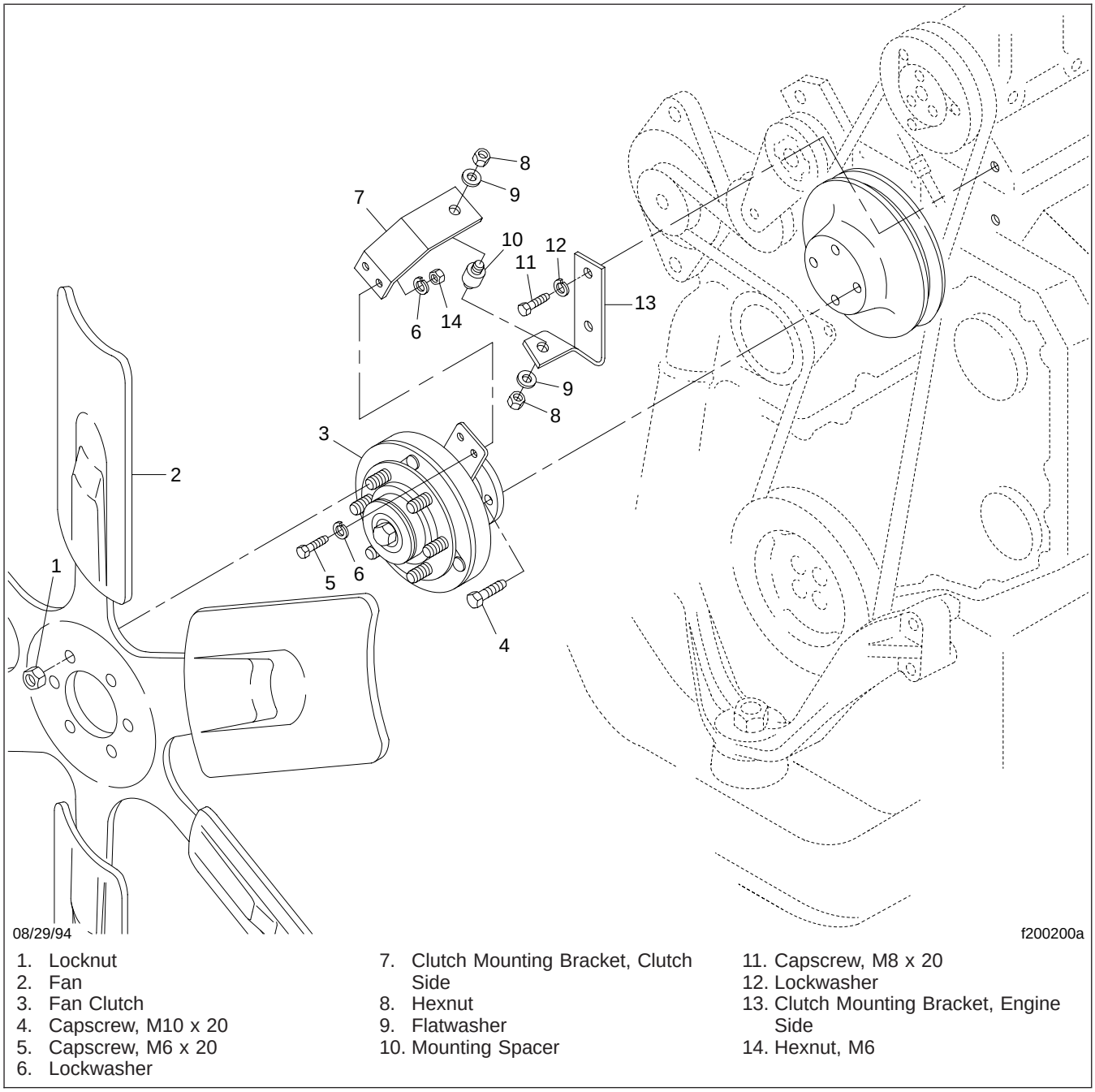
     For a Cummins B Series engine, tighten the locknuts 38 lbf·ft (52 N·m).
   - 5.5 Connect the fan clutch field coil wiring to the engine wiring harness.
6. Test the fan clutch operation by running the engine until the coolant temperature is above 200°F (93°C). The fan clutch should engage.
7. Lower the hood, and remove the chocks from the tires.

Fan Clutch Replacement



1. Locknut
2. Fan
3. Capscrew, M6 x 20
4. Lockwasher
5. Fan Clutch
6. Clutch Mounting Bracket, Clutch Side
7. Hexnut, M6
8. Mounting Spacer
9. Flatwasher
10. Hexnut
11. Clutch Mounting Bracket, Engine Side
12. Lockwasher
13. Capscrew, M8 x 45
14. Capscrew, M10 x 25
15. Lockwasher
16. Fan Clutch Adaptor
17. Hexnut, M10
18. Capscrew, M10 x 30

Fig. 1, Fan Clutch Mounting, Cummins B Series Engine



1. Locknut
2. Fan
3. Fan Clutch
4. Capscrew, M10 x 20
5. Capscrew, M6 x 20
6. Lockwasher
7. Clutch Mounting Bracket, Clutch Side
8. Hexnut
9. Flatwasher
10. Mounting Spacer
11. Capscrew, M8 x 20
12. Lockwasher
13. Clutch Mounting Bracket, Engine Side
14. Hexnut, M6

Fig. 2, Fan Clutch Mounting, Cummins C Series Engine

Replacement

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Open the hood and locate the temperature switch/sensor. See **Fig. 1** or **Fig. 2**.

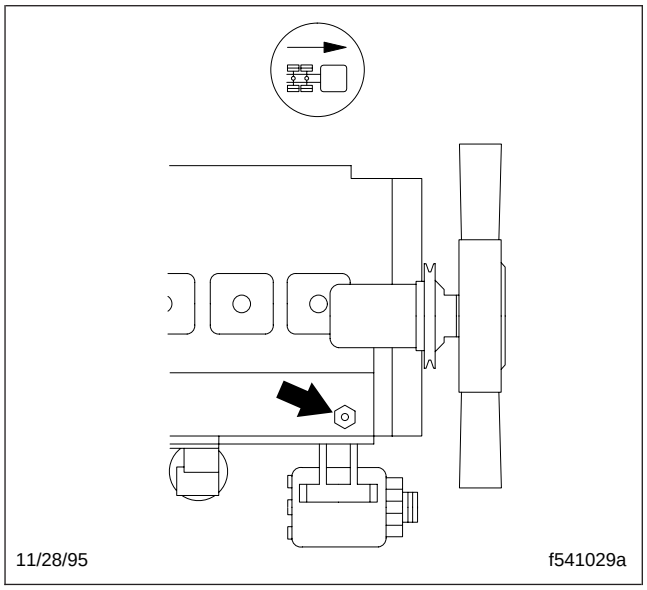


Fig. 1, Temperature Switch/Sensor Location, Cummins B Series Engine

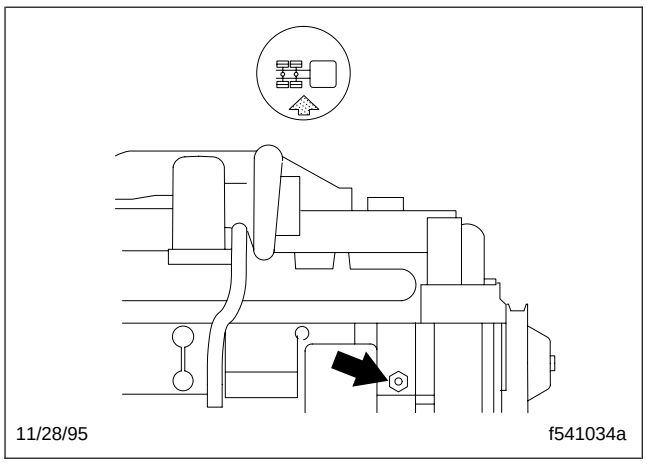


Fig. 2, Temperature Switch/Sensor Location, Cummins C Series Engine

WARNING

Do not drain the cooling system while the engine is hot. To avoid personal injury from scalding coolant, wait until the engine has cooled down before draining the system.

3. Drain coolant from the system until the coolant level drops below the temperature switch/sensor location.
   - 3.1 With the engine cool, loosen the radiator cap to release pressure from the radiator, then tighten the cap.
   - 3.2 Place a clean drain pan under the drain plug or petcock located at the bottom of the radiator left end-tank. See **Fig. 3**. Remove the drain plug or open the petcock. If necessary, use a deflector to channel coolant away from the front springs and into the drain pan.

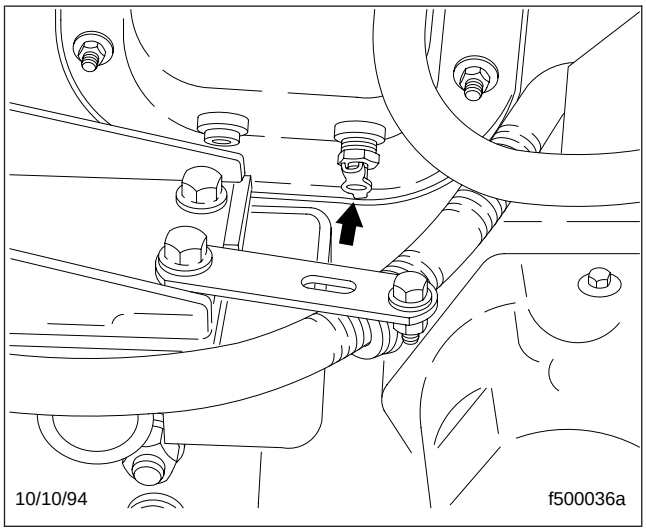


Fig. 3, Radiator Drain Location, Typical

   - 3.3 Install the drain plug or tighten the petcock.
4. Disconnect the wires from the temperature switch (or unplug the wiring harness connector from the temperature sensor), and unscrew the switch/sensor from the engine.
5. Clean old sealant residue from the threads of the switch/sensor port in the engine.

Temperature Switch/Sensor Replacement

6. Apply pipe thread sealant to the threads of the new switch/sensor, and install it in the engine port. Tighten the switch/sensor until it is snug.
7. Connect the vehicle wiring harness to the temperature switch/sensor.
8. Fill the cooling system.
9. Start the engine, check for leaks, and check that the fan clutch and coolant temperature gauge are operating properly.
10. Return the hood to the operating position.
11. Remove the chocks from the tires.

Refrigerant Pressure ("Override") Switch Replacement

Replacement

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Open the hood and locate the "override" pressure switch on the A/C receiver-drier. See **Fig. 1**.

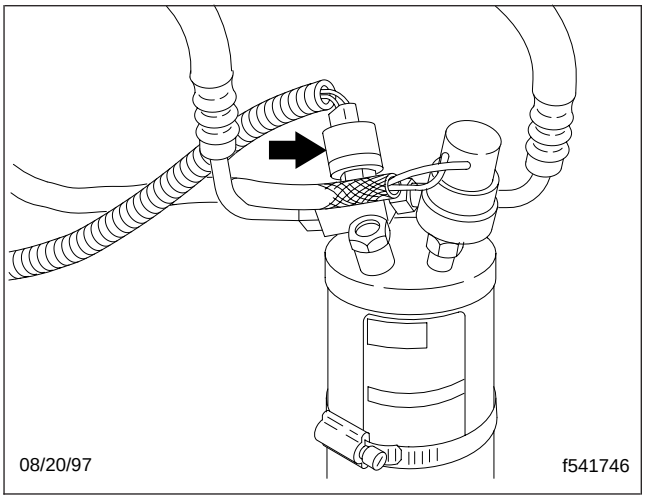


Fig. 1, Override Switch Location

NOTE: It is not necessary to recover refrigerant from the A/C system before removing the override switch. The receiver-drier fitting is equipped with a Schrader valve which closes automatically as the override switch is removed.

3. Disconnect the switch electrical connector and unscrew the switch from the receiver-drier.

IMPORTANT: Be sure that you have the correct replacement switch before installing it. Switches with yellow leads have normally-closed contacts, while switches with white leads have normally-open contacts. Installing an incorrect switch will cause the fan clutch to operate improperly.

4. Screw the override switch onto the receiver-drier fitting and tighten it securely.
5. Plug the switch connector into the vehicle wiring harness connector.
6. Start the engine, turn on the air conditioning system, and verify that the fan clutch operates properly.
7. Close the hood and remove the chocks from the tires.

Kysor Temperature Transducer Module (TTM) Removal and Installation

Removal

1. Remove the extruded rubber trim strip at the top of the dashboard. See **Fig. 1**.

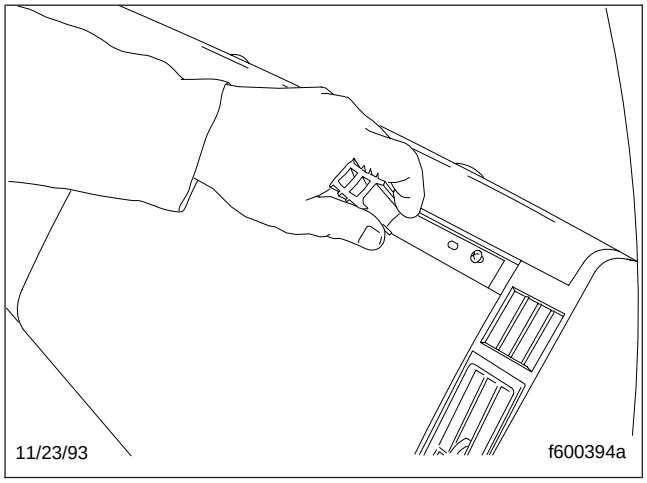


Fig. 1, Trim Strip Removal

2. Remove the right hand dash panel.
   - 2.1 Remove the two screws from the top of the right hand dash panel and pivot the top of the panel rearward.
   - 2.2 Lift out the dash panel. See **Fig. 2**.

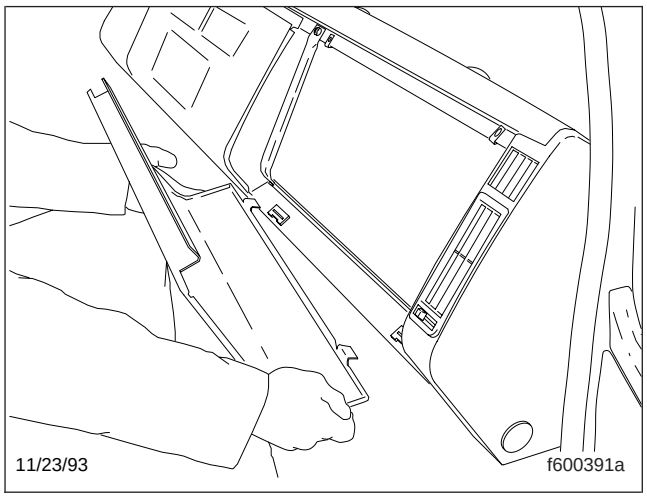


Fig. 2, Dash Panel Removal

NOTE: The TTM mounting location varies slightly depending on installed equipment. On vehicles equipped with an engine warning system, but without an engine shutdown system, the TTM is fastened to the top of the electrical accessories mounting bracket. On vehicles equipped with both engine warning and engine shutdown systems, the TTM is mounted to the underside of the accessories mounting bracket.

3. If equipped with an electronically-controlled automatic transmission, remove the transmission control module fasteners and reposition the module to allow TTM access. See **Fig. 3**.

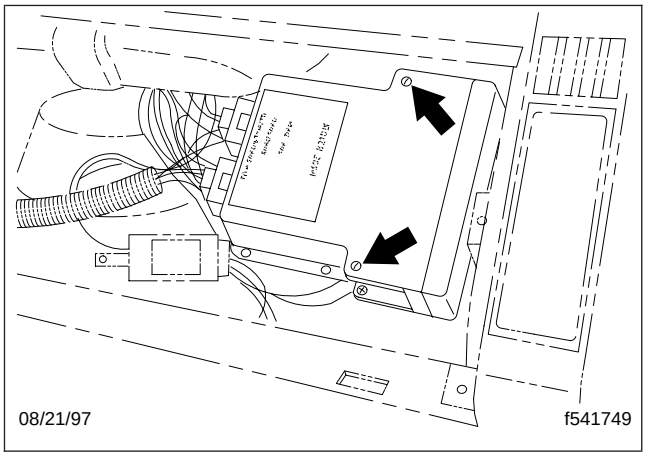


Fig. 3, Transmission Control Module Fastener Access Holes

4. If necessary, reposition or remove the right-hand dash outlet air duct. See **Fig. 4**.
5. Remove the torx fasteners securing the TTM to the electrical accessories mounting bracket (**Fig. 5**). Reposition the TTM to access its electrical connectors, disconnect the connectors, and remove the TTM.

Installation

1. Place the TTM on the electrical accessories mounting bracket and connect the wiring harness connectors to the TTM.
2. Reposition the TTM as necessary to install its mounting screws and tighten the screws. See **Fig. 5**.
3. If necessary, install or reposition the right-hand dash outlet air duct. Keep the duct as straight and kink-free as possible, to prevent reduced air flow from the dash outlet.

Kysor Temperature Transducer Module (TTM) Removal and Installation

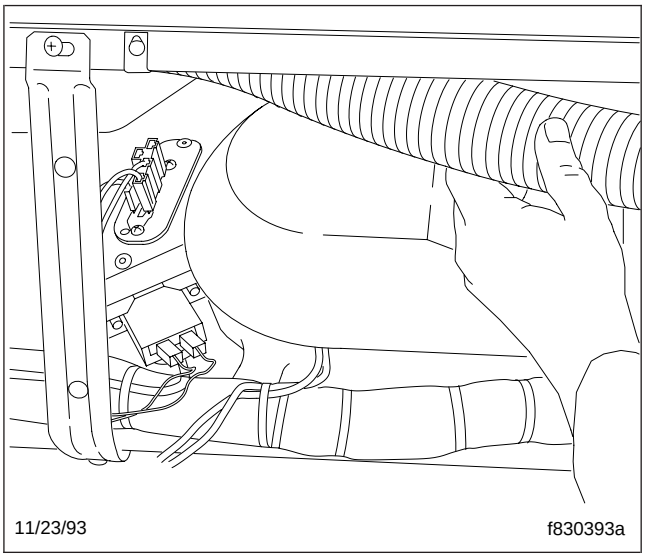


Fig. 4, Defroster Duct Repositioning

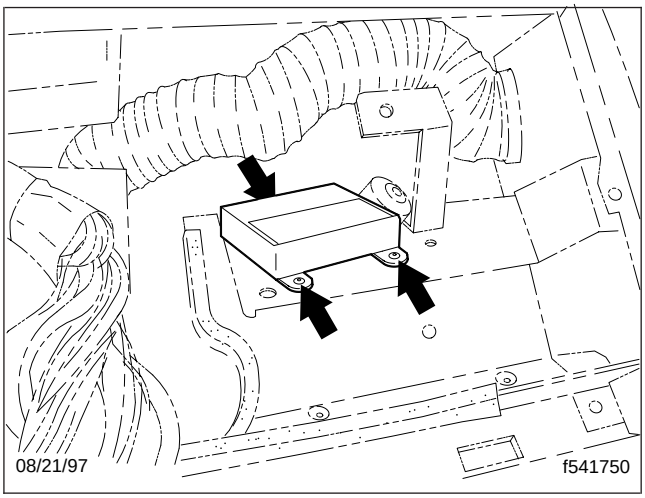


Fig. 5, Kysor TTM Fasteners

4. If equipped with an electronically-controlled automatic transmission, move the module back into position on the electrical accessories mounting bracket. Install the module mounting screws and tighten them. See **Fig. 3**.
5. Install the right-hand dash panel.
   5.1 Insert the two tabs on the lower edge of the dash panel into the slots in the dashboard. Then, pivot the top of the panel forward until it contacts the dashboard. See **Fig. 2**.
   5.2 Install the two torx screws at the top of the dash panel and tighten them.
6. Install the extruded rubber strip into the slot at the top of the dashboard. See **Fig. 1**.

Replacement

1. Remove the quarter-turn fasteners securing the fuse/relay/circuit breaker panel cover to the instrument panel and remove the cover. See **Fig. 1**.

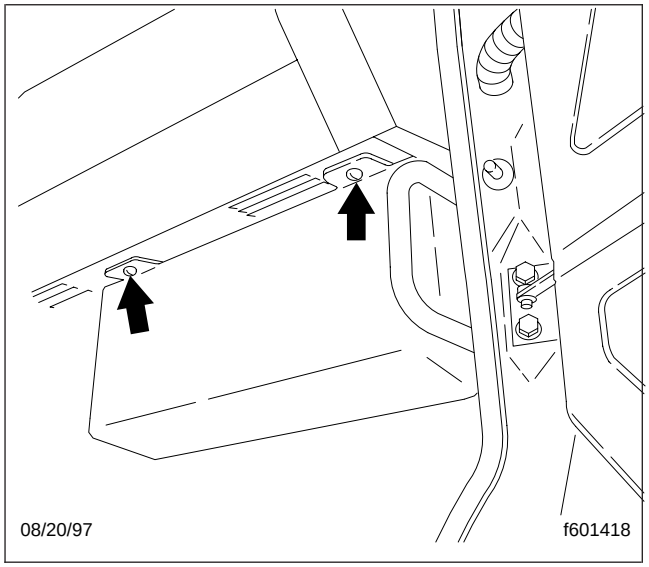
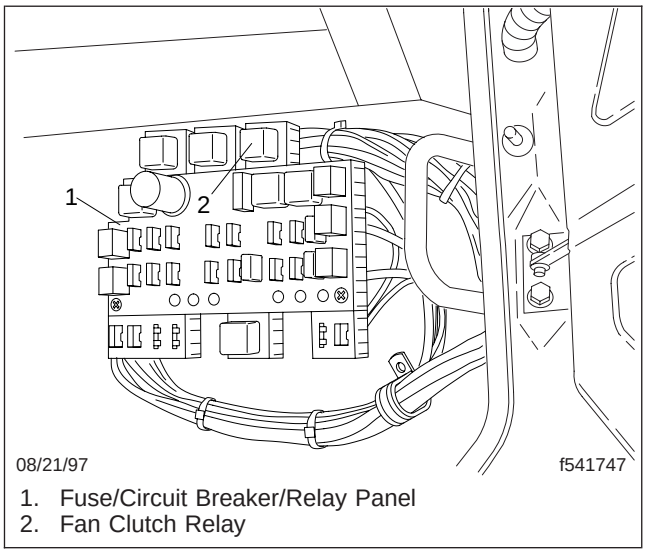


Fig. 1, Fuse/Relay/Circuit Breaker Panel Cover Fasteners

2. Locate the fan clutch relay, which is attached to the upper edge of the fuse/circuit breaker/relay panel. See **Fig. 2**. The exact mounting location varies depending upon the number and type of electrical accessories present on the vehicle, but the fan clutch relay can be positively identified by the four circuits connected to the relay: circuits 234 (2), 234A, and 234B.
3. Unplug the old relay, and install the new one.
4. Install the fuse/relay/circuit breaker panel panel.



1. Fuse/Circuit Breaker/Relay Panel
2. Fan Clutch Relay

Fig. 2, Fan Clutch Relay Mounting Location (typical)

Troubleshooting Tables

WITHOUT ENGINE PROTECTION OR SHUTDOWN SYSTEM

Problem—The Fan Clutch Does Not Engage

Problem—The Fan Clutch Does Not Engage	
Possible Cause	**Remedy**
Power is not reaching the coolant temperature switch (or the A/C override switch, if equipped).	Check for a blown fuse; replace the fuse, if necessary. Check for battery voltage at the coolant temperature switch (and A/C override switch, if equipped). If voltage is not present, repair or replace wiring as required.
The coolant temperature switch is faulty or an incorrect switch has been installed.	Check the switch temperature rating and verify that the switch closes when the rated temperature is reached. This can be done by connecting a voltmeters positive lead to the switches output terminal, and the voltmeters negative lead to a good ground. Then, start the engine and monitor engine coolant temperature as the engine heats up (to monitor the temperature use the instrument panel temperature gauge, a scan tool on electronic engines, or remove the radiator cap and install a thermometer before starting the engine). When the engine reaches the switches rated temperature, the voltmeter should show battery voltage.
The A/C override switch is faulty or an incorrect switch has been installed.	Install an A/C manifold gauge set on the vehicle and check the override switch closing and opening points. If the switch contacts do not close, replace the switch.
Power is not reaching the fan clutch coil.	Use an ohmmeter to check the continuity of circuit 234A between the coolant temperature switch and the fan clutch coil connector. Repair or replace the wiring, as necessary. Use an ohmmeter to check the continuity of circuits 234E and 234A between the A/C override switch and the fan clutch coil connector. Repair or replace the wiring, as necessary.
The fan clutch coil ground circuit is faulty.	Use an ohmmeter to check the continuity of the GND circuit between the ground terminal on the engine block and the fan clutch coil connector. Clean/tighten the ground terminal, or repair/replace the wiring, as necessary.
The fan clutch coil is faulty.	Unplug the fan clutch coil connector and use an ohmmeter to measure clutch coil resistance. Infinite resistance indicates an open coil; replace the fan clutch. Resistance above 5 ohms indicates a damaged coil; replace the fan clutch.

Troubleshooting

Problem—The Fan Clutch Does Not Disengage

Problem—The Fan Clutch Does Not Disengage	
Possible Cause	**Remedy**
The coolant temperature switch is faulty or an incorrect switch has been installed.	Make sure that the coolant temperature switch is a normally open switch, not a normally closed switch. Replace the switch if it is the wrong type. Use an ohmmeter to verify that the switch is open (infinite resistance) when the engine is cold. If the ohmmeter indicates low (or no) resistance when the engine is cold, replace the coolant temperature switch.
The A/C override switch is faulty or an incorrect switch has been installed.	Make sure that the override switch is a normally open switch, not a normally closed switch. Replace the switch if it is the wrong type. Install an A/C manifold gauge set on the vehicle and check the override switch closing and opening points. If the switching points are incorrect, replace the switch.
The fan clutch is seized due to damage (overheating, improper service, etc.)	Replace the fan clutch assembly.

Problem—The Fan Clutch Cycles Frequently

Problem—The Fan Clutch Cycles Frequently	
Possible Cause	**Remedy**
The fan clutch control circuit has a loose connection or is poorly grounded.	Check all wiring and connections; repair the circuit as needed.
An incorrect coolant temperature switch (wrong temperature rating) has been installed.	Determine the correct fan clutch switch-on temperature for the engine installed in the vehicle. Compare the specified switch-on temperature to that of the switch that is installed on the vehicle. Replace the temperature switch with one having the correct switch-on temperature, if necessary.
The coolant temperature switch is faulty.	Check the switch temperature rating and verify that the switch closes when the rated temperature is reached. This can be done by connecting a voltmeters positive lead to the switches output terminal, and the voltmeters negative lead to a good ground. Then, start the engine and monitor engine coolant temperature as the engine heats up (to monitor the temperature use the instrument panel temperature gauge, a scan tool on electronic engines, or remove the radiator cap and install a thermometer before starting the engine). When the engine reaches the switches rated temperature, the voltmeter should show battery voltage. The switch should remain closed until coolant temperature drops to about 7 degrees below the switches rated temperature. Replace the switch if it does not perform as described.
The A/C override switch switches too soon.	Install an A/C manifold gauge set on the vehicle and check the A/C override switch closing and opening points. If the switching points are incorrect, replace the A/C override switch
There is an air restriction in front of the radiator.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.

Problem—The Fan Clutch Engages, But the Engine Still Overheats

Problem—The Fan Clutch Engages, But the Engine Still Overheats	
Possible Cause	**Remedy**
There is an air restriction in front of the fan.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
There is a problem somewhere else in the cooling system.	See the cooling system troubleshooting section in this group.

WITH ENGINE PROTECTION OR SHUTDOWN SYSTEM

Problem—The Fan Clutch Does Not Engage

Problem—The Fan Clutch Does Not Engage	
Possible Cause	**Remedy**
Power is not reaching the fan clutch relay and/or Temperature Transducer Module (TTM). NOTE: If power is not reaching the TTM, the coolant temperature gauge, the high temperature warning lamp, and the fan clutch will be affected. If any one of these three devices is operating normally, power to the TTM is not the problem.	Check for a blown fuse; replace the fuse, if necessary. Check for battery voltage at the fan clutch relay and the Temperture Transducer Module (TTM). If voltage is not present, repair or replace wiring as required.
The fan clutch relay is faulty.	Access the TTM and the electrical mounting panel behind the right hand side of the instrument panel. With the ignition turned off, disconnect the 6 cavity connector from the TTM. Then, turn the ignition switch to run and check for battery voltage at relay terminal 87a. If battery voltage isn't present, replace the relay.
The coolant temperature transducer is faulty or the wrong type of transducer has been installed. NOTE: A faulty or incorrect temperature tranducer will affect the coolant temperature gauge, the high temperature warning lamp, and the fan clutch. If any one of these three devices is operating normally, the temperature transducer is not the problem.	Make sure that the coolant temperature transducer is a KYSOR positive temperature coefficient (PTC) transducer. A negative temperature coefficient (NTC) sensor, like the type normally used to drive the coolant temperature gauge, will not work. Replace the transducer if it is the wrong type. Check transducer resistance when the engine is at room temperature and compare to specifications. If the transducer is questionable, remove it from the engine, and place it in a water bath with a thermometer. Connect an ohmmeter to the transducer terminals and measure resistance as the water bath is heated. Resistance will increase with increasing temperature. If resistances are not within specifications, replace the transducer.
Power is not reaching the fan clutch coil.	Use an ohmmeter to check the continuity of circuits 234B and 234C between the fan clutch relay and the fan clutch coil connector. Repair or replace the wiring, as necessary.
The fan clutch coil ground circuit is faulty.	Use an ohmmeter to check the continuity of the GND circuit between the ground terminal on the engine block and the fan clutch coil connector. Clean/tighten the ground terminal, or repair/replace the wiring, as necessary.

Troubleshooting

Problem—The Fan Clutch Does Not Engage	
Possible Cause	**Remedy**
The fan clutch coil is faulty.	Unplug the fan clutch coil connector and use an ohmmeter to measure clutch coil resistance. Infinite resistance indicates an open coil; replace the fan clutch. Resistance above 5 ohms indicates a damaged coil; replace the fan clutch.

Problem—The Fan Clutch Does Not Disengage

Problem—The Fan Clutch Does Not Disengage	
Possible Cause	**Remedy**
The coolant temperature transducer is disconnected, faulty, or an incorrect sensor has been installed.	Make sure that the coolant temperature transducer connector is connected to, and firmly seated on the transducer. Use an ohmmeter to verify that the transducer is not open (infinite resistance) at any temperature. If the ohmmeter indicates infinite resistance at any temperature, replace the transducer.
The A/C override switch is disconnected, faulty or and incorrect switch has been installed. NOTE: The TTM is programmed to keep the fan clutch engaged for 36 seconds following override switch closing. Do not mistake this for a system fault. Also, the module is programmed to respond to an override switch or circuit problem by running the fan for 5 minutes.	Make sure that the override switch is a normally closed switch, not a normally open switch. Replace the switch if it is the wrong type. Use an ohmmeter to verify that the transducer is not open (infinite resistance) when the A/C system is turned off. If the ohmmeter indicates low (or no) resistance when the system is off, replace the override switch. Install an A/C manifold gauge set on the vehicle and observe the override switch opening and closing points. If the switching points are incorrect, replace the switch.
The fan clutch relay is faulty.	Access the electrical mounting panel behind the right hand side of the instrument panel. With the ignition switch in run, connect one end of a jumper wire to the relay signal circuit (234A) and touch the other end of the jumper to a good ground. The relay should energize, disengaging the fan. If the relay does not energize, replace it.
The fan clutch is seized due to damage (overheating, improper service, etc.)	Replace the fan clutch assembly.

Problem—The Fan Clutch Cycles Frequently

Problem—The Fan Clutch Cycles Frequently	
Possible Cause	**Remedy**
The fan clutch control circuit has a loose connection or is poorly grounded.	Check all wiring connections, and repair the circuit as needed.
The temperature transducer module is activating the fan too soon.	Check the fan clutch switch-on temperature for the engine installed in the vehicle. Compare the specified switch-on temperature to that of the temperature transducer module (TTM) that is installed on the vehicle. Replace the TTM with one having the correct switch-on temperature, if necessary.

Problem—The Fan Clutch Cycles Frequently	
Possible Cause	**Remedy**
The A/C override switch on the receiver-drier switches too soon.	Install an A/C manifold gauge set on the vehicle and check the A/C switch closing and opening points. If the switching points are incorrect, replace the A/C override switch.
There is an air restriction in front of the radiator.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
The engine temperature transducer is faulty or the wrong type of transducer has been installed.	Check transducer resistance when the engine is at room temperature and compare to specifications. If the transducer is questionable, remove it from the engine, and place it in a water bath with a thermometer. Connect an ohmmeter to the transducer terminals and measure resistance as the water bath is heated. Resistance will increase with increasing temperature. If resistances are not within specifications, replace the transducer.

Problem—The Fan Clutch Engages, But the Engine Still Overheats

Problem—The Fan Clutch Engages, But the Engine Still Overheats	
Possible Cause	**Remedy**
There is an air restriction in front of the fan.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
There is a problem somewhere else in the cooling system.	See the cooling system troubleshooting section in this group.

Specifications

For fan clutch system wiring diagrams, see **Fig. 1**, **Fig. 2**, and **Fig. 3**.

For fan clutch engine wiring harness information for a Cummins C Series engine, see **Fig. 4**.

For fan clutch engine wiring harness information for a Cummins B Series engine, see **Fig. 5**.

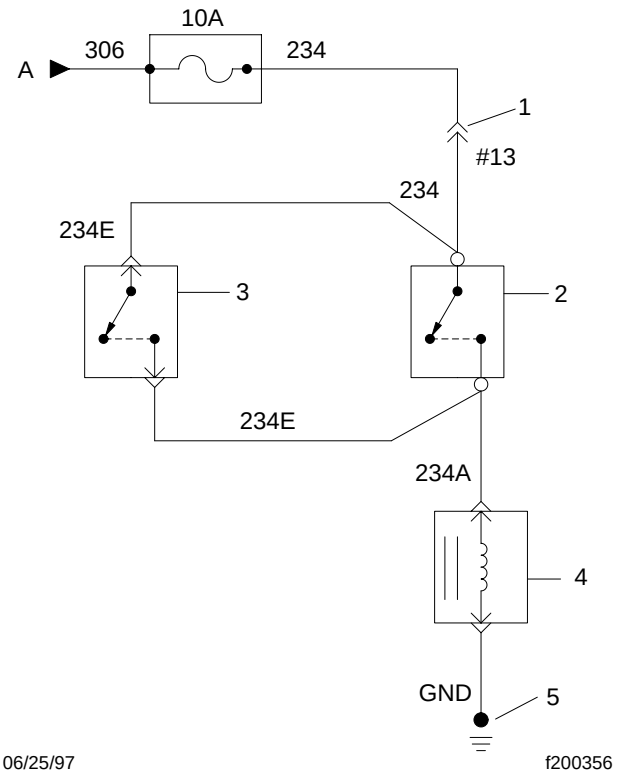
Torque Values				
Description	**Type of Engine**	**Size**	**lbf·ft (N·m)**	**lbf·in (N·cm)**
Fan to Fan Clutch Locknuts:				
4-Stud Fan Clutches	Cummins B Series	M10 x 1.5	38 (52)	—
6-Stud Fan Clutches	Cummins C Series	5/16–18	16 (22)	—
Fan Clutch Capscrews:				
Fan Clutch to Adaptor	Cummins B Series	M10	34 (46)	—
Fan Clutch to Fan Hub	Cummins C Series	M10	34 (46)	—
Fan Clutch to Fan Clutch Bracket Capscrews	—		—	62 (700)

Table 1, Torque Values

KYSOR Temperature Transducer Resistance	
Temperature °F (°C)	**Resistance (Ohms)**
70 (21)	970
80 (27)	1010
90 (32)	1060
100 (38)	1100
110 (43)	1150
120 (49)	1190
130 (54)	1240
140 (60)	1290
150 (66)	1350
160 (71)	1400
170 (77)	1450
180 (82)	1510
190 (88)	1570
195 (91)	1600
200 (93)	1630
205 (96)	1650
210 (99)	1680
215 (102)	1710
220 (104)	1740

Table 2, KYSOR Temperature Transducer Resistance

Specifications

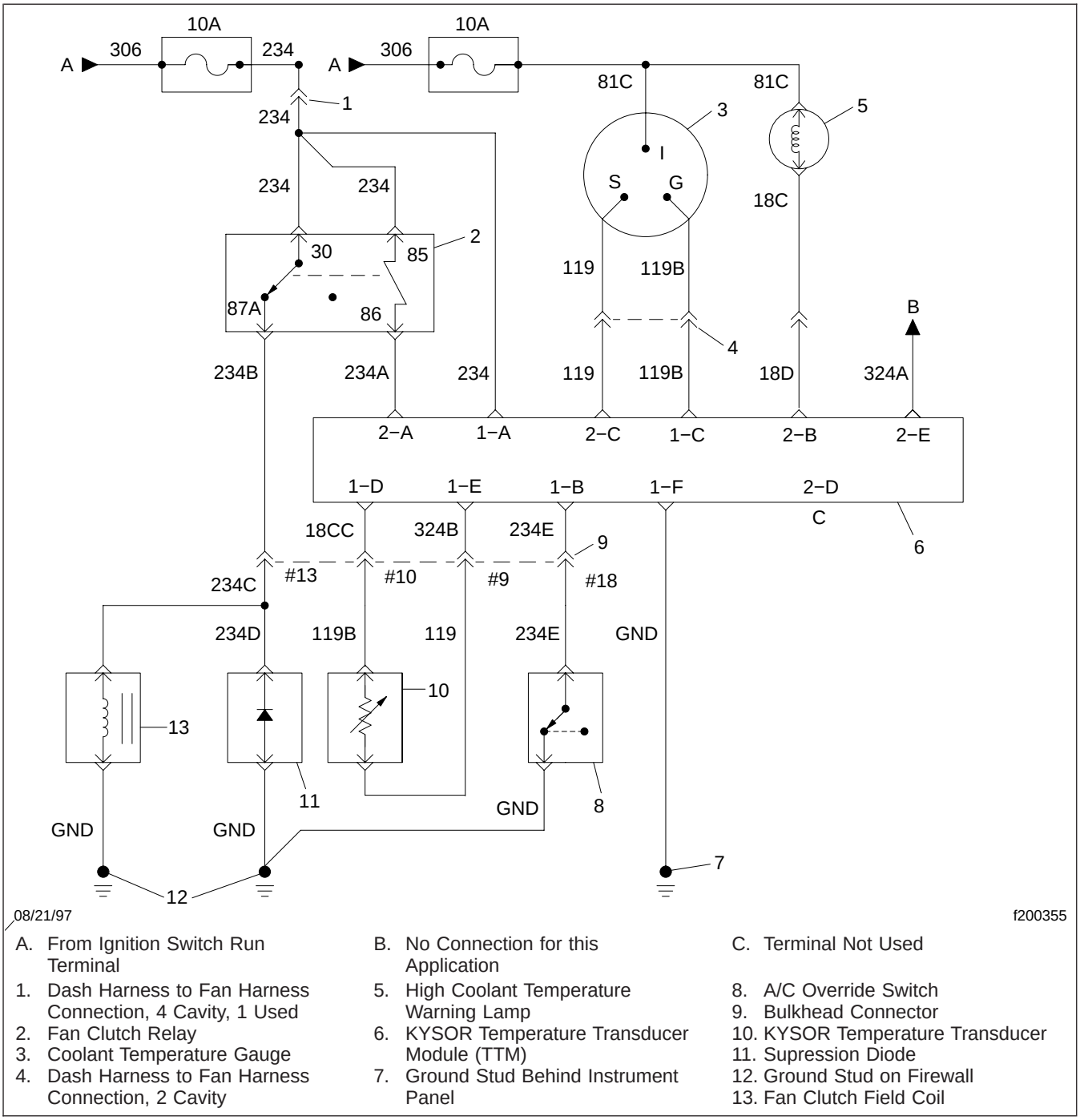


NOTE: Vehicles without air conditioning do not have an A/C override switch. On these vehicles, the wiring harness connector for the override switch is covered with a weather-tight cap.

A. From ignition switch run terminal.

1. Bulkhead Connector
2. Coolant Temperature Switch
3. A/C Override Switch
4. Fan Clutch Field Coil
5. Ground Stud on Firewall

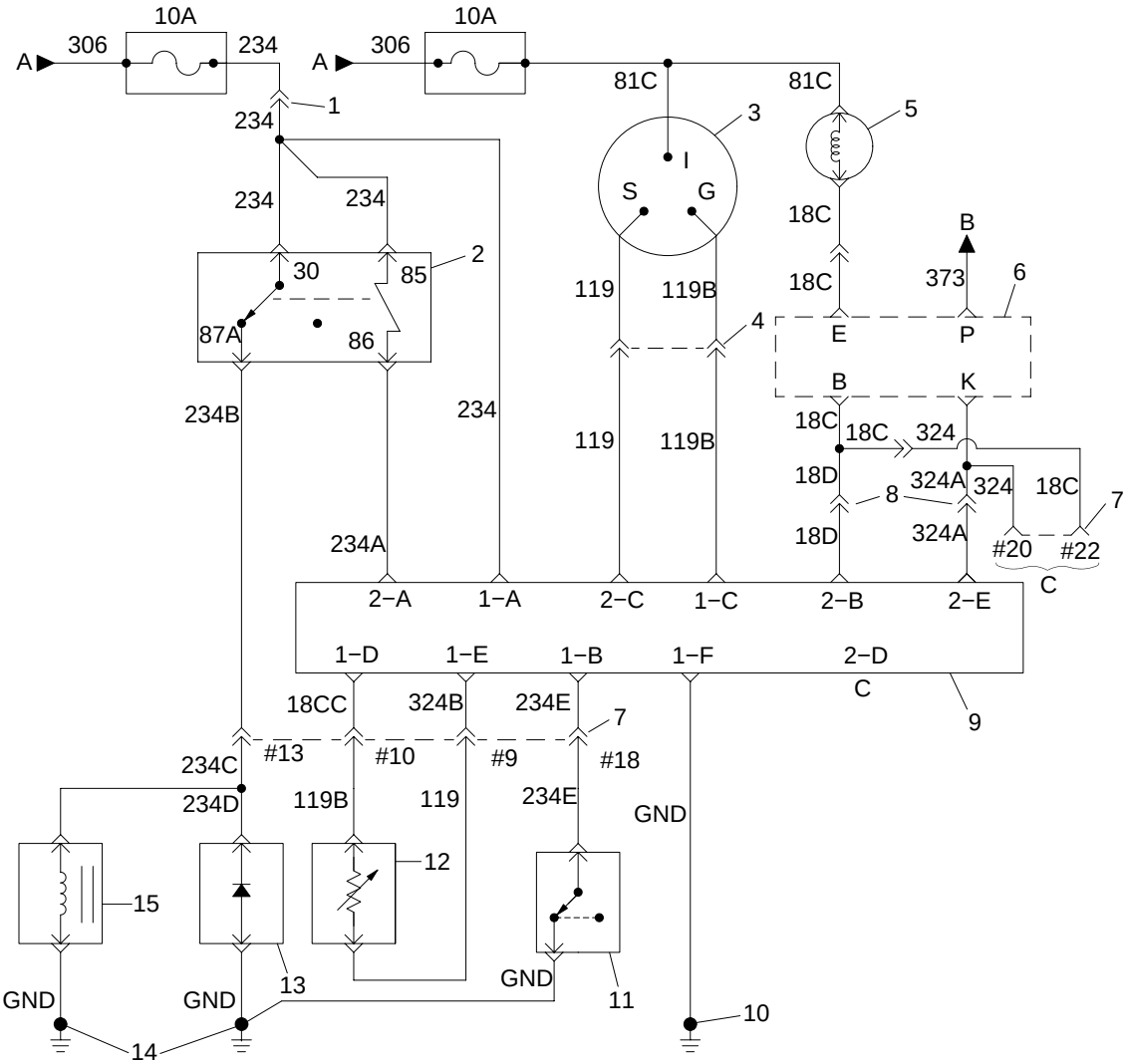
Fig. 1, Wiring Diagram, Horton EC450 Fan Clutch Control Without Engine Protection System or Engine Shutdown System



A. From Ignition Switch Run Terminal
B. No Connection for this Application
C. Terminal Not Used
1. Dash Harness to Fan Harness Connection, 4 Cavity, 1 Used
2. Fan Clutch Relay
3. Coolant Temperature Gauge
4. Dash Harness to Fan Harness Connection, 2 Cavity
5. High Coolant Temperature Warning Lamp
6. KYSOR Temperature Transducer Module (TTM)
7. Ground Stud Behind Instrument Panel
8. A/C Override Switch
9. Bulkhead Connector
10. KYSOR Temperature Transducer
11. Supression Diode
12. Ground Stud on Firewall
13. Fan Clutch Field Coil

Fig. 2, Wiring Diagram, Horton EC450 Fan Clutch Control With Engine Protection System, Without Engine Shutdown System

Specifications

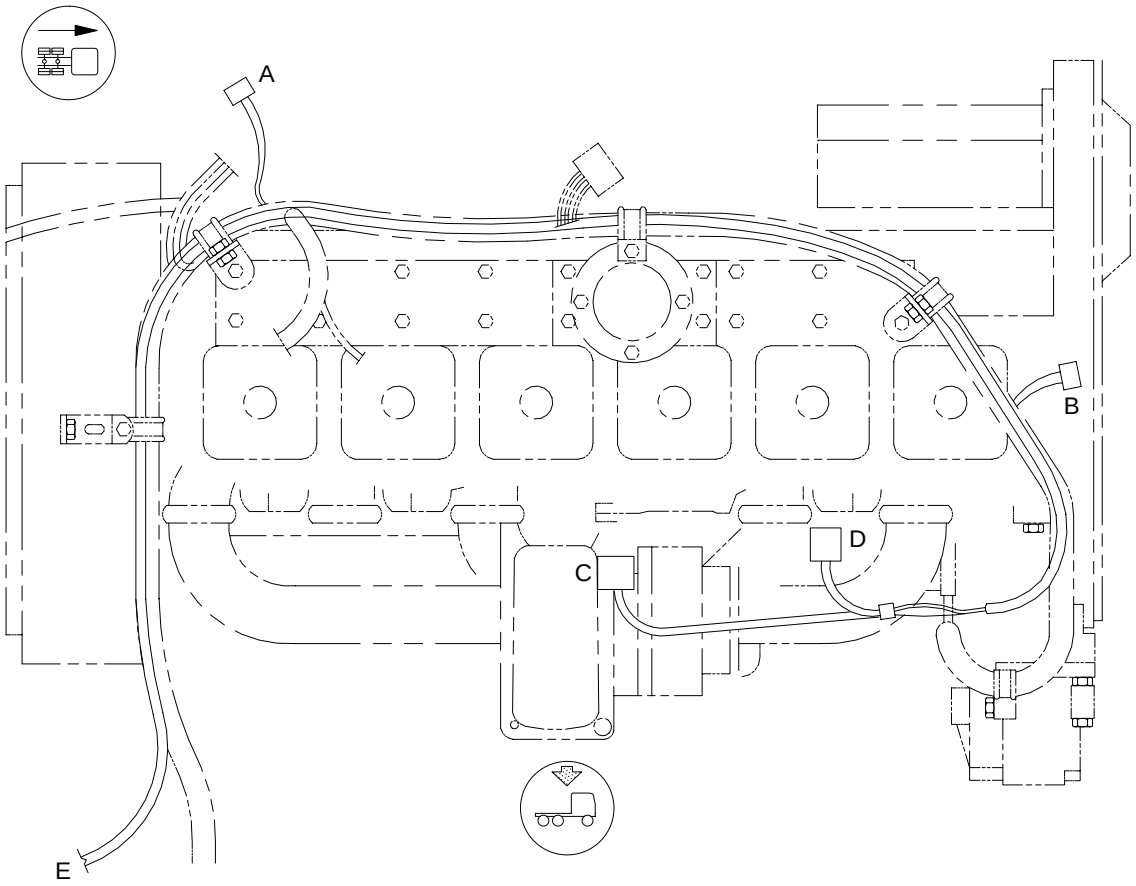


12/21/1999 f200354

A. From Ignition Switch Run Terminal
B. To Engine Shutdown Relay
C. Not Used

1. Dash Harness to Fan Harness Connection, 4 Cavity, 1 Used
2. Fan Clutch Relay
3. Coolant Temperature Gauge
4. Dash Harness to Fan Harness Connection, 2 Cavity
5. High Coolant Temperature Warning Lamp
6. KYSOR Shutdown Module
7. Bulkhead Connector
8. Fan Harness to Shutdown Harness Connections, 1 cavity each
9. KYSOR Temperature Transducer Module (TTM)
10. Ground Stud Behind Instrument Panel
11. A/C Override Switch
12. KYSOR Temperature Transducer
13. Supression Diode
14. Ground Stud on Firewall
15. Fan Clutch Field Coil

Fig. 3, Wiring Diagram, Horton EC450 Fan Clutch Control With Engine Shutdown System

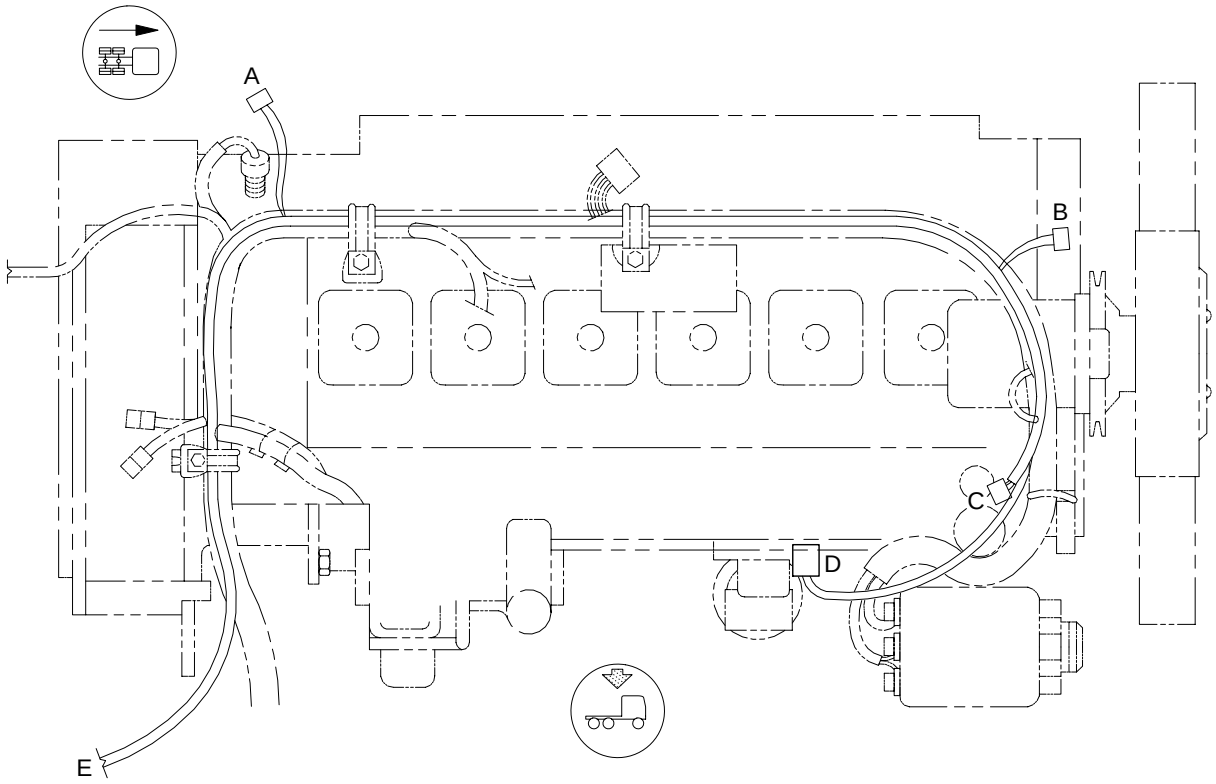


08/12/93 f200203

A. Connection to A/C override switch on receiver-drier. On vehicles without air conditioning or an engine protection/shutdown system, the wiring harness connector is covered by a weather-tight cap. On vehicles without air conditioning, but with an engine protection/shutdown system, connector terminals are bridged by a jumper and covered by a weather-tight cap.
B. Connection to Horton EC450 fan clutch.
C. On vehicles without an engine protection/shutdown system, wires connect to the coolant temperature switch.
D. On vehicles equipped with an engine protection/shutdown system, wiring connects to the Kysor temperature transducer, which is installed in place of the standard gauge sender.
E. Leads to the bulkhead connector.

Fig. 4, Wiring Harness Installation, Cummins C Series Engine

Specifications



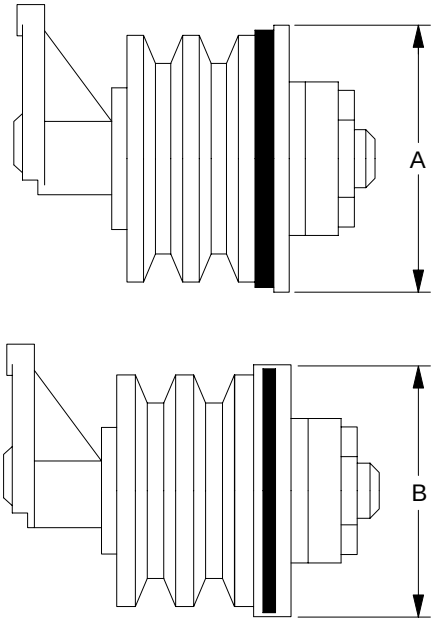
08/17/93 f200204

A. Connection to A/C override switch on receiver-drier. On vehicles without air conditioning or an engine protection/shutdown system, the wiring harness connector is covered by a weather-tight cap. On vehicles without air conditioning, but with an engine protection/shutdown system, connector terminals are bridged by a jumper and covered by a weather-tight cap.
B. Connection to Horton EC450 fan clutch.
C. On vehicles without an engine protection/shutdown system, wires connect to the coolant temperature switch.
D. On vehicles equipped with an engine protection/shutdown system, wiring connects to the Kysor temperature transducer, which is installed in place of the standard gauge sender.
E. Leads to the bulkhead connector.

Fig. 5, Wiring Harness Installation, Cummins B Series Engine

General Information and Principles of Operation

The fan drive is a temperature-controlled, air-operated clutch for the engine cooling fan. It controls engine temperature by engaging or disengaging the fan. Internal spring pressure disengages the fan clutch when the coolant temperature is below the specified temperature range; internal air pressure engages the fan clutch when the coolant temperature rises above that range. Freightliner uses two models of Horton Advantage fan clutches: S Type and HT/S Type. See **Fig. 1**.



03/30/95 f200262a

A. The S Type fan clutch has a 7.5 inch (187.5 mm) wide piston friction disc.
B. The HT/S Type fan clutch has a 9.5 inch (237.5 mm) wide piston friction disc.

Fig. 1, Horton Advantage Fan Clutches

Air pressure to the fan clutch is controlled by a solenoid valve; the solenoid valve is controlled by a temperature switch that is installed in the thermostat housing. See **Fig. 2** and **Fig. 3**.

When you start a cold engine, the solenoid valve restricts air pressure to the cylinder, and the fan clutch remains disengaged.

When the coolant temperature rises to the temperature switch setting, the switch provides power to the solenoid valve, and the valve releases compressed air to engage the fan clutch.

When the coolant temperature drops to the temperature switch cutoff setting, the solenoid stops the compressed air, and the clutch disengages.

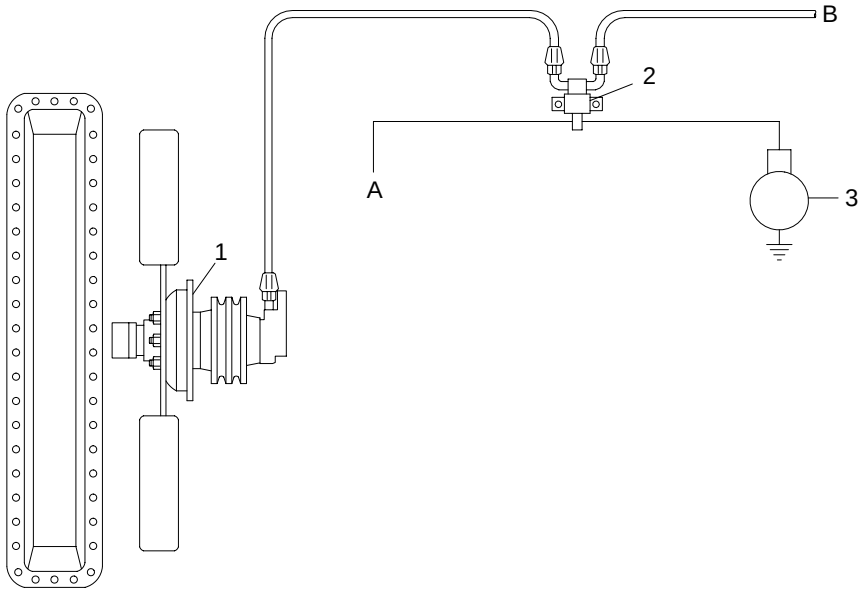
On vehicles with air conditioning, the fan clutch solenoid valve is connected to a fan cycling switch at the receiver-dryer. If the refrigerant pressure exceeds the setting of the fan cycling switch, the switch supplies power to the solenoid valve, which supplies air to engage the fan clutch.

Most Horton Advantage fan clutches include System Sentry™ fuses that protect the fan clutch from overheating. See **Fig. 4**. The System Sentry fuse is a brass fitting in the piston friction disc; the fitting uses lead alloy solder to hold a brass plug. If anything causes the fan clutch to slip excessively, heat from the slippage will melt the solder and release the plug. Air pressure inside the clutch will escape, and the clutch will release before heat build-up can damage the clutch bearings. The fuse is balanced by two counterweights.

If the fan clutch includes the System Sentry fuse, and the clutch will not engage, check to see if the fuse is melted, and check to see what might be making the fan clutch slip excessively.

For the fan clutch model number and serial number, refer to the side of the air chamber. See **Fig. 5**.

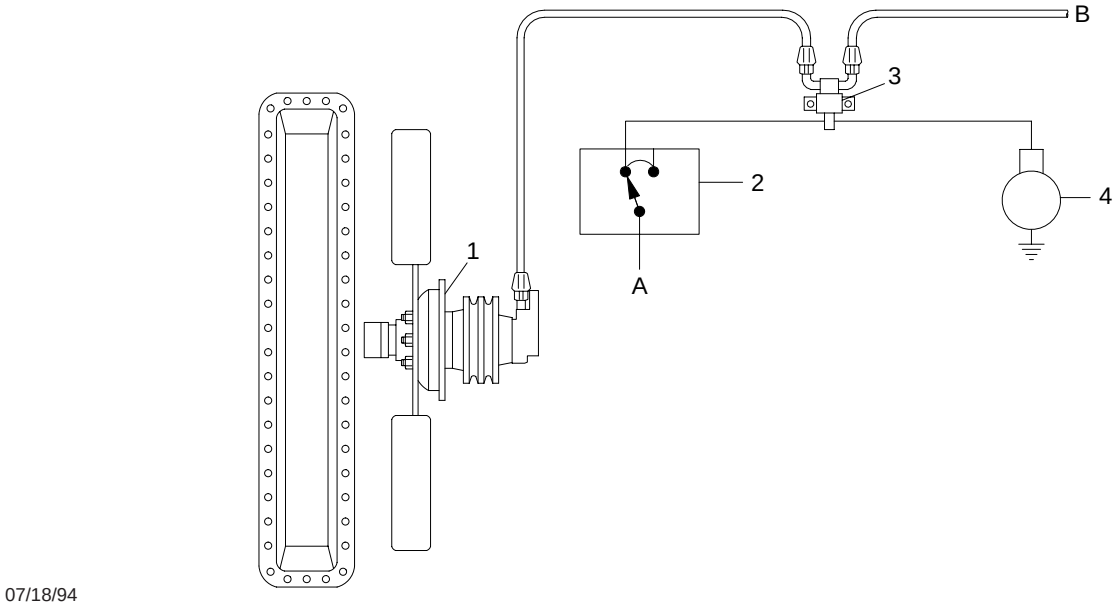
General Information and Principles of Operation



07/18/94 f200019a

A. To the circuit breaker.
B. From the secondary air tank.
1. Fan Clutch
2. Solenoid Valve
3. Temperature Switch

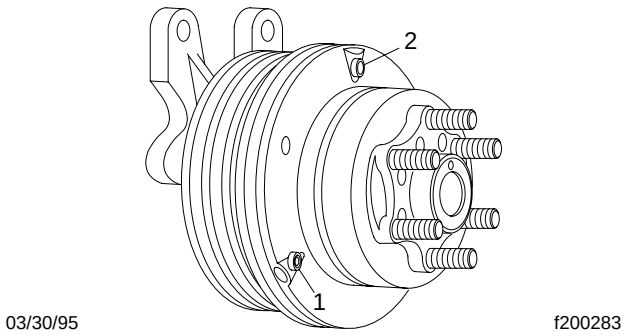
Fig. 2, Fan Clutch Piping and Wiring, Vehicle Without Air Conditioning



07/18/94 f200020a

A. To the circuit breaker.
B. From the secondary air tank.
1. Fan Clutch
2. Fan Cycling Switch at the Receiver-Drier
3. Solenoid Valve
4. Temperature Switch

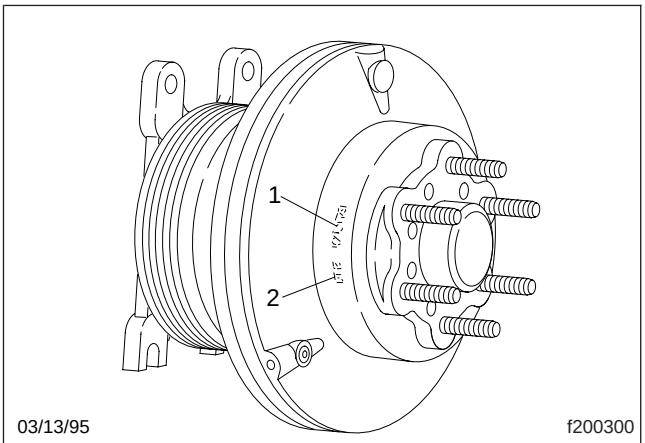
Fig. 3, Fan Clutch Piping and Wiring, Vehicle With Air Conditioning



03/30/95 f200283

1. System Sentry Fuse
2. Counterweight

Fig. 4, Horton Fan Clutch with System Sentry Fuse



03/13/95 f200300

1. Model Number
2. Serial Number

Fig. 5, Fan Clutch Information, Model HTS 981144 Shown

Removal (See Fig. 1)

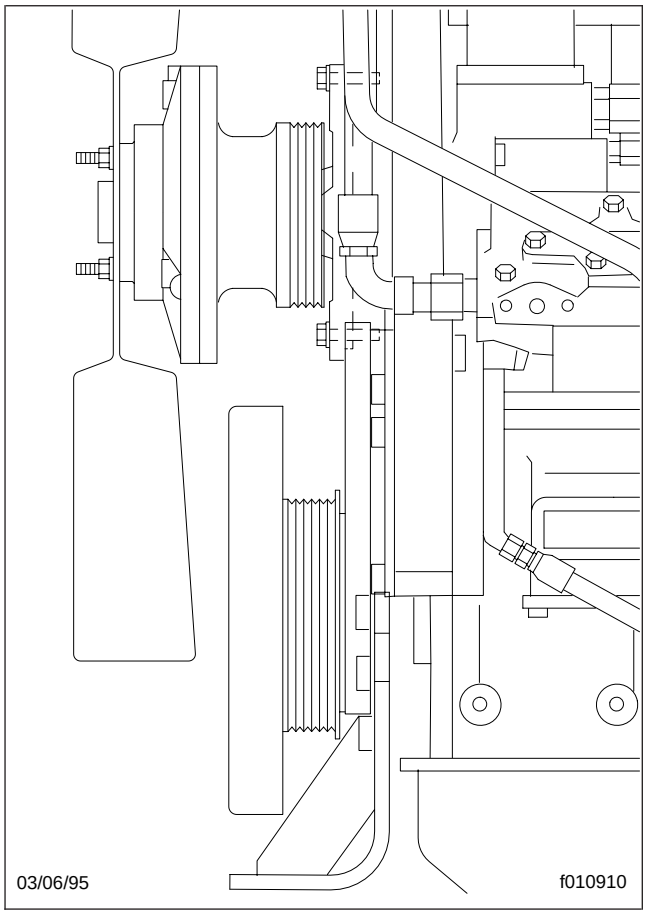


Fig. 1, Fan Clutch Installed, Cat CFE Engine Shown

NOTE: The following procedure pertains to vehicles equipped with all engines except Detroit Diesel Series 55 engines. For vehicles equipped with that engine, see **Subject 105.**

1. Apply the parking brakes, and chock the tires.

⚠ WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

2. Remove the drain plug from the right side of the radiator bottom tank, and drain about seven liters (two gallons) of coolant. Install the drain plug and tighten it firmly.
3. Disconnect the radiator inlet hose and the radiator vent hose from the radiator, and move both hoses away from the radiator and fan shroud.
4. Disconnect the air intake hoses from the aftercooler, and move both hoses away from the aftercooler and fan shroud.
5. Remove the six 3/8–inch capscrews that hold the fan shroud to the radiator.
6. Loosen the fan belt. For instructions, refer to the applicable section in this manual.

⚠ WARNING

Use care when loosening the air line fitting. The line could be under pressure and may have dirt or sludge in the air stream. If quickly disconnected, the line may whip, possibly causing eye injury or other bodily injury.

7. Find the air line that runs between the fan clutch and the clutch solenoid, and disconnect the line from the solenoid. Cut any tie straps that secure the line to the engine.

⚠ WARNING

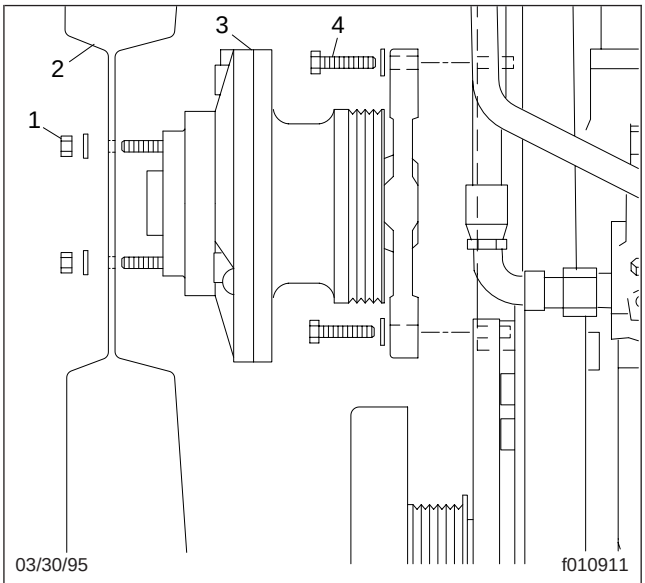
The fan clutch is heavy, and lifting it from, or installing it in, the center of a crowded engine compartment can be awkward. To avoid injury, a hoist should be used or two people should work together, to remove and install the fan clutch.

8. Remove the fan and fan clutch from the engine. **See Fig. 2.**

   NOTE: Four M8 x 35 mm capscrews hold the fan clutch to the engine. Two capscrews go through holes in the upper end of the fan clutch mounting plate, and two capscrews go through *notches* in the bottom of the mounting plate. If you loosen the lower capscrews, slightly, you can remove the two top capscrews, and the fan clutch will remain on the engine until you lift it straight up.

   8.1 Loosen the two lower capscrews that hold the fan clutch to the front of the engine.

Removal and Installation



1. 3/8–Inch Locknut
2. Fan
3. Fan Clutch
4. Capscrew, M8 x 35 mm, Grade 8.8

Fig. 2, Fan Clutch, Installation Components

8.2 Remove the two upper capscrews that hold the fan clutch to the engine.

8.3 With a helper, lift the fan clutch and fan up and out of the engine compartment. Move the fan shroud as needed.

8.4 Place the fan clutch on a work bench, and remove the six nuts that hold the fan to the fan clutch. Remove the fan from the fan clutch.

Installation

⚠ WARNING

The fan clutch is heavy and placing it in the center of a crowded engine compartment can be awkward. To avoid injury, two people should work together to place the fan clutch on the engine.

1. Install the fan and fan clutch on the engine.

   1.1 Place the fan on the fan clutch, and secure the fan with six nuts. Tighten the nuts 15 lbf·ft (20 N·m).

   NOTE: Four M8 x 35 mm capscrews hold the fan clutch to the engine. Two capscrews go through holes in the upper end of the fan clutch mounting plate, and two capscrews go through *notches* in the bottom of the mounting plate. If you install the lower capscrews in the engine, you can position the fan clutch on the lower capscrews and the fan clutch will remain on the engine as you install the upper capscrews.

   1.2 Install the lower capscrews in the front of the engine, but don't tighten them completely.

   1.3 With a helper, position the fan and fan clutch on the two lower mounting capscrews. The notches in the bottom of the fan clutch mounting plate should slide down over the capscrews. Move the fan shroud as needed.

   1.4 Install the two upper capscrews and tighten all four capscrews 13 lbf·ft (18 N·m).

   1.5 Route the air line up, behind the alternator mount and across the front of the engine to the solenoid. Connect the air line to the solenoid, and secure the line to the engine with tie straps.

2. Work the belt over the fan, and route and adjust the belt. For instructions, refer to **Group 01** in this manual.
3. Install the fan shroud on the radiator.
4. Connect the coolant hoses to the radiator, and the air hoses to the aftercooler.
5. Take the coolant drained from the radiator, and pour it back into the surge tank.
6. Check the fan clutch for proper operation. For instructions, refer to **Group 20** in this manual.

Removal and Installation, Equipped with Detroit Diesel Series 55 Engine

Fan Clutch Removal

1. Park the vehicle, set the parking brake, then chock the tires.
2. Disconnect the batteries.
3. Drain the air tanks.
4. Tilt the hood and support it on a stand.
5. Remove the four fasteners holding the fan shroud in place.
6. Remove the fan blade, then put it inside the radiator shroud.
7. Remove the fasteners attaching the radiator struts to the sides of the radiator. Swing the struts outboard.
8. Tilt the radiator forward, then lift the fan and shroud out of the engine compartment.
9. Remove the drive belts from their pulleys.
   - 9.1 Using a wrench, loosen one belt tensioner, then rotate it back until the drive belt slips off.
   - 9.2 Repeat the procedure for the other belt tensioner.

⚠ WARNING

Use care when loosening the air line fitting. The line could be under pressure and may have dirt or sludge in the air stream. If quickly disconnected, the line may whip, possibly causing eye injury or other bodily injury.

10. Disconnect the air line from the fan clutch.

⚠ WARNING

The fan clutch is heavy, and lifting it from the center of a crowded engine compartment can be awkward. To avoid injury, two people should work together to lift the fan clutch from the engine.

11. Remove the two hexbolts and the one nut and washer holding the fan clutch to the engine. See **Fig. 1.**
12. Remove the fan clutch from the engine, along with the two drive belts.

Fan Clutch Installation

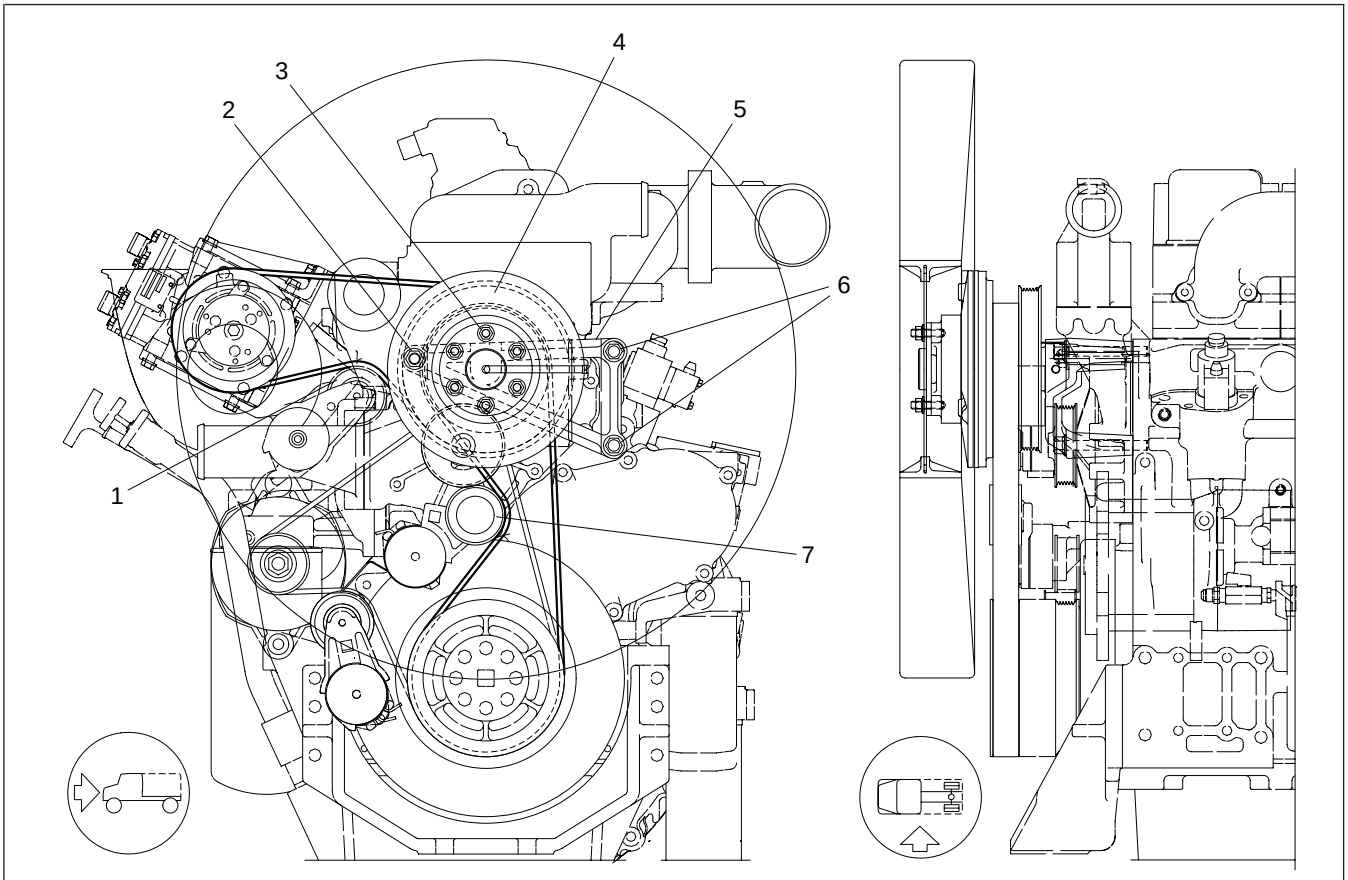
1. Install the drive belts onto the fan clutch pulleys.

⚠ WARNING

The fan clutch is heavy, and installing it in the center of a crowded engine compartment can be awkward. To avoid injury, two people should work together to install the fan clutch onto the engine.

2. Install the fan clutch with the drive belts onto the engine.
   - 2.1 Position the fan clutch on the engine, aligning the one hole with the stud on the engine, and the other two holes with holes in the engine.
   - 2.2 Install the two bolts and the one nut and washer. Tighten them 60 lbf·ft (81 N·m).
3. Install the drive belts.
   - 3.1 Install the rearward drive belt first, by putting a wrench on the upper belt tensioner, then rotating it inward. Slide the belt over the tensioner, then release the tension on it.
   - 3.2 Repeat the procedure for the other drive belt.
4. Install the fan blade. Tighten the fasteners 28 lbf·ft (38 N·m).
5. Install the fan shroud. Tighten the four fasteners loosely.
6. Install the radiator struts onto the radiator. Tighten the fasteners 90 lbf·ft (122 N·m).
7. Align the fan shroud so that the fan blade will clear it, then tighten the fan shroud fasteners 108 lbf·in (1220 N·cm).
8. Connect the air line to the fan clutch.
9. Connect the batteries.
10. Close the hood.
11. Remove the chocks from the tires.

Removal and Installation, Equipped with Detroit Diesel Series 55 Engine



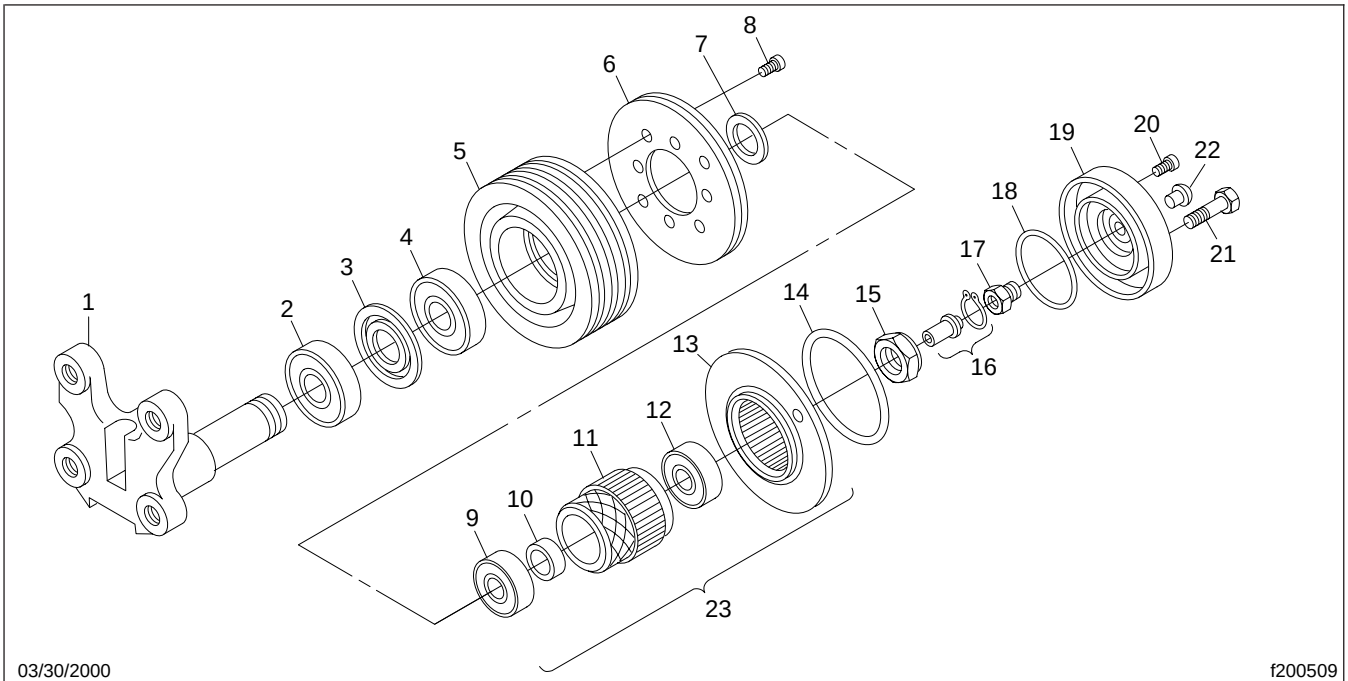
02/05/97 f011117

1. Upper Belt Tensioner
2. Hexnut, M12 and Washer, 1/2"
3. Hexnut, 3/8–16 (6 qty.)
4. Fan Clutch
5. Mounting Bracket
6. Flanged Hexbolts, M12 x 100
7. Lower Belt Tensioner

Fig. 1, Fan Clutch Installation, DDEC Series 55 Engine

Disassembly (See Fig. 1)

NOTE: This procedure involves a major rebuild of the Horton Advantage fan clutch, using parts from the manufacturer's Major or Super Kit. If you are replacing just the air cartridge, System Sentry® fuse, or the face seal, go to **Subject 120**.



1. Mounting Bracket Assembly
2. Rear Sheave Bearing
3. Inner and Outer Bearing Spacers
4. Forward Sheave Bearing
5. Sheave
6. Friction Facing
7. Journal Spacer
8. Socket-Head Capscrew
9. Rear Hub Bearing
10. Bearing Spacer
11. Splined Hub
12. Forward Hub Bearing
13. Piston Friction Disc
14. Large O-Ring
15. Locknut
16. Air Cartridge Assembly
17. Face Seal
18. Small O-Ring
19. Air Chamber
20. Socket-Head Capscrew
21. Hexbolt (some vehicles equipped with studs)
22. Rubber Umbrella Valve
23. Disc and Piston Assembly

Fig. 1, Horton Advantage Fan Clutch

1. Remove the fan and clutch assembly from the vehicle. For instructions, refer to **Subject 100**.
2. Clamp the fan clutch in a vise. See **Fig. 2**.
3. On some vehicles, the fan clutch has threaded studs on the air chamber and the fan is attached with nuts. On other vehicles, the fan is attached to the air chamber with hexbolts.

   If hexbolts were used to attach the fan, install two of the removed hexbolts in the air chamber so that a screwdriver can be used to keep the air chamber from rotating. See **Fig. 3**.

   Remove the socket-head capscrews from the air chamber.
4. If applicable, remove the two hexbolts previously installed.

⚠ WARNING

Apply air pressure slowly to the fan clutch. A sudden blast of air might blow the air chamber off the clutch, resulting in possible injury.

Fan Clutch Major Rebuild

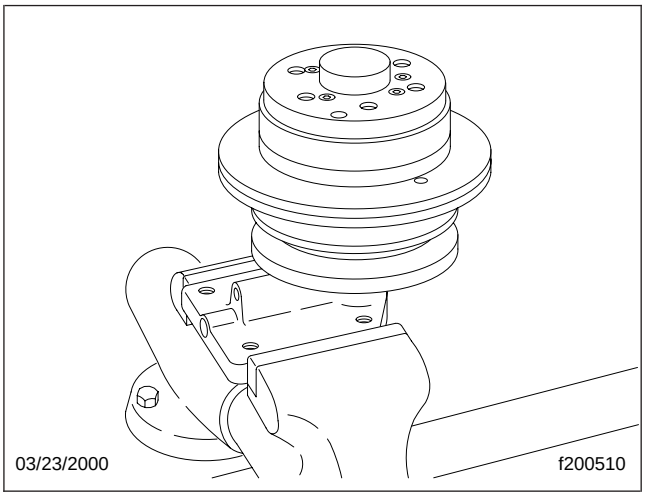


Fig. 2, Fan Clutch Placed in a Vise

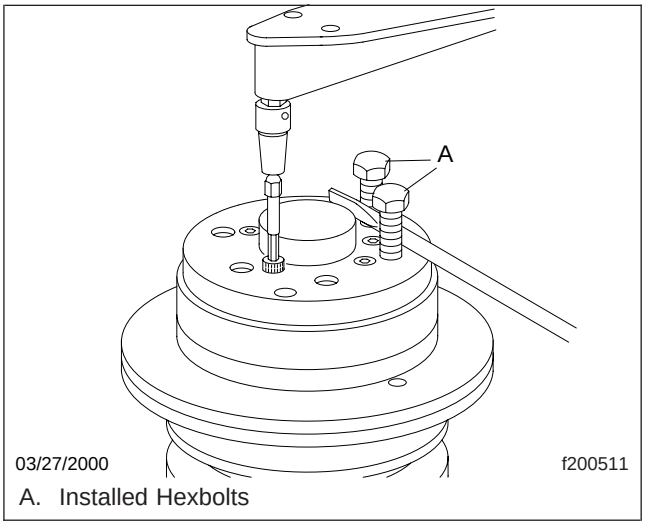


Fig. 3, Remove the Socket-Head Capscrews

5. Connect a shop air hose to the cylinder inlet. See **Fig. 4** . Slowly apply air pressure, and remove the air chamber assembly.
6. Remove and discard the O-rings from the air chamber and the piston friction disc. Clean the O-ring contact surfaces.
7. Remove the face seal from the air chamber.
8. Remove the System Sentry fuse from the piston friction disc. *Note that it is a left-hand thread.*
9. Remove the rubber umbrella valve from the air chamber.

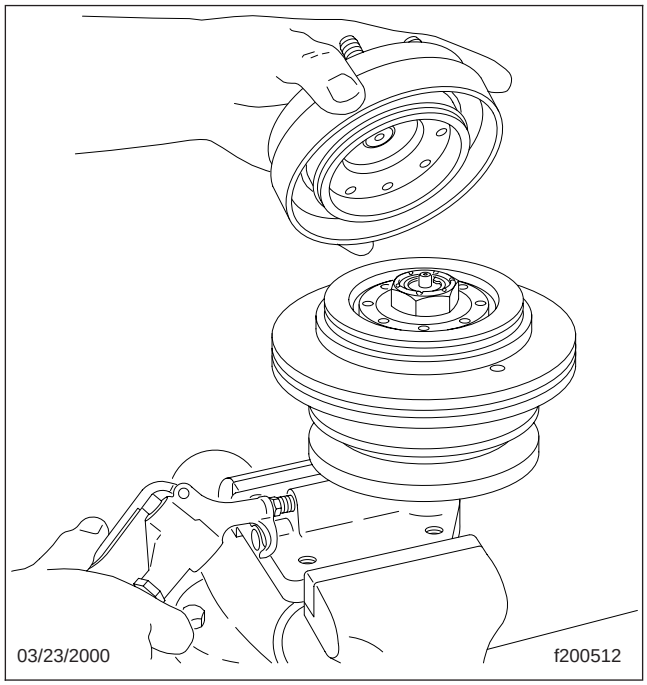


Fig. 4, Remove the Air Chamber

10. Remove the adjusting nut. See **Fig. 5**.

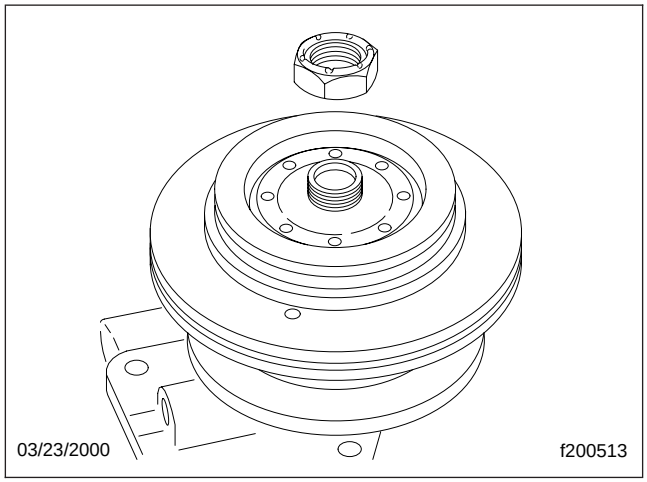


Fig. 5, Remove the Adjusting Nut

11. Remove the disc and piston assembly, and the journal spacer. See **Fig. 6**.
12. Slide the sheave and bearings off the mounting bracket assembly. See **Fig. 7**.
13. Remove the socket-head capscrews from the friction facing. Remove the friction facing.

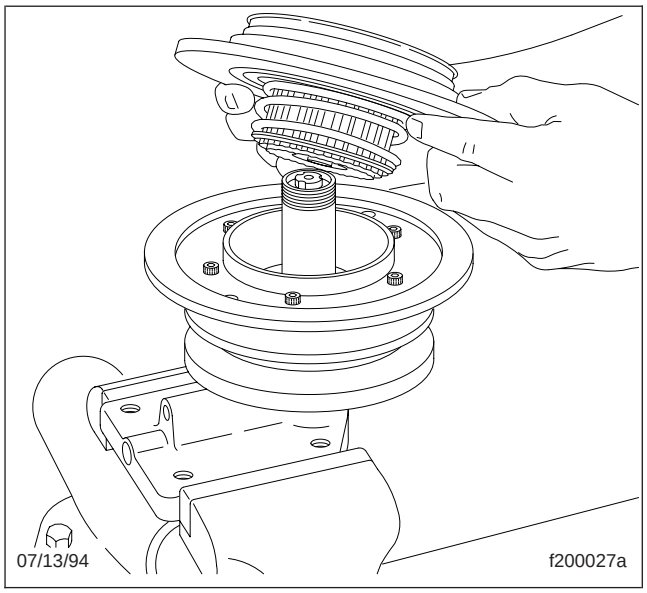


Fig. 6, Remove the Disc and Piston

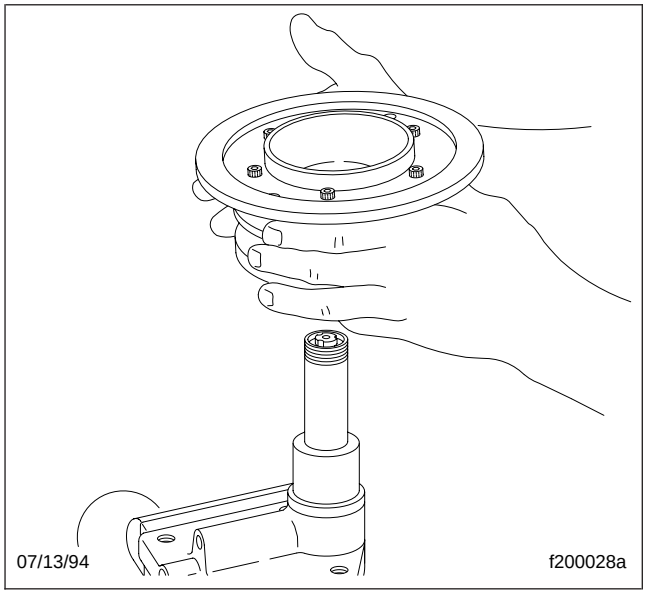


Fig. 7, Slide Off the Sheave and Bearings

14. Remove the retaining ring from the air cartridge assembly. See **Fig. 8**.

    Remove the cartridge assembly from the mounting bracket assembly. See **Fig. 9**.

15. Support the sheave and press out the bearings.

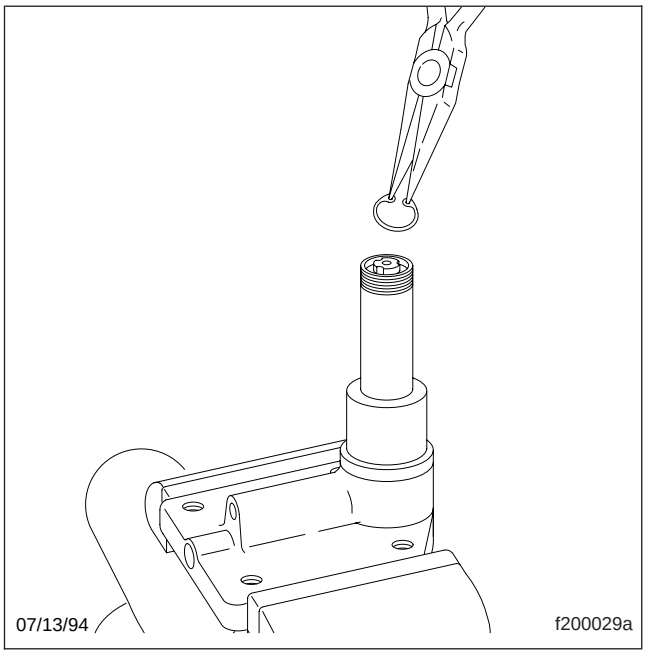


Fig. 8, Remove the Retaining Ring

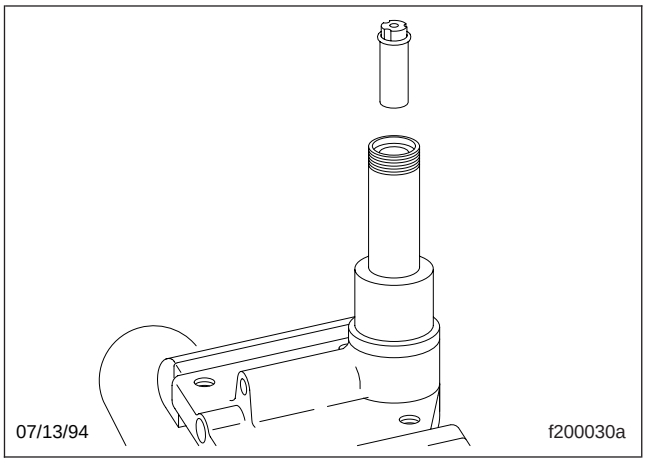


Fig. 9, Remove the Air Cartridge Assembly

Assembly

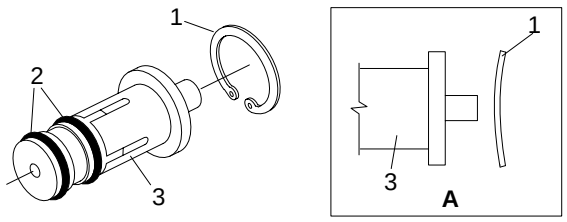
1. Coat the new sheave bearings with grease and press them into the sheave.

NOTE: Some models have a spacer between the bearings. Install the spacer if equipped.

2. Install a new air cartridge assembly in the mounting bracket assembly. Note that the retaining ring

Fan Clutch Major Rebuild

is curved. Make sure the ring is installed with the convex surface toward the air cartridge. See **Fig. 10** .



A. Convex Surface of Retaining Ring Toward the Air Cartridge
1. Retaining Ring
2. O-Rings
3. Air Cartridge

Fig. 10, Air Cartridge Assembly

3. Slide the sheave and bearings onto the mounting bracket assembly.
4. Install a new friction facing onto the sheave. Following a star pattern, tighten the socket-head capscrews 60 lbf·in (680 N·cm).

CAUTION

Never fill more than one-third of the bearing void with grease. Too much grease can cause overheating and possible bearing damage.

5. Install the journal spacer, and the disc and piston assembly. Make sure that the lip on the journal spacer is facing up. See **Fig. 11**.
6. Install the adjusting nut. Tighten 150 lbf·ft (203 N·m).
7. Remove any dust and debris from the air chamber.
8. Coat the new O-rings with an approved lubricant and install them. See **Fig. 12**.
9. Install the new face seal in the air chamber. Tighten 50 lbf·in (565 N·cm).
10. Install the new rubber umbrella valve in the air chamber.
11. Install the new System Sentry fuse in the piston friction disc. *Note that it is a left-hand thread.*

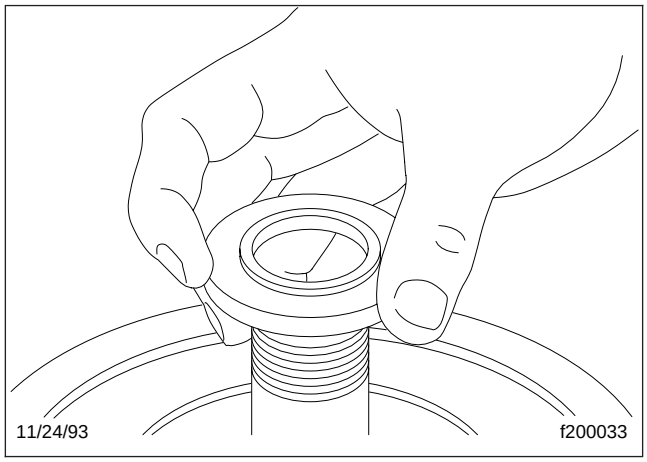


Fig. 11, Check the Journal Lip

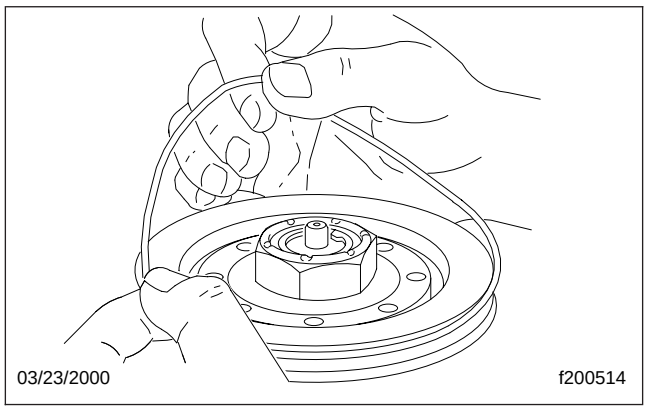


Fig. 12, Install New O-Rings

12. Slide the air chamber assembly onto the clutch. If applicable, install two of the hexbolts that hold the fan in place.
13. Using a screwdriver to keep the air chamber from rotating, install the socket-head capscrews. Following a star pattern, tighten 15 lbf·ft (20 N·m).
14. If applicable, remove the two hexbolts previously installed.
15. Install the fan and clutch assembly on the engine. For instructions, refer to **Subject 100**.

Disassembly

NOTE: This procedure involves replacing only the air cartridge, System Sentry® fuse, the face seal, and the O-rings, using parts from the manufacturer's Seal Kit. If doing a major rebuild, go to **Subject 120**.

1. Remove the fan and clutch assembly from the vehicle. For instructions, refer to **Subject 100**.
2. Clamp the fan clutch in a vise. See **Fig. 1**.

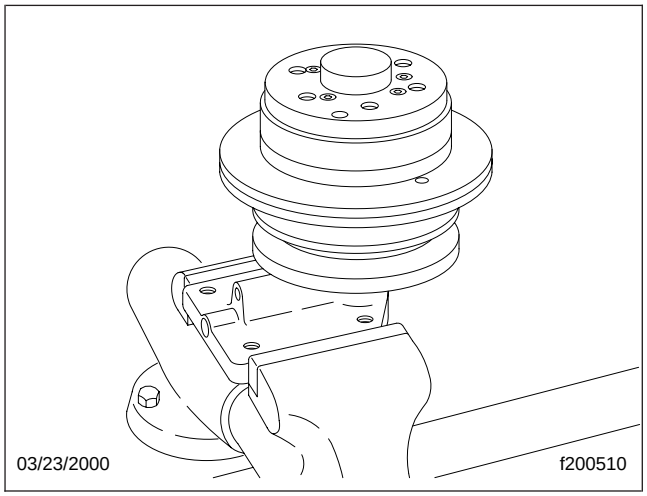


Fig. 1, Fan Clutch Placed in a Vise

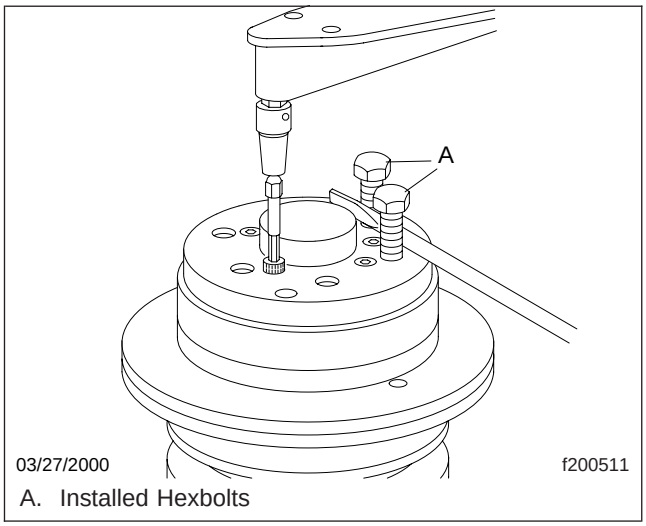
3. On some vehicles, the fan clutch has threaded studs on the air chamber and the fan is attached with nuts. On other vehicles, the fan is attached with hexbolts.

   If hexbolts were used to attach the fan, install two of the removed hexbolts in the air chamber so a screwdriver can be used to keep the air chamber from rotating. See **Fig. 2**.

   Remove the socket-head capscrews from the air chamber.
4. If applicable, remove the two hexbolts previously installed.

⚠ WARNING

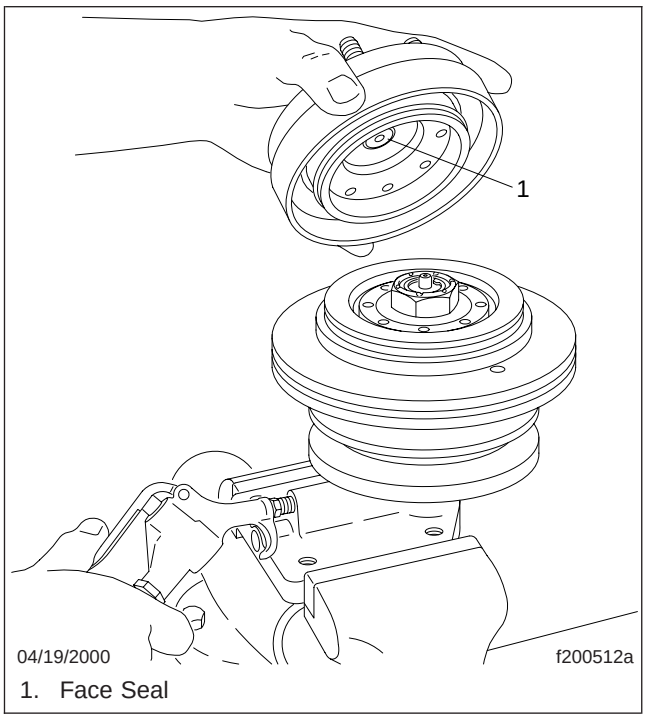
Apply air pressure slowly to the fan clutch. A sudden blast of air might blow the air chamber off the clutch, resulting in possible injury.



A. Installed Hexbolts

Fig. 2, Remove the Socket-Head Capscrews

5. Connect a shop air hose to the cylinder inlet. See **Fig. 3** . Slowly apply air pressure, and remove the air chamber assembly.



1. Face Seal

Fig. 3, Remove the Air Chamber

Fan Clutch Minor Rebuild

6. Remove and discard the O-rings from the air chamber and the piston friction disc. Clean the O-ring contact surfaces.
7. Remove the face seal from the air chamber. See **Fig. 3** .
8. Remove the System Sentry fuse from the piston friction disc. *Note that it is a left-hand thread.*
9. Remove the rubber umbrella valve from the air chamber.
10. Remove the adjusting nut. See **Fig. 4**.

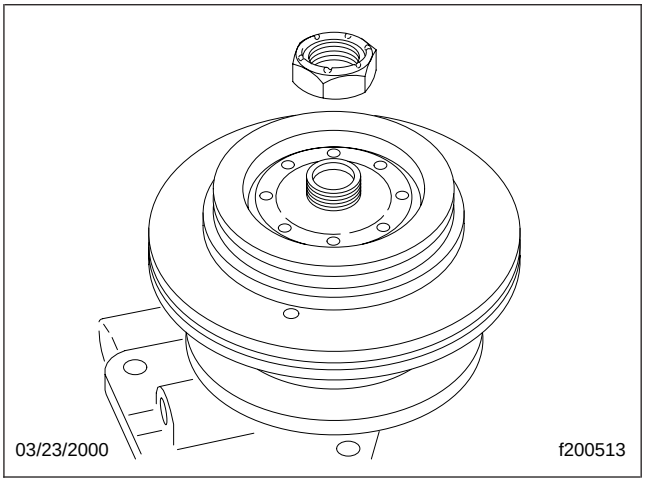


Fig. 4, Remove the Adjusting Nut

11. Remove the retaining ring from the air cartridge assembly. See **Fig. 5**.

    Remove the cartridge assembly from the mounting bracket assembly. See **Fig. 6**.

Assembly

1. Install a new air cartridge assembly in the mounting bracket assembly. Note that the retaining ring is curved. Make sure the ring is installed with the convex surface toward the air cartridge. See **Fig. 7** .
2. Install the adjusting nut. Tighten 150 lbf·ft (203 N·m).
3. Remove any dust and debris from the air chamber.
4. Coat the new O-rings with an approved lubricant and install them. See **Fig. 8**.

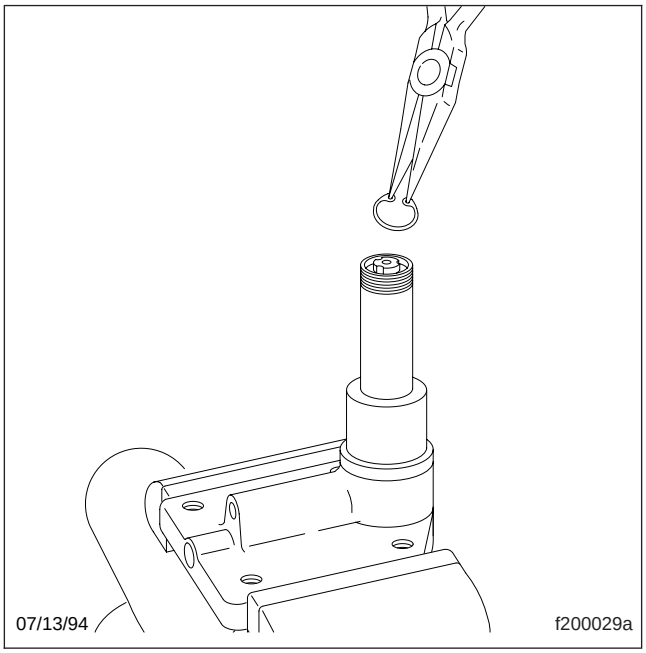


Fig. 5, Remove the Retaining Ring

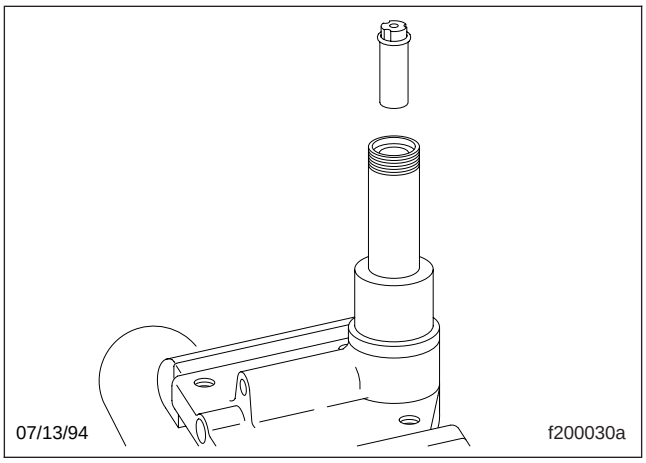
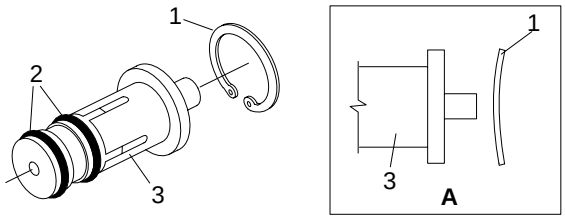


Fig. 6, Remove the Air Cartridge Assembly

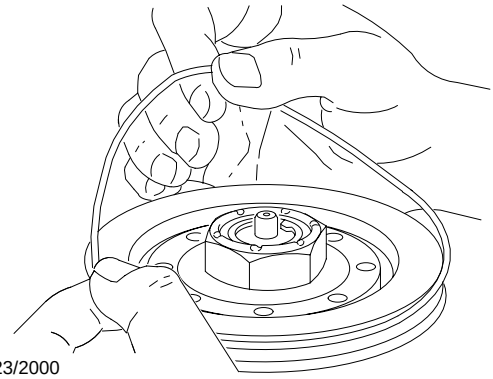
5. Install the new face seal in the air chamber. Tighten 50 lbf·in (565 N·cm).
6. Install the new rubber umbrella valve in the air chamber.
7. Install the new System Sentry fuse in the piston friction disc. *Note that it is a left-hand thread.*
8. Slide the air chamber assembly onto the clutch. If applicable, install two of the hexbolts that held the fan in place.



03/27/2000 f200515

A. Convex Surface of Retaining Ring Toward the Air Cartridge
1. Retaining Ring
2. O-Rings
3. Air Cartridge

Fig. 7, Air Cartridge Assembly



03/23/2000 f200514

Fig. 8, Install New O-Rings

9. Using a screwdriver to keep the air chamber from rotating, install the socket-head capscrews. Following a star pattern, tighten 15 lbf·ft (20 N·m).
10. If applicable, remove the two hexbolts previously installed.
11. Install the fan and clutch assembly on the engine. For instructions, refer to **Subject 100**.

Fastener	Torque	
	N·m (lbf·ft)	N·cm (lbf·in)
Fan Nut	20 (15)	—
Adjusting Nut	203 (150)	—
Air Chamber Capscrew	20 (15)	—
Friction Facing Capscrew	—	680 (60)
Fan Clutch Mounting Capscrews	18 (13)	—

Table 1, Torque Values

Approved Greases

Amoco Rykon Premium No. 2 EP

Chevron SRI-2

Texaco Premium RB No. 2

Exxon Unirex No. 2

Shell Dolium Grease No. 2

Approved Lubricants

Parker O-Ring Lube

Horton O-Ring Lube No. 13220

Wiring

See Fig. 1 for the fan clutch wiring diagram.

Specifications

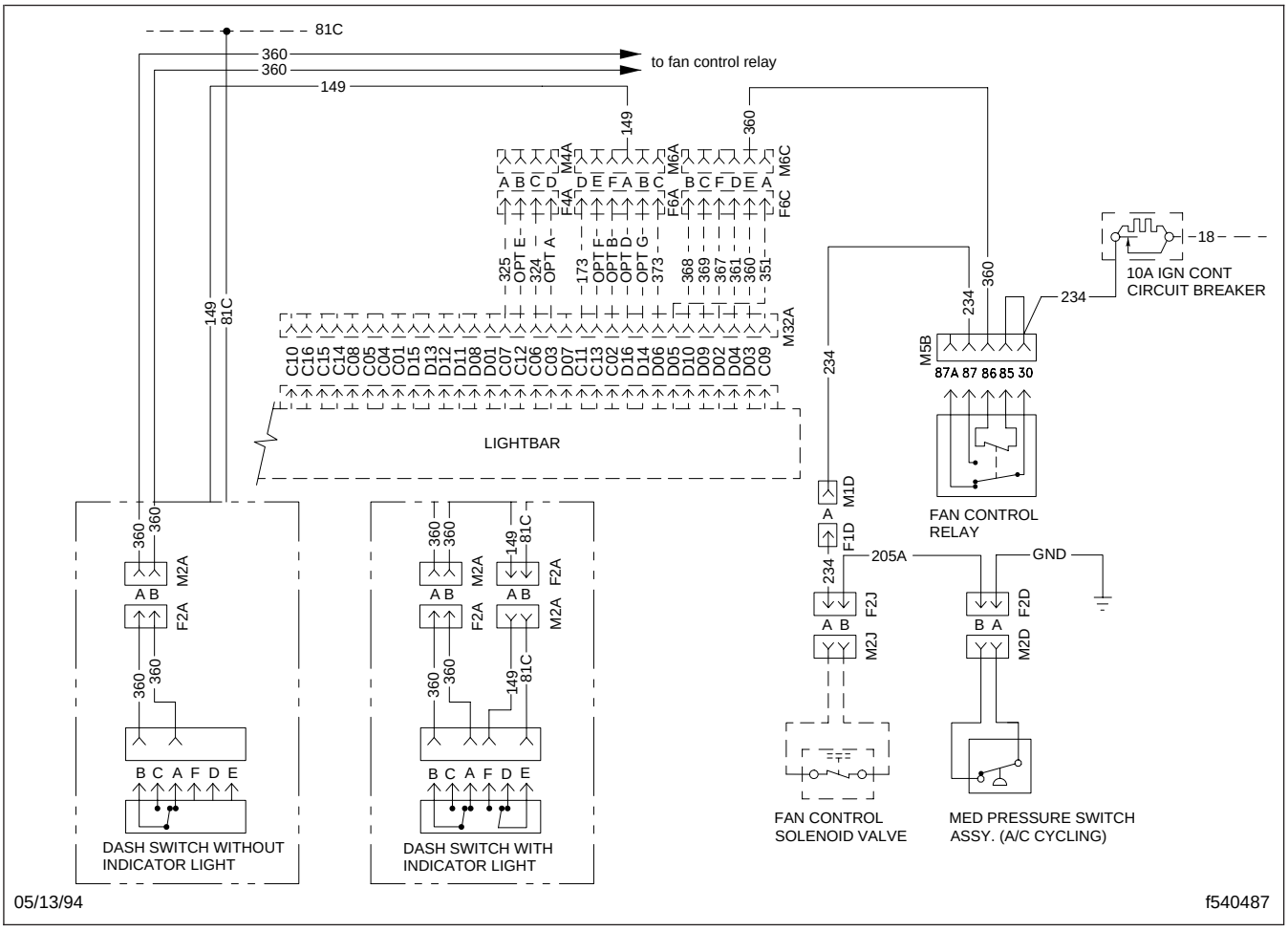


Fig. 1, Fan Clutch Wiring Diagram

General Information

The K22RA fan drive unit is an air-operated, temperature-controlled clutch for the engine cooling fan. It is installed only on Caterpillar 3126 and Detroit Diesel Series 50 engines. Its purpose is to maintain engine temperature by engaging or disengaging the fan. The fan clutch is disengaged when the coolant temperature is at or below the specified temperature range. The fan clutch engages when the coolant temperature rises above the range.

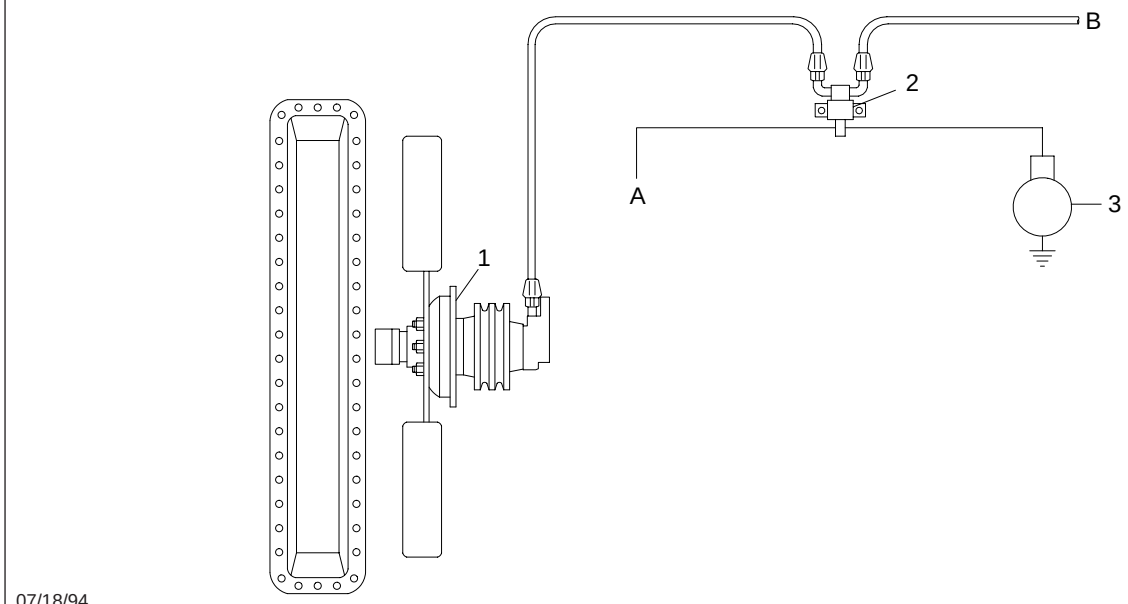
Air pressure to the fan clutch is controlled by a solenoid valve; the solenoid valve is controlled by a temperature switch that is installed in the thermostat housing. See **Fig. 1**.

lenoid is controlled by a temperature switch that is immersed in the engine coolant.

When a cold engine is started, the temperature switch is open, which activates the solenoid. The solenoid valve allows compressed air to enter the cylinder, and the fan clutch remains disengaged. The fan does not turn.

When the coolant temperature rises to the temperature switch setting, the switch closes. The solenoid valve releases the compressed air from the cylinder. The fan clutch spring engages the clutch and the fan turns.

When the coolant temperature drops to the temperature switch cutoff setting, the switch opens, activating



A. To the circuit breaker
B. From the secondary air tank
1. Fan Clutch
2. Solenoid Valve
3. Temperature Switch

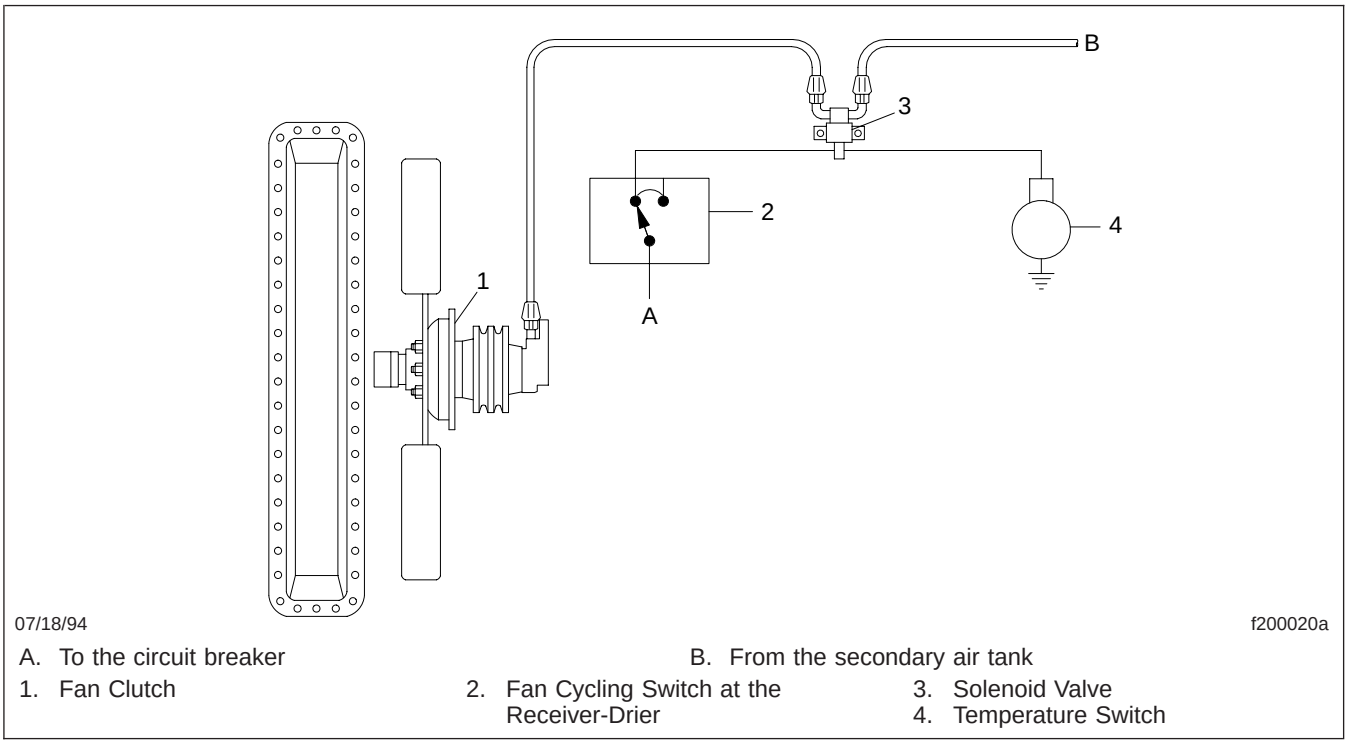
Fig. 1, Fan Clutch Piping and Wiring, Vehicle Without Air Conditioning

On vehicles with air conditioning, the fan clutch solenoid valve is connected to a fan cycling switch at the receiver-drier. If the refrigerant pressure exceeds the setting of the fan cycling switch, the switch supplies power to the solenoid valve. See **Fig. 2**.

The fan clutch is spring-loaded in the engaged position. It is disengaged when air pressure is applied to the cylinder on the front of the unit. Air pressure to the cylinder is controlled by a solenoid valve: the solenoid. Compressed air passes to the cylinder disengaging the clutch.

On vehicles with air conditioning, the fan clutch solenoid valve is connected to a fan cycling switch at the receiver-drier. If the refrigerant pressure exceeds the setting of the fan cycling switch, the switch supplies power to the solenoid valve, which stops air flow and allows the internal spring to engage the fan clutch.

General Information



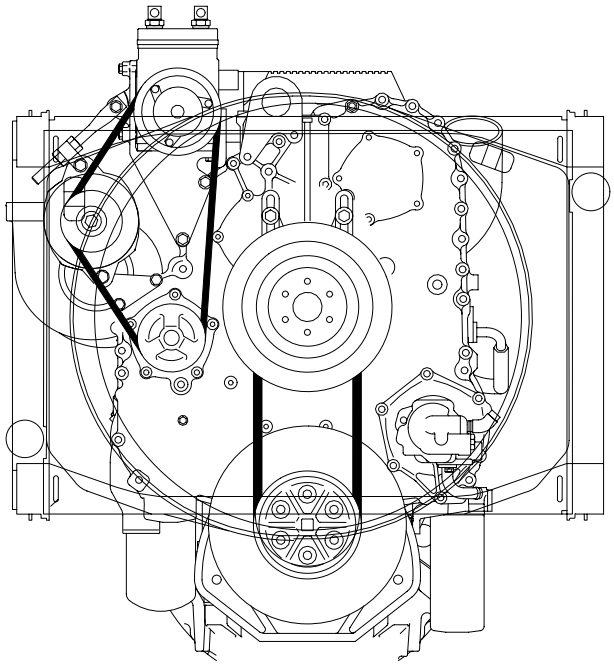
A. To the circuit breaker
B. From the secondary air tank
1. Fan Clutch
2. Fan Cycling Switch at the Receiver-Drier
3. Solenoid Valve
4. Temperature Switch

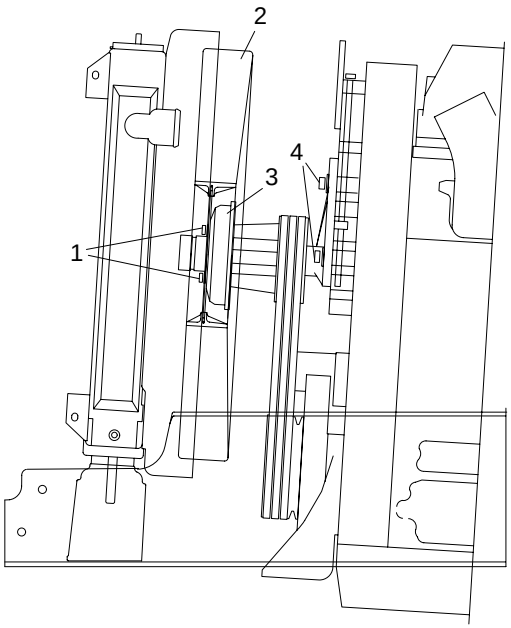
Fig. 2, Fan Clutch Piping and Wiring, Vehicle With Air Conditioning

NOTE: When disengaged, it is normal for the housing and fan to spin at about 300 rpm. When the compressed air is released and the clutch engages, the bearing housing and fan move forward approximately 1/10th-inch (2.5 mm).

Fan Clutch Removal and Installation, Kysor K22RA

Removal (Fig. 1)





06/22/95 f200312

1. Nut 3/8–24, grade 5; Washer
2. Fan
3. Fan Clutch
4. Flanged Bolt, M12 x 35 mm, grade 10.9; Washer

Fig. 1, Kysor Fan Clutch (Detroit Diesel Series 60 engine)

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.

WARNING

Use care when loosening the air line fitting. The line could be under pressure and may have dirt or sludge in the air stream. If quickly disconnected, the line may whip, possibly causing eye injury or other bodily injury.

3. Disconnect the air line from the fan clutch.
4. If necessary to tilt the radiator forward to gain sufficient clearance, remove the support struts from the top of the radiator.

   With one person holding each side of the radiator, tilt the top of the radiator forward.
5. With the radiator tilted forward, remove the fasteners attaching the fan to the fan clutch.

WARNING

If the fan clutch engages during the next step, it could cause personal injury. Keep the fan clutch disengaged throughout this procedure by maintaining between 90 and 120 psi (620 and 830 kPa) of air pressure.

6. Align the access holes in the fan clutch with the allen screws on the fan hub. See **Fig. 2**.

   6.1 Using shop air and a suitable nozzle attachment, apply between 90 and 120 psi (620 and 827 kPa) of air pressure to the fan clutch to disengage the clutch.

   6.2 Line up the access holes

Fan Clutch Removal and Installation, Kysor K22RA

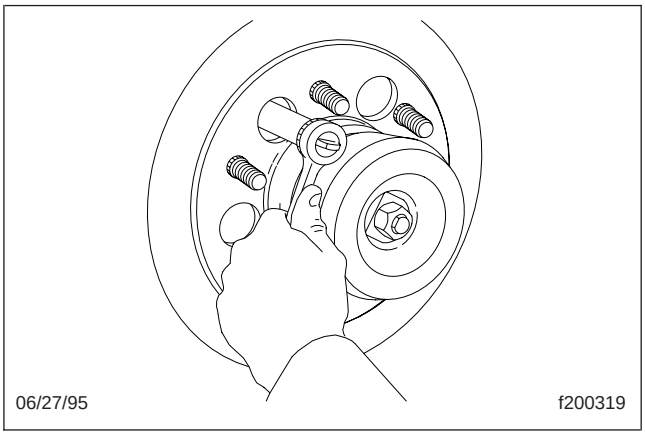


Fig. 2, Line Up the Access Holes

7. Remove the air pressure from the fan clutch, and allow it to engage.
8. Remove the allen screws holding the fan clutch to the fan hub.
9. Remove the fan clutch from the fan clutch hub. It may be necessary to gently pry the clutch from the hub.

Installation

IMPORTANT: A new coupler must be used when installing the clutch onto the hub.

1. Install the fan clutch onto the fan clutch hub.
   - 1.1 Install a new coupler onto the fan hub.
   - 1.2 Position the fan clutch onto the fan hub, then push it toward the rear of the vehicle and rotate the clutch until the flats of the coupler engage the fan clutch.
   - 1.3 Line up the access holes in the clutch with the holes for the allen screws in the clutch hub.
   - 1.4 Install the allen screws, and tighten them 44 lbf·ft (60 N·m).
2. Install the fan. Tighten the fasteners firmly.
3. If the radiator was moved forward, position the radiator flat on its mounts, and connect the support struts to the top of the radiator.
4. Connect the air line to the fan clutch.
5. Lower the hood.
6. Remove the chocks from the tires.

Fan Clutch Minor Rebuild, Kysor K22RA

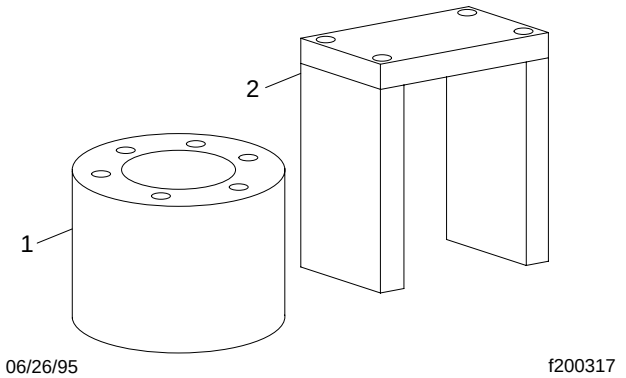
Special Tools

IMPORTANT: Special tools are recommended, but not required for this procedure. See **Table 1** for the special tool set.

Special Tools		
Description	**Part Number**	**Order From**
Support and Compressor (see **Fig. 1**)	1090-00000-02	Wright Brothers Enterprises 8171 Hibma Marion, MI 49665 Telephone: 231-825-2939

Table 1, Special Tools

Rebuild



1. Support
2. Compressor

Fig. 1, Special Tools

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Remove the fan clutch from the vehicle. For instructions, refer to **Subject 110**.

CAUTION

When caging and compressing the engagement spring of the fan clutch, depress the clutch shaft only enough to relieve the pressure on the retaining plates (about 1/16-inch, or 1.5 mm). Applying additional force after the clutch shaft bottoms in the housing will damage the housing and render it unserviceable.

NOTE: There are two methods of caging the engagement spring. One uses the special tools and a press. The other uses carriage bolts, washers, and wingnuts. Either method is effective.

3. Cage the engagement spring.

   If using the special support and compressor tools, place the fan clutch in a press to cage the engagement spring. See **Fig. 2**.

   If using the optional method of caging the engagement spring, do the following:

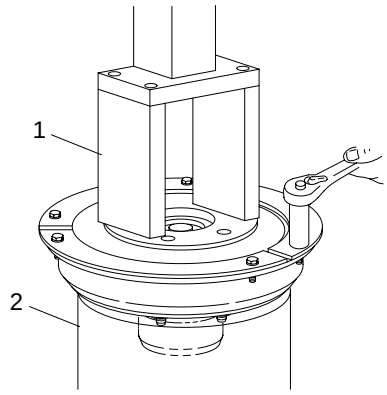
   3.1 With the access holes in the housing assembly aligned with those in the shaft assembly, install two 3-1/2-inch (89-mm) long carriage bolts and suitable washers on opposite sides of the clutch assembly.

   3.2 On the shaft assembly side, install about a 1/2-inch (13-mm) thickness of washers onto each carriage bolt.

   3.3 Install a wingnut on the end of each carriage bolt and tighten the wingnuts evenly until the engagement spring is caged.

4. Remove the lining retaining plates and the lining. See **Fig. 2** and **Fig. 3**.

Fan Clutch Minor Rebuild, Kysor K22RA



1. Compressor Tool
2. Support Tool

Fig. 2, Caging the Engagement Spring and Removing the Lining Retaining Plates

CAUTION

Do not press on the cylinder during this step, or the cylinder will be damaged. Use a 5/8-inch wrench as shown in Fig. 4 on the piston rod flats.

5. If applicable, turn the clutch over in the press, and use the special compressor tool to cage the engagement spring while removing the cylinder nut and cylinder. See **Fig. 4**.
6. Inspect the fan clutch. See **Fig. 3**
   - 6.1 Inspect the two surfaces where the lining rides.
   - 6.2 Inspect the needle bearing race on the shaft.
   - 6.3 Inspect the needle bearings inside the clutch housing.
   - 6.4 Inspect the piston bearing by rotating the piston.
7. If you find cracking or scoring on any surface, or if the bearings are rough, loose, or missing, replace the fan clutch.

NOTE: If you find metal particles in the existing grease, replace the fan clutch or contact Kysor for the training needed to perform a major fan clutch rebuild. Kysor will not provide parts for a major rebuild until the technician has completed rebuild training provided by Kysor.

IMPORTANT: Do not wash the clutch parts in solvent.

8. Using **Fig. 3** as a reference, lubricate the following rebuild parts with lubricant supplied with the rebuild kit (if the lubricant is unavailable, use one of the approved lubricants listed in **Specifications, 400)** :
   - The piston seal (pack the seal groove also)
   - The dust seal (pack the seal groove also)
   - The needle bearings inside the housing
   - The inside of the engagement spring
   - The outside of the piston rod assembly
   - The inside of the piston rod assembly
   - The inside of the cylinder assembly
   - Pack the lip of the grease seal

CAUTION

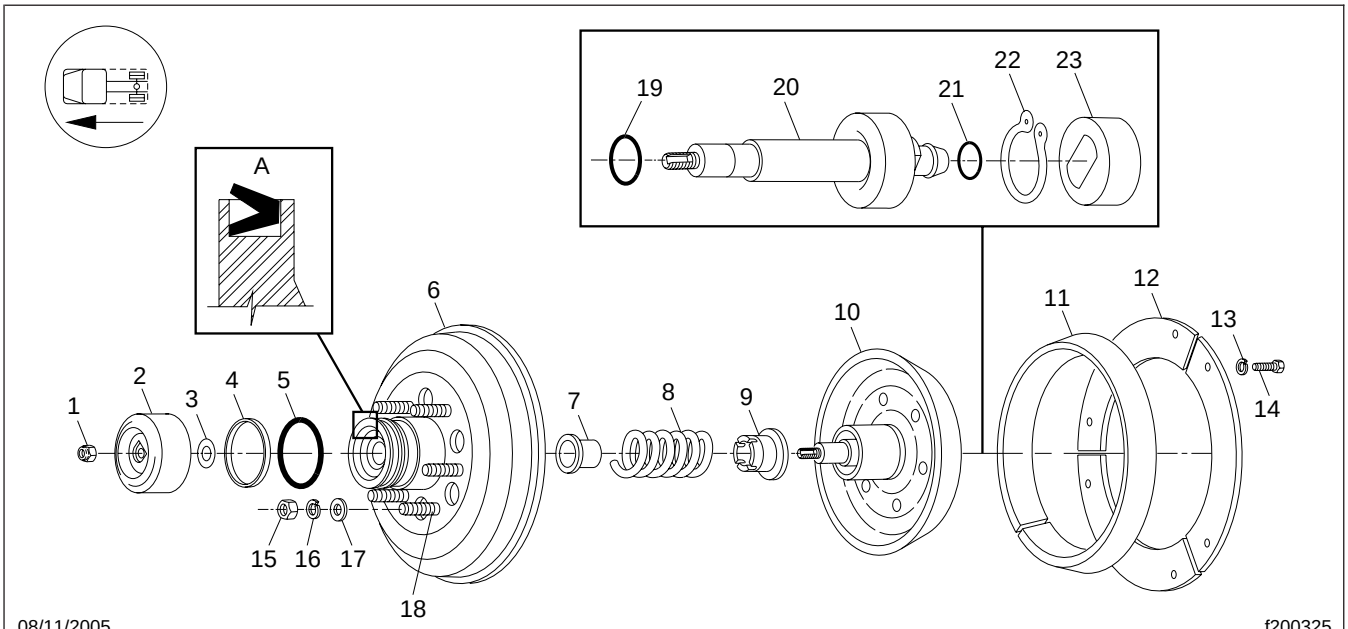
When caging the engagement spring, make sure the bottom edges of the housing assembly and the shaft assembly are flush and aligned all the way around. Failure to do so will cause the engagement spring pressure to affect the torque of the cylinder nut. This could result in the cylinder nut not being tight enough to effectively compress the piston seal washer, which could cause leakage and eventual fan clutch failure.

IMPORTANT: When caging the engagement spring, compress the clutch shaft only 1/16-inch (1.5 mm).

9. Assemble the fan clutch parts according to **Fig. 3**. Using either the special tools and a press, or carriage bolts, washers, and wingnuts, cage the engagement spring when installing the cylinder and lining. Be careful to depress the clutch shaft only 1/16-inch (1.5 mm).

   The piston rod seal washer is the last item to install before the cylinder goes on. See **Fig. 5**.
10. Tighten the cylinder nut 84 lbf·in (940 N·cm).
11. Tighten the lining screws 30 lbf·in (340 N·cm).

Fan Clutch Minor Rebuild, Kysor K22RA



A. If a lip seal is used, install it so that it faces away from the fan studs.

1. Cylinder Nut
2. Cylinder Assembly
3. Piston Rod Seal Washer
4. Lip Seal (may be O-Ring)
5. Dust Seal
6. Housing Assembly
7. Engagement Spring End Cap
8. Engagement Spring
9. Engagement Spring Carrier
10. Shaft Assembly
11. Lining
12. Lining Retaining Plates
13. Lockwasher
14. Screw
15. Fan Nut
16. Lockwasher
17. Flatwasher
18. Fan Stud
19. O-Ring
20. Piston Rod Assembly
21. O-Ring
22. Snap Ring
23. Coupling

Fig. 3, Kysor K22RA Fan Clutch (exploded view)

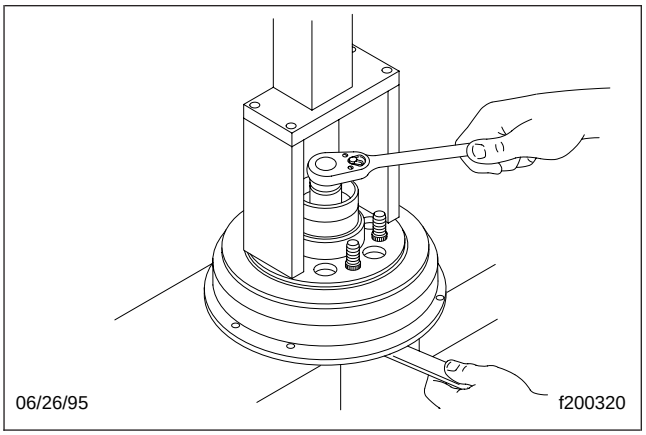


Fig. 4, Removing the Cylinder Nut and Cylinder

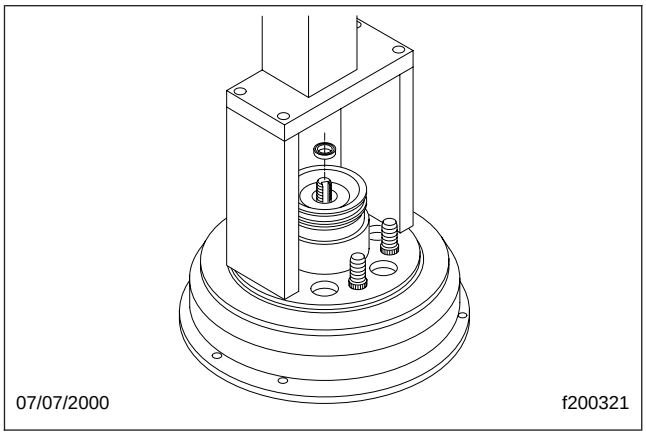


Fig. 5, Installing the Piston Rod Seal Washer

Fan Clutch Minor Rebuild, Kysor K22RA

12. As applicable, remove the fan clutch from the press or remove the carriage bolts, washers, and wing nuts.
13. Check the front-to-rear travel of the fan clutch. For instructions, refer to Group 20 in the *Business Class Trucks Maintenance Manual.*
14. Install the fan clutch on the engine. For instructions, refer to **Subject 110**.
15. Close the hood and remove the chocks from the tires.

Fan Clutch Relining, Kysor K22RA

Relining (See Fig. 1)

IMPORTANT: Premature wearing of the fan clutch lining is due to either insufficient air pressure necessary to fully engage the clutch or a problem in the control circuit for the fan.

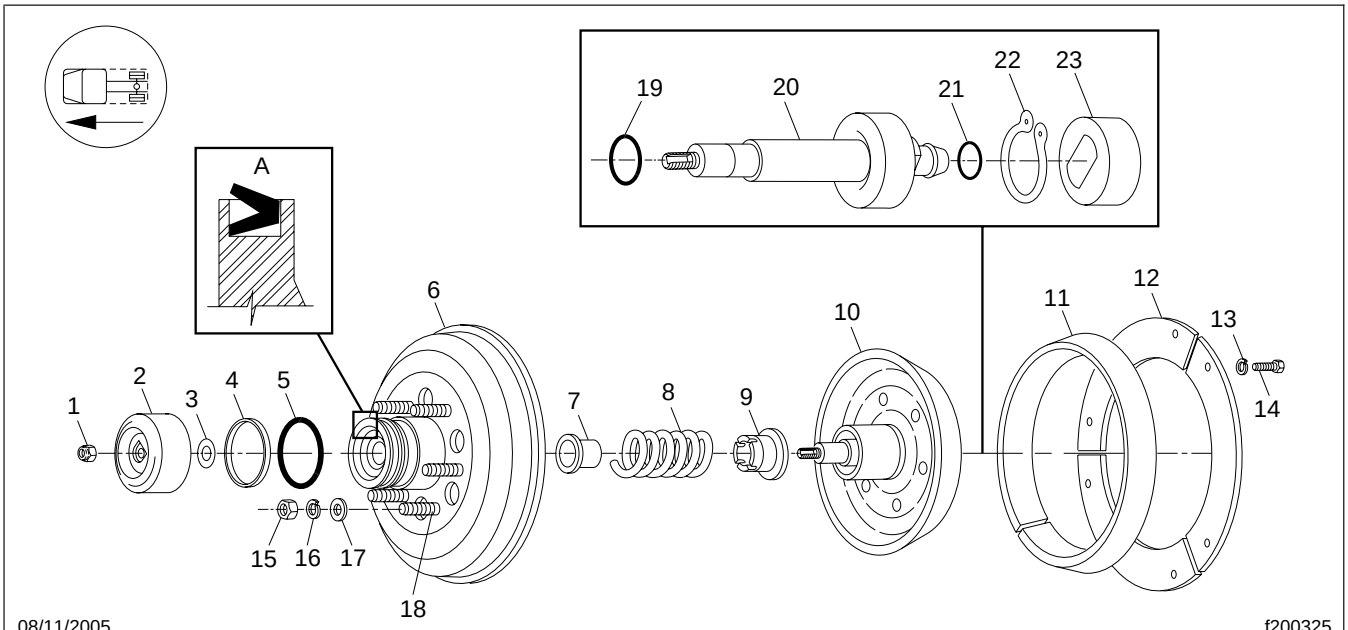
Before putting the fan clutch back in service, check the fan control and air supply systems and make any necessary repairs.

1. Park the vehicle, apply the parking brakes, and chock the tires.

WARNING

If the fan clutch engages during the next step, it could cause personal injury. Keep the fan clutch disengaged throughout this procedure by maintaining between 90 and 120 psi (620 and 830 kPa) of air pressure.

2. Remove the six lining plate screws, and remove the three lining plates. See **Fig. 2**.
3. Replace the lining.
4. Install the new lining plates, and tighten the screws 30 lbf·in (340 N·cm).
5. Remove the air pressure from the fan clutch, and allow the fan to engage.
6. Close the hood, and remove the chocks from the tires.



A. If a lip seal is used, install it so that it faces away from the fan studs.

1. Cylinder Nut
2. Cylinder Assembly
3. Piston Rod Seal Washer
4. Lip Seal (may be O-Ring)
5. Dust Seal
6. Housing Assembly
7. Engagement Spring End Cap
8. Engagement Spring
9. Engagement Spring Carrier
10. Shaft Assembly
11. Lining
12. Lining Retaining Plates
13. Lockwasher
14. Screw
15. Fan Nut
16. Lockwasher
17. Flatwasher
18. Fan Stud
19. O-Ring
20. Piston Rod Assembly
21. O-Ring
22. Snap Ring
23. Coupling

Fig. 1, Kysor K22RA Fan Clutch (exploded view)

Fan Clutch Relining, Kysor K22RA

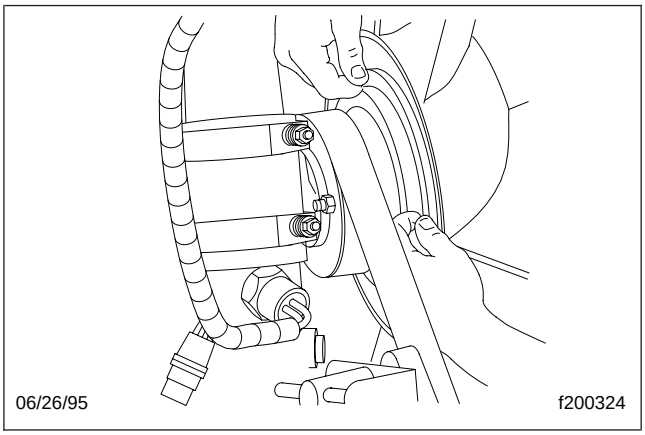


Fig. 2, Remove the Lining Plates

Problem—Fan Clutch Fails to Engage

Problem—Fan Clutch Fails to Engage	
Possible Cause	**Remedy**
There is no power to the fan clutch control circuit.	Check all electrical connections, and repair or replace wiring as needed.
The engine temperature switch is damaged or an incorrect sensor has been installed.	Make sure the switch is normally closed, not normally open. Replace the switch if it is damaged or if the switch is the wrong type.
The solenoid valve is malfunctioning.	Replace the solenoid valve.
The fan clutch is leaking.	Install a new seal kit.
The air supply to the fan clutch is restricted.	Make sure the fan clutch air lines are not leaking or pinched. Repair the lines as needed.

Problem—Fan Clutch Does Not Disengage

Problem—Fan Clutch Does Not Disengage	
Possible Cause	**Remedy**
The engine temperature switch is damaged or an incorrect sensor has been installed.	Make sure the switch is normally closed, not normally open. Replace the switch if it is damaged or if the switch is the wrong type.
A restricted air line does not allow air to vent from the clutch.	Make sure the air lines are not pinched or plugged. Repair the air lines as needed.
The solenoid is not exhausting.	Make sure the solenoid exhaust port is not plugged.

Problem—Fan Clutch Cycles Frequently

Problem—Fan Clutch Cycles Frequently	
Possible Cause	**Remedy**
The fan clutch control circuit has a loose connection or is poorly grounded.	Check all wiring connections and repair the circuit as needed.
The temperature control settings are incorrect.	Check the fan clutch control setting of the temperature switch according to the engine installed in the vehicle. Repair or replace the temperature switch as needed.
The fan cycling switch at the receiver-drier is set too low.	Check the switch at the receiver-drier and, if needed, replace the switch with a switch with a higher setting.
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
The temperature switch is malfunctioning.	Replace the temperature switch.

Problem—Fan Clutch Engages, But the Engine Still Overheats

Problem—Fan Clutch Engages, But the Engine Still Overheats	
Possible Cause	**Remedy**
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.

Troubleshooting

Problem—Fan Clutch Engages, But the Engine Still Overheats	
Possible Cause	**Remedy**
There is a problem somewhere else in the cooling system.	Refer to "Cooling System Troubleshooting," **Section 20.00** in this group.

Specifications

If the lubricant that comes with the rebuild kit for the Kysor K22RA fan clutch is unavailable, use one of the following approved lubricants:

- Aeroshell 5
- Shell Alvania R3
- Chevron SR12
- Amoco Rykon Premium #2EP
- Texaco RB Premium

Kysor K22RA Fan Clutch Torques		
Description	Torque	
	lbf·ft (N·m)	lbf·in (N·cm)
Clutch-to-Hub Fasteners	45 (61)	—
Fan-to-Clutch Fasteners	26 (35)	—
Front Piston Nut	—	84 (950)
Lining Plate Screws	—	30 (340)

Table 1, Kysor K22RA Fan Clutch Torques

General Information

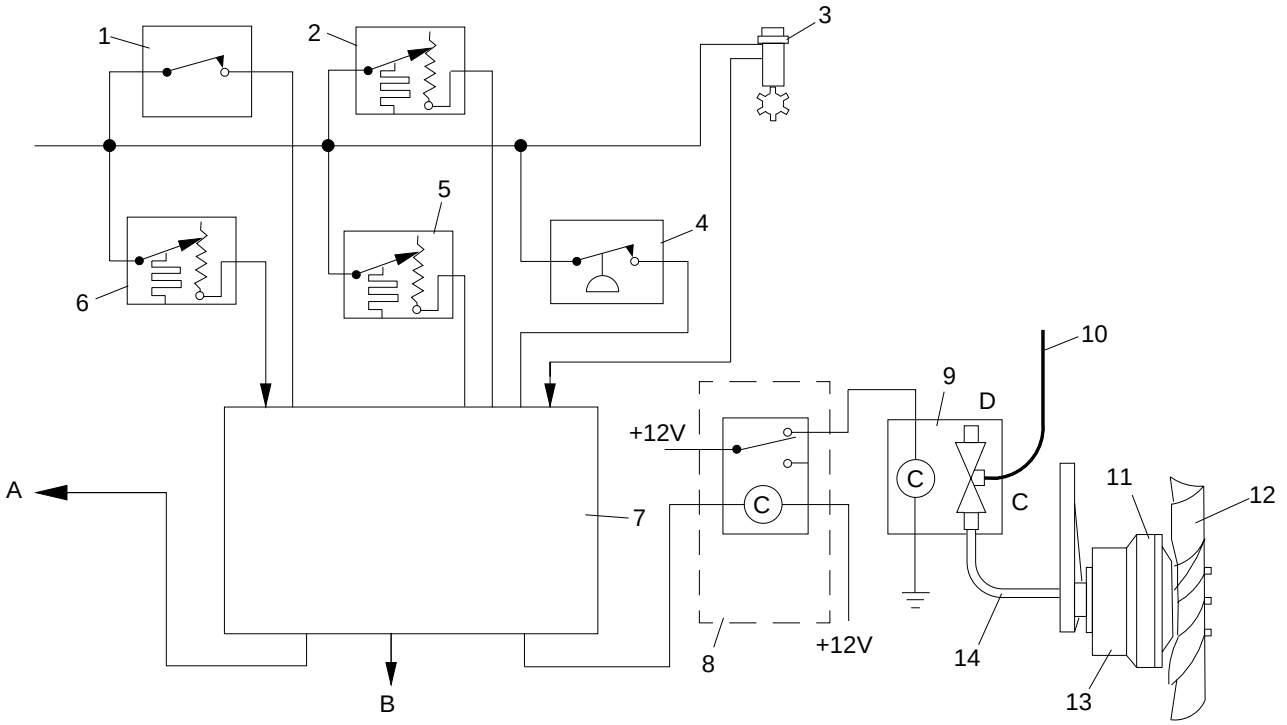
The Horton DriveMaster® fan clutch is a temperature-controlled, air-operated clutch for the engine cooling fan. It is spring engaged, and controls the engine temperature by engaging or disengaging the fan.

When the coolant temperature is below a specified range, air pressure keeps the fan disengaged to save engine power. When the coolant temperature rises above the specified range, air pressure to the fan clutch is cut off and internal spring pressure engages the fan.

Air pressure to the fan clutch is controlled by a solenoid valve; the solenoid valve is controlled by a temperature switch installed in the thermostat housing. The temperature switch is connected to the engine ECM, which controls the solenoid valve. See **Fig. 1**. When you start a cold engine, the solenoid valve allows air pressure to the fan clutch and the clutch remains disengaged. When the coolant temperature rises to the temperature switch setting, the switch provides power to the solenoid valve and the valve cuts off compressed air to engage the fan.

On vehicles with air conditioning, the fan clutch solenoid valve is connected to a fan cycling switch at the receiver-dryer. If the refrigerant pressure exceeds the setting of the fan cycling switch, the switch supplies power to the solenoid valve, which cuts off air to the fan clutch, engaging the fan.

General Information



A. To Indicators and Gauges
B. To Electronic Injectors and Other Actuators
C. Normally Closed
D. Normally Open

1. Fan Override Switch
2. Air Temperature Sensor
3. Engine Speed Sensor
4. A/C Pressure Switch
5. Coolant Temperature Sensor
6. Foot Throttle
7. Engine ECM
8. Fan Relay (not present in all systems)
9. Solenoid Valve
10. Air Supply from Reservoir
11. Fan Clutch
12. Air Supply to Fan Clutch

Fig. 1, Fan Clutch Schematic (engine ECM controlled)

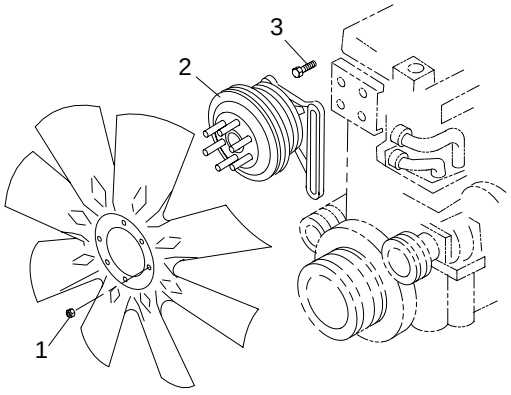
Removal

1. Park the vehicle on a level surface, shut down the engine, set the parking brakes, and chock the tires.

⚠ WARNING

Wear safety goggles when draining the air system or disconnecting an air line, because dirt and sludge could fly out at high speeds. Do not direct the airstreams at anyone. Do not disconnect pressurized air lines, as they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

2. Drain the air tanks.
3. Tilt the hood.
4. Disconnect the left-side hose from the charge air cooler.
5. Remove the drive belts from the engine.
6. Disconnect the air line from the fan hub.
7. Remove the fan.
8. Remove the fan clutch assembly from the engine. See **Fig. 1**.



05/29/2002 f200576

1. Hexnut
2. Fan Clutch Assembly
3. Hexbolt

Fig. 1, Fan Clutch Removal (typical)

8.1 If equipped with a metal fan ring, remove the two top fasteners holding the upper mounting bracket for the fan ring.

8.2 Remove the fasteners holding the fan clutch mounting bracket to the front of the engine.

⚠ WARNING

The fan clutch assembly may weigh up to 55 lb (25 kg). Be careful when lifting it. Use a helper or a hoist, if necessary. Failure to use care when lifting the fan clutch could result in injury or component damage.

8.3 Remove the fan clutch assembly from the vehicle. If equipped with a metal fan ring, carefully push the ring forward to allow removal of the fan clutch assembly.

Installation

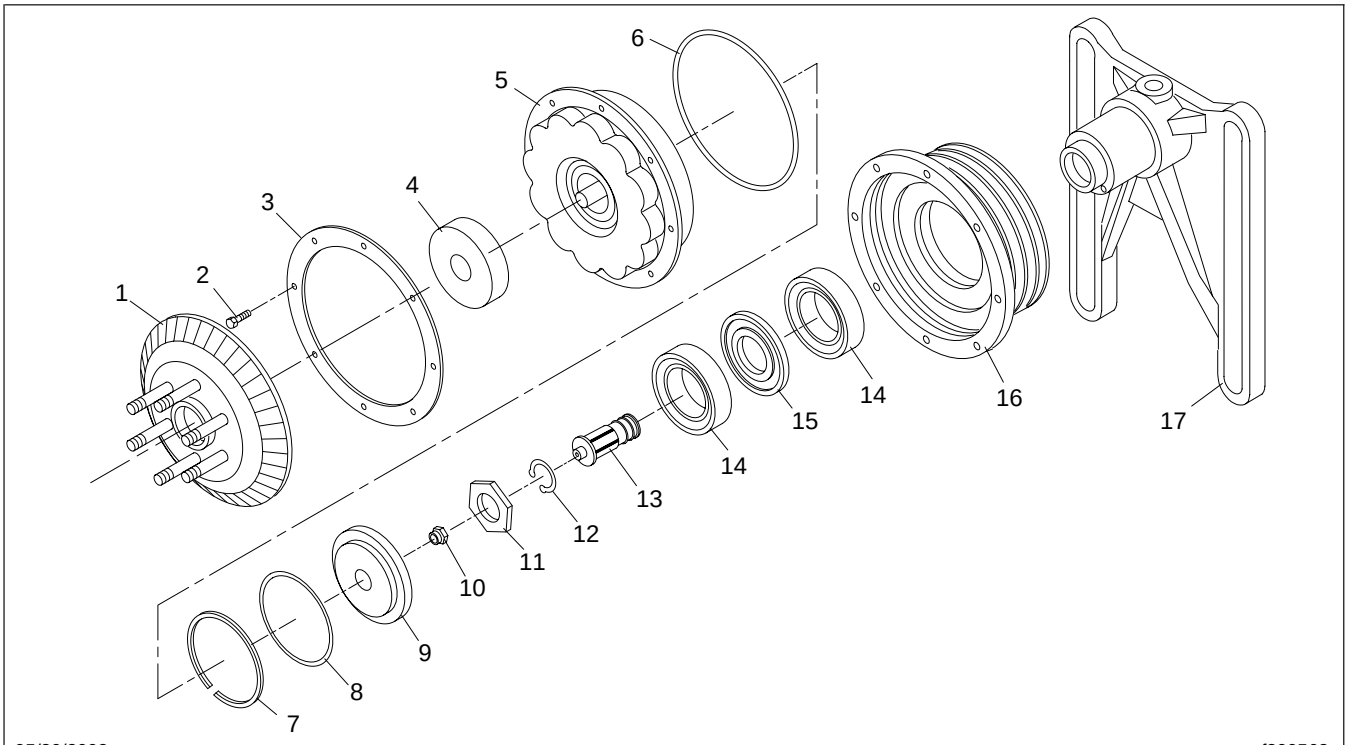
1. Using either a helper or a hoist, position the fan clutch assembly in place on the front of the engine, aligning the holes in the mounting bracket with those in the front of the engine.
2. Install the fasteners.

   If equipped with a metal fan ring, don't tighten the upper fan clutch fasteners completely.
3. Install the drive belts.
4. Connect the air line to the fan clutch.
5. Install the fan. Tighten the fan mounting nuts firmly.
6. Tighten the M8 fan-clutch mounting fasteners 15 lbf·ft (20 N·m).
7. Connect the left-side hose to the charge air cooler.
8. Lower the hood.
9. Remove the chocks from the tires.

Disassembly

NOTE: This procedure involves a major rebuild of the Horton DriveMaster® fan clutch, using parts from the manufacturer's Super Kit. If you are replacing just the seals or the air cartridge, see **Subject 120** for the minor rebuild procedure.

Refer to **Fig. 1** for this procedure.



1. Fan Mounting Disc
2. Torx®-Head Screw (8 qty.)
3. Friction Lining
4. Cage Nut (supplied with repair kit)
5. Spring Housing/Piston Assembly
6. Air Chamber Seal
7. Air Chamber Cap Retaining Ring
8. O-Ring
9. Air Chamber Cap
10. Face Seal
11. Bearing Nut
12. Air Cartridge Retaining Ring
13. Air Cartridge Assembly
14. Sheave Bearings
15. Bearing Spacer
16. Sheave
17. Journal Bracket

Fig. 1, Horton DriveMaster Fan Clutch

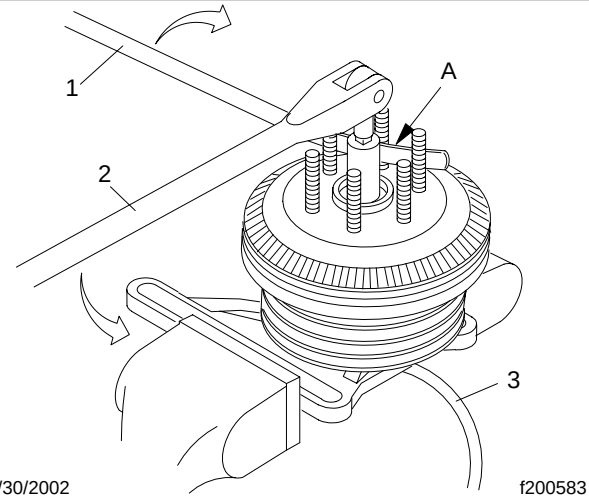
1. Remove the fan clutch assembly from the vehicle. For instructions, see **Subject 100**.
2. Put the fan clutch assembly in a vise.
3. Connect a shop air hose to the fan clutch air inlet.
4. Apply 80 to 120 psi (552 to 827 kPa) to the fan clutch to lift the fan mounting disc off the spring housing/piston assembly.

CAUTION

Use care when placing the pry bar onto the fan mounting disc. Make sure it is secure and flat on the surface. Failure to do so make cause the pry bar to slip, which could result in damage to studs or the fan mounting disc.

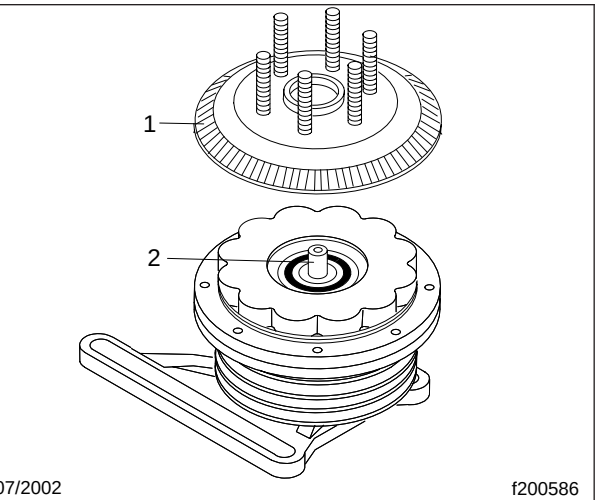
5. Using a pry bar, wrench, and a T55 Torx® bit, loosen the jack bolt (left-hand thread) by turning it counterclockwise. See **Fig. 2**.
6. Unscrew the fan mounting disc from the jack bolt. See **Fig. 3**

Fan Clutch Major Rebuild



A. Place the pry bar here.
1. Pry Bar (push clockwise)
2. Torx Bit and Wrench (turn counterclockwise)
3. Shop Air Hose (connected to the inlet port)

Fig. 2, Loosening the Jack Bolt



1. Fan Mounting Disc
2. Jack Bolt (left-hand thread)

Fig. 3, Fan Mounting Disc Removal and Installation

7. Inspect the fan mounting disc for wear or damage.

⚠ WARNING

Do not disassemble the spring housing from the piston. The interior springs are very strong, and if released could eject the housing with considerable force, possibly resulting in serious injury. Always use the cage nut to hold the spring housing and the piston together.

8. Using a wrench and a T55 Torx bit to hold the jack bolt, install the cage nut from the kit onto the jack bolt (left-hand thread). Hand tighten it onto the spring housing.

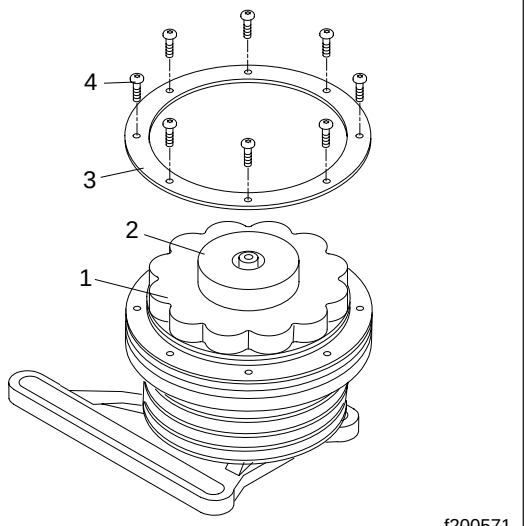
   The cage nut will keep the spring housing and piston together as an assembly. It will also maintain pressure on the internal springs after the Torx-head screws holding the friction lining in place are removed.

9. Release the air pressure from the fan clutch.

⚠ WARNING

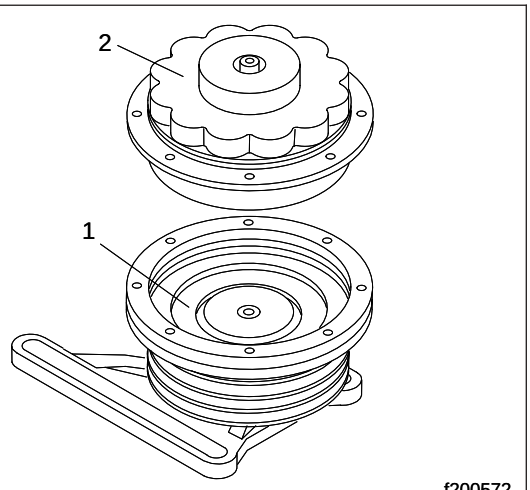
Release the air pressure from the fan clutch before removing the friction lining Torx-head screws. Failure to release the air pressure could result in the spring housing/piston assembly being ejected with force, which could result in personal injury.

10. Using a T27 Torx bit, remove the eight Torx-head screws holding the friction lining in place.
11. Remove the friction lining. See **Fig. 4**.
12. *Keeping the cage nut installed and tightened,* remove the spring housing/piston assembly. See **Fig. 5** .
13. Remove the air chamber seal. See **Fig. 6** .
14. Examine the inside of the air chamber for signs of moisture and/or contaminants.
15. Remove the air chamber cap retaining ring. See **Fig. 6** .
16. Using two small screwdrivers placed 180 degrees apart, gently and evenly pry the air chamber cap out of the sheave.
17. Remove the O-ring seal from the air chamber cap. See **Fig. 6** .
18. Remove the face seal. See **Fig. 6** .



1. Spring Housing/Piston Assembly
2. Cage Nut
3. Friction Lining
4. Torx-Head Screws

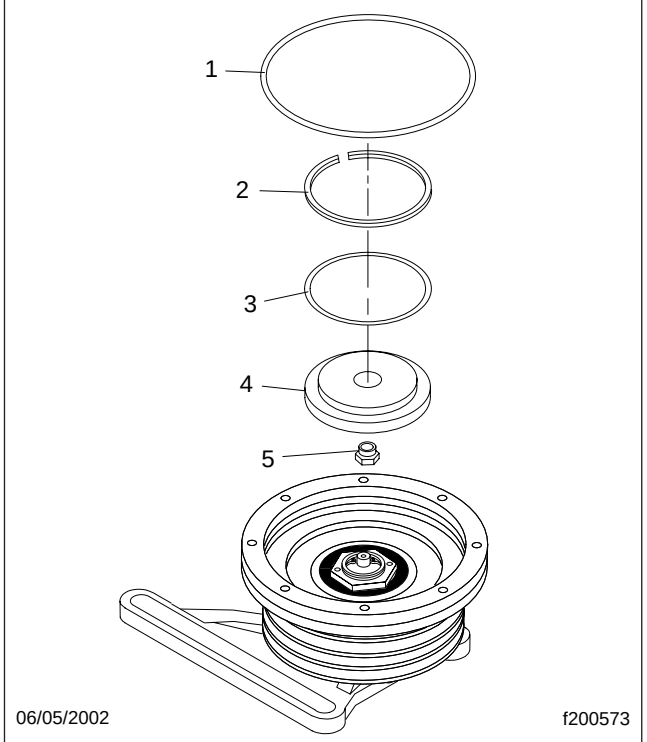
Fig. 4, Friction Lining Removal and Installation



1. Air Chamber
2. Spring Housing/Piston Assembly (with cage nut installed)

Fig. 5, Spring Housing/Piston Assembly Removal and Installation

19. Inspect the face seal for signs of wear. Wear indicates that dirt may exist in the air system



1. Air Chamber Seal
2. Retaining Ring
3. O-Ring Seal
4. Air Chamber Cap
5. Face Seal

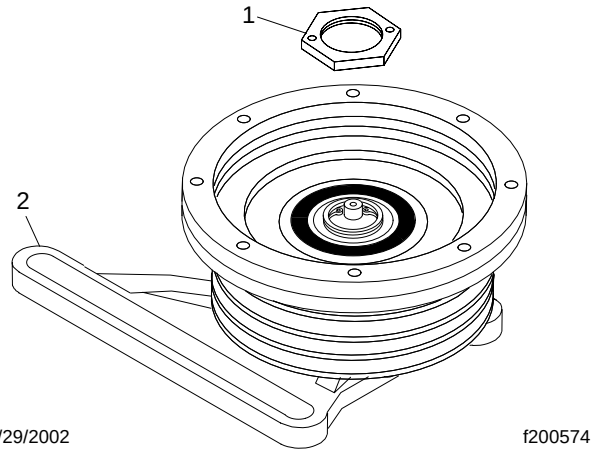
Fig. 6, Air Chamber Seal Removal and Installation

20. Remove the bearing nut from the mounting bracket. See **Fig. 7** .
21. Remove the sheave from the mounting bracket. See **Fig. 8** .
22. If replacing the bearings, support the sheave and press them out.
23. Clean and remove any dirt, debris, or corrosion that may be present.
24. Remove the air cartridge.
    - 24.1 Remove the retaining ring. See **Fig. 9**.
    - 24.2 Remove the air cartridge assembly. See **Fig. 10** .

Assembly

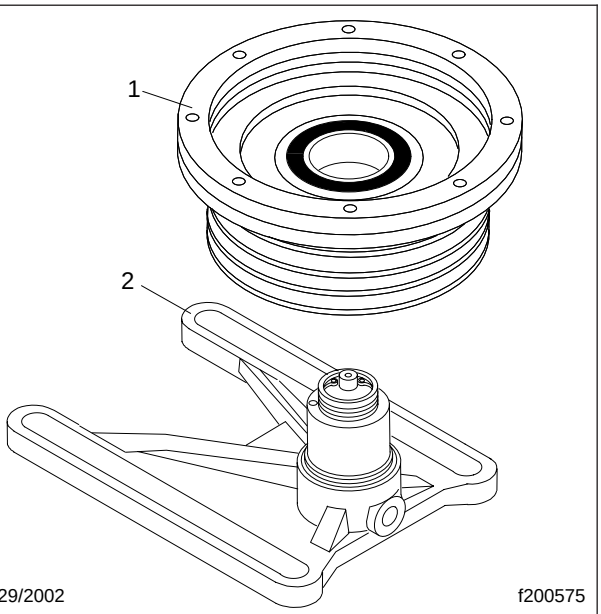
1. If necessary, clean the air cartridge bore in the mounting bracket.

Fan Clutch Major Rebuild



1. Bearing Nut
2. Mounting Bracket

Fig. 7, Bearing Nut Removal and Installation



1. Sheave
2. Mounting Bracket

Fig. 8, Removing the Sheave

NOTE: The sheave bearings do not require lubrication.

2. If replacing the sheave bearings, do the following:

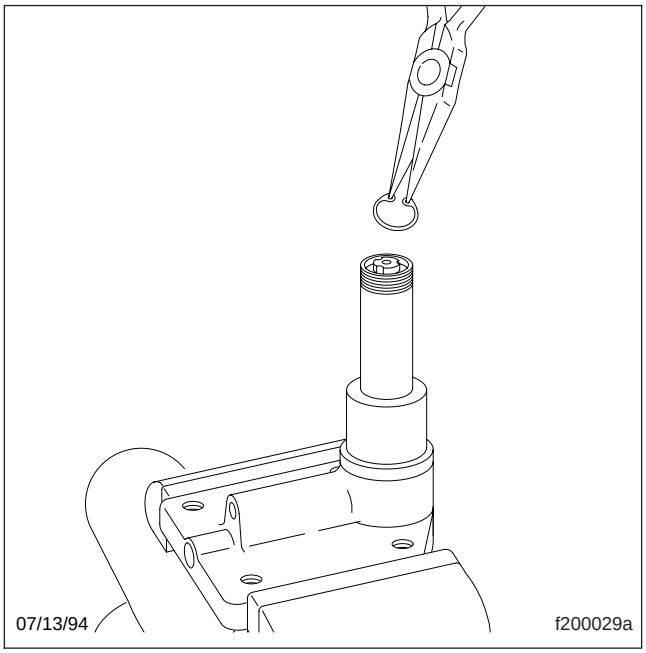
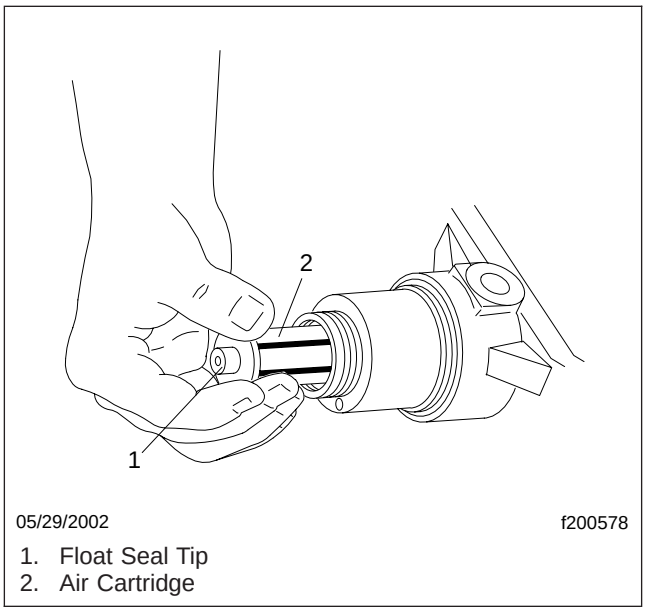


Fig. 9, Retaining Ring Removal and Installation

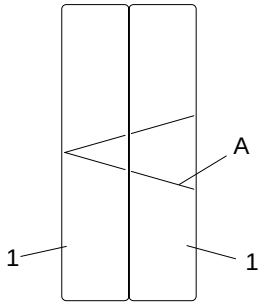


1. Float Seal Tip
2. Air Cartridge

Fig. 10, Removing the Air Cartridge

2.1 If equipped with two bearings, assemble the bearings so the markings on their edges line up to form an arrow. See

Fig. 11 . It doesn't matter which way the arrow faces when the bearings are installed.



05/30/2002 f200582

A. Align the markings to form an arrow.
1. Sheave Bearing

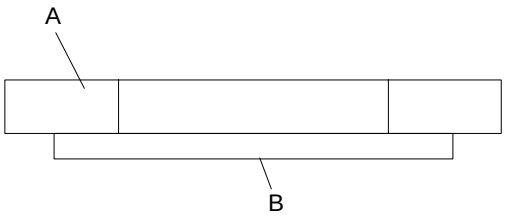
Fig. 11, Aligning the Bearings

IMPORTANT: If the fan clutch uses spacers, be sure to install them between the bearings.

2.2 Supporting the sheave, press the new sheave bearings — and spacers, if applicable — into place. Note the position of the lip inside the sheave.

2.3 Slide the sheave onto the mounting bracket. See **Fig. 8** .

2.4 Making sure that the bearing nut hex is facing up, install the bearing nut. See **Fig. 12** . Tighten 130 lbf·ft (176 N·m). See **Fig. 7** .

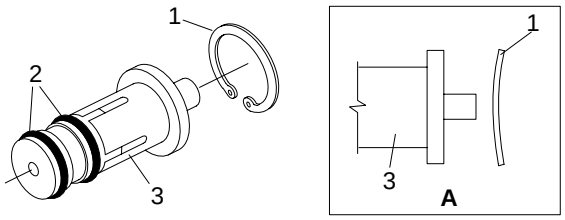


05/30/2002 f200580

A. Hex faces up.
B Relief faces toward mounting bracket and bearings.

Fig. 12, Correct Bearing Nut Orientation

3. Apply O-ring lubricant from the kit to the outside O-rings of the new air cartridge assembly. See **Fig. 13** .



03/27/2000 f200515

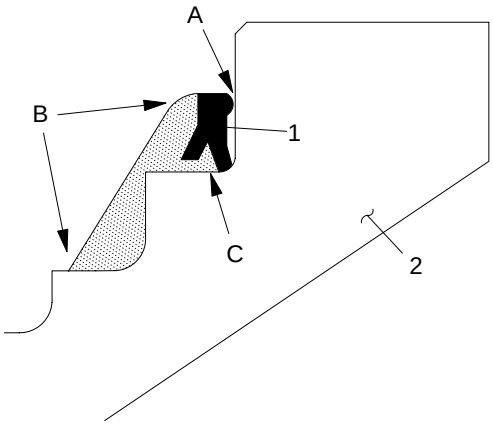
A. Convex surface of the retaining ring goes toward the air cartridge.
1. Retaining Ring
2. O-Rings
3. Air Cartridge

Fig. 13, Installing the Air Cartridge Retaining Ring

4. Install the new air cartridge assembly into the mounting bracket.
5. Install the retaining ring, making sure the convex surface of the ring is toward the air cartridge. See **Fig. 13** .
6. Using a clean, dry cloth, clean both the float seal tip of the air cartridge and the face seal of the air chamber cap.
7. Assemble the air chamber cap and face seal. See **Fig. 6** .

   Tighten the face seal 75 to 100 lbf·in (850 to 1130 N·cm).
8. Lubricate the O-ring seal with the fresh lubricant from the kit.
9. Install the O-ring seal on the air chamber cap. See **Fig. 6** .
10. Carefully set the air chamber cap into the sheave. See **Fig. 6** .
11. Install the retaining ring. See **Fig. 6** .
12. Install the air chamber seal into the sheave. Be sure the seal is evenly seated against the side and bottom of the groove surfaces, and the "V" of the seal is facing down. See **Fig. 14** .
13. Lubricate contact surfaces with the fresh lubricant from the kit.

Fan Clutch Major Rebuild



05/29/2002 f200579

A. Seal is seated evenly against side and bottom of groove.
B. Apply grease only between these areas.
C. "V" of Seal Facing Down
1. Air Chamber Seal
2. Sheave

Fig. 14, Correct Installation of Air Chamber Seal (cross-section view)

WARNING

The new spring housing/piston assembly from the kit has a cage nut installed on it. Do not remove the cage nut. This will cause the spring housing to be forcibly ejected from the piston assembly, which could result in serious injury.

14. Carefully set the new spring housing/piston assembly into position. See **Fig. 6** . Note that the new assembly has a cage nut installed on it.
15. Rotate the new spring housing/piston assembly to align the mounting holes with those of the sheave.

IMPORTANT: Handle the new friction liner by the edges to avoid contamination.

16. Set the new friction liner from the kit into place, being careful to touch only the edges.
17. Using a T27 Torx bit, install the eight Torx-head screws. See **Fig. 4** . Tighten alternately 80 lbf·in (900 N·cm).
18. Apply a minimum of 80 psi (552 kPa) of clean air to the air inlet.
19. Remove the cage nut from the spring housing/piston assembly.
20. Install the new fan mounting disc from kit.

CAUTION

Use care when placing the pry bar onto the fan mounting disc. Make sure it is secure and flat on the surface. Failure to do so make cause the pry bar to slip, which could result in damage to studs or the fan mounting disc.

21. Using a suitable wrench, a T55 Torx bit, and a pry bar, tighten the jack bolt (left-hand thread) 100 lbf·ft (136 N·m). Turn the wrench clockwise and push the pry bar counterclockwise.
22. Using shop air, actuate the fan clutch and check for correct engagement and disengagement of the fan mounting disc. If there is a problem, it must be corrected before installing the fan clutch onto the engine.
23. Check for air leaks at the bleed hole and around the spring housing/piston assembly.
24. Install the fan clutch assembly onto the engine. See **Subject 100** for instructions.

Disassembly

NOTE: This procedure involves a minor rebuild of the Horton DriveMaster® fan clutch, using parts from the manufacturer's Seal Kit. If a major rebuild of the fan clutch is needed, see **Subject 110**.

1. Remove the fan clutch assembly from the vehicle. For instructions, see **Subject 100**.
2. Put the fan clutch assembly in a vise.
3. Connect a shop air hose to the fan clutch air inlet.
4. Apply 80 to 120 psi (552 to 827 kPa) to the fan clutch to lift the fan mounting disc off the spring housing/piston assembly.

⚠ CAUTION

Use care when placing the pry bar onto the fan mounting disc. Make sure it is secure and flat on the surface. Failure to do so make cause the pry bar to slip, which could result in damage to studs or the fan mounting disc.

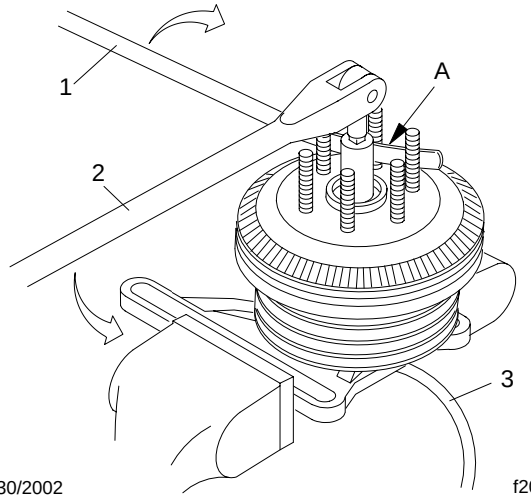
5. Using a pry bar, wrench, and a T55 Torx® bit, loosen the jack bolt (left-hand thread) by turning it counterclockwise. See **Fig. 1**.
6. Unscrew the fan mounting disc from the jack bolt. See **Fig. 2**.
7. Inspect the fan mounting disc for wear or damage.

⚠ WARNING

Do not disassemble the spring housing from the piston. The interior springs are very strong, and if released could eject the housing with considerable force, possibly resulting in serious injury. Always use the cage nut to hold the spring housing and the piston together.

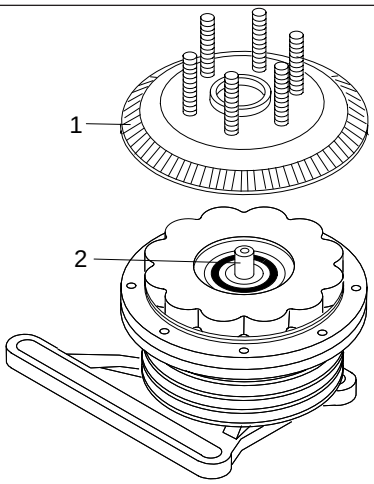
8. Using a wrench and T55 Torx bit to hold the jack bolt, install the cage nut from the kit onto the jack bolt (left-hand thread). Hand tighten it onto the spring housing.

   The cage nut will keep the spring housing and piston together as an assembly. It will also maintain pressure on the internal springs after the Torx-head screws holding the friction lining in place are removed.



A. Place the pry bar here.
1. Pry Bar (push clockwise)
2. Torx Bit and Wrench (turn counterclockwise)
3. Shop Air Hose (connected to the inlet port)

Fig. 1, Loosening the Jack Bolt



1. Fan Mounting Disc
2. Jack Bolt (left-hand thread)

Fig. 2, Fan Mounting Disc Removal and Installation

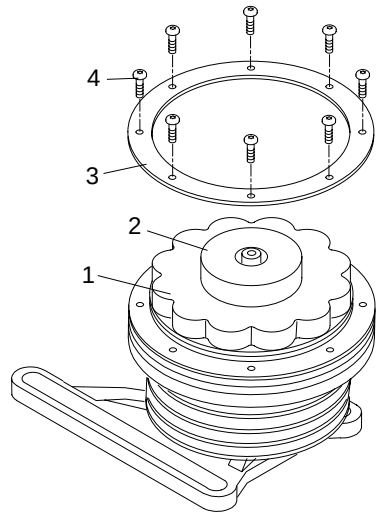
9. Release the air pressure from the fan clutch.

Fan Clutch Minor Rebuild

⚠ WARNING

Release the air pressure from the fan clutch before removing the friction lining Torx-head screws. Failure to release the air pressure could result in the spring housing/piston assembly being ejected with force, which could result in personal injury.

10. Using a T27 Torx bit, remove the eight Torx-head screws holding the friction lining in place.
11. Remove the friction lining. See **Fig. 3**.

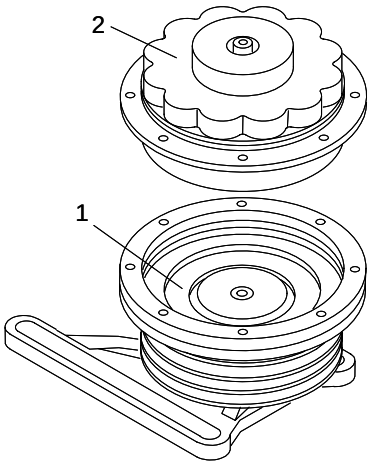


06/05/2002 f200571

1. Spring Housing/Piston Assembly
2. Cage Nut
3. Friction Lining
4. Torx-Head Screws

Fig. 3, Friction Lining Removal and Installation

12. *Keeping the cage nut installed and tightened,* remove the spring housing/piston assembly. See **Fig. 4** .
13. Remove the air chamber seal. See **Fig. 5** .
14. Examine the inside of the air chamber for signs of moisture and/or contaminants.
15. Remove the air chamber cap retaining ring. See **Fig. 5** .
16. Using two small screwdrivers placed 180 degrees apart, gently and evenly pry the air chamber cap out of the sheave.



05/28/2002 f200572

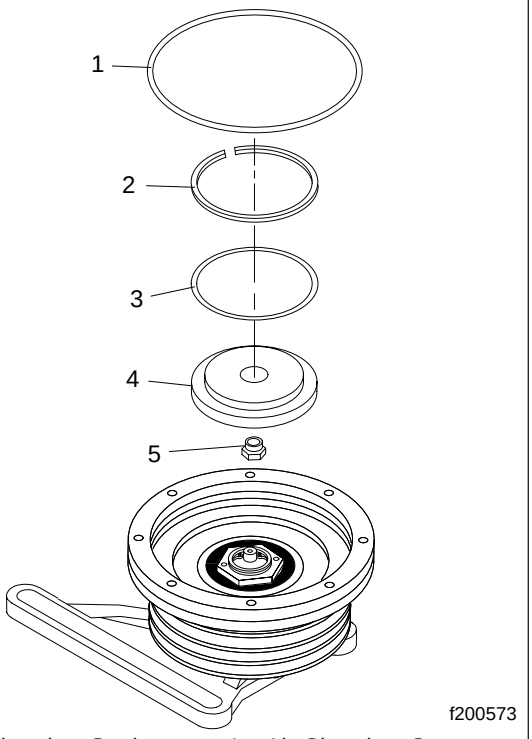
1. Air Chamber
2. Spring Housing/Piston Assembly (with cage nut installed)

Fig. 4, Spring Housing/Piston Assembly Removal and Installation

17. Remove the O-ring seal from the air chamber cap. See **Fig. 5** .
18. Remove the face seal. See **Fig. 5** .
19. Inspect the face seal for signs of wear. Wear indicates that dirt may exist in the air system.
20. Remove the air cartridge.
    - 20.1 Remove the retaining ring. See **Fig. 6**.
    - 20.2 Remove the air cartridge assembly. See **Fig. 7** .

Assembly

1. Clean the mounting bracket bore if necessary.
2. Apply O-ring lubricant from the kit to the outside O-rings of the new air cartridge assembly. See **Fig. 8** .
3. Install the new air cartridge assembly into the mounting bracket.
4. Install the retaining ring, making sure the convex surface of the ring is toward the air cartridge. See **Fig. 8** .



1. Air Chamber Seal
2. Retaining Ring
3. O-Ring Seal
4. Air Chamber Cap
5. Face Seal

Fig. 5, Air Chamber Seal Removal and Installation

5. Using a clean, dry cloth, clean both the float seal tip of the air cartridge and the face seal of the air chamber cap.
6. Assemble the air chamber cap and face seal. See **Fig. 5** .

   Tighten the face seal 75 to 100 lbf·in (850 to 1130 N·cm).
7. Lubricate the O-ring seal with the fresh lubricant from the kit.
8. Install the O-ring seal on the air chamber cap. See **Fig. 5** .
9. Carefully set the air chamber cap into the sheave. See **Fig. 5** .
10. Install the retaining ring. See **Fig. 5** .
11. Install the air chamber seal into the sheave. Be sure the seal is evenly seated against the side

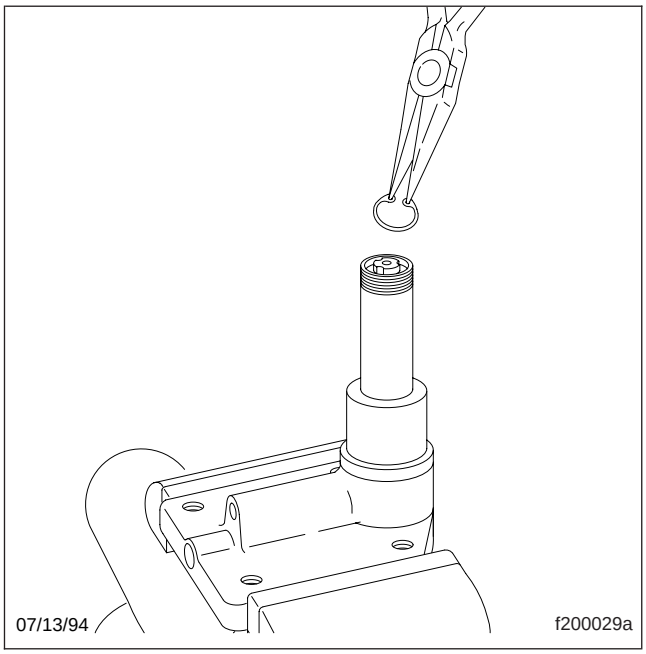
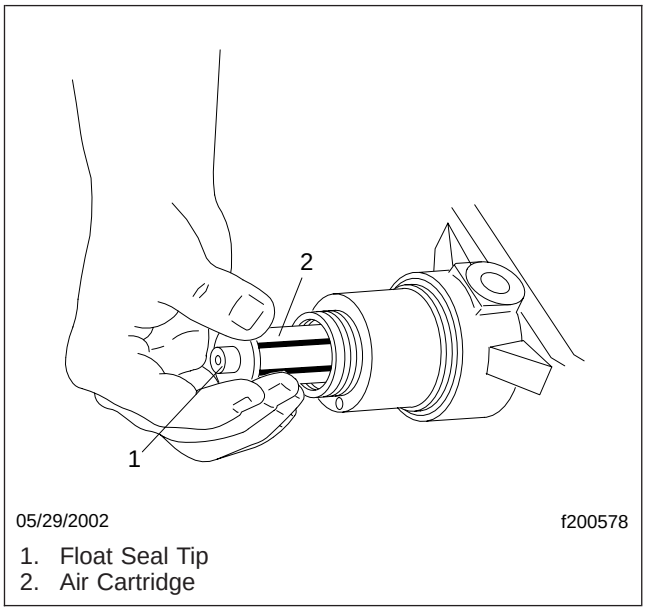


Fig. 6, Retaining Ring Removal and Installation (sheave not shown)



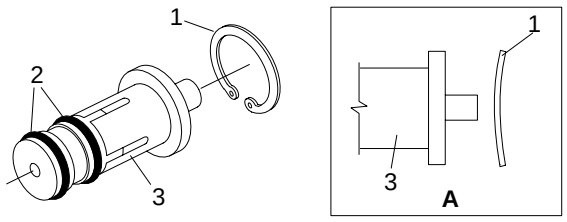
1. Float Seal Tip
2. Air Cartridge

Fig. 7, Removing the Air Cartridge (sheave not shown)

and bottom of the groove surfaces, and the "V" of the seal is facing down. See **Fig. 9** .

12. Lubricate contact surfaces with the fresh lubricant from the kit.

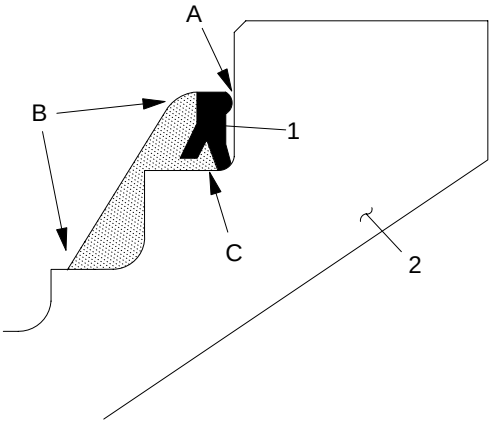
Fan Clutch Minor Rebuild



03/27/2000 f200515

A. Convex surface of the retaining ring goes toward the air cartridge.
1. Retaining Ring
2. O-Rings
3. Air Cartridge

Fig. 8, Installing the Air Cartridge Retaining Ring



05/29/2002 f200579

A. Seal is seated evenly against side and bottom of groove.
B. Apply grease only between these areas.
C. "V" of Seal Facing Down.
1. Air Chamber Seal
2. Sheave

Fig. 9, Correct Installation of Air Chamber Seal (cross-section view)

⚠ WARNING

The new spring housing/piston assembly from the kit has a cage nut installed on it. Do not remove the cage nut. This will cause the spring housing to be forcibly ejected from the piston assembly, which could result in serious injury.

13. Carefully set the new spring housing/piston assembly into position. See **Fig. 4** . Note that the new assembly has a cage nut installed on it.
14. Rotate the new spring housing/piston assembly to align the mounting holes with those of the sheave.
15. Set the friction liner from the kit into place, being careful to touch only the edges.
16. Using a T27 Torx bit, install the eight Torx-head screws. See **Fig. 3** . Tighten alternately 80 lbf·in (900 N·cm).
17. Apply a minimum of 80 psi (552 kPa) of clean air to the air inlet.
18. Remove the cage nut from the spring housing/piston assembly.

⚠ CAUTION

Use care when placing the pry bar onto the fan mounting disc. Make sure it is secure and flat on the surface. Failure to do so make cause the pry bar to slip, which could result in damage to studs or the fan mounting disc.

19. Using a suitable wrench, a T55 Torx bit, and a pry bar, tighten the jack bolt (left-hand thread) 100 lbf·ft (136 N·m). Turn the wrench clockwise and the pry bar counterclockwise.
20. Using shop air, actuate the fan clutch and check for correct engagement and disengagement of the fan mounting disc. If there is a problem, it must be corrected before installing the fan clutch onto the engine.
21. Check for air leaks at the bleed hole and around the spring housing/piston assembly.
22. Install the fan clutch assembly onto the engine. See **Subject 100** for instructions.

Troubleshooting Tables

Problem—Air Is Leaking from the Fan Clutch

Problem — Air Is Leaking from the Fan Clutch	
Possible Cause	**Remedy**
The face seal or air cartridge is damaged or worn.	Install a new seal kit.
The O-ring seals are damaged or worn.	Install a new seal kit.

Problem — The Fan Clutch Fails to Engage

Problem — The Fan Clutch Fails to Engage	
Possible Cause	**Remedy**
There's no power to the fan clutch control circuit.	Check all electrical connections, and repair or replace wiring as needed. Check the circuit breaker for the engine fan and repair or replace as needed.
The engine temperature switch is damaged or an incorrect sensor has been installed.	Make sure the switch is normally open, not normally closed. Replace the switch if it is damaged or if the switch is the wrong type.
The solenoid valve is malfunctioning.	Replace the solenoid valve.
The solenoid is not exhausting.	Make sure the solenoid exhaust port is not plugged.

Problem—The Fan Clutch Does Not Disengage

Problem — The Fan Clutch Does Not Disengage	
Possible Cause	**Remedy**
The engine temperature switch is damaged or an incorrect sensor has been installed.	Make sure the switch is normally open, not normally closed. Replace the switch if it is damaged or if the switch is the wrong type.
A restricted air line doesn't allow air supply to the clutch.	Make sure the air lines are not pinched or plugged. Repair the air lines as needed.
The fan clutch is leaking.	Install a new seal kit.
The air supply to the fan clutch is restricted.	Make sure the fan clutch air lines are not leaking or pinched. Repair the lines as needed.
The piston is seized due to contamination or dry seals.	Clean the air supply. Do a major rebuild.

Problem—The Fan Clutch Cycles Frequently

Problem — The Fan Clutch Cycles Frequently	
Possible Cause	**Remedy**
The fan clutch control circuit has a loose connection or is poorly grounded.	Check all wiring connections, and repair the circuit as needed. Check the circuit breaker for the engine fan and repair or replace as needed.
The temperature control settings are incorrect.	Check the fan clutch control setting of the temperature switch, according to the engine installed in the vehicle. Repair or replace the temperature switch as needed.

Troubleshooting

Problem — The Fan Clutch Cycles Frequently	
Possible Cause	**Remedy**
The fan cycling switch at the receiver-dryer is set too low.	Check the switch at the receiver-dryer, and if needed, replace the switch with a switch with a higher setting. Check the ACPU switch and unit.
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
The engine temperature is too high.	Check the programmable engine control parameters, and reprogram as needed.
The temperature switch is malfunctioning.	Replace the temperature switch.

Problem—The Fan Clutch Engages, But the Engine Still Overheats

Problem — The Fan Clutch Engages, But the Engine Still Overheats	
Possible Cause	**Remedy**
There is an air restriction in front of the fan clutch.	Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions.
There is a problem somewhere else in the cooling system.	Refer to the cooling system troubleshooting section, **Section 20.00**.

Specifications

Horton DriveMaster® Repair Kits		
Kit Description *	**Part Number**	**When Used**
Super Kit	HOR994347	Fan Clutch Major Rebuild
Seal Kit	HOR994346	Replacing Seals and Air Cartridge
Friction Disc Kit	HOR994348	Replacing Fan Mounting Disc and Friction Lining
Friction Liner Kit	HOR994349	Replacing Friction Lining Only

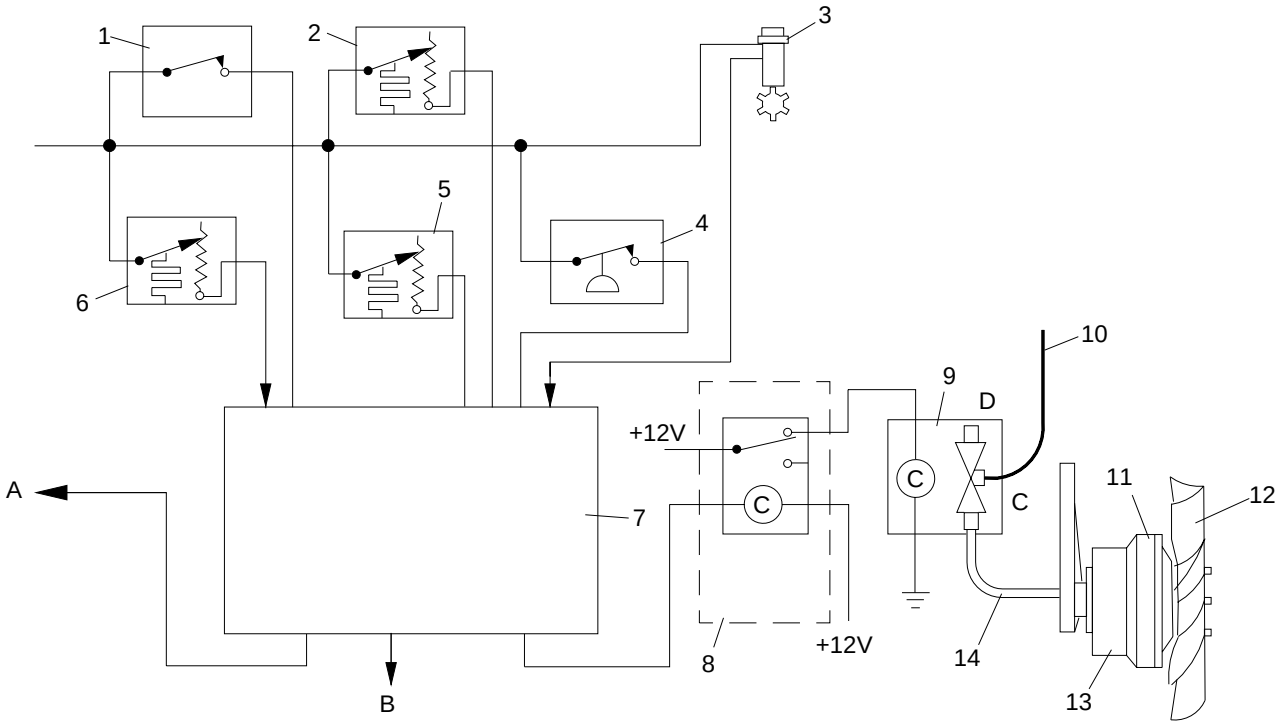
* All kits are available from the PDCs.

Table 1, Horton DriveMaster Repair Kits

Description	Torque	
	lbf·in (N·cm)	**lbf·ft (N·m)**
Friction Lining Screws	80 (900)	—
Face Seal	75 to 100 (850 to 1130)	—
Bearing Nut	—	130 (176)
Jack Bolt	—	100 (136)

Table 2, Torque Values

Specifications



A. To Indicators and Gauges
B. To Electronic Injectors and Other Actuators
C. Normally Closed
D. Normally Open

1. Fan Override Switch
2. Air Temperature Sensor
3. Engine Speed Sensor
4. A/C Pressure Switch
5. Coolant Temperature Sensor
6. Foot Throttle
7. Engine ECM
8. Fan Relay (not present in all systems)
9. Solenoid Valve
10. Air Supply from Reservoir
11. Fan Clutch
12. Air Supply to Fan Clutch

Fig. 1, Fan Clutch Schematic (engine ECM controlled)

General Description and Principles of Operation

Spicer Angle-Ring 310 mm and 350 mm clutches are a single-plate dry-disc design. There are no internal adjustments.

The clutch-cover assembly is bolted directly to the flywheel with twelve capscrews. The clutch-cover assembly drives the pressure plate through three drive straps. The driven disc uses ceramic friction material and has a spring-loaded center section for dampening.

The Angle-Ring clutch is a push-type release design. Depressing the clutch pedal moves the release (throw-out) bearing toward the engine flywheel. As the clutch is depressed, the pressure plate retracts from contact with the driven disc assembly, and the clutch is disengaged. As the clutch pedal is released, the release bearing and clutch levers move away from the engine flywheel. The belleville spring exerts pressure through the levers onto the pressure plate causing the driven disc to be locked up between the friction surfaces of the pressure plate and the engine flywheel. The clutch is then engaged.

Removal

1. Park the vehicle. Apply the parking brake and chock the tires.
2. Remove the transmission. See the applicable section in **Group 26**.

NOTE: The release bearing will drop to the bottom of the bell housing when the transmission is removed.

3. Remove the bell housing.
   - 3.1 On vehicles with Mercedes-Benz engines remove the twelve capscrews.

     On vehicles with Cummins B Series engines, loosen the nuts on the U-bolt holding the exhaust pipe to the bell housing. See **Fig. 1**. Remove the two capscrews (**Fig. 2**) holding the U-bolt bracket to the housing, and rotate the U-bolt bracket out of the way.

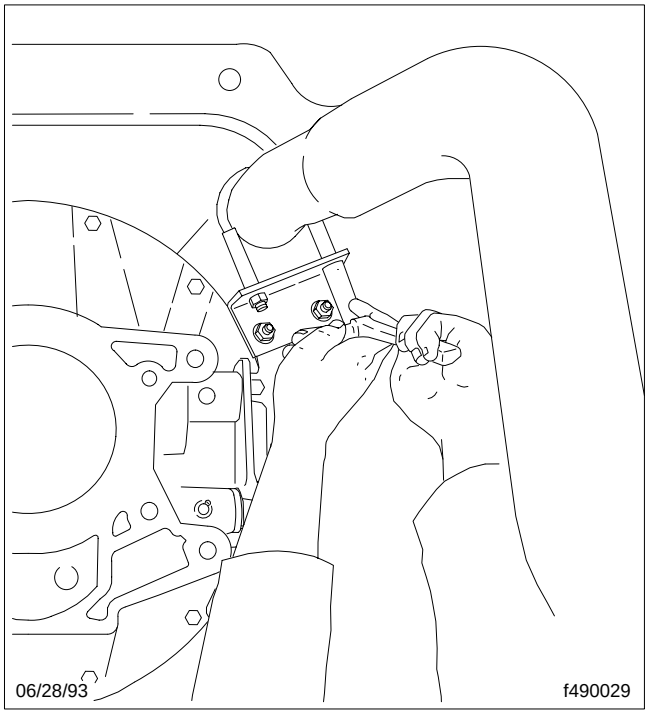


Fig. 1

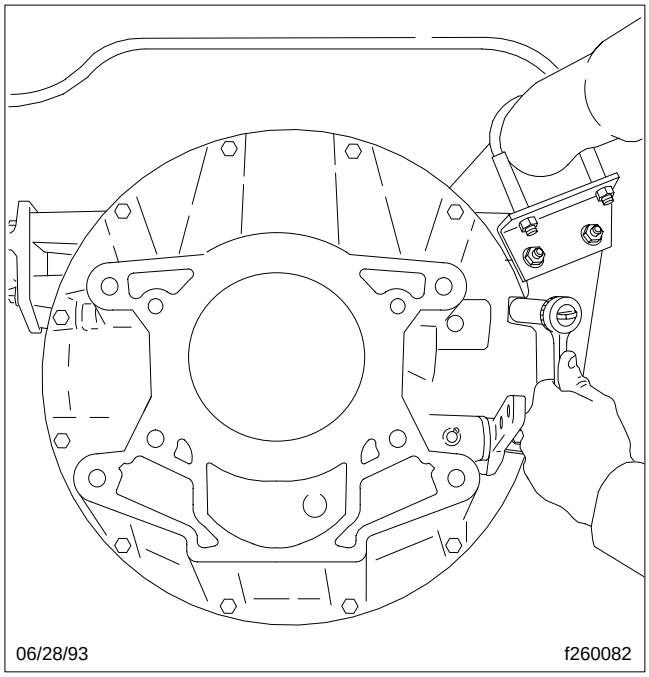


Fig. 2

   - 3.2 On vehicles with Cummins B Series engines, remove the remaining ten capscrews around the bell housing. See **Fig. 3**.
   - 3.3 On all vehicles, lift off the housing. See **Fig. 4**.
4. Remove the clutch assembly.
   - 4.1 Insert the pilot tool. See **Fig. 5**.
   - 4.2 Remove two capscrews from the top of the clutch and install dowels to support the pressure plate and cover assembly. See **Fig. 6**. Remove the remaining capscrews.
   - 4.3 Remove the clutch disc, pressure plate, and cover assembly along with the pilot tool. See **Fig. 7**.
5. Using a puller, remove the pilot bearing. See **Fig. 8**.

Inspection

1. Clean the clutch assembly thoroughly to inspect the parts. If there is excessive wear or damage

Clutch Removal, Inspection, and Installation

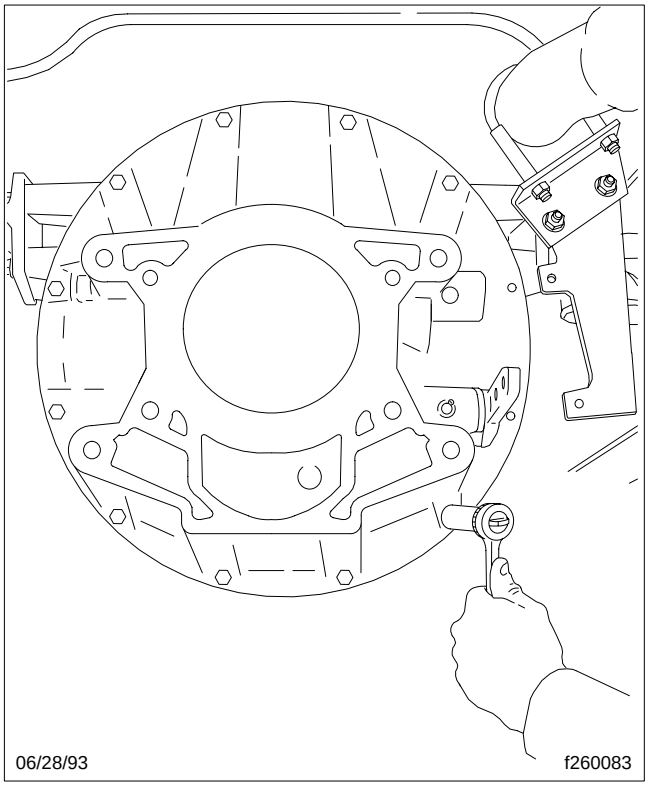


Fig. 3

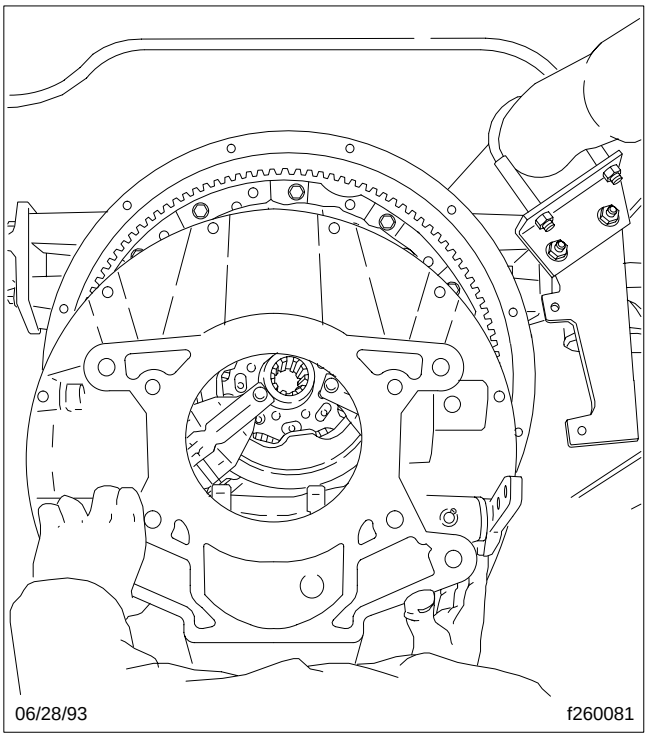


Fig. 4

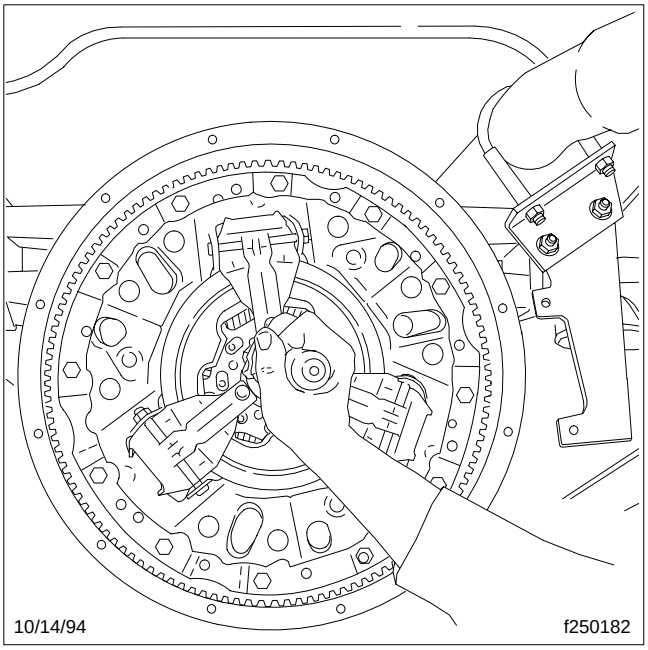


Fig. 5

or if parts are in questionable condition, replace them with a new clutch and driven disc assembly.

IMPORTANT: When taking the following readings, rotate the engine by hand; do not crank the engine with the starter. The engine may be rotated by the flywheel-mounting bolts or the starter ring-gear on the flywheel.

NOTE: Due to the design of the clutch assembly, do not rebuild it.

2. Clean the surfaces being measured to ensure accurate measurements.

NOTE: Before measuring the flywheel or flywheel housing, check the end-play of the crankshaft. Mount the dial indicator on the flywheel housing, with the indicator's finger against the flywheel. Force the crankshaft back and forth with a pry bar. If end-play exceeds the maxi-

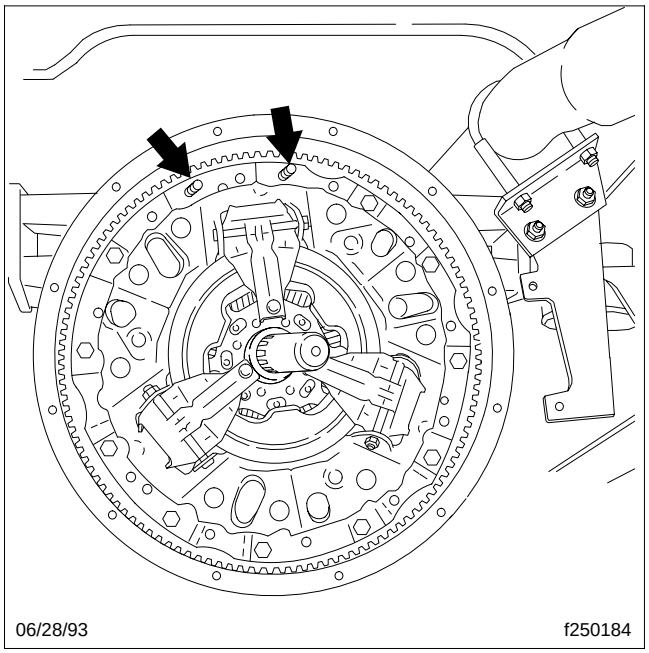


Fig. 6

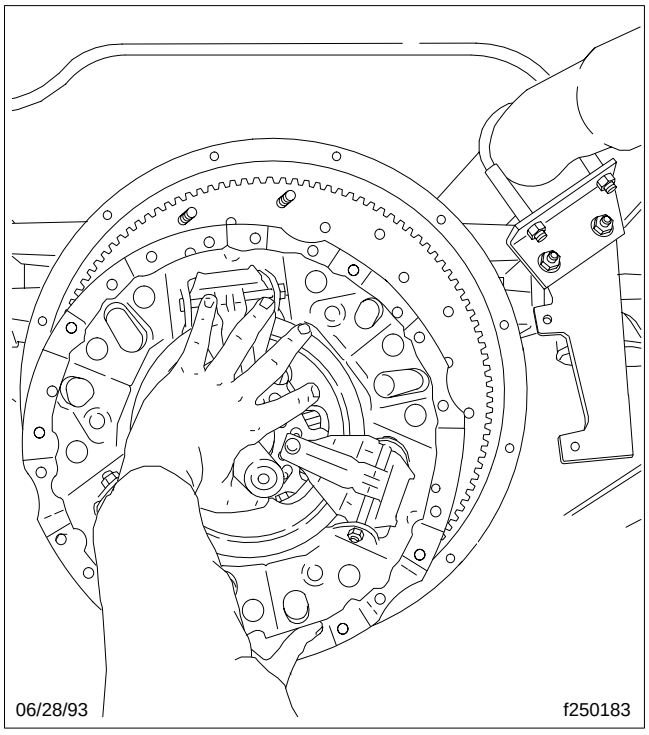


Fig. 7

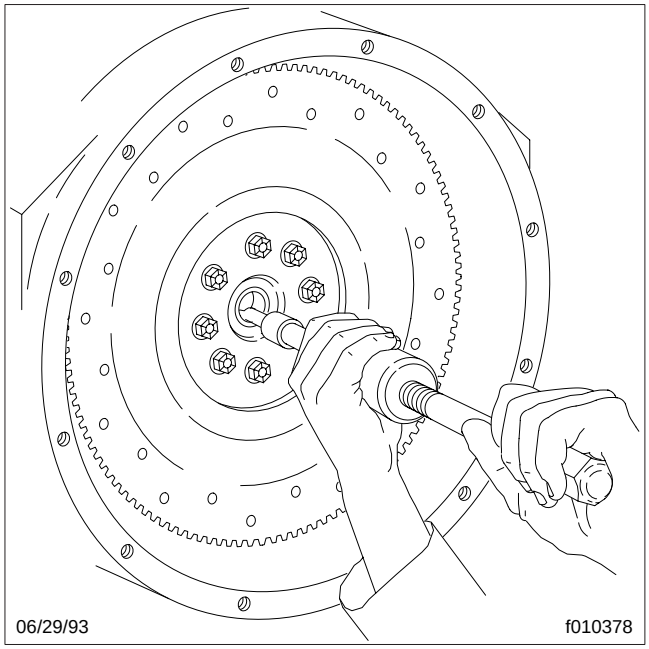


Fig. 8

mum, correct it. For specifications and instructions, see the engine manufacturer's service manual.

3. Inspect for a worn or corroded pilot (**Fig. 9**) on both the bell housing, and the flywheel housing. The pilot lip of the clutch housing can wear into the flywheel housing. This can be caused by the transmission loosening up, or by road and engine vibration after high mileage. Any measurable wear on either part will cause misalignment; replace the part. Wear may first appear between the 3 o'clock and 8 o'clock positions. See **Fig. 10**.

   3.1 Measure the runout of the pilot (bore) of the flywheel housing. Secure the dial indicator to the flywheel (or crankshaft), with the gauge finger against the housing pilot. See **Fig. 11**. With chalk or soapstone, mark the high and low points on the flywheel housing flange, while rotating the flywheel (or crankshaft) by hand. The total runout will be the difference between the highest plus and minus readings. See **Fig. 12**.

   The SAE maximum total runout for the flywheel housing pilot is 0.2 mm (0.008

Clutch Removal, Inspection, and Installation

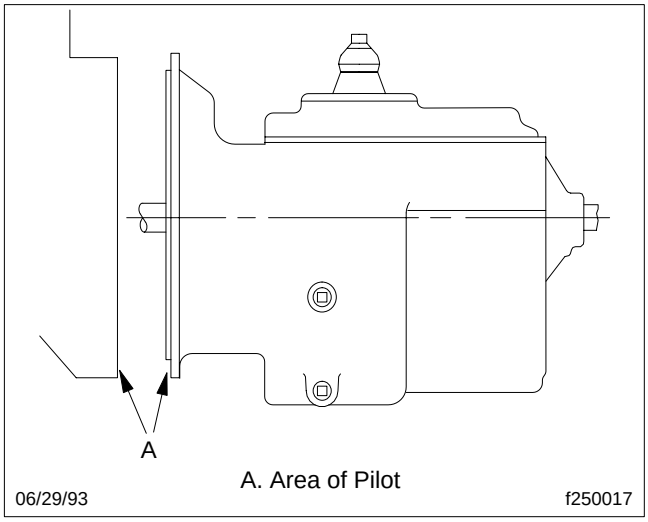


Fig. 9

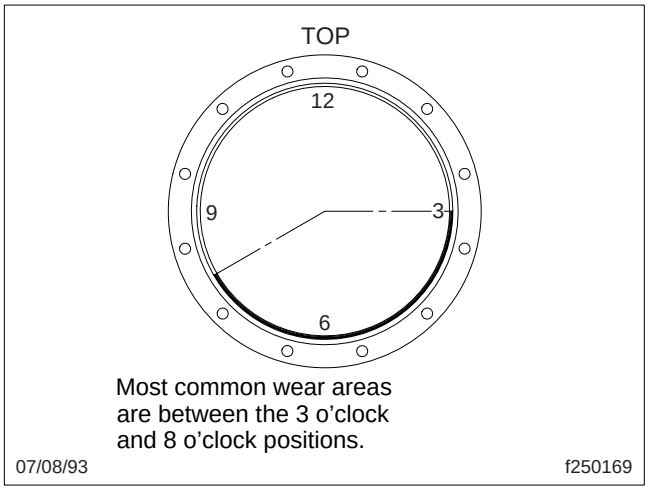


Fig. 10

inch). If the readings are higher, replace the housing. For instructions, see the engine manufacturer's service manual.

3.2 Measure the runout of the face of the flywheel housing. With the dial indicator secured to the flywheel (or crankshaft), move the finger to contact the face of the housing. See **Fig 13**. Mark the high and low points.

The SAE maximum total runout for the flywheel housing face is 0.2 mm (0.008 inch). If the readings are higher, replace the housing. For instructions, see the engine manufacturer's service manual.

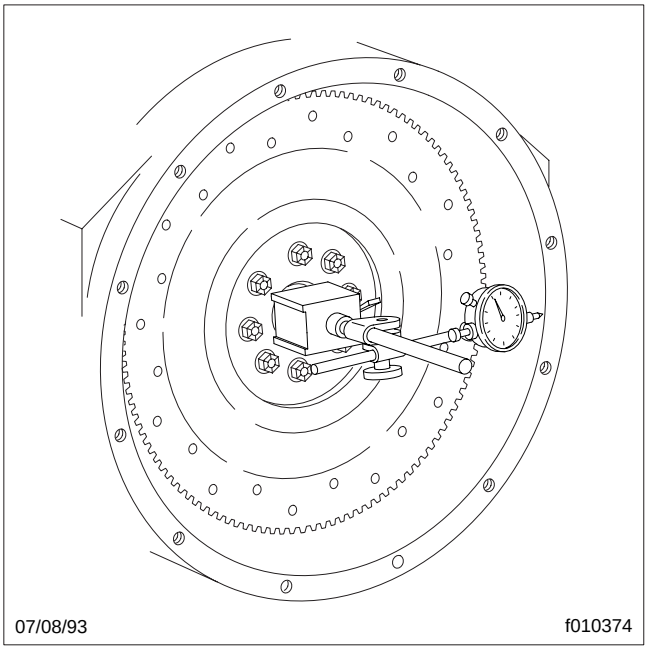


Fig. 11

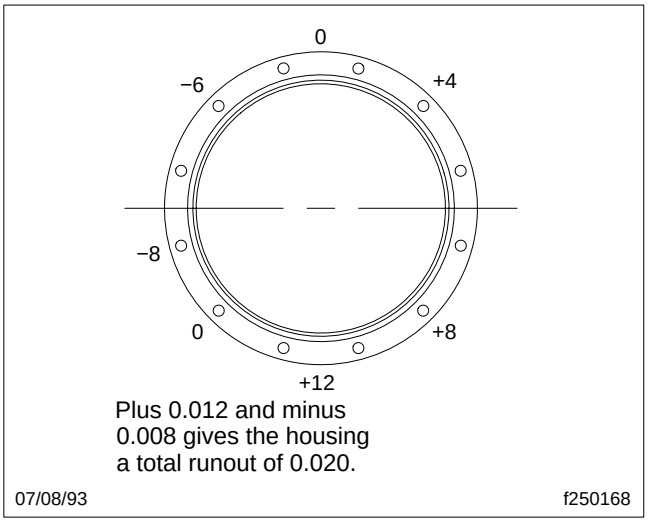


Fig. 12

NOTE: It is necessary to mark the high and low runout readings in clock positions only if you have to reposition the flywheel housing.

4. Measure the runout of the flywheel face. Secure the dial indicator to the flywheel housing, with the

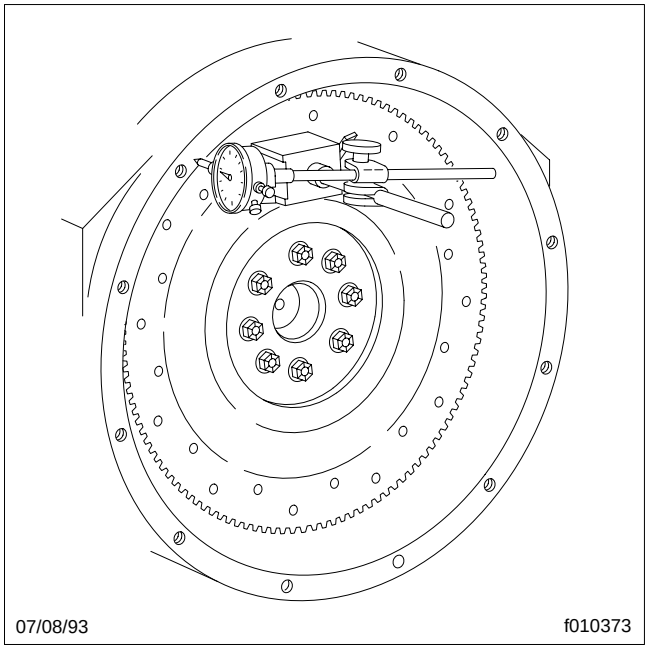


Fig. 13

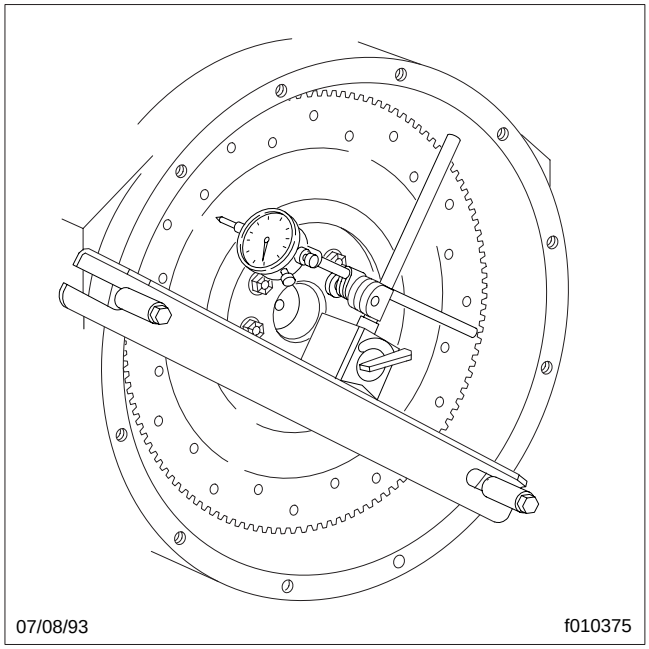


Fig. 14

gauge finger against the face of the flywheel near the outer edge. See **Fig. 14**. Turn the flywheel to obtain readings. With readings taken just outside the outer edge of the clutch disc wear pattern, the maximum tolerance is 0.18 mm (0.007 inch) for the 350-mm (14-inch) clutch and 0.17 mm (0.006 inch) for the 310-mm (13-inch) clutch. If the readings are higher, repair or replace the flywheel. See the engine manufacturer's service manual for instructions.

5. Measure the runout of the pilot-bearing bore of the flywheel. With the indicator secured to the flywheel housing, move the gauge finger to contact the pilot-bearing bore surface. See **Fig. 15**. Turn the flywheel to obtain the readings.

   The SAE maximum total runout for the pilot-bearing bore is 0.13 mm (0.005 inch). If the readings are higher, see the engine manufacturer's service manual for instructions.

6. Measure the runout of the transmission clutch-housing face and pilot.

   The SAE maximum runout for the clutch-housing face and pilot is 0.20 mm (0.008 inch). If the readings are higher, replace the clutch housing; see the transmission manufacturer's service manual.

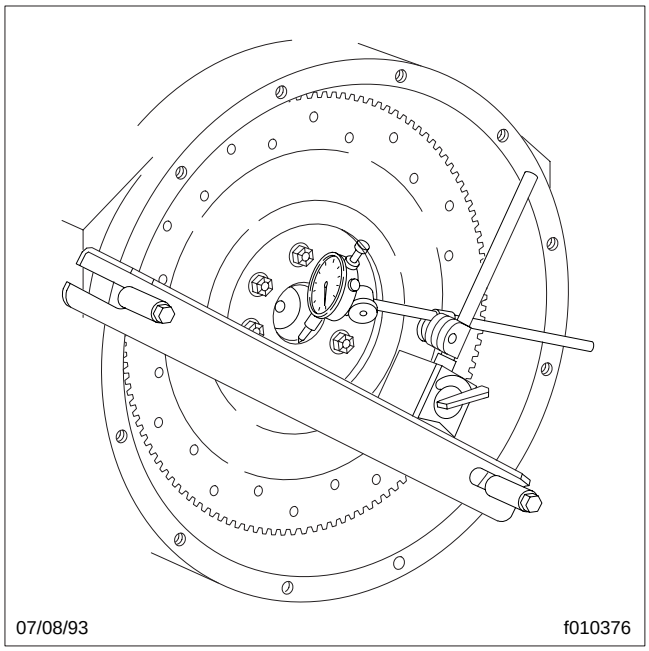


Fig. 15

Clutch Removal, Inspection, and Installation

⚠ CAUTION

CAUTION: The engine and transmission must line up. Misalignment of any parts will cause premature wear of drivetrain components.

NOTE: The clutch-housing face and pilot cannot be checked accurately unless you have a set of case-bore plugs and shaft. This set consists of plugs to be tapped into the front and rear bores of the transmission case. They have a very close fit in the bores. A shaft runs through the center of the plugs, and extends to the front far enough to secure a dial indicator and obtain a reading on the clutch housing.

7. Inspect the friction surface of the flywheel for unevenness, heat checks, scoring, and wear on the contact surface. Inspection for heat checks and scoring must be visual, and based on experience; however, measure the friction surface wear with a straightedge and feelers.

   Replace or repair the flywheel if the wear is extreme. For instructions, see the engine manufacturer's recommendations concerning flywheel replacement or rebuilding.

   If the flywheel has been replaced, measure the runout of the face and pilot diameters to make sure the measurements are within the engine manufacturer's specifications.

8. Check the fit of the splined hub of the clutch disc by sliding it on the transmission input shaft splines. The hub must slide freely so the clutch will release cleanly. If necessary, use a hand stone to dull the sharp edges of the splines. If the input shaft splines are badly worn or notched, replace the input shaft; for instructions, see the transmission manufacturer's service manual.

9. Check for wear on the fingers of the clutch release yoke, release shaft, and the release shaft bushings. Replace any worn parts.

10. Check the pilot bearing and release bearing. Replace parts as needed. Excessive wear can cause poor clutch performance and shortened clutch life.

11. Remove any oil or grease from the flywheel and bell housing area.

Installation

1. Using a driver, install a new pilot bearing. See **Fig. 16**.

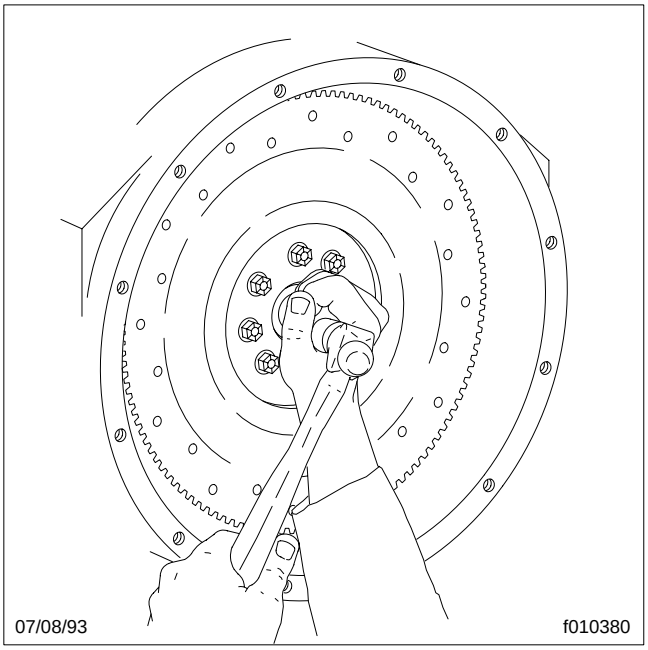


Fig. 16

2. Install the clutch assembly.

   2.1 Assemble the clutch disc and pressure plate on the pilot tool making sure the correct side of the disc will face the flywheel. See **Fig. 17**.

   2.2 If they were removed, install the dowels in the two upper holes in the flywheel.

   2.3 Lift the clutch disc, pressure plate, and pilot tool into position and hang them on the dowels. See **Fig. 7**.

   2.4 Install capscrews in the holes without dowels. Remove the dowels and install the remaining capscrews. Tighten them 45 N·m (33 lbf·ft) in the sequence shown in **Fig. 18**.

   2.5 Remove the pilot tool.

3. Lift the bell housing into position (**Fig. 4**) and install the twelve capscrews around the housing. Tighten the capscrews 54 N·m (40 lbf·ft).

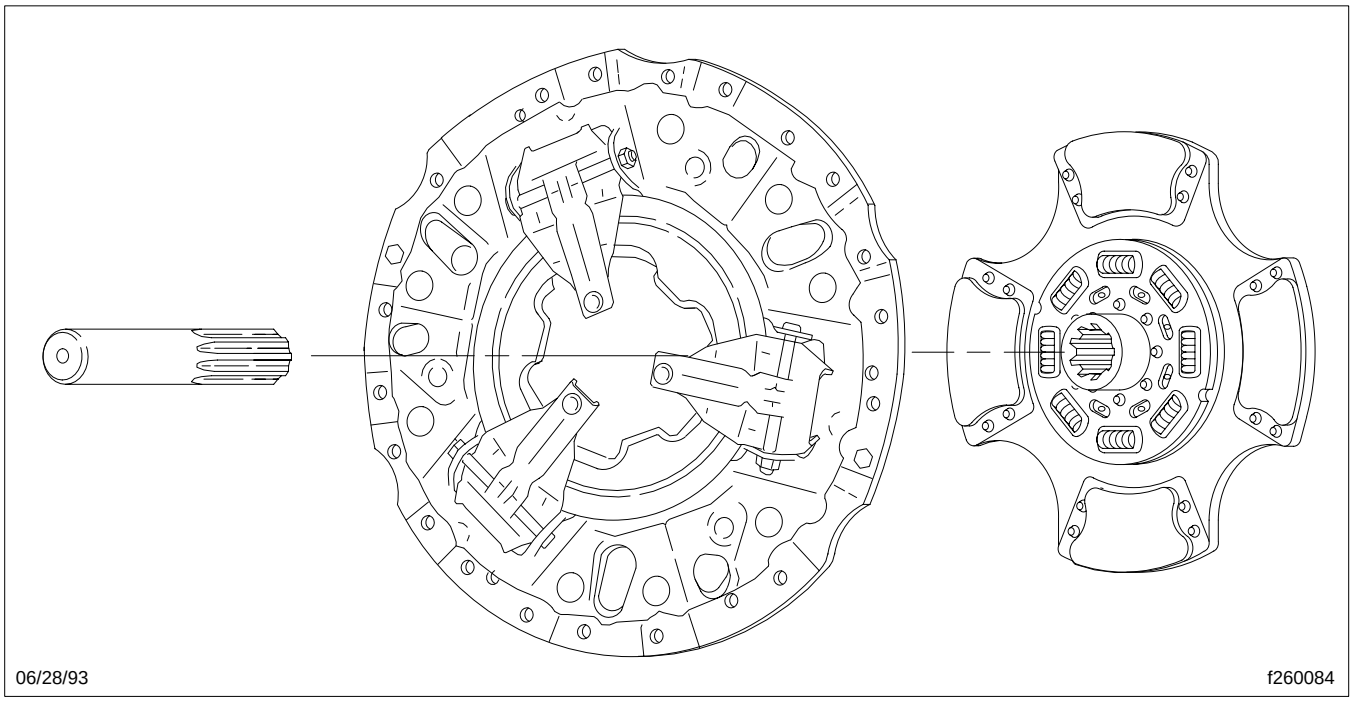


Fig. 17

NOTE: On vehicles with Cummins B Series engines some of the capscrews also hold brackets for the exhaust and various lines and cables (**Fig. 1** and **Fig. 2**).

4. Pull the clutch release fork back (**Fig. 19**); then, slide the release bearing into position.
5. Install the transmission. See the applicable section in **Group 26**.
6. Remove the chocks from the tires.
7. Test drive the vehicle to check for correct clutch operation.

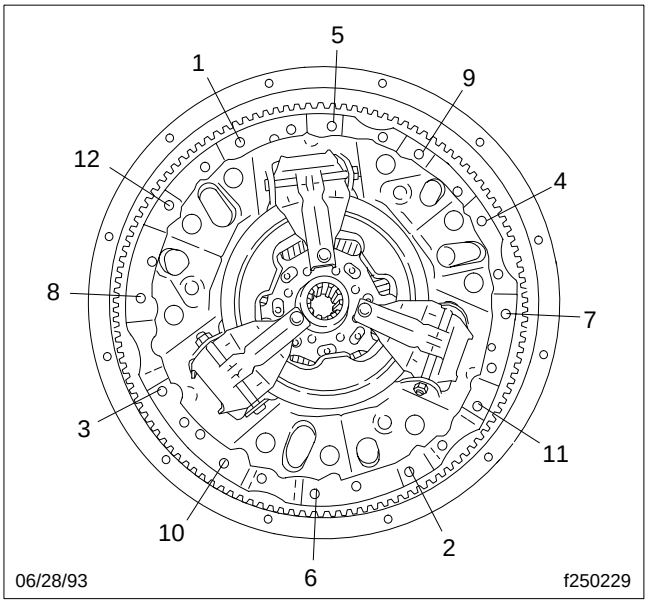


Fig. 18

Clutch Removal, Inspection, and Installation

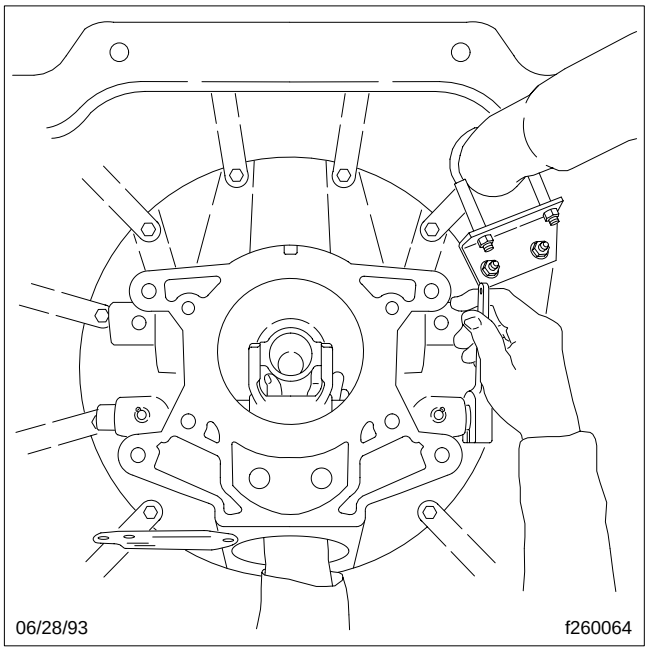


Fig. 19

Troubleshooting

This subject contains the following troubleshooting tables:

- Clutch Drags and Doesn't Release Completely
- Clutch Slips

Problem—Clutch Drags and Doesn't Release Completely

Possible Cause	Remedy
Slave cylinder is leaking or not working correctly.	Repair or replace the slave cylinder as needed.
Master cylinder is leaking or not working correctly.	Repair or replace the master cylinder as needed.
The clutch driven disc is bent or warped.	Replace the driven disc.

Problem—Clutch Slips

Possible Cause	Remedy
The shipping blocks were not removed.	Remove the shipping blocks and install the clutch correctly.
There is grease or oil on the clutch driven disk, the pressure plate, or the flywheel.	Clean the clutch components with isopropyl alcohol as needed. If the problem is due to a leaking rear crankshaft seal or transmission seal, replace seals as needed.
The driver is riding the clutch pedal.	Instruct the driver in the correct driving techniques. Slipping the clutch will cause clutch and flywheel damage.

Specifications

This subject contains the following tables:

- Torque Values
- Spicer Clutch Specifications

Description	Size (inches)	Torque N·m (lbf·ft)
Clutch-to-Flywheel Mounting Bolts	3/8	45 (33)
Transmission-to-Bell Housing Bolts	3/8	54 (40)

Table 1, Torque Values

Description	Clutch Size	
	310 mm (13 inch)	350 mm (14 inch)
Lever Height from Flywheel Surface	52.38 mm (2-1/16 inches)	61.93 mm (2-7/16 inches)
Bolt Circle Diameter	371.47 mm (14-5/8 inches)	393.7 mm (15-1/2 inches)
Rated Plate Load	10 700 N (2400 lbf)	10 700 N (2400 lbf)
Number of Splines	10	10
Spline Diameter	38.1 mm (1-1/2 inches)	38.1 mm (1-1/2 inches)
Driven Disc Facing Material	Ceramic	Ceramic
Facing Thickness (new)	10.16 mm (0.400 inch)	10.16 mm (0.400 inch)
Hub Type	Dampened 6-Spring	Dampened 8-Spring

Table 2, Spicer Clutch Specifications

General Description

Eaton® Fuller® Stamped Angle-Spring® (SAS), Easy-Pedal™, and Solo™ clutches are pull-type clutches of a dry-disc design.

Angle-Spring Clutches

Eaton® Fuller® Stamped Angle-Spring® (SAS) clutches are used in medium-duty applications and offered in two 14-inch (350-mm) versions:

- SAS 1401, with one driven disc, is standard on FL80 and optional on other medium-duty models. It is not available with non-synchronized transmissions.
- SAS 1402, with two driven discs, is optional on all medium-duty models.

All SAS clutches are adjustable using a lockstrap or the Kwik-Adjust™ mechanism. Both versions are mounted to a flat flywheel. See **Fig. 1**.

In the dual-disc version, the intermediate plate separating the driven discs is mounted directly to the flywheel. The flywheel ring carries four drivestraps to retract the pressure plate when the clutch is disengaged.

Clutch capacity for Angle-Spring clutches is indicated by the color code of the damper springs in the cover assembly. See the appropriate Angle-Spring clutch table in **Specifications, 400** for color codes.

Easy-Pedal Clutches

Easy-Pedal clutches are available in 14-inch (350-mm) dual-disc assemblies used in medium-duty applications and 15.5-inch (394-mm) dual-disc assemblies used in heavy-duty applications (FL112). All Easy-Pedal clutches are adjustable using a lockstrap or the Kwik-Adjust™ mechanism. See **Fig. 2**.

Clutch capacity for Easy-Pedal clutches is indicated by the color code of the damper springs in the cover assemblies. See the appropriate Easy-Pedal clutch table in **Specifications, 400** for color codes.

Easy-Pedal 14-Inch Clutches

14-inch Easy-Pedal Plus® dual-disc clutches are used in medium-duty applications. On these clutches, the intermediate plate separating the driven discs is carried on six pins mounted in the flange of a "pot-type" flywheel. Four return springs attached to the cover assembly retract the pressure plate when the clutch is disengaged.

Medium-duty Easy-Pedal clutch discs are offered in the following configurations:

- Eight spring dampers with three ceramic facings;
- Eight spring dampers with four ceramic facings.

Super-duty clutches have thicker intermediate plates, and ceramic facings on each side of each disc. Do not mix standard-duty and super-duty discs.

- Standard-duty clutches use a thin intermediate plate of approximately 0.58 to 0.63 inches (15 to 16 mm) and thicker discs of approximately 0.45 inches (11 mm).
- Super-duty clutches use a thicker intermediate plate of approximately 0.75 to 0.81 inches (19 to 21 mm) and thin discs of approximately 0.36 inches (9 mm).

Easy-Pedal 15.5-Inch Clutches

15.5-inch Easy-Pedal 2000 clutches are available on FL112 models only. On these clutches, the intermediate (center) plate separating the driven discs is carried on four lugs within the cover assembly. The cover assembly is mounted on a flat flywheel. Four return springs attached to the cover assembly retract the pressure plate when the clutch is disengaged.

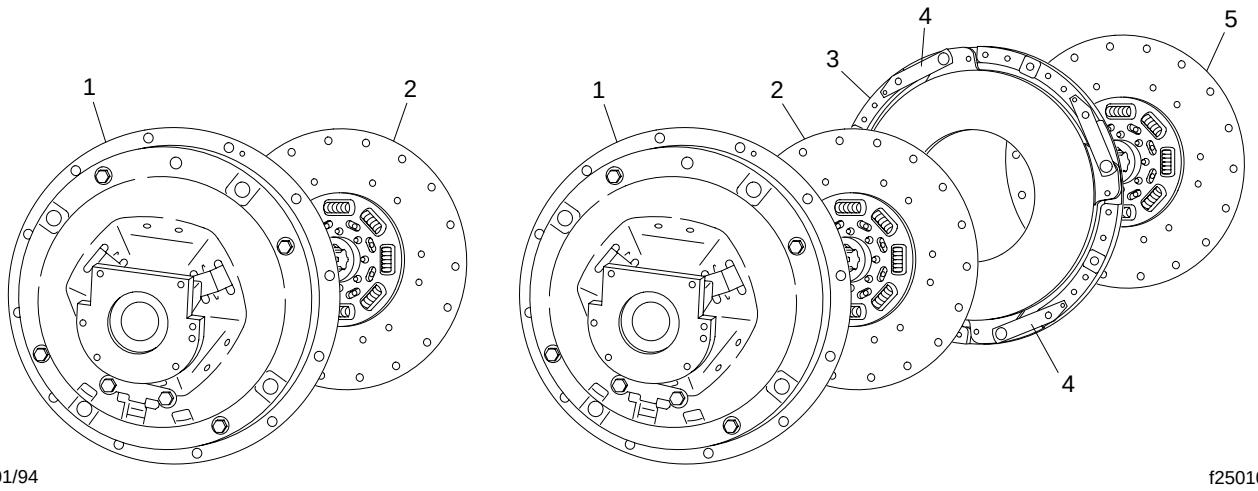
Heavy-duty Easy-Pedal clutch discs are offered in a standard configuration (see **Fig. 3**) and one optional configuration (see **Fig. 4**):

- Seven spring dampers with four ceramic facings are standard on FL112.
- Seven spring dampers with six ceramic facings and vibration control technology (VCT™plus) are optional on FL112.

NOTE: An earlier version of vibration control technology (VCT™) had a disc with six spring dampers and six ceramic facings. This disc has now been replaced by VCT™plus.

On older vehicles, clutch discs with eight-, nine-, or ten-spring dampers may be installed. In heavy-duty applications, these older types of dampers are not adequate for modern high-horsepower engines that operate at lower peak torques.

General Information



1. Cover Assembly
2. Driven Disc (on dual-disc models, rear driven disc)
3. Intermediate Plate
4. Drivestrap
5. Front Driven Disc

Fig. 1, Stamped Angle-Spring (SAS) Clutches

CAUTION

If your vehicle was originally equipped with six- or seven-spring discs, do not substitute eight- or ten-spring discs. This could cause excessive torsional vibration and component damage.

Solo Clutches

Eaton Fuller Solo™ clutches are 14-inch (350-mm) single- or dual-disc assemblies used in medium-duty applications and 15.5-inch (394-mm) dual-disc assemblies used in heavy-duty applications. See **Fig. 5**. Both versions are mounted to a flat flywheel.

Solo clutches are totally adjustment-free. As the clutch wears, its innovative wear-adjusting technology monitors clutch components and makes any necessary adjustments. The wear-adjusting technology comes from two sliding cams, which rotate to maintain the proper adjustment. Atop the upper cam, a wear indicating tab mirrors the cam's movement to let you know when it's time to replace the clutch. See **Fig. 6**. This tab cannot be used as a mechanism for adjusting the clutch.

Solo Medium-Duty 14-Inch Clutches

14-Inch Solo 1401 and 1402 clutches are optional on all medium-duty models. They are available in two 14-inch (350-mm) versions:

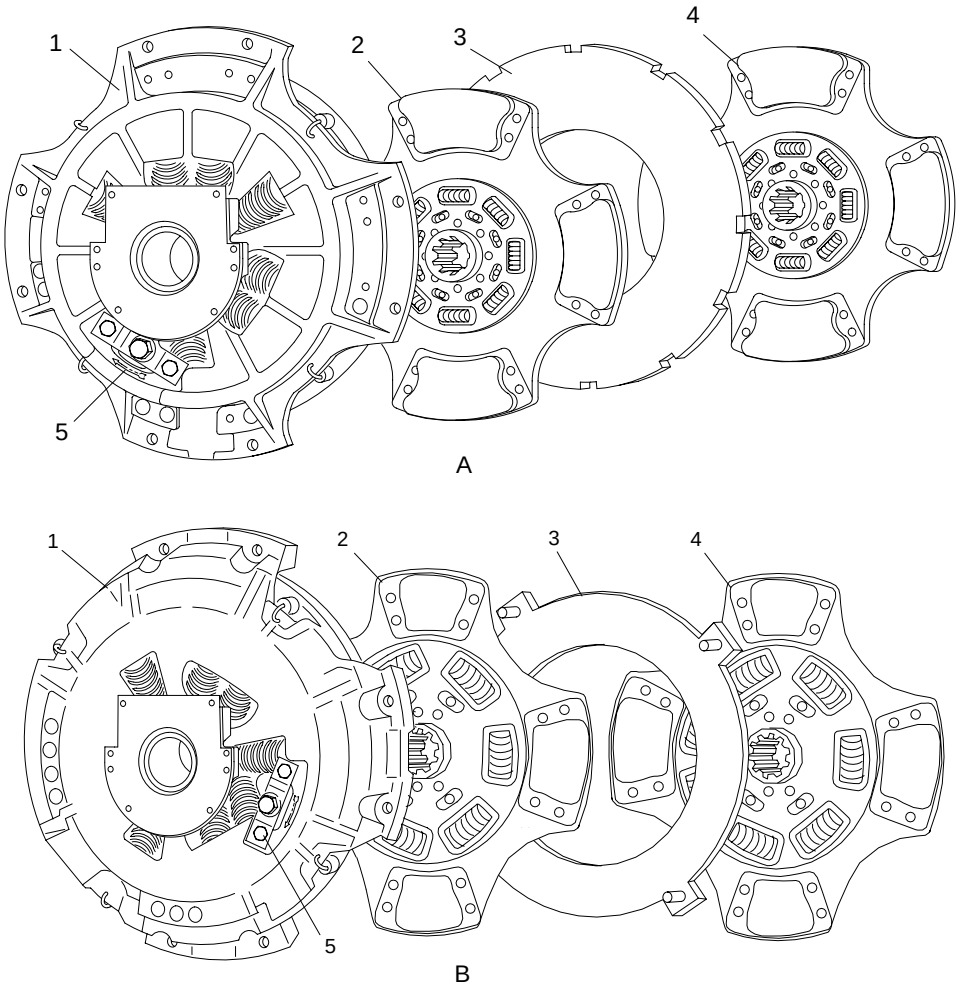
- Solo 1401, with one driven disc
- Solo 1402, with two driven discs

In the dual-disc version, the intermediate plate separating the driven discs is mounted directly to the flywheel. The flywheel ring carries four drivestraps (see **Fig. 5**) to retract the pressure plate when the clutch is disengaged. Four positive separator pins™ (roll pins) ensure an equal gap on all sides of the intermediate plate and increase the life of the clutch.

Medium-duty Solo clutch discs are available in two optional configurations:

- eight-spring dampers with three ceramic facings;
- eight-spring dampers with four ceramic facings.

For clutch capacities, see the appropriate Solo medium-duty clutch table in **Specifications, 400**.



07/16/2003 f250167b

A. 14-Inch Easy-Pedal Clutch
B. 15.5 Inch Easy-Pedal Clutch

1. Cover Assembly
2. Rear Driven Disc
3. Intermediate Plate
4. Front Driven Disc
5. Kwik-Adjust Mechanism

Fig. 2, Easy-Pedal Clutches

NOTE: On vehicles manufactured before May 16, 1994, short-stroke Solo 1401 and 1402 clutches were available with hydraulic clutch actuation.

Solo Heavy-Duty 15.5-Inch Clutches

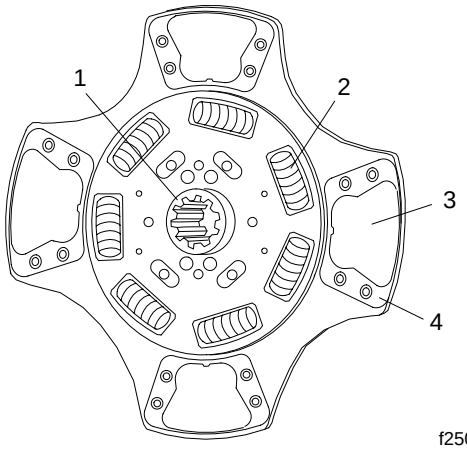
Solo Heavy-Duty clutches are available on FL112 models only. See **Fig. 7**.

Heavy-duty Solo clutch discs are offered in the following configurations:

- seven spring dampers with six ceramic facings and improved vibration control technology (VCTplus™);
- seven spring dampers with four ceramic facings.

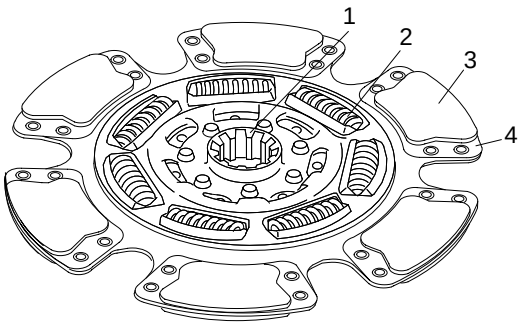
NOTE: An earlier version of vibration control technology (VCT™) had a disc with six spring

General Information



1. Hub
2. Damper
3. Facing
4. Paddle

Fig. 3, Driven Disc With Four Ceramic Facings



1. Hub
2. Damper
3. Facing
4. Paddle

Fig. 4, Driven Disc With Six Ceramic Facings

dampers and six ceramic facings. This disc has now been replaced by VCT™plus.

The intermediate plate separating the driven discs is carried on four lugs within the cover assembly, which is mounted on a flat flywheel. Four positive separator pins™ (roll pins) ensure an equal gap on all sides of the intermediate plate and increase the life of the clutch.

For clutch capacities, see the appropriate Solo heavy-duty clutch table in **Specifications, 400**.

Principles of Operation

The primary purpose of the clutch is to transfer the power of the engine from the engine flywheel to the transmission. At the point where clutch engagement begins (clutch pedal partially released), the transmission input shaft may be stationary, as when the vehicle is not moving, or it may be rotating at a different speed than the flywheel, as in the case of upshifting or downshifting. Once the clutch is fully engaged (clutch pedal fully released), both the engine flywheel and the transmission input shaft will be rotating at the same speed.

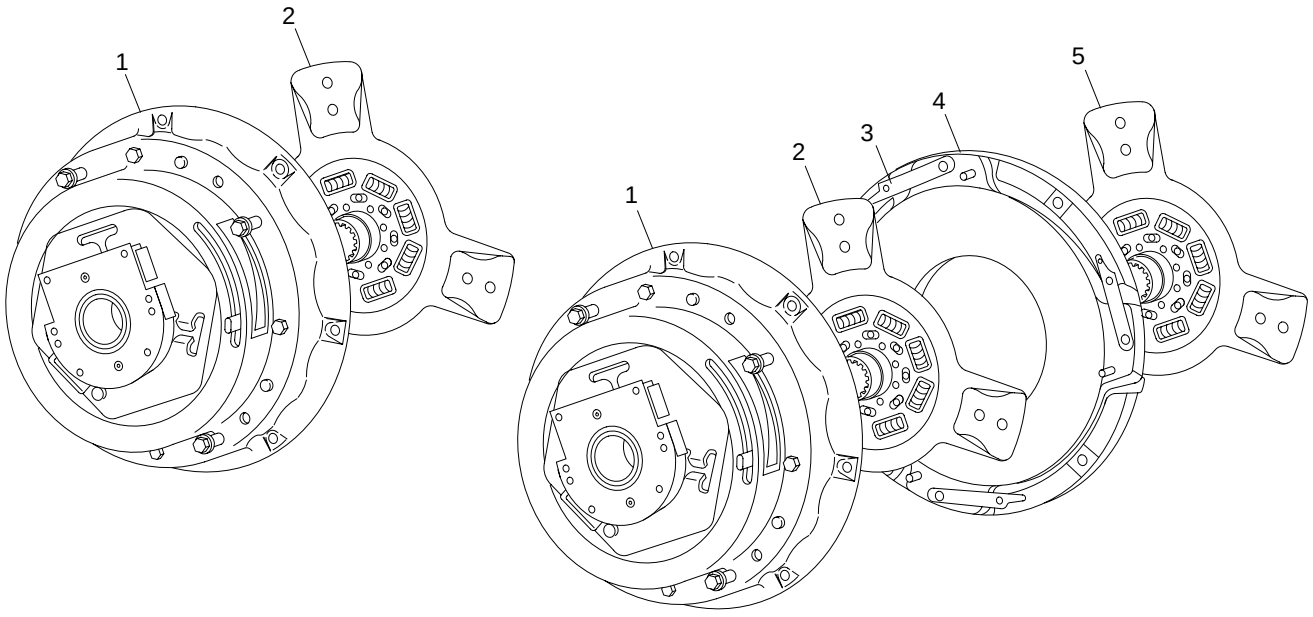
The secondary purpose of the clutch is to damp unwanted vibrations that normally exist in the driveline system. The springs within each driven disc provide a flexible link between the friction surfaces and the disc hubs. Damped clutch discs are specifically designed to prolong the life of drivetrain components by reducing vibrations from the engine, non-uniform U-joint angles, and road dips and bumps.

When the clutch pedal is first pressed down, the first 1/2-inch to 1-inch (12.7 to 25.4 mm) of pedal movement (clutch free-pedal) causes the release yoke fingers to move into contact with the wear pads of the release bearing (release yoke free-travel). See **Fig. 8**. The release yoke pulls the release bearing away from the pressure plate inside the clutch cover. This compresses the pressure springs, allowing the driven discs to slip freely, and at a different speed from the drive discs.

Further downward movement of the clutch pedal (clutch release-pedal), causes the release bearing to move into contact with the clutch brake (release bearing travel). As the clutch begins to release, the pressure springs force the pressure plate toward the engine flywheel, applying friction to the driven discs. Slippage occurs between the drive and driven discs because of the difference in their speeds.

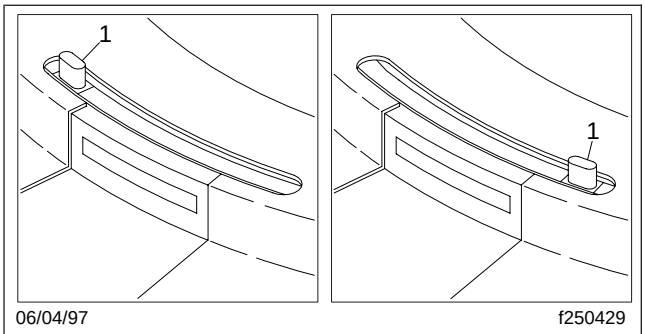
In the last 1 inch to 1-1/4 inches (25 to 33 mm) of downward pedal movement, the clutch brake and the release bearing are pressed together (clutch brake squeeze). The friction applied to the discs increases, and the slippage and difference in speeds decreases. When the pedal is fully released, pressure and friction are sufficient to stop the discs from slipping. With no slippage, the driving and driven members turn at the same speed.

When the vehicle is stationary, the clutch brake permits shifting into first gear or reverse gear without



1. Cover Assembly
2. Front Disc
3. Drivestrap
4. Intermediate Plate
5. Rear Disc

Fig. 5, Solo Medium-Duty Clutches



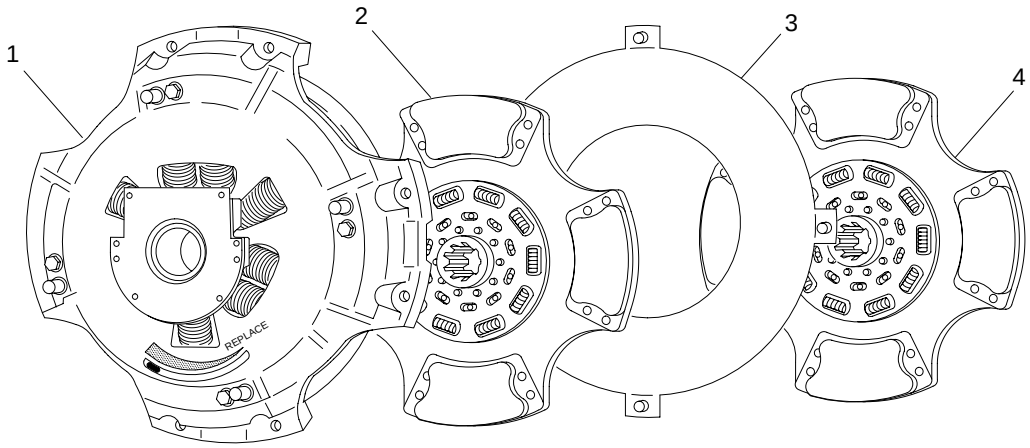
1. Wear Indicating Tab

Fig. 6, Wear Indicator

severe gear clash. The clutch brake is between the release bearing housing and the transmission bearing cap, and is engaged by tangs to the transmission input shaft. When the pedal is fully depressed, the clutch brake is squeezed between the release bearing housing and the transmission bearing cap, stopping the rotation of the main drive gear.

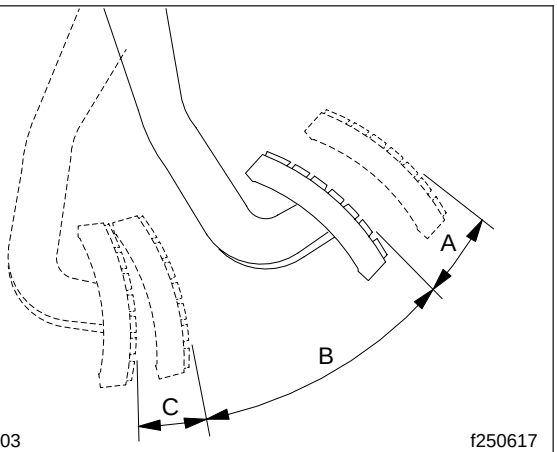
The clutch brake may be a disc type or a torque-limiting type. To prevent overloads to it, the torque-limiting clutch brake is designed to slip when loads of 20 to 25 lbf·ft (27 to 34 N·m) are reached. Clutch brakes are not designed for upshifting.

General Information



1. Clutch Cover
2. Rear Driven Disc
3. Intermediate Plate
4. Front Driven Disc

Fig. 7, Solo Heavy Duty Clutches



A. Clutch Free-Pedal
B. Clutch Release-Pedal
C. Clutch Brake Squeeze

Fig. 8, Clutch Pedal Movement

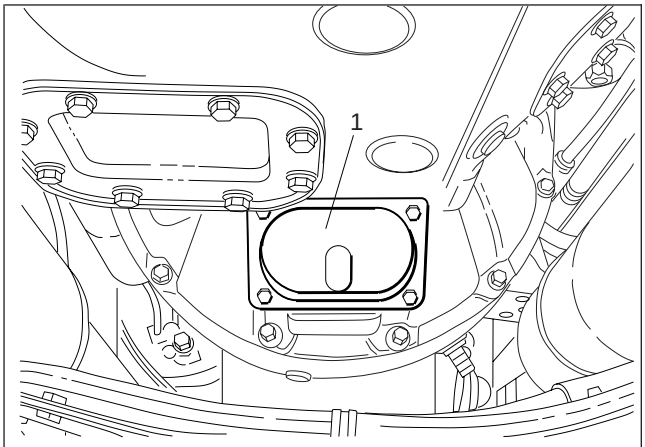
NOTE: The following procedures apply only to Eaton® Fuller® Easy-Pedal® and Stamped Angle Spring clutches. Solo™ clutches are adjustment-free.

Release Bearing Travel (synchronized transmissions)

Measurement

IMPORTANT: Do not skip steps in the adjustment operations. Internal adjustments must be correct before making any linkage adjustments for pedal free play. Incorrect adjustments can cause transmission gear clash, and slipping and burning of clutch components.

1. Apply the parking brakes, and chock the front tires.
2. Remove the clutch inspection cover from the bottom of the transmission clutch housing. See **Fig. 1**.

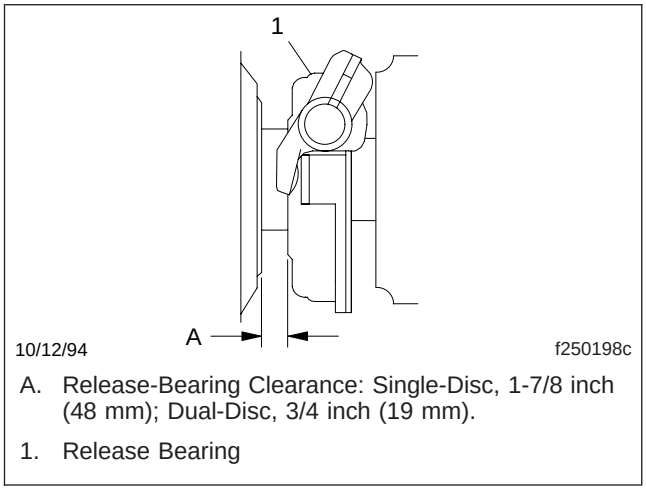


1. Clutch Inspection Cover

Fig. 1, Remove the Clutch Inspection Cover

NOTE: When checking release bearing clearance, remove the free travel by *lightly* pulling the release fork against the clutch release bearing. This eliminates any bearing movement.

3. Measure the clearance between the release bearing and the clutch cover. For a single-disc clutch, this clearance must be 1-7/8 inch (48 mm) in order for the release-bearing to release properly. For a dual-disc clutch, this clearance must be 3/4 inch (19 mm) in order for the release-bearing to release properly. See **Fig. 2**. If the release bearing clearance is not within the specifications, then an adjustment is needed. Go to "Adjustment" in this section.



A. Release-Bearing Clearance: Single-Disc, 1-7/8 inch (48 mm); Dual-Disc, 3/4 inch (19 mm).
1. Release Bearing

Fig. 2, Release Bearing Clearance

4. If the release bearing clearance measurement is okay, check and adjust the clutch linkage. For instructions, see **Section 25.02**.

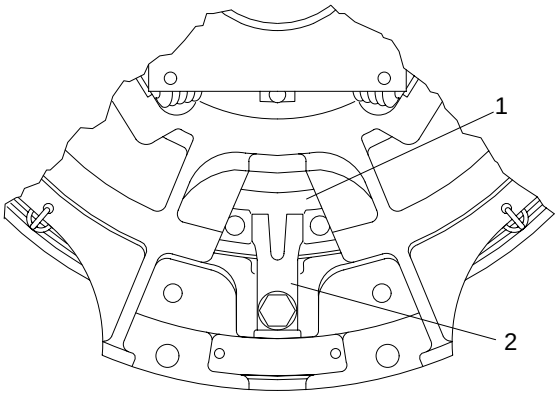
Adjustment

Angle-Spring and Easy-Pedal clutches are adjusted with either a lockstrap (**Fig. 3**), or with the Kwik-Adjust® mechanism (**Fig. 4**).

Clutches with a Lockstrap

1. Turn the engine flywheel until the lockstrap is aligned with the clutch inspection-cover opening. See **Fig. 1** and **Fig. 3**.
2. Remove the lockstrap. See **Fig. 3**.
3. Release the clutch by depressing the pedal. Block the pedal in the released position, or have someone assist you by holding the pedal down during the adjustment procedure.
4. Using a clutch adjusting tool, turn the adjusting ring clockwise to move the release bearing toward the transmission, or counterclockwise to move the release bearing toward the engine.

Clutch Adjustments



1. Adjusting Ring
2. Lockstrap

Fig. 3, Clutch Equipped with a Lockstrap

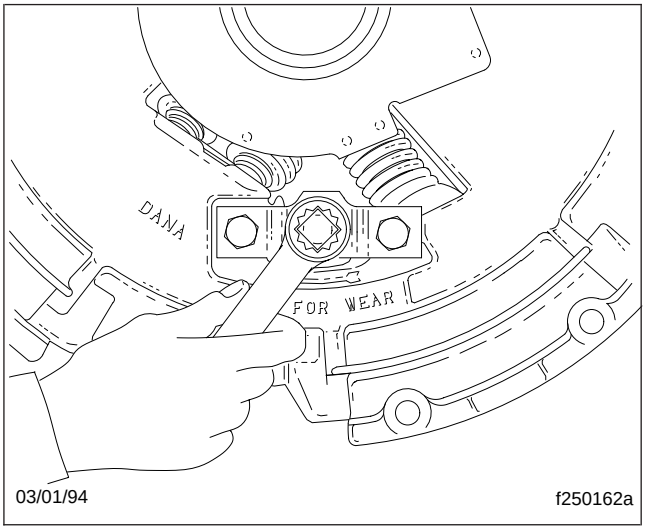


Fig. 4, Clutch Equipped with Kwik-Adjust

NOTE: Each notch in the adjusting ring represents about 0.020-inch (0.5-mm) release-bearing travel. Thus, three notches moved means 0.060 inch (1.5 mm) or about 1/16-inch release-bearing travel.

5. After adjusting, release the pedal, and check the clearance between the release-bearing housing and the clutch cover. For a single-disc clutch, when the clearance is 1-7/8 inch (48 mm), the internal adjustment is complete. For a dual-disc clutch, when the clearance is 3/4 inch (19 mm), the internal adjustment is complete.
6. Install the lockstrap, and tighten the bolt 35 to 40 lbf·ft (47 to 54 N·m).

IMPORTANT: Use the same length bolt when installing the lockstrap. A longer bolt will lock-up the clutch assembly.

NOTE: If the lockstrap will not engage the notches of the adjusting ring, check the clutch assembly for worn parts. For instructions, see **Subject 120**.

7. If the release bearing clearance measurement is okay, check and adjust the clutch linkage. For instructions, see **Section 25.02**.

Clutches with Kwik-Adjust

1. Turn the engine flywheel until the lockstrap is aligned with the clutch inspection-cover opening. See **Fig. 1** and **Fig. 4**.
2. Release the clutch by depressing the pedal. Block the pedal in the released position, or have someone assist you by holding the pedal down during the adjustment procedure.

NOTE: An open-end wrench is not recommended for the following step.

3. Insert a 12 point 3/4-inch socket or box-end wrench through the inspection cover opening. Depress the square bolt to adjust the release-bearing clearance.

   Rotate the adjusting ring counterclockwise to move the release-bearing toward the engine. Rotate the adjusting ring clockwise to move the release-bearing toward the transmission.

   Be sure the adjustment bolt is locked when you have completed the adjustment.

NOTE: Each quarter of a turn of the adjustment bolt represents about 0.017-inch (0.4-mm) release-bearing movement.

4. After adjusting, release the pedal, and check the internal clearance between the release-bearing housing and the clutch cover. For a single-disc clutch, when the internal clearance is 1-7/8 inch (48 mm), the adjustment is complete. For a dual-disc clutch, when the internal clearance is 3/4 inch (19 mm), the adjustment is complete.

5. If the release bearing clearance measurement is okay, check and adjust the clutch linkage. For instructions, see **Section 25.02**.

Release Bearing Travel (nonsynchronized transmissions)

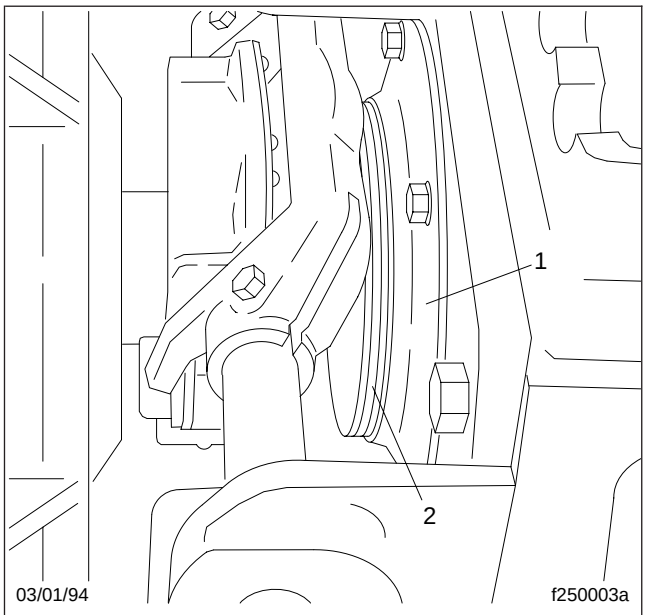
Measurement

IMPORTANT: Do not skip steps in the adjustment operations. Internal adjustments must be correct before making any linkage adjustments for pedal free-travel. Incorrect adjustments can cause transmission gear clash, and slipping and burning of clutch components.

1. Apply the parking brakes, and chock the front tires.
2. Remove the clutch inspection cover from the bottom of the transmission clutch housing. See **Fig. 1**.
3. Slide the clutch-brake discs and washer, or torque-limiting clutch brake, tight against the transmission input shaft bearing cap. See **Fig. 5**. Also, slide the release-bearing as far as possible towards the transmission.
4. Measure the internal clearance between the aft face of the release-bearing and the forward face of the clutch brake disc, or torque-limiting clutch brake. This internal clearance must be 1/2 inch to 9/16 inch (12.7 mm to 14.3 mm) in order for the release-bearing to release properly. See **Fig. 6**.

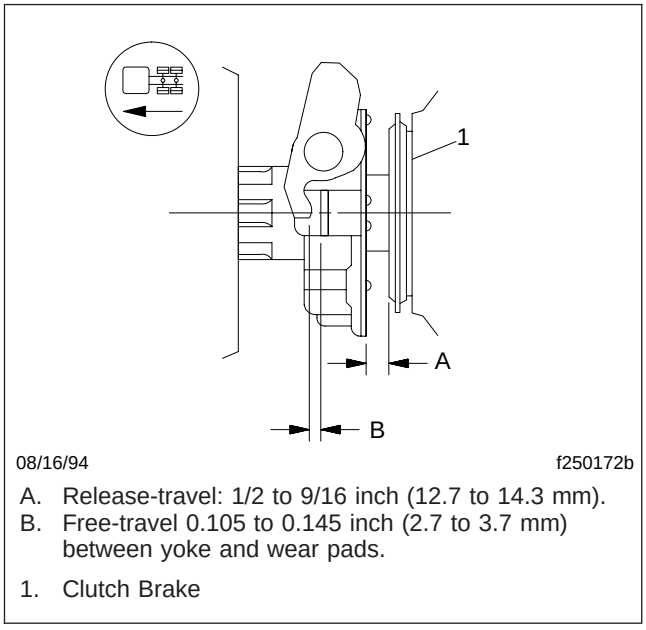
IMPORTANT: An inspection tool A02–12419 (available through the PDCs) can be used to check the distance between the release-bearing and the clutch brake. See **Fig. 7**. One end of the tool has green tape on it and is 0.50 inch (12.7 mm) in diameter; the other end has blue tape on it and is 0.56 inch (14.3 mm) in diameter.

5. If using tool A02–12419 to check the distance between the release-bearing and the clutch brake, position the tool so that the legs straddle the transmission input shaft. Check the gap with both ends of the tool as follows:



1. Transmission Input Shaft Bearing Cap
2. Clutch Brake Discs and Washer

Fig. 5, Position the Clutch Brake



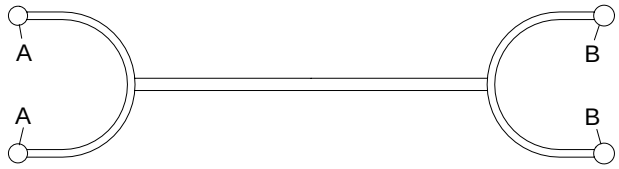
A. Release-travel: 1/2 to 9/16 inch (12.7 to 14.3 mm).
B. Free-travel 0.105 to 0.145 inch (2.7 to 3.7 mm) between yoke and wear pads.

1. Clutch Brake

Fig. 6, Clutch Travel Adjustments

5.1 Insert the blue 0.56-inch (14.3-mm) end. If it fits loosely, the gap is too wide and ad-

Clutch Adjustments



03/26/96 f580133

A. 0.50 inch (12.7 mm)
B. 0.56 inch (14.3 mm)

Fig. 7, Inspection Tool A02-12419

justment is needed. Go to "Adjustment" in this section.

5.2 If the blue 0.56-inch (14.3-mm) end can't be inserted in the gap, then try to insert the green 0.50-inch (12.7-mm) end. If the green end of the tool fits, snug or loose, then no adjustment is needed.

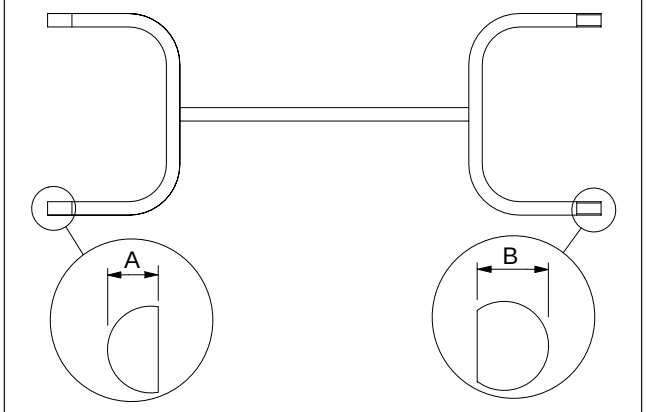
5.3 If the green end of the tool can't be inserted in the gap, adjustment is needed. Go to "Adjustment" in this section.

IMPORTANT: An inspection tool A02–12254 (available through the PDCs) can be used to check the distance between the release-bearing and the release yoke (free travel). See **Fig. 6** and **Fig. 8**. The legs on one end of the tool have green tape on them and are 0.105 inch (2.7 mm) thick; the legs on the other end have blue tape on them and are 0.145 inch (3.7 mm) thick.

6. If using tool A02–12254 to check the distance between the release-bearing and the release yoke, position the tool so it straddles the yoke to ensure that there won't be any misalignment. Check the distance with both ends of the tool as follows:

6.1 Insert the blue 0.145-inch (3.7-mm) end. If it fits loosely, the gap is too wide and linkage adjustment is needed. For instructions, see **Section 25.02**.

6.2 If the blue 0.145-inch (3.7-mm) end can't be inserted in the gap, then try to insert the green 0.105-inch (2.7-mm) end. If the green end of the tool fits, snug or loose, then no adjustment is needed.



03/26/96 f580132

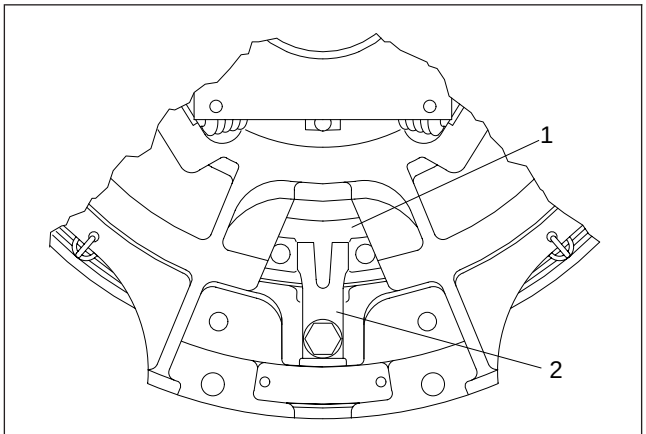
A. 0.105 inch (2.7 mm)
B. 0.145 inch (3.7 mm)

Fig. 8, Inspection Tool A02-12254

6.3 If the green end of the tool can't be inserted in the gap, the gap is too narrow and linkage adjustment is needed. For instructions, see **Section 25.02**.

Adjustment

Angle-Spring and Easy-Pedal clutches are adjusted with either a lockstrap (**Fig. 9**), or with the Kwik-Adjust® mechanism (**Fig. 10**).



03/01/94 f250005a

1. Adjusting Ring
2. Lockstrap

Fig. 9, Clutch Equipped with a Lockstrap

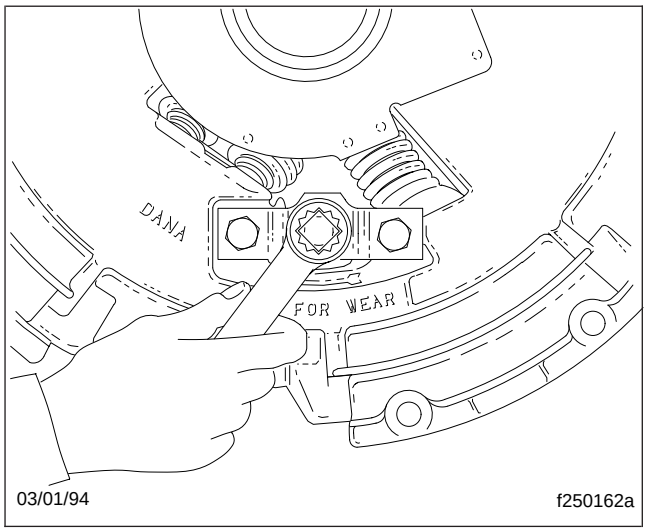


Fig. 10, Clutch Equipped with Kwik-Adjust

Clutches with a Lockstrap

1. Turn the engine flywheel until the lockstrap is aligned with the clutch inspection-cover opening. See **Fig. 1** and **Fig. 9**.
2. Remove the lockstrap. See **Fig. 9**.
3. Release the clutch by depressing the pedal. Block the pedal in the released position, or have someone assist you by holding the pedal down during the adjustment procedure.
4. Using a clutch adjusting tool, turn the adjusting ring to adjust release travel (the clearance between the release-bearing housing and the forward clutch brake disc).

   If clearance between the release-bearing housing and the clutch brake is *less than* 1/2 inch (12.7 mm), rotate the adjusting ring counterclockwise to move the release-bearing toward the engine.

   If clearance between the release-bearing housing and the clutch brake is *more than* 9/16 inch (14.3 mm), rotate the adjusting ring clockwise to move the release-bearing toward the transmission.

   The lockstrap bolt may be installed and used as a fulcrum in turning the adjusting ring.

NOTE: Each notch in the adjusting ring represents about 0.020-inch (0.5-mm) release-bearing travel. Thus, three notches moved means 0.060-inch (1.5-mm) or about 1/16-inch release-bearing travel.

5. After adjusting, release the pedal, and check the clearance between the release-bearing housing and the forward clutch brake disc, or torque-limiting clutch brake. When the clearance is 1/2 inch to 9/16 inch (12.7 mm to 14.3 mm), the adjustment is complete.
6. Install the lockstrap, and tighten the bolt 35 to 40 lbf·ft (47 to 54 N·m).

IMPORTANT: Use the same length bolt when installing the lockstrap. A longer bolt will lock-up the clutch assembly.

NOTE: If the lockstrap will not engage the notches of the adjusting ring, check the clutch assembly for worn parts. For instructions, see **Subject 120**.

7. Check and adjust the clutch linkage. For instructions, see **Section 25.02**.

Clutches with Kwik-Adjust

1. Turn the engine flywheel until the lockstrap is aligned with the clutch inspection-cover opening. See **Fig. 1** and **Fig. 10**.
2. Release the clutch by depressing the pedal. Block the pedal in the released position, or have someone assist you by holding the pedal down during the adjustment procedure.

NOTE: An open-end wrench is not recommended for the following step.

3. Insert a 12 point 3/4-inch socket or box-end wrench through the inspection cover opening. Depress the square bolt to adjust the release-bearing clearance.

   If clearance between the release-bearing housing and the clutch brake is *less than* 1/2 inch (12.7 mm), rotate the adjusting ring counterclockwise to move the release-bearing toward the engine.

   If clearance between the release-bearing housing and the clutch brake is *more than* 9/16 inch (14.3 mm), rotate the adjusting ring clockwise to move the release-bearing toward the transmission.

   Be sure the adjustment bolt is locked when you have completed the adjustment.

NOTE: Each quarter of a turn of the adjustment bolt represents about 0.017-inch (0.4-mm) release-bearing movement.

4. After adjusting, release the pedal, and check the clearance between the release-bearing housing and the forward clutch brake disc, or torque-limiting clutch brake. When the clearance is 1/2 inch to 9/16 inch (12.7 mm to 14.3 mm), the adjustment is complete.
5. Check and adjust the clutch linkage. For instructions, see **Section 25.02**.

Self-Adjusting Clutch

IMPORTANT: The self-adjusting clutch normally compensates for wear, and should only need adjustment when it is first installed. If the release-bearing clearance check shows the self-adjusting clutch to be out of adjustment, be sure that:

A. the actuator arm is correctly inserted into the release-bearing sleeve retainer (see **Fig. 11**);

B. the adjuster arm is not bent;

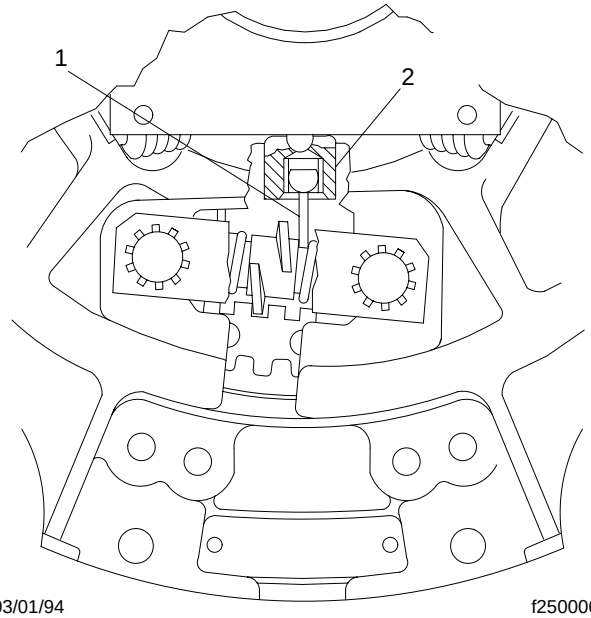
C. the release-bearing has a 1/2 inch to 9/16 inch (12.7 mm to 14.3 mm) travel;

D. other clutch parts (such as the adjusting ring) aren't frozen or damaged.

If the clutch is damaged, replace it.

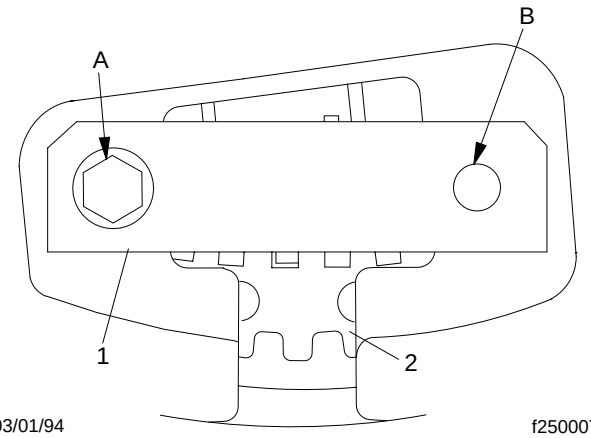
If adjustment is needed, do the following:

1. Turn the engine flywheel until the adjuster assembly is in line with the clutch inspection-cover opening. See **Fig. 1** and **Fig. 11**.
2. Remove the right-side bolt from the adjuster assembly, and loosen the left-side bolt one turn. See **Fig. 12**.
3. To allow manual adjustment, rotate the adjuster assembly upward. See **Fig. 13**. This will disengage the adjuster worm gear from the adjusting ring. Hold the adjuster assembly disengaged, and tighten the left-side bolt.
4. Release the clutch by depressing the pedal; block it in this position.
5. Using a clutch adjusting tool in the lower teeth, turn the adjusting ring clockwise to move the release-bearing toward the transmission, or counterclockwise to move the release-bearing toward the engine. See **Fig. 11**.



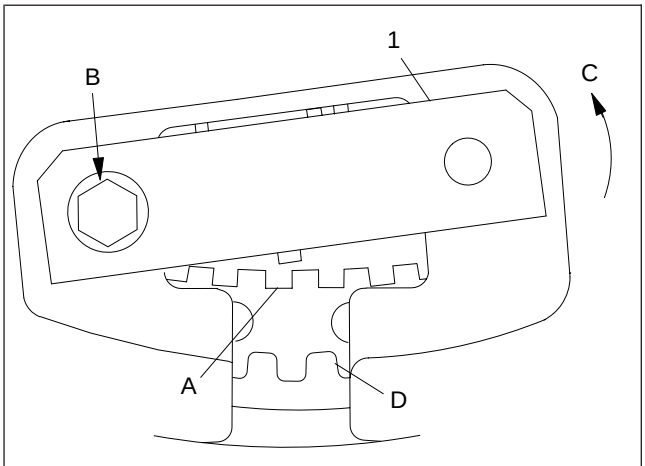
1. Actuator Arm
2. Release-Bearing Sleeve Retainer

Fig. 11, Correct Actuator Arm Insertion



A. Loosen this bolt.
B. Remove this bolt.
1. Adjuster Assembly
2. Adjusting Ring

Fig. 12, Remove the Right-Side Bolt



A. Do not pry on the innermost teeth.
B. Tighten the bolt.
C. Rotate up.
D. Use a clutch adjusting tool in the lower teeth.

1. Adjuster Assembly

Fig. 13, Rotate the Adjuster Assembly

CAUTION

Do not pry on the innermost gear teeth of the adjusting ring. See Fig. 13. Doing so could damage the teeth, and prevent the clutch from self-adjusting.

NOTE: Each lower gear tooth of the adjusting ring represents about 0.010-inch (0.25-mm) release-bearing movement. Thus, six notches moved means 0.060-inch (1.5-mm) or about 1/16-inch release-bearing movement.

6. After adjusting, release the clutch pedal, and check the clearance between the release-bearing housing and the forward clutch brake disc, or torque-limiting clutch brake. When the clearance is 1/2 inch to 9/16 inch (12.7 mm to 14.3 mm), the adjustment is complete.

IMPORTANT: The clutch will not self-adjust if release-bearing travel is less than 1/2 inch (12.7 mm).

7. Loosen the left-side adjuster bolt, and rotate the adjuster assembly down, meshing the adjuster worm gear with the adjusting ring teeth. The ring may have to be moved slightly, to allow the worm to mesh. Install the right-side bolt, and tighten both bolts 30 to 35 lbf·ft (41 to 47 N·m).
8. Visually check that the actuator arm is inserted in the release-bearing sleeve retainer. See **Fig. 9**. If the adjuster assembly is installed correctly, the adjuster assembly spring will move back and forth as the clutch pedal is depressed and released.

IMPORTANT: The clutch will not self-adjust if the actuator arm is not correctly inserted in the release-bearing sleeve retainer.

After making release-bearing adjustments, check and adjust the clutch linkage. For instructions, see **Section 25.02**.

Removal

Stamped Angle-Spring™ Clutch

NOTE: Before pulling the transmission from the bell housing, disconnect the external clutch linkage and rotate the release yoke so the yoke will clear the release bearing when it is removed.

1. Remove the transmission. See **Section 26.00**.

⚠ CAUTION

Do not let the rear of the transmission drop, and do not let the transmission hang unsupported in the splined hubs of the clutch discs. Taking these precautions will prevent bending and distortion of the clutch discs.

2. If installed, remove the clutch brake from the transmission input shaft. See **Fig. 1**.

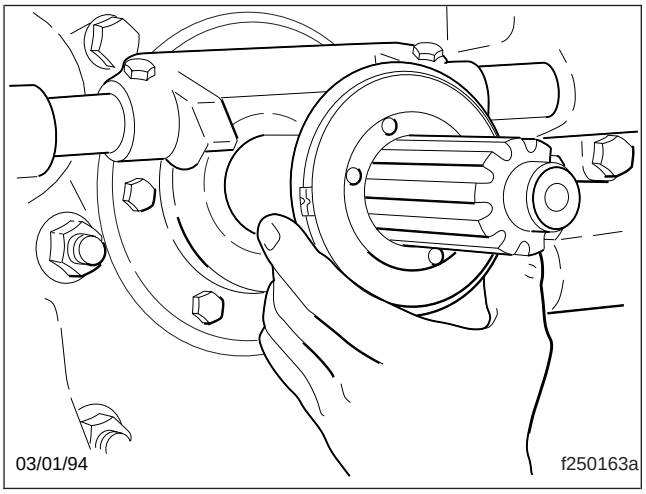
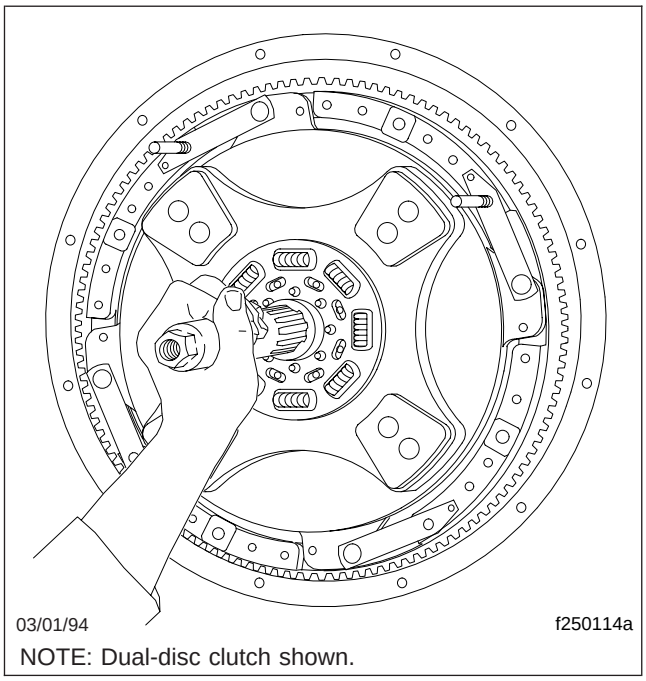


Fig. 1, Clutch Brake Removal

3. Install a spline aligning tool into the release bearing assembly, and through the driven discs. See **Fig. 2**. An old transmission input shaft may be used for this purpose.
4. Use a release tool and two 1- to 1.5-inch (25 to 37 mm) spacer blocks to pull the bearing back.
5. Remove the two top mounting capscrews from the cover assembly. Install two 3/8–16 x 3 guide studs in the open holes to help support the clutch assembly during removal. See **Fig. 3**.



NOTE: Dual-disc clutch shown.

Fig. 2, Installing a Spline Aligning Tool, SAS

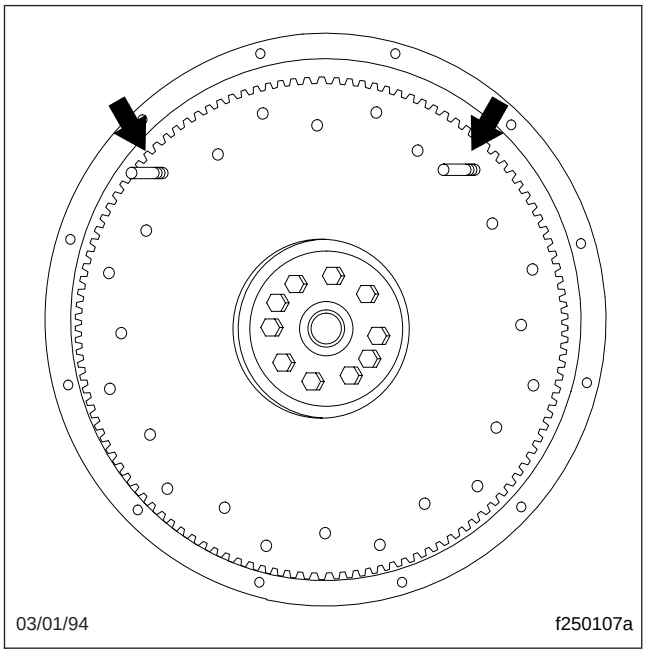


Fig. 3, Install the Guide Studs, SAS

6. Progressively loosen each of the mounting capscrews. See **Fig. 4**. This will prevent warping or

Clutch Removal

bending within the clutch, and will ease removal of the clutch mounting capscrews.

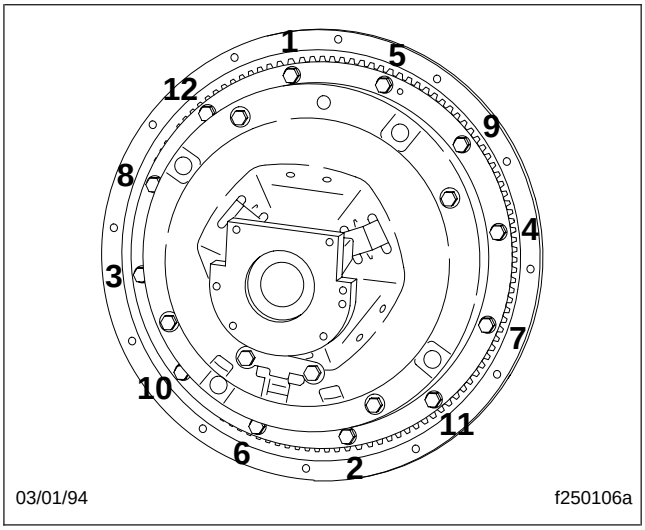


Fig. 4, Loosening Sequence, SAS

⚠ WARNING

The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

7. Remove the mounting capscrews, and carefully remove the clutch assembly together with the spline aligning tool.
8. Use an appropriate puller to remove the pilot bearing. Inspect the old pilot bearing for any unusual wear or damage. Discard the pilot bearing.

Easy-Pedal™ Clutch

NOTE: Before pulling the transmission from the bell housing, disconnect the external clutch linkage and rotate the release yoke so the yoke will clear the release bearing when it is removed.

1. Remove the transmission. See **Section 26.00**.

⚠ CAUTION

Do not let the rear of the transmission drop, and do not let the transmission hang unsupported in the splined hubs of the clutch discs. Taking these precautions will prevent bending and distortion of the clutch discs.

2. Remove the clutch brake from the transmission input shaft. See **Fig. 1**.
3. Install a spline aligning tool into the release bearing assembly, and through the driven discs. See **Fig. 5**. An old transmission input shaft may be used for this purpose.

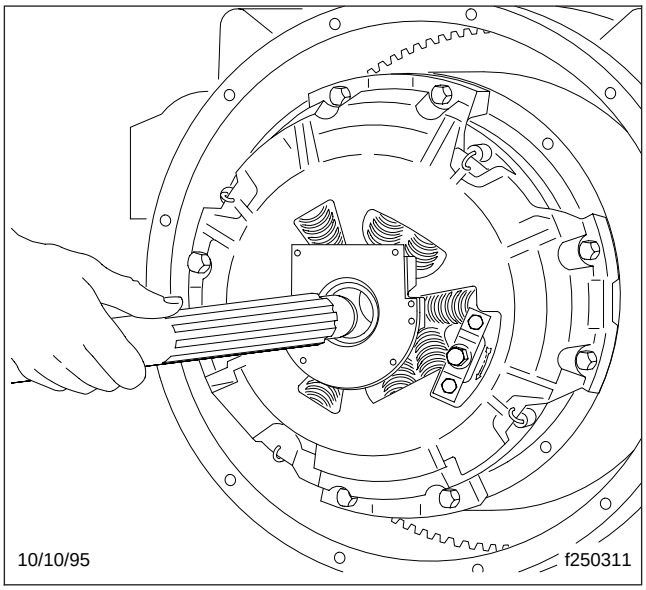


Fig. 5, Installing a Spline Aligning Tool, Easy-Pedal

4. Use a release tool and two 5/8-inch (16 mm) spacer blocks to pull the bearing back. See **Fig. 6**. The spacer blocks relieve the internal spring load in the clutch assembly, and facilitate clutch removal.
5. Remove the two top mounting bolts from the cover assembly. Install guide studs in the open holes to help support the clutch assembly during removal. See **Fig. 7**.

NOTE: Use 3/8–16 x 3 guide studs on 14-inch Easy-Pedal clutches and 7/16–14 x 5 guide studs on 15.5-inch clutches (installed on FL112 only).

6. Progressively loosen each of the mounting bolts in the pattern shown in **Fig. 8**. This will prevent warping or bending within the clutch, and will ease removal of the clutch mounting bolts.

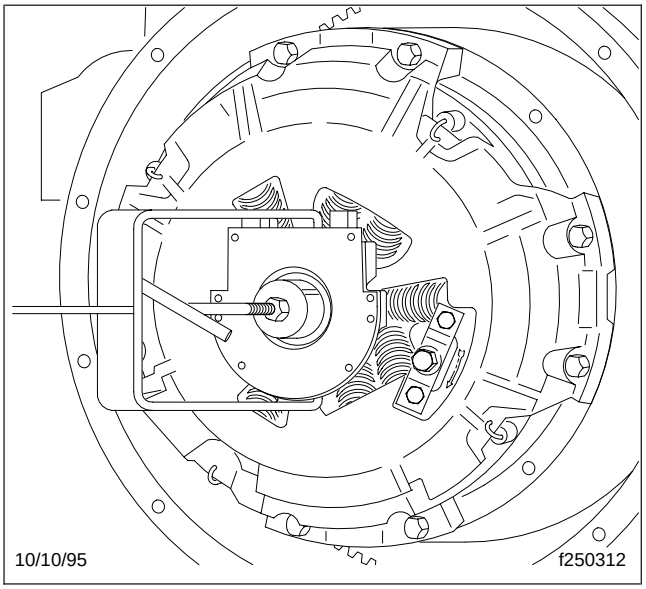


Fig. 6, Pulling the Bearing

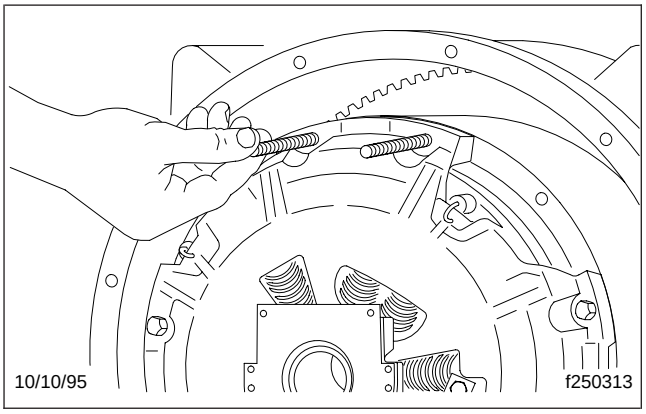


Fig. 7, Install the Guide Studs, Easy-Pedal

⚠ WARNING

The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

7. Remove the mounting bolts, and carefully remove the clutch assembly.

   Be careful to keep the spline aligning tool in place to retain the discs and intermediate plate. Remove the spline aligning tool, the rear driven disc, the intermediate plate, and the front driven disc.

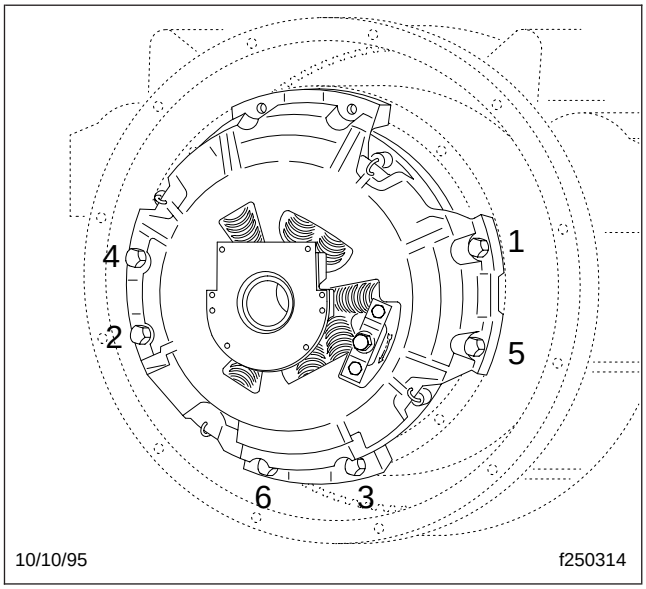


Fig. 8, Loosening Sequence, Easy-Pedal

8. Use an appropriate puller to remove the pilot bearing. Inspect the old pilot bearing. Correct the cause of any unusual wear or damage. Discard the bearing.

Solo™ Clutch

⚠ CAUTION

For proper installation of the Solo clutch, the wear indicating tab must be reset. Resetting the wear indicating tab allows the clutch to release and prevents possible clutch damage.

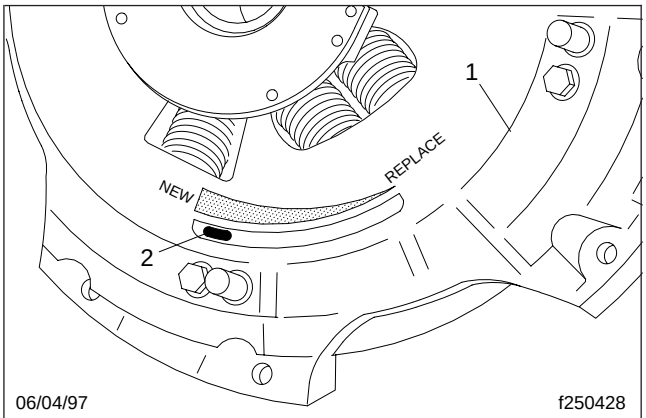
NOTE: This procedure requires two persons: one under the vehicle with access to the wear indicating tab, and the other in the vehicle to press the clutch pedal.

1. Reset the wear indicating tab with the clutch in the vehicle.

   1.1 From inside the cab, press the clutch pedal all the way down. Hold the clutch pedal down until the wear indicating tab is reset.

   1.2 Through the clutch inspection cover, slide the wear indicating tab to the left until it is at the "NEW" position on the indicator. See **Fig. 9**.

Clutch Removal



With the clutch pedal down, set the tab to the "NEW" position on the indicator.

1. Clutch Cover
2. Wear Indicating Tab

Fig. 9, Resetting the Wear Indicating Tab

IMPORTANT: Take note of the position of the wear indicating tab on the clutch cover. If the wear indicating tab is near the "REPLACE" position on the indicator, it is time to replace the clutch.

1.3 From inside the cab, release the clutch pedal. Check to be sure the wear indicating tab stays at the "NEW" position on the indicator.

NOTE: Before pulling the transmission from the bell housing, disconnect the external clutch linkage and rotate the release yoke so the yoke will clear the release bearing when it is removed.

2. Remove the transmission. See **Section 26.00**.

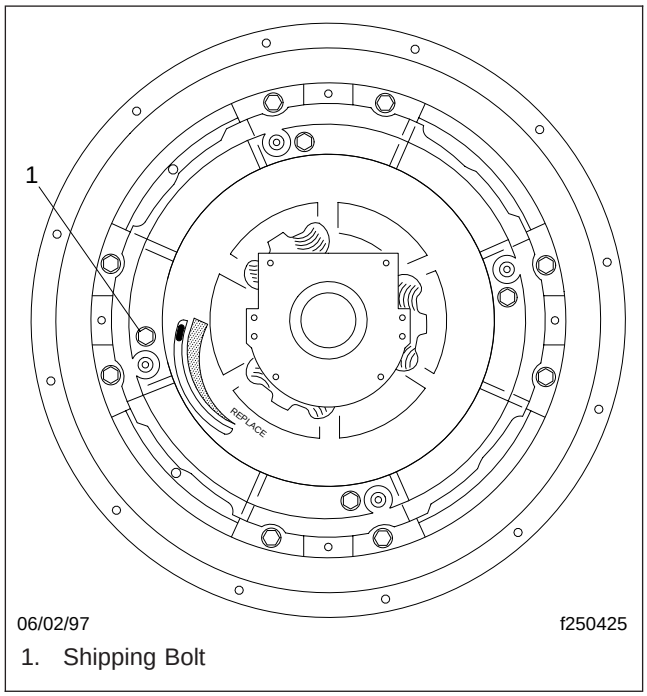
⚠ CAUTION

Do not let the rear of the transmission drop, and do not let the transmission hang unsupported in the splined hubs of the clutch discs. Taking these precautions will prevent bending and distortion of the clutch discs.

3. Remove the clutch brake from the transmission input shaft. See **Fig. 1**.
4. Install a spline aligning tool into the release bearing assembly, and through the driven discs. An old transmission input shaft may be used for this purpose.
5. Locate the four shipping bolts (hexhead machine screws). These shipping bolts were installed on the clutch cover prior to installation.

NOTE: Use 3/8–16 x 1-1/4 bolts on medium duty Solo 1401 or 1402 clutches and 7/16–14 x 1-3/4 bolts on heavy-duty 15.5-inch clutches (installed on FL112 only).

6. Install the four shipping bolts into the four clutch cover holes and fasten them finger-tight. See **Fig. 10**.



1. Shipping Bolt

Fig. 10, Install the Shipping Bolts

7. Remove the two top mounting capscrews from the cover assembly. Install two guide studs in the open holes to help support the clutch assembly during removal.

NOTE: Use 3/8–16 x 3 guide studs on medium-duty 14-inch clutches and 7/16–14 x 5 guide studs on heavy-duty 15.5-inch clutches (installed on FL112 only).

8. Progressively loosen each of the mounting capscrews in the pattern shown in **Fig. 11**. This will prevent warping or bending within the clutch, and will ease removal of the clutch mounting capscrews.

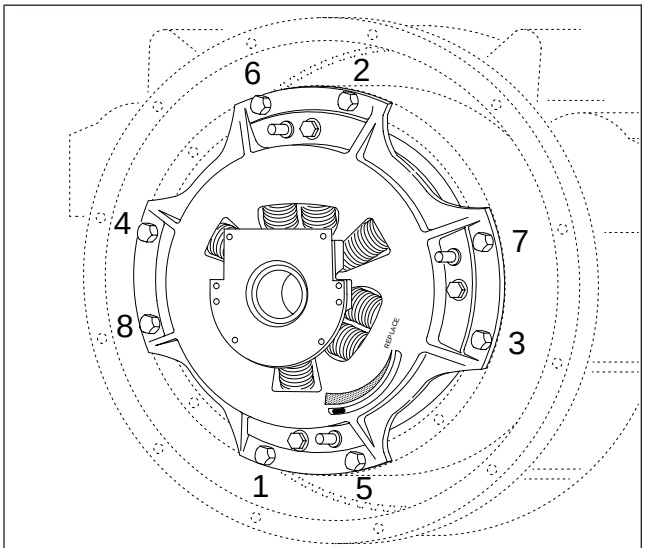


Fig. 11, Loosening Sequence, Solo

WARNING

The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

9. Remove the mounting capscrews, and carefully remove the clutch assembly together with the spline aligning tool.

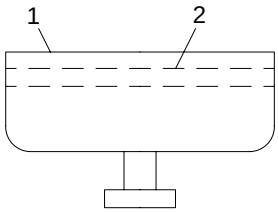
NOTE: For installation, mark the proper position of the discs and intermediate plate adaptor ring.

10. Reset the pressure plate wear pins. See **Fig. 12**.

    10.1 Progressively tighten the four shipping bolts in a crisscross pattern.

    10.2 Measure the depth of the pressure plate. On 14-inch clutches, the wear pins are reset when the pressure plate is 0.50 inches (12.7 mm) below the mounting surface. On 15.5-inch clutches (FL112 only), the wear pins are reset when the pressure plate is 1.75 to 1.78 inches (44.4 to 45.2 mm) below the mounting surface.

NOTE: Resetting the pressure plate wear pins will allow the clutch to release after installation.



NOTE: On 14-inch clutches, the wear pins reset when the pressure plate is 0.50 inches (12.7 mm) below the mounting surface. On 15.5-inch clutches (FL112 only), the wear pins reset when the pressure plate is 1.75 to 1.78 inches (44.4 to 45.2 mm) below the mounting surface.

1. Mounting Surface
2. Pressure Plate

Fig. 12, Reset Wear Pins

11. Use an appropriate puller to remove the pilot bearing. Inspect the old pilot bearing for any unusual wear or damage. Discard the pilot bearing.

Resetting the Wear Indicating Tab (clutch out of vehicle)

CAUTION

For proper installation of the Solo clutch, the wear indicating tab must be reset. Resetting the wear indicating tab allows the clutch to release and prevents possible clutch damage.

NOTE: Use this procedure if the transmission and clutch were removed without resetting the wear indicating tab.

1. Remove the four shipping bolts (if installed).
2. Support the clutch cover in an arbor press with the release bearing facing down. When setting up the arbor press, allow at least 1 inch (25 mm) clearance for both movement of the release bearing and access to install shipping bolts. See **Fig. 13**.
3. Center the ram and press downward on the retainer until it comes to a stop. Lock the ram in position.
4. Slide the wear indicating tab to the left until it is at the new position of the indicator (**Fig. 9**) and hold it in position with a magnet.
5. Locate the four shipping bolts.

Clutch Removal

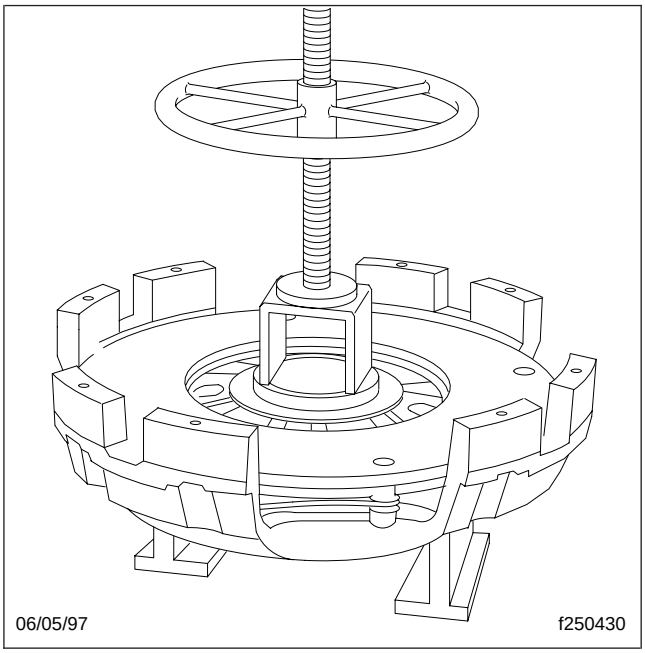


Fig. 13, Arbor Press Setup

NOTE: Use 3/8–16 x 1-1/4 bolts on medium duty Solo 1401 or 1402 clutches and 7/16–14 x 1-3/4 bolts on heavy-duty 15.5-inch clutches (installed on FL112 only).

6. Install the four 7/16–14 x 1-3/4 shipping bolts into the four clutch cover holes and fasten them finger-tight. See **Fig. 10**.

NOTE: You may need to temporarily install slightly longer bolts to allow engagement of the shipping bolts.

7. Reset the pressure plate wear pins. See **Fig. 12**.

   7.1 Progressively tighten the four shipping bolts in a crisscross pattern.

   7.2 Measure the depth of the pressure plate. On 14-inch clutches, the wear pins are reset when the pressure plate is 0.50 inches (12.7 mm) below the mounting surface. On 15.5-inch clutches (FL112 only), the wear pins are reset when the pressure plate is 1.75 to 1.78 inches (44.4 to 45.2 mm) below the mounting surface.

NOTE: Resetting the pressure plate wear pins will allow the clutch to release after installation.

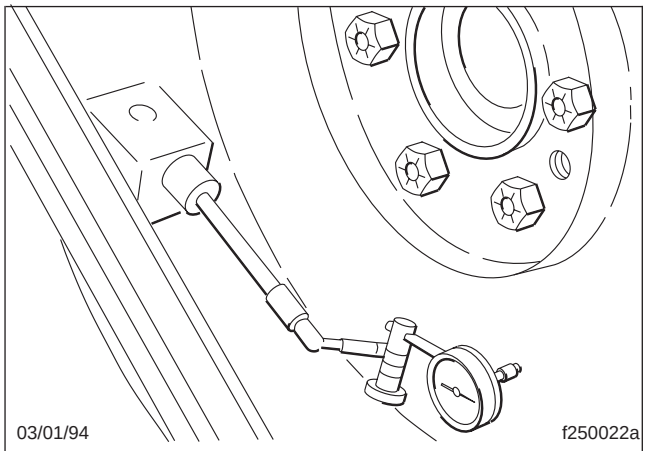
Clutch Inspection

CAUTION

Misalignment of any parts described in these procedures will cause premature wear of drivetrain components.

IMPORTANT: When taking the following readings, rotate the engine by hand; do not crank the engine with the starter. The engine may be rotated by the pulley nut at the front of the crankshaft, the flywheel mounting bolts, or the starter ring-gear on the flywheel.

1. Clean the surfaces being measured to ensure accurate measurements.
2. Measure the runout of the flywheel face (friction surface). See **Fig. 1** for the correct set-up.



Secure the dial indicator to the flywheel housing, with the gauge finger against the flywheel face, and near the outer edge.

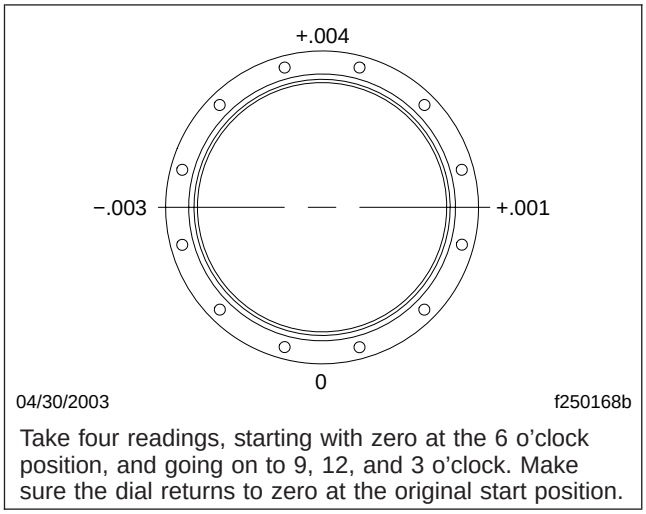
Fig. 1, Measure the Flywheel Face

2.1 Secure the dial indicator to the flywheel housing, with the gauge finger against the face of the flywheel near the outer edge.

2.2 Turn the flywheel through one complete revolution. With chalk or soapstone, mark the high and low points on the flywheel face.

2.3 The total runout will be the difference between the highest plus and minus readings. To calculate the runout, see **Fig. 2**.

Example: The highest reading is +0.004 at 12 o'clock. The lowest reading is –0.003 at 9 o'clock. Therefore the total runout is 0.007 inch.

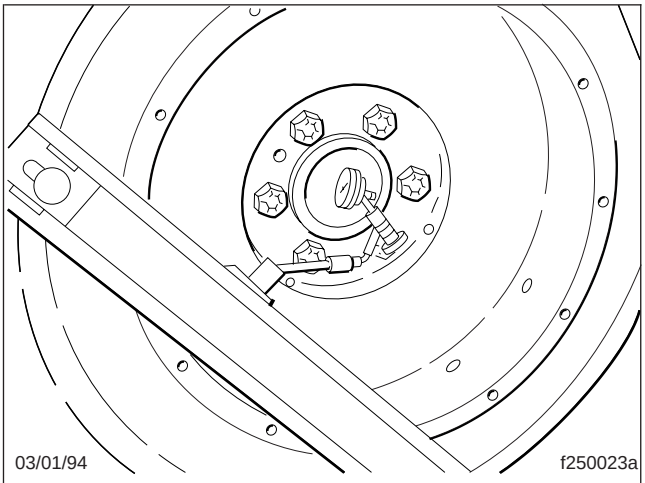


Take four readings, starting with zero at the 6 o'clock position, and going on to 9, 12, and 3 o'clock. Make sure the dial returns to zero at the original start position.

Fig. 2, Calculate the Runout

2.4 The SAE maximum total runout for the flywheel face is 0.008 inch (0.20 mm). If the readings are higher, see the engine manufacturer's manual for instructions.

3. Measure the runout of the pilot-bearing bore in the flywheel. See **Fig. 3** for the correct set-up.



Secure the dial indicator to the flywheel housing, with the gauge finger on the surface of the pilot-bearing bore.

Fig. 3, Measure the Pilot-Bearing Bore

Clutch Inspection

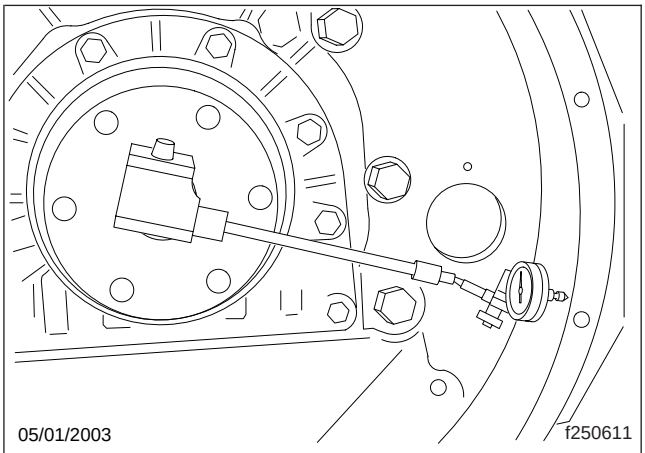
3.1 With the indicator still secured to the flywheel housing, move the gauge finger to contact the surface of the pilot-bearing bore.

3.2 Turn the flywheel through one complete revolution. With chalk or soapstone, mark the high and low points on the bore of the pilot bearing.

3.3 Calculate the runout as before.

3.4 The SAE maximum total runout for the pilot-bearing bore is 0.005 inch (0.13 mm). If the readings are higher, see the engine manufacturer's manual for instructions.

4. Measure the runout of the flywheel housing bore. See **Fig. 4** for the correct set-up.



Secure the dial indicator to the crankshaft, with the gauge finger against the side of the flywheel housing.

Fig. 4, Measure the Flywheel Housing Bore

4.1 Secure the dial indicator to the crankshaft, with the gauge finger against the side of the flywheel housing.

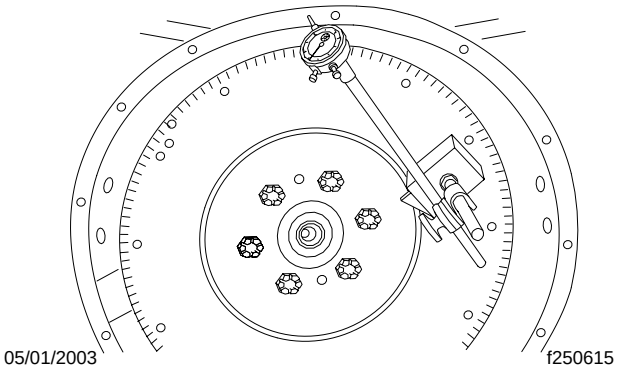
4.2 Turn the flywheel through one complete revolution. With chalk or soapstone, mark the high and low points on the side of the flywheel housing.

4.3 Calculate the runout as before.

NOTE: Only if you have to reposition the flywheel housing is it necessary to mark the high and low runout readings in clock positions.

4.4 The SAE maximum total runout for the flywheel-housing bore is 0.008 inch (0.20 mm). If readings are higher, replace the flywheel housing. For instructions, see the engine manufacturer's manual.

5. Measure the runout of the face of the flywheel housing. See **Fig. 5** for the correct set-up.



Secure the dial indicator to the outer diameter of the flywheel, with the gauge finger against the face of the flywheel housing.

Fig. 5, Measure the Flywheel Housing Face

5.1 With the dial indicator secured to the outer diameter of the flywheel, move the gauge finger to contact the face of the flywheel housing.

5.2 Turn the flywheel through one complete revolution. With chalk or soapstone, mark the high and low points on the face of the flywheel housing.

5.3 Calculate the runout as before.

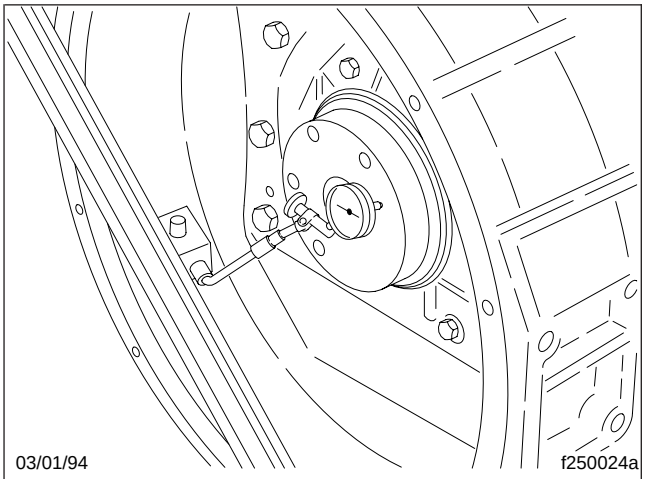
NOTE: Only if you have to reposition the flywheel housing is it necessary to mark the high and low runout readings in clock positions.

5.4 The SAE maximum total runout for the flywheel-housing face is 0.008 inch (0.20 mm). If the readings are higher, replace the housing. For instructions, see the engine manufacturer's manual.

NOTE: Use a case-bore plug and shaft set to measure the bell-housing face and pilot. Case-bore plugs are tapped into the front and rear bores of the transmission case, and have very

close tolerances. The shaft runs through the center of the plugs, and extends to the front far enough to secure a dial indicator and obtain a reading on the bell housing.

6. Measure the runout of the bell housing face and pilot.
   - 6.1 Secure the dial indicator to the case-bore shaft, with the gauge finger against the face of the bell housing.
   - 6.2 Turn the case-bore shaft through one complete revolution. With chalk or soapstone, mark the high and low points on the face of the bell housing.
   - 6.3 Calculate the runout as before.
   - 6.4 The SAE maximum total runout for the bell-housing face is 0.008 inch (0.20 mm). If the readings are higher, replace the bell housing. See the transmission manufacturer's service manual for instructions.
7. Remove the flywheel (see the engine manufacturer's manual), and measure the runout of the flywheel crankshaft face. See **Fig. 6**.



Secure the dial indicator to the flywheel housing, with the gauge finger against the crankshaft face, and near the outer edge.

Fig. 6, Measure the Crankshaft Face Runout

   - 7.1 Secure the dial indicator to the flywheel housing, with the gauge finger against the crankshaft face, and near the outer edge.
   - 7.2 Turn the crankshaft through one complete revolution. With chalk or soapstone, mark the high and low points on the face of the crankshaft.
   - 7.3 Calculate the runout as before.
   - 7.4 See the engine manufacturer's manual for maximum runout, corrective measures, and flywheel installation instructions.

Pre-Installation Procedures

Before installing a new, rebuilt, or used clutch, do the following procedures:

1. Install a new pilot bearing. Be sure that the pilot bearing has a press-fit in the flywheel.

⚠ CAUTION

Tap on the outer race only. Tapping on the inner race could damage the pilot bearing.

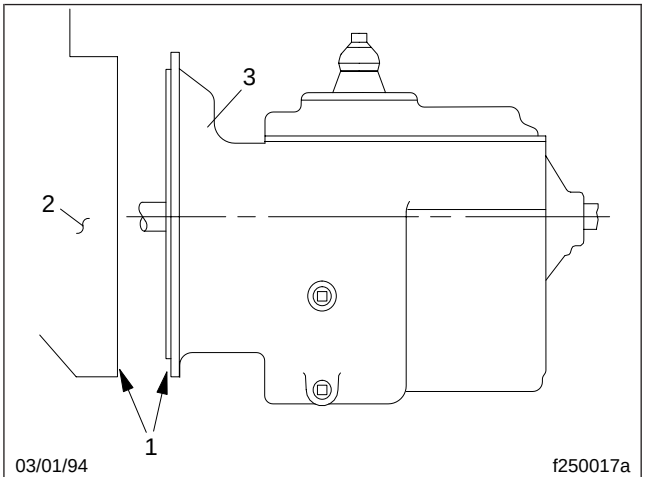
NOTE: To discourage warranty claims for drag or clutch noise, use a premium grade C3/C4 pilot bearing. Due to increased operating temperatures and longer clutch life, the standard pilot bearings and grease are no longer acceptable.

2. Check for wear on the mating surfaces of the flywheel housing and the transmission bell housing. Any noticeable wear on either part causes misalignment. If worn, replace the part. See **Fig. 7**.
3. Check the flywheel for wear caused by the bell housing pilot (projecting lip of the bell housing). The correct dimension is 1/8-inch (3.2-mm). Wear is most likely to appear between the 3 o'clock and 8 o'clock positions. See **Fig. 8**.

NOTE: The pilot (lip) of the bell housing can wear into the flywheel housing. This can be caused by the transmission loosening up, or by road and engine vibration after high mileage.

4. Inspect the flywheel. Replace or repair the flywheel if the wear is extreme.
   - 4.1 Visually inspect the friction surface of the flywheel for heat checks and scoring.

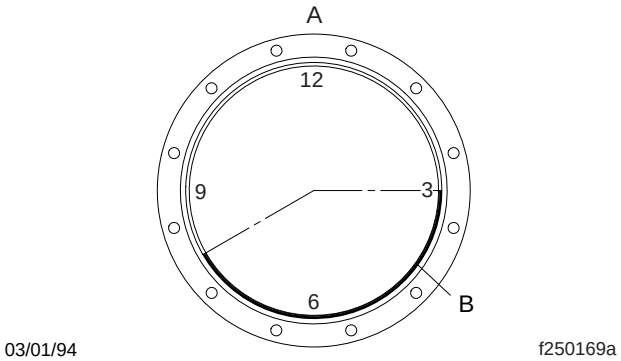
Clutch Inspection



03/01/94 f250017a

1. Mating Surfaces
2. Engine Flywheel Housing
3. Transmission Bell Housing

Fig. 7, Inspect the Mating Surfaces



03/01/94 f250169a

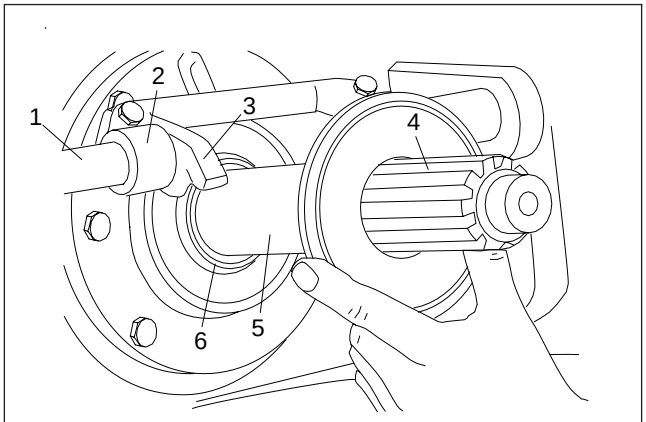
A. Top
B. The most common areas of wear are between the 3 o'clock and 8 o'clock positions.

Fig. 8, Check for Wear

4.2 Measure the friction surface wear with a straightedge and feeler gauge. For instructions, see the engine manufacturer's manual.

5. Inspect the input shaft, both the splined and the smooth area. See **Fig. 9**.

5.1 Check the fit of the splined hubs of the driven discs by sliding them along the splines of the input shaft. The hubs must slide freely so the clutch will release



05/01/2003 f250613

1. Cross-Shaft
2. Sleeve Bushing
3. Release Yoke Finger
4. Input Shaft (splined area)
5. Input Shaft (smooth area)
6. Bearing Cap

Fig. 9, Clutch Inspection Points

cleanly. If necessary, use a hand stone to dull the sharp edges of the splines.

5.2 If the input shaft splines are worn or notched, or if the hubs still do not slide freely, replace the input shaft. For instructions, see the transmission manufacturer's service manual.

5.3 Inspect the smooth area of the input shaft for wear and/or rough spots. Replace the input shaft if necessary.

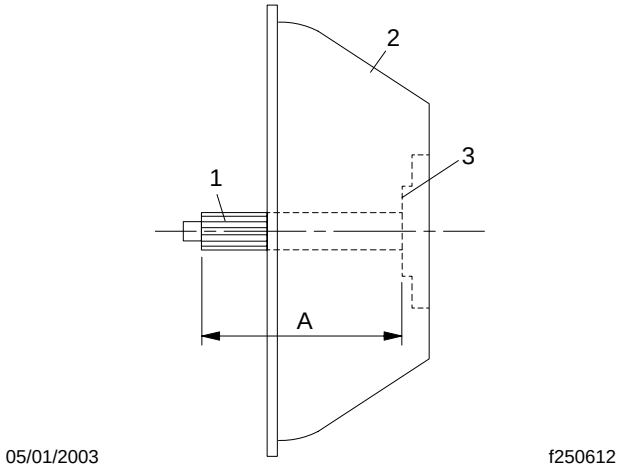
6. To prevent side-loading, inspect all pivot points of the clutch linkage for excessive wear and replace them if necessary. See **Fig. 9**. Pay special attention to the following points:

6.1 Check for excessive wear at the fingers of the release yoke where they contact release bearing wear pads.

6.2 Check the clutch cross-shaft and sleeve bushings for excessive wear. Check the sleeve bushings for walk-out.

7. To prevent clutch brake wear, check the input-shaft bearing cap and measure it as shown in **Fig. 10**.

7.1 Visually check the bearing cap for excessive wear.



A. Length of Input Shaft, from the Splined End to the Bearing Cap

1. Input Shaft
2. Bell Housing
3. Bearing Cap

Fig. 10, Measure the Input Shaft

7.2 Measure the distance between the splined end of the input shaft and the bearing cap (dimension A). If dimension A is greater than 8.71 inches (221.5 mm), replace the bearing cap.

NOTE: Torque-limiting clutch brakes are a one-piece assembly with a large and a small face. When installing a torque-limiting clutch brake on an Eaton® Fuller® or Meritor™ transmission, install the smaller face toward the transmission.

8. On unsynchronized transmissions,install a new clutch brake on the transmission input shaft, as shown in **Fig. 11**. Slide it tight against the input-shaft bearing cap.
9. Check the diameter of the flywheel bore opening (this is the recessed area for the flywheel bolt circle). See **Table 1** for minimum flywheel bore diameters for each disc type.

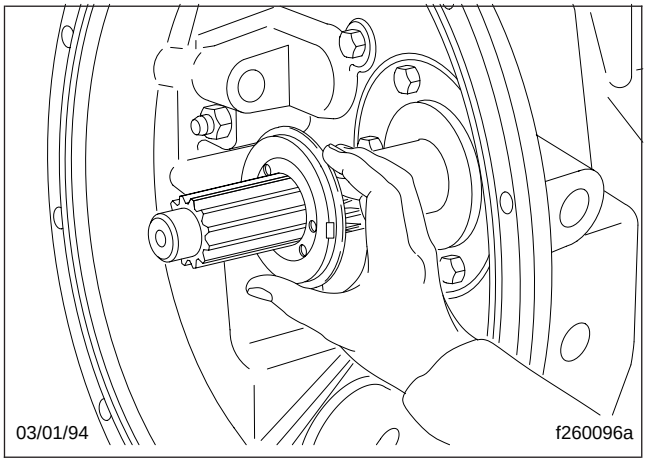


Fig. 11, Install the Clutch Brake

Minimum Flywheel Bores	
Disc Type	**Flywheel Bore in inch (mm)**
10-Spring	8.562 (217.48)
9-Spring	9.750 (247.65)
8-Spring	7.250 (184.15)
7-Spring	9.750 (247.65)
6-Spring	9.750 (247.65)

Table 1, Minimum Flywheel Bores

Installation

IMPORTANT: For 15.5-inch clutches, see the installation procedures in **Subject 140**.

Stamped Angle-Spring® Single-Disc Clutch

NOTE: Do the clutch inspection and pre-installation procedures in **Subject 120** before installing the clutch.

1. If the clutch is new, remove any protective coating applied to the pressure plate.
2. If not already in place, install two 3/8–16 x 3 guide studs in two upper mounting holes of the flywheel. See **Fig. 1**.

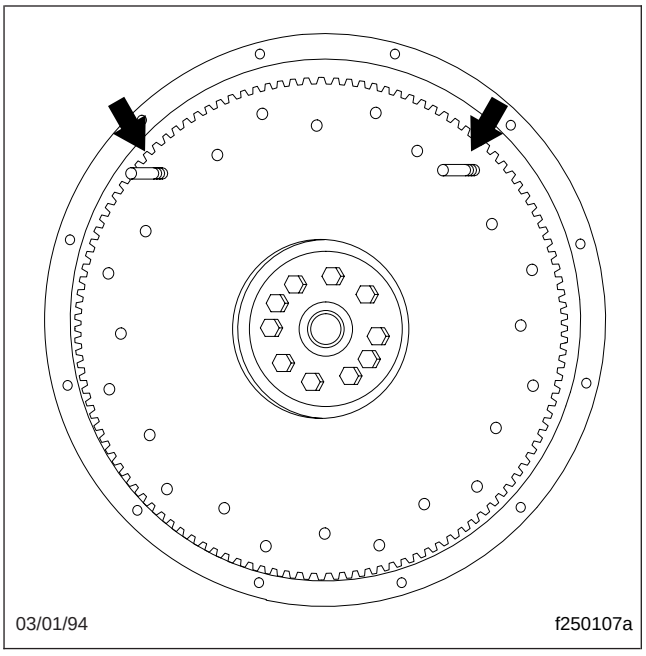


Fig. 1, Install the Guide Studs, SAS Single-Disc

3. Install the single driven disc on the flywheel.
   - 3.1 Insert an aligning tool through the splines of the driven disc and then, with the driven disc attached, into the pilot bearing. See **Fig. 2**.
   - 3.2 Be sure the side marked *PRESSURE PLATE SIDE* faces the pressure plate.

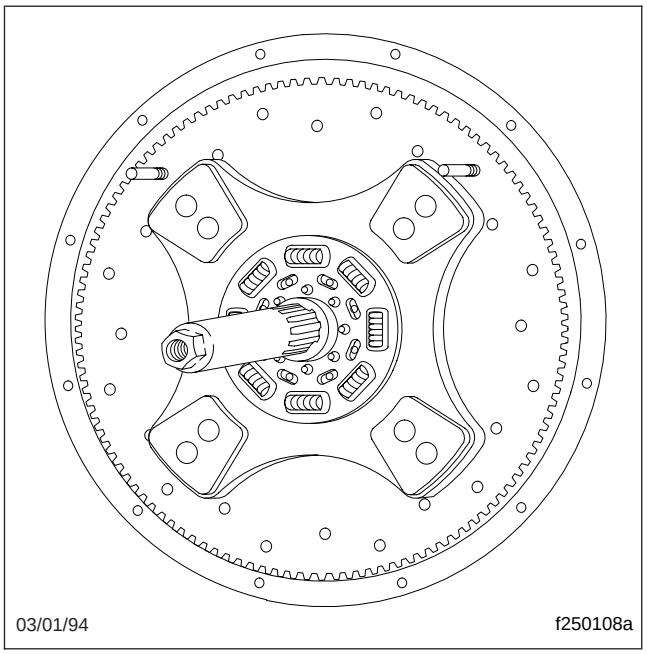


Fig. 2, Insert an Aligning Tool, SAS Single-Disc

See **Fig. 3** for the position of the driven disc when installed.

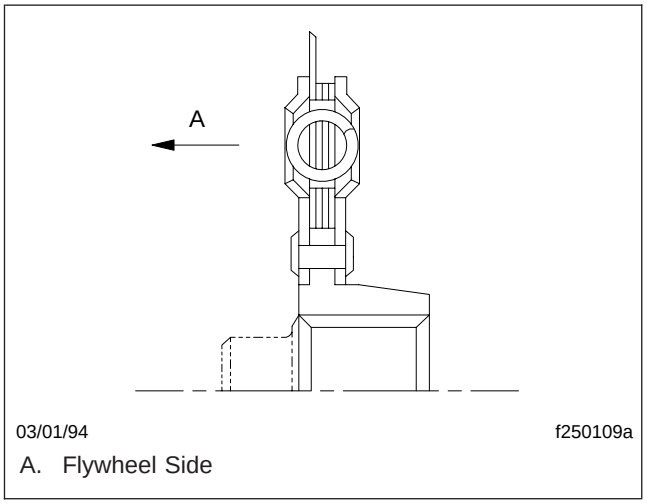


Fig. 3, Single Driven Disc Installed, SAS

WARNING

The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

14-Inch Clutch Installation

4. Install the cover assembly. See **Fig. 4**.

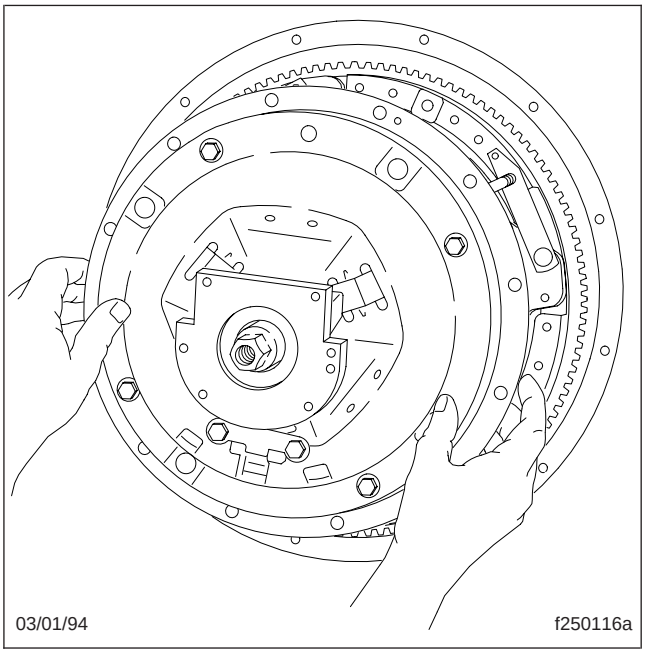


Fig. 4, Positioning the Clutch Cover, SAS

4.1 With the aligning tool still in place, slide the cover assembly over the aligning tool.

4.2 Align the lockstrap or adjustment bolt to be visible through the clutch inspection cover in the bell housing.

CAUTION

If the capscrews are not tightened in sequence, it may cause permanent damage to the clutch cover and create an out-of-balance condition.

5. Install the clutch mounting capscrews. See **Fig. 5** for the tightening sequence.

5.1 In the cover plate, start six (grade 5 or better) 3/8–16 capscrews with lockwashers. Fasten them finger-tight.

5.2 Remove the guide studs and replace them with two more mounting capscrews, as above.

5.3 Tighten the eight capscrews progressively. The final torque is 30 to 35 lbf·ft (40 to 47 N·m).

5.4 Remove the aligning tool.

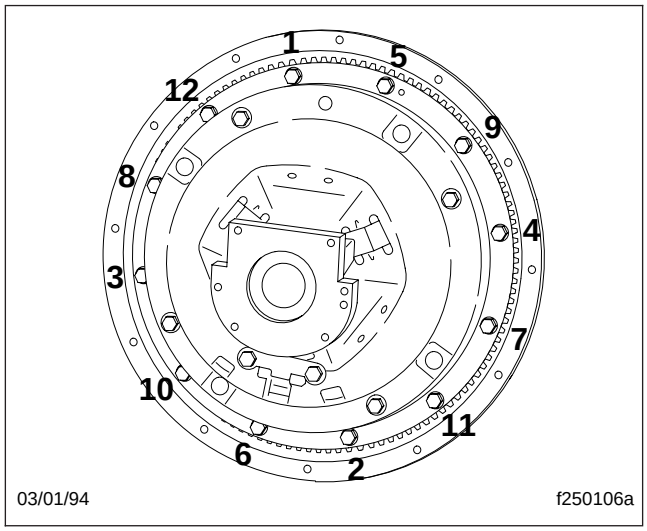


Fig. 5, Tightening Sequence, SAS

6. Remove the wooden spacer blocks installed at the time of removal.

7. Shift the transmission into gear so that during assembly the transmission input shaft can be rotated into line with the clutch driven-disc hub splines.

8. Install the transmission and attach the clutch linkage. For instructions, see **Group 26**.

CAUTION

Avoid springing the driven discs when the transmission is being installed. Don't force the transmission into the clutch or flywheel housing if it doesn't enter freely. Don't let the transmission drop or hang unsupported in the driven discs. These practices can damage the clutch assembly.

IMPORTANT: Be sure the release-bearing yoke clears the bearing, and is rotated over the wear pads as the transmission is moved forward. See **Fig. 20**. Align the splines by turning the transmission output shaft.

9. Adjust the clutch according to the procedures in **Subject 100**.

Stamped Angle-Spring® Dual-Disc Clutch

NOTE: Do the clutch inspection and pre-installation procedures in **Subject 120** before installing the clutch.

1. If the clutch is new, remove any protective coating applied to the pressure plate and the intermediate plate.
2. If not already in place, install two 3/8–16 x 3 guide studs in two upper mounting holes of the flywheel (at the 11 and 1 o'clock positions). See **Fig. 6**.

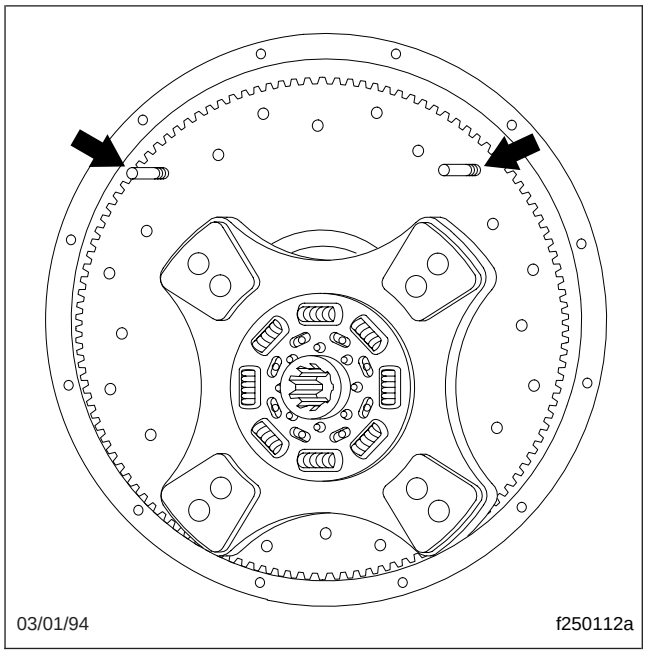


Fig. 6, Install the Guide Studs, SAS Dual-Disc

3. Place the front driven disc in the bell housing with the side marked *FLYWHEEL SIDE* facing the flywheel. See **Fig. 7**.
4. Install the drivestrap intermediate plate over the guide studs. Make sure the side marked *FLYWHEEL SIDE* faces the flywheel. See **Fig 8**.

IMPORTANT: The drivestraps of the intermediate plate must face the pressure plate.

NOTE: The four holes through the drivestraps are the pilot holes for the adapter ring.

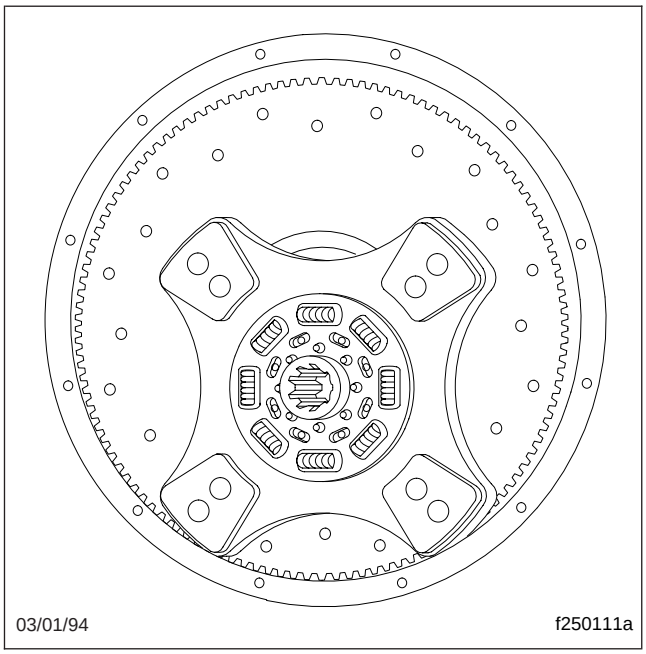


Fig. 7, Position the Front Disc, SAS

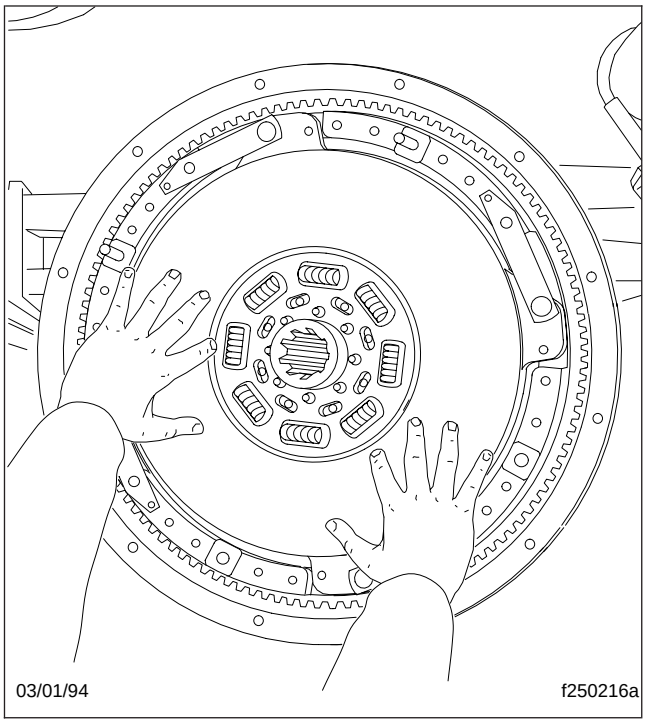


Fig. 8, Install the Intermediate Plate, SAS and Solo

5. Raise the front driven disc to fit into the intermediate plate opening.

14-Inch Clutch Installation

6. Install the rear driven disc.

   6.1 Insert an aligning tool through the splines of the rear disc and then, with the rear disc attached, into the pilot bearing. See **Fig. 9**.

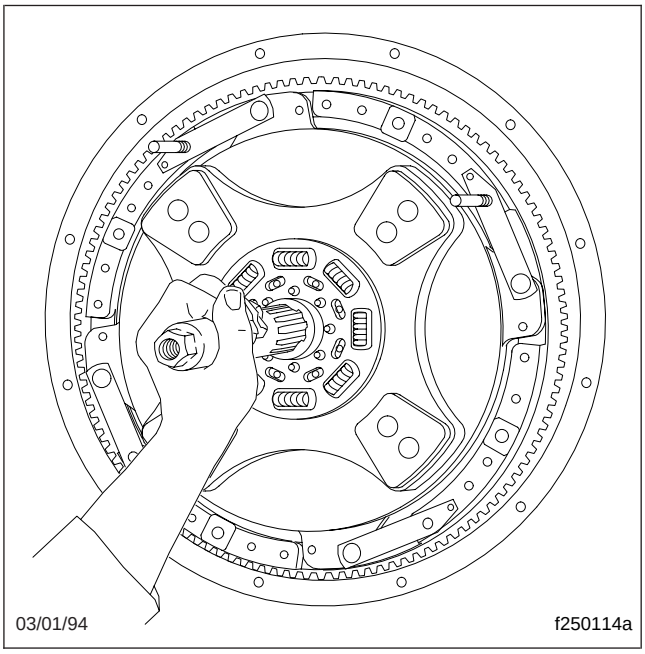


Fig. 9, Insert an Aligning Tool, SAS Dual-Disc

   6.2 Be sure the side marked *PRESSURE PLATE SIDE* faces the pressure plate. See **Fig. 10** for the position of the driven disc when installed.

⚠ WARNING

The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

7. Install the cover assembly. See **Fig. 4**.

   7.1 With the aligning tool still in place, carefully slide the cover assembly over the aligning tool.

   7.2 Align the lockstrap or self-adjuster with the access hole in the bell housing.

   7.3 Slide the clutch assembly over the guide studs and against the spacer ring.

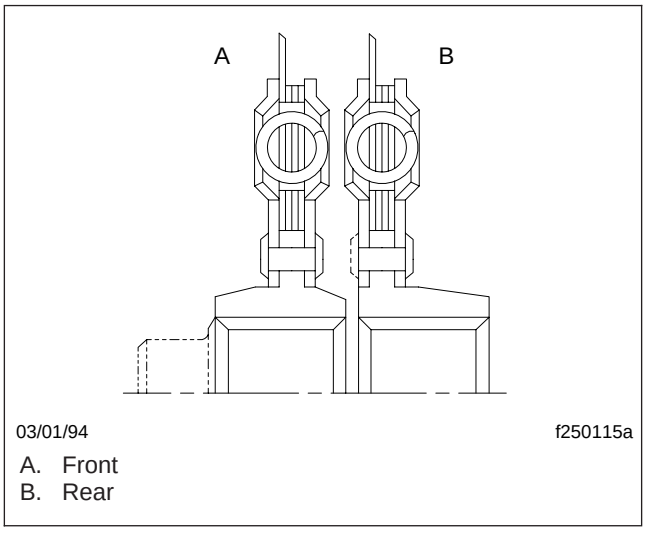


Fig. 10, Dual Driven Discs Installed, SAS

⚠ CAUTION

If the capscrews are not tightened in sequence, it may cause permanent damage to the clutch cover and create an out-of-balance condition.

8. Install the clutch mounting capscrews. See **Fig. 5** for the tightening sequence.

   8.1 In the cover plate, start six (grade 5 or better) 3/8–16 capscrews with lockwashers. Fasten them finger-tight.

   8.2 Remove the guide studs and replace them with two more mounting capscrews, as above.

   8.3 Tighten the eight capscrews progressively. The final torque is 30 to 35 lbf·ft (40 to 47 N·m).

   8.4 Remove the aligning tool.

9. Remove the wooden spacer blocks installed at the time of removal.

10. Shift the transmission into gear so that during assembly the transmission input shaft can be rotated into line with the clutch driven-disc hub splines.

11. Install the transmission and attach the clutch linkage. For instructions, see **Group 26**.

⚠ CAUTION

Avoid springing the driven discs when the transmission is being installed. Don't force the transmission into the clutch or flywheel housing if it doesn't enter freely. Don't let the transmission drop or hang unsupported in the driven discs. These practices can damage the clutch assembly.

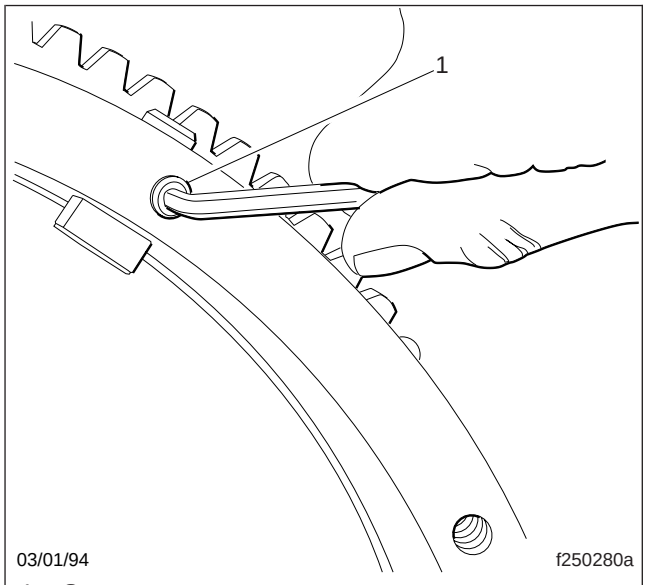
IMPORTANT: Be sure the release-bearing yoke clears the bearing, and is rotated over the wear pads as the transmission is moved forward. See **Fig. 20**. Align the splines by turning the transmission output shaft.

12. Adjust the clutch according to the procedures in **Subject 100**.

Easy-Pedal Plus® Clutch

NOTE: Do the clutch inspection and preinstallation procedures in **Subject 120** before installing the clutch.

1. Remove the old drive pins from the flywheel. See **Fig. 11**.



1. Setscrew

Fig. 11, Remove the Setscrews

1.1 Remove the flywheel from the engine. For instructions, see the engine manufacturer's service manual.

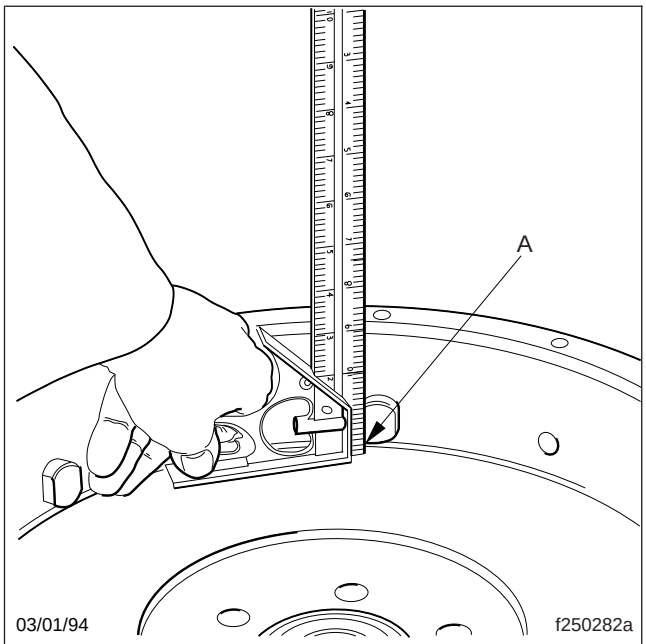
⚠ WARNING

The drive pins are made of hardened steel. Wear eye protection when removing the old drive pins. Do not hit steel parts with a steel hammer. Parts can break or chip and cause injury.

1.2 Remove the setscrews from each of the drive pins.

1.3 Using a hammer and drift, remove the drive pins.

2. Install new drive pins in the flywheel. See **Fig. 12**.



A. Drive pin must be square to flywheel.

Fig. 12, Install the Drive Pins

2.1 Install six new drive pins in the flywheel, equally spaced. Make sure that the shanks of the drive pins are press-fit in the flywheel rim, and that the heads are square with the friction face.

NOTE: Before doing the next step, place two small spacers on the friction surface of the flywheel. This will prevent the intermediate plate from pinching your fingers, and will also allow an easy fingerhold when removing the plate.

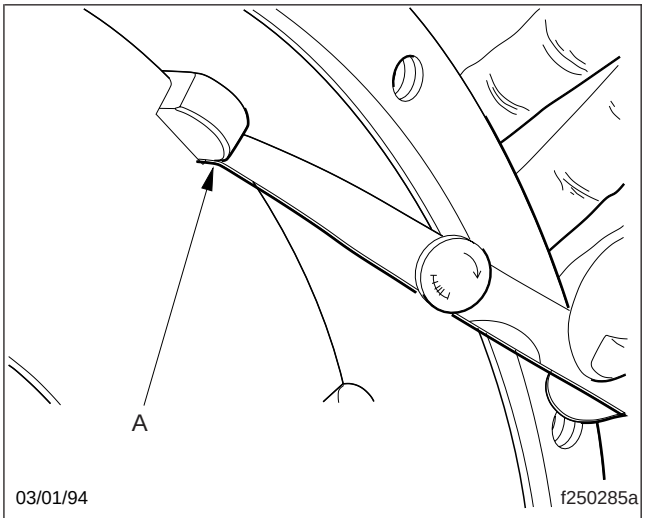
14-Inch Clutch Installation

2.2 Carefully position the intermediate plate over the drive pins. Turn the intermediate plate in one direction as far as it will go.

⚠ CAUTION

Don't file the intermediate-plate slots to obtain the correct clearance. Doing so will cause an unequal load on the pins. This is a frequent cause of poor- or no-release complaints in newly installed clutches, and can result in broken drive pins.

2.3 Check the clearance between each drive pin and drive slot. Check each pin on the same side. See **Fig. 13**.



A. Drive Pin-to-Intermediate Plate Minimum Clearance: 0.006 inch (0.152 mm)

Fig. 13, Measure the Clearance

The minimum clearance between the drive pins and the drive slots is 0.006 inch (0.152 mm).

2.4 If the clearance is correct, remove the intermediate plate, and check the squareness alignment of the drive-pin heads to the friction face.

2.5 If the alignment and clearance are okay, remove the intermediate plate, and lock each of the pins in place with a new locking-type 3/8 by 3/8-inch setscrew. If only non-locking setscrews are available, tighten them 25 lbf·ft (35 N·m).

2.6 Install the flywheel. For instructions, see the engine manufacturer's service manual.

3. If the clutch is new, remove any protective coating applied to the pressure plate and the intermediate plate.

4. Place the front driven-disc assembly in the flywheel, with the side stamped *FLYWHEEL SIDE* facing the engine. See **Fig. 14**.

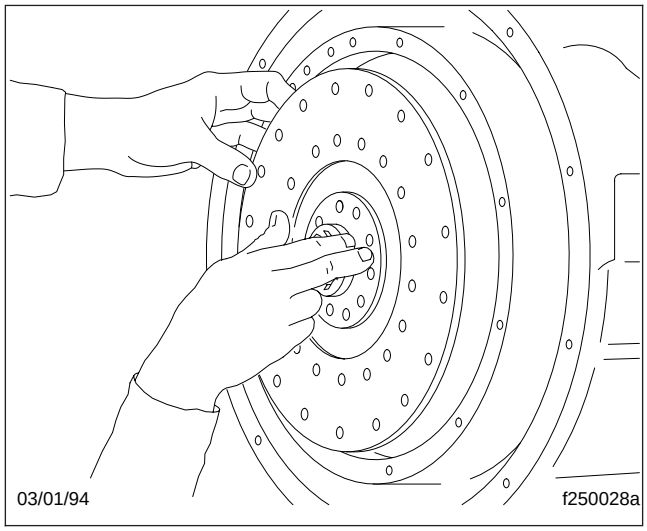


Fig. 14, Position the Front Disc, Easy-Pedal

5. Install the intermediate plate in the flywheel, locating the drive slots on the drive pins. See **Fig. 15**.

⚠ WARNING

Wear heavy gloves when installing the anti-rattle springs. Otherwise, the sharp edges can cut your hands.

6. On super-duty clutches only, install three anti-rattle springs equally spaced between the drive pins. See **Fig. 16**.

6.1 Wearing heavy gloves, install the springs with the rounded sections toward the flywheel face.

6.2 Push the springs toward the engine until they bottom against the face of the flywheel.

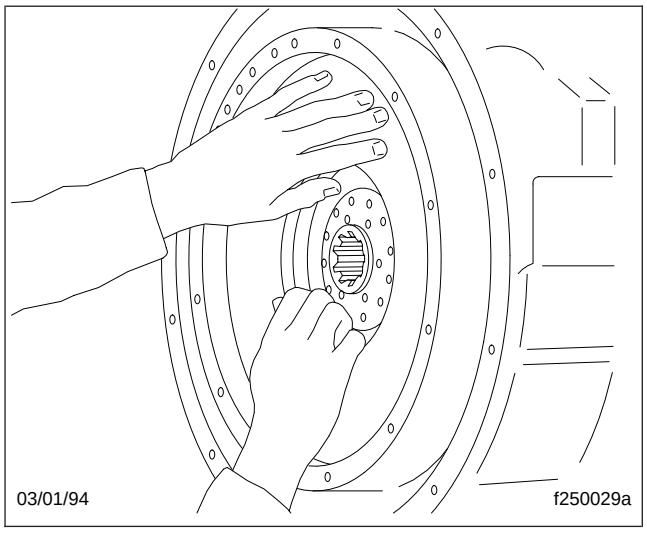


Fig. 15, Install the Intermediate Plate, Easy-Pedal

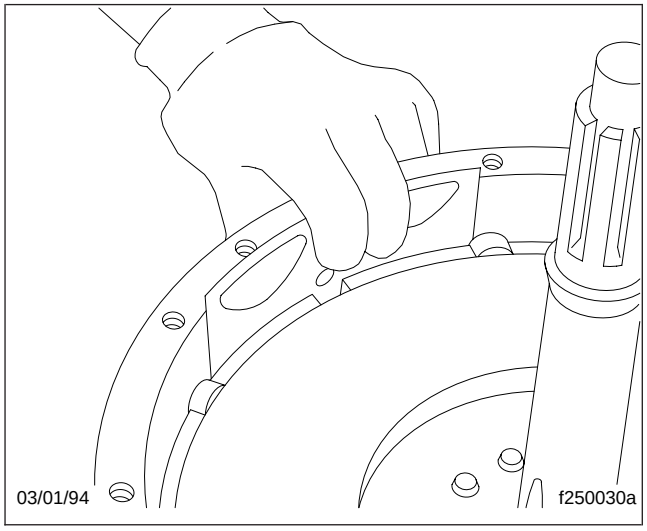
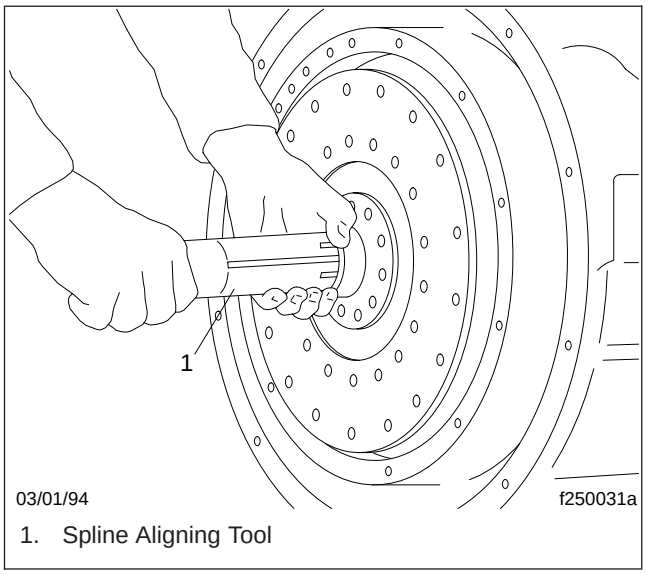


Fig. 16, Install the Anti-Rattle Springs

NOTE: Super-duty clutch discs have thicker intermediate plates. Do not mix standard and super-duty discs.

7. Install the rear driven disc. See **Fig. 17**.

   7.1 Insert an aligning tool through the hub of the rear driven disc. Make sure the side stamped *PRESSURE PLATE SIDE* is facing the transmission.



1. Spline Aligning Tool

Fig. 17, Install the Rear Disc, Easy-Pedal

   7.2 Install two 3/8–16 x 2-1/2 guide studs in two upper mounting holes of the flywheel (at the 11 and 1 o'clock positions).

   7.3 Insert the aligning tool through the hub of the front driven disc, and into the pilot bearing.

   7.4 Install the rear driven disc behind the intermediate plate.

8. Position the cover assembly on the flywheel, with the lockstrap aligned with the opening in the transmission clutch housing. See **Fig. 18**.

CAUTION

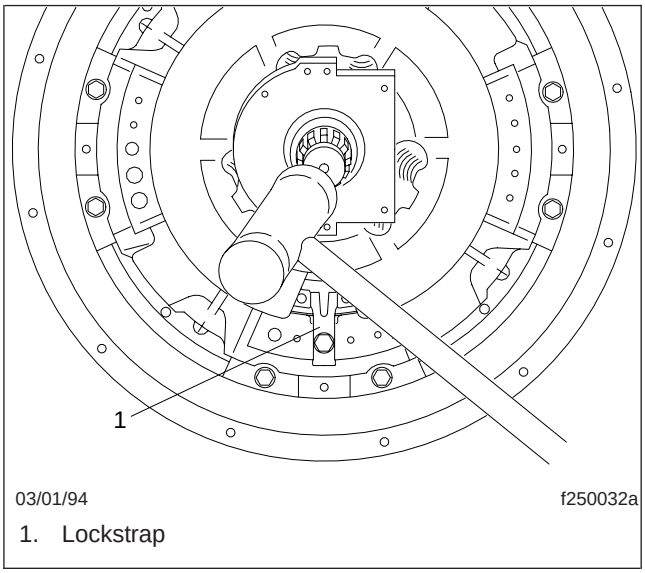
If the capscrews are not tightened in sequence, it may cause permanent damage to the clutch cover and create an out-of-balance condition.

9. Install the clutch mounting capscrews. See **Fig. 19** for the tightening sequence.

   9.1 Start six 3/8–16 x 1-1/4 clutch mounting capscrews with lockwashers. Fasten them finger-tight.

   9.2 Tap the aligning tool to make sure it is centered and seated in the pilot bearing, then remove the two guide studs and replace them with 3/8–16 x 1-1/4 clutch mounting capscrews with lockwashers.

14-Inch Clutch Installation



1. Lockstrap

Fig. 18, Position the Clutch Cover, Easy-Pedal

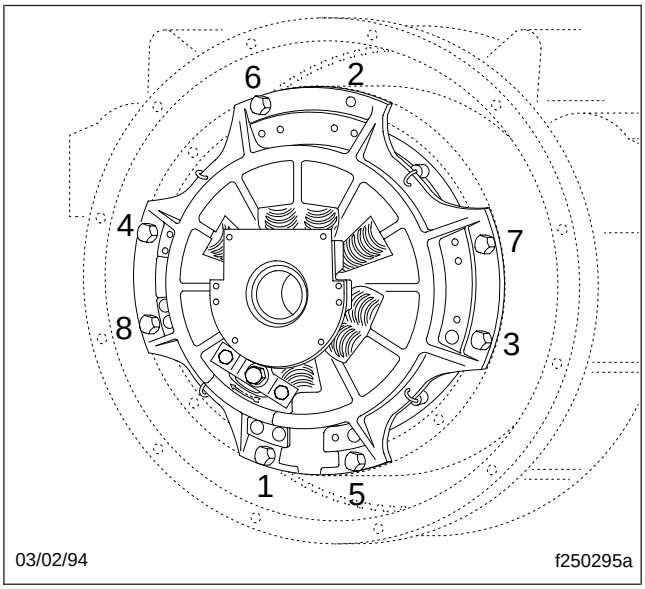


Fig. 19, Tightening Sequence, Easy-Pedal

9.3 Tighten the eight capscrews progressively. The final torque is 25 to 35 lbf·ft (34 to 47 N·m).

9.4 As the capscrews are tightened, the release-bearing spacers should fall free. If they don't, remove them. This may require light taps with a mallet on the end of the aligning tool. See **Fig. 18**.

9.5 Remove the aligning tool.

10. Shift the transmission into gear, so the transmission input shaft can be rotated into line with the clutch driven-disc hub splines during assembly.

11. Install the transmission and attach the clutch linkage. For instructions, See **Group 26**.

CAUTION

Avoid springing the driven discs when the transmission is being installed. Don't force the transmission into the clutch or flywheel housing if it doesn't enter freely. Don't let the transmission drop or hang unsupported in the driven discs. These practices can damage the clutch assembly.

IMPORTANT: Be sure the release-bearing yoke clears the bearing, and is rotated over the wear pads as the transmission is moved forward. See **Fig. 20**. Align the splines by turning the transmission output shaft.

12. Grease the release bearing and release shafts. For instructions and recommended lubricants, see **Group 25** of the *Business Class Trucks Maintenance Manual*.

13. Adjust the clutch according to the procedures in **Subject 100**.

Solo 1401 Single-Disc Clutch

NOTE: Do the clutch inspection and preinstallation procedures in **Subject 120** before installing the clutch.

1. If the clutch is new, remove any protective coating applied to the pressure plate.

2. If not already in place, install two 3/8–16 x 3 guide studs in the two upper mounting holes of the flywheel (at the 11 and 1 o'clock positions). See **Fig. 21**.

3. Install the single driven disc on the flywheel. See **Fig. 22**.

3.1 Insert an aligning tool through the splines of the driven disc and then, with the driven disc attached, into the pilot bearing.

3.2 Be sure the side marked *PRESSURE PLATE SIDE* faces the pressure plate.

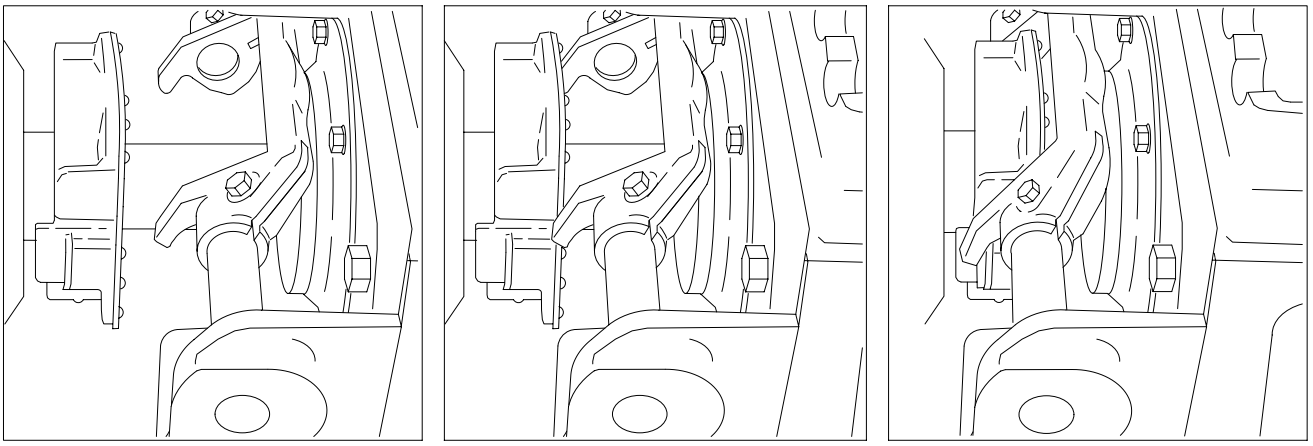


Fig. 20, Make Sure the Release Yoke Clears the Bearing

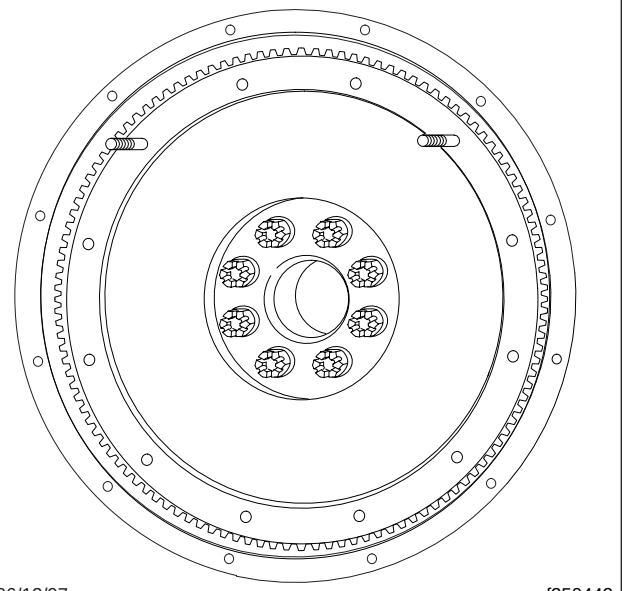


Fig. 21, Install the Guide Studs, Solo

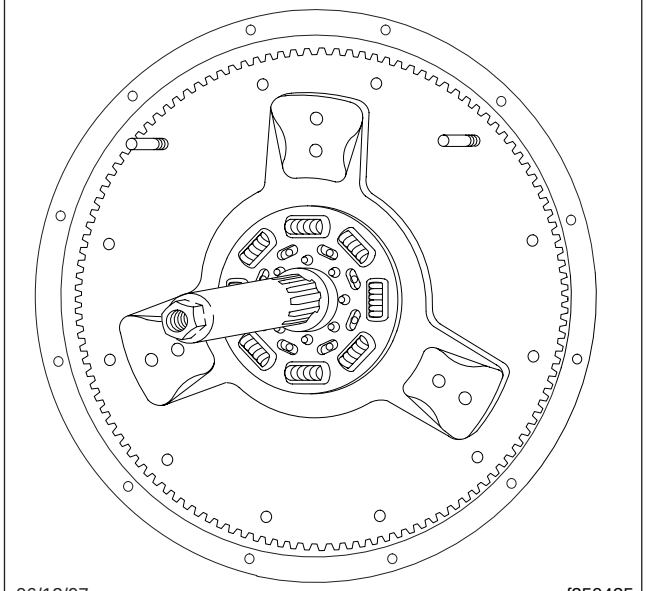


Fig. 22, Position the Driven Disc, Solo

⚠ WARNING

The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

4. With the aligning tool still in place, slide the cover assembly over the aligning tool and the two guide studs. See **Fig. 23**.

14-Inch Clutch Installation

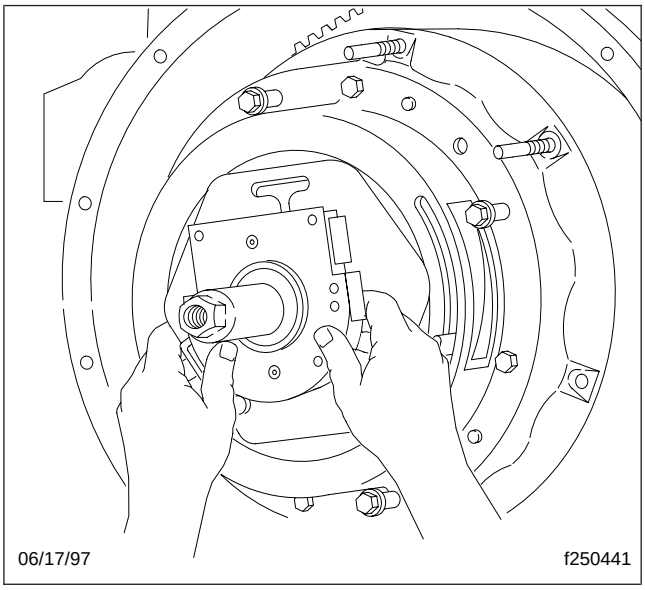


Fig. 23, Position the Clutch Cover, Solo

CAUTION

If the capscrews are not tightened in sequence, it may cause permanent damage to the clutch cover and create an out-of-balance condition.

5. Install the clutch mounting capscrews. See **Fig. 24** for the tightening sequence.

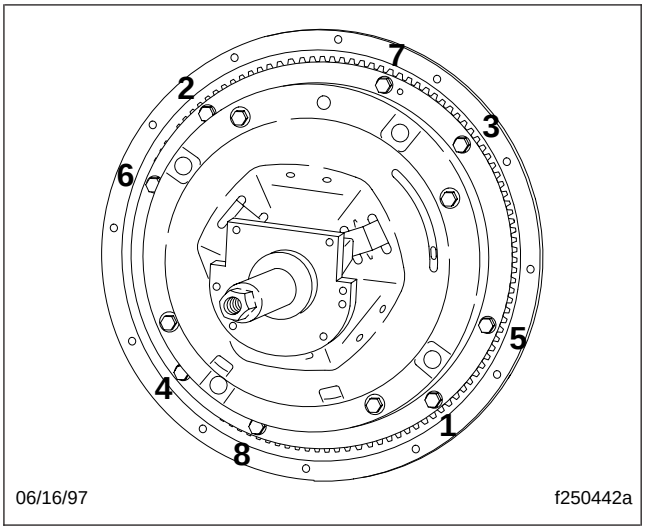


Fig. 24, Tightening Sequence, Solo

   5.1 In the cover plate, start six (grade 5 or better) 3/8–16 capscrews with lockwashers. Fasten them finger-tight.

   5.2 Remove the guide studs and replace them with two more mounting capscrews, as above.

   5.3 Tighten the eight capscrews progressively. The final torque is 30 to 35 lbf·ft (40 to 47 N·m).

   5.4 Remove the aligning tool.

6. Using a 9/16-inch socket and following a criss-cross pattern, remove the four yellow-colored shipping bolts from the clutch cover. See **Fig. 25**.

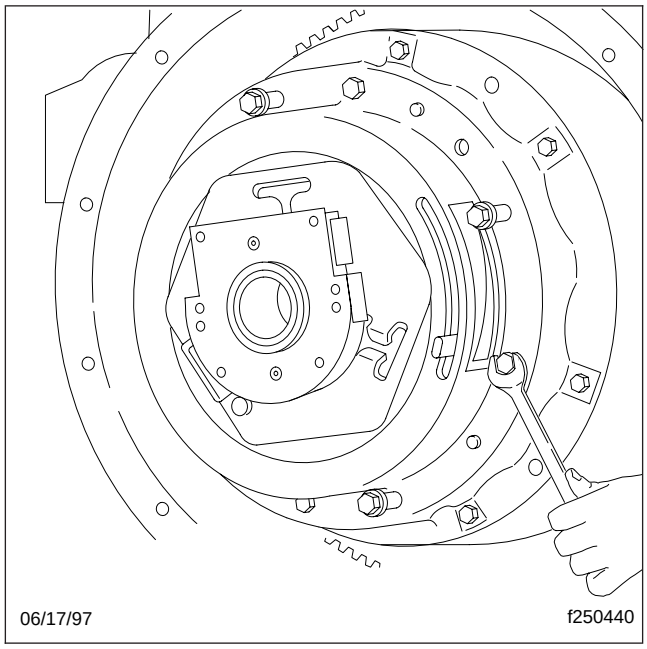


Fig. 25, Remove the Shipping Bolts

NOTE: Retain these four shipping bolts. These bolts will be needed in the future to secure the clutch assembly during removal and installation.

7. Using a clean cloth, remove all grease from the input shaft.
8. Shift the transmission into gear so that during assembly the transmission input shaft can be rotated into line with the clutch driven-disc hub splines.
9. Install the transmission and attach the clutch linkage. For instructions, see **Group 26**.

⚠ CAUTION

Avoid springing the driven discs when the transmission is being installed. Don't force the transmission into the clutch or flywheel housing if it doesn't enter freely. Don't let the transmission drop or hang unsupported in the driven discs. These practices can damage the clutch assembly.

IMPORTANT: Be sure the release-bearing yoke clears the bearing, and is rotated over the wear pads as the transmission is moved forward. See **Fig. 20**. Align the splines by turning the transmission output shaft.

10. Position a pipe, or similar tool, over the cross-shaft release lever and rotate it until the release bearing comes to a complete stop. Repeat this procedure a total of five times.
11. Lubricate the release bearing and the cross-shaft bushings. For instructions and recommended lubricants, see **Group 25** of the *Business Class Trucks Maintenance Manual*.

Solo 1402 Dual-Disc Clutch

NOTE: Do the clutch inspection and pre-installation procedures in **Subject 120** before installing the clutch.

1. If the clutch is new, remove any protective coating applied to the pressure plate and the intermediate plate.
2. If not already in place, install two 3/8–16 x 3 guide studs in the two upper mounting holes of the flywheel (at the 11 and 1 o'clock positions). See **Fig. 21**.
3. Install the front driven disc on the flywheel. See **Fig. 22**.
   - 3.1 Insert an aligning tool through the splines of the front disc and then, with the front disc attached, into the pilot bearing.
   - 3.2 Be sure the side marked *FLYWHEEL SIDE* faces the flywheel.
4. Install the intermediate plate assembly over the two guide studs and slide it forward until it touches the flywheel. See **Fig. 8**.

IMPORTANT: The drivestraps of the intermediate plate must face the pressure plate.

5. Install the rear driven disc. See **Fig. 26**.

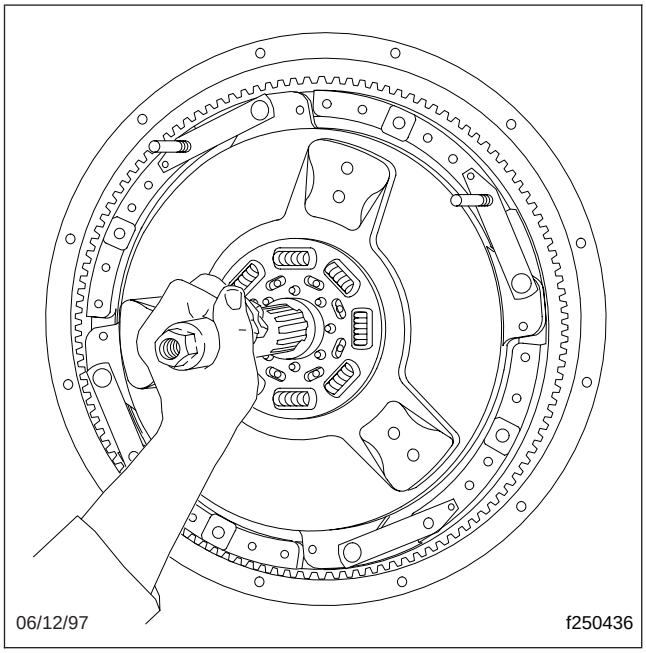


Fig. 26, Position the Rear Disc, Solo

   - 5.1 Remove the aligning tool from the pilot bearing.
   - 5.2 Insert the aligning tool through the splines of the rear driven disc, and then, with the rear disc attached, into the pilot bearing.
   - 5.3 Be sure the side of the rear disc marked *PRESSURE PLATE SIDE* faces the pressure plate.
6. Make sure that the ceramic buttons on each disc are as closely aligned as possible. See **Fig. 27**.

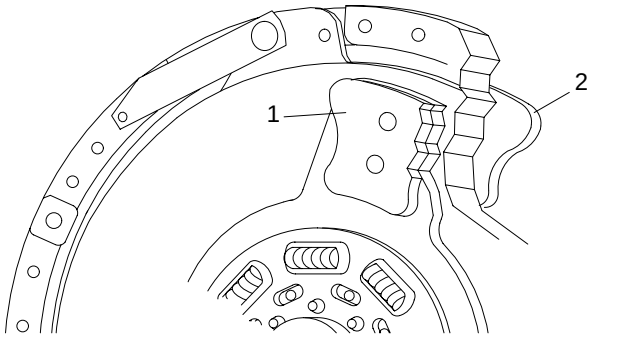
NOTE: Aligning the discs in this way aids the function of the positive separator pins.

7. With the aligning tool still in place, slide the cover assembly over the aligning tool and the two guide studs until it rests against the intermediate plate assembly. See **Fig. 23**.

⚠ CAUTION

If the capscrews are not tightened in sequence, it may cause permanent damage to the clutch cover and create an out-of-balance condition.

14-Inch Clutch Installation



1. Front Ceramic Button
2. Rear Ceramic Button

Fig. 27, Driven Disc Alignment

8. Install the clutch mounting capscrews. See **Fig. 24** for the tightening sequence.
   - 8.1 Start six 3/8–16 (grade 5 or better) mounting capscrews in the cover plate. Fasten them finger-tight.
   - 8.2 Remove the guide studs and replace them with the two remaining mounting capscrews, as above.
   - 8.3 Tighten the eight capscrews progressively. The final torque is 30 to 35 lbf·ft (41 to 47 N·m).
   - 8.4 Remove the aligning tool.
9. Using a 9/16-inch socket and following a criss-cross pattern, remove the four yellow-colored shipping bolts from the clutch cover. See **Fig. 25**.

NOTE: Retain these four shipping bolts. These bolts will be needed in the future to secure the clutch assembly during removal and installation.

⚠ WARNING

Wear safety goggles when tapping the pins. If any of the metal parts were to chip, flying pieces of metal could possibly cause eye injury.

10. Set the positive separator pins™.
    - 10.1 Locate the positive separator pin access holes. See **Fig. 28**.

    NOTE: Only a small portion of the pin is visible through the access hole. See **Fig. 29**.

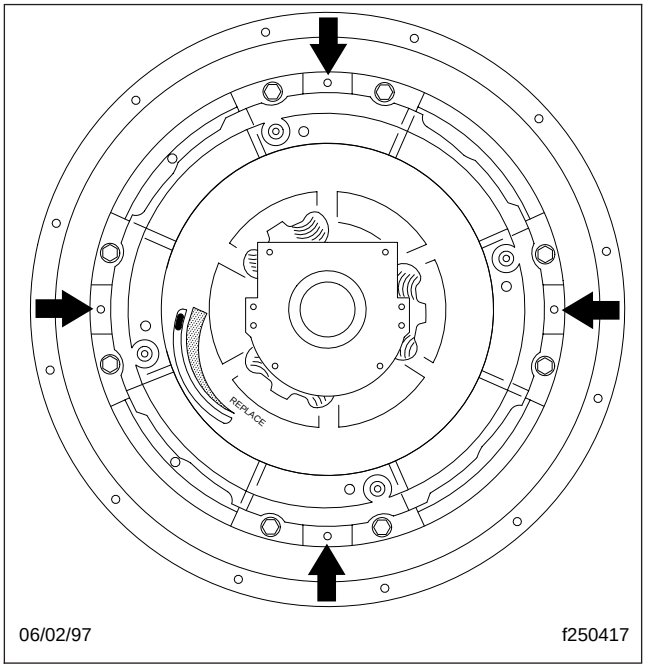
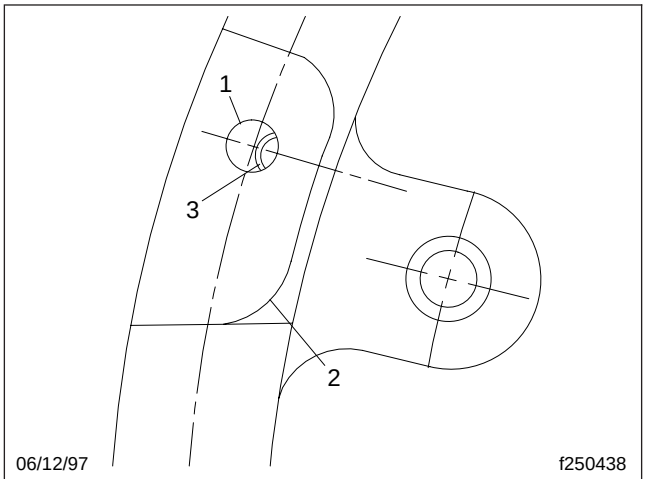


Fig. 28, Positive Separator Pin Access Holes

- 10.2 Using a 1/4-inch (6-mm) flat nose punch, *lightly* tap the four positive separator pins (roll pins) through the access holes of the clutch cover. See **Fig. 30**.



NOTE: Only a small portion of the pin is visible through the access hole.

1. Access Hole
2. Clutch Cover
3. Positive Separator Pin (roll pin)

Fig. 29, Positive Separator Pin Offset

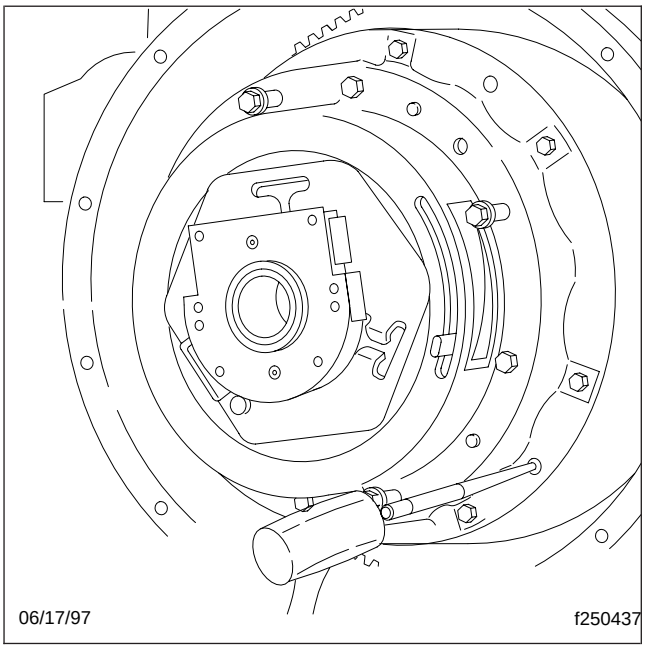


Fig. 30, Setting the Positive Separator Pins

NOTE: Do this step to ensure that all four pins are flush against the flywheel. This allows an equal gap on all sides of the intermediate plate during clutch disengagement.

11. Using a clean cloth, remove all grease from the input shaft.
12. Shift the transmission into gear so that during assembly the transmission input shaft can be rotated into line with the clutch driven-disc hub splines.
13. Install the transmission and attach the clutch linkage. For instructions, see **Group 26**.

⚠ CAUTION

Avoid springing the driven discs when the transmission is being installed. Don't force the transmission into the clutch or flywheel housing if it doesn't enter freely. Don't let the transmission drop or hang unsupported in the driven discs. These practices can damage the clutch assembly.

IMPORTANT: Be sure the release-bearing yoke clears the bearing, and is rotated over the wear pads as the transmission is moved forward. See **Fig. 20**. Align the splines by turning the transmission output shaft.

14. Position a pipe, or similar tool, over the cross-shaft release lever and rotate it until the release bearing comes to a complete stop. Repeat this procedure a total of five times.
15. Lubricate the release bearing and the cross-shaft bushings. For instructions and recommended lubricants, see **Group 25** of the *Business Class Trucks Maintenance Manual*.

Installation

IMPORTANT: For 14-inch clutches, see the installation procedures in **Subject 130**.

Easy-Pedal 2000™ Clutch

NOTE: Do the clutch inspection and preinstallation procedures in **Subject 120** before installing the clutch.

1. If the clutch is new, remove any protective coating applied to the pressure plate and the intermediate plate.
2. If not already installed, insert two 7/16–14 x 5 guide studs in the upper mounting holes of the flywheel. See **Fig. 1**. Rotate the flywheel to level the guide studs.

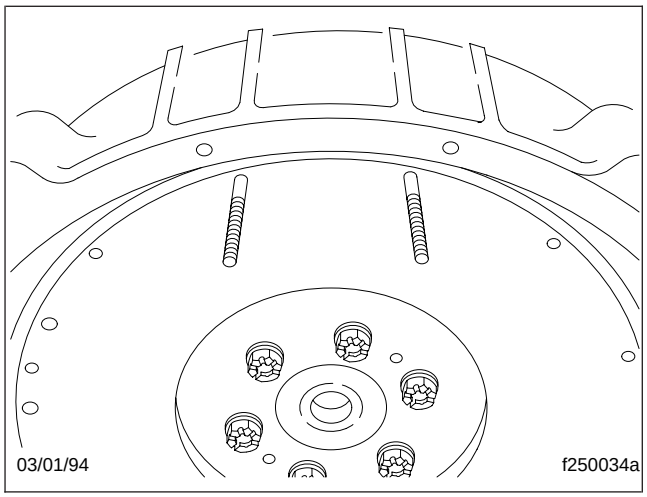


Fig. 1, Install the Guide Studs

3. Set the clutch cover upright, and insert a spline aligning tool through the release bearing sleeve. See **Fig. 2**.

NOTE: Six-spring driven discs are identical, front and rear. Either disc can be installed first on the aligning tool.

4. Install the rear driven disc and intermediate plate.
   - 4.1 Install the rear driven disc on the aligning tool, with the side stamped *INTERMEDIATE PLATE SIDE* facing away from the clutch cover. See **Fig. 3**.

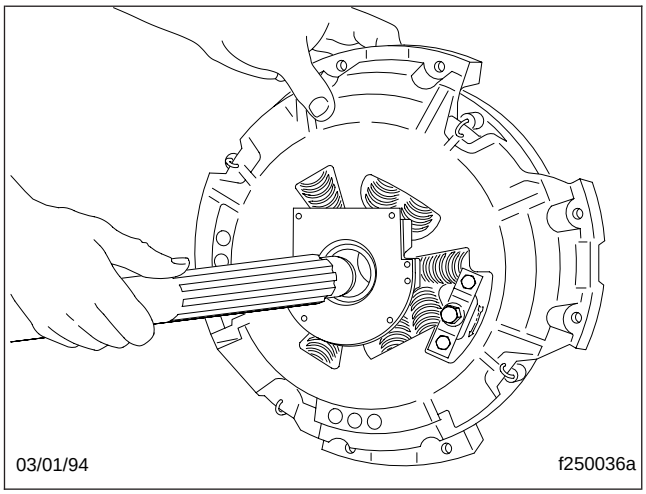


Fig. 2, Insert an Aligning Tool, Easy-Pedal

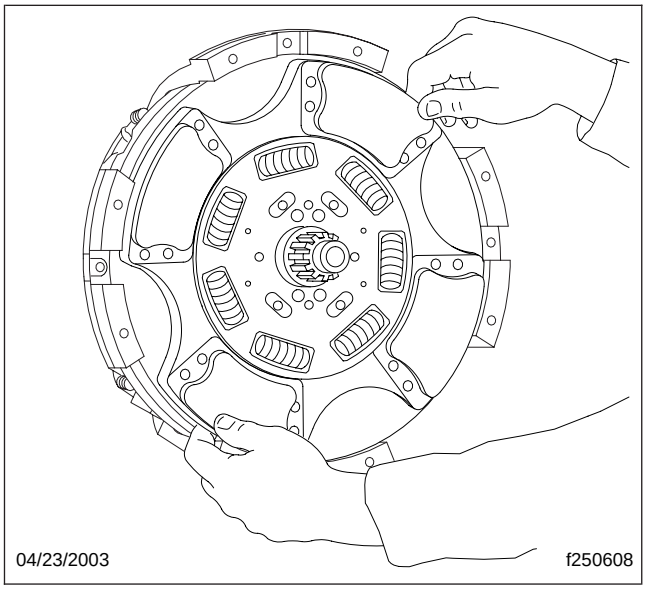
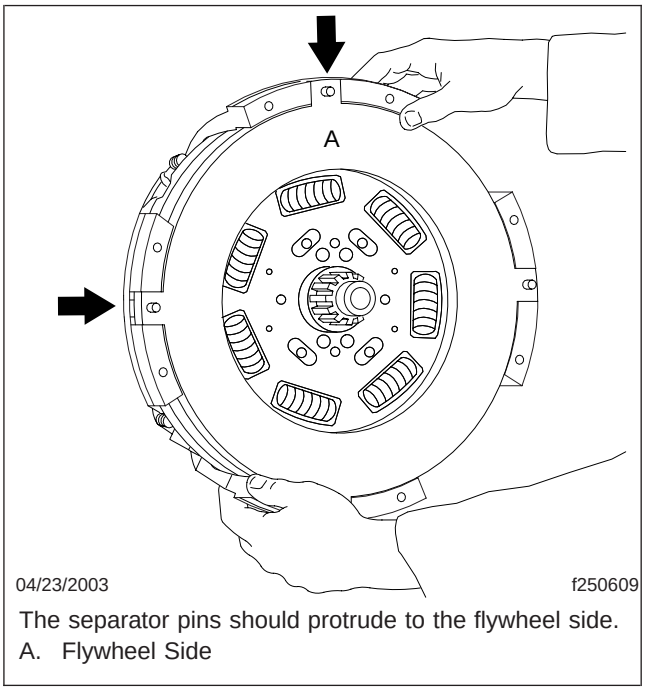


Fig. 3, Installing the Rear Driven Disc

NOTE: On 8-, 9-, and 10-spring discs, this side is stamped *FLYWHEEL SIDE*.

- 4.2 Place the intermediate plate in the clutch cover. Align the drive lugs of the plate with the notches in the cover. See **Fig. 4**.
- 4.3 Make sure the positive separator pins™ protrude toward the flywheel side. See **Fig. 4**. The pins should be flush on the pressure-plate side.

15.5-Inch Clutch Installation



The separator pins should protrude to the flywheel side.
A. Flywheel Side

Fig. 4, Positioning the Intermediate Plate

5. Install the front driven disc on the aligning tool, with the side stamped *INTERMEDIATE PLATE SIDE* facing the intermediate plate. See **Fig. 5**.

   Be sure that both driven discs are aligned as shown in **Fig. 6**.

NOTE: On 8-, 9-, and 10-spring discs, this side is stamped *FLYWHEEL SIDE*.

WARNING

The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

6. Position the clutch over the two guide studs, and slide the assembly forward until it starts in the flywheel pilot. See **Fig. 7**.

CAUTION

If the capscrews are not tightened in sequence, it may cause permanent damage to the clutch cover and create an out-of-balance condition.

7. Install the clutch mounting capscrews. See **Fig. 8** for the tightening sequence.

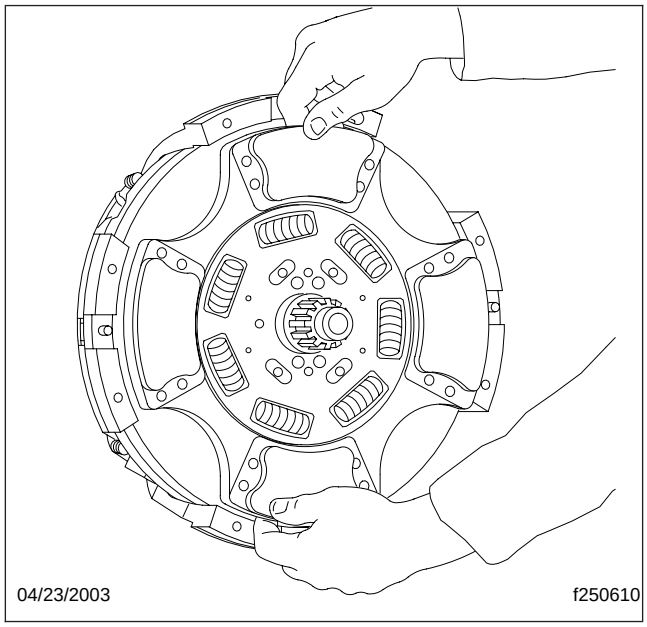


Fig. 5, Installing the Front Driven Disc

   7.1 Start six (grade 5 or better) 7/16–14 x 2-1/4 mounting capscrews with lockwashers. Fasten them finger-tight.

   7.2 Tap the aligning tool to make sure it is centered and seated in the pilot bearing. Remove the two guide studs and replace them with 7/16–14 x 2-1/4 capscrews and lockwashers.

   7.3 Tighten the eight clutch mounting capscrews progressively. The final torque is 40 to 50 lbf·ft (54 to 68 N·m).

   7.4 As the capscrews are tightened, the release bearing spacers should fall free. If they don't, remove them. This may require light taps with a mallet on the end of the aligning tool.

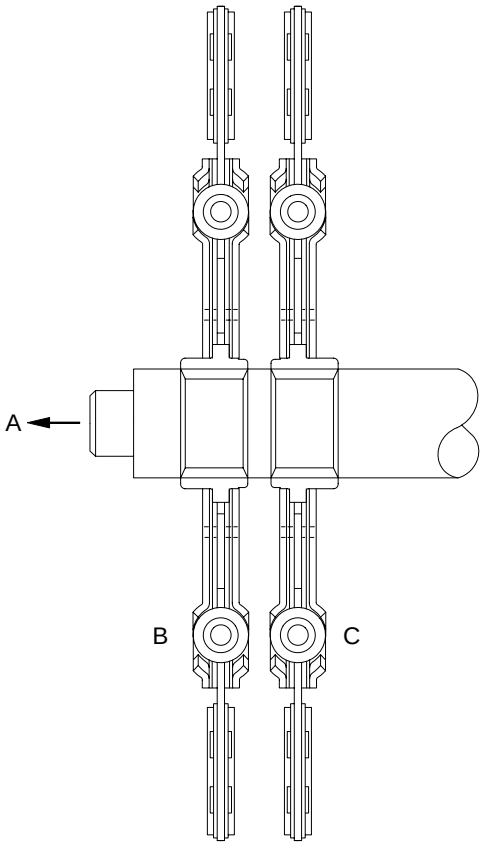
   7.5 Remove the aligning tool.

8. Set the positive separator pins.

   8.1 Locate the pin access holes. See **Fig. 9**.

WARNING

Wear safety goggles when tapping the pins. If any of the metal parts were to chip, flying pieces of metal could possibly cause eye injury.



A. Flywheel Side
B. Front Driven Disc
C. Rear Driven Disc

Fig. 6, Checking Disc Alignment

8.2 Using a 1/4-inch (6-mm) diameter flat nose punch, *lightly* tap each of the four positive separator pins toward the flywheel through the access holes. This step verifies that all the four pins are flush against the flywheel. See **Fig. 10**.

NOTE: Failure to perform this step properly may cause the clutch to drag (clutch does not release). If necessary, after the transmission has been installed, the four pins can be set through the inspection opening of the transmission bell housing.

9. Using a clean cloth, remove all grease from the input shaft.

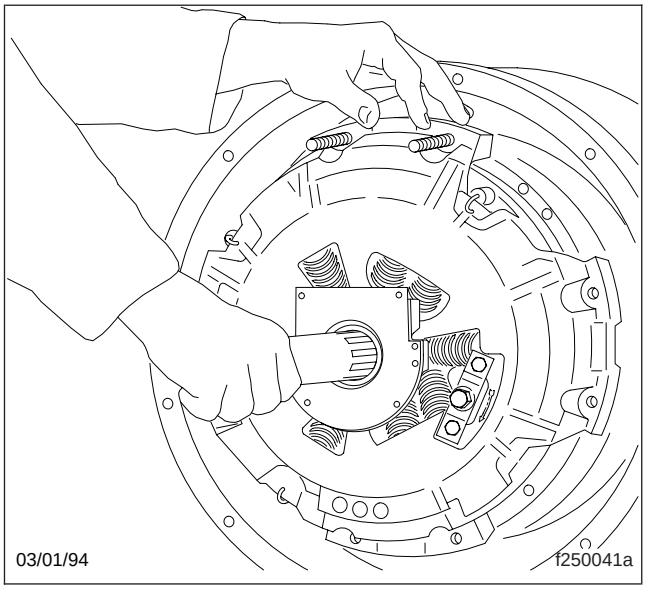


Fig. 7, Positioning the Clutch, Easy-Pedal

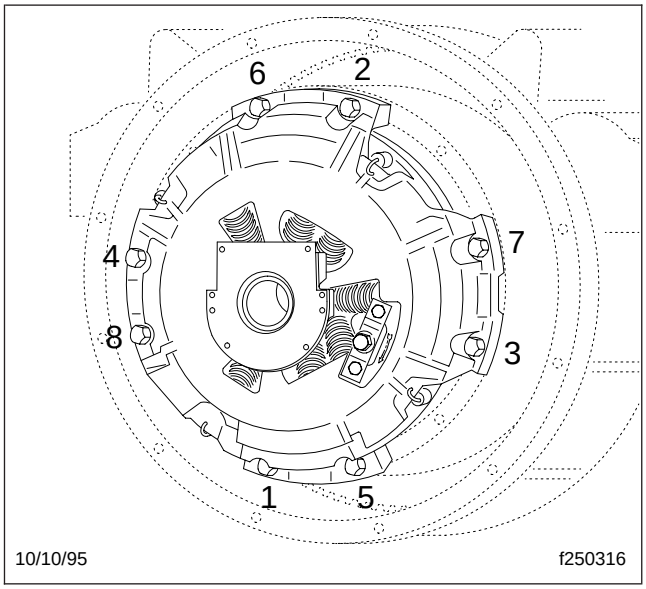


Fig. 8, Tightening Sequence, Easy-Pedal

10. Shift the transmission into gear. Rotate the transmission input shaft to line up with the clutch driven-disc hub splines during assembly.

⚠ CAUTION

Avoid springing the driven discs when the transmission is being installed. Don't force the trans-

15.5-Inch Clutch Installation

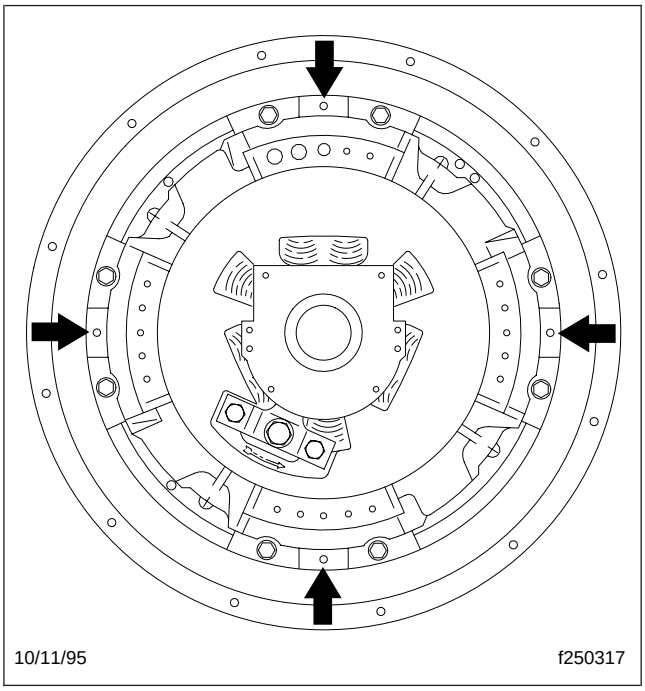
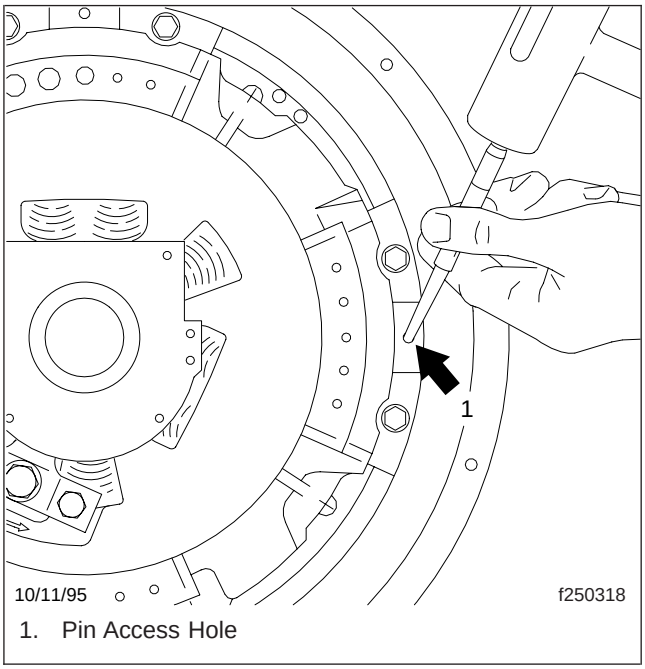


Fig. 9, Pin Access Holes, Easy-Pedal



1. Pin Access Hole

Fig. 10, Tapping the Pin, Easy-Pedal

mission into the clutch or flywheel housing if it doesn't enter freely. Don't let the transmission drop or hang unsupported in the driven discs. These practices can damage the clutch assembly.

11. Install the transmission and attach the clutch linkage. See **Group 26** for instructions.

IMPORTANT: Be sure the release yoke clears the bearing, and is rotated over the wear pads as the transmission is moved forward. See **Fig. 11**. Align the splines by turning the transmission output shaft.

12. Grease the release bearing and release shafts. For instructions and recommended lubricants, See **Group 25** of the *Business Class Trucks Maintenance Manual*.
13. Adjust the clutch according to the procedures in **Subject 100**.

Solo™ Heavy-Duty Clutch

NOTE: Do the clutch inspection and pre-installation procedures in **Subject 120** before installing the clutch.

1. If the clutch is new, remove any protective coatings applied to the pressure plate and the intermediate plate.
2. If not already in place, insert two 7/16–14 x 5 guide studs in the upper mounting holes of the flywheel. See **Fig. 1**. Rotate the flywheel to level the guide studs.
3. Set the clutch cover upright, and insert a spline aligning tool through the release bearing sleeve. See **Fig. 12**.

NOTE: Six-spring driven discs are identical, front and rear. Either disc can be installed first on the aligning tool.

4. Install the rear driven disc and intermediate plate.
   - 4.1 Install the rear driven disc on the aligning tool, with the side stamped *INTERMEDIATE PLATE SIDE* facing away from the clutch cover. See **Fig. 3**.
   - 4.2 Place the intermediate plate in the clutch cover. Align the drive lugs of the plate with the notches in the cover. See **Fig. 4**.
   - 4.3 Make sure the positive separator pins™ protrude toward the flywheel side. See

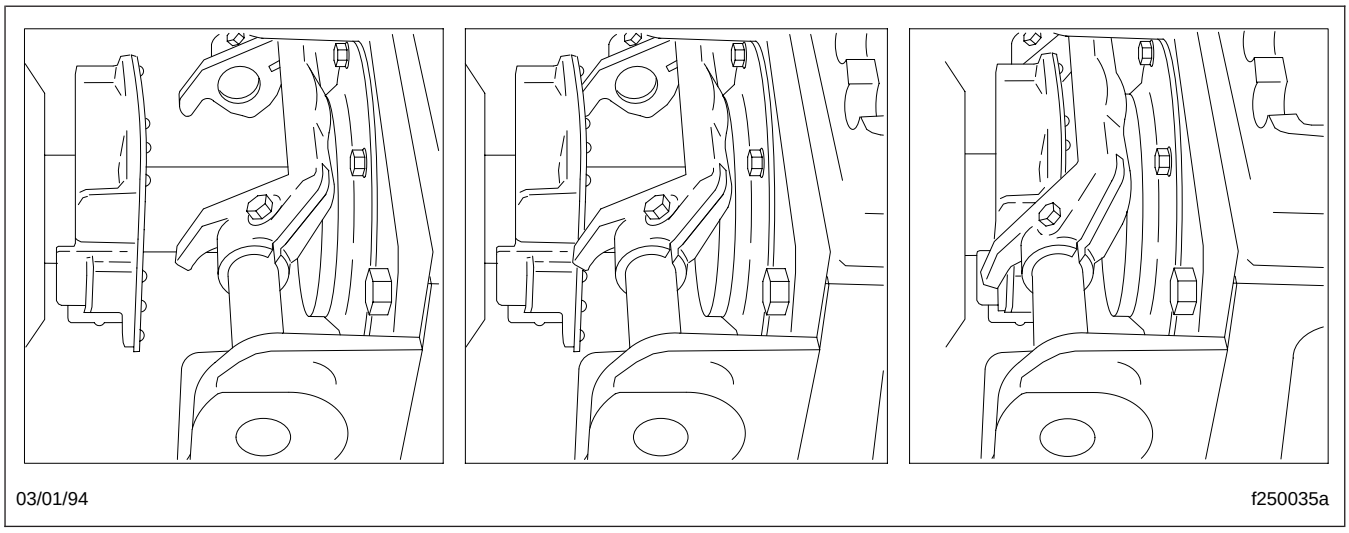


Fig. 11, Make Sure the Release Yoke Clears the Bearing

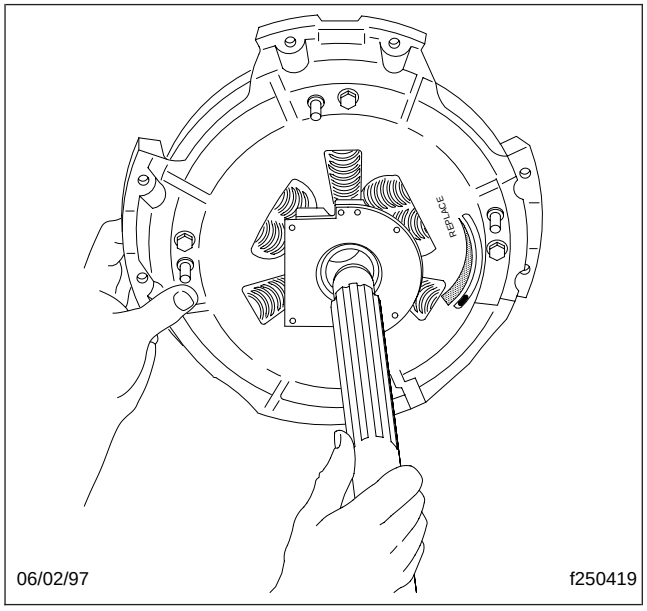


Fig. 12, Insert an Aligning Tool, Solo

Fig. 4. The pins should be flush on the pressure-plate side.

5. Install the front driven disc on the aligning tool, with the side stamped *INTERMEDIATE PLATE SIDE* facing the intermediate plate. See **Fig. 5**.

⚠ WARNING

The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

6. Position the clutch over the two guide studs, and slide the assembly forward until contact is made with the flywheel surface. See **Fig. 13**.

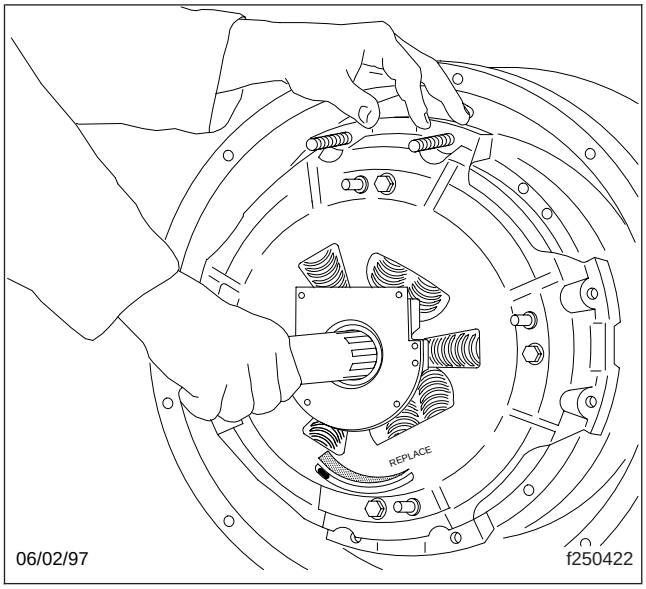


Fig. 13, Positioning the Clutch Cover, Solo

15.5-Inch Clutch Installation

CAUTION

If the capscrews are not tightened in sequence, it may cause permanent damage to the clutch cover and create an out-of-balance condition.

7. Install the clutch mounting capscrews. See **Fig. 14** to tap the aligning tool and **Fig. 15** for the tightening sequence.

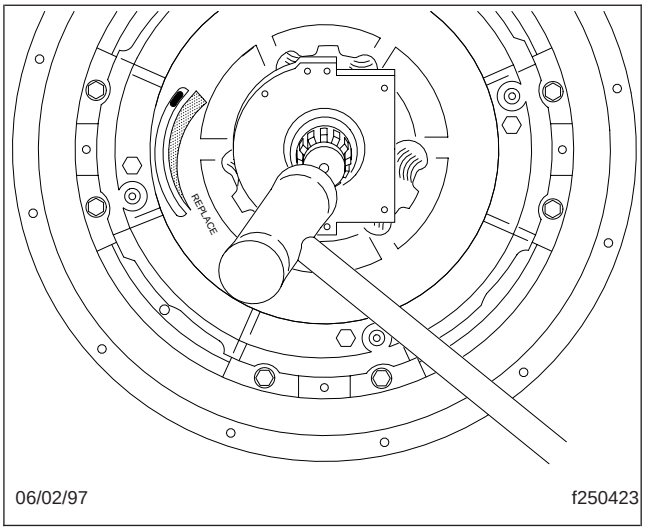


Fig. 14, Tap Aligning Tool

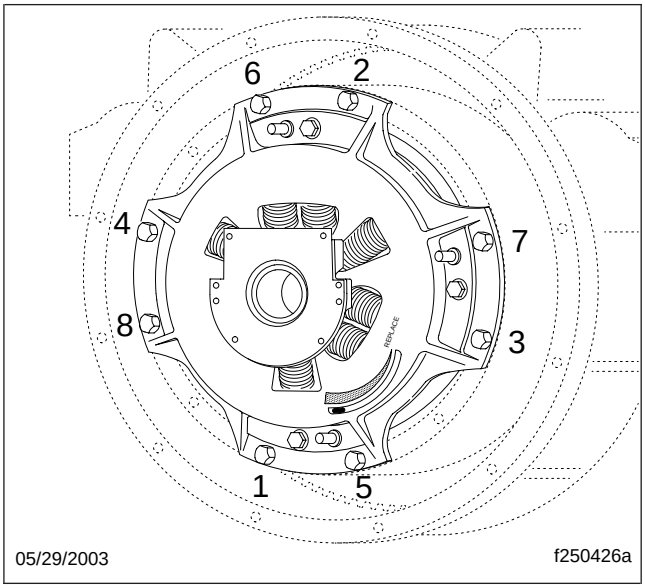


Fig. 15, Tightening Sequence, Solo

7.1 Start six (grade 5 or better) 7/16–14 x 2-1/4 mounting capscrews with lockwashers. Fasten them finger-tight.

7.2 Tap the aligning tool to make sure it is centered and seated in the pilot bearing.

7.3 Remove the two guide studs and replace them with the two remaining mounting capscrews and lockwashers.

7.4 Tighten the eight mounting capscrews progressively, in a crisscross pattern. The final torque is 40 to 50 lbf·ft (54 to 68 N·m).

7.5 Remove the aligning tool.

8. Following a crisscross pattern, remove and retain the four yellow shipping bolts from the clutch cover. See **Fig. 16**.

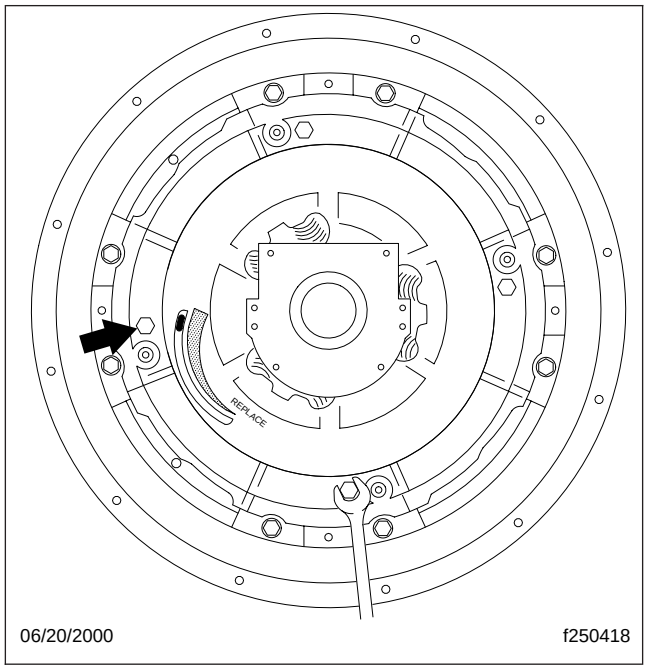


Fig. 16, Remove the Shipping Bolts

NOTE: Retain these four shipping bolts. These bolts will be needed in the future to secure the clutch assembly during removal and installation.

9. On maintenance-free clutches only, remove the input shaft sleeve.

NOTE: Do not be concerned if the release bearing housing touches the clutch cover.

⚠ WARNING

Wear safety goggles when tapping the pins. If any of the metal parts were to chip, flying pieces of metal could possibly cause eye injury.

10. Set the positive separator pins.

    10.1 Locate the pin access holes. See **Fig. 17**.

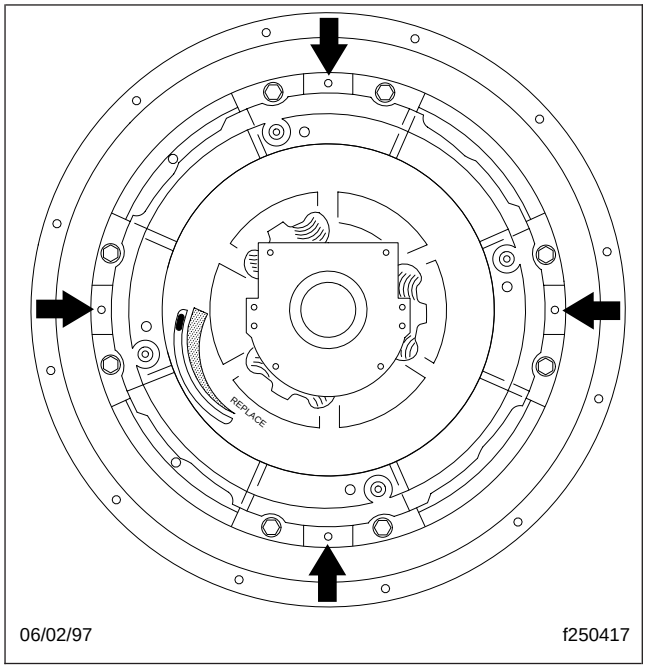


Fig. 17, Pin Access Holes, Solo

    10.2 Using a 1/4-inch (6-mm) diameter flat nose punch, *lightly* tap each of the four positive separator pins toward the flywheel through the access holes. This step verifies that all the four pins are flush against the flywheel. See **Fig.18**.

NOTE: Failure to perform this step properly may cause the clutch to drag (clutch does not release). If necessary, after the transmission has been installed, the four pins can be set through the inspection opening of the transmission bell housing.

11. Using a clean cloth, remove all grease from the input shaft.

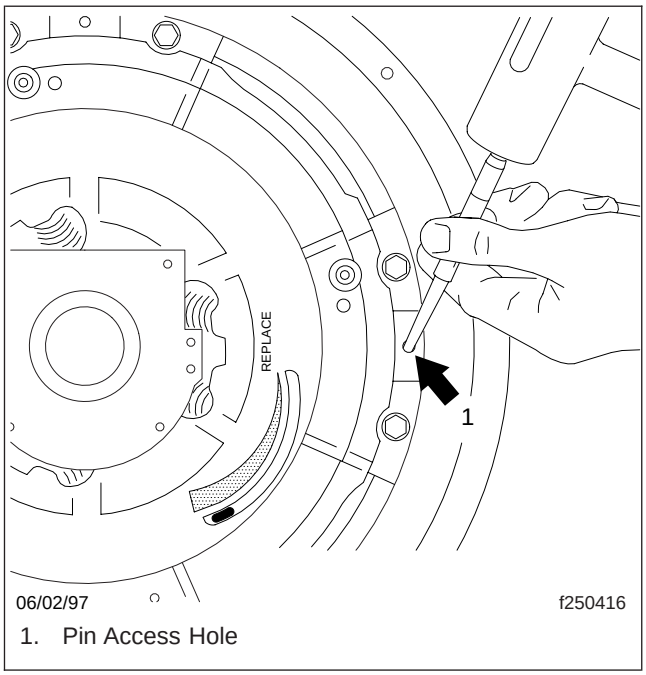


Fig. 18, Tapping the Pin, Solo

12. Shift the transmission into gear so that during assembly the transmission input shaft can be rotated into line with the clutch driven-disc hub splines.

13. Install the transmission and attach the clutch linkage. See **Group 26** for instructions.

⚠ CAUTION

Avoid springing the driven discs when the transmission is being installed. Don't force the transmission into the clutch or flywheel housing if it doesn't enter freely. Don't let the transmission drop or hang unsupported in the driven discs. These practices can damage the clutch assembly.

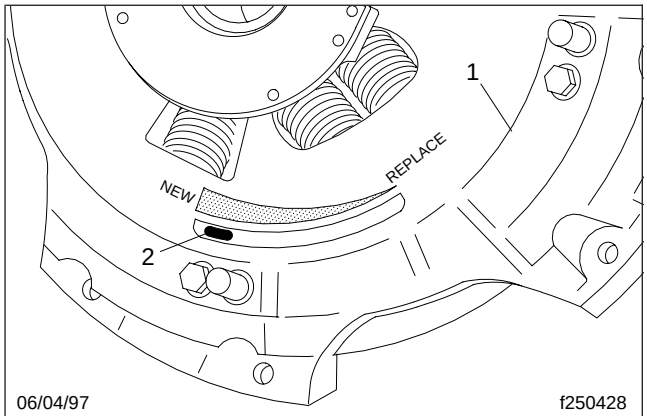
IMPORTANT: Be sure the release yoke clears the bearing, and is rotated over the wear pads as the transmission is moved forward. See **Fig. 11**. Align the splines by turning the transmission output shaft.

14. Lubricate the release bearing and cross-shaft bushings. For instructions and recommended lubricants, see **Group 25** of the *Business Class Trucks Maintenance Manual*.

Resetting

NOTE: This procedure requires two persons; one under the vehicle with access to the wear indicating tab, and the other in the vehicle to operate the clutch pedal.

1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires.
2. Inside the cab, press the clutch pedal all the way down, and hold it there until instructed to release it later in this procedure.
3. Through the clutch cover, use moderate force to slide the wear indicating tab leftward until it is at the "NEW" position on the indicator. See **Fig. 1**. If the tab does not move, follow the instructions under the heading "Releasing a Seized Cam".



With the clutch pedal down, set the tab to the "NEW" position on the indicator.
1. Clutch Cover 2. Wear Indicating Tab

Fig. 1, Resetting the Wear Indicating Tab

4. Release the clutch pedal.
5. To remove the gap between the sleeve and the pin, install four 7/16–14 x 1-3/4 bolts (shipping bolts may be used when available), and use a hand tool to tighten them until the gap is removed and the bolts are snug. See **Fig. 2**.
6. Remove the bolts.
7. Press the clutch pedal all the way down, and squeeze the clutch brake five times to reposition the bearing.

Releasing a Seized Cam

A seized cam may be caused by grease, dust, or other debris accumulated around the outer perimeter of the cam. The cam must operate freely for the clutch to work properly. The Eaton Seized Cam Adjustment Tool is designed specifically for releasing a seized cam. See **Table 1**.

1. While an assistant holds down the clutch pedal, insert the tip of the Seized Cam Adjustment Tool through the access panel and position it under the bearing. See **Fig. 3**.
2. Align the tool so that the threaded bolt extends into the slot in the cam. See **Fig. 3**.

IMPORTANT: Use the Seized Cam Adjustment Tool carefully. Do not use heavy force on it; heavy force can break the cam.

3. Using the tool, carefully try to move the cam toward the right or "Replace" position.

   If the cam moves easily, move it back to the left to verify that spring tension will pull it back to the right. If it returns to the right, then the cam has been released and you can continue with the resetting procedure. If it will not return to the right, the cam spring may be broken.

   If the cam does not move easily, continue to the next step.

IMPORTANT: Use WD-40® only. Do not substitute another penetrant for WD-40.

4. Use sideways pressure to the right and lightly pull the tool away from the engine to separate the top cam from the bottom cam. If the cam moves slightly to the right, let up on the clutch pedal. If the cam is still seized, spray WD-40 into the cam slot and three spring perches. To access all three perches, rotate the engine as needed.

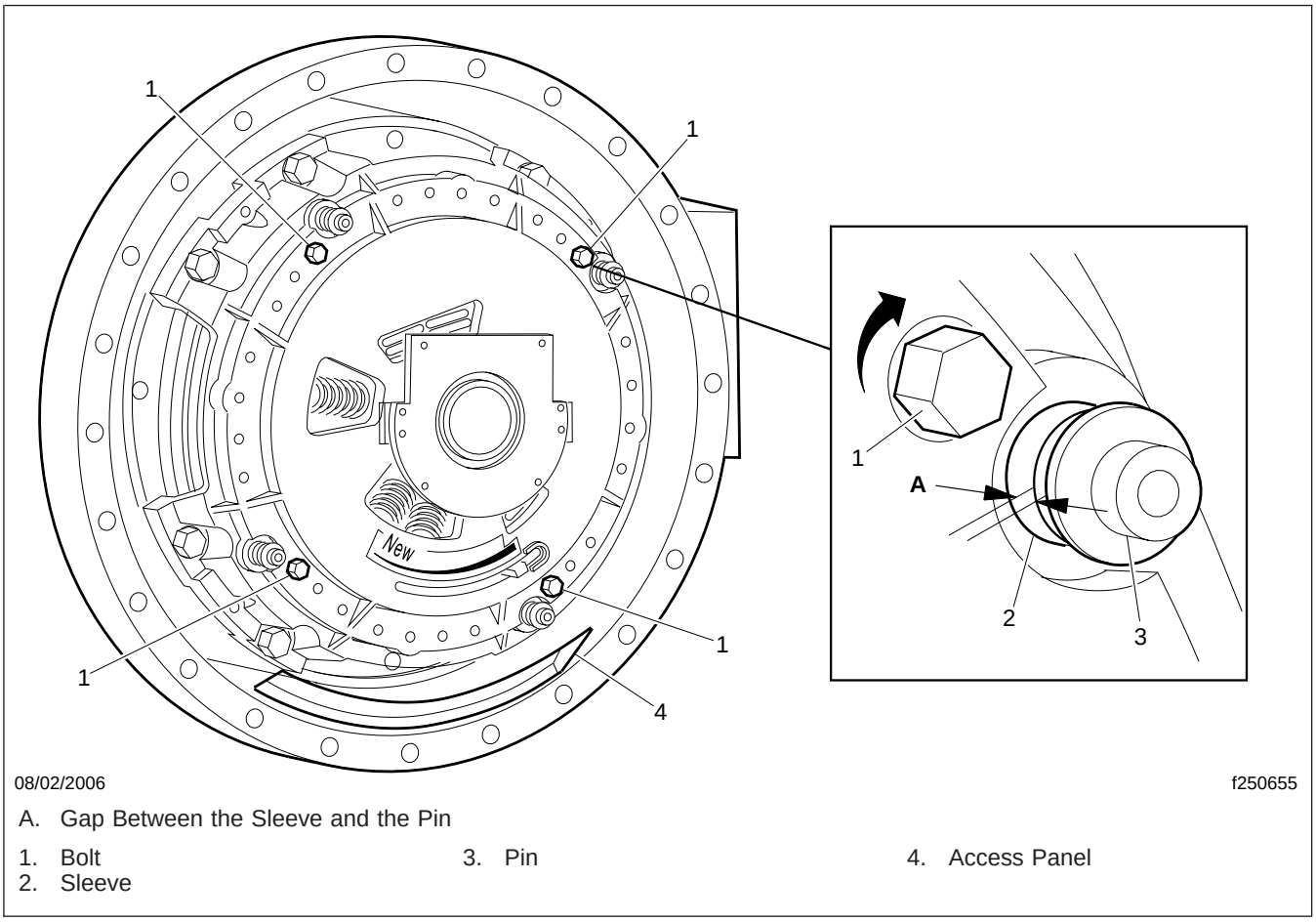
   If the cam is still seized, do the following.

   4.1 Again spray WD-40 into the cam slot and all three spring perches.

   4.2 Inside the cab, release the clutch pedal, then press it all the way down. Next, with the clutch pedal pressed down, jiggle the tool in the cam slots to apply pressure in all directions.

5. Remove the tool.

Resetting the Clutch



A. Gap Between the Sleeve and the Pin

1. Bolt
2. Sleeve
3. Pin
4. Access Panel

Fig. 2, Removing the Gap Between the Sleeve and the Pin

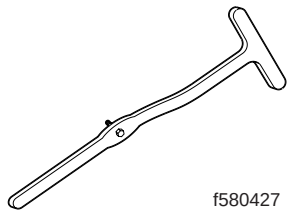
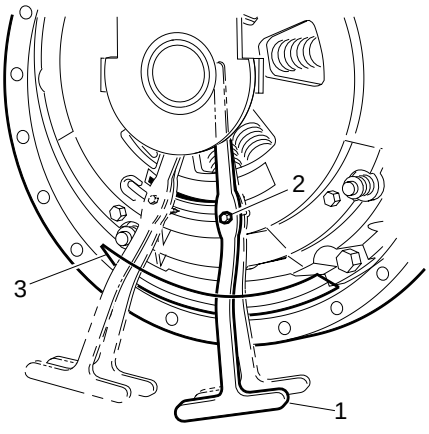
Tool	Description	Eaton Tool Part Code
 f580427	Seized Cam Adjustment Tool	CLPI-SOLOTOOL

Table 1, Special Tool for Releasing a Seized Cam



1. Seized Cam Adjustment Tool
2. Threaded Bolt
3. Access Panel

Fig. 3, Releasing a Seized Cam

Troubleshooting Tables

Problem—The Clutch Does Not Release Completely

Problem—The Clutch Does Not Release Completely	
Possible Cause	**Remedy**
The clutch pedal height is incorrect.	Adjust the clutch to obtain the following settings: • 1/2 to 9/16 inch (12.7 to 14.3 mm) release bearing travel; • 0.105 to 0.145 inch (2.7 to 3.7 mm) release yoke free-travel; and • 1/2 to 1 inch (12.7 to 25.4 mm) clutch brake squeeze.
The bushing in the release bearing sleeve assembly is damaged.	Replace the clutch cover.
The clutch cover assembly is not properly seated into the flywheel.	Re-seat the clutch cover assembly into the flywheel. Use a crisscross pattern when tightening the mounting bolts.
The intermediate plate and/or pressure plate is cracked or broken.	Replace any damaged parts.
The cross shafts protrude through the release yoke (a side-loading condition exists).	Check for protruding cross shafts. Repair or replace as necessary.
The release yoke fingers are bent or worn (a side-loading condition exists).	Install a new release yoke.
The engine housing and bell housing are misaligned (a side-loading condition exists).	Check for loose transmission mounting bolts. Tighten the transmission mounting bolts to the proper torque.
The clutch linkage is set up improperly (a side-loading condition exists).	Thoroughly examine the clutch linkage and adjust as necessary.
The driven discs are distorted or warped.	Replace any distorted or warped driven discs. If the transmission is allowed to hang unsupported during clutch installation, the driven discs may become distorted.
The driven discs are installed backwards, or the front and rear driven discs were switched with each other.	Install new driven discs. Also, check the clutch cover for any damage. Replace the clutch cover if damaged.
The input shaft spline is worn.	Replace the input shaft. Also, check the driven disc hubs for wear. Replace the driven discs if worn.
The input shaft spline is coated with grease, anti-seize compound, etc.	Clean and dry the input shaft spline before installation.
The input shaft splines are twisted.	Select a new driven disc and slide it along the full length of the splines. If the disc does not slide freely, replace the input shaft.
The input-shaft bearing cap is worn.	Replace the input-shaft bearing.
The flywheel pilot bearing fits either too tight or too loose in the flywheel and/or end of input shaft.	Check the pilot bearing for proper fit and replace it if worn.
The pilot bearing is dry or damaged.	Replace the pilot bearing.
The positive separator pins are bent, damaged or incorrectly set.	Be sure to use the proper tool when setting the positive separator pins. Also, take great care when handling the intermediate plate. For procedures, see **Subject 130**.

Troubleshooting

Problem—The Clutch Does Not Release Completely	
Possible Cause	**Remedy**
The clutch brake is damaged and/or not functioning.	Install a new clutch brake.
The driven disc faces are coated with oil or grease.	Replace the driven disc assemblies. Cleaning the old driven discs is not recommended.
There is foreign material (dirt, chaff, salt, etc.) inside the clutch cover.	Remove the foreign material and make sure the clutch inspection cover is installed.
The drive pins are cocked, causing the intermediate plate to stick on the drive lugs (Easy-Pedal only).	The drive pins must be ninety degrees square to the flywheel surface with a 0.006-inch (0.15-mm) minimum clearance between drive pins and intermediate plate slots. Repair or replace as necessary.
The pressure plate is not fully retracting (Easy-Pedal only).	Check the pressure plate return springs through the clutch inspection cover. If any are bent, stretched, or broken, replace them as necessary.
The release bearing travel is excessive and is causing the lever to contact the pressure plate (Easy-Pedal only).	Adjust the release bearing travel from 1/2 to 9/16 inch (12.7 to 14.3 mm).
The three anti-rattle springs were installed backwards (Easy-Pedal only).	Install the anti-rattle springs so the rounded sections are pointed toward the flywheel/engine.

Problem—The Clutch Rattles or Is Noisy

Problem—The Clutch Rattles or Is Noisy	
Possible Cause	**Remedy**
There is excessive flywheel runout.	Repair or replace the flywheel. For procedures, see the engine manufacturer's manual.
There is corrosion between the input shaft spline and the driven disc hubs.	Clean the mating parts between the input shaft and driven discs to ensure that the discs slide freely over the input shaft spline.
The engine idle is too fast.	Readjust engine idle to proper idling speed.
The clutch release bearing is dry or damaged.	Lubricate the clutch release bearing. If the noise persists, install a new clutch cover.
The flywheel pilot bearing is dry or damaged.	Replace the flywheel pilot bearing.
The bridge of the release yoke is hitting the clutch cover (an over-stroking condition exists).	Check for a worn, broken or missing clutch brake. Also, check the release yoke and input-shaft bearing cap for wear. Replace any worn parts.
The release yoke fingers are hitting the clutch cover.	Check if the release bearing, clutch cover, or release yoke fingers are worn or broken. Replace worn parts.
The clutch inspection cover is not installed.	Re-install the clutch inspection cover.
The sleeve bushings are worn.	Investigate for any side-loading conditions on the release bearing housing. If there is a side-loading condition, determine its cause. Also, before installing the new clutch, make sure that the side-loading condition has been corrected.
The clutch linkage is rattling excessively.	Clean, lubricate and reassemble or replace missing/worn parts.
An idle gear rattle is coming from the transmission.	Specify low-vibration driven discs. Check the engine for correct idle speed. For procedures, consult the engine manufacturer's manual.

Problem—The Clutch Rattles or Is Noisy	
Possible Cause	**Remedy**
The damper spring cover of the driven disc assembly is interfering with the flywheel.	Install the correct clutch assembly.
The rivets of the rear driven disc are interfering with the retainer assembly (Easy-Pedal only).	Adjust the clutch internally (via the adjustment bolt). For procedures, see **Subject 100**.

Problem—The Clutch Vibrates

Problem—The Clutch Vibrates	
Possible Cause	**Remedy**
The flywheel is loose.	Retighten the flywheel mounting bolts to the proper specifications.
The universal joints are worn.	Replace the worn parts.
The driveshaft is not properly phased.	Investigate and correct the phasing of the driveshaft.
The driveshaft is not balanced.	Balance and straighten the driveshaft.
The driveline angles are incorrect.	Shim the drivetrain components to equalize universal joint angles.
The flywheel is not balanced.	Balance the flywheel.
The pilot area of the clutch is not completely seated into the flywheel.	Ensure that no dirt, burrs, etc., are preventing the clutch cover from completely seating into the flywheel mounting surface.
The engine mounts are loose, damaged, or worn out.	Replace any worn or damaged parts. Retighten all bolts to proper specifications.
The engine is misfiring.	The engine is not in tune. To correct the problem, see the engine manufacturer's manual.
There is excessive flywheel runout.	Repair or replace the flywheel. For procedures, see the engine manufacturer's manual.
The rivets of the rear driven disc are interfering with the retainer assembly (Easy-Pedal only).	Adjust the clutch internally (via the adjustment bolt). For procedures, see **Subject 100**.

Problem—The Clutch Needs Frequent Adjustments

Problem—The Clutch Needs Frequent Adjustments	
Possible Cause	**Remedy**
The release yoke free-travel is insufficient.	After first adjusting the clutch for 1/2 to 9/16 inch (12.7 to 14.3 mm) release bearing travel, adjust the clutch linkage to obtain release yoke free-travel of 0.105 to 0.145 inch (2.7 to 3.7 mm).
The clutch specification is incorrect.	Check the clutch specifications in **Subject 400**. Install a new clutch with the proper specifications, if necessary.
The cross shafts and/or clutch linkage system is worn.	Investigate the entire clutch linkage system to determine if it is binding or operating sporadically and/or worn excessively.
The clutch driven discs are worn down to the rivets.	Install a new clutch. For procedures, see **Subject 130**.

Troubleshooting

Problem—The Clutch Needs Frequent Adjustments	
Possible Cause	**Remedy**
The crankshaft has excessive end play.	Repair or replace the crankshaft. Consult the engine manufacturer's manual for procedures.

Problem—The Clutch Slips

Problem—The Clutch Slips	
Possible Cause	**Remedy**
The clutch pedal has no free travel.	Readjust the clutch.
The clutch is overloaded.	Verify that the proper clutch has been specified for the particular vehicle application.
The release mechanism is binding.	Free up the release mechanism and linkage. Also, check the clutch linkage adjustment.
The driven disc faces are coated with oil or grease.	Replace the driven disc assembly.
The driver is riding the clutch pedal.	Use correct driving procedures.
The input shaft spline is worn.	Replace the input shaft.

Problem—The Clutch Grabs or Chatters

Problem—The Clutch Grabs or Chatters	
Possible Cause	**Remedy**
The clutch is worn out.	Replace the clutch and all worn components.
The linkage system is not operating freely.	Check the clutch linkage for binding or excessive wear. Replace all worn parts.
The driven disc faces are coated with oil or grease.	Replace the driven disc assembly.
The engine mounts are loose.	Retighten the engine mounts to manufacturer's specifications.
The release yoke fingers and/or the release bearing wear pads are worn excessively.	Replace all the worn parts.

All Clutches

Clutch Torque Values in lbf·ft (N·m)				
Description	**Size**	**Grade**	**Easy-Pedal**	**Solo®**
Mounting Bolts, Clutch Cover to Flywheel on 14-inch clutch	3/8–16 x 1-1/4	5	25–35 (34–47)	30–35 (40–47)
Mounting Bolts, Clutch Cover to Flywheel on 15.5-inch clutch	7/16–14 x 2-1/4	5	40–50 (54–68)	40–50 (54–68)

Table 1, Clutch Torque Values

Clutch Adjustments		
Dimension	**Definition**	**Specification in inch (mm)**
Release Bearing Travel (internal adjustment)	The distance between the release bearing and the clutch brake.	1/2–9/16 (12.7–14.3)*
Release Yoke Free-Travel (linkage adjustment)	The distance between the release yoke fingers and the release bearing wear pads.	0.105–0.145 (2.7–3.7)
Clutch Brake Squeeze (pedal adjustment)	The movement of the clutch pedal from the time that the clutch brake contacts the release bearing until the pedal reaches the end of its stroke.	1/2–1 (12.7–25.4)

* On short-stroke hydraulic clutches (installed before 5/16/94), the release bearing travel is 0.41 to 0.47 inch (10.4 to 11.9 mm).

Table 2, Clutch Adjustments

Clutch Inspection Tolerances			
Measurement	**Dial Indicator at**	**Gauge Finger at**	**Maximum Runout in inch (mm)**
Flywheel Face Runout	Flywheel Housing	Flywheel Face	0.008 (0.20)
Pilot Bearing Bore Runout	Flywheel Housing	Pilot Bearing Bore	0.005 (0.13)
Flywheel Housing Bore Runout	Crankshaft	Flywheel Housing Bore	0.008 (0.20)
Flywheel Housing Face Runout	Flywheel Outer Diameter	Flywheel Housing Face	0.008 (0.20)

Table 3, Clutch Inspection Tolerances

Minimum Flywheel Bores	
Disc Type	**Minimum Flywheel Bore in inch (mm)**
10-Spring	8.562 (217.48)
9-Spring	9.750 (247.65)
8-Spring	7.250 (184.15)
7-Spring	9.750 (247.65)
6-Spring	9.750 (247.65)

Table 4, Minimum Flywheel Bores

Specifications

Stamped Angle-Spring Clutches

Angle-Spring Clutch Capacity and Spring Color Codes			
Clutch Type	**Spring Color Code**	**Facing**	**Torque in lbf·ft (N·m)***
SAS 1401 (single-disc)	Blue	Ceramic	500 (678)
	Purple	Ceramic	560 (759)
SAS 1402 (dual-disc)	Blue	Ceramic	800 (1085)
	Green	Ceramic	800 (1085)
	Purple	Ceramic	800 (1085)

* The clutch torque rating must equal or exceed the rated torque of the engine.

Table 5, Angle-Spring Clutch Capacity and Spring Color Codes

Easy-Pedal Clutches

Easy-Pedal Clutch Component Dimensions		
Dimension	**Standard Duty in inch (mm)**	**Super Duty in inch (mm)**
Driven Disc Thickness (new)	0.450 (11.43)	0.360 (9.43)
Intermediate Plate Thickness (new)	0.580–0.630 (14.73–16.00)	0.750–0.810 (19.05–20.57)

Table 6, Easy-Pedal Clutch Component Dimensions

Easy-Pedal Plus™ Medium-Duty 14-inch (350mm) Clutches

Easy-Pedal Medium-Duty Clutch Specifications				
Easy-Pedal Part Number	**Damper Style**	**No. of Springs**	**No. of Facings**	**Facing Style**
107683–5	Free Travel	8	3	Super Button
107237–8	Free Travel	8	3	Trap
107237–10	Low Rate	8	3	Trap
107342–4	Free Travel	8	3	Trap
107342–11	Low Rate	8	3	Trap

Table 7, Easy-Pedal Medium-Duty Clutch Specifications

Easy-Pedal Medium-Duty Clutch Capacity			
Easy-Pedal Part Number	**Spline Diameter**	**No. of Discs**	**Torque in lbf·ft (N·m)***
107683–5	1.75 (44.5)	One	620 (840)
107237–8	1.75 (44.5)	Two	860 (1165)
107237–10	1.75 (44.5)	Two	860 (1165)
107342–4	2.00 (50.8)	Two	860 (1165)

Easy-Pedal Medium-Duty Clutch Capacity			
Easy-Pedal Part Number	**Spline Diameter**	**No. of Discs**	**Torque in lbf·ft (N·m)***
107342–11	2.00 (50.8)	Two	860 (1165)

* The clutch torque rating must equal or exceed the rated torque of the engine.

Table 8, Easy-Pedal Medium-Duty Clutch Capacity

Easy-Pedal 2000™ Heavy-Duty 15.5-inch (394mm) Clutches

Easy-Pedal Heavy-Duty Clutch Specifications				
Easy-Pedal Part Number	**Flywheel Bore in inch (mm)**	**Damper Style**	**No. of Springs**	**No. of Facings**
108391–81	7.0 (178)	Free Travel	8	4
108391–74B	8.5 (216)	Free Travel	10	4
108925–82B	10.0 (254)	Low Rate	7	4
108925–20	10.0 (254)	VCTplus	7	6
108925–25	10.0 (254)	VCTplus	7	6

Table 9, Easy-Pedal Heavy-Duty Clutch Specifications

Easy-Pedal Heavy-Duty Clutch Capacity			
Easy-Pedal Part Number	**Plate Load in lbf (N)**	**Torque in lbf·ft (N·m)***	**Pressure Spring Color Code**
108391–81B	3600 (16 000)	1400 (2000)	White
108391–74B	3600 (16 000)	1650 (2235)	Plain
108925–82B	4000 (18 000)	1700 (2305)	Plain
108925–20	4000 (18 000)	1860 (2520)	Red
108925–25	4000 (18 000)	2050 (2780)	White

* The clutch torque rating must equal or exceed the rated torque of the engine.

Table 10, Easy-Pedal Heavy-Duty Clutch Capacity

Solo Clutches

Solo Clutch Pressure Plate Wear Pin Resetting		
Component	**Depth in inch (mm)**	
	14-Inch Clutch	**15.5-Inch Clutch**
Pressure Plate Face	0.5 (12.7)	1.75–1.78 (44.4–45.2)

Table 11, Solo Clutch Pressure Plate Wear Pin Resetting

Solo Medium-Duty 14-inch (350mm) Clutches

Specifications

Solo 14-Inch Medium-Duty Clutch Specifications				
Solo Part Number		Damper Style	No. of Facings	Facing Style
Standard Yoke	Roller Yoke			
109400–5	109410–5Y	Free Travel	3	Super Button
109500–8	109507–8Y	Free Travel	3	Trap
109500–10	109507–10Y	Low Rate	3	Trap
109504–8	N/A	Free Travel	3	Trap
109504–10	109508–10Y	Low Rate	3	Trap
109504–20	109508–20Y	Low Rate	4	Super Button
N/A	109508–11Y	Low Rate	4	Super Button
Short Stroke (on hydraulic clutches installed before 5/16/94)				
109404–5	N/A	Free Travel	3	Super Button
109503–10	N/A	Low Rate	3	Trap
109505–10	N/A	Low Rate	3	Trap

Table 12, Solo Medium-Duty Clutch Specifications

Solo Medium-Duty Clutch Capacity				
Solo Part Number		Spline Diameter	No. of Discs	Torque in lbf·ft (N·m)*
Standard Yoke	Roller Yoke			
109400–5	109410–5Y	1.75 (44.5)	One	620 (840)
109500–8	109507–8Y	1.75 (44.5)	Two	860 (1165)
109500–10	109507–10Y	2.00 (50.8)	Two	860 (1165)
109504–8	N/A	2.00 (50.8)	Two	860 (1165)
109504–10	109508–10Y	2.00 (50.8)	Two	860 (1165)
109504–20	109508–20Y	2.00 (50.8)	Two	1050 (1425)
N/A	109508–11Y	2.00 (50.8)	Two	1150 (1560)
Short Stroke (on hydraulic clutches installed before 5/16/94)				
109404–5	N/A	1.75 (44.5)	One	620 (840)
109503–10	N/A	1.75 (44.5)	Two	860 (1165)
109505–10	N/A	2.00 (50.8)	Two	860 (1165)

* The clutch torque rating must equal or exceed the rated torque of the engine.

Table 13, Solo Medium-Duty Clutch Capacity

Solo Heavy-Duty 15.5-inch (394mm) Clutches

Solo Heavy-Duty Clutch Specifications					
Solo Part Number		Flywheel Bore in inch (mm)	Damper Style	No. of Springs	No. of Facings
Standard Yoke	Roller Yoke				
109701–81	N/A	7.0 (178)	Free Travel	8	4
109701–74	N/A	8.5 (216)	Free Travel	10	4
109701–82	109705–82Y	10.0 (254)	Low Rate	7	4
109701–20	109705–20Y	10.0 (254)	VCTplus	7	6
109701–25	109705–25Y	10.0 (254)	VCTplus	7	6
N/A	109706–32Y	10.0 (254)	VCTplus	7	6

Table 14, Solo Heavy-Duty Clutch Specifications

Solo Heavy-Duty Clutch Capacity				
Solo Part Number		Plate Load in lbf (N)	Torque in lbf·ft (N·m)*	Pressure Spring Color Code
Standard Yoke	Roller Yoke			
109701–81	N/A	3600 (16 000)	1400 (2000)	White
109701–74	N/A	3600 (16 000)	1650 (2235)	Plain
109701–82	109705–82Y	4000 (18 000)	1700 (2305)	Plain
109701–20	109705–20Y	4000 (18 000)	1860 (2520)	Red
109701–25	109705–25Y	4000 (18 000)	2050 (2780)	White
N/A	109706–32Y	4000 (18 000)	2250 (3050)	Green

* The clutch torque rating must equal or exceed the rated torque of the engine.

Table 15, Solo Heavy-Duty Clutch Capacity

General Information

The clutch linkage transfers the motion of the clutch pedal to the clutch release bearing.

Free-play in the clutch pedal is required to ensure that the fingers of the release bearing do not run against the release bearing. There should not be any play or looseness in the connections and joints of the clutch linkage.

Two types of clutches may be installed on the vehicle: pull or push.

- On push-type clutches, depressing the clutch pedal moves the release bearing toward the engine flywheel. As the clutch is depressed, the pressure plate moves away from the driven disc assembly, and the clutch is disengaged. As the clutch pedal is released, the release bearing and clutch levers move away from the engine flywheel causing the driven disc to be locked up between the friction surfaces of the pressure plate and the engine flywheel. The clutch is then engaged.
- On pull-type clutches depressing the clutch pedal pulls the release bearing away from the pressure plate, disengaging the clutch. As the clutch pedal is released, the pressure plate is forced toward the engine flywheel until the driving and driven discs turn at the same speeds, engaging the clutch.

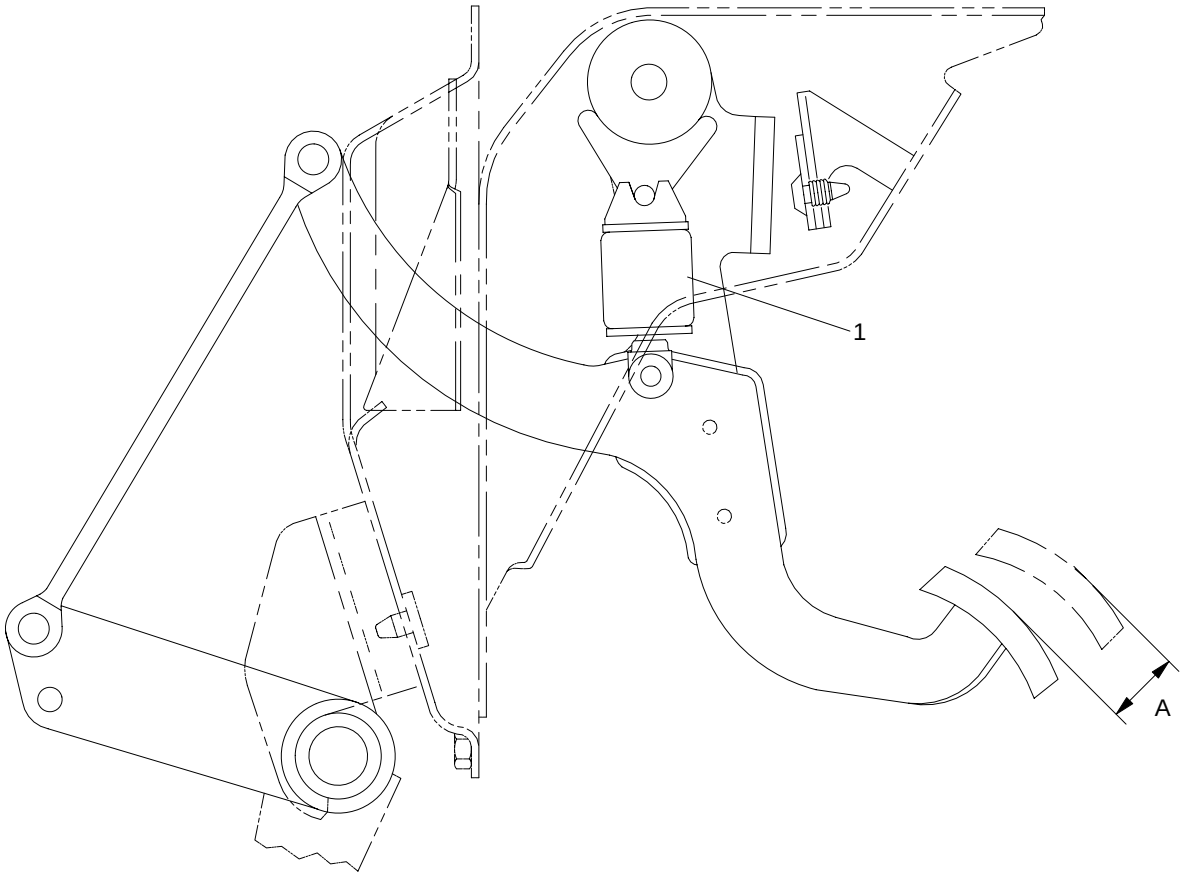
IMPORTANT: On pull-type clutches, release bearing and release fork clearance are internal clutch adjustments, and *can not be adjusted* by adjusting the clutch linkage. For internal clutch adjustments, see either the applicable clutch section in this group, or the clutch manufacturer's service literature.

On vehicles with right-hand drive, the clutch pedal is installed with the brake pedal inside a special pedal box assembly. Both pedals must be removed as a unit. Clutch adjustment procedures are not affected by this change.

Clutch Linkage Adjustment

IMPORTANT: Vehicles equipped with Rockwell clutches use clutch pedals with an over-center spring. See **Fig. 1**. Clutch pedals without an over-center spring are used on all vehicles except those equipped with Rockwell clutches. See **Fig. 2**.

- If the clutch free pedal is less than 19 mm (3/4 inch), adjust the clutch internally, not at the linkage. See **Fig. 1**, Ref. A.
- Be sure internal clutch adjustments are correct before making adjustments to the clutch linkage. For instructions, refer to the applicable clutch section in this group.
- Adjust the clutch linkage only after repair or replacement of the clutch or clutch linkage components.
- If equipped with cab air-suspension, be sure the air bags are properly inflated. If



06/06/94 f250126

A. Clutch free pedal should be about 51 mm (2 inches)
1. Over-Center Spring

Fig. 1, Clutch Pedal With Over-Center Spring

Pull-Type Clutch

1. Observe the following points before beginning clutch linkage adjustment:

Clutch Linkage Adjustment

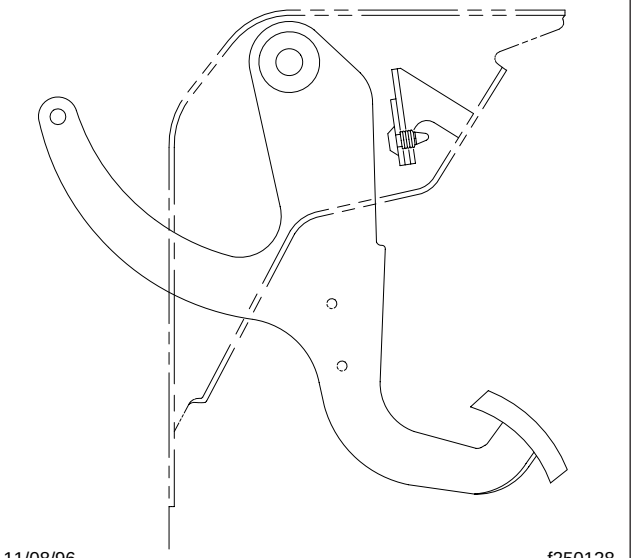
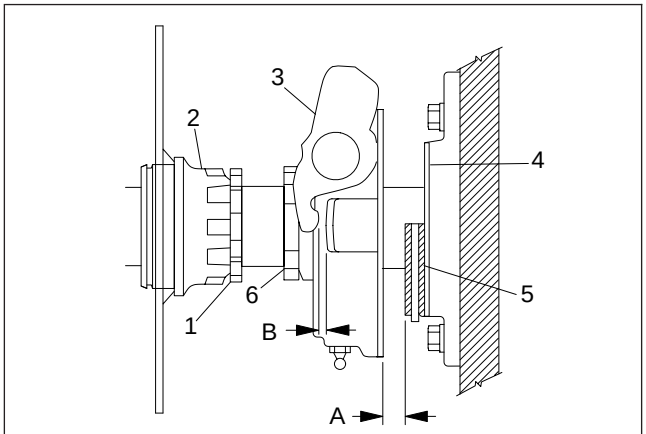


Fig. 2, Clutch Pedal Without Over-Center Spring

the air bags are not inflated, the clutch linkage can't be adjusted correctly.

2. Tilt the hood.
3. Remove the clutch inspection cover from the bottom of the bell housing.
4. Be sure the clutch pedal is all the way up, against the upper stop.
5. Check the internal clutch adjustment. Refer to the applicable clutch section in this group for instructions, and adjust if needed.
6. Measure the distance between the release yoke and the release bearing. See **Fig. 3**. If this measurement is 2.7 to 3.7 mm (0.105 to 0.145 inch), no further work is needed. If the measurement is incorrect, do all of the remaining steps.
7. Remove the nut that attaches the lower clutch rod to the relay lever. Disconnect the lower clutch rod from the relay lever. Loosen the jam nut (**Fig. 4**, Ref. 6) on the lower clutch rod.

IMPORTANT: On vehicles built before January 1996, and if the clutch pedal has an over-center spring, adjust the clutch linkage using a special tool, part number 02–12448–000. See **Fig. 5**. If the clutch pedal doesn't have an over-center spring, adjust the clutch linkage using a different



A. 12.7 to 14.3 mm (1/2 to 9/16 inch) With Clutch Brake
B. 2.7 to 3.7 mm (0.105 to 0.145 inch)

1. Locknut Ring
2. Release Bearing Coupler
3. Release Yoke
4. Bearing Cover
5. Bearing Pad
6. Adjuster Ring

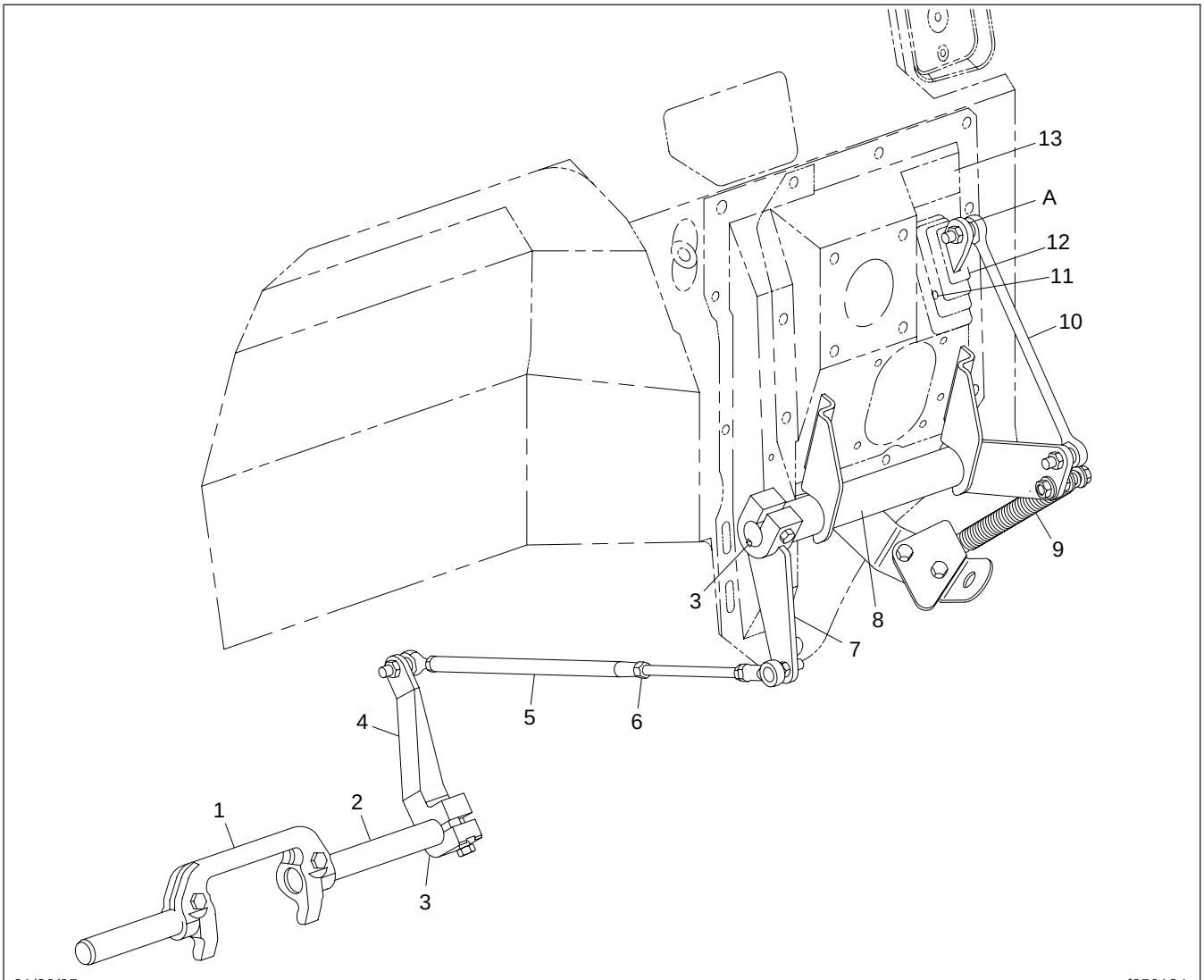
Fig. 3, Clutch Adjustment Specifications

special tool, part number 02–12447–000. See **Fig. 6**. On vehicles built from January 1996, adjust the clutch linkage using a special tool, part number H18–33130–000. See **Fig. 7**. These special tools may be ordered from the PDCs.

8. Place the special tool between the clutch pedal and the plastic pedal stop. See **Fig. 5**, **Fig. 6**, or **Fig. 7.**

IMPORTANT: Don't apply excessive force when pulling the lower clutch rod forward as this could partially disengage the clutch.

9. Pull the lower clutch rod forward until resistance is felt. The release yoke is now touching the release bearing.
10. Hold the rod in the same position. Adjust the rod length (in or out) until the rod end lines up with the hole in the relay lever. Install the rod end in the relay lever. Tighten the nut 35 to 45 N·m (26 to 33 lbf·ft).
11. Tighten the jam nut on the lower clutch rod 16 to 20 N·m (12 to 15 lbf·ft).
12. Remove the special tool from the clutch pedal.



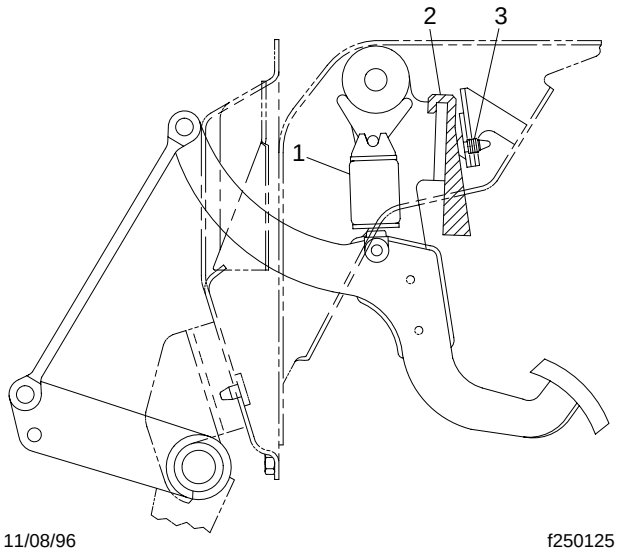
A. To clutch pedal.

1. Clutch Release Yoke
2. Clutch Release Shaft
3. Clutch Release Key
4. Clutch Release Lever
5. Lower Clutch Rod
6. Jam Nut
7. Clutch Relay Lever
8. Bellcrank Pivot Assembly
9. Return Spring
10. Upper Clutch Rod
11. Crosshead Screw
12. Boot
13. Pie-Pan Assembly

Fig. 4, Linkage for Pull-Type Clutch

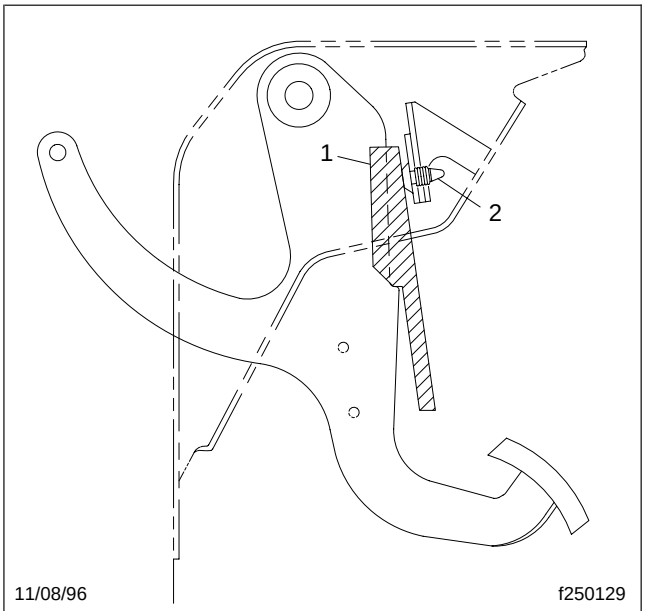
13. Measure the distance between the release yoke and the release bearing. If this measurement is 2.7 to 3.7 mm (0.105 to 0.145 inch), go to the next step. If the measurement is incorrect, repeat the previous steps.
14. Install the inspection cover on the bottom of the bell housing.
15. Check the clutch free pedal. See **Fig. 1**, Ref. A.

Clutch Linkage Adjustment



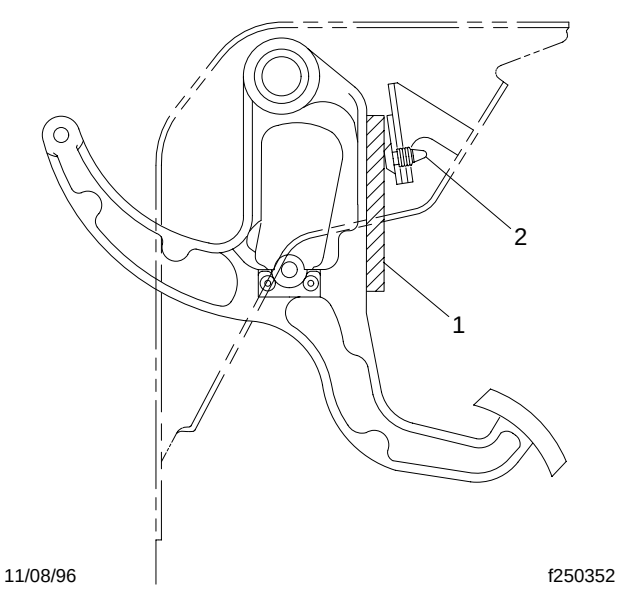
1. Over-Center Spring
2. Special Tool (part number 02–12448–000)
3. Plastic Pedal Stop

Fig. 5, Adjusting a Clutch Pedal with Over-Center Spring (vehicles built before January 1996)



1. Special Tool (part number 02–12447–000)
2. Plastic Pedal Stop

Fig. 6, Adjusting a Clutch Pedal without an Over-Center Spring (vehicles built before January 1996)



1. Special Tool (part number H18–33130–000)
2. Plastic Pedal Stop

Fig. 7, Adjusting a Cast Clutch Pedal (vehicles built from January 1996)

Push-Type Clutch

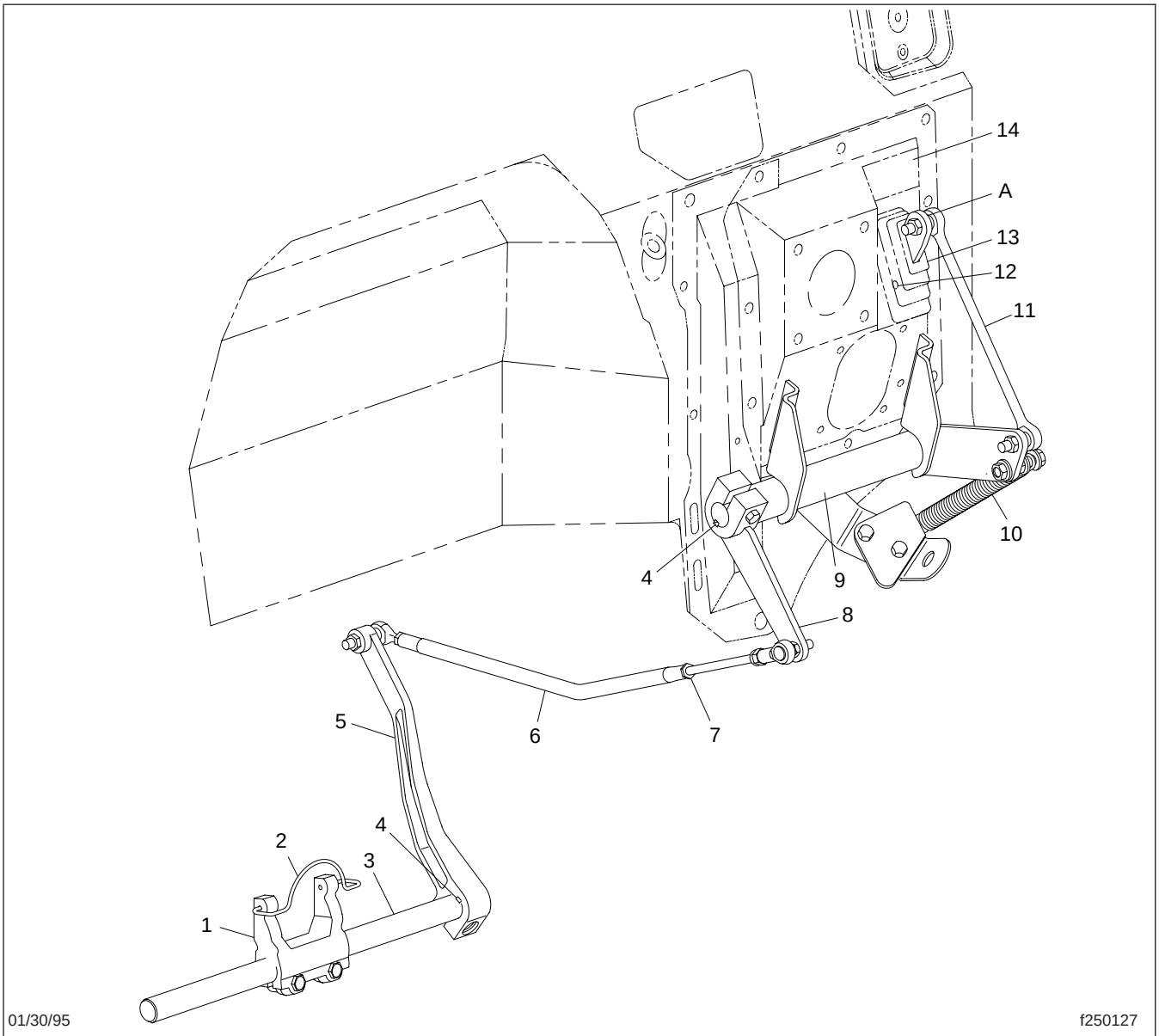
IMPORTANT: If the clutch free pedal is less than 19 mm (3/4 inch), adjust the clutch at the linkage, not internally. See **Fig. 1**, Ref. A.

1. Tilt the hood.
2. Remove the nut that attaches the lower clutch rod to the relay lever. Disconnect the lower clutch rod from the relay lever. Loosen the jam nut (**Fig. 8**, Ref. 7) on the lower clutch rod.
3. On vehicles built before January 1996, place the special tool 02–12447–000 between the clutch pedal and the plastic pedal stop. **See Fig. 6**. On vehicles built from January 1996, place the special tool H18–33130–000 between the clutch pedal and the plastic pedal stop. See **Fig. 7**.

IMPORTANT: Don't apply excessive force when pulling the lower clutch rod forward as this could partially disengage the clutch.

4. Pull the lower clutch rod forward until resistance is felt. The release yoke is now touching the release bearing.

Clutch Linkage Adjustment



A. To clutch pedal.

1. Clutch Release Yoke
2. Retainer Clip
3. Clutch Release Shaft
4. Clutch Release Key
5. Clutch Release Lever
6. Lower Clutch Rod
7. Jam Nut
8. Clutch Relay Lever
9. Bellcrank Pivot Assembly
10. Return Spring
11. Upper Clutch Rod
12. Crosshead Screw
13. Boot
14. Pie-Pan Assembly

Fig. 8, Linkage for Push-Type Clutch

5. Hold the rod in the same position. Adjust the rod length (in or out) until the rod end lines up with the hole in the relay lever. Install the rod end in the relay lever. Tighten the nut 35 to 45 N·m (26 to 33 lbf·ft).

Clutch Linkage Adjustment

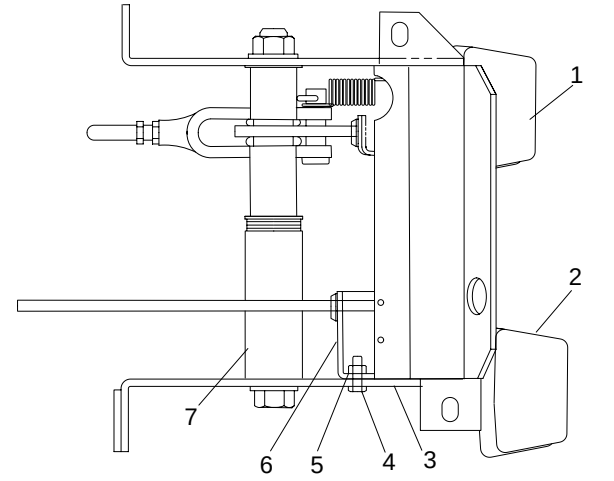
6. Tighten the jam nut on the lower clutch rod 16 to 20 N·m (12 to 15 lbf·ft).
7. Remove the special tool from the clutch pedal.
8. Check the clutch free pedal. See **Fig. 1**, Ref. A.

Clutch Pedal Removal and Installation, RH DR

Removal

IMPORTANT: It is easier to remove the clutch pedal with the steering column removed. See **Section 46.02, Subject 110** for procedures.

1. Set the parking brake and chock the tires.
2. Remove the clutch stop and allow the overcenter bolt to fall down. Set aside the washer, spring and plastic nut for later installation. See **Fig. 1**.

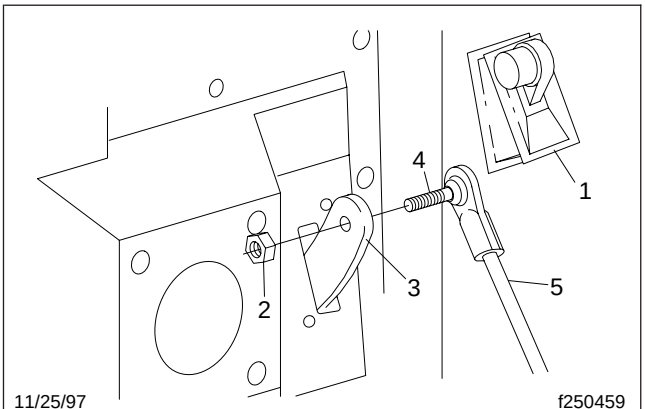


11/26/97 f250461

1. Brake Pedal
2. Clutch Pedal
3. Pedal Box
4. Stop Bolt, 1/4–20
5. Stop Nut, 1/4–20
6. Clutch Stop Bracket
7. Cross-Through Shaft

Fig. 1, Remove the Clutch Stop

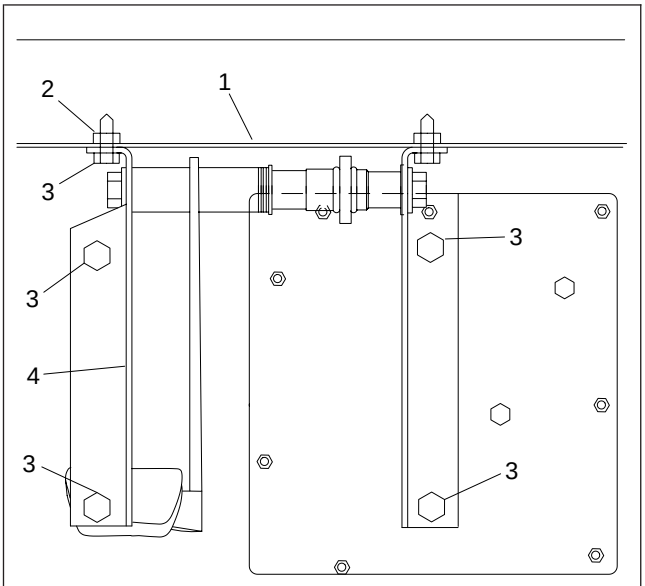
3. Disconnect the clutch switch harness.
4. Tilt the hood.
5. From the outside of the cab, disconnect the clutch linkage. See **Fig. 2**.
6. Remove the two 1/4–20 foot valve mounting capscrews on the RH side of the pedal box.
7. From inside the cab, remove the six M10 bolts on the pedal box.
8. Remove the pedal box assembly from the cab. See **Fig. 3**.
9. With the pedal box assembly removed, disconnect the brake pedal return spring.



11/25/97 f250459

1. Boot
2. Nut
3. Clutch Pedal
4. Ball Stud
5. Clutch Rod

Fig. 2, Disconnect the Clutch Linkage



12/03/97 f250462

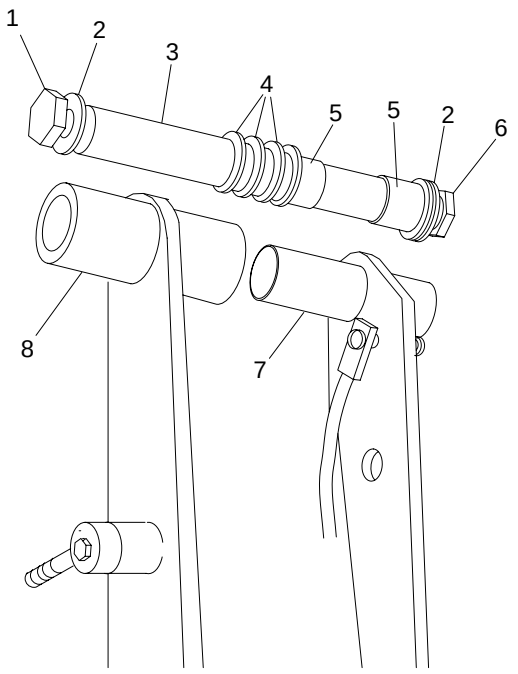
1. Frontwall
2. Hexnut, M10
3. Capscrew, M10
4. Pedal Box

Fig. 3, Pedal Box Assembly

10. Remove the cross-through bolt, nut and washers from the pedal box assembly. See **Fig. 4**.

IMPORTANT: There are many small parts installed on the cross-through shaft. Be careful to preserve the correct order for reassembly.

Clutch Pedal Removal and Installation, RH DR



1. Cross-Through Bolt
2. Washer
3. Cross-Through Shaft
4. Spacers
5. Plastic Sleeve
6. Cross-Through Nut
7. Brake Pedal
8. Clutch Pedal

Fig. 4, Cross-Through Shaft

11. Remove the cross-through shaft, with the clutch pedal and brake pedal, from the pedal box.

Installation

1. Install the cross-through shaft in the pedal box. Make sure the spacers, plastic sleeve, and washers are installed in the correct order, as removed. See **Fig. 4**.
   - 1.1 Install the plastic sleeve onto the brake pedal.
   - 1.2 Insert the brake pedal, plastic sleeve, spacers, and clutch pedal onto the cross-through shaft.
   - 1.3 Spread the pedal box slightly and insert the cross-through shaft into the space between the two ends of the box.
2. Insert the cross-through bolt, with washers, and attach the nut. Tighten the nut 135 lbf·ft (183 N·m).
3. Install the brake pedal return spring.
4. Seat the pedal box assembly in the cab. The assembly is seated properly when the bolt holes line up with the holes in the frontwall and the clutch pedal extends through the slot provided. See **Fig. 3**.

CAUTION

When installing the pedal box assembly, be careful not to damage the plastic HVAC tubing.

   - 4.1 From inside the cab, install the six M10 bolts to hold the box in place.
   - 4.2 From outside the cab, install the two 1/4–20 foot valve mounting capscrews and tighten them 84 lbf·in (940 N·cm).
   - 4.3 Install the M10 nuts on the M10 capscrews and tighten the nuts 30 lbf·ft (41 N·m).
5. Install the overcenter spring. See **Fig. 1**.
   - 5.1 Pull the clutch pedal out as far as it will go.
   - 5.2 Slip the washer, spring and plastic retainer onto the stop bolt.
   - 5.3 Push the clutch pedal in.
6. Install the clutch stop. Tighten the stop bolt 84 lbf·in (940 N·cm).
7. From outside the cab, connect the clutch linkage. See **Fig. 2**.
8. Attach the clutch switch electrical connector.
9. If removed, install the steering column. See **Section 46.02, Subject 110** for procedures.
10. Lower the hood and remove the chocks from the tires.

Specifications

Torque Values, Clutch Adjustment	
Description	**Torque lbf·ft (N·m)**
Clutch Rod Nut	26 to 33 (35 to 45)
Jam Nut	12 to 15 (16 to 20)

Table 1, Torque Values, Clutch Adjustment

Torque Values, Clutch Pedal Installation		
Description	**Torque**	
	lbf·ft (N·m)	**lbf·in (N·cm)**
Foot Valve Mounting Capscrew, 1/4–20	—	84 (940)
Clutch Stop Mounting Capscrew, 1/4–20	—	84 (940)
Cross-Through Nut	135 (183)	—
Pedal Box Mounting Capscrews, M10	30 (41)	—

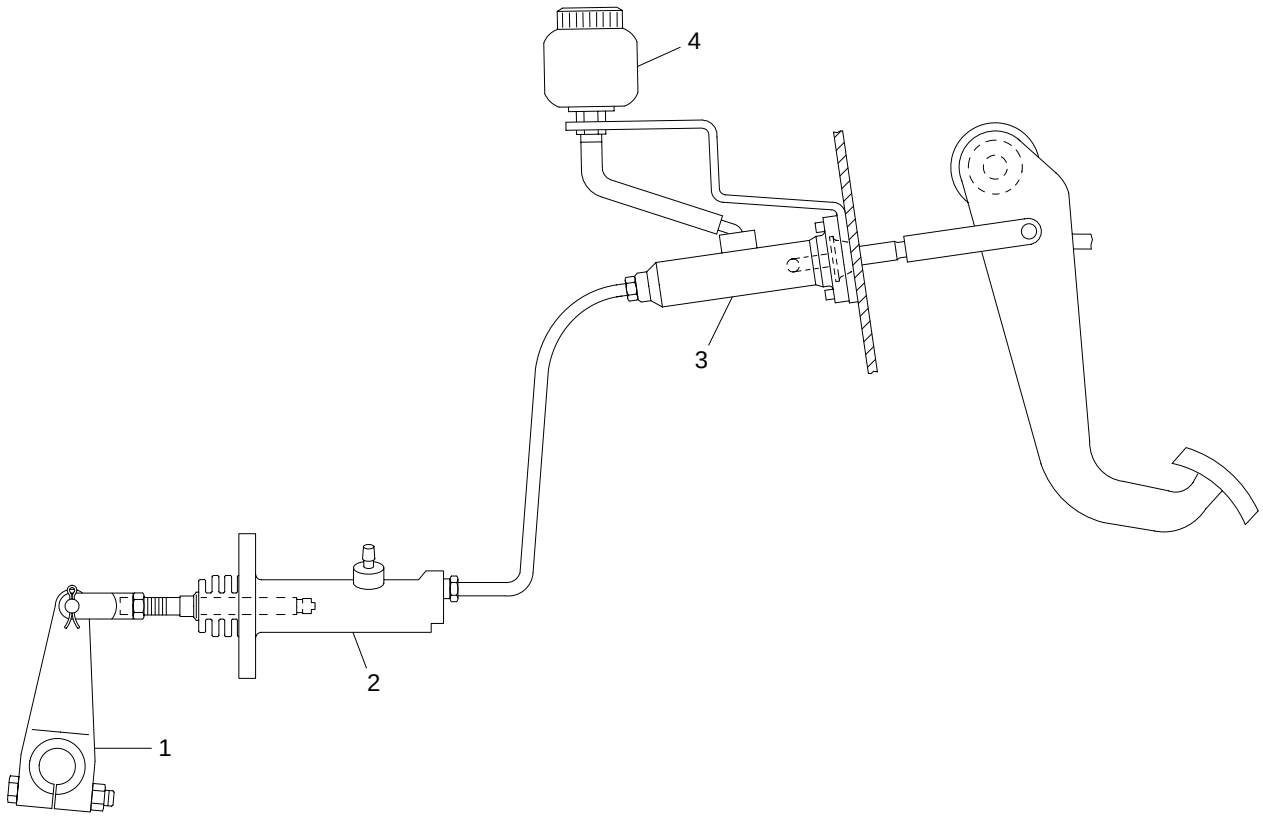
Table 2, Torque Values, Clutch Pedal Installation

General Information

The clutch linkage uses a hydraulic system consisting of a fluid reservoir, a master cylinder, and a slave cylinder. **See Fig. 1.**

Principles of Operation

When the clutch pedal is depressed, the fluid in the master cylinder is forced through a hydraulic line to the slave cylinder. The fluid pressure moves the slave cylinder piston, pushing the plunger rod and clutch release lever, which disengages the clutch. The system is self-adjusting. No "linkage" adjustment is required. Some clutch models have an internal adjustment, however.



1. Clutch Release Lever
2. Slave Cylinder
3. Master Cylinder
4. Reservoir

Fig. 1

Master Cylinder Removal and Installation

Removal

WARNING

WARNING: Hydraulic brake fluid is hazardous. It may be a skin irritant and can cause blindness if it gets in your eyes. Always wear safety glasses when handling hydraulic brake fluid or bleeding hydraulic lines. If you get hydraulic brake fluid on your skin, wash it off as soon as possible.

CAUTION

CAUTION: Do not spill hydraulic fluid on the cab paint. Clean it off immediately if any is spilled. Hydraulic brake fluid can damage paint.

1. On vehicles built since December 1992, go to the next step.

   On vehicles built before December 1992, remove the capscrews (**Fig. 1**) holding the reservoir mounting bracket to the master cylinder mounting bracket.

   1.1 Pour the hydraulic fluid out of the reservoir and safely discard it.

   1.2 Disconnect the hydraulic line from the reservoir and remove the reservoir. **See Fig. 2.**

   1.3 Unscrew the fitting (**Fig. 3**) at the bottom end of the master cylinder and disconnect the hydraulic line.

   1.4 Remove the two capscrews (**Fig. 4**) that hold the master cylinder mounting bracket to the firewall.

   1.5 From the backside of the mounting bracket remove the two capscrews (**Fig. 5**) that mount the master cylinder to the bracket.

2. On vehicles built from December 1992, remove the fasteners that attach the master cylinder and the hydraulic fluid reservoir mounting bracket to the firewall.

   2.1 Remove the cap from the hydraulic fluid reservoir and empty the reservoir into a container. Safely discard the fluid.

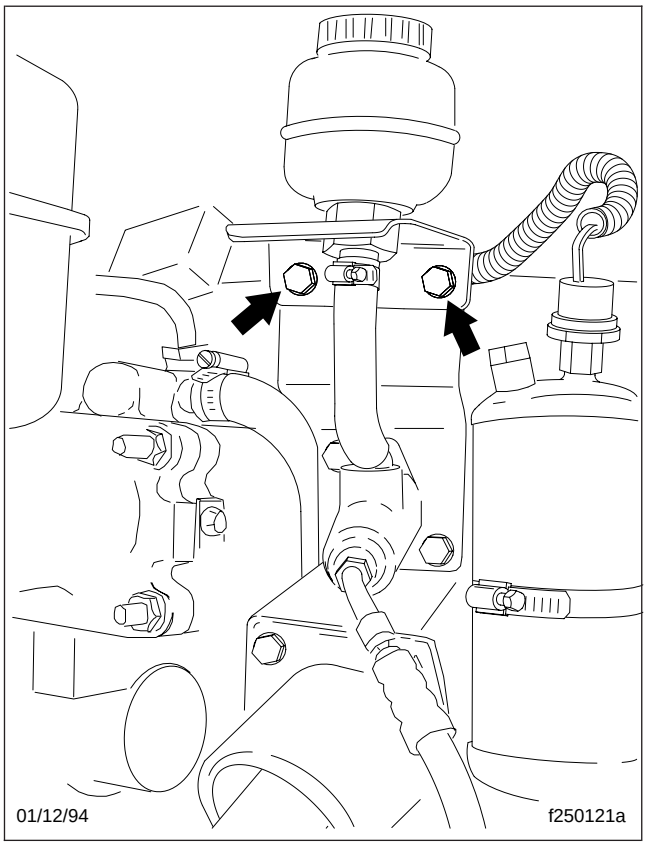


Fig. 1

   2.2 Unscrew the fitting at the bottom end of the master cylinder and disconnect the hydraulic line.

   2.3 Disconnect the hydraulic line from the reservoir and remove the master cylinder.

Installation

1. Adjust the master cylinder plunger rod.

   1.1 Before attaching the master cylinder, loosen the plunger rod jam nut.

CAUTION

CAUTION: Adjust the plunger rod to extend 38.5 mm (about 1-1/2 inches) beyond the outside surface of the firewall. If the rod extends too far, the piston seals will be damaged when the piston travels too far in the master cylinder bore. In addition, the clutch will not self-adjust because the

Master Cylinder Removal and Installation

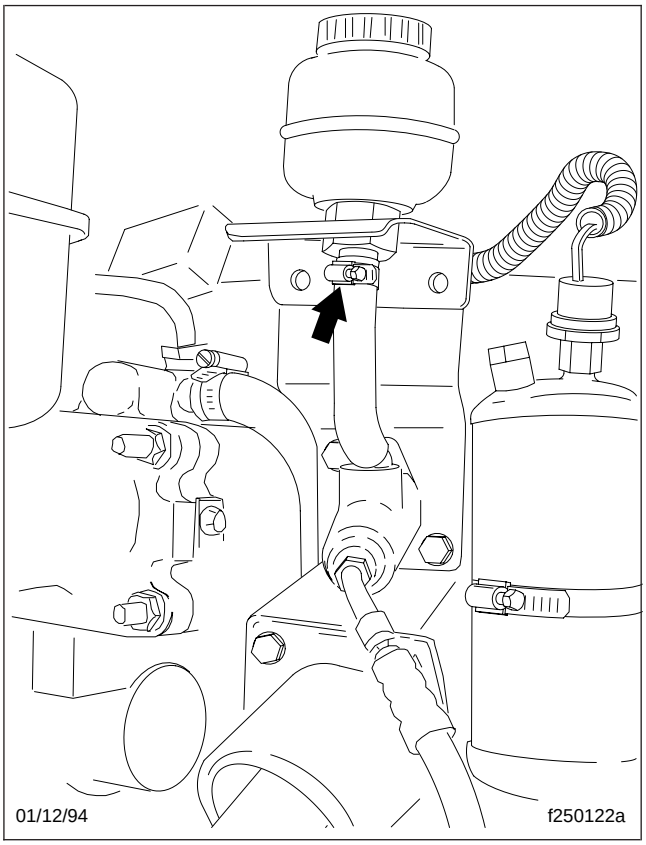


Fig. 2

opening to the clutch fluid reservoir will be blocked. If the rod doesn't extend far enough, there will be play at the clutch pedal.

NOTE: There is normally no play with a hydraulic clutch linkage.

1.2 Adjust the plunger rod by turning it in or out of the clevis yoke until it extends 38.5 mm (1-1/2 inches) beyond the firewall outside surface. **See Fig. 6.**

1.3 Tighten the jam nut.

2. On vehicles built since December 1992, go to the next step. On vehicles built before December 1992, install the master cylinder.

2.1 Position the master cylinder on the master cylinder mounting bracket. Install the two capscrews (**Fig. 5**). Tighten them 880 N·cm (78 lbf·in).

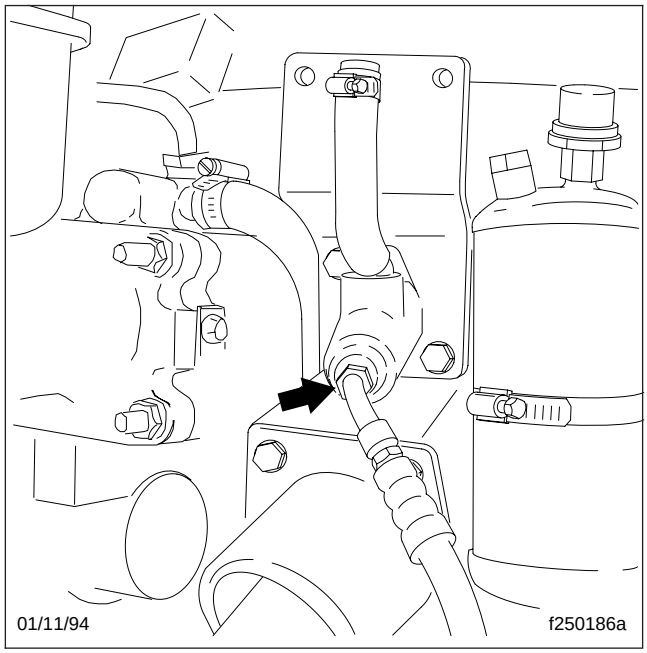


Fig. 3

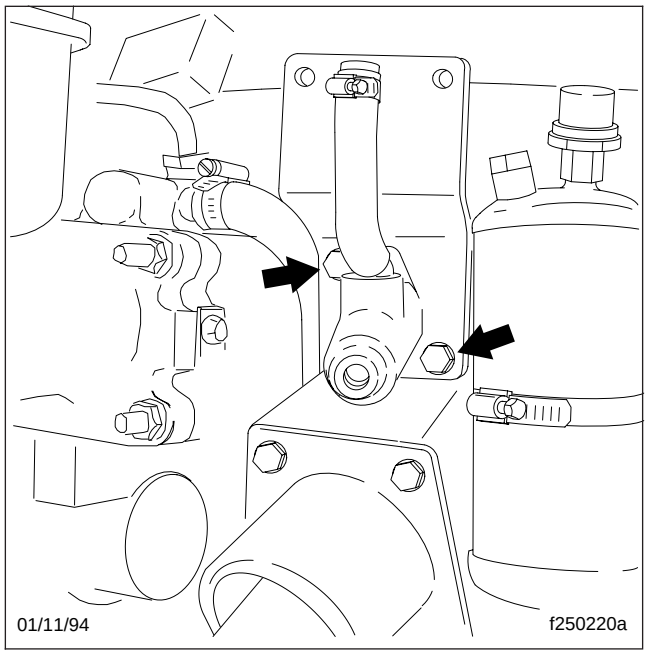


Fig. 4

2.2 Position the master cylinder mounting bracket on the firewall, sliding the plunger rod through the rubber wiper until it seats in the master cylinder.

Master Cylinder Removal and Installation

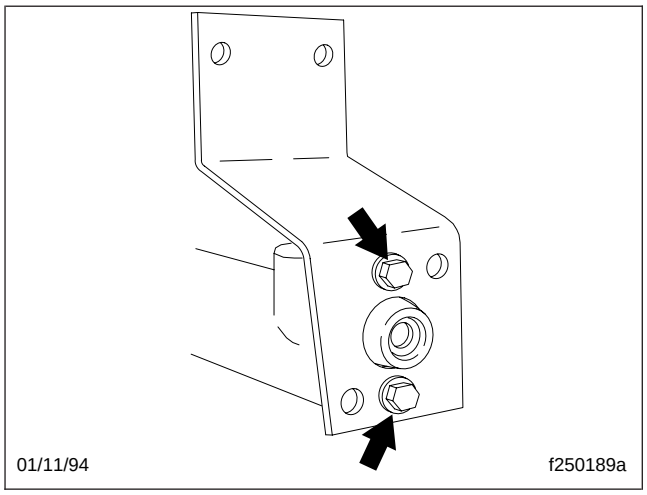
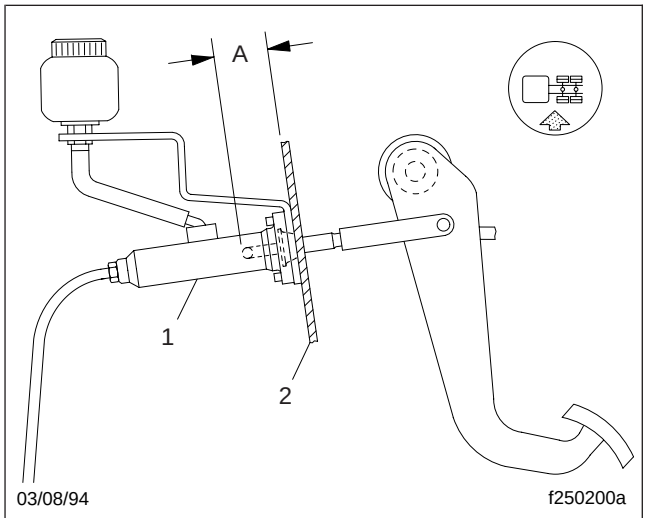


Fig. 5



A. 38.5 mm (about 1-1/2") beyond firewall outside surface
1. Master Cylinder
2. Firewall

Fig. 6, Plunger Adjustment

2.3 Install the mounting capscrews (**Fig. 4**) and tighten them 20 N·m (15 lbf·ft).

2.4 Install and fill the hydraulic fluid reservoir.

2.5 Connect the hydraulic line to the master cylinder. Tighten the fitting (**Fig. 3**) 18 to 24 N·m (13 to 18 lbf·ft).

2.6 Mount the reservoir and its bracket onto the master cylinder mounting bracket. Tighten the two capscrews (**Fig. 1**) 1080 N·cm (96 lbf·in).

2.7 Connect the hydraulic fluid line from the master cylinder to the reservoir. Tighten the hose clamp (**Fig. 2**).

2.8 Fill the reservoir with D.O.T. #3 hydraulic brake fluid.

3. On vehicles built since December 1992, install the master cylinder.

3.1 Connect the hydraulic line to the master cylinder. Tighten the fitting 18 to 24 N·m (13 to 18 lbf·ft).

3.2 Connect the hydraulic fluid line from the master cylinder to the reservoir. Tighten the hose clamp.

3.3 Position the master cylinder and hydraulic fluid reservoir mounting bracket on the firewall. Install and tighten the two capscrews 20 N·m (15 lbf·ft).

3.4 Fill the reservoir with D.O.T. #3 hydraulic brake fluid.

4. Bleed the clutch hydraulic system. For instructions, **refer to Subject 140.**

Slave Cylinder Removal and Installation

Removal

⚠ WARNING

WARNING: Hydraulic brake fluid is hazardous. It may be a skin irritant and can cause blindness if it gets in your eyes. Always wear safety glasses when handling hydraulic brake fluid or bleeding hydraulic lines. If you get hydraulic brake fluid on your skin, wash it off as soon as possible.

1. Disconnect the hydraulic line from the slave cylinder and drain the fluid into a container.
2. Remove the rubber boot from the plunger rod. Remove the slave cylinder mounting capscrews (**Fig. 1**) and nuts; then, remove the slave cylinder.

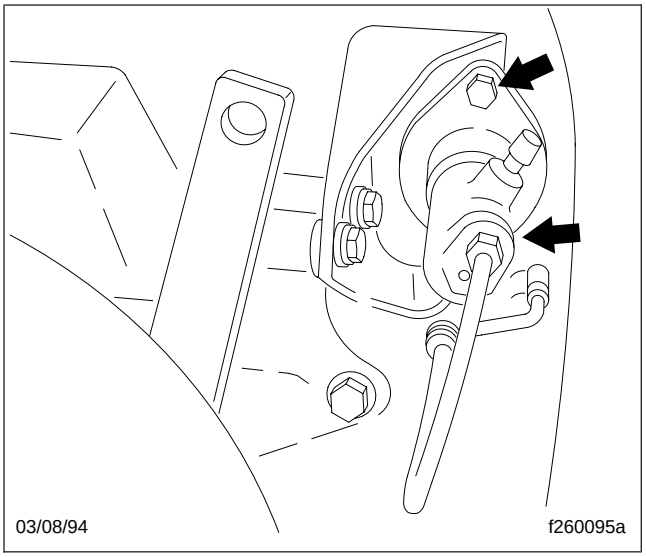


Fig. 1

Installation

1. Make sure that the index marks on the clutch release lever and the release shaft are aligned. **See Fig. 2.**
2. Install the slave cylinder.
   - 2.1 Place a new rubber boot on the plunger rod. Position the clutch slave cylinder on its bracket, making sure that the slave cylinder bleeding valve is pointing up.

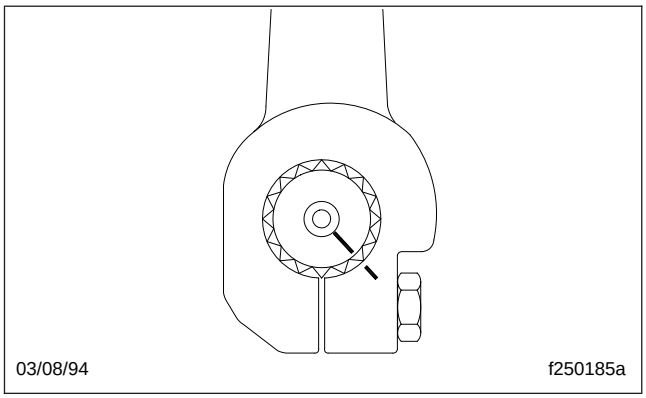


Fig. 2, Index Marks Aligned

   - 2.2 Install the mounting capscrews and nuts. Tighten them 41 N·m (30 lbf·ft).

⚠ CAUTION

CAUTION: Do not push the slave cylinder piston more than 65 mm (2-1/2 inches) into the cylinder, or the piston seal will be damaged by the bleed hole.

   - 2.3 Connect the hydraulic line to the slave cylinder. Tighten the hydraulic line fitting 18 to 24 N·m (13 to 18 lbf·ft).

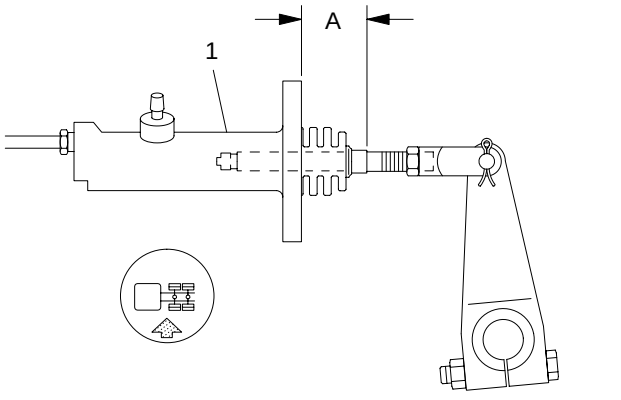
3. Adjust the slave cylinder plunger rod.

   NOTE: The dimensions below apply only to new push-type clutches and correctly adjusted pull-type clutches.

   - 3.1 Turn the plunger rod, moving it in or out of the clevis yoke, to obtain the correct distance between the cylinder mounting surface and the step on the plunger rod shaft. **See Fig. 3** and **Fig. 4**.
     - On a push-type clutch for vehicles built before May 1, 1992, that distance is 44 mm (about 1-3/4 inches): On vehicles built from May 1, 1992, that distance is 62 mm (about 2-1/2 inches).
     - On a pull-type clutch for vehicles with a synchronized transmission, that distance is 44 mm (about 1-3/4 inches): On vehicles with a nonsynchronized transmission, the dis-

Slave Cylinder Removal and Installation

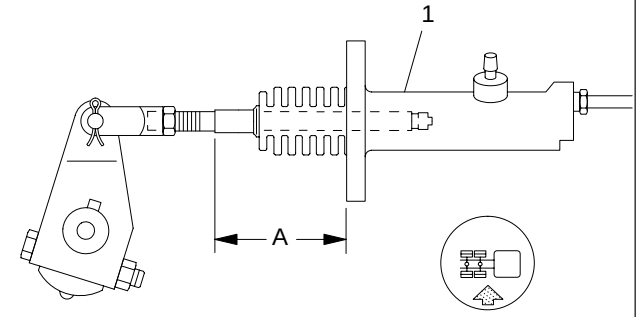
tance is 82 mm (about 3-7/32 inches).



03/08/94 f250201a

A. Prior to 1 May 92– 44 mm (about 1-3/4"); From 1 May 92– 62 mm (about 2-1/2")
1. Slave Cylinder

Fig. 3, Slave Cylinder Adjustment (Push–Type Clutch)



03/08/94 f250202a

A. With synchronized transmissions 44 mm (about 1-3/4"); with nonsynchronized transmissions 82 mm (about 3-7/32")
1. Slave Cylinder

Fig. 4, Slave Cylinder Adjustment (Pull–Type Clutch)

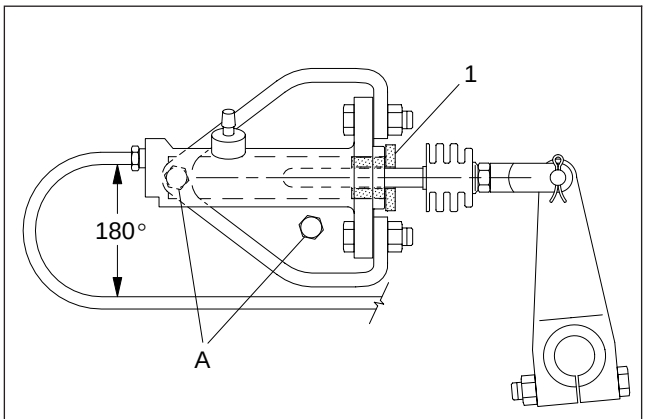
3.2 Tighten the jam nut.

4. Check the alignment of the slave cylinder.

4.1 Carefully detach the rubber boot from the slave cylinder, and push it forward to allow a clear view of the plunger rod where it enters the cylinder bore.

4.2 Place the slave cylinder alignment tool (part number 02-12245-000) over the plunger rod with the flange end of the tool away from the cylinder. Gently slide the tool towards the open end of the cylinder bore, and if possible, insert it into the cylinder bore until the flange of the tool is firmly seated against the end of the cylinder. If there is resistance, lightly press and rotate the tool until it slides into the cylinder. **See Fig. 5.** If the tool can be rotated 360 degrees around the plunger rod, the cylinder and rod are aligned as well as is possible. No other alignment is needed. Remove the tool. Install the rubber boot and make sure that the small end of the boot is located in the groove of the plunger rod and that the other end is seated properly on the slave cylinder flange. Fill and bleed the clutch hydraulic system. **See Subject 140** for instructions.

Otherwise, if the tool can't be rotated 360 degrees around the plunger rod, the cylinder and rod require further alignment. With the tool seated, it can be seen in which direction the rod and or cylinder need to be adjusted. Center the rod horizontally if required. Vehicles with synchronized transmissions (slave cylinder on the right) and non-synchronized transmissions (slave cylinder on the left) can be adjusted for horizontal alignment.

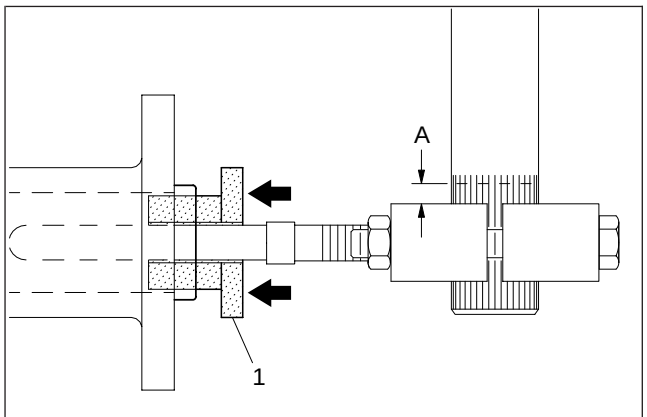


03/08/94 f250097a

A. Adjust here.
1. Slave Cylinder Alignment Tool

Fig. 5

4.3 Scribe or paint a line on the clutch release shaft at the edge of the clutch release lever opposite the direction the lever must be moved. This is in order to mark the original location of the lever on the shaft for later reference.



A. Measure adjustment.
1. Slave Cylinder Alignment Tool

Fig. 6

4.4 Loosen the pinch bolt securing the lever to the shaft, and slide the lever until the plunger rod is centered in the cylinder bore. When the rod is centered, the tool will seat against the end of the cylinder with the slot vertical. Tighten the pinch bolt 34 to 42 N·m (25 to 31 lbf·ft), being careful not to move the lever. Check to ensure that the plunger rod is still approximately centered in the cylinder.

4.5 Using the mark on the shaft as reference, measure the distance the lever was moved to align the plunger rod. **See Fig. 6.** If the lever was moved 5 mm (0.2 inch) or more, the rod was probably cocking the piston, and future cylinder leakage is likely. Replace the cylinder.

5. This step applies only to vehicles with synchronized transmissions (slave cylinder on the right). Center the rod vertically, if required.

5.1 Loosen the two fasteners that mount the slave cylinder bracket to the transmission. **See Fig. 5.**

5.2 Move the mounting bracket up or down until the plunger rod is centered vertically in the cylinder, and the tool will rotate 360 degrees around the plunger rod while pressed against the end of the cylinder; then tighten the two mounting fasteners 34 to 42 N·m (25 to 31 lbf·ft). Check alignment with the alignment tool. Readjust if necessary.

NOTE: The slave cylinder alignment tool is designed to be used during production, or in cases of realignment such as this. The need for readjustment does not necessarily mean that the previous setting was out of specification.

6. When the plunger rod is correctly aligned, and the slave cylinder has been replaced if necessary, carefully install the rubber boot on the cylinder. Ensure that the small end of the boot is located in the groove of the plunger rod and that the other end is seated properly on the slave cylinder flange.

7. Fill and bleed the clutch hydraulic system. **See Subject 140** for instructions.

Clutch Hydraulic System Filling and Bleeding

Filling and Bleeding Using a Pressurized Bleeding Unit

IMPORTANT: If a clutch with internal adjustments is installed on the vehicle, make sure those adjustments are correct before adjusting the plunger rod. Refer to the applicable clutch section in this group for instructions. Also, make sure the slave cylinder plunger rod is properly adjusted. For instructions, refer to **Subject 120**.

⚠ WARNING

WARNING: Hydraulic brake fluid is hazardous. It may be a skin irritant and can cause blindness if it gets in your eyes. Always wear safety glasses when handling hydraulic fluid or bleeding hydraulic lines. If you get hydraulic fluid on your skin, wash it off as soon as possible.

⚠ CAUTION

CAUTION: Do not spill hydraulic brake fluid on the cab paint. Clean it off immediately if any is spilled. Hydraulic brake fluid can damage paint.

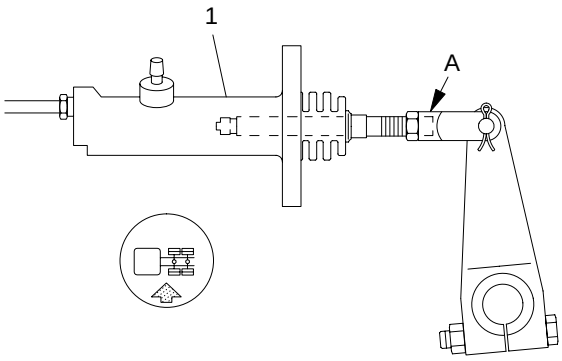
1. Apply the parking brake and chock the tires.
2. Remove the cap from the clutch hydraulic fluid reservoir. Make sure that the reservoir is at least two-thirds full.

NOTE: A pressure bleeding unit (J29532) and a bleeder adaptor (J35798) for the fluid reservoir are available through Kent-Moore Tools and may be used to complete the following procedure. To order these parts, call Kent-Moore at 1-800-328-6657.

3. Prepare the pressure bleeding unit for use according to the manufacturer's instructions. Use DOT #3 hydraulic brake fluid. Also, allow some fluid to run through the pressure unit hose to remove air from the hose. Pressurize the unit to 207 kPa (30 psi).
4. Connect the pressure bleeding unit to the reservoir.
5. Connect a clear drain line to the slave cylinder bleed valve.

IMPORTANT: The slave cylinder may not be mounted in a horizontal position. If it isn't, remove the slave cylinder and hold it in a horizontal position to completely purge all air from the cylinder.

6. Fully depress the clutch pedal and block it in this position.
7. Open the slave cylinder bleed valve; then, open the valve on the bleeder unit. Observe the flow of hydraulic fluid through the slave cylinder drain line. When no bubbles appear in the fluid, close the valve on the slave cylinder. Then, close the valve at the bleeding unit.
8. Move the slave cylinder plunger rod 13 mm (1/2 inch) in and out several times until a firm resistance is felt, or until no bubbles appear in the reservoir. **See Fig. 1.**



06/22/94 f250201b

A. Move the plunger rod in and out about 13 mm (1/2 inch).
1. Slave Cylinder

Fig. 1

9. Disconnect the bleeding unit, and install the cap on the slave cylinder bleeder valve.
10. Check the fluid level in the reservoir. If necessary, add or remove hydraulic fluid to bring the fluid level to the MAX line. Install the reservoir cap.
11. Depress the clutch pedal a few times. There should be resistance over the full pedal stroke.
12. Check the clutch function.
    - 12.1 Make sure that the parking brake is still set.

Clutch Hydraulic System Filling and Bleeding

12.2 Fully depress the clutch and hold it in this position.

12.3 With the transmission in neutral, start the engine.

12.4 Shift the transmission through the gears. All gears must engage easily.

12.5 Keep the clutch pedal fully depressed, the engine running, and the transmission in gear.

12.6 If the clutch begins to engage within approximately three minutes, the system is not working properly. Shut down the engine. Repeat the filling/bleeding procedure.

NOTE: If the clutch system still is not working properly, check the master and slave cylinder operation.

13. Check the entire system for leaks. Tighten connections if necessary. Check the fluid level in the reservoir again.

14. Remove the chocks from the tires.

Clutch Linkage Adjustment

NOTE: Clutch linkage adjustment may be necessary if the master cylinder or slave cylinder is being replaced. It is not necessary after replacing the clutch. Also, there is no linkage adjustment on used push-type clutches. On push-type clutches, the adjustment procedure below applies only to the original installation.

Adjustment

NOTE: If a clutch with internal adjustments is installed on the vehicle, make sure those adjustments are correct before checking the clutch linkage. If internal adjustment is needed, refer to the applicable clutch section in this group.

1. If the master cylinder is being replaced, check the master cylinder plunger rod adjustment.

   1.1 If adjustment is needed, and before attaching the master cylinder, loosen the plunger rod jam nut.

CAUTION

CAUTION: Adjust the plunger rod to extend 38.5 mm (about 1-1/2 inches) beyond the outside surface of the firewall. If the rod extends too far, the piston seals will be damaged when the piston travels too far in the master cylinder bore. In addition, the clutch will not self-adjust because the opening to the clutch fluid reservoir will be blocked. If the rod doesn't extend far enough, there will be play at the clutch pedal.

NOTE: There is normally no play with a hydraulic clutch.

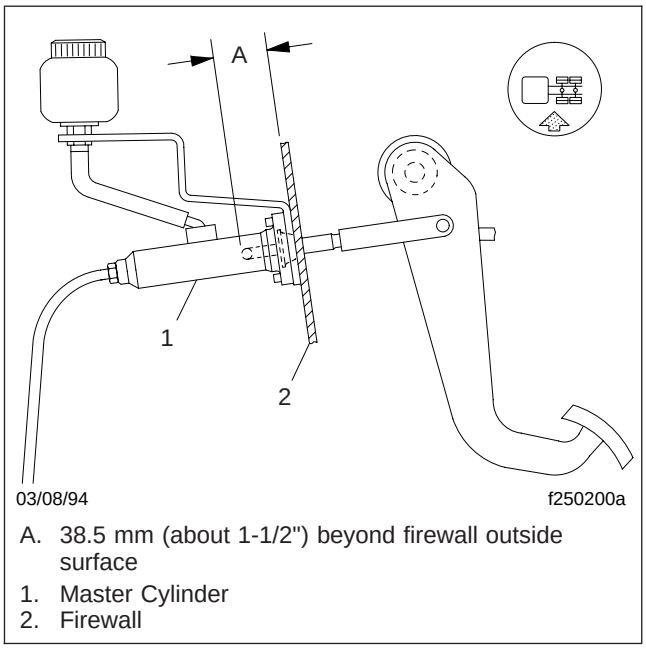
1.2 Adjust the plunger rod by turning it in or out of the clevis yoke until it extends 38.5 mm (about 1-1/2 inches) beyond the outside surface of the firewall. **See Fig. 1.**

1.3 Tighten the jam nut.

1.4 Install the master cylinder. For instructions, **refer to Subject 100**.

2. If the slave cylinder is being replaced, check the slave cylinder plunger rod adjustment.

   2.1 Make sure that the index marks on the clutch release lever and the release shaft are aligned. **See Fig. 2.**



A. 38.5 mm (about 1-1/2") beyond firewall outside surface
1. Master Cylinder
2. Firewall

Fig. 1, Plunger Adjustment

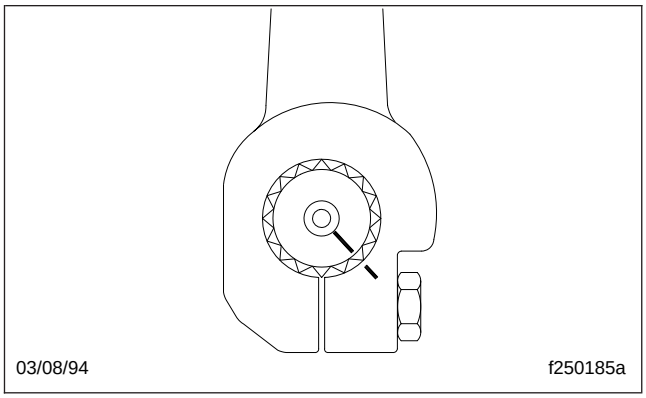


Fig. 2, Index Marks Aligned

2.2 Install the slave cylinder. **Refer to Subject 120** for instructions.

CAUTION

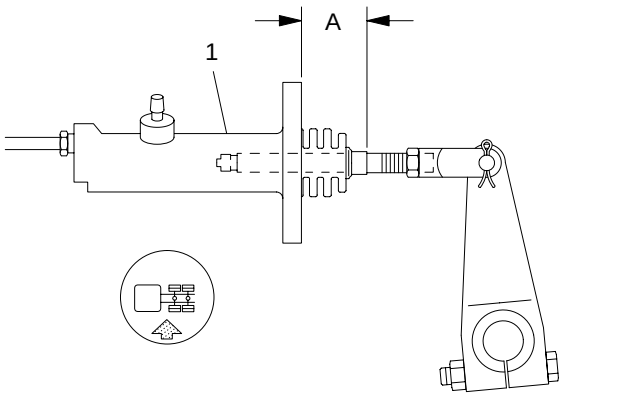
CAUTION: Do not push the slave cylinder piston more than 65 mm (2-1/2 inches) into the cylinder, orthe piston seal will be damaged by the bleed hole.

2.3 If adjustment is needed, adjust the slave cylinder plunger rod by turning it in or out of the clevis yoke to obtain the correct

Clutch Linkage Adjustment

distance between the cylinder mounting surface and the step on the plunger rod shaft. **See Fig. 3** and **Fig. 4**.

- On a push-type clutch for vehicles built before May 1, 1992, that distance is 44 mm (about 1-3/4 inches): On vehicles built from May 1, 1992, that distance is 62 mm (about 2-1/2 inches).
- On a pull-type clutch for vehicles with a synchronized transmission, that distance is 44 mm (about 1-3/4 inches): On vehicles with a nonsynchronized transmission, the distance is 82 mm (about 3-7/32 inches).

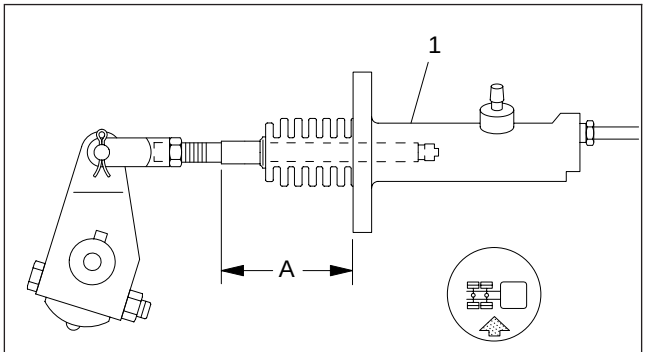


03/08/94 f250201a

A. Prior to 1 May 92&-—44 mm (about 1-3/4"); From 1 May 92—62 mm (about 2-1/2")
1. Slave Cylinder

Fig. 3, Slave Cylinder Adjustment (Push-Type Clutch)

2.4 Tighten the jam nut.



03/08/94 f250202a

A. With synchronized transmissions 44 mm (about 1-3/4"); with nonsynchronized transmissions 82 mm (about 3-7/32")
1. Slave Cylinder

Fig. 4, Slave Cylinder Adjustment (Pull-Type Clutch)

General Description (See Fig. 1)

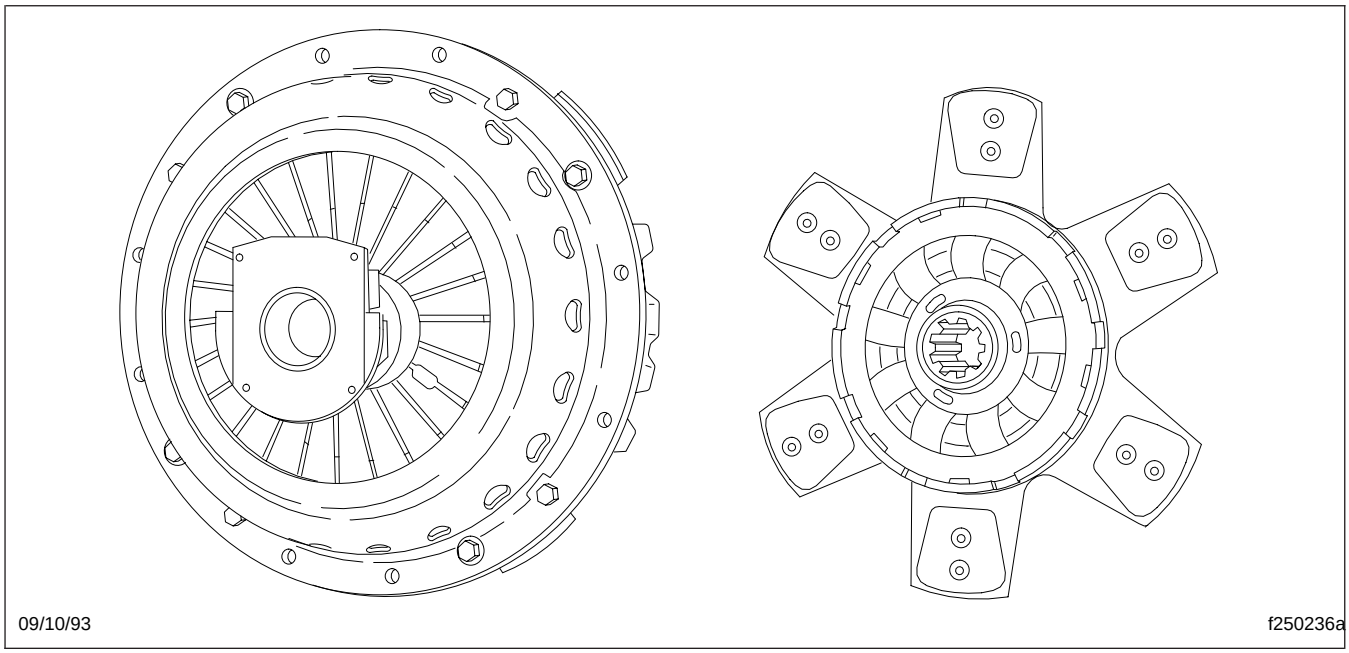


Fig. 1, Valeo 14-Inch Clutch

Valeo clutches installed in Freightliner Business Class vehicles are available in 14-inch and 16-inch models. They are single-plate, diaphragm spring, pull-type clutches. A dampened driven disc is standard. The lining is a "cerametallic" material.

See **Specifications, 400** for additional information.

Special Tools

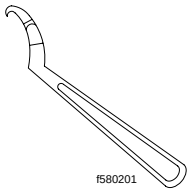
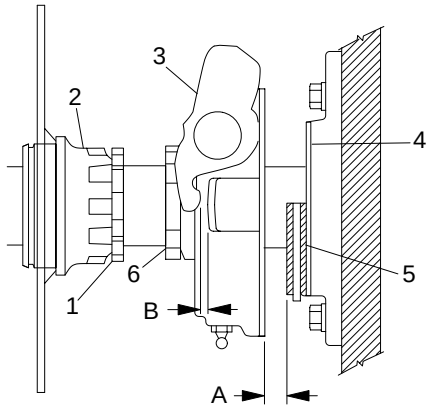
Special Tools				
Quantity Needed	**Tool**	**Description**	**Manufacturer**	**Part Number**
2	 f580201	Adjustable Hook Spanner Wrench	Kent-Moore	J4749

Table 1, Special Tools

Clutch Adjustments

Valeo clutches require two adjustments: release bearing clearance (this distance must be 12.7 to 14.3 mm (1/2 to 9/16 inch) and (on mechanical clutch linkage systems only) clutch free-travel (this distance must be 2.7 to 3.7 mm (0.105 to 0.145 inch). See **Fig. 1**.



09/10/93 f250250a

A. 1/2 to 9/16 inch (12.7 to 14.3 mm) With Clutch Brake
B. 0.105 to 0.145 inch (2.7 to 3.7 mm)
1. Locknut Ring
2. Release Bearing Coupler
3. Release Yoke
4. Bearing Cover
5. Bearing Pad
6. Adjuster Ring

Fig. 1, Clutch Adjustment Measurements

HYDRAULIC CLUTCH CONTROL SYSTEM

1. Using Kent-Moore tool J4749, loosen the locknut ring (**Fig. 1**). Then, rotate the sleeve with the adjuster ring to the specified release bearing clearance.

   With non-synchronized transmissions equipped with a clutch brake, release bearing clearance is 1/2 to 9/16 inch (12.7 to 14.3 mm). See **Fig. 1**.

   With non-synchronized transmissions and no clutch brake, release bearing clearance is 3/4 inch (19 mm).

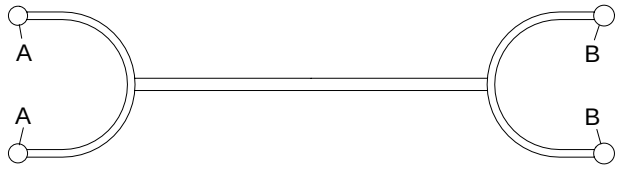
2. Using Kent-Moore tool J4749, tighten the locknut ring against the release bearing coupler. Tighten the locknut 35 to 40 lbf·ft (47 to 61 N·m).

MECHANICAL LINKAGE CLUTCH CONTROL SYSTEM

IMPORTANT: An inspection tool A02–12419 (available through the PDCs) can be used to check the distance between the release bearing and the clutch brake. See **Fig. 2**. One end of the tool has green tape on it and is 0.50 inch (12.7 mm) in diameter; the other end has blue tape on it and is 0.56 inch (14.3 mm) in diameter.

1. If using tool A02–12419 to check the distance between the release bearing and the clutch brake, position the tool so that the legs straddle the transmission input shaft. Check the gap with both ends of the tool as follows:

Clutch Adjustments



A. 0.50 inch (12.7 mm)
B. 0.56 inch (14.3 mm)

Fig. 2, Inspection Tool A02-12419

1.1 Insert the blue 0.56-inch (14.3-mm) end. If it fits loosely the gap is too wide and adjustment is needed. Go to the next step.

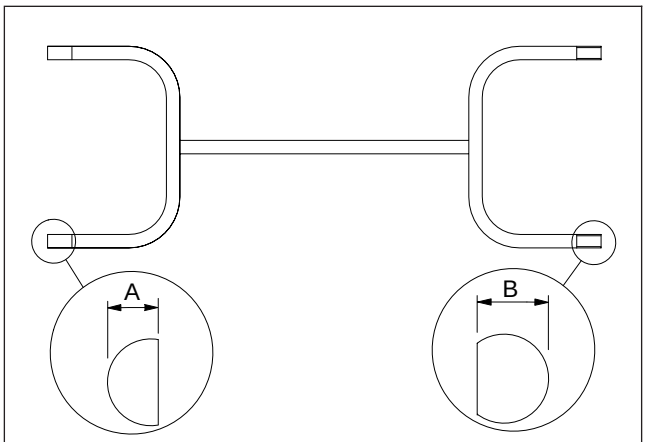
1.2 If the blue 0.56-inch (14.3-mm) end can't be inserted in the gap, then try to insert the green 0.50-inch (12.7-mm) end. If the green end of the tool fits, snug or loose, then no adjustment is needed.

1.3 If the green end of the tool can't be inserted in the gap, adjustment is needed. Go to the next step.

2. Disconnect the external linkage to allow free movement of the release yoke.
3. Using two spanner wrenches (Kent-Moore J4749), loosen the release bearing locknut. Thread the locknut back toward the transmission a small distance to ensure that it will not interfere with the adjustment procedure.
4. Rotate the sleeve with the adjuster ring to the specified release bearing clearance.
5. Using the two spanner wrenches, place one on the notches of the release bearing coupler and the other on the release bearing locknut. Use the first wrench to prevent the coupler from rotating while using the second wrench to tighten the locknut against the coupler as a jamnut.
6. Tighten the locknut ring against the release bearing coupler by placing the two wrenches in notches that will result in the two wrench handles diverging slightly from one another. Then both handles can be grasped with one hand and squeezed closely together.

IMPORTANT: An inspection tool A02–12254 (available through the PDCs) can be used to check the distance between the release bearing and the release fork (free travel). See **Fig. 3**. The legs on one end of the tool have green tape on them and are 0.105 inch (2.7 mm) thick; the legs on the other end have blue tape on them and are 0.145 inch (3.7 mm) thick.

7. If using tool A02–12254 to check the distance between the release bearing and the release fork, position the tool so it straddles the fork to ensure that there won't be any misalignment. Check the distance with both ends of the tool as follows:



A. 2.7 mm (0.105 inch)
B. 3.7 mm (0.145 inch)

Fig. 3, Inspection Tool A02-12254

7.1 Insert the blue 3.7-mm (0.145-inch) end. If it fits loosely the gap is too wide and adjustment is needed. Connect the external linkage, then go to the section on clutch linkage adjustment in this group.

7.2 If the blue 3.7-mm (0.145-inch) end can't be inserted in the gap, then try to insert the green 2.7-mm (0.105-inch) end. If the green end of the tool fits, snug or loose, then no adjustment is needed.

7.3 If the green end of the tool can't be inserted in the gap, adjustment is needed. Connect the external linkage, then perform a clutch linkage adjustment. For instructions, see **Section 25.02**.

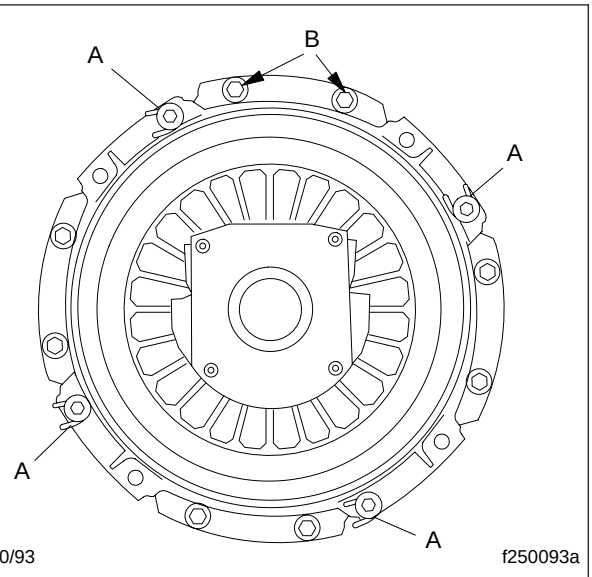
Removal

1. Remove the transmission. Follow the procedures in **Group 26** of this manual.

CAUTION

CAUTION: Do not let the transmission drop, and do not let the transmission hang unsupported by the input shaft in the pilot bearing. Taking these precautions will prevent damage to the clutch assembly and the pilot bearing.

2. Remove the clutch brake (if equipped) from the transmission input shaft.
3. To facilitate clutch removal and installation, Valeo clutches employ four U-clips to hold the pressure plate toward the clutch. Install the four U-clips. See **Fig. 1**.



A. Install U-clips here.
B. Install guide pins here.

Fig. 1, 14-Inch and 16-Inch Clutches

4. Install a clutch alignment tool through the clutch and into the flywheel pilot bearing to support the clutch assembly during removal.

NOTE: If an alignment tool is not available, use an input shaft from a manual transmission. Remove the gear from the end of the input shaft.

5. Remove the top two capscrews from the pressure plate assembly as indicated in **Fig. 1**. Install guide pins in the two holes. If guide pins are not available, they may be made by removing the heads from two capscrews.
6. Remove the remaining capscrews which secure the cover assembly to the flywheel.

WARNING

WARNING: The cover assembly is heavy and should be removed only with a lifting device. If the assembly is lifted improperly or dropped, it could cause serious personal injury.

7. Lift the pressure plate, release bearing, and clutch assembly over the alignment tool and guide pins.
8. Whenever the clutch assembly is serviced or the engine is removed, the pilot bearing in the flywheel should be removed and replaced. Use an appropriate internal puller and a slide hammer to remove the pilot bearing. Install the new pilot bearing with an appropriate driver.

Inspection

1. Inspect the release fork, the cross shaft, and the shaft bushings. Inspect the transmission input shaft splines. Minor scratches may be removed with emery cloth. Replace any damaged or excessively worn parts.
2. Inspect the flywheel for heat spots, warpage, scoring, or cracks around the bolt holes. If necessary, machine or replace the flywheel.
3. Inspect the pressure plate friction surface for wear or damage. If the plate is cracked, replace it. Heat marks are normally found on a pressure plate after operation. These marks can usually be removed with emery cloth. If you cannot remove heat marks with emery cloth, replace the pressure plate.
4. Inspect the pilot bearing. Although the pilot bearing should be replaced whenever the clutch is removed, any excessive wear or damage to the pilot bearing could indicate other problems which should be remedied.

Clutch Removal, Inspection, and Installation

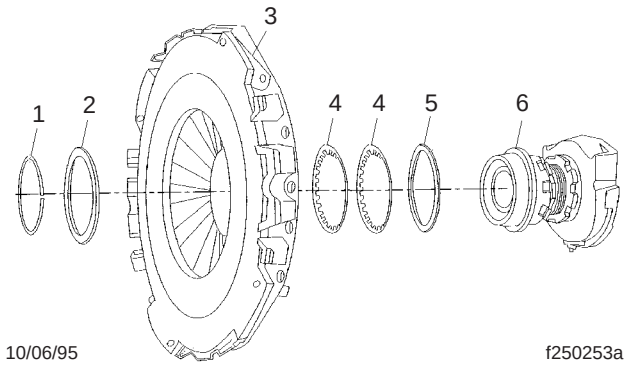
5. Inspect the clutch release linkage, the shafts, and the yoke for wear or binding. Make any necessary repairs.
6. If a clutch brake is installed, inspect the clutch brake wear surface on the transmission. Replace the transmission front bearing cover if necessary.

Installation

NOTE: If you are installing components which have been in operation, do the inspection procedure in this subject before installing the clutch.

1. Lubricate the bore in the crankshaft for the pilot bearing with the specified lubricant. Do not overlubricate. Excess lubricant can contaminate the disc and cause the clutch to slip.

   Using an appropriate driver, install the pilot bearing. Refer to the engine manufacturer's service manual for instructions.
2. Install guide pins in the top two bolt holes of the flywheel. If guide pins are not available, make them by removing the heads from two capscrews.
3. If necessary, install the release bearing assembly on the pressure plate. See **Fig. 2** for assembly.

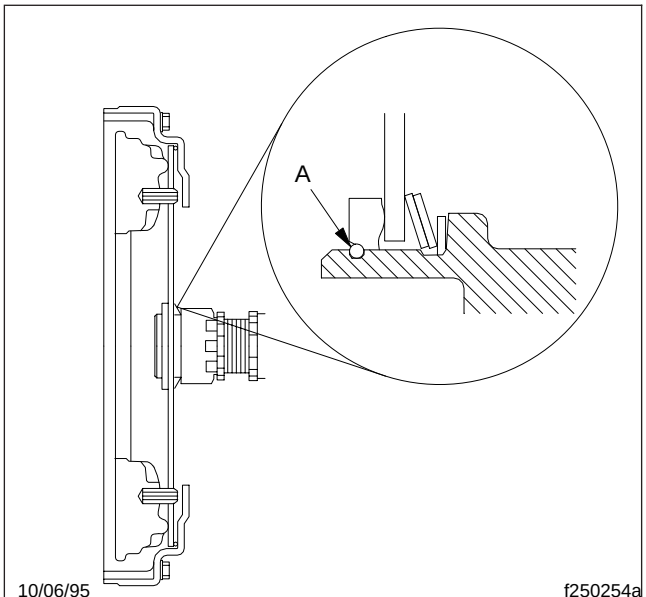


1. Wire Retaining Ring
2. Fulcrum Ring
3. Pressure Plate Cover Assembly
4. Belleville Spring Washer
5. Shim
6. Release Bearing Assembly

Fig. 2, Install the Release Bearing Assembly

3.1 Be sure that the Belleville spring fingers are toward the shim, and that the rounded face of the fulcrum ring is toward the diaphragm fingers of the pressure plate.

3.2 Install the fulcrum ring and the wire retaining ring on the end of the release bearing coupler. Be sure that the wire retaining ring is fully seated in its groove. See **Fig. 3**.



A. Make sure the retaining ring is fully seated in the groove.

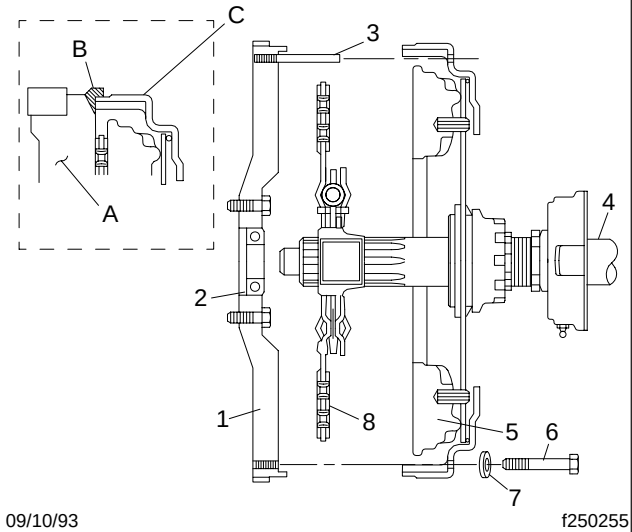
Fig. 3, Seat the Wire Retaining Ring

4. Position the clutch alignment tool in the clutch disc so the flat side of the disc marked *FLYWHEEL SIDE* will face the flywheel. Insert the alignment tool into the pilot bearing.

⚠ WARNING

WARNING: The cover assembly is heavy and should be installed only with a lifting device. If the assembly is lifted improperly or dropped, it could cause serious personal injury.

5. Install the pressure plate assembly over the alignment tool and the guide pins. See **Fig. 4**.
6. Install the mounting capscrews finger-tight in the cover assembly.



A. Flywheel
B. Raised Step
C. Pressure Plate Assembly

1. Flywheel
2. Pilot Bearing
3. Guide Pin
4. Alignment Tool
5. Pressure Plate Assembly
6. Capscrew
7. Washer
8. Clutch Disc

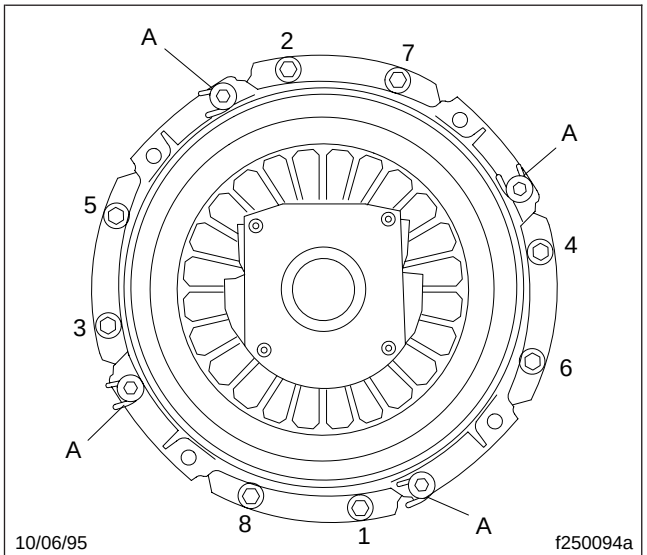
Fig. 4, Pressure Plate Installation, 16-Inch Clutches

For 16-inch clutches, be sure the pressure plate cover fits inside the raised step of the flywheel. Refer to the detail in **Fig. 4**.

Remove the two guide pins, and install the remaining two capscrews.

IMPORTANT: Use hardened washers and grade 8 capscrews. Be sure the capscrews are the correct length. Capscrews which are too short will strip; capscrews which are too long will damage the flywheel and may break off under engine torque.

7. Tighten the capscrews one turn at a time until they are snug. Then, tighten the capscrews as specified below. Follow the tightening sequence in **Fig. 5**.
   - 14-Inch Clutches: 47 to 54 N·m (35 to 40 lbf·ft).
   - 16-Inch Clutches: 54 to 61 N·m (40 to 45 lbf·ft).



A. U-Clip

Fig. 5, 14-Inch and 16-Inch Clutch

8. Remove the four wire U-clips (**Fig. 5**). Remove the clutch alignment tool.
9. Install the transmission. Follow the procedures in **Group 26** of this manual.

CAUTION

CAUTION: Do not let the transmission drop, and do not let the transmission hang unsupported by the input shaft in the pilot bearing bore in the flywheel. Taking these precautions will prevent damage to the clutch assembly and the pilot bearing. If excessive force is required to install the transmission into the flywheel housing, investigate the cause and make necessary corrections.

Specifications

Designation	Definition
EV	Eaton Valeo
115	x 10 = Maximum torque capacity in lbf·ft

Designation	Definition
16	Clutch size in inches

Table 1, Model Nomenclature

Weight and Torque Ratings				
Model	**Total Weight kg (lbs)**	**Torque Rating N·m (lbf·ft)**	**Housing**	**Flywheel**
14-Inch				
EV06514	28 (62)	881 (650)	SAE #2	14-Inch Flat
EV08814	28 (62)	1193 (880)		
EV10514	30 (66)	1424 (1050)		
16-Inch				
EV11516	39 (87)	1559 (1150)	SAE #2	16-Inch Flat
EV12516	41 (91)	1250 (1695)		
EV14016	41 (91)	1898 (1400)		

Table 2, Weight and Torque Ratings

Cover Assembly Torque Values		
Description	**Clutch**	**Torque N·m (lbf·ft)**
Cover Assembly Capscrews (grade 8)	14-Inch	47–54 (35–40)
	16-Inch	54–61 (40–45)

Table 3, Cover Assembly Torque Values

Adjustment Values	
Description	**Adjustment mm (inch)**
Release Yoke Finger to Bearing Pad Clearance	3 (1/8)
Clutch Pedal Free Travel (minimum)	19 (3/4)
Release Travel Clearance: Non-Synchronized Transmission With Clutch Brake	13 (1/2)

Table 4, Adjustment Values

Specifications

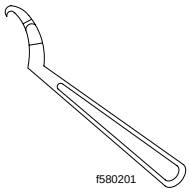
Special Tools			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580201	Adjustable Hook Spaner Wrench	Kent-Moore Tools Kent-Moore Tool Division, 28784 Little Mack, Roseville, MI 48066	J4749

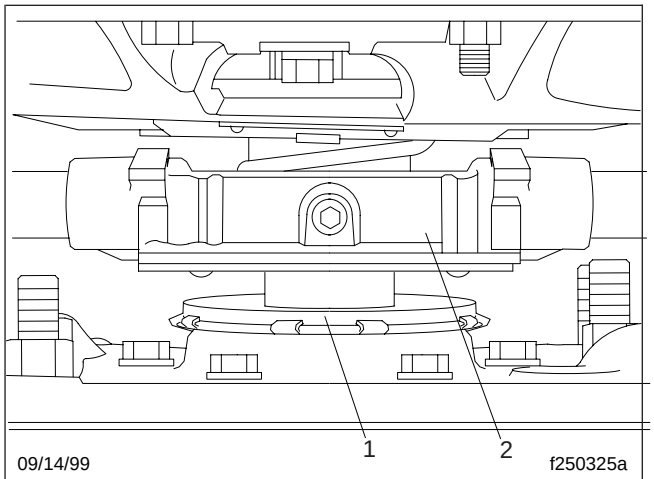
Table 5, Special Tools

General Description

When the vehicle is stationary, a clutch brake permits shifting into first gear or reverse gear without severe gear clash.

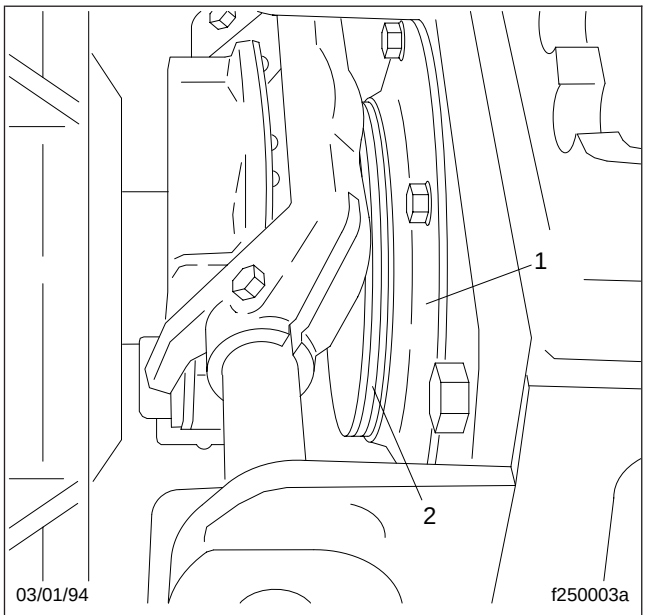
Clutch brake engagement occurs approximately during the last 1 to 1-1/4 inches (25 to 33 mm) of downward pedal travel. The clutch brake is between the release-bearing housing (see **Fig. 1**) and the transmission bearing cap, and is engaged by tangs to the transmission input shaft. When the pedal is fully depressed, the clutch brake is squeezed between the release-bearing housing and the transmission bearing cap (see **Fig. 2**), stopping the rotation of the main drive gear.

The clutch brake may be a disc-type or a torque-limiting type. In addition, the clutch brake may be either a one-piece or two-piece design. To prevent overloads to it, the torque-limiting clutch brake is designed to slip when loads of 20 to 25 lbf·ft (27 to 34 N·m) are reached. Clutch brakes are not designed for upshifting.



1. Clutch Brake
2. Release Bearing

Fig. 1, Clutch Brake and Release Bearing



1. Transmission Input Shaft Bearing Cap
2. Clutch Brake Discs and Washer

Fig. 2, Clutch Brake and Bearing Cap

One-Piece Clutch Brake Replacement

Replacement

1. Shut down the engine, set the parking brake, and chock the tires.
2. Tilt the hood.
3. Drain the air tanks.
4. Disconnect the batteries.
5. Place the transmission in gear.
6. Remove the shift tower from the top of the transmission. See **Group 26** in this manual for instructions.
7. Disconnect the driveline from the rear of the transmission. See **Group 41** in this manual for instructions.
8. Disconnect the midship bearing. See **Group 41** in this manual for instructions. Pull the driveshaft aside and position it out of the way.
9. Remove the fuel tank compression brace. See **Group 47** in this manual for instructions.
10. Disconnect the clutch rod from the clutch release lever. See **Section 25.02** in this group for instructions.
11. Disconnect the transmission wiring.
12. Disconnect the transmission air lines.
13. Remove the auxiliary air tank, if so equipped.
14. Remove the transmission oil cooler and set it aside, out of the way.

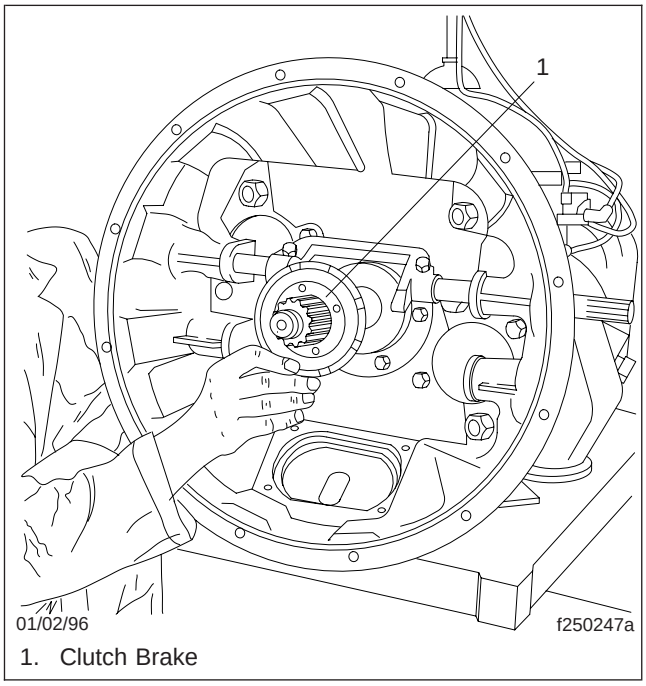
IMPORTANT: Do not disconnect the oil cooler lines.

15. Place a transmission jack in position below the transmission. Adjust the jack to support the transmission.
16. Secure the transmission to the jack.
17. Remove the flywheel housing-to-clutch housing bolts. See **Group 26** in this manual for instructions.

CAUTION

Do not let the rear of the transmission drop, and do not let the transmission hang unsupported in the splined hubs of the clutch discs. Taking these precautions will prevent bending and distortion of the clutch discs.

18. Pull the transmission back until the input shaft clears the flywheel.
19. Remove the old clutch brake from the transmission input shaft. See **Fig. 1**.



1. Clutch Brake

Fig. 1, Clutch Brake Removal

20. Align the tangs of the new clutch brake with the grooves on the input shaft and slide the clutch brake into position. See **Fig. 2**.

CAUTION

Use care to avoid springing the drive discs when the transmission is being installed. Do not force the transmission into the clutch or flywheel housing if it does not enter freely. Do not let the transmission drop or hang unsupported in the driven discs. These practices can damage the clutch assembly.

21. Install the transmission. See **Group 26** in this manual for instructions.
22. Remove the transmission jack.
23. Connect the air lines and the transmission wiring.

One-Piece Clutch Brake Replacement

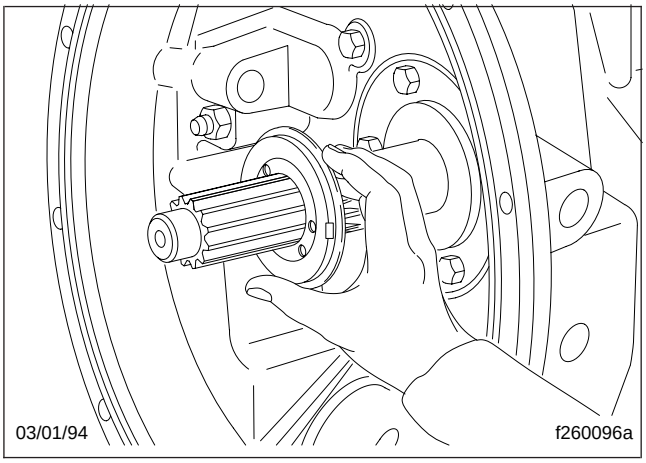


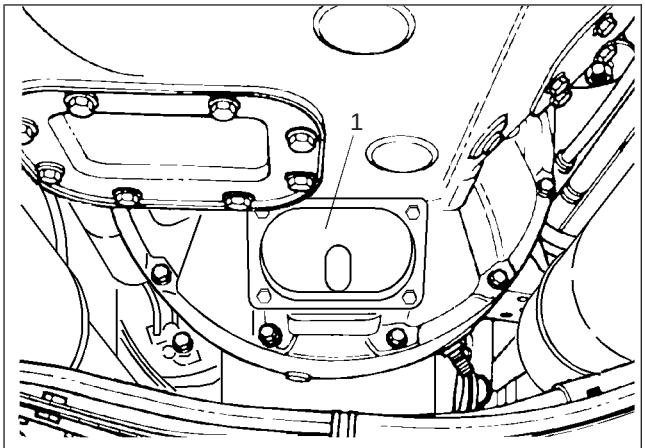
Fig. 2, Clutch Brake Installation

24. Install the fuel tank compression brace. See **Group 47** in this manual for instructions.
25. Install the auxiliary air tank, if so equipped.
26. Install the transmission oil cooler.
27. Install the shift tower on the top of the transmission. See **Group 26** in this manual for instructions.
28. Connect the clutch rod to the clutch release lever. See **Section 25.02** in this group for instructions.
29. Connect the driveline at the rear of the transmission. See **Group 41** in this manual for instructions.
30. Connect the midship bearing. See **Group 41** in this manual for instructions.
31. Ensure that the transmission is out of gear and adjust the clutch. See **Group 25** in this manual for instructions.
32. Connect the batteries.
33. Lower the hood and remove the chocks from the tires.
34. Test drive the vehicle and ensure that the clutch brake and clutch operate properly.

Replacement of a One-Piece Clutch Brake with a Two-Piece Clutch Brake

Replacement

1. Shut down the engine, set the parking brake, and chock the tires.
2. Tilt the hood.
3. Remove the four fasteners and the clutch inspection cover. See **Fig. 1**.



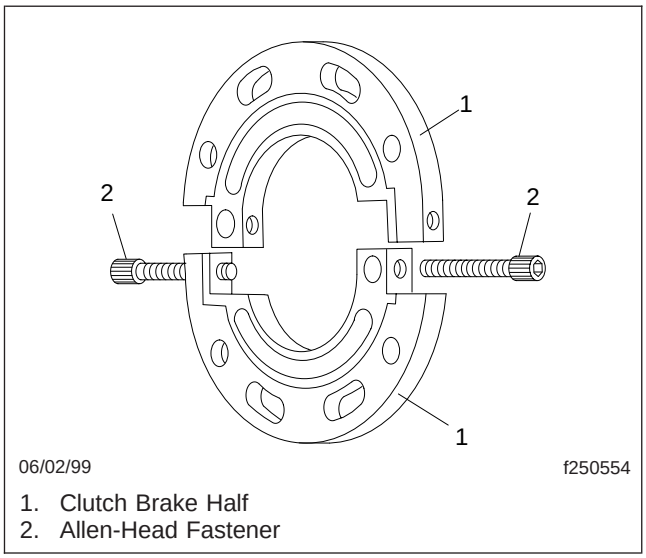
1. Inspection Cover

Fig. 1, Clutch Inspection Cover

⚠ WARNING

Wear safety goggles when cutting off the old clutch brake. If any of the metal parts were to chip, flying pieces of metal could cause eye injury.

4. Using an air chisel, carefully cut off the old clutch brake.
5. Check the orientation and fit of the new two-piece clutch brake halves.
6. Place one half of the new two-piece clutch brake onto the input shaft and rotate it to the top side of the shaft. See **Fig. 2**.
7. Align the lower half with the upper half at the connecting points.
8. Hold both halves together and start the fasteners on both sides.
9. Align the fasteners with the grooves on the input shaft.



1. Clutch Brake Half
2. Allen-Head Fastener

Fig. 2, Two-Piece Clutch Brake (Spicer shown)

10. Tighten Allen-head fasteners 60 lbf·in (675 N·cm).

NOTE: Other types of two-piece clutch brakes use roll pins for fasteners.

⚠ WARNING

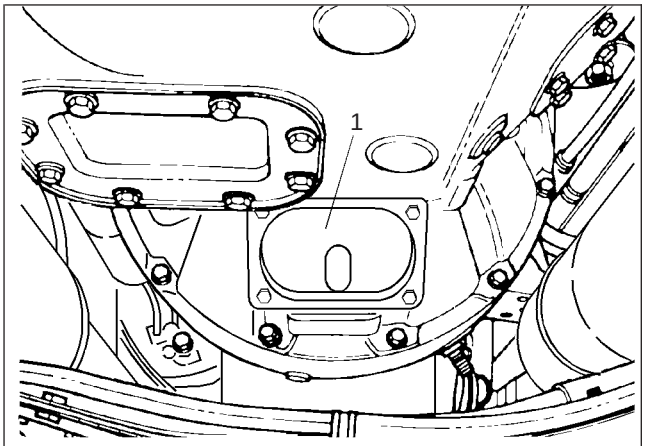
Wear safety goggles when driving in roll pins. If any of the metal parts were to chip, flying pieces of metal could cause eye injury.

11. If the replacement clutch brake uses roll pins, carefully drive in the roll pins equally with a punch and mallet, securing the halves to each other.
12. Install the clutch inspection cover and the four fasteners. Tighten the fasteners securely.
13. Adjust the clutch. See **Group 25** in this manual for instructions.
14. Lower the hood and remove the chocks from the tires.
15. Test drive the vehicle and ensure that the clutch brake and clutch operate properly.

Two-Piece Clutch Brake Replacement

Replacement

1. Shut down the engine, set the parking brake, and chock the tires.
2. Tilt the hood.
3. Remove the four fasteners and the clutch inspection cover. See **Fig. 1**.



1. Inspection Cover

Fig. 1, Clutch Inspection Cover

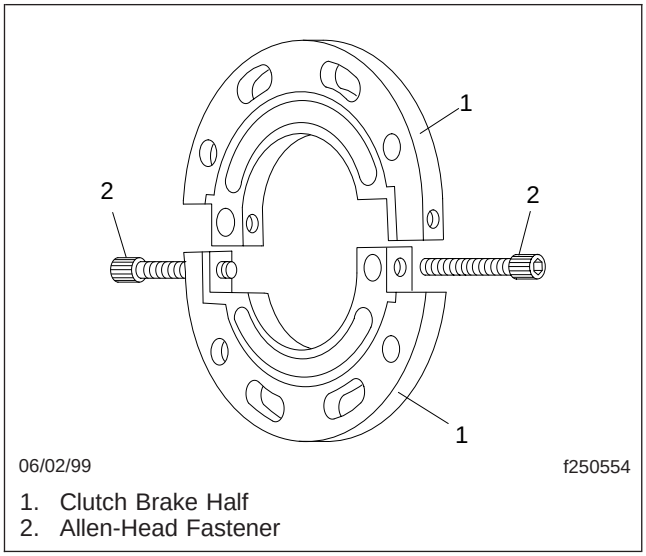
NOTE: Some types of two-piece clutch brakes use roll pins for fasteners.

4. Rotate the input shaft until the Allen-head fasteners or roll pins securing the two clutch brake halves are visible.
5. If the old clutch brake uses Allen-head fasteners, remove the fasteners and remove the two brake halves from the input shaft.

⚠ WARNING

Wear safety goggles when driving out roll pins. If any of the metal parts were to chip, flying pieces of metal could cause eye injury.

6. If the old clutch brake uses roll pins, carefully drive out the pins with a punch and mallet and remove the two brake halves from the input shaft.
7. Check the orientation and fit of the new two-piece clutch brake halves.
8. Place one half of the new two-piece clutch brake onto the input shaft and rotate it to the top side of the shaft. See **Fig. 2**.



1. Clutch Brake Half
2. Allen-Head Fastener

Fig. 2, Two-Piece Clutch Brake (Spicer shown)

9. Align the lower half with the upper half at the connecting points.
10. Hold both halves together and start the fasteners on both sides.
11. Align the fasteners with the grooves on the input shaft.
12. Tighten Allen-head fasteners 60 lbf·in (675 N·cm).

⚠ WARNING

Wear safety goggles when driving in roll pins. If any of the metal parts were to chip, flying pieces of metal could cause eye injury.

13. If the replacement clutch brake uses roll pins, carefully drive in the roll pins equally with a punch and mallet, securing the halves to each other.
14. Install the clutch inspection cover and the four fasteners. Tighten the fasteners securely.
15. Adjust the clutch. See **Group 25** in this manual for instructions.
16. Lower the hood and remove the chocks from the tires.

Two-Piece Clutch Brake Replacement

17. Test drive the vehicle and ensure that the clutch brake and clutch operate properly.

Troubleshooting Tables

Problem—Broken Tabs on the Clutch Brake

Problem—Broken Tabs on the Clutch Brake	
Possible Cause	**Remedy**
Vibration.	Inspect the clutch disc hubs; check the installation of the clutch. Make sure dampened discs are used.
The clutch linkage is incorrectly adjusted.	Adjust the clutch linkage. Also, check the installation of the clutch.
The driver used the clutch brake while the vehicle was moving.	Use correct driving technique.
The driver used the clutch to hold the vehicle on a hill when stopped.	Use correct driving technique.**Problem - Broken Tabs on the Clutch Brake**

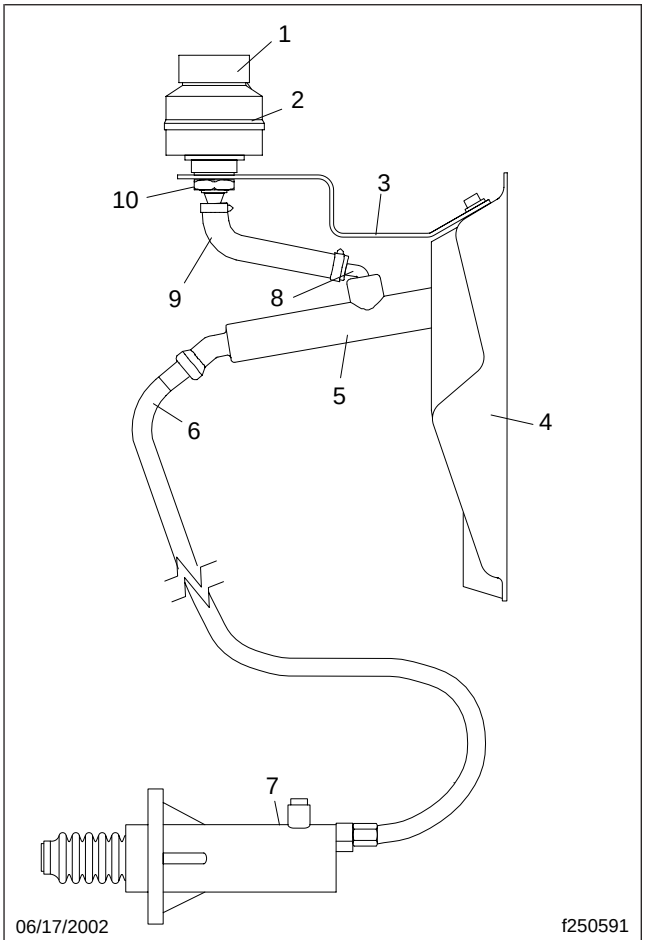
Problem—Poor Clutch Release

Problem—Poor Clutch Release	
Possible Cause	**Remedy**
The clutch brake is damaged and/or not functioning.	Install a new clutch brake.**Problem - Poor Clutch Release**

General Information

The Sachs hydraulic clutch is a 14.5-inch (365 mm) push-type clutch that is used with the MBT520 and MBT660 medium-duty transmissions. All Mercedes-Benz transmission models require a hydraulic clutch system. For more information on the Mercedes-Benz transmissions, see **Section 26.00**.

The hydraulic clutch control system consists of a fluid reservoir, a master cylinder, various connectors and hoses, and a slave cylinder. See **Fig. 1**.



1. Reservoir
2. Reservoir Cap
3. Reservoir Bracket
4. Clutch Support Plate
5. Master Cylinder
6. Hydraulic Hose
7. Slave Cylinder
8. Elbow Connector
9. Reservoir Hose
10. Jam Nut

Fig. 1, Clutch Components

Principles of Operation

When the clutch pedal is pressed, the fluid in the master cylinder is forced through a hydraulic line to the slave cylinder. The fluid pressure moves the slave cylinder piston, pushing the plunger rod and clutch release lever, which disengages the clutch.

The hydraulic system is self-adjusting. To bleed the system, see **Subject 140**.

Reservoir Removal and Installation

Removal

⚠ WARNING

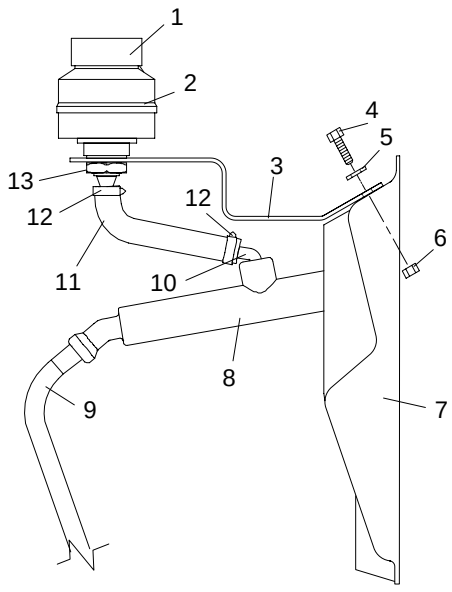
Clutch hydraulic fluid (DOT 3 brake fluid) is hazardous. It may be a skin irritant and can cause blindness if it gets in your eyes. Always wear safety glasses when handling clutch hydraulic fluid or bleeding hydraulic lines. If you get clutch hydraulic fluid on your skin, wash it off as soon as possible.

1. Shut down the engine.
2. Apply the parking brakes, chock the front and rear tires, and open the hood.
3. Using a flat-head screwdriver, remove the quick-disconnect clamp that attaches the hydraulic hose to the slave cylinder. Retain the clamp for later installation.

⚠ CAUTION

Do not spill clutch hydraulic fluid (DOT 3 brake fluid) on the cab paint. Clean it off immediately if any is spilled. DOT 3 brake fluid can damage paint.

4. Drain the hydraulic fluid from the entire system.
   - 4.1 Using a drain pan or other suitable container, collect the fluid that drains from the reservoir, not more than 0.3 quarts (0.3 liters).
   - 4.2 Allow the open end of the drain hose to remain over the drain pan.
   - 4.3 Press down on the pedal several times, until no more fluid drains from the reservoir.
   - 4.4 Cover the hose to avoid contamination of the hydraulic fluid.
5. Using a flat-head screwdriver, remove the hose clamp that attaches the reservoir hose to the master cylinder. Retain the clamp for later installation.
6. Remove the two 5/16–24 mounting bolts, washers, and locknuts with nylon inserts attaching the reservoir bracket to the clutch support plate (pie pan). See **Fig. 1**.



02/26/2003 f250601

1. Reservoir Cap
2. Reservoir
3. Reservoir Bracket
4. Bracket Mounting Bolt, 5/16–24
5. Hardened Flatwasher
6. Locknut, 5/16–24
7. Clutch Support Plate
8. Master Cylinder
9. Hydraulic Hose
10. Elbow Connector
11. Reservoir Hose
12. Hose Clamp
13. Jam Nut, M18

Fig. 1, Reservoir and Bracket

7. Remove the reservoir and reservoir bracket from the vehicle.
8. Clamp the reservoir bracket in a vise.
9. Loosen the M18 jam nut attaching the reservoir to the reservoir bracket. Remove the reservoir from the bracket.

Installation

1. Position the reservoir on the bracket, with the bracket still in the vise. Tighten the jam nut 147 lbf·ft (199 N·m).

Reservoir Removal and Installation

2. Mount the reservoir bracket on the flange of the clutch support plate, as removed.
3. With the bracket mounted on the vehicle, remove the vise holding the reservoir and bracket.
4. Install the two bracket mounting bolts and tighten them 13 lbf·ft (18 N·m).
5. Connect the reservoir hose to the master cylinder. Install the clamp, as removed.

⚠ WARNING

Use only approved clutch hydraulic fluid (DOT 3 brake fluid). Do not mix different types of brake fluid. The wrong fluid will damage the rubber parts of the system, causing loss of clutch function and the risk of serious personal injury.

6. Fill the reservoir with approved DOT 3 hydraulic brake fluid. Flush and bleed the system according to the procedures in **Subject 140**.

NOTE: Make sure clean fluid comes out while bleeding.

7. Check the function of the clutch actuation system according to the procedures under the heading "Clutch Actuation System Check" in **Troubleshooting, 300**.

Replacement

WARNING

Clutch hydraulic fluid (DOT 3 brake fluid) is hazardous. It may be a skin irritant and can cause blindness if it gets in your eyes. Always wear safety glasses when handling clutch hydraulic fluid or bleeding hydraulic lines. If you get clutch hydraulic fluid on your skin, wash it off as soon as possible.

1. Drain the hydraulic fluid from the entire system. For detailed procedures, see **Subject 100**.
2. Remove the reservoir, following the procedures in **Subject 100**.

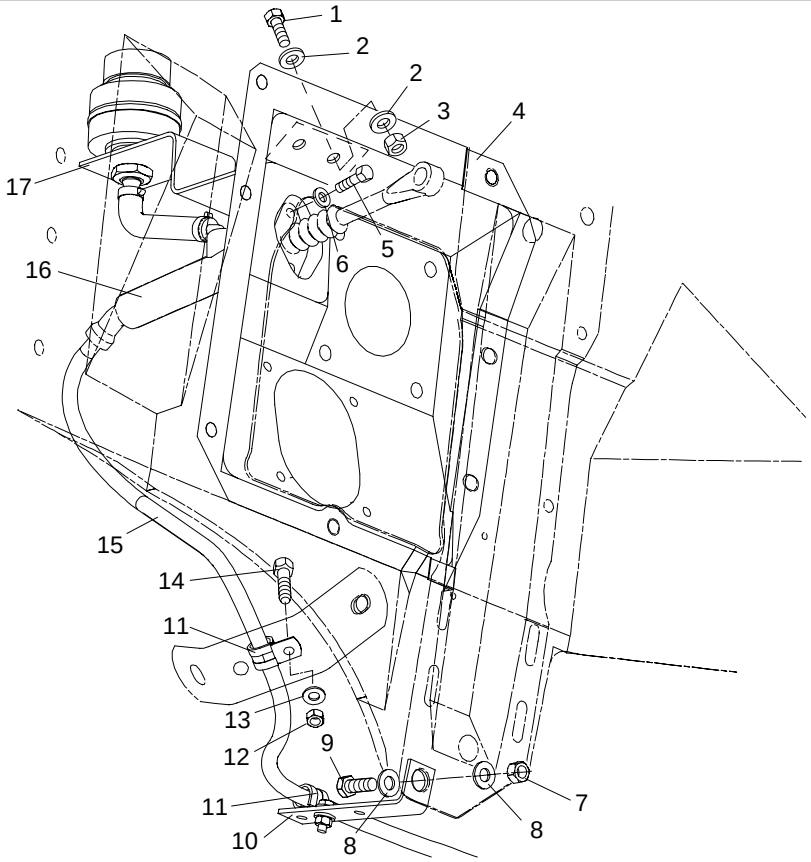
CAUTION

Do not spill clutch hydraulic fluid (DOT 3 brake fluid) on the cab paint. Clean it off immediately if any is spilled. DOT 3 brake fluid can damage paint.

3. Using a flat-head screwdriver, remove the quick-disconnect clamp that attaches the hydraulic hose to the hose connector on the master cylinder. Retain the clamp for later installation. Remove the hose connector from the opening in the end of the master cylinder. See **Fig. 1**.
4. Remove the two M6 master cylinder capscrews and washers from the holes in the clutch support plate.
5. Slide the clevis on the master cylinder off the clevis pin on the clutch pedal.
6. Remove the old master cylinder from the clutch support plate.
7. Attach the clevis on the new master cylinder to the clevis pin on the clutch pedal.
8. Fasten the new master cylinder to the clutch support plate. Tighten the capscrews 60 lbf·in (680 N·cm).
9. Attach the hose connector and hydraulic hose to the opening in the end of the master cylinder.
10. Moisten the tip of the elbow connector in DOT 3 brake fluid. Insert the moistened tip of the elbow into the opening in the top of the master cylinder.
11. Install the reservoir hose.
12. Install the reservoir, following the procedures in **Subject 100**.

NOTE: Make sure clean fluid comes out while bleeding.

Master Cylinder Replacement



06/20/2002 f250593

1. Reservoir Bracket Mounting Bolt, 5/16–24
2. Steel-Plated Washer, 5/16
3. Locknut, 5/16–24
4. Clutch Support Plate
5. Master Cylinder Capscrew, M6
6. Hardened Flatwasher, M6
7. Locknut, 1/2–13
8. Hardened Flatwasher, 0.53
9. Frontwall Bracket Mounting Bolt, 1/2–13
10. Frontwall Standoff Bracket
11. Cushioned Clamp
12. Locknut, 1/4–20
13. Steel-Plated Washer, 1/4
14. Clamp Mounting Bolt, 1/4–20
15. Hydraulic Hose
16. Master Cylinder
17. Reservoir Bracket

Fig. 1, Clutch Master Cylinder

Replacement

WARNING

Clutch hydraulic fluid (DOT 3 brake fluid) is hazardous. It may be a skin irritant and can cause blindness if it gets in your eyes. Always wear safety glasses when handling clutch hydraulic fluid or bleeding hydraulic lines. If you get clutch hydraulic fluid on your skin, wash it off as soon as possible.

1. Shut down the engine.
2. Apply the parking brakes, chock the front and rear tires, and open the hood.
3. Using a flat-tip screwdriver, remove the quick-disconnect clamp that attaches the hydraulic hose to the slave cylinder. Retain the clamp for later installation.

WARNING

Never take the slave cylinder apart while it is connected to the hydraulic hose. If the slave cylinder is removed from the bell housing, the metal pushrod inside the cylinder can be released at high speed, causing component damage and serious personal injury.

4. Drain the hydraulic fluid from the entire system. See **Fig. 1**. For detailed procedures, see **Subject 100**.
5. Loosen the four M8 slave cylinder mounting capscrews attaching the slave cylinder to the bell housing.
6. After bracing the slave cylinder so that it does not fall, remove the four slave cylinder mounting capscrews. Retain the capscrews for later installation.

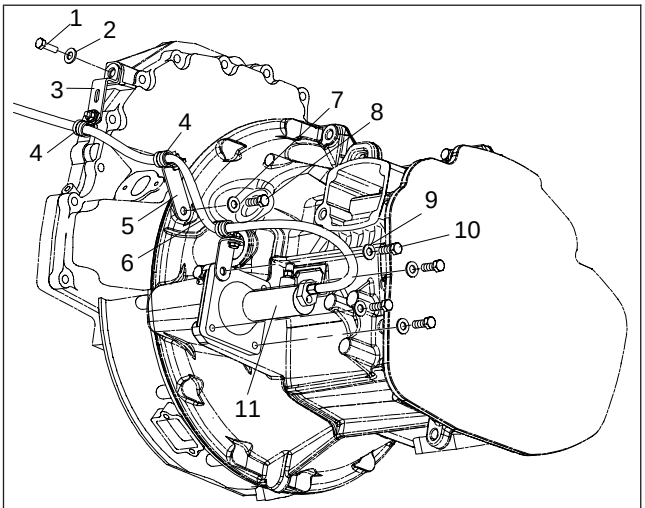
IMPORTANT: Be sure to mount the slave cylinder with the bleed valve on top, as shown in **Fig. 1**.

7. Mount the slave cylinder on the bell housing, as removed.
   - 7.1 Make sure that the pushrod is attached to the clutch fork and inserted into the pushrod bore in the slave cylinder.
   - 7.2 Push the slave cylinder against the bell housing to compress the internal spring.
8. Install the four slave cylinder mounting capscrews and tighten them 13 lbf·ft (18 N·m).
9. Connect the hydraulic hose to the slave cylinder. Install the clamp, as removed.

WARNING

Use only approved clutch hydraulic fluid (DOT 3 brake fluid). Do not mix different types of brake fluid. The wrong fluid will damage the rubber parts of the system, causing loss of clutch function and the risk of serious personal injury.

10. Fill the reservoir with approved DOT 3 hydraulic brake fluid. Flush and bleed the system according to the procedures in **Subject 140**.



06/20/2002 f250592

1. Timing Case Mounting Capscrew, M10
2. Hardened Flatwasher, M10
3. Timing Case Standoff Bracket
4. Cushioned Clamp
5. Bell Housing Standoff Bracket
6. Hydraulic Hose
7. Flatwasher, M10
8. Bell Housing-to-Timing Case Mounting Capscrew, M10
9. Flatwasher, M8
10. Slave Cylinder Mounting Capscrew, M8
11. Slave Cylinder

Fig. 1, Clutch Slave Cylinder

Slave Cylinder Replacement

NOTE: Make sure clean fluid comes out while bleeding.

11. Check the function of the clutch actuation system according to the procedures under the heading "Clutch Actuation System Check" in **Trouble-shooting, 300**.

Special Tools

A special tool is used for this procedure. See **Table 1**.

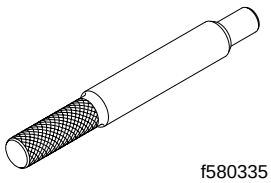
Special Tool			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580335	Clutch Centering Pin	Kent-Moore	J-45719

Table 1, Special Tool

NOTE: To check tool availability, and to order tools, call SPX Kent-Moore at 1-800-328-6657.

Removal

1. Remove the transmission from the engine. For instructions, see **Section 26.00**, Subject 110.
2. Remove the cover assembly. See **Fig. 1**. Loosen the capscrews in a star pattern, taking care not to loosen any one capscrew too much before loosening the next one.

IMPORTANT: The clutch disc is under tension. If one capscrew is loosened too much, it places too much tension on the cover assembly.

3. Remove the clutch disc assembly.

Installation

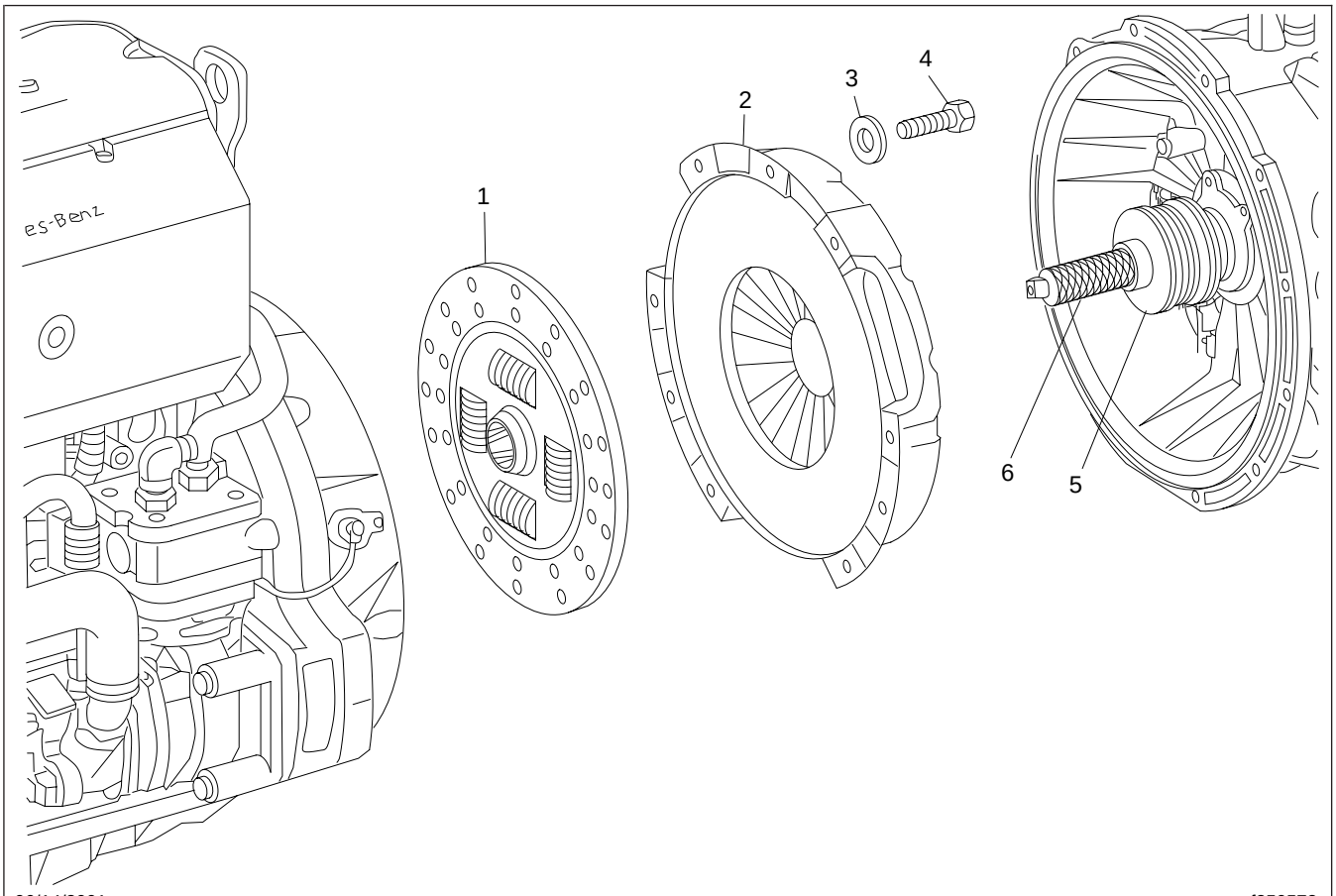
1. Grease the splines of the input shaft and the hub of the disc assembly. Remove any excess grease.

NOTE: Do not grease the guide of the release bearing. The release bearing is made of plastic with an embedded grease.

IMPORTANT: Don't remove the centering pin until the clutch is completely installed.

2. Using the centering pin (**Table 1**), center the disc assembly on the input shaft. See **Fig. 2**.
3. Install the cover assembly.
   - 3.1 Tighten the capscrews progressively in a star pattern. Do not put more tension on one side of the clutch than on the other.
   - 3.2 Tighten the eight clutch capscrews to a final torque of 37 lbf·ft (50 N·m).
4. When all bolts have been tightened, remove the centering pin.
5. Install the transmission on the engine. For instructions, see **Section 26.00**, Subject 110.

Hydraulic Clutch Removal and Installation



1. Disc Assembly
2. Cover Assembly
3. Washer
4. Clutch Capscrews, 3/8–16 x 13/16
5. Release Bearing
6. Input Shaft

Fig. 1, Clutch Assembly

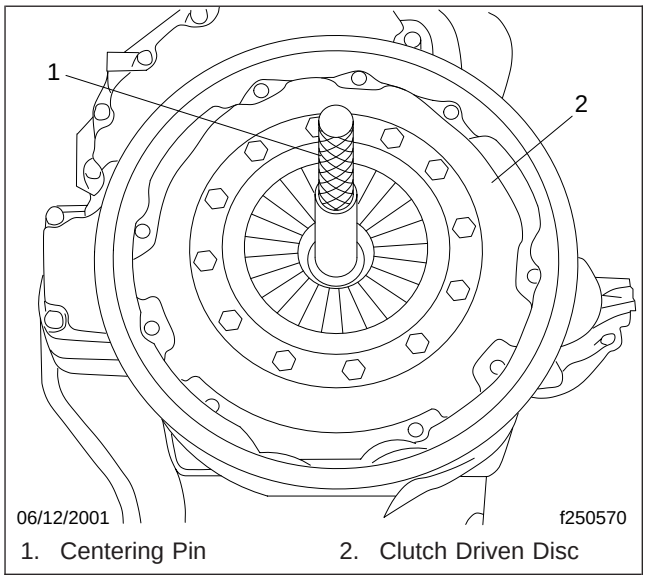


Fig. 2, Centering the Disc

NOTE: Use pressurized bleeding to flush a unit for service. Use manual bleeding if a problem arises during the pressurized bleeding process.

Filling and Bleeding Using a Pressurized Bleeding Unit

1. Apply the parking brake and chock the tires.

⚠ WARNING

Clutch hydraulic fluid (DOT 3 brake fluid) is hazardous. It may be a skin irritant and can cause blindness if it gets in your eyes. Always wear safety glasses when handling clutch hydraulic fluid or bleeding hydraulic lines. If you get clutch hydraulic fluid on your skin, wash it off as soon as possible.

2. Prepare the pressure bleeding equipment according to the manufacturer's instructions. Use DOT 3 brake fluid. Pressurize the bleeder unit to 15 psi (103 kPa).

⚠ WARNING

Use only approved clutch hydraulic fluid (DOT 3 brake fluid). Do not mix different types of brake fluid. The wrong fluid will damage the rubber parts of the system, causing loss of clutch function and the risk of serious personal injury.

3. Remove the reservoir lid and install the pressure bleed adaptor on the reservoir. See **Fig. 1**.
4. Remove the cap from the bleed valve. Install a transparent drain hose on the bleed valve of the slave cylinder. See **Fig. 2**.

IMPORTANT: The slave cylinder may not be mounted in a horizontal position. If it isn't, remove the slave cylinder and hold it in a horizontal position to completely purge all air from the cylinder.

5. Pressurize the reservoir, filling the system. Open the bleed valve on the bleed tank.

NOTE: A pressure bleeder hose (J-29532) and a bleeder adaptor (J-35798) for the fluid reservoir are available through SPX Kent-Moore Tools and may be used to complete the following procedure. To order these parts, call Kent-Moore at 1-800-328-6657.

6. Press the clutch pedal all the way down and keep it down.
7. Open the slave cylinder bleed valve. Observe the flow of clutch hydraulic fluid through the drain hose. When no bubbles appear in the fluid, close the valve on the slave cylinder. Release the clutch pedal and then close the valve at the bleeder unit.

NOTE: Make sure clean fluid comes out while bleeding.

8. Disconnect the bleeder unit, and install the cap on the slave cylinder bleed valve. Tighten the bleed screw 65 lbf·in (740 N·cm).
9. Check the fluid level in the reservoir. If necessary, add or remove DOT 3 brake fluid to bring the fluid level to the MAX line. Install the reservoir cap.
10. Depress the clutch pedal a few times. There should be resistance over the full pedal stroke.
11. Check the entire system for leaks. Tighten connections if necessary. Check the fluid level in the reservoir again.
12. Remove the chocks from the tires.

Manual Filling and Bleeding

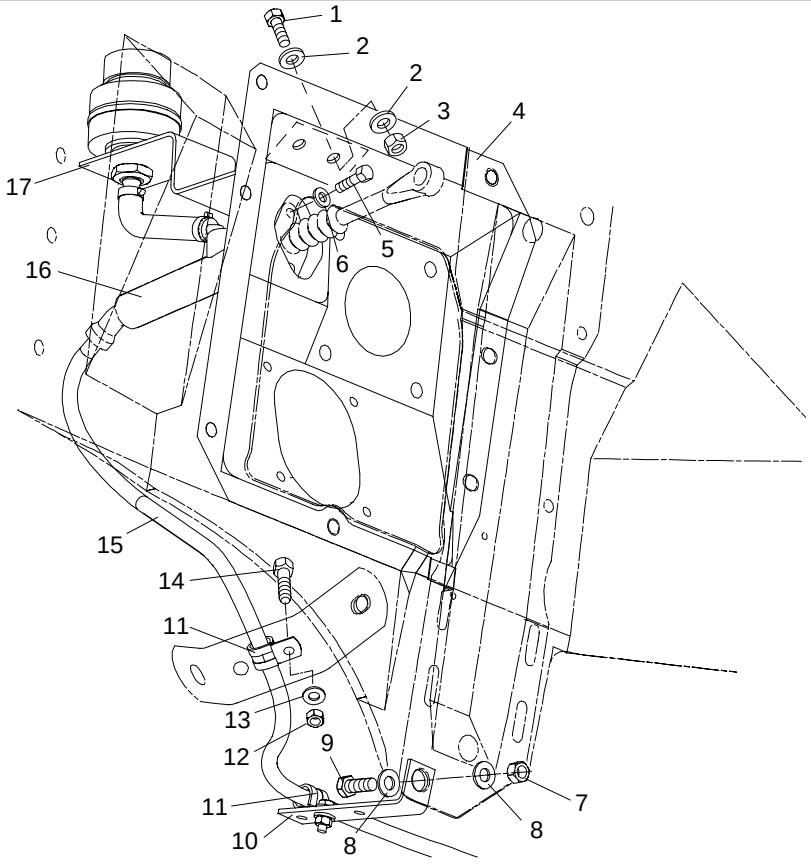
1. Apply the parking brake and chock the tires.
2. Raise the hood.

⚠ WARNING

Clutch hydraulic fluid (DOT 3 brake fluid) is hazardous. It may be a skin irritant and can cause blindness if it gets in your eyes. Always wear safety glasses when handling clutch hydraulic fluid or bleeding hydraulic lines. If you get clutch hydraulic fluid on your skin, wash it off as soon as possible.

3. Fill the reservoir with DOT 3 brake fluid. Check periodically throughout the bleed process to make sure that the reservoir remains full.

Clutch Hydraulic System Filling and Bleeding



06/20/2002 f250593

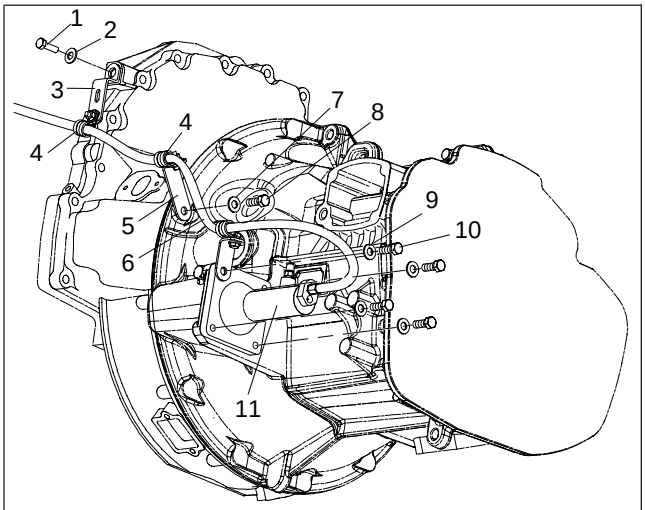
1. Reservoir Bracket Mounting Bolt, 5/16–24
2. Steel-Plated Washer, 5/16
3. Locknut, 5/16–24
4. Clutch Support Plate
5. Master Cylinder Capscrew, M6
6. Hardened Flatwasher, M6
7. Locknut, 1/2–13
8. Hardened Flatwasher, 0.53
9. Frontwall Bracket Mounting Bolt, 1/2–13
10. Frontwall Standoff Bracket
11. Cushioned Clamp
12. Locknut, 1/4–20
13. Steel-Plated Washer, 1/4
14. Clamp Mounting Bolt, 1/4–20
15. Hydraulic Hose
16. Master Cylinder
17. Reservoir Bracket

Fig. 1, Clutch Master Cylinder

⚠ WARNING

Use only approved clutch hydraulic fluid (DOT 3 brake fluid). Do not mix different types of brake fluid. The wrong fluid will damage the rubber parts of the system, causing loss of clutch function and the risk of serious personal injury.

4. Place a wrench on the bleed valve.
5. Remove the cap from the bleed valve. Install a transparent drain hose on the bleed valve of the slave cylinder.
6. Open the bleed valve and allow the fluid to drain into a drain pan or other suitable container.
7. Observe the flow of clutch hydraulic fluid through the drain hose. When no bubbles appear in the fluid, close the bleed valve.



06/20/2002 f250592

1. Timing Case Mounting Capscrew, M10
2. Hardened Flatwasher, M10
3. Timing Case Standoff Bracket
4. Cushioned Clamp
5. Bell Housing Standoff Bracket
6. Hydraulic Hose
7. Flatwasher, M10
8. Bell Housing-to-Timing Case Mounting Capscrew, M10
9. Flatwasher, M8
10. Slave Cylinder Mounting Capscrew, M8
11. Slave Cylinder

Fig. 2, Clutch Slave Cylinder

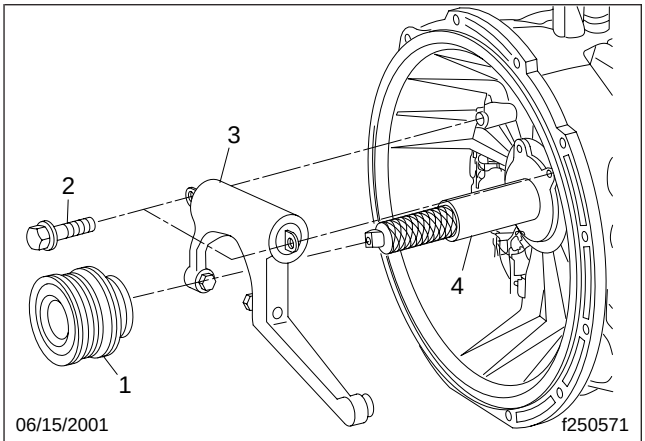
NOTE: The following procedure requires two persons, one to operate the bleed valve and the other to press on the clutch pedal.

8. Bleed the air from the hydraulic clutch system.
   - 8.1 Press the clutch pedal down by hand, using a slow stroke. Stop before the pedal reaches the floor.
   - 8.2 Open the bleed valve while the other person is pressing down on the pedal.
   - 8.3 Close the bleed valve quickly, before the pedal stroke has ended.
   - 8.4 Slowly return the pedal to the top of its travel.
   - 8.5 With the bleed valve closed, pump the pedal several times slowly.
   - 8.6 Observe the clean fluid in the drain hose for air bubbles. Repeat this procedure as often as necessary, until no bubbles appear in the fluid.

   NOTE: Make sure clean fluid comes out while bleeding.
9. Check the function of the clutch actuation system according to the procedures under the heading "Clutch Actuation System Check" in **Troubleshooting, 300**.
10. If the pedal still feels soft or spongy, there may be air in the system.
    - 10.1 Press the pedal halfway down, then quickly jerk the pedal back to the top of its travel. Repeat a few times.
    - 10.2 Repeat the bleed procedure above until the pedal feels firm and responsive.
11. Check the fluid level in the reservoir and add fluid if necessary.
12. Tighten the bleed screw 65 lbf·in (740 N·cm).
13. Remove the chocks from the tires.

Replacement

1. Remove the transmission from the engine. For instructions, see **Section 26.00**, Subject 110.
2. Remove the release bearing from the release yoke. See **Fig. 1**.



1. Release Bearing
2. Mounting Capscrew
3. Release Yoke
4. Input Shaft

Fig. 1, Release Yoke Assembly

3. Remove the two capscrews attaching the release yoke to the bell housing. Remove the release yoke from the transmission.
4. Install the release yoke. Tighten the two capscrews 33 lbf·ft (45 N·m).

IMPORTANT: Position the release bearing with the stop pin located at either the top or the bottom.

5. Install the bearing onto the release yoke.

NOTE: Do not grease the guide of the release bearing. The release bearing is made of plastic with an embedded grease.

6. Install the transmission on the engine. For instructions, see **Section 26.00**, Subject 110.

Hydraulic Hose Replacement

Replacement

1. Shut down the engine.
2. Apply the parking brakes, chock the front and rear tires, and open the hood.

⚠ WARNING

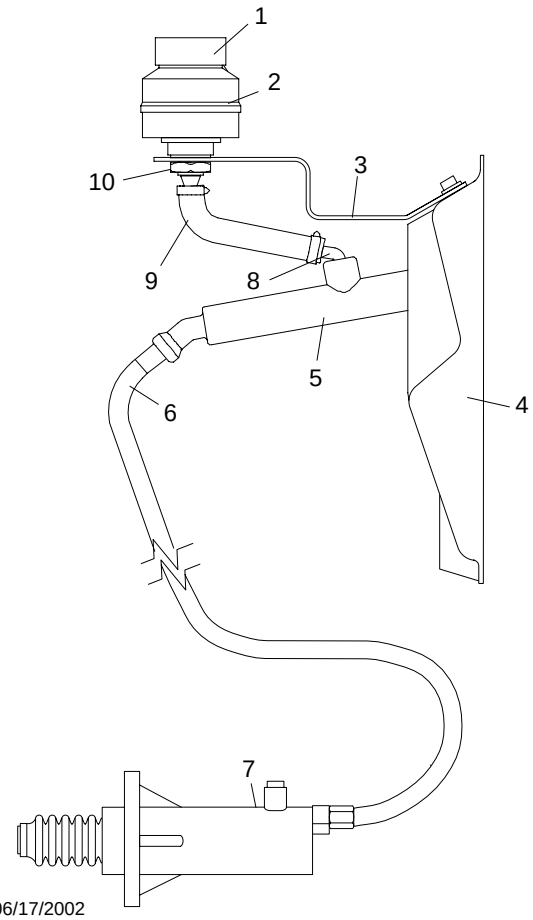
Clutch hydraulic fluid (DOT 3 brake fluid) is hazardous. It may be a skin irritant and can cause blindness if it gets in your eyes. Always wear safety glasses when handling clutch hydraulic fluid or bleeding hydraulic lines. If you get clutch hydraulic fluid on your skin, wash it off as soon as possible.

3. Using a flat-head screwdriver, remove the quick-disconnect clamp that attaches the hydraulic hose to the slave cylinder. Retain the clamp for later installation. See **Fig. 1**.
4. Drain the hydraulic fluid from the entire system. For detailed procedures, see **Subject 100**.
5. Using a flat-tip screwdriver, remove the quick-disconnect clamp that attaches the old hydraulic hose to the hose connector on the master cylinder. Retain the clamp for later installation.
6. Connect the new hydraulic hose to the slave cylinder and the hose connector. Install the clamps, as removed.

⚠ WARNING

Use only approved clutch hydraulic fluid (DOT 3 brake fluid). Do not mix different types of brake fluid. The wrong fluid will damage the rubber parts of the system, causing loss of clutch function and the risk of serious personal injury.

7. Fill the reservoir with approved DOT 3 hydraulic brake fluid and bleed the system according to the procedures in **Subject 140**.
8. Check the function of the clutch actuation system according to the procedures under the heading "Clutch Actuation System Check" in **Trouble-shooting, 300**.

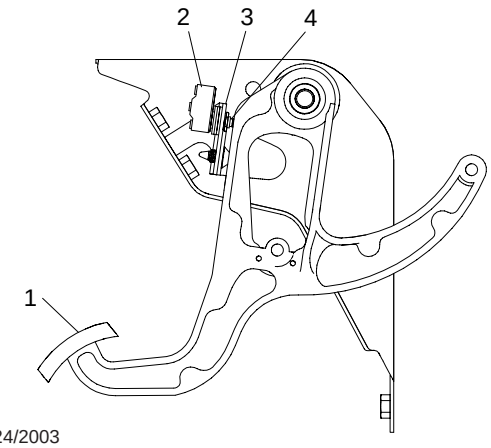


1. Reservoir
2. Reservoir Cap
3. Reservoir Bracket
4. Clutch Support Plate
5. Master Cylinder
6. Hydraulic Hose
7. Slave Cylinder
8. Elbow Connector
9. Reservoir Hose
10. Jam Nut

Fig. 1, Clutch Components

Replacement

1. Disconnect the clutch control switch connector located under the dash just above the clutch pedal.
2. Remove the fasteners holding the switch to the pedal stop bracket. Retain the fasteners for later installation. See **Fig. 1**.



1. Pedal
2. Clutch Switch
3. Pedal Stop Bracket
4. Fasteners

Fig. 1, Clutch Switch Replacement

3. Remove the switch assembly from the pedal stop bracket.
4. Mount the new switch assembly on the pedal stop bracket and tighten the 15/32–32 hexnuts.
5. Connect the clutch control electrical connector, and check the function of the clutch actuation system according to the procedures under the heading "Clutch Switch Check" in **Troubleshooting, 300**.

IMPORTANT: If any problems are noticed during these diagnostic checks, take corrective action using the information under the heading "Troubleshooting Tables."

When repairing any components of the hydraulic clutch system, bleed the clutch before restoring the vehicle to service. This will prevent air from remaining in the system.

Clutch Leak Check

⚠ WARNING

Air in the clutch hydraulic system can prevent the gears from engaging properly, and cause a serious accident resulting in personal injury.

1. Shut down the engine.
2. Apply the parking brakes, chock the front and rear tires, and open the hood.

NOTE: This step requires two persons.

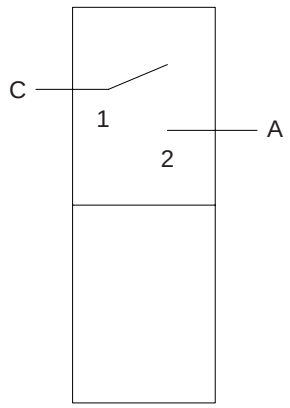
3. Have one person press down on the clutch pedal while the other person checks the clutch hydraulic system for signs of leakage.

Clutch Actuation System Check

1. Shut down the engine.
2. Apply the parking brakes, chock the front and rear tires, and open the hood.
3. Do the "Clutch Leak Check."
4. Press the pedal all the way to the floor several times and check the action of the pedal. The pedal should be easy to operate and return without difficulty to its original position. It should feel firm and responsive, not soft or spongy.
5. With both the brake and the clutch pedals pressed down, start the engine.
   - 5.1 If the engine does not start, take corrective action using the information under the heading "Troubleshooting Tables."
   - 5.2 If the clutch does not disengage properly, the engine will start and then stall. Take corrective action using the information under the heading "Troubleshooting Tables."
6. Remove the chocks from the front and rear tires.
7. Test drive the vehicle.
   - 7.1 Check for proper clutch functioning while shifting gears.
   - 7.2 With cruise control on, press the clutch pedal down. If cruise control does not deactivate, take corrective action using the information under the heading "Troubleshooting Tables."

Clutch Switch Check

1. Shut down the engine.
2. Apply the parking brakes, chock the front and rear tires, and open the hood.
3. Disconnect the clutch control switch connector located under the dash just above the clutch pedal.
4. Do a continuity check between pin A and pin C of the connector. See **Fig. 1**.



03/24/2003 f250590a

The switch is normally open, but held closed.

NOTE: Pin "B" is not used.

1. Open Position 2. Closed Position

Fig. 1, Clutch Switch Positions

Troubleshooting

4.1 With the pedal not pressed, the circuit should be closed and resistance should be measured.

4.2 With the pedal pressed down about 4 inches (10 cm), the switch should open and no resistance should be measured.

Troubleshooting Tables

Problem–The Clutch Pedal Feels Soft or Spongy

Problem–The Clutch Pedal Feels Soft or Spongy	
Possible Cause	**Remedy**
There is air in the hydraulic system.	Bleed the hydraulic system. See **Subject 140** for instructions.
There is a hydraulic fluid leak.	Check the fluid level. Check for leakage and replace any components found to be leaking. Fill and bleed the hydraulic system.

Problem–The Clutch Pedal Is Unusually Hard To Operate

Problem–The Clutch Pedal Is Unusually Hard To Operate	
Possible Cause	**Remedy**
The clutch is damaged.	Check clutch function and make any necessary repairs. See the instructions under the heading "Clutch Actuation System Check."
The assist spring is broken.	Replace the clutch pedal.
The pedal assembly is worn or jammed.	Replace the clutch pedal.
The master cylinder has components that are jammed or broken.	Replace the master cylinder. See **Subject 110** for instructions.

Problem–The Clutch Does Not Completely Disengage; Shifting Is Difficult

Problem–The Clutch Does Not Completely Disengage; Shifting Is Difficult	
Possible Cause	**Remedy**
The clutch is worn.	Replace the clutch. See **Subject 130** for instructions.
There is air in the hydraulic system.	Bleed the hydraulic system. See **Subject 140** for instructions.
There is a hydraulic fluid leak.	Check the fluid level. Check for leakage and replace any components found to be leaking. Fill and bleed the hydraulic system.
The slave cylinder is defective.	Replace the slave cylinder. See **Subject 120** for instructions.
The slave cylinder is loose.	Tighten the M8 slave cylinder mounting capscrews 12 lbf·ft (16 N·m).
The wrong type of brake fluid was used.	Replace the complete system. Fill only with approved DOT 3 brake fluid.

Problem–The Clutch Switch Does Not Activate

Problem–The Clutch Switch Does Not Activate	
Possible Cause	**Remedy**
The switch contacts are damaged or worn.	Replace the clutch switch assembly. See **Subject 170** for instructions.
The switch cam is damaged.	Replace the clutch pedal.

WARNING

Do not attempt to disassemble the preloaded assist spring. Sudden release of the assist spring could cause property damage and serious personal injury.

Problem–The Clutch Pedal Does Not Return

Problem–The Clutch Pedal Does Not Return	
Possible Cause	**Remedy**
The assist spring is broken.	Replace the clutch pedal.

Problem–Cruise Control or Engine Brake Does Not Deactivate When the Clutch Pedal Is Pressed Down

Problem–Cruise Control or Engine Brake Does Not Deactivate When the Clutch Pedal Is Pressed Down	
Possible Cause	**Remedy**
The clutch switch is damaged.	Check switch function and make any necessary repairs. See the instructions under the heading "Clutch Switch Check."
There has been an external electrical failure.	See **Section 54.01** for instructions.

Specifications

For fastener torque values, see **Table 1**.

Torque Values, Hydraulic Clutch				
Description	**Size**	**Grade**	**Torque in lbf·ft (N·m)**	**Torque in lbf·in (N·cm)**
Bleed Screw	—	—	—	65 (740)
Clutch Capscrews	3/8–16	5	37 (50)	—
Master Cylinder Mounting Capscrews	M6	8.8	—	60 (680)
Release Yoke Mounting Capscrews	—	—	33 (45)	—
Reservoir Bracket Jam Nut	M18	—	147 (199)	—
Reservoir Bracket Mounting Bolts	5/16–24	5	13 (18)	—
Slave Cylinder Mounting Capscrews	M8	10.9	13 (18)	—
Standoff Bracket Mounting Capscrews	1/4–20	8	10 (14)	—

Table 1, Torque Values, Sachs Hydraulic Clutch

Special Tools

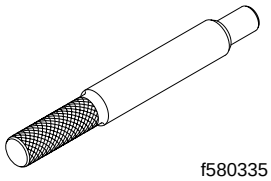
Special Tool			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580335	Clutch Centering Pin	Kent-Moore	J-45719

Table 1, Special Tool for Clutch Removal and Installation

Eaton® Fuller® and Meritor™ Transmission Removal and Installation

Removal

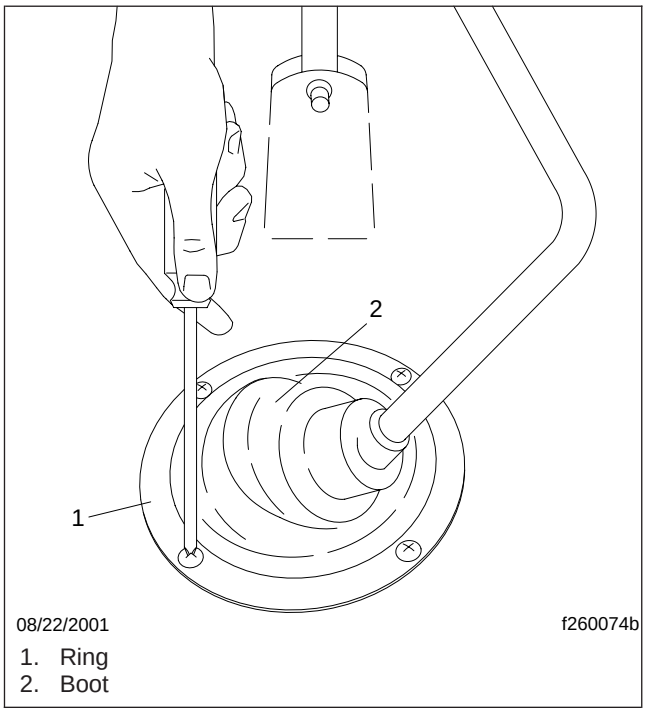
1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires.

⚠ WARNING

Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

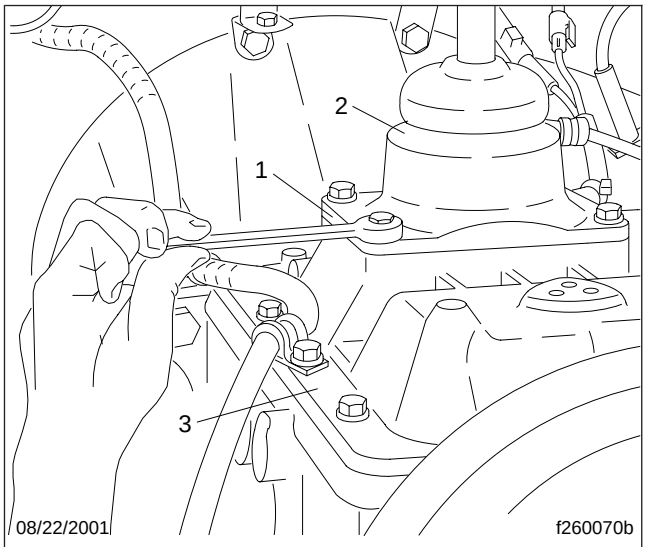
2. If applicable, drain the vehicle system at the air reservoirs.
3. If applicable, disconnect the transmission air supply and signal lines. Label the lines for reconnection.
4. Remove the shift lever from the transmission.
   - 4.1 Place the transmission in high gear.
   - 4.2 Remove the four screws from the retaining ring around the shift lever boot. See **Fig. 1**. Remove the ring and the boot.
   - 4.3 Remove the four capscrews from the plate holding the shift tower to the top cover. See **Fig. 2**.
   - 4.4 Lift up on the shift lever assembly and remove it and the air signal lines (if applicable). See **Fig. 3**.
   - 4.5 Cover the opening in the shift tower to prevent entry of dirt.
5. Disconnect the driveshaft from the transmission.
   - 5.1 If the vehicle is equipped with a driveline parking brake, remove the nuts on the brake flange. See **Fig. 4**.

     If the vehicle is not equipped with a driveline parking brake, remove the transmission yoke U-joint end caps.
   - 5.2 Loosen the bolts holding the midship bearing bracket so that the driveshaft can slide to the rear. See **Fig. 5**.



1. Ring
2. Boot

Fig. 1, Shift Lever Ring and Boot



1. Plate
2. Shift Tower
3. Top Cover

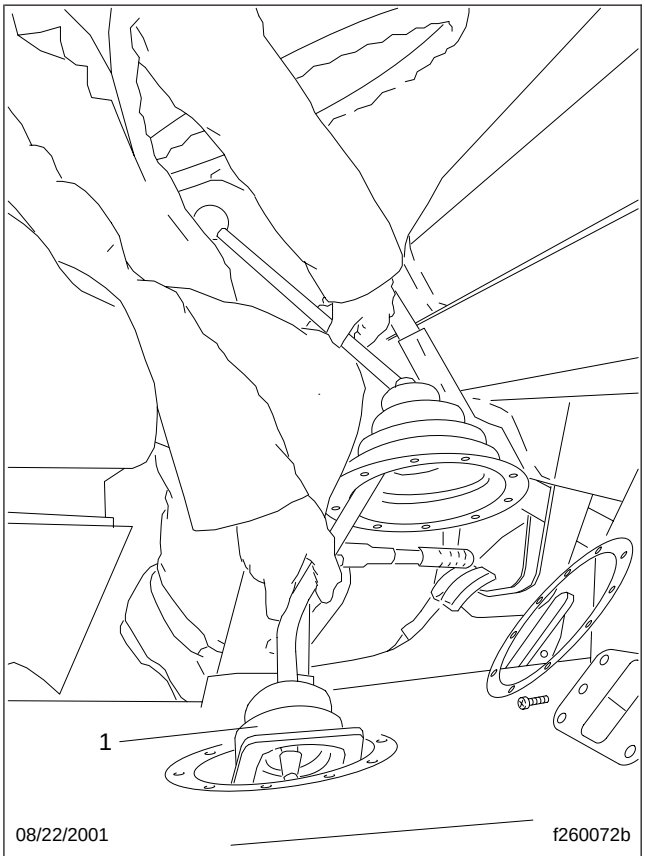
Fig. 2, Shift Tower Removal

Eaton® Fuller® and Meritor™ Transmission Removal and Installation

5.3 Slide the front of the driveshaft off of the driveline brake flange or out of the transmission output yoke.

NOTE: It may be necessary to remove the bolts from the midship bearing bracket so that the driveshaft can be moved far enough back.

5.4 Support the disconnected driveshaft or tie it out of the way.



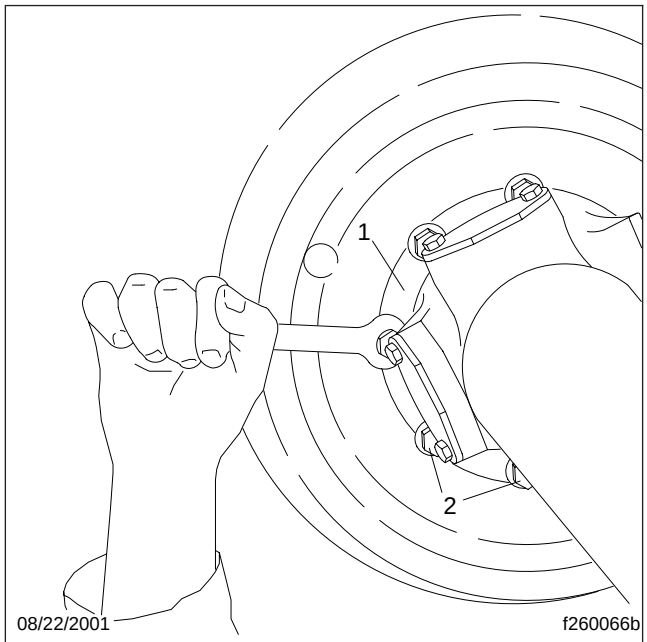
1. Shift Lever Assembly

Fig. 3, Remove the Shift Lever Assembly

6. Remove all electrical connections from the transmission.

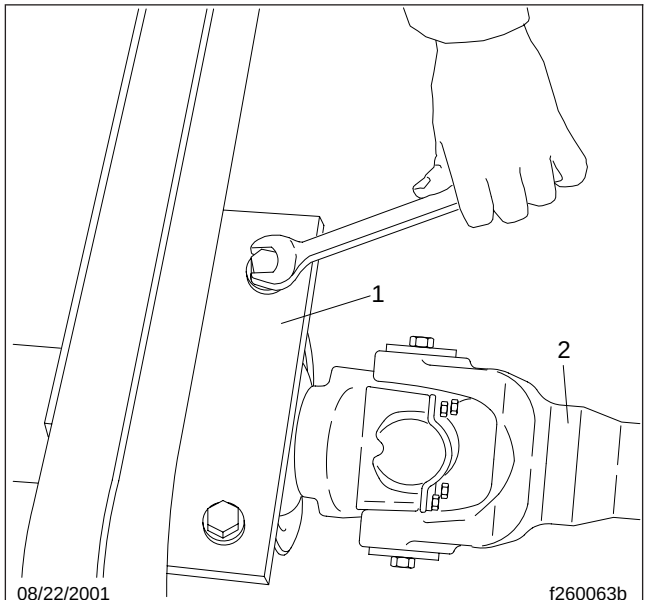
6.1 Disconnect the back-up light harnesses. See **Fig. 6**.

6.2 Disconnect the electrical harness from the speedometer sensor. See **Fig. 7**.



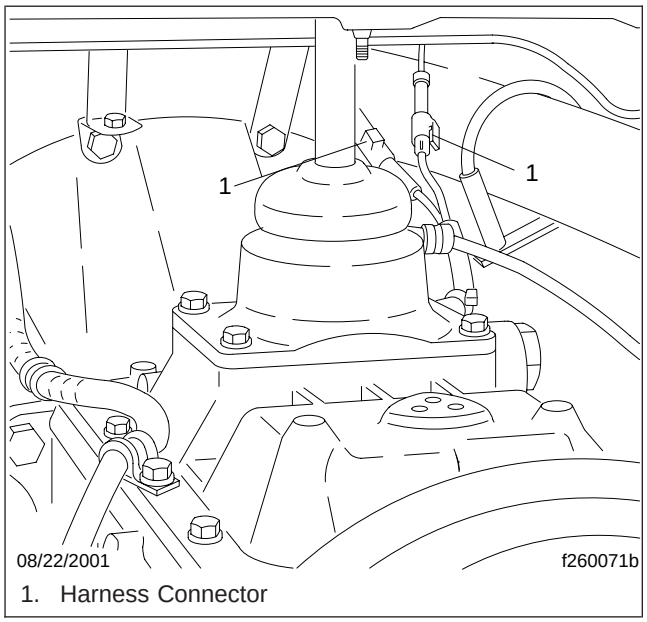
1. Brake Flange
2. Nut

Fig. 4, Brake Flange (driveline parking brake)



1. Midship Bearing Bracket
2. Driveshaft

Fig. 5, Midship Bearing Bracket



1. Harness Connector

Fig. 6, Back-Up Light Harness Connectors

6.3 Loosen the capscrews holding the speedometer sensor wiring harness to the transmission. See **Fig. 8**. Move the harness out of the way.

7. If the vehicle is equipped with a driveline parking brake, remove the cotter pin holding the clevis to the driveline brake lever. See **Fig. 9**. Remove the two bolts holding the driveline brake cable bracket to the transmission, then remove the bracket.

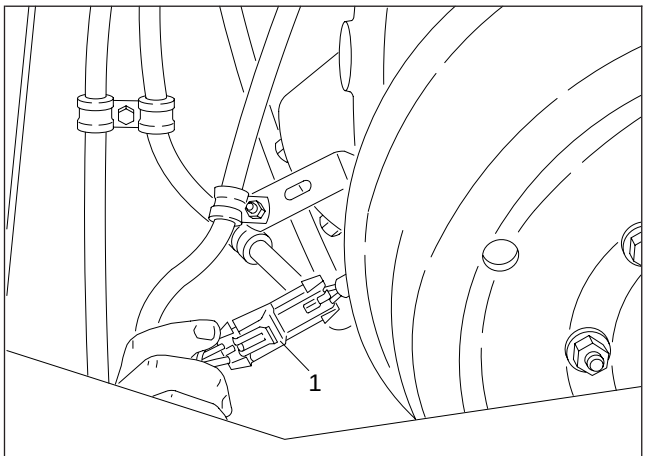
8. On vehicles with a manual clutch, disconnect the clutch linkage rod from the clutch release lever. Rotate the clutch release yoke so it will clear the clutch release bearing.

9. On vehicles with a hydraulic clutch, disconnect and move the clutch slave cylinder.

9.1 Remove the cotter pin holding the slave cylinder clevis to the clutch release lever. See **Fig. 10**.

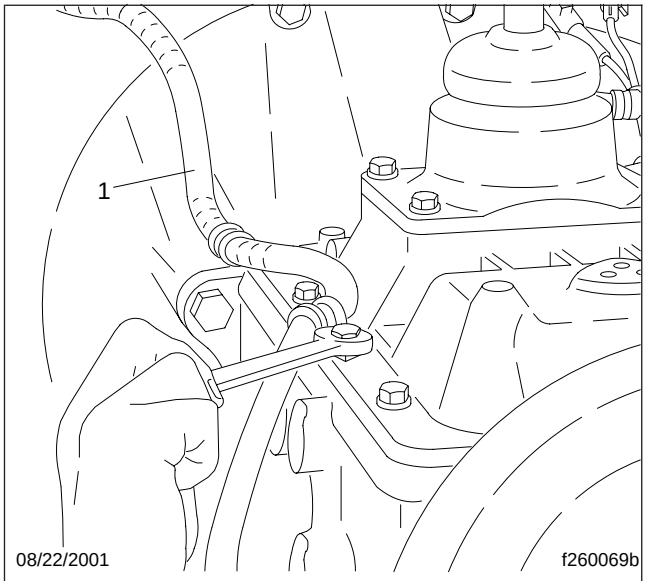
9.2 Remove the two capscrews holding the clutch slave cylinder bracket to the transmission. See **Fig. 11**. Remove the slave cylinder, and support it.

10. If the vehicle is equipped with optional dual fuel tanks, remove the fuel crossover line and the support between the tanks.



1. Connector

Fig. 7, Speedometer Sensor Connector



1. Wire Harness

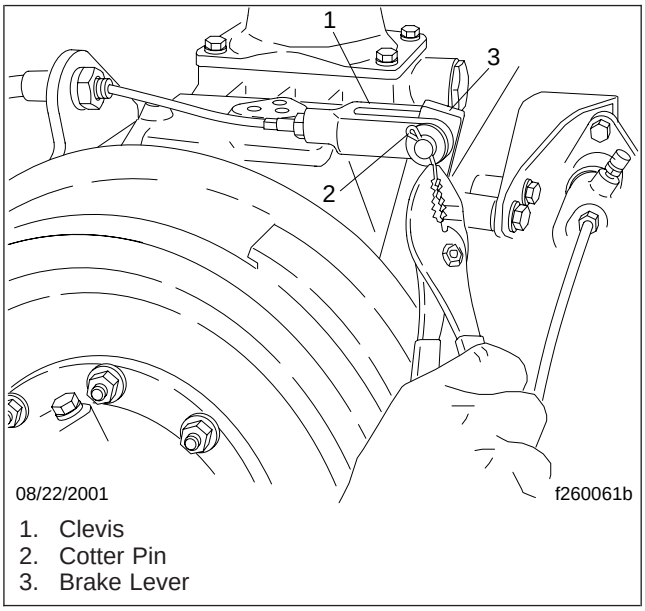
Fig. 8, Speedometer Sensor Wire Harness

10.1 Remove the mounting clamps holding the fuel crossover line to the support. See **Fig. 12**.

10.2 Remove the support mounting bolts. See **Fig. 13**. Then, remove the support.

10.3 Close the fuel crossover line shutoff valve at the bottom of the passenger-side fuel tank. See **Fig. 14**.

Eaton® Fuller® and Meritor™ Transmission Removal and Installation

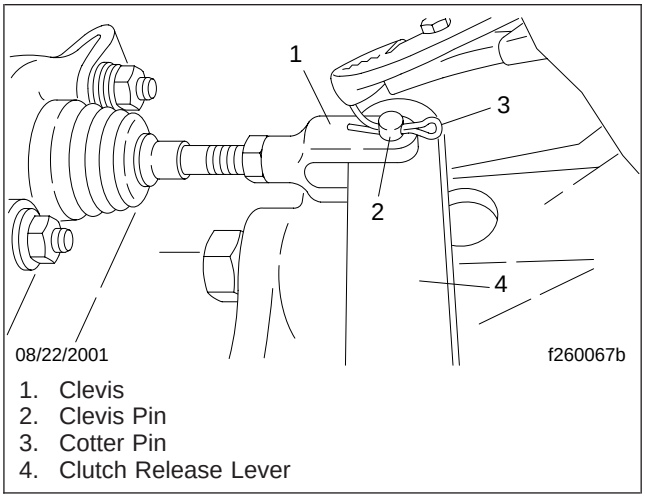


1. Clevis
2. Cotter Pin
3. Brake Lever

Fig. 9, Driveline Brake Lever and Clevis

10.4 Remove the allen-head plug in the driver-side fuel tank and drain the tank. See **Fig. 15**.

10.5 Disconnect the fuel crossover line from the driver-side fuel tank. See **Fig. 16**.

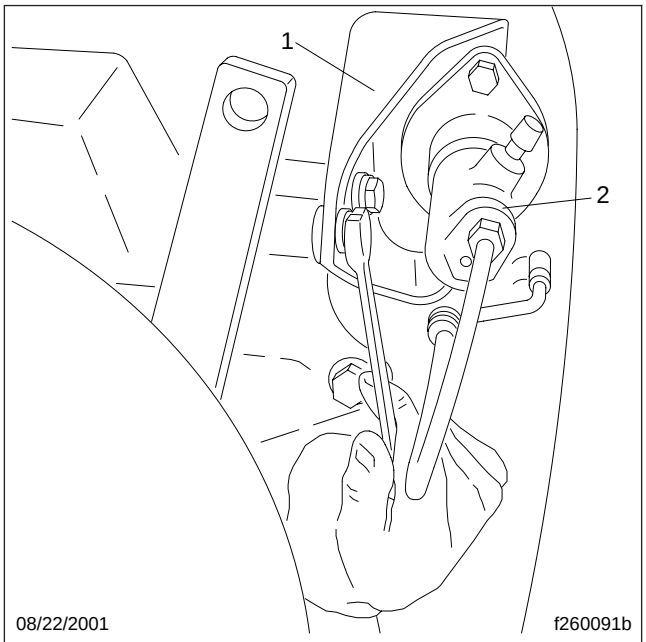


1. Clevis
2. Clevis Pin
3. Cotter Pin
4. Clutch Release Lever

Fig. 10, Clutch Release Lever and Clevis

11. Support the transmission with a jack.

11.1 Position a transmission jack under the transmission and raise the support plates against the bottom of the transmission.



1. Slave Cylinder Bracket
2. Slave Cylinder

Fig. 11, Slave Cylinder and Bracket

11.2 Adjust the support plates to cradle the transmission.

11.3 Using a chain, secure the transmission to the jack.

12. Remove the transmission.

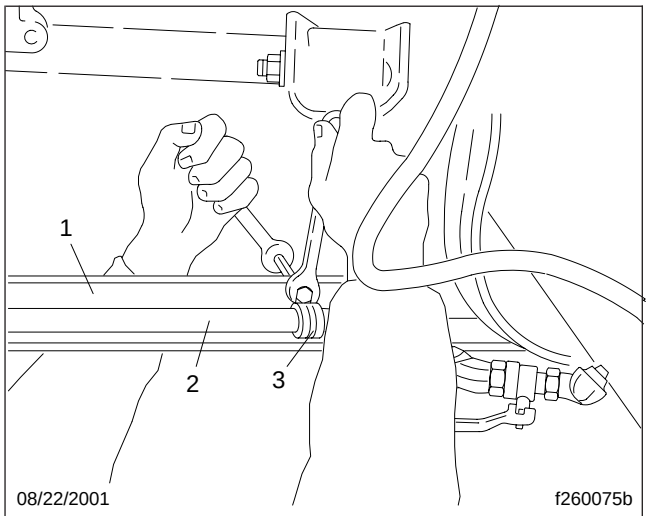
12.1 Remove the capscrews that hold the bell housing to the flywheel housing, and remove the bell housing with the transmission.

12.2 Pull the transmission and jack straight back, until the transmission input shaft is clear of the clutch.

12.3 If required, lower the jack supporting the transmission. Raise the front of the vehicle and slide the transmission and jack out from under the vehicle.

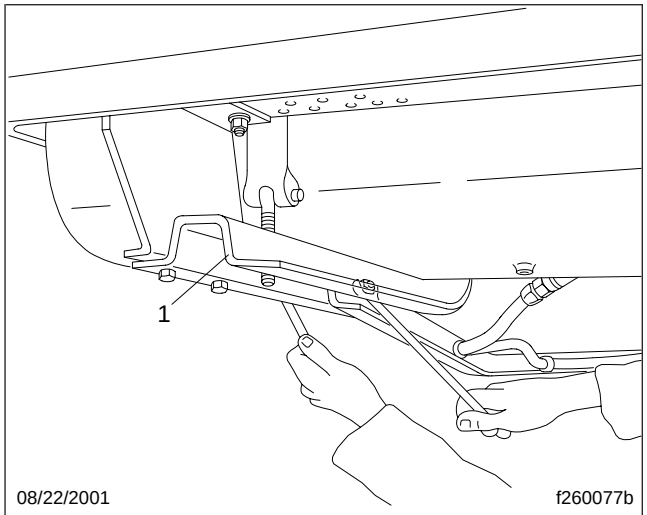
⚠ CAUTION

Do not allow the rear of the transmission to drop, and do not let the transmission hang unsupported in the splined hubs of the clutch disc(s). Keep the flange of the bell housing parallel (all



1. Support
2. Fuel Crossover Line
3. Clamp

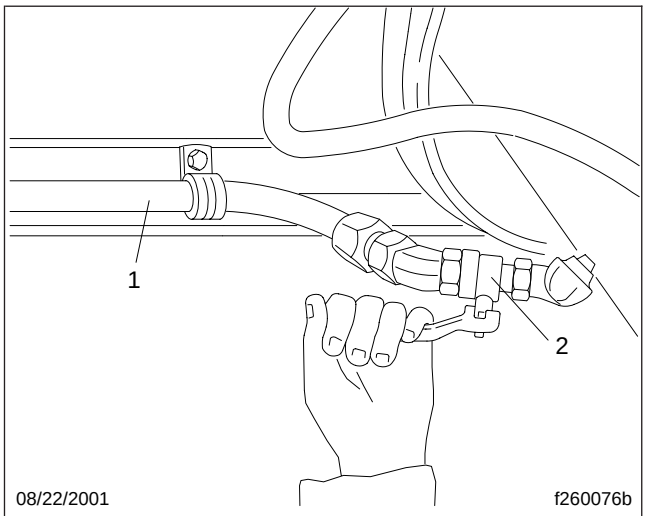
Fig. 12, Fuel Crossover Line Clamp



1. Support

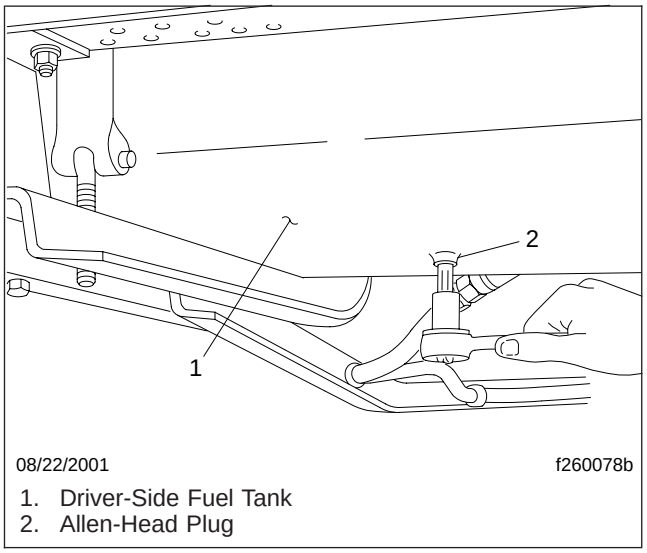
Fig. 13, Fuel Crossover Line Support

the way around) to the flange of the flywheel housing, until the input shaft is clear of the clutch. Taking these precautions will prevent damage to the clutch disc(s).



1. Fuel Crossover Line
2. Shutoff Valve

Fig. 14, Fuel Crossover Line Shutoff Valve



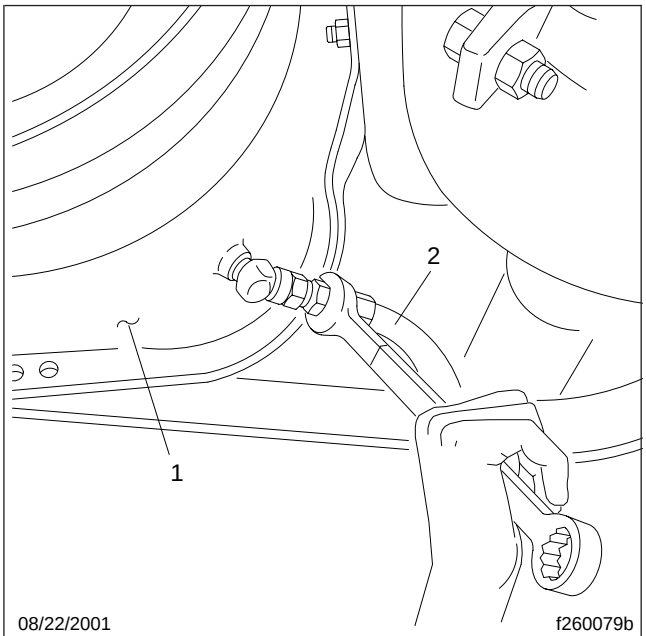
1. Driver-Side Fuel Tank
2. Allen-Head Plug

Fig. 15, Fuel Tank Drain Plug

Installation

IMPORTANT: Before installing the transmission, ensure that the rear tires are securely chocked and that the transmission is securely chained to the transmission jack support plates.

Eaton® Fuller® and Meritor™ Transmission Removal and Installation



1. Driver-Side Fuel Tank
2. Crossover Line

Fig. 16, Fuel Crossover Line (at driver-side fuel tank)

1. If the vehicle is equipped with a clutch brake, install it on the transmission input shaft. Slide it tightly against the input shaft bearing cap.

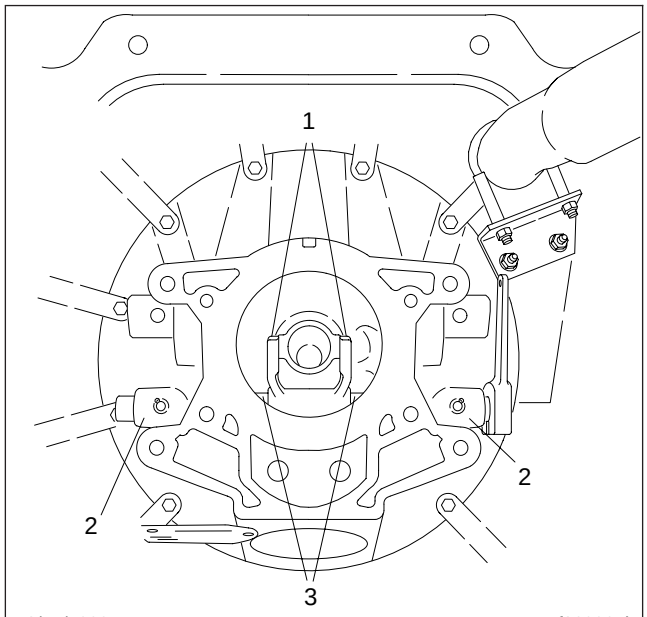
NOTE: When installing a torque-limiting clutch brake on an Eaton Fuller transmission, install the smaller face toward the transmission.

2. Check for wear on the fingers of the clutch release yoke, release shaft, and the release shaft bushings. Replace any worn parts, as needed. See **Fig. 17**.

3. Install the transmission.

   3.1 Shift the transmission into gear, so that the transmission input shaft can be rotated during assembly to align it with the clutch driven-disc hub splines.

   3.2 Align the jack and the transmission behind the engine. Raise the transmission, and adjust the angle of the jack until the bell housing and the transmission input flange (single-countershaft transmissions) or the flywheel housing flange and the bell housing flange (twin-countershaft transmissions) are parallel.



1. Release Shaft Bushing
2. Clutch Release Yoke Finger
3. Clutch Release Shaft

Fig. 17, Clutch Release Mechanism

   3.3 Push the transmission and jack straight forward making sure that the flanges remain parallel.

   NOTE: On twin-countershaft transmissions, be sure that the release-bearing yoke clears the bearing, and is rotated over the wear pads as the transmission is moved forward. See **Fig. 18**. Align the splines by turning the transmission output shaft.

   3.4 Reach through the access hole in the bottom of the bell housing and hold the release bearing in place by hand. See **Fig. 19**.

   3.5 Slide the splined input shaft into the clutch driven disc.

⚠ CAUTION

Use care to avoid springing the driven disc(s) when the transmission is being installed. Do not force the transmission into the bell housing if it does not enter freely. Do not let the transmission

drop or hang unsupported in the driven disc(s). These practices can damage the clutch assembly.

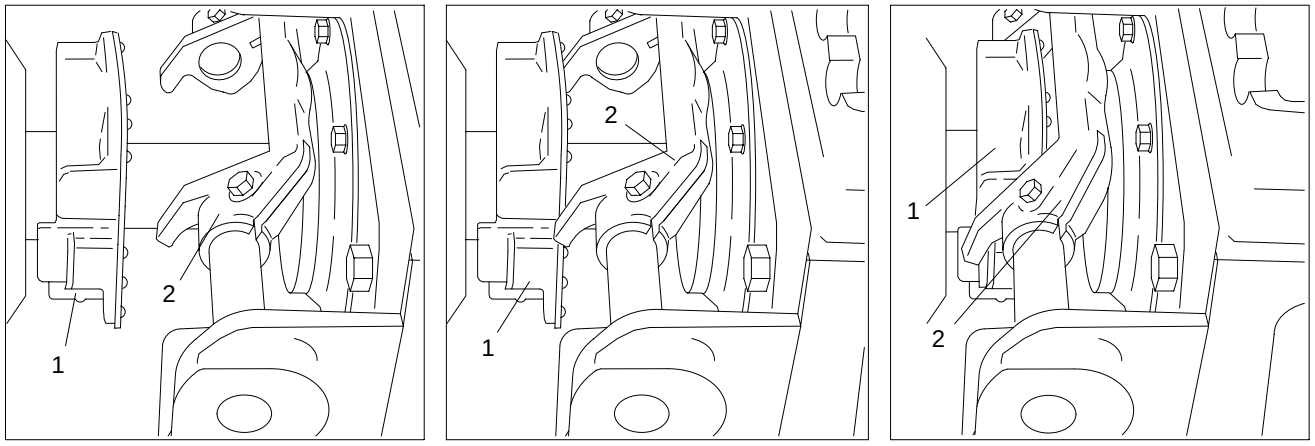
3.6 Install the capscrews holding the bell housing to the flywheel housing and tighten 34 lbf·ft (46 N·m).

3.7 Remove the chain securing the transmission to the jack, then remove the jack.

5. On vehicles with a manual clutch, connect the clutch rod to the clutch release lever, as removed.

6. On vehicles with a hydraulic clutch, install and connect the clutch slave cylinder.

6.1 Install the two capscrews holding the clutch slave cylinder bracket to the transmission and tighten 40 lbf·ft (54 N·m). See **Fig. 11**.



08/22/2001 f250035b

1. Release Bearing
2. Yoke

Fig. 18, Release Bearing and Yoke

4. If the vehicle is equipped with the optional dual fuel tanks, install the fuel crossover line and the support between the tanks.

4.1 Install the allen-head drain plug in the driver-side fuel tank. See **Fig. 15**. Tighten it finger tight; then, tighten it 1-1/2 turns more.

4.2 Install the fuel crossover line support and the mounting bolts and tighten 95 lbf·ft (129 N·m). See **Fig. 13**.

4.3 Connect the fuel crossover line to the driver-side fuel tank. See **Fig. 16**.

4.4 Open the fuel crossover line shutoff valve at the bottom of the passenger-side fuel tank. See **Fig. 14**.

4.5 Install the mounting clamps holding the fuel crossover line onto the support and tighten 40 lbf·ft (54 N·m). See **Fig. 12**.

6.2 Attach the slave cylinder clevis to the clutch release lever; then, insert and lock the cotter pin. See **Fig. 10**.

7. If the vehicle is equipped with a driveline parking brake, mount the driveline brake cable bracket to the transmission. Install the two bolts and tighten 100 lbf·ft (136 N·m). Attach the clevis to the brake lever; then, insert and lock the cotter pin. See **Fig. 9**.

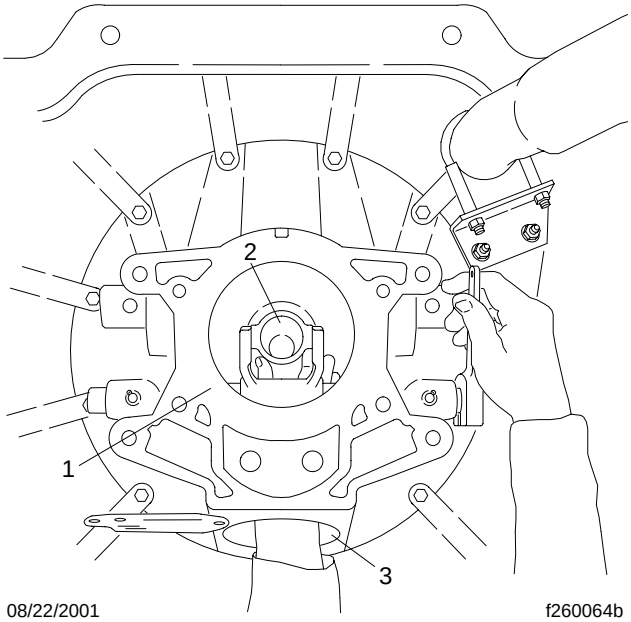
8. Connect all electrical lines to the transmission.

8.1 Connect the back-up light harness connectors. See **Fig. 6**.

8.2 Connect the electrical harness to the speedometer sensor. See **Fig. 7**.

8.3 Install the speedometer sensor wiring harness. Install the capscrews attaching it to

Eaton® Fuller® and Meritor™ Transmission Removal and Installation



1. Bell Housing
2. Release Bearing
3. Access Hole

Fig. 19, Release Bearing

the transmission and tighten 40 lbf·ft (54 N·m). See **Fig. 8**.

9. Connect the driveshaft.
   - 9.1 Slide the front of the driveshaft into the transmission output yoke or onto the driveline parking brake flange, if so equipped.
   - 9.2 On vehicles without a driveline parking brake, install the transmission yoke U-joint end caps and tighten 45 lbf·ft (61 N·m).

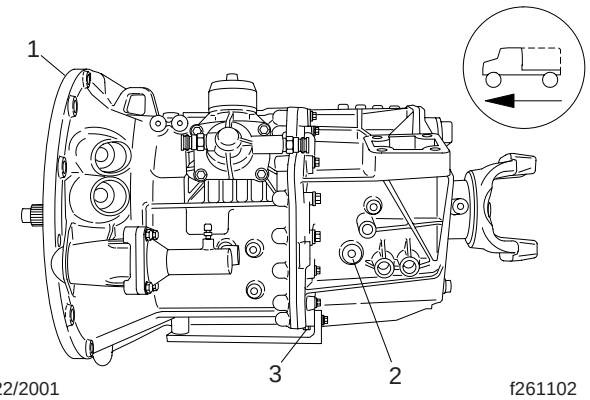
     On vehicles with a driveline parking brake, slide the driveshaft flange onto the studs in the parking brake.

     Install the nuts and tighten 40 lbf·ft (54 N·m).
   - 9.3 Install the capscrews and the nuts on the midship bearing bracket and tighten 95 lbf·ft (129 N·m).
10. Install the shift lever.
    - 10.1 Remove the covering from the opening in the shift tower.
    - 10.2 Install the shift lever and the plate. See **Fig. 3**.
    - 10.3 Install the four capscrews in the plate and tighten 40 lbf·ft (54 N·m). See **Fig. 2**.
    - 10.4 Install the rubber boot and the retaining ring. Install the four screws and tighten them 28 lbf·ft (38 N·m). See **Fig. 1**.
11. If applicable, connect the air signal and supply lines to the transmission.

Mercedes-Benz Transmission Removal and Installation

Removal

1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the rear tires.
2. Drain the transmission fluid. See **Fig. 1** for the location of the drain plug.

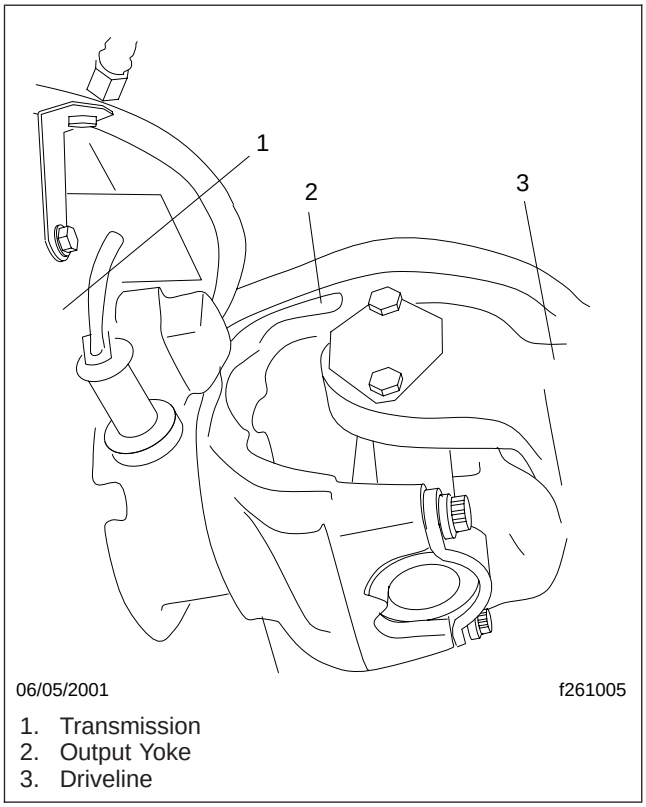


NOTE: The transmission is shown from the left-hand side.

1. Transmission
2. Fill Plug
3. Drain Plug

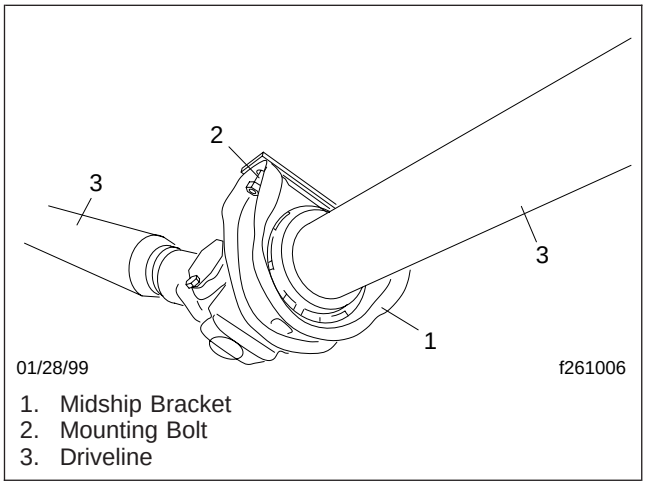
Fig. 1, Transmission Drain and Fill Plugs

3. Disconnect the driveshaft from the transmission.
   - 3.1 Support the midship bearing.
   - 3.2 Remove the bolts from the U-joint end caps and slide the front of the driveshaft out of the transmission output yoke. See **Fig. 2**.
   - 3.3 Remove the midship bearing bracket. See **Fig. 3**.
   - 3.4 Support the disconnected driveshaft and chain it out of the way. See **Fig. 4**.
4. Remove the shift lever from the transmission.
   - 4.1 Before removing the shift lever, place the transmission in high gear.
   - 4.2 Disconnect the electrical connector from the shift lever and mark it with a paint pen for ease of installation.



1. Transmission
2. Output Yoke
3. Driveline

Fig. 2, Output Yoke



1. Midship Bracket
2. Mounting Bolt
3. Driveline

Fig. 3, Midship Bearing Bracket

   - 4.3 Remove the four screws from the retaining ring around the shift lever boot. See **Fig. 5**. Remove the ring and the boot.

Mercedes-Benz Transmission Removal and Installation

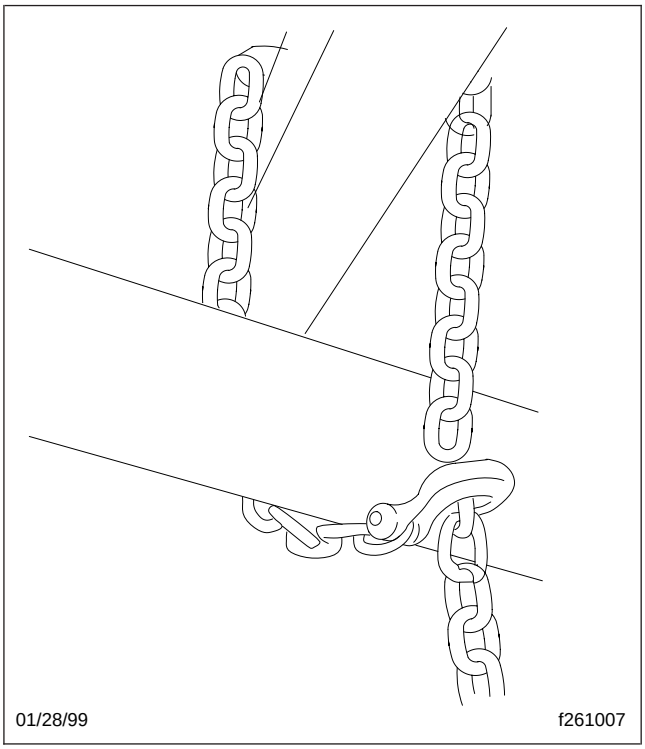


Fig. 4, Support the Driveline

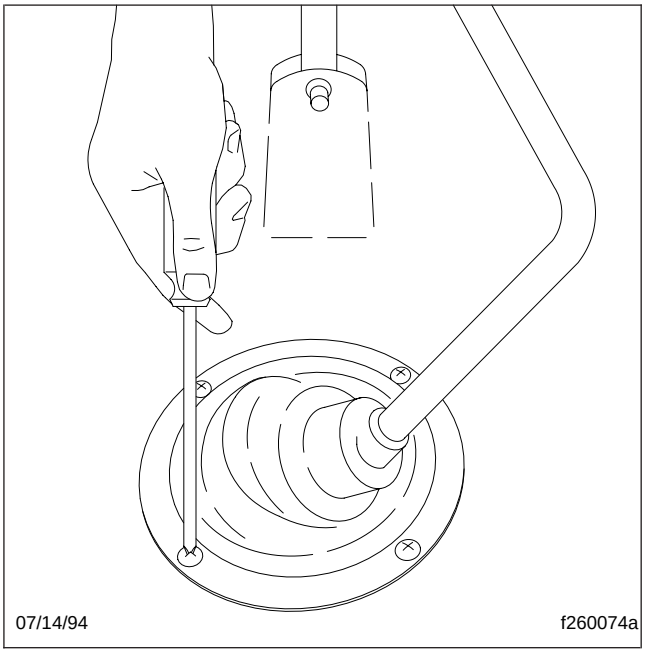
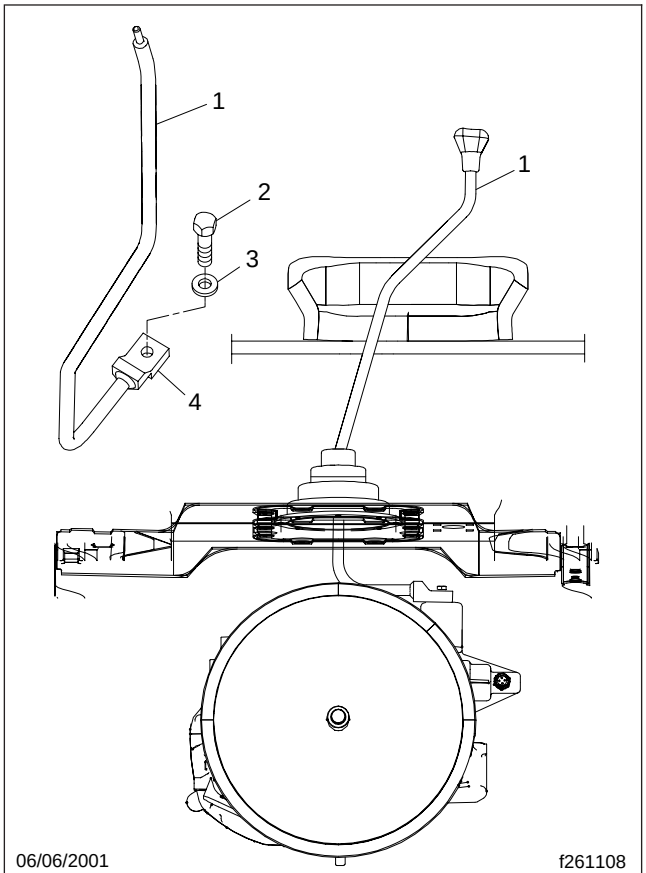


Fig. 5, Shift Lever and Boot

4.4 Remove the head of the shift lever from the shift linkage on the transmission. See **Fig. 6**.



1. Shift Lever
2. Shift Lever Mounting Bolt
3. Thick Washer
4. Head of Shift Lever

Fig. 6, Shift Lever Connection

5. Remove the fuel lines and the fuel line standoff bracket from the transmission. See **Fig. 7**.
6. Disconnect the electrical connectors for the reverse gear switch and the optional starter lock switch (if installed). Mark with a paint pen for ease of installation.

Mercedes-Benz Transmission Removal and Installation

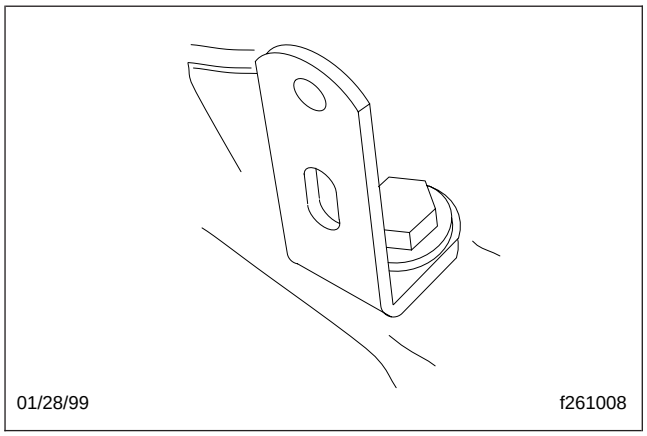
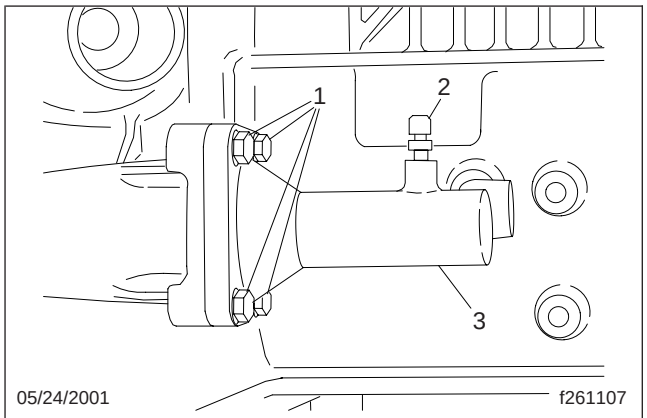


Fig. 7, Fuel Line Standoff Bracket

⚠ WARNING

Do not press down on the clutch pedal after removing the slave cylinder. Hydraulic brake fluid may squirt out, causing personal injury and damage to the vehicle.

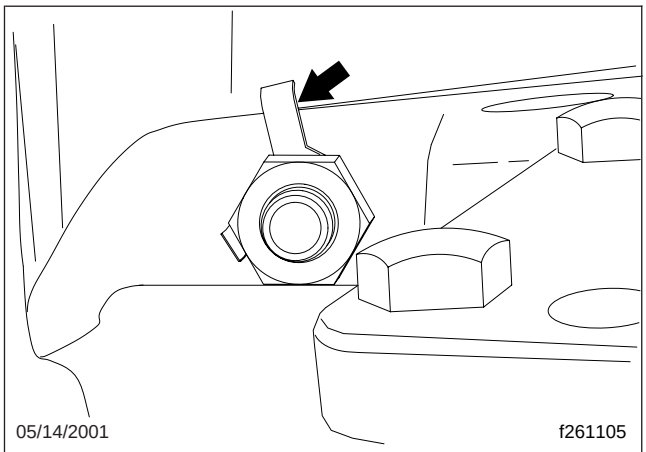
7. Remove the bolts attaching the clutch slave cylinder to the mounting bracket. Move the slave cylinder out of the way. See **Fig. 8**.



1. Mounting Bolts, M8
2. Bleed Valve
3. Slave Cylinder

Fig. 8, Hydraulic Clutch Slave Cylinder

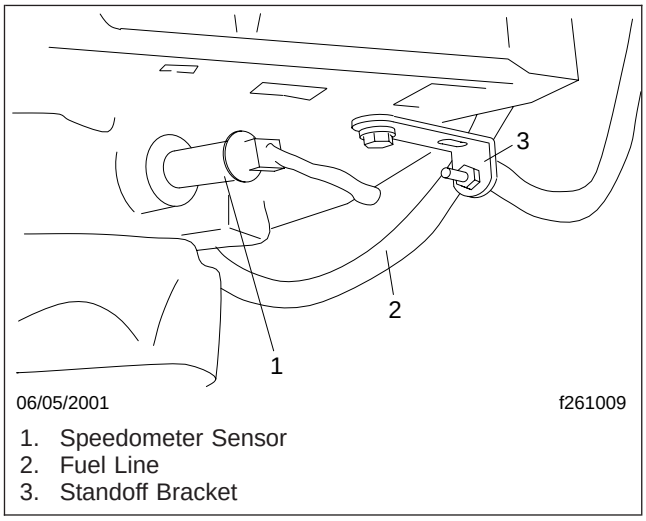
8. Bend back the nut retainers and remove the power take-off unit (PTO). See **Fig. 9**.
9. If the vehicle is equipped with optional dual fuel tanks, remove the fuel cross-over line and its support between the tanks.



Bend back the nut retainer (arrow).

Fig. 9, Power Take-Off Unit (PTO) Nut Retainers

10. Disconnect the electrical cable from the speedometer sensor and mark it with a paint pen for ease of installation. See **Fig. 10**.

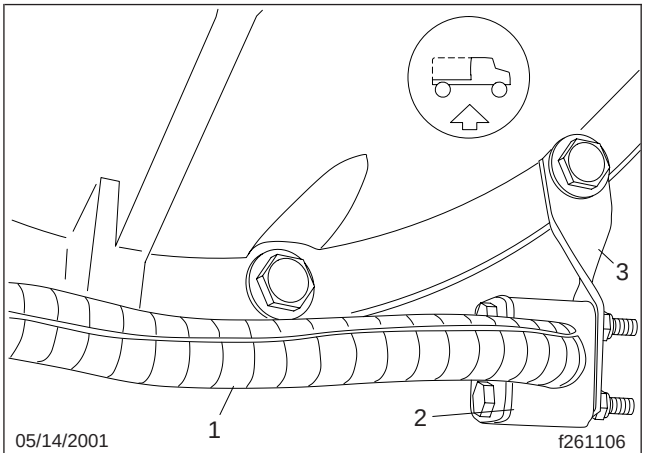


1. Speedometer Sensor
2. Fuel Line
3. Standoff Bracket

Fig. 10, Speedometer Sensor

11. Remove the battery cable bracket(s) around the transmission and move the battery cables out of the way. See **Fig. 11**.
12. Remove the exhaust clamp at the exhaust elbow. For ease of transmission removal and installation, move the exhaust pipe to the side and out of the way.
13. Support the transmission with a jack. See **Fig. 12**.

Mercedes-Benz Transmission Removal and Installation



1. Battery Cable
2. Battery Cable Clamp
3. Battery Cable Bracket

Fig. 11, Battery Cable Routing

13.1 Position a transmission jack under the transmission and raise its support plates against the base of the transmission.

13.2 Adjust the support plates to cradle the transmission.

13.3 Using a chain, secure the transmission to the jack.

14. Remove the 16-mm capscrews attaching the timing case to the bell housing. See **Fig. 13**.

14.1 Remove each of the eleven capscrews.

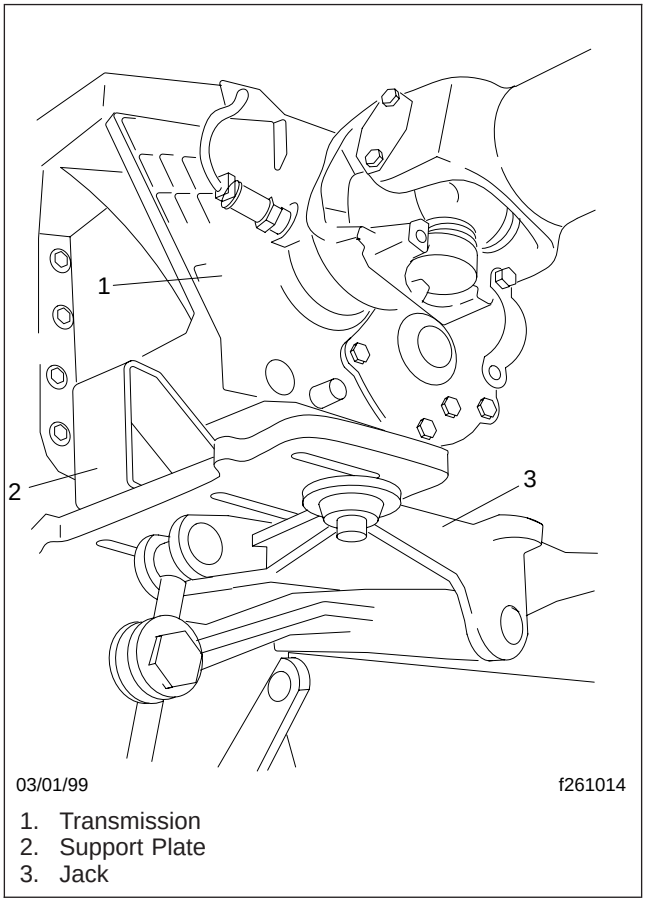
14.2 After removing the transmission, insert the capscrews into the holes in the timing case for safekeeping.

⚠ CAUTION

Do not allow the rear of the transmission to drop, and do not allow the transmission to hang unsupported. Keep the flange of the bell housing parallel (all the way around) to the flange of the timing case, until the input shaft is clear of the flywheel. Taking these precautions will prevent damage to the input shaft, flywheel, and clutch.

15. Remove the transmission. See **Fig. 14**.

15.1 Pull the transmission and jack straight back until the transmission input shaft is clear of the clutch.



1. Transmission
2. Support Plate
3. Jack

Fig. 12, Supporting the Transmission

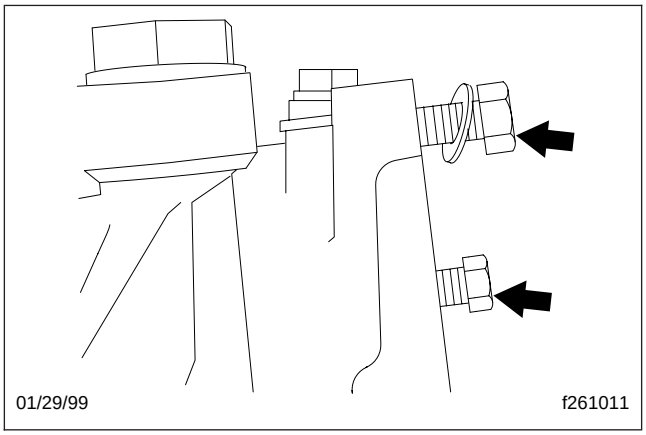


Fig. 13, Insert the Capscrews in the Timing Case

15.2 Turn the left-hand front wheel to allow room for the transmission to pass. If necessary, lower the jack supporting the

Mercedes-Benz Transmission Removal and Installation

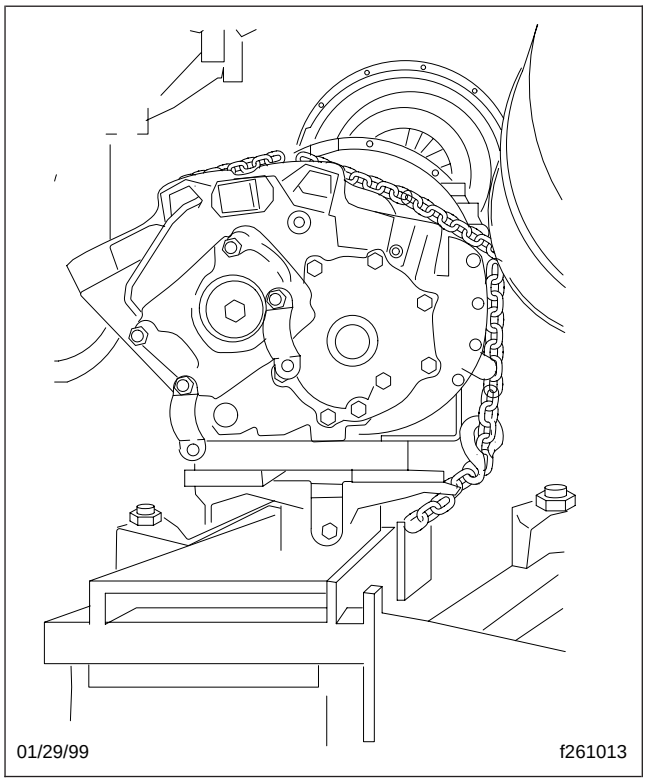


Fig. 14, Remove the Transmission

transmission. It might also be necessary to jack up the truck to get enough clearance to allow the transmission to pass.

IMPORTANT: Watch closely the clearance between the bell housing and the leaf spring.

15.3 Pull the transmission out through the space behind the front wheel.

Installation

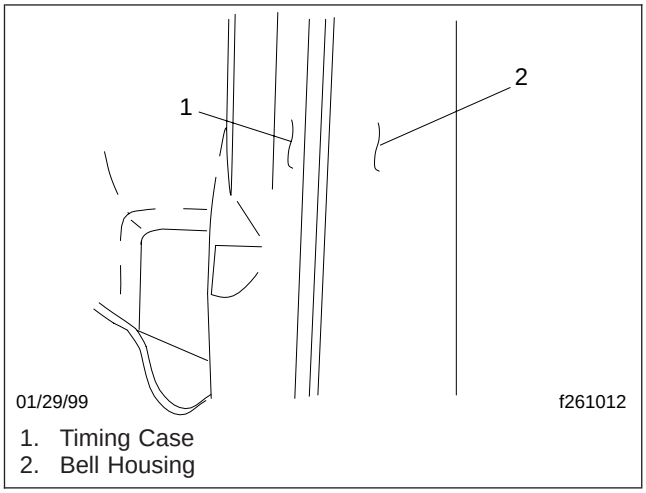
IMPORTANT: Before installing the transmission, make sure that the rear tires are chocked and that the transmission is securely chained to the support plates on the transmission jack.

1. Install the transmission.

   1.1 Align the jack and the transmission behind the engine.

   1.2 Raise the transmission and adjust the angle of the jack until the bell housing and the timing case flange are parallel.

   1.3 Push the transmission and jack straight forward, making sure the flanges remain parallel and the mating seals align with each other without overlap as shown in **Fig. 15**.



1. Timing Case
2. Bell Housing

Fig. 15, Correct Seal Alignment

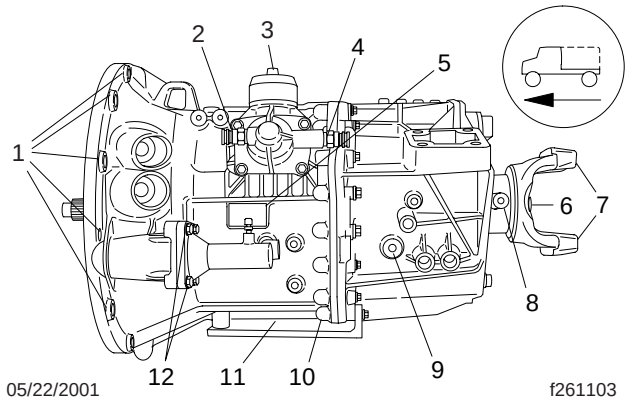
   1.4 Install the eleven M10 capscrews holding the bell housing to the timing case. Use a crossover pattern. Do a final tightening of the capscrews to 33 lbf·ft (45 N·m). See **Fig. 16**.

   1.5 While installing the bell housing-to-timing case capscrews, also install the battery cable bracket(s), as removed.

   1.6 Remove the chain securing the transmission to the jack; then remove the jack.

2. Install the exhaust clamp at the exhaust elbow, as removed.
3. If the vehicle is equipped with the optional dual fuel tanks, install the fuel cross-over line and its support between the tanks. Tighten the clamps 40 lbf·ft (54 N·m) and the mounting bolts 95 lbf·ft (129 N·m).
4. Install the PTO cover on the transmission. Tighten the M10 hardened mounting capscrews 43 lbf·ft (58 N·m). Bend back the tabs on the nut retainers.

Mercedes-Benz Transmission Removal and Installation



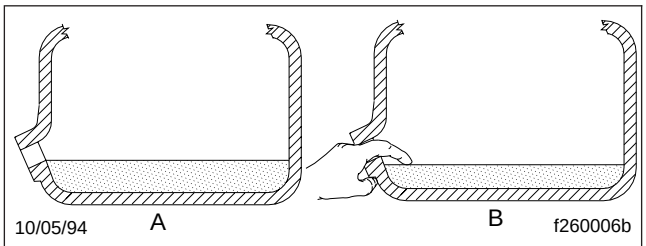
NOTE: The transmission is shown from the left-hand side.

1. Bell Housing-to-Timing Case Capscrews
2. Reverse Gear Switch
3. Shift Lever Mounting Bolt
4. Starter Lock Switch
5. Nameplate
6. Pressure Plate Mounting Capscrew
7. U-Joint End Cap Bolts
8. Speedometer Sensor Lock
9. Transmission Fluid Fill Plug
10. Transmission Fluid Drain Plug
11. PTO Mounting Capscrews
12. Clutch Slave Cylinder Mounting Bolts

Fig. 16, Transmission Fasteners

5. Connect the driveshaft.
   - 5.1 Slide the front of the driveshaft into the transmission output yoke.
   - 5.2 Install the U-joint end caps on the output yoke. Tighten the nuts 50 lbf·ft (68 N·m) for 3/8-inch end cap bolts and 110 lbf·ft (149 N·m) for 1/2-inch end cap bolts.
   - 5.3 Install the bolts and nuts on the midship bearing bracket. Tighten the nuts 95 lbf·ft (129 N·m).
6. Install the fuel line standoff bracket and connect the fuel lines to the bracket.
7. Connect the electrical connectors. Connect the electrical cable to the speedometer sensor. Connect the electrical connector(s) on the shift lever.
8. Install the shift lever.
   - 8.1 Fit the shift lever over the cone of the transmission tower.
   - 8.2 Insert the hardened M10 x 20 shift lever mounting bolt and a thick washer into the hole in the shift lever. See **Fig. 6**.

   IMPORTANT: Don't forget to install the washer. Without the washer, the shift lever may loosen. The driver could lose control of the vehicle.
   - 8.3 Tighten the M10 bolt 50 lbf·ft (68 N·m).
   - 8.4 Install the rubber boot and the metal retaining ring. Install the four screws and tighten against the cab floor 28 lbf·ft (38 N·m). See **Fig. 5**.
9. Fasten the clutch slave cylinder to the mounting bracket and tighten the four M8 mounting bolts 15 lbf·ft (20 N·m).
10. Bleed the hydraulic clutch system. For detailed instructions, see **Section 25.03**, Subject 140, in this manual.
11. Clean the transmission drain plug and install it on the transmission, along with a new aluminum gasket. Tighten the drain plug 42 lbf·ft (57 N·m).
12. Add transmission fluid until it is level with the lower edge of the fill opening. See **Fig. 1** for the location of the fill plug and **Fig. 17** for the correct level. See Chapter 26 of the *Business Class® Trucks Maintenance Manual* for approved transmission lubricants and lubricant capacities.



A. Full
B. Low

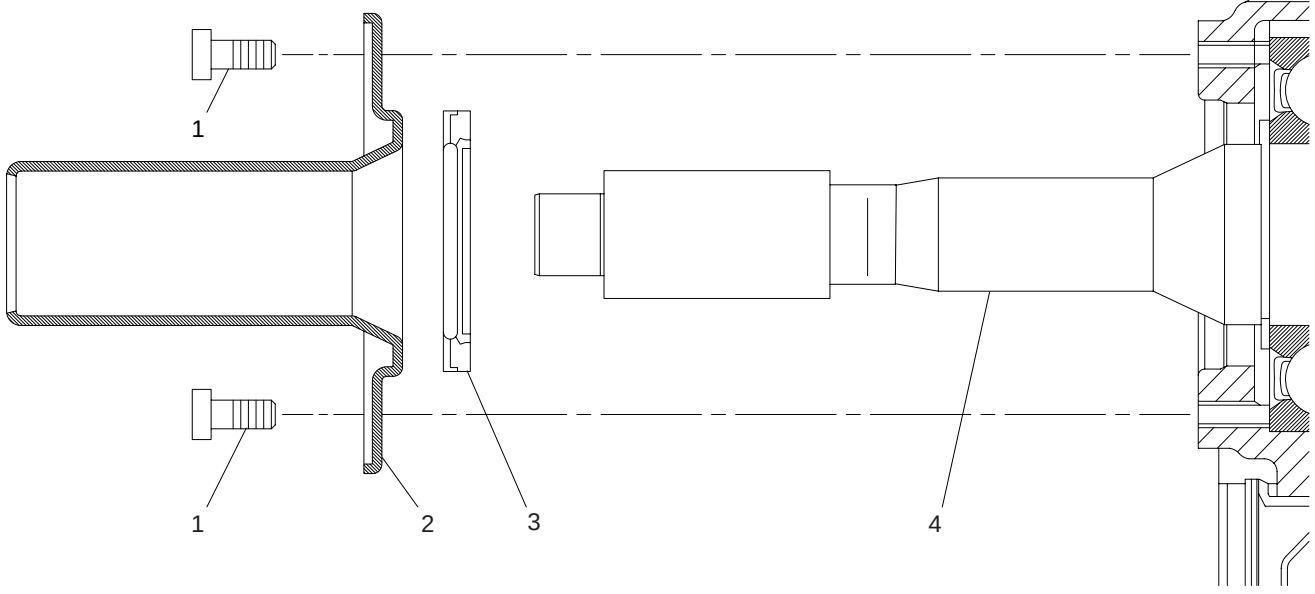
Fig. 17, Transmission Fluid Level Checking

13. Clean the transmission fill plug and install it on the transmission, along with a new aluminum gasket. Tighten the fill plug 42 lbf·ft (57 N·m).
14. Remove the chocks from the rear tires.

Mercedes-Benz Transmission Input Shaft Radial Seal Replacement

Replacement

1. Remove the transmission from the engine. For procedures, see **Subject 110**.
2. Remove the release fork and release bearing.
3. Remove the guide tube from the transmission case. Discard the mounting bolts. See **Fig. 1**.
6. Install the guide tube on the transmission case. Use new mounting capscrews (p/n N000000000761). Tighten the capscrews 17 lbf·ft (23 N·m).
7. Install the release fork and release bearing.
8. Install the transmission on the engine. For procedures, see **Subject 110**.



1. Guide Tube Mounting Capscrew
2. Radial Seal
3. Guide Tube
4. Input Shaft

Fig. 1, Input Shaft Radial Seal Replacement

4. Remove the radial seal from the input shaft. Discard the old radial seal.

CAUTION

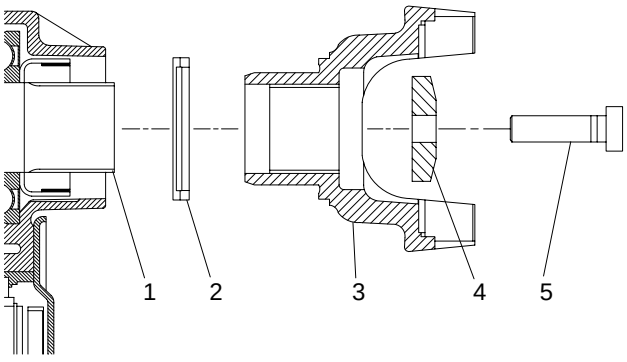
To prevent damage, make sure that the new radial seal is not installed on the race of the old seal.

5. Install a new radial seal (p/n A 021 997 25 47) on the input shaft.

Mercedes-Benz Transmission Output Shaft Radial Seal Replacement

Replacement

1. Secure the output yoke so that it cannot turn on the output shaft.
2. Remove the pressure plate mounting capscrew. Remove the pressure plate. See **Fig. 1**.



1. Output Shaft
2. Radial Seal
3. Output Yoke
4. Pressure Plate
5. Pressure Plate Mounting Capscrew

Fig. 1, Output Yoke Assembly

3. Remove the output yoke. Use a suitable extractor tool.
4. Remove the radial seal from the output shaft. Discard the old radial seal.

CAUTION

To prevent damage, make sure that the new radial seal is not installed on the race of the old seal.

5. Install a new radial seal (p/n A 024 997 04 47) on the output shaft. Use a rubber hammer or a piece of wood to prevent damage to the bearings.
6. If the radial seal cannot be pressed on cold, preheat the output yoke to 176°F (80°C) and try again.
7. Position the pressure plate on the output shaft. Secure it to the shaft using the pressure plate mounting capscrew. Tighten the M16 capscrew 190 lbf·ft (258 N·m).

Specifications

Torque Values, Eaton/Meritor Transmissions	
Description	**Torque In lbf·ft (N·m)**
Bell Housing-to-Flywheel Housing Capscrews	34 (46)
Clutch Slave Cylinder Bracket Mounting Bolts	40 (54)
Driveline Parking Brake Cable Bracket Mounting Bolts	100 (136)
Driveline Parking Brake Stud Nuts	40 (54)
Fuel Cross-Over Line Mounting Bolts	95 (129)
Fuel Cross-Over Line Mounting Clamps	40 (54)
Fuel Tank Drain Plug	finger-tight + 1-1/2 turns
Midship Bearing Bracket Capscrews	95 (129)
Shift Lever Retaining Ring Screws	28 (38)
Shift Lever Plate Capscrews	40 (54)
Speedometer Sensor Wiring Harness Clamp Mounting Capscrews	40 (54)
Transmission Top Cover Capscrews	40 (54)
U-Joint End Cap Bolts	45 (61)

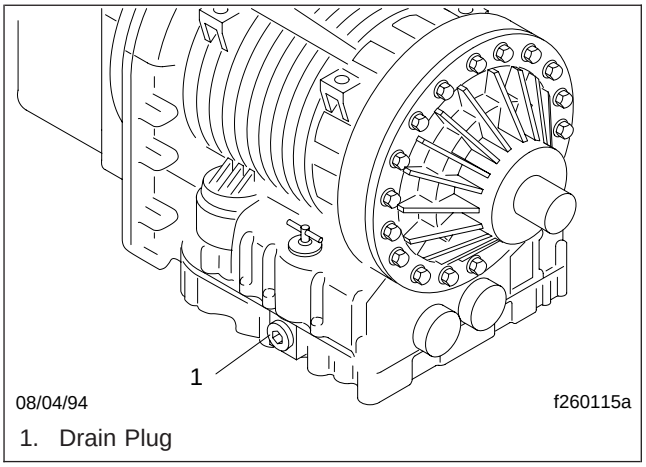
Table 1, Torque Values, Eaton/Meritor Transmissions

Torque Values, Mercedes-Benz Transmissions			
Description	**Size**	**Grade**	**Torque In lbf·ft (N·m)**
Bell Housing-to-Timing Case Capscrews	M10	8.8	33 (45)
Clutch Slave Cylinder Bracket Mounting Bolts	M8	8.8	15 (20)
Guide Tube Mounting Capscrew	—	—	17 (23)
Fuel Cross-Over Line Mounting Bolts	—	—	95 (129)
Fuel Cross-Over Line Mounting Clamps	—0	—	40 (54)
Midship Bearing Bracket Capscrews	3/4–11	—	95 (129)
Power Take-Off Unit (PTO) Mounting Capscrews	M10	10.9	43 (58)
Pressure Plate Mounting Capscrew	M16	10.9	190 (258)
Reverse Gear Switch	M20	8.8	42 (57)
Shift Lever Mounting Bolt	M10	10.9	50 (68)
Shift Lever Retaining Ring Screws	—	—	28 (38)
Speedometer Sensor Lock	M8	8.8	28 (38)
Starter Lock Switch (optional)	M20	8.8	42 (57)
Transmission Fluid Drain Plug	M24	8.8	42 (57)
Transmission Fluid Fill Plug	M24	8.8	42 (57)
U-Joint End Cap Bolts	3/8–24	—	50 (68)
	1/2–20	—	110 (149)

Table 2, Torque Values, Mercedes-Benz Transmissions

Removal

1. Apply the parking brake, chock the tires, and disconnect the batteries.
2. Remove the transmission drain plug and drain the automatic transmission fluid. **See Fig. 1.** Install the drain plug and tighten it 25 to 32 N·m (18 to 24 lbf·ft).



1. Drain Plug

Fig. 1

NOTE: The ATF drained from the transmission can be used again if it is clean and if the container into which it was drained contained no ethylene glycol.

3. Support the driveline with a jack stand between the transmission output yoke and the midship bearing.
4. Disconnect the driveline from the transmission.
   - 4.1 Loosen the bolts holding the midship bearing bracket so the driveshaft can slide to the rear. **See Fig. 2.**
   - 4.2 If the vehicle is equipped with a driveline parking brake, remove the nuts on the brake flange. **See Fig. 3.**

     If the vehicle is not equipped with a driveline parking brake, remove the transmission yoke U-joint end caps or lock straps.
   - 4.3 Slide the front of the driveshaft off the driveline brake flange or out of the transmission output yoke.

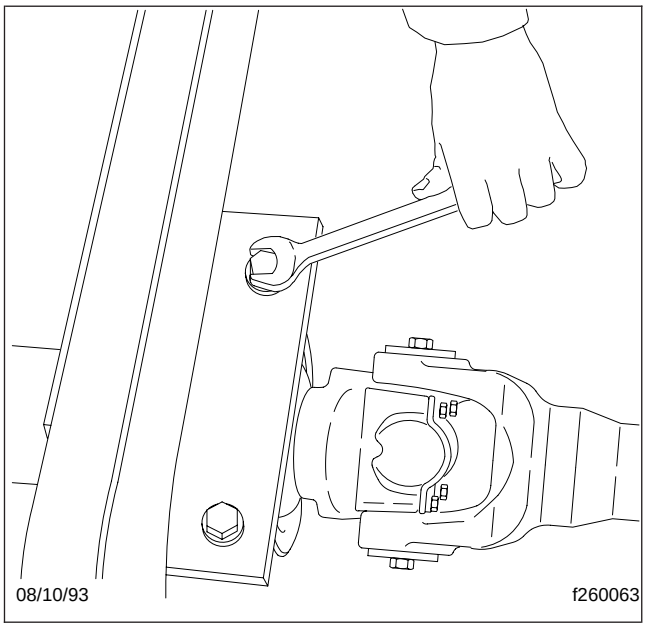


Fig. 2

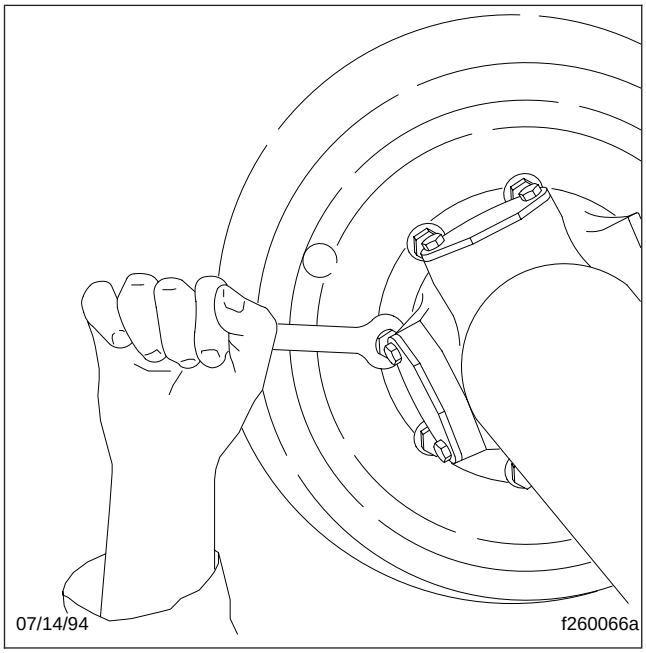


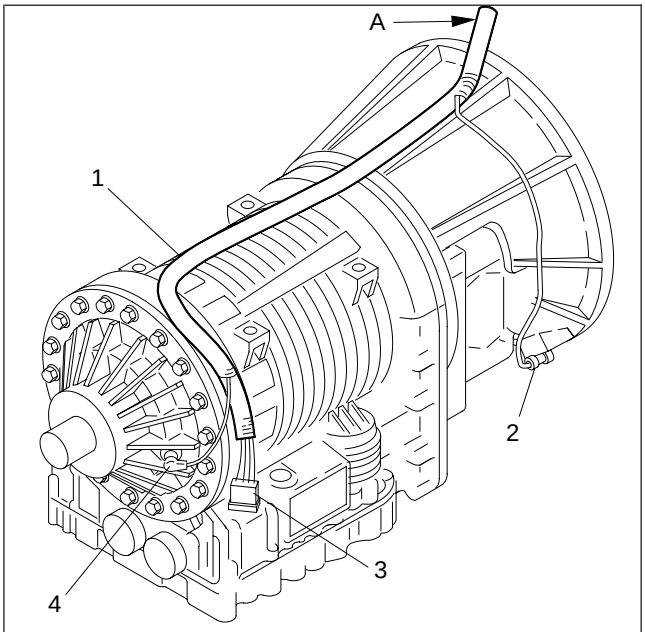
Fig. 3

NOTE: It may be necessary to remove the mounting bolts from the midship bearing bracket so the driveshaft can be moved far enough back.

Removal and Installation

4.4 Support the disconnected driveshaft and tie it to the frame rail.

5. Disconnect the three electrical connections to the transmission. **See Fig. 4.**



A. to bulkhead connector
1. Transmission Wiring Harness
2. Engine Speed Sensor
3. Transmission Control Connector
4. Output Speed Sensor

Fig. 4

6. If the vehicle is equipped with a driveline parking brake, release the parking brake, and remove the cotter pin holding the clevis to the driveline brake lever. **See Fig. 5.** Remove the flanged bolt and flanged nut holding the driveline brake cable bracket to the transmission; then, remove the bracket.

7. Remove the ATF fill/dipstick tube. **See Fig. 6.**

   7.1 Remove the U-bolt holding the fill/dipstick tube to its support bracket.

   7.2 Remove the bolt and metal strap holding the fill/dipstick tube.

   7.3 Pull the fill/dipstick tube out of the transmission case.

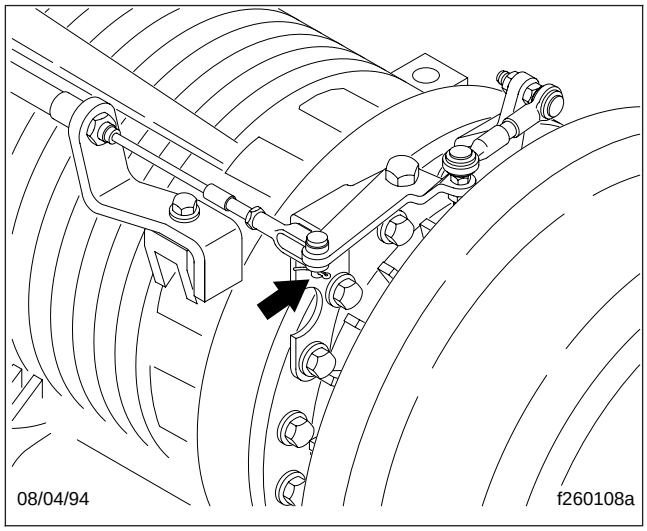


Fig. 5

   7.4 Plug the hole with a clean rag to prevent entry of foreign material.

8. Disconnect the flexplate from the transmission.

   8.1 Remove the capscrews holding the ring gear access cover. Then, remove the cover. **See Fig. 7.**

   NOTE: For easier access on Mercedes-Benz engines, first remove the three bolts holding the exhaust pipe to the turbocharger exhaust elbow. Then, lower the exhaust pipe.

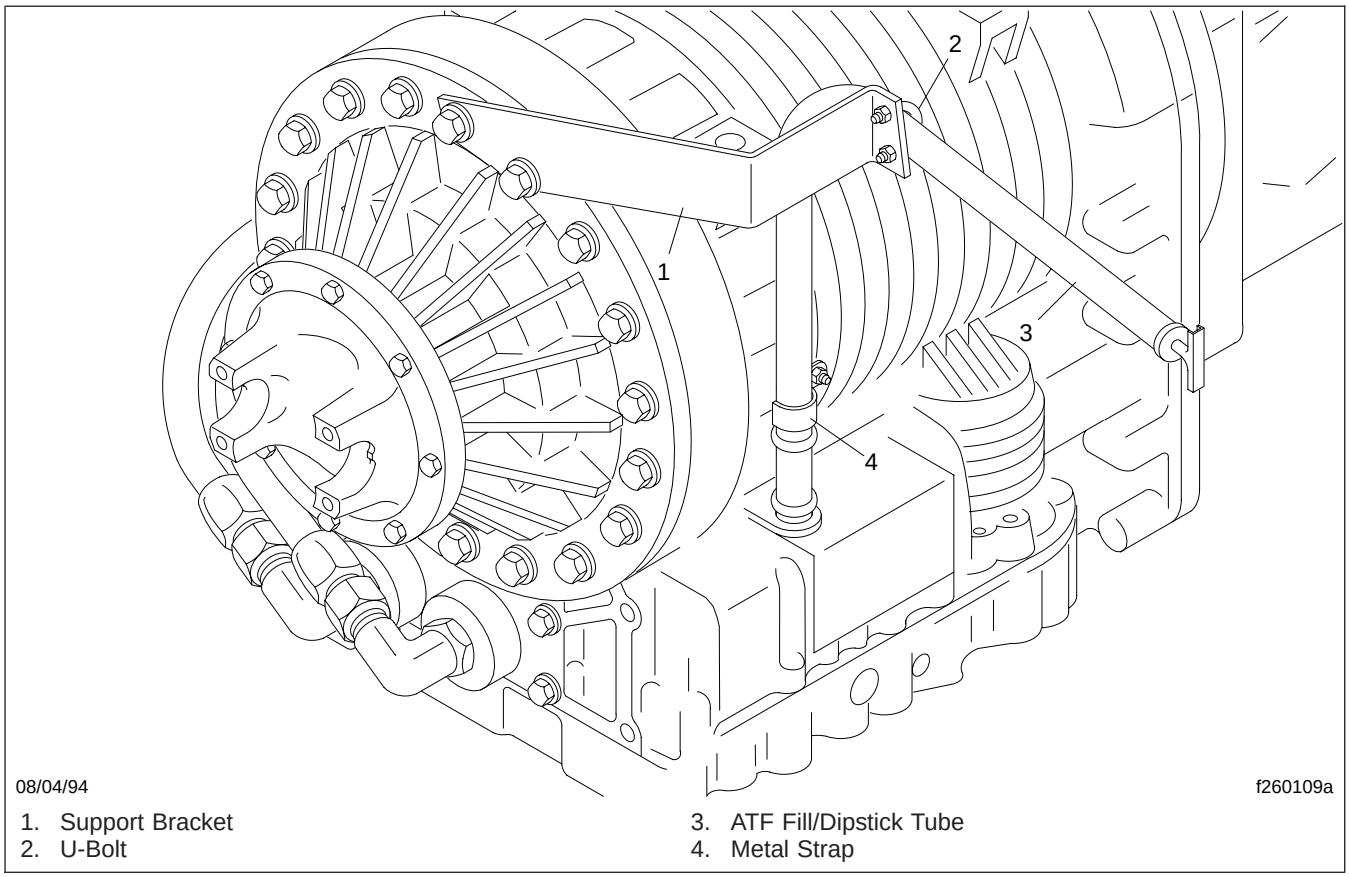
   8.2 Using a screwdriver, turn the ring gear until one of the capscrews holding the flexplate adapter to the torque converter can be removed. Continue turning the ring gear and removing the capscrews through the access hole until all twelve are removed.

9. Remove the wiring harness and the air line from the standoff bracket (**Fig. 8**) on the right side of the transmission. Remove the standoff bracket.

10. Disconnect the transmission fluid cooler lines (**Fig. 9**) from the transmission and drain the remaining ATF.

11. Place a piece of plywood on a transmission jack to support the transmission.

12. Slide the jack into place under the transmission. Secure the transmission with a chain. Anchor the



1. Support Bracket
2. U-Bolt
3. ATF Fill/Dipstick Tube
4. Metal Strap

Fig. 6

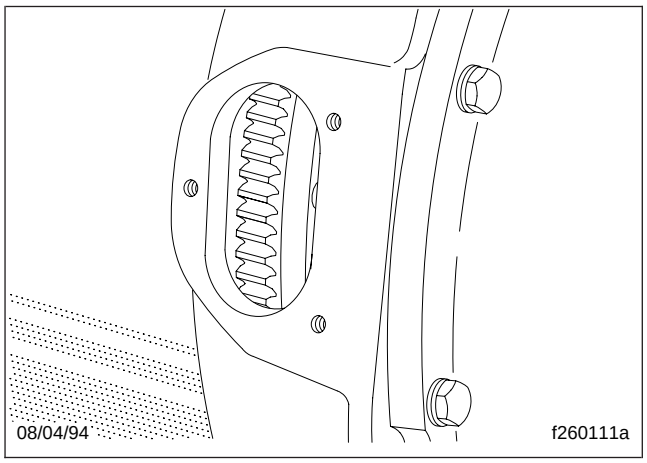


Fig. 7

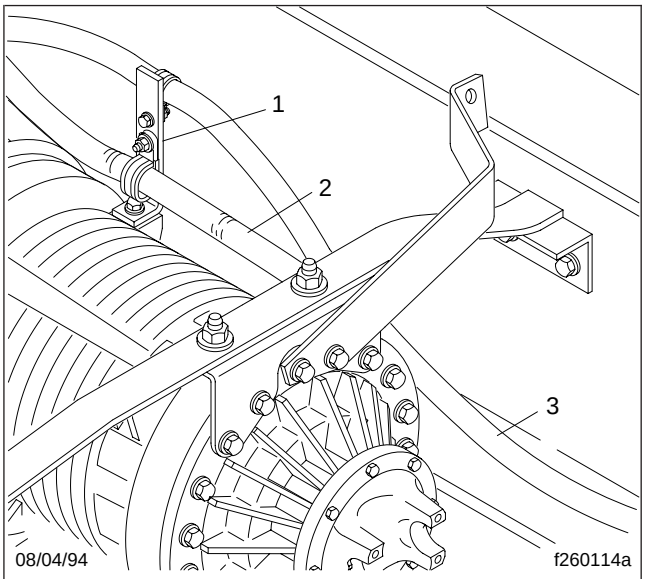
chain with bolts at the front lifting bosses on the top of the transmission. **See Fig. 10.**

13. Remove the two bolts holding the transmission to the rear overslung transverse support spring. **See Fig. 11.**
14. Remove the twelve transmission flange bolts. **See Fig. 12.**
15. Move the transmission jack to the rear. Lower the jack and lift the front of the truck, as needed, so the transmission clears the frame rail and any attached components.
16. Place jack stands under the raised front of the vehicle.
17. Roll the transmission jack back, and remove the transmission.

Installation

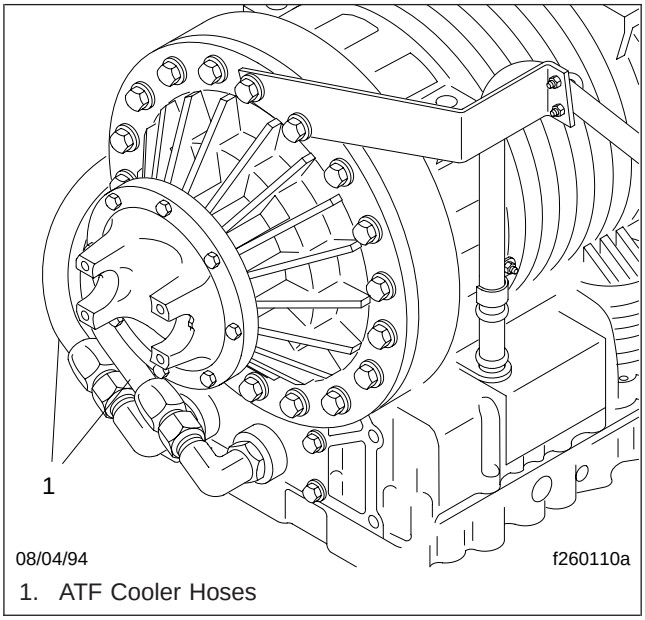
IMPORTANT: Before installing the transmission, make sure the rear tires are chocked and the

Removal and Installation



1. Standoff Bracket
2. Wiring Harness
3. Air Line

Fig. 8



1. ATF Cooler Hoses

Fig. 9

transmission is securely chained to the transmission jack.

1. Raise the front of the vehicle frame with a hydraulic jack to obtain adequate clearance for installing the transmission. Place jack stands under the front of the vehicle.

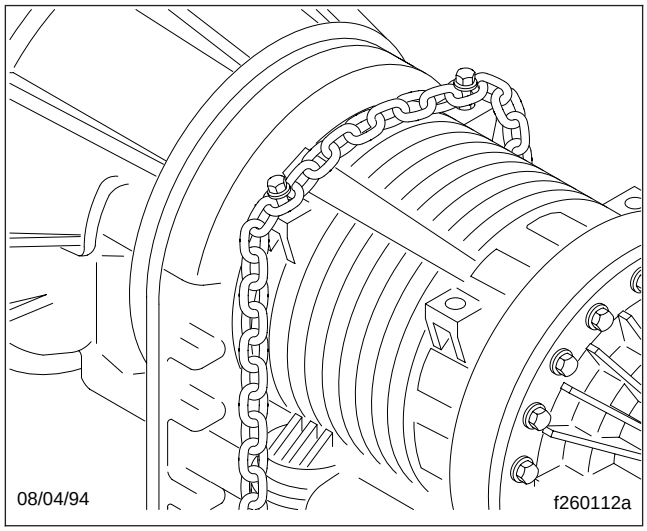


Fig. 10

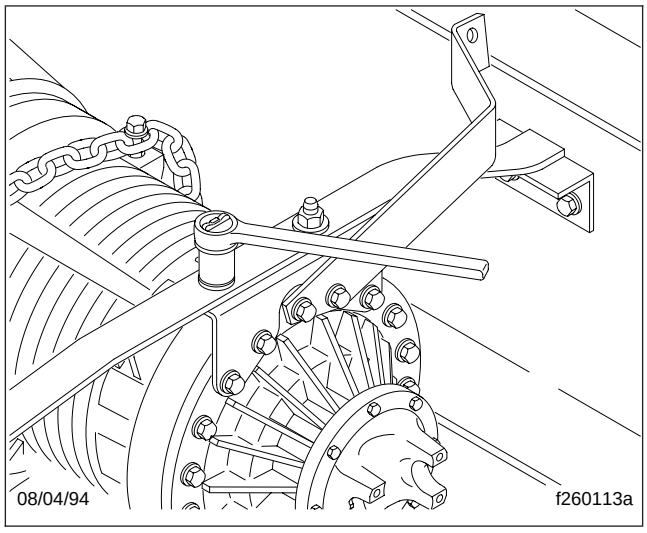


Fig. 11

2. With the transmission on a jack, roll the transmission into place behind the flexplate. Remove the jack stands, and lower the front of the vehicle frame.
3. Raise the jack until the transmission lines up with the flexplate.
4. Push the transmission toward the engine until it seats squarely against the engine flywheel hous-

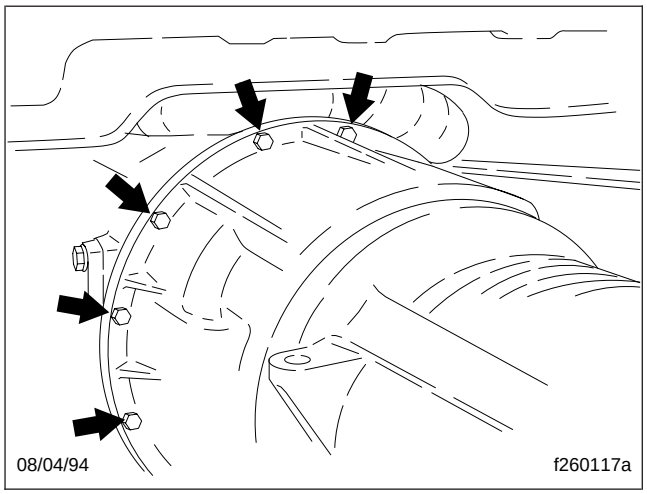


Fig. 12

ing with the bolt holes in the transmission housing aligned with those in the flywheel housing.

NOTE: No force is required. If interference is encountered, move the transmission away from the engine and correct the problem.

5. Install the transmission flange bolts finger-tight.
6. Install the transverse support spring at the rear of the transmission. Install the two bolts and washers. Tighten the bolts 184 N·m (136 lbf·ft). **See Fig. 11.**
7. Remove the chain holding the transmission to the transmission jack.
8. Lower the transmission jack and remove it.
9. Connect the transmission fluid cooler hoses to the transmission. Tighten the fittings 54 to 68 N·m (40 to 50 lbf·ft). **See Fig. 9.**
10. Install the twelve flexplate adapter capscrews.
    - 10.1 Turning the ring gear for access, install all the capscrews through the access hole. Don't tighten them now.

      Be careful not to drop the capscrews inside the torque converter cover. The transmission must be removed to get them out.

    IMPORTANT: Install all the capscrews before tightening any of them to prevent cocking of the flexplate adapter.

    - 10.2 Tighten the capscrews 24 to 29 N·m (18 to 21 lbf·ft) in a star pattern.
    - 10.3 Install the access cover and its capscrews. There are three capscrews on Mercedes-Benz engines, two on Cummins and Detroit Diesel engines.
11. Tighten the twelve M10 transmission flange bolts (**Fig. 12**) 51 to 61 N·m (38 to 45 lbf·ft) in a star pattern.
12. If the vehicle is equipped with a driveline parking brake, mount the driveline brake cable bracket to the transmission. Install the two flanged bolts and flanged nuts, and tighten them 31 N·m (23 lbf·ft). Attach the clevis to the brake lever; then, insert and lock the cotter pin. **See Fig. 5.**
13. Connect the driveshaft.
    - 13.1 Slide the front of the driveshaft into the transmission output yoke or onto the driveline parking brake flange if so equipped.
    - 13.2 On vehicles without a driveline parking brake, install the transmission yoke U-joint end caps or lock straps.

      On vehicles with a driveline parking brake, slide the driveshaft flange onto the studs in the parking brake. Install the nuts, and tighten them 54 N·m (40 lbf·ft).
    - 13.3 If the midship bearing bracket bolts and nuts were removed, install them. Tighten the nuts 129 N·m (95 lbf·ft).
14. On Mercedes-Benz engines, if the exhaust pipe was disconnected from the turbocharger exhaust elbow, connect the pipe and tighten the bolts 81 N·m (60 lbf·ft).
15. Install the ATF fill/dipstick tube.
    - 15.1 Install the fill/dipstick tube support bracket. Tighten the two capscrews 108 N·m (80 lbf·ft).
    - 15.2 Inspect the fill/dipstick tube seal. Replace it if damaged.
    - 15.3 Install the fill/dipstick tube and clamp. Tighten the capscrew 16 N·m (12 lbf·ft).
    - 15.4 Install the U-bolt and nuts holding the fill/dipstick tube to the bracket. Tighten the U-bolt nuts 11 N·m (8 lbf·ft).

Removal and Installation

16. Install the standoff bracket on the right side of the transmission.

    Make sure the air line and the wiring harness are securely attached to the standoff bracket.

17. Fill the transmission with ATF.

18. Connect all electrical lines to the transmission.

    18.1 Connect the transmission control connector.

    18.2 Connect the electrical cable to the output speed sensor.

    18.3 Connect the cable to the engine speed sensor.

    18.4 Using tie straps, secure the cables where necessary.

19. Connect the batteries and remove the chocks from the tires.

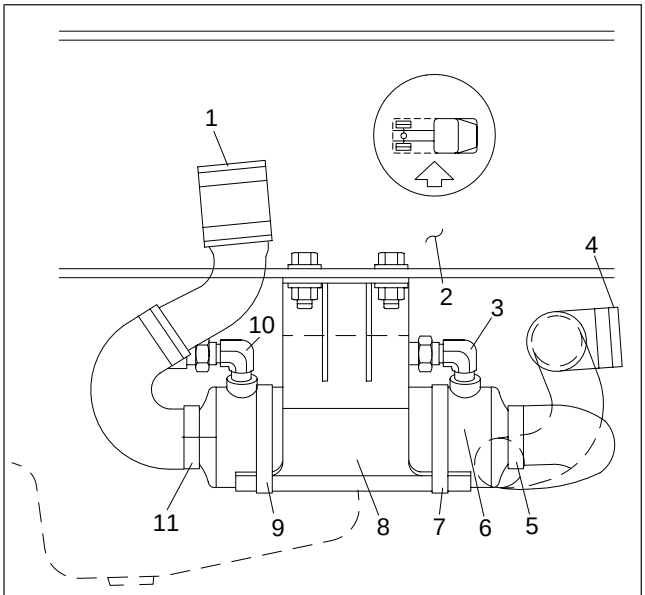
20. Start the engine, and check for any leaks. Repair leaks as needed.

21. Check the ATF level. Add fluid as needed.

22. Road test the vehicle, and check for correct transmission operation.

ATFCooler Removal and Installation

Removal (See Fig. 1 and Fig. 2)



06/06/97 f260431

1. Coolant Return Hose
2. Frame Rail
3. ATF Supply Line
4. Coolant Supply Hose
5. Coolant Clamp
6. ATF Cooler
7. T-Bolt Clamp
8. ATF Cooler Mounting Bracket
9. T-Bolt Clamp
10. ATF Return Line
11. Coolant Clamp

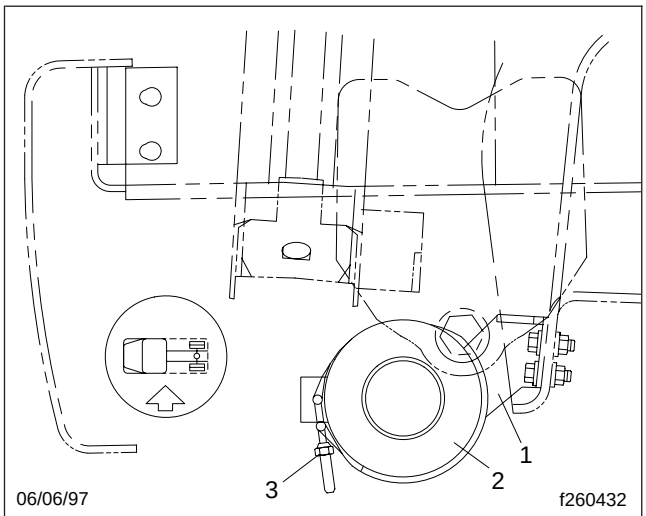
Fig. 1, ATF Cooler (frame mounted)

1. Apply the parking brakes and chock the tires.

⚠ WARNING

Drain the coolant system only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

2. With the engine cool, loosen the surge tank cap to release cooling system pressure.
3. Place a suitable container under the radiator. Open the drain petcock at the bottom of the radiator and drain the cooling system. Close the drain petcock.
4. Disconnect the coolant hoses from the fittings at both sides of the automatic transmission fluid (ATF) cooler. When the coolant stops draining, secure the ends of the hoses to prevent leakage.



06/06/97 f260432

1. ATF Cooler Mounting Bracket
2. ATF Cooler
3. T-Bolt Clamp

Fig. 2, ATF Cooler (transverse mounted)

5. Disconnect the ATF hoses from the fittings at both sides of the ATF cooler. Catch the ATF by directing the disconnected end of each hose into a drain pan. When the ATF stops draining, plug the hoses and cap the fittings.
6. Remove the two hexnuts and washers that attach the ATF cooler to the T-bolt mounting bracket assembly, and remove the ATF cooler. Drain the ATF cooler into a drain pan.

Installation

1. Hold the ATF cooler in place; then install the hexnuts and washers on the T-bolt mounting bracket assembly. Tighten them 28 lbf·ft (38 N·m).
2. Attach the coolant hoses to the fittings at both sides of the ATF cooler, as removed.
3. Remove the plugs from the ATF hoses and the caps from the fittings. Attach the ATF hoses to the fittings at both sides of the ATF cooler. Tighten the fittings 40 to 50 lbf·ft (54 to 68 N·m).
4. Fill the coolant system and install the surge tank cap.
5. Start the engine and operate the transmission for one or two minutes, then add the correct ATF to

ATFCooler Removal and Installation

the transmission as needed. For instructions and lubricant specifications, see Group 26 of the *Business Class Trucks Maintenance Manual*.

6. Run the engine until operating temperature is reached and check for leaks in the coolant system or ATF cooler. Repair leaks as needed.
7. Check the coolant level and add as needed.
8. Remove the tire chocks.

Specifications

Fastener Torques	
Description	**Torque lbf·ft (N·m)**
Transmission Drain Plug	136 (184)
ATF Cooler Hose Fittings	40–50 (54–68)
Flexplate Adapter Capscrews	18–21 (24–29)
Transmission Flange Bolts	38–45 (51–61)
Driveline Parking Brake Cable Bracket Mounting Nuts	23 (31)
Driveline Parking Brake Stud Nuts	40 (54)
Midship Bearing Bracket Nuts	95 (129)
Exhaust Pipe-to-Turbocharger Mounting Bolts	60 (81)
ATF Fill/Dipstick Tube Support Bracket Capscrews	80 (108)
ATF Fill/Dipstick Tube Clamp Capscrews	12 (16)
ATF Fill/Dipstick Tube-to-Bracket U-Bolt Nuts	8 (11)
ATF Cooler T-Bolt Nuts	28 (38)

Table 1, Fastener Torques

Removal

CAUTION

To avoid component damage, be sure to remove the transmission and torque converter as an assembly. The converter drive plate, pump bushing, and oil seal can be damaged if the converter is left attached to the drive plate during removal.

1. Apply the parking brake, chock the tires, and disconnect the batteries.
2. Drain the automatic transmission fluid (ATF). If equipped, remove the transmission drain plug. Otherwise, remove the transmission oil pan. When removing the drain plug, use one wrench to hold the nut and another to turn the drain plug.

   After draining the ATF, install the oil pan (or drain plug, if equipped). Tighten all oil pan bolts 17 N·m (13 lbf·ft). Tighten the drain plug nut (if equipped) 17 N·m (13 lbf·ft) also.
3. Remove the exhaust system components. See **Fig. 1**.

   IMPORTANT: Mark both oxygen sensors, left-hand and right-hand. Be careful not to mix them up during assembly.

   3.1 Remove both oxygen sensors, one from each exhaust pipe.

   3.2 Disconnect the exhaust manifold saddle brackets.

   3.3 Disconnect the clamps attaching each pipe to the catalytic converter.

   3.4 Remove the rubber isolators from the exhaust support. Push the exhaust pipes back until the exhaust hangers clear the brackets. Remove both exhaust pipes from the vehicle.
4. Disconnect the driveline from the transmission. See **Fig. 2**.

   4.1 Support the driveline with a jack stand between the transmission output yoke and the midship bearing.

   4.2 Make one reference mark on the driveline and another on the transmission output yoke, for use during assembly.

   4.3 Remove the midship bracket and end bracket.

   4.4 Pull the driveline straight back until it comes free of the splined shaft on the transmission output yoke.

   4.5 Support the disconnected driveline and tie it to the frame rail.
5. Disconnect the transmission fluid cooler lines (see **Fig. 3**) from the transmission. Disconnect the standoff bracket.
6. Remove the two engine-to-transmission struts. See **Fig. 4**.

   6.1 Remove the transmission-to-strut bolt.

   6.2 Remove the engine-to-strut bolt. After removing the strut, install the bolt; this bolt is part of the engine mount.

   6.3 Remove the strap for the ATF cooler lines from the left-hand strut.
7. Remove the ATF fill/dipstick tube. See **Fig. 5**.

   7.1 Remove the bolt attaching the fill/dipstick tube bracket to the engine.

   7.2 Pull the fill/dipstick tube out of the transmission case.

   7.3 Plug the hole with a clean rag to prevent entry of foreign material.

CAUTION

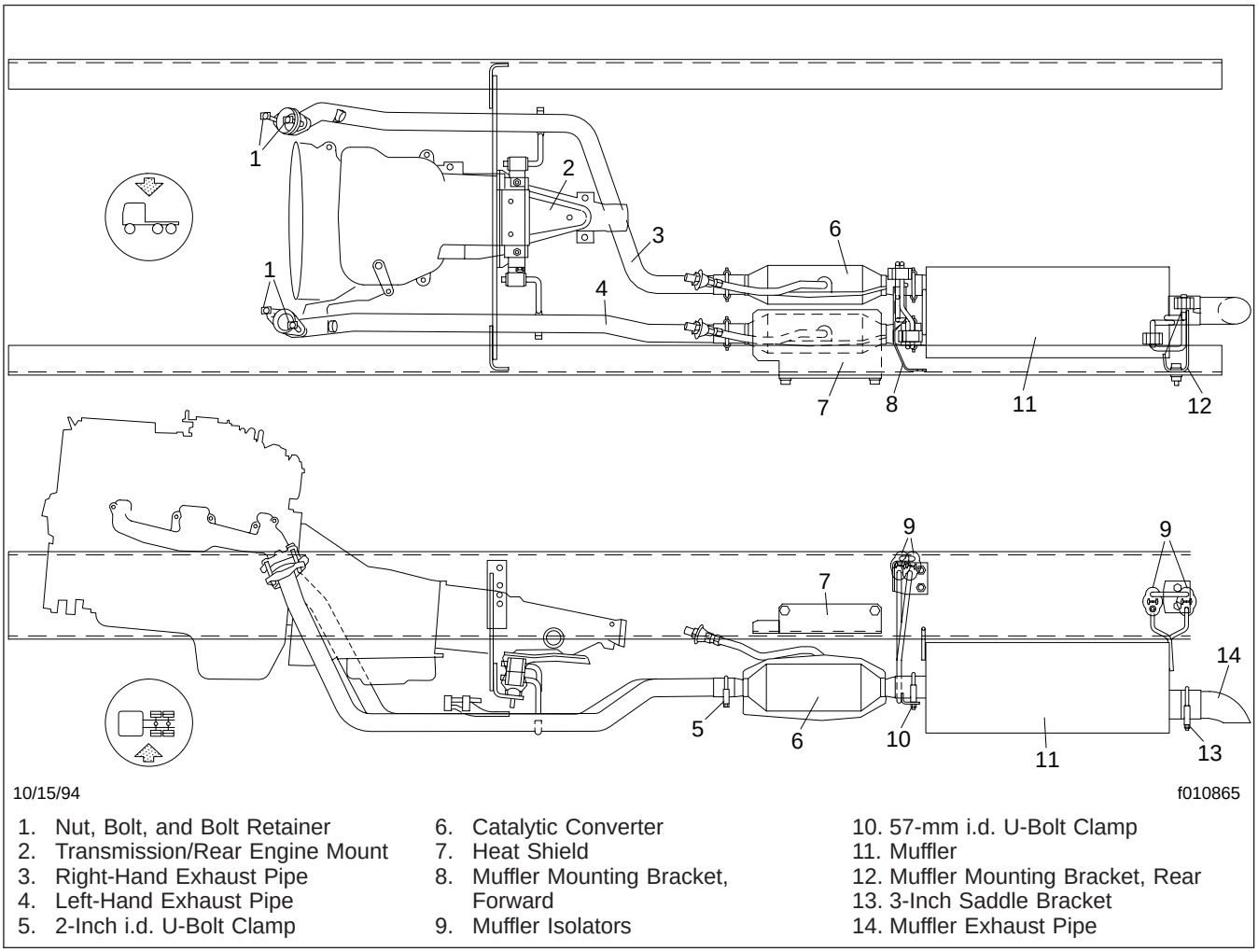
The crankshaft position sensor will be damaged if the transmission is removed (or installed) while the sensor is still bolted to the engine block. To avoid damage, be sure to remove the sensor before removing the transmission.

8. Disconnect the five electrical connections to the transmission.

   8.1 Remove the crankshaft position sensor (bolted to the engine at the bell housing). See **Fig. 6**.

   8.2 Disconnect the transmission temperature sensor attached to the forward ATF cooler

Removal and Installation



1. Nut, Bolt, and Bolt Retainer
2. Transmission/Rear Engine Mount
3. Right-Hand Exhaust Pipe
4. Left-Hand Exhaust Pipe
5. 2-Inch i.d. U-Bolt Clamp
6. Catalytic Converter
7. Heat Shield
8. Muffler Mounting Bracket, Forward
9. Muffler Isolators
10. 57-mm i.d. U-Bolt Clamp
11. Muffler
12. Muffler Mounting Bracket, Rear
13. 3-Inch Saddle Bracket
14. Muffler Exhaust Pipe

Fig. 1, Exhaust System Components

line (pressure line) at the transmission case. See **Fig. 7**.

8.3 Disconnect the park-neutral position switch located on the transmission case just aft of the inner shift lever. See **Fig. 7**.

8.4 Disconnect the transmission overdrive solenoid located on the transmission case behind the throttle valve cable. See **Fig. 7**.

8.5 Disconnect the vehicle speed sensor from the speedometer adapter located on the overdrive unit just forward of the U-joint. See **Fig. 7**.

9. Remove the shift linkage from the transmission.

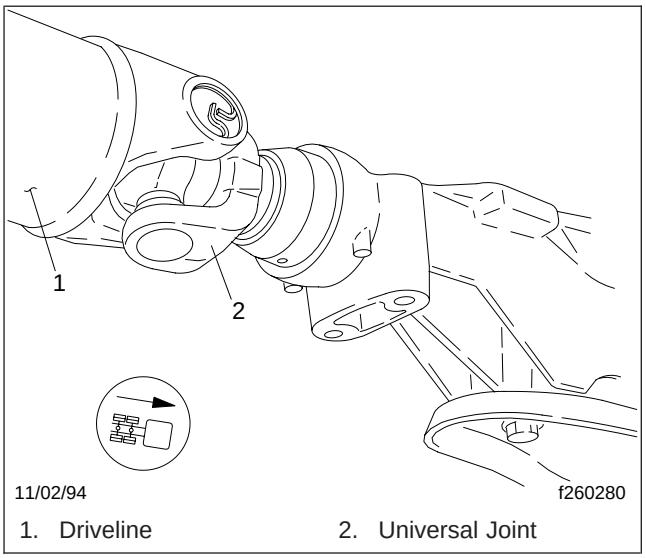
9.1 Remove the U-bolt holding the shift cable to the shift cable support bracket. See **Fig. 8** .

9.2 Remove the clip attaching the shift cable to the inner shift lever. See **Fig. 9** .

10. Remove the throttle valve linkage from the transmission. See **Fig. 10**.

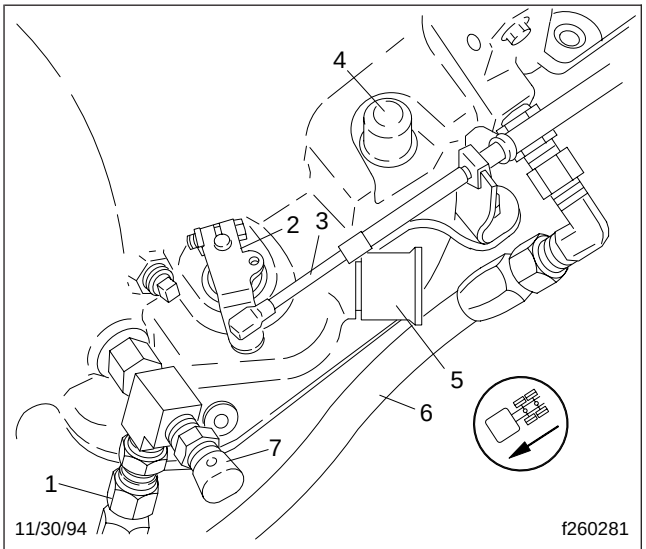
10.1 Disconnect the spring attaching the throttle lever to the spring bracket.

10.2 Using a screwdriver blade, remove the quick-disconnect fitting at the clamp on the throttle valve cable. Then snap off the



1. Driveline
2. Universal Joint

Fig. 2, Transmission Output Yoke



NOTE: Inner shift lever and shift cable not shown.

1. Forward Cooler Line
2. Throttle Valve Lever
3. Throttle Valve Cable
4. Transmission Overdrive Solenoid
5. Park/Neutral Position Switch
6. Aft Cooler Line
7. Transmission Temperature Sensor

Fig. 3, ATF Cooler Lines

plastic connector attaching the cable to the ball stud on the throttle lever.

11. Remove the starter from the bell housing.

    11.1 Remove the battery cable standoff brackets. Remove the battery cable bolt and bracket. Do not remove the clamp from the battery cable.

    11.2 Mark and disconnect the battery and solenoid cable leads. Remove the two starter mounting bolts.

    11.3 Move the starter forward until the nose of the starter gear housing clears the lower mounting stud. See **Fig. 11**.

12. Remove the two bolts attaching the fuel line support bracket to the transmission case. Remove it from the fuel lines and set it aside for assembly. See **Fig. 12**. Remove the standoff bracket from the air pump hose going to the catalytic converter.

13. Remove the torque converter from the drive plate.

    13.1 Remove the three bolts on the torque converter access cover. Make alignment marks on the torque converter and drive plate for reference. See **Fig. 13**.

    13.2 Using a socket wrench, turn the crankshaft vibration damper clockwise until converter bolts are accessible. Then remove the bolts one at a time.

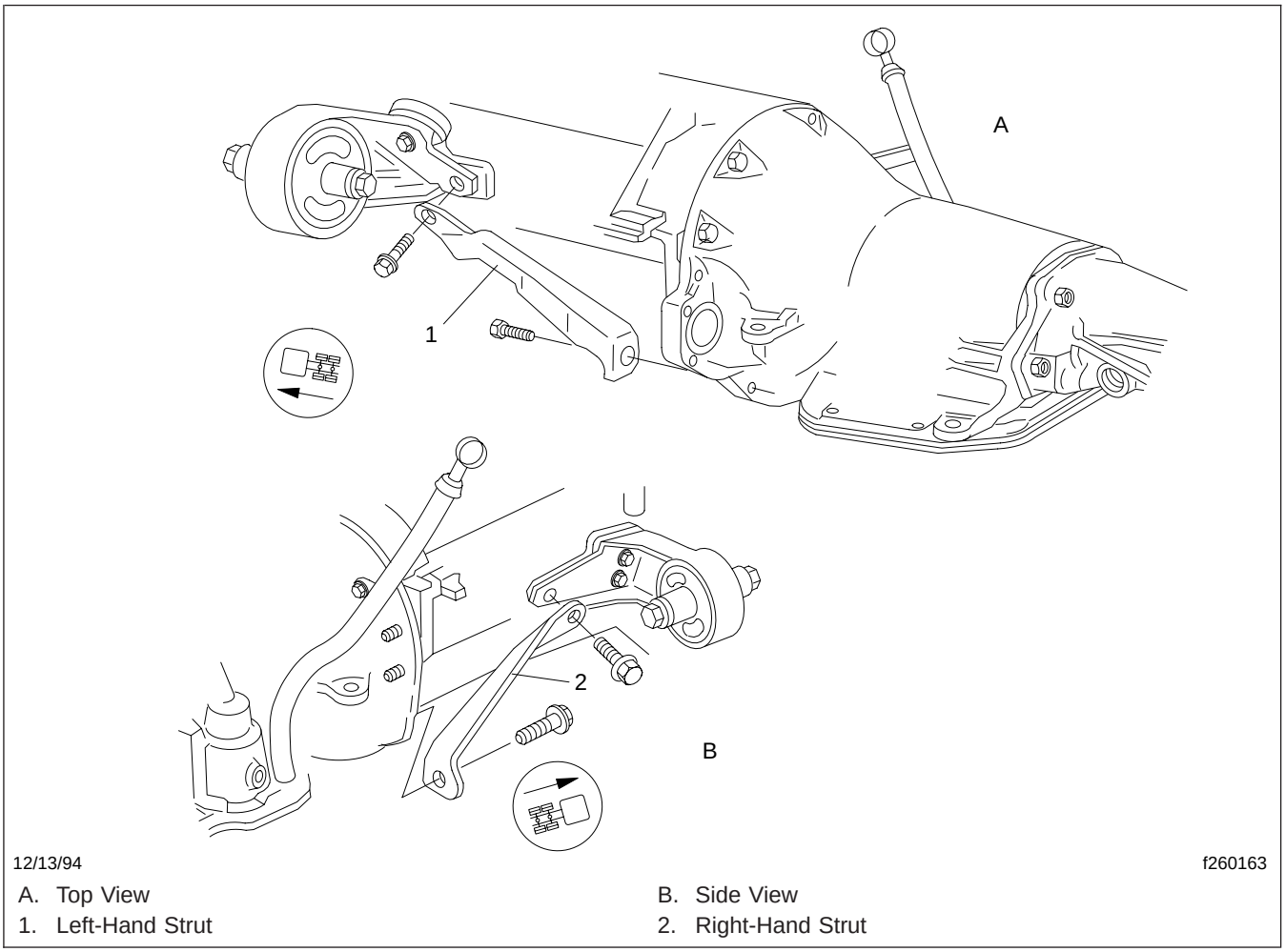
14. Remove the main support crossmember. See **Fig. 14**.

    14.1 Lift the front or the rear of the vehicle, as needed, to allow the transmission to clear the frame rail and any attached components. Support the rear of the engine with a safety stand or jack. Place other safety stands under the vehicle as needed.

    14.2 Secure the transmission jack to the transmission. Using the jack, raise the transmission slightly to relieve the load on the crossmember.

    IMPORTANT: Make sure the chain or cable securing the transmission to the jack is not interfering with the shift and throttle valve linkage levers on the right-hand side of the transmission.

Removal and Installation



A. Top View
1. Left-Hand Strut
B. Side View
2. Right-Hand Strut

Fig. 4, Engine-to-Transmission Struts

14.3 Remove the three bolts holding the transmission to the triangular rear support bracket connected to the crossmember. Remove the bolts attaching the crossmember to each frame rail bracket.

NOTE: The crossmember is not symmetrical. To save installation time, mark the front of the crossmember before removal.

14.4 Remove the crossmember and rear support bracket as a unit. Carefully lower them, taking care to clear the battery cable and any other lines or hoses.

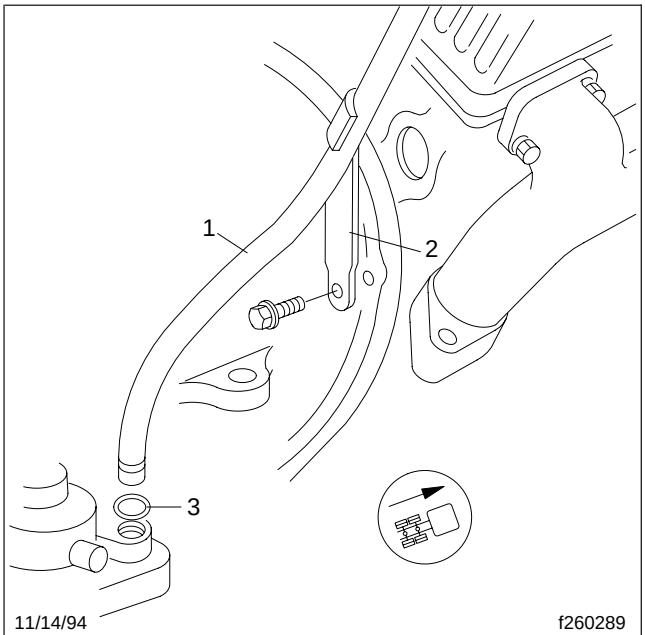
15. Remove the transmission flange bolts attaching the engine block to the bell housing.

15.1 Remove the five out-facing offset bolts on the bell housing.

15.2 Remove the last, in-facing bolt by pushing the transmission forward, loosening the bolt, pushing the transmission backward to gain more room, and repeating this process until the bolt is out. See **Fig. 15**.

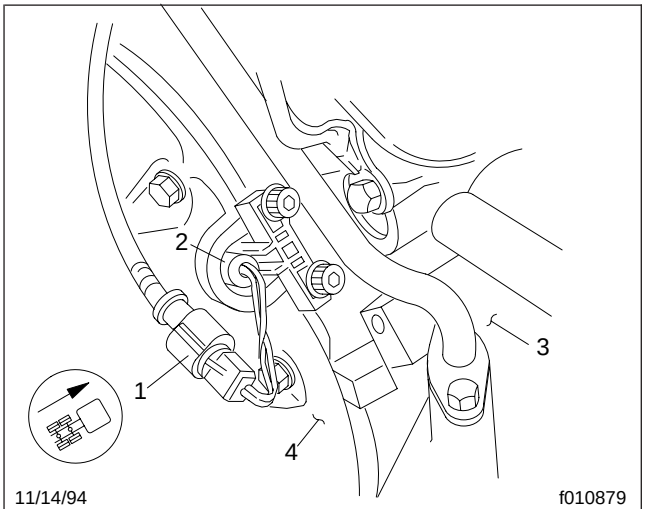
16. Use a C-clamp or wedge tool to hold the torque converter in position while the transmission is being removed. See **Fig. 16**.

17. Remove the transmission from the vehicle. Make sure clearance is adequate and safety stands are properly placed. Adjust vehicle height and placement of supports, if necessary.



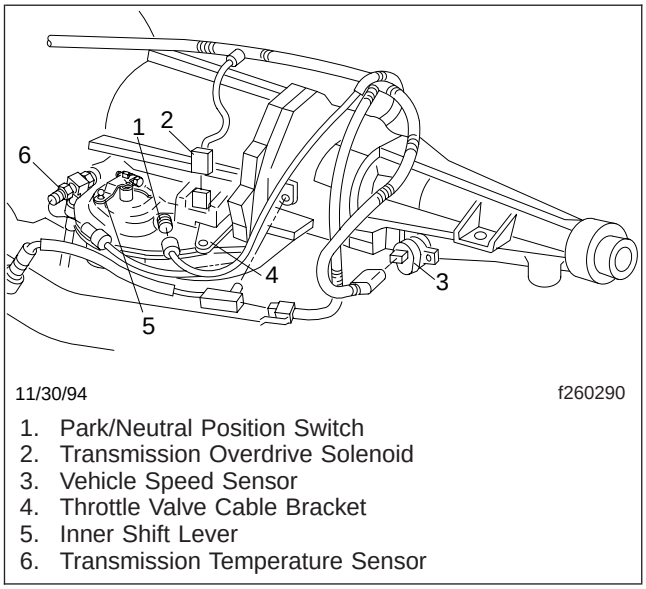
1. ATF Fill/Dipstick Tube
2. Support Bracket
3. O-Ring

Fig. 5, Fill/Dipstick Tube Attachment



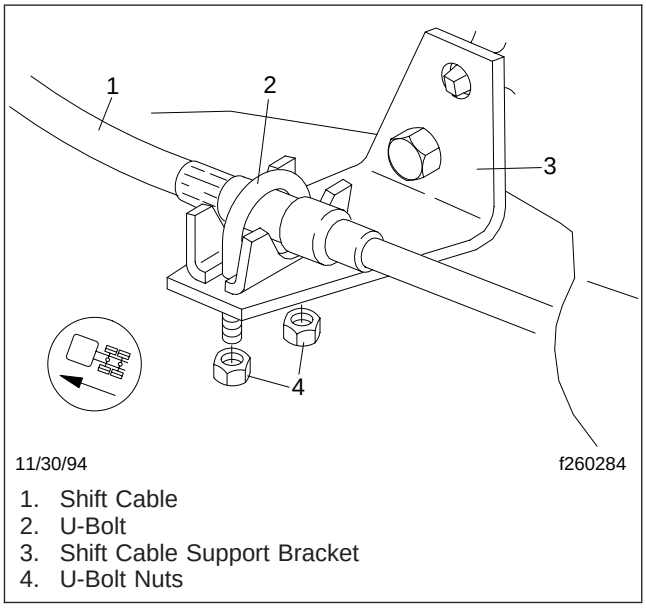
1. Electrical Connector
2. Crankshaft Position Sensor
3. Engine Block
4. Transmission Bell Housing

Fig. 6, Crankshaft Position Sensor



1. Park/Neutral Position Switch
2. Transmission Overdrive Solenoid
3. Vehicle Speed Sensor
4. Throttle Valve Cable Bracket
5. Inner Shift Lever
6. Transmission Temperature Sensor

Fig. 7, Transmission Electrical Connectors

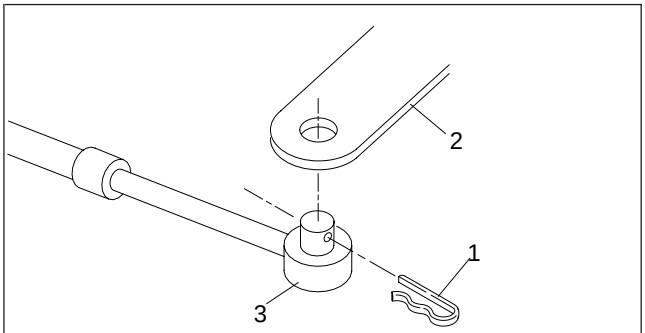


1. Shift Cable
2. U-Bolt
3. Shift Cable Support Bracket
4. U-Bolt Nuts

Fig. 8, Shift Cable U-Bolt

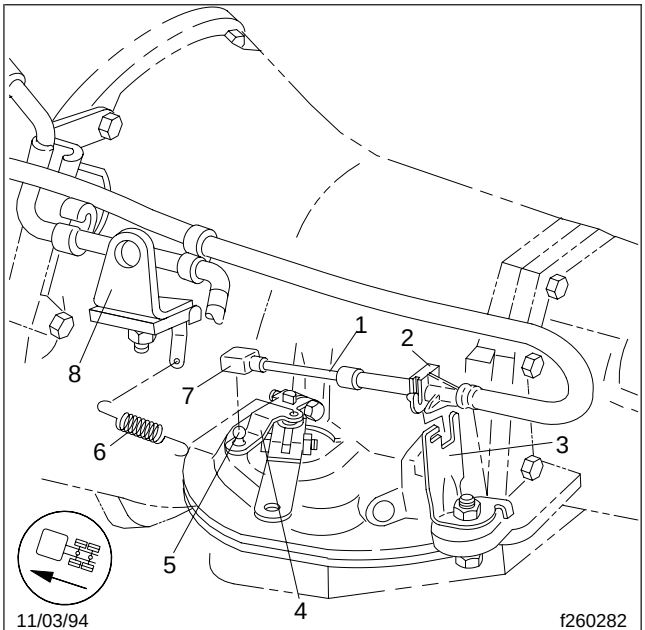
18. Inspect the torque converter for damage and replace it if necessary. Check the torque converter drive hub for condition. Lubricate the drive hub and oil pump seal lip with transmission fluid.

Removal and Installation



1. Clip
2. Inner Shift Lever
3. Shift Cable

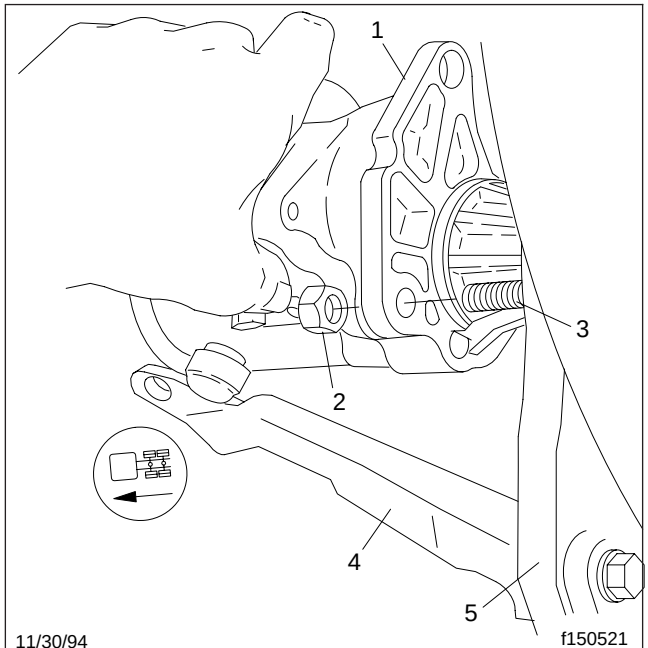
Fig. 9, Disconnecting the Shift Cable



1. Throttle Valve Cable
2. Quick-Disconnect Fitting
3. Cable Bracket
4. Throttle Lever
5. Ball Stud
6. Spring
7. Snap-On Plastic Connector
8. Spring Bracket

Fig. 10, Throttle Valve Linkage

NOTE: If replacing the transmission, replace the torque converter also. Drain the transmission fluid from the torque converter before replacing it.



1. Starter
2. Mounting Stud Nut
3. Mounting Stud
4. Engine-to-Transmission Strut
5. Bell Housing

Fig. 11, Starter Removal and Installation

Installation

IMPORTANT: Before installing the transmission, make sure the rear tires are chocked, the engine is supported, and the transmission is securely chained to the transmission jack.

1. Install the transmission on the vehicle.

   1.1 Raise the front of the vehicle frame with a hydraulic jack to obtain adequate clearance for installing the transmission. Place safety stands under the front of the vehicle.

   1.2 Check converter seating with steel scale and straightedge (see **Fig. 17**). The surface of the converter lugs should be 13 mm (1/2 inch) to the rear of the straightedge when fully seated.

   1.3 With the transmission on a jack, roll the transmission into place behind the drive

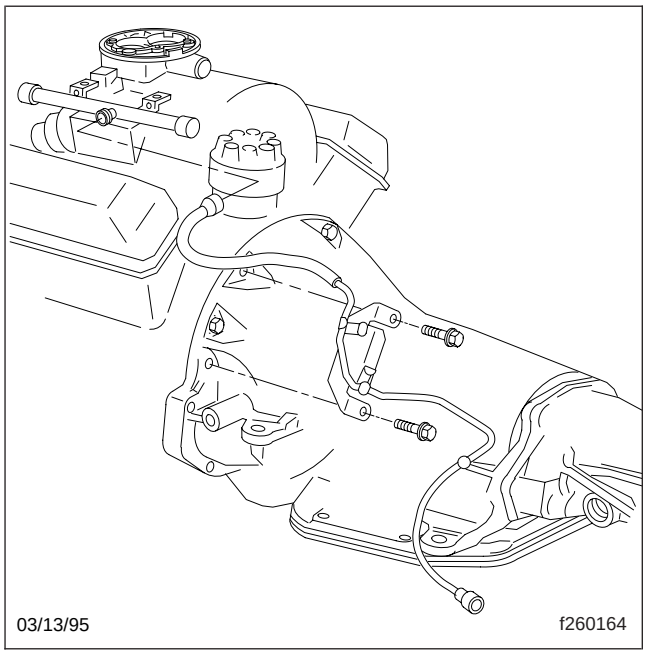


Fig. 12, Fuel Line Support Bracket

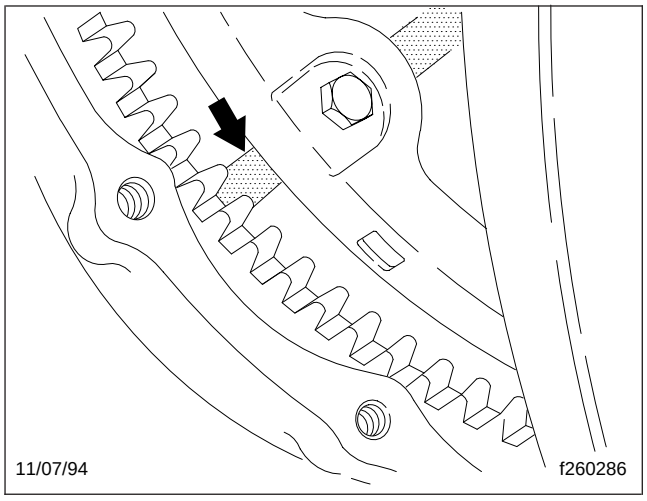
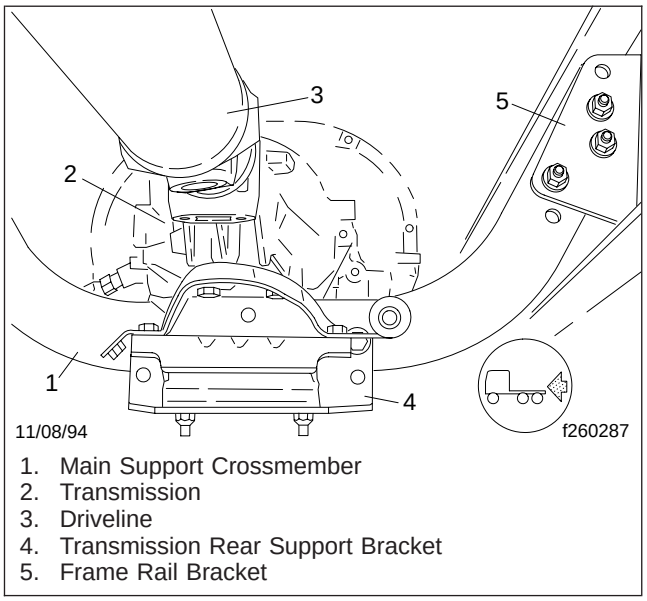


Fig. 13, Alignment of Drive Plate and Torque Converter

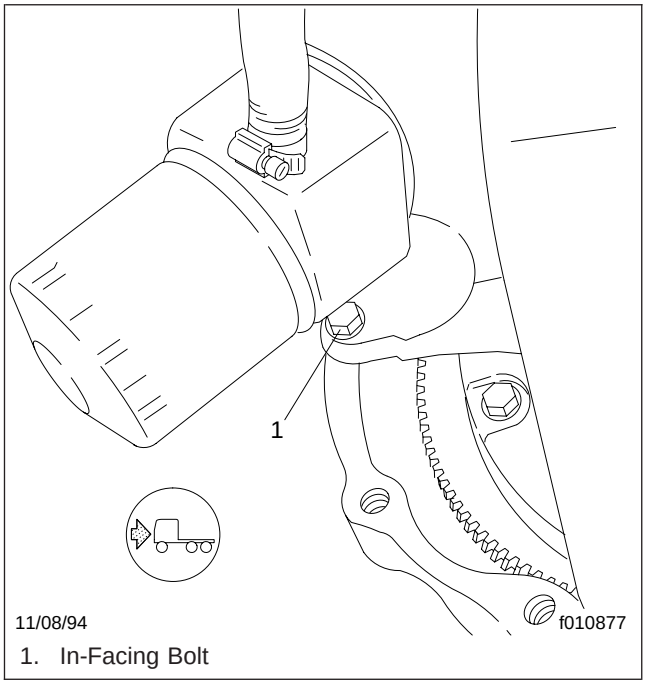
plate. Remove the C-clamp from the torque converter.

IMPORTANT: If reinstalling the old transmission, check drive plate for cracks, distortion, and damage. Be sure the transmission dowel pins are seated in the engine block and that they stick out far enough to hold the transmission in alignment.



1. Main Support Crossmember
2. Transmission
3. Driveline
4. Transmission Rear Support Bracket
5. Frame Rail Bracket

Fig. 14, Main Support Crossmember



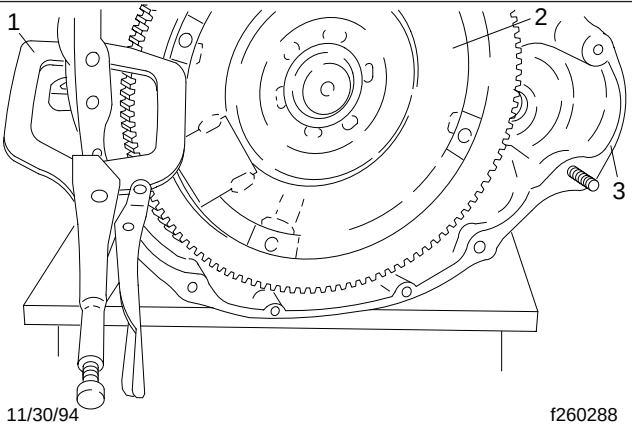
1. In-Facing Bolt

Fig. 15, In-Facing Bolt Location

1.4 Raise the jack until the transmission lines up with the drive plate.

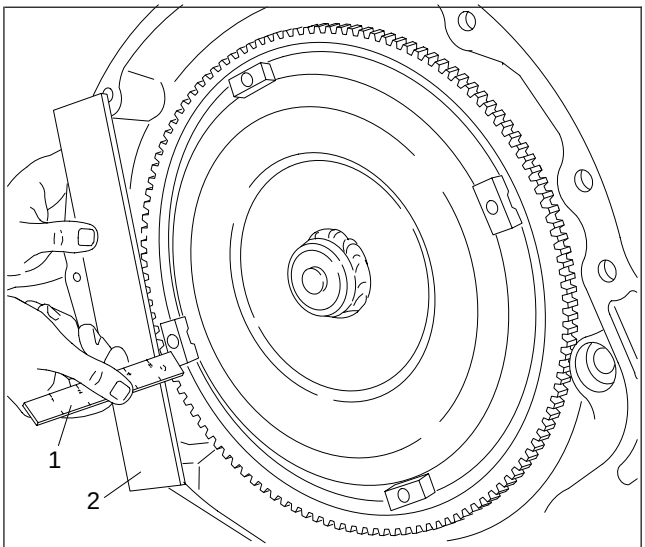
1.5 Push the transmission toward the engine until it seats squarely against the drive

Removal and Installation



1. C-Clamp
2. Torque Converter
3. Bell Housing

Fig. 16, Clamping the Torque Converter



1. Scale
2. Straightedge

Fig. 17, Typical Method of Checking Converter Seating

plate, and the bolt holes in the transmission housing align with those in the engine block.

NOTE: No force is required. If interference is encountered, move the transmission away from the engine and correct the problem.

1.6 Install the transmission flange bolts. First, tighten the in-facing bolt (bolt head toward front of vehicle) located directly behind the oil filter. Then, tighten the five out-facing bolts. Tighten all six bolts 41 N·m (30 lbf·ft).

2. Install the main support crossmember and triangular rear support bracket.

   2.1 Line up the crossmember using the reference mark made on removal. The crossmember is in front of the frame brackets when correctly installed. See **Fig. 14**.

   2.2 Install the standoff bracket for the battery cable to the lower frame rail.

   NOTE: Be sure the battery cable is above the crossmember before tightening the bolts.

   2.3 Install the crossmember to the frame rail brackets on each side of the vehicle. Tighten all six bolts 68 N·m (50 lbf·ft).

   2.4 Adjust the transmission again, if necessary.

   2.5 Install the transmission mount onto the transmission using the three bolts on the bottom of the support bracket. Tighten all bolts 68 N·m (50 lbf·ft).

3. Remove the safety stands under the engine. Remove the chain holding the transmission to the jack. Lower the jack and remove it.

4. Align the engine with the transmission.

   4.1 Turn the engine until the alignment mark made on removal becomes visible. Use a socket wrench to turn the crankshaft vibration damper clockwise to install the bolts.

   NOTE: Be careful not to drop the bolts inside the torque converter. The transmission must be removed to get them out.

   4.2 Tighten each torque converter bolt 31 N·m (23 lbf·ft).

   4.3 Install the torque converter access cover.

5. Install the ATF fill/dipstick tube.

   5.1 Replace the fill/dipstick tube seal.

   5.2 Insert the fill/dipstick tube into the hole in the transmission housing.

5.3 Fasten the fill/dipstick tube bracket to the engine.

6. Install the two engine-to-transmission struts. Tighten each transmission-to-strut bolt 102 N·m (75 lbf·ft). Tighten each engine-to-strut bolt 47 N·m (35 lbf·ft).

NOTE: Be sure to install the strap for the transmission fluid cooler lines onto the standoff bracket attached to the left-hand strut.

7. Connect all electrical lines and sensors to the transmission (see **Fig. 6** and **Fig. 7**).

7.1 Install the crankshaft position sensor. Install the bolts and connect the receptacle.

7.2 Connect the coolant temperature sensor to the three-pin plug on the forward transmission cooler line fitting.

7.3 Connect the park-neutral position switch to the three-pin plug on the side of the transmission case just aft of the inner shift lever.

7.4 Connect the transmission solenoid to the three-pin plug on top of the transmission case above the throttle lever.

7.5 Connect the vehicle speed sensor to the three-pin receptacle on the speedometer adapter just before the U-joint.

7.6 Using tie straps, secure all lines and cables as needed.

8. Connect the shift linkage to the transmission.

⚠ CAUTION

Do not overtighten the small U-bolt to the shift cable. If this bolt is too tight, it could squeeze the cable housing and prevent the transmission from shifting.

8.1 Attach the small U-bolt to the shift cable. Tighten the nuts.

8.2 Install the clip attaching the shift cable to the shift lever. See **Fig. 9**.

9. Connect the throttle valve linkage to the transmission.

9.1 Attach the battery cable standoff bracket to the flange on the right-hand side of the transmission case. Using the same bolt, attach the spring bracket to the standoff bracket and fasten the nuts finger-tight.

9.2 Attach the throttle valve cable to the cable bracket and the ball stud on the throttle valve lever.

9.3 Attach the spring on the throttle valve lever to the spring bracket.

9.4 Tighten the nuts on the standoff bracket.

10. Connect the ATF cooler lines to the transmission. Tighten the fittings 18 N·m (13 lbf·ft).

11. Install the starter.

11.1 Attach the battery cable connectors to the starter, as previously marked. Tighten the connector on the battery lead 800 to 1240 N·cm (70 to 110 lbf·in). Tighten the connector on the solenoid lead 500 to 740 N·cm (45 to 65 lbf·in)

11.2 Insert the starter gear housing into the hole in the torque converter access cover. Slip the starter into place over the starter mounting stud.

11.3 Install the two starter mounting bolts and tighten them 68 N·m (50 lbf·ft). Install the starter mounting nut on the stud and tighten it 27 N·m (20 lbf·ft).

11.4 Install the battery cable standoff brackets.

12. Tighten up the wiring harness lines and cables.

12.1 Install the fuel line support bracket on the transmission case and attach the fuel lines to it. See **Fig. 12**.

12.2 Attach the standoff bracket to the air pump hose going to the catalytic converter.

12.3 Attach the standoff bracket to the electrical lines.

12.4 Secure all lines and wires with tie straps as needed.

13. Connect the driveline to the transmission.

13.1 Slide the front of the driveshaft into the splined end of the transmission output yoke. Use the reference marks made on removal to align the driveshaft and output yoke.

Removal and Installation

13.2 Install the midship bracket and end bracket bolts and nuts. Tighten the nuts 68 N·m (50 lbf·ft).

14. Install the exhaust pipes. Attach the saddle brackets to the exhaust manifold and the clamps to the catalytic converter. Tighten the saddle brackets 34 N·m (25 lbf·ft) and the clamps 43 N·m (32 lbf·ft). Install the rubber isolators (if removed). Attach the left-hand and right-hand oxygen sensors, using the markings made on removal.
15. Fill the transmission with Mopar ATF Plus, Type 7176. If the torque converter was drained and/or replaced, add 5.7 liters (6 quarts). If the torque converter was not drained or replaced, add 1.9 liters (2 quarts). Lower the vehicle and remove the safety stands.
16. Connect the batteries and remove the chocks from the tires.
17. Start the engine, and check for any leaks. Repair leaks as needed.
18. With the engine running, check the ATF level. Follow the procedure for checking the fluid level in Group 26 of the *Business Class Trucks Maintenance Manual*. Add fluid or drain excess as needed.
19. Road test the vehicle, and check the transmission for correct operation.

ATF Cooler Removal and Installation

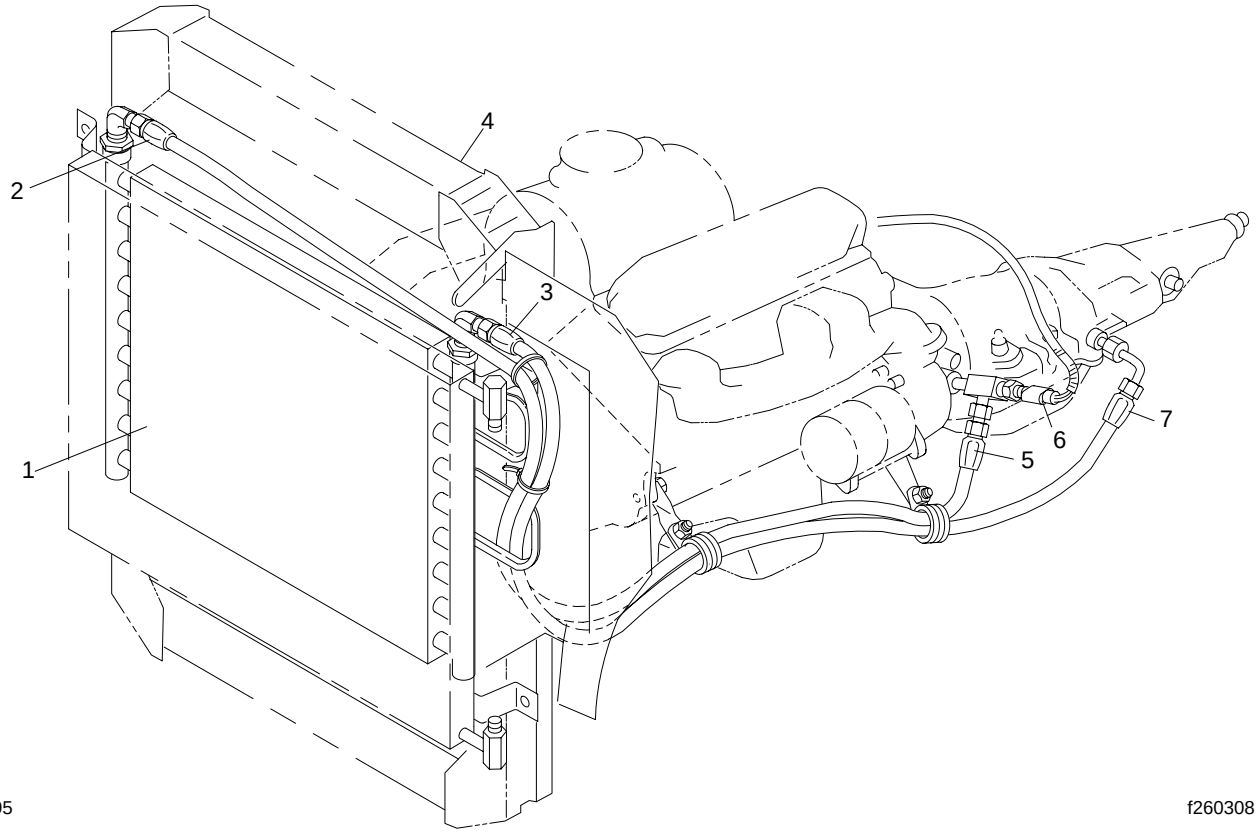
Removal (See Fig. 1)

CAUTION

If a leak should occur inside the internal radiator-mounted transmission ATF cooler, engine coolant may become mixed with automatic transmission fluid (ATF). To prevent damage to the cooling system and the transmission, drain and inspect both systems.

1. Apply the parking brake, chock the tires, and disconnect the batteries.
2. If equipped, remove the air conditioning condenser. For procedures, refer to **Group 83** in this manual.
3. Remove the transmission oil pan and drain the ATF.
4. Disconnect both ATF cooler lines from the cooler. See **Fig. 2**.
5. Remove the four ATF cooler mounting bolts. Remove the ATF cooler from the vehicle.

Installation



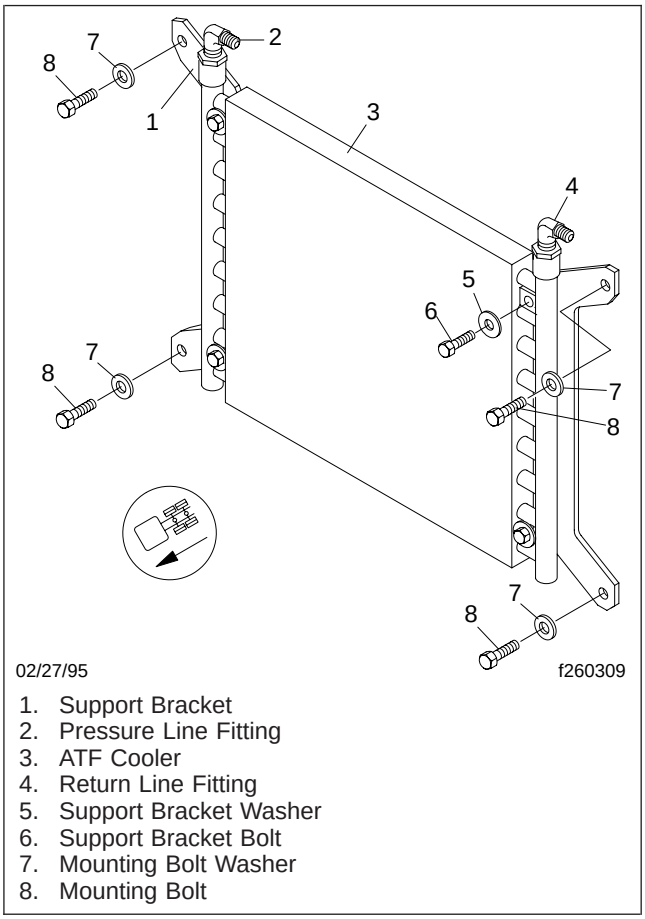
NOTE: On models with air conditioning, the air conditioning condenser is installed in front of the ATF cooler.

1. ATF Cooler
2. Pressure Line (at Cooler)
3. Return Line (at Cooler)
4. Radiator
5. Pressure Line (at Transmission)
6. Transmission Temperature Sensor
7. Return Line (at Transmission)

Fig. 1, Automatic Transmission Fluid (ATF) Cooling System

1. Install the ATF cooler on the radiator.

ATF Cooler Removal and Installation



1. Support Bracket
2. Pressure Line Fitting
3. ATF Cooler
4. Return Line Fitting
5. Support Bracket Washer
6. Support Bracket Bolt
7. Mounting Bolt Washer
8. Mounting Bolt

Fig. 2, ATF Cooler Mounting Components

1.1 Tighten the support bracket bolts 20 N·m (15 lbf·ft), if needed.

1.2 Install the upper mounting bolts but do not tighten them yet.

1.3 Position the oil cooler on the radiator so that the lower mounting bolts line up with the bolt holes on the radiator flange.

1.4 Install the lower mounting bolts. Tighten both the upper and lower mounting bolts 1100 N·cm (95 lbf·in).

2. Connect the ATF cooler lines to the oil cooler.

2.1 If a fitting requires replacement, apply Loctite® 242 to the fitting threads.

2.2 Wipe the cooler line and fitting with a clean, dry cloth.

2.3 Connect the ATF cooler lines and tighten the fittings 18 N·m (13 lbf·ft).

3. Fill the transmission with Mopar ATF Plus, Type 7176. Add 1.9 liters (2 quarts).

4. If equipped, install the air conditioning condenser. For instructions, see **Group 83** in this manual.

5. Connect the batteries and remove the chocks from the tires.

6. Start the engine, and check for leaks. Repair any leaks as needed.

7. With the engine running, check the ATF level. Follow the procedure for checking the fluid level in Group 26 of the *Business Class Trucks Maintenance Manual*. Add fluid or drain excess as needed.

8. Road test the vehicle, and check the transmission for correct operation.

Specifications

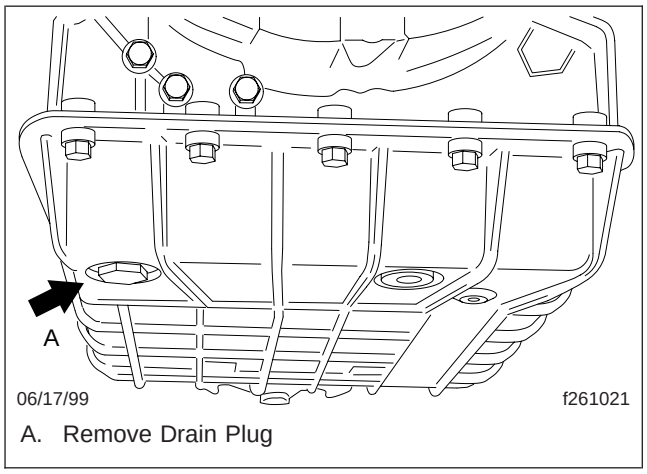
Description	Torque N·m (lbf·ft)	Torque N·cm (lbf·in)
ATF Cooler Line Fittings (Into Transmission)	18 (13)	—
ATF Cooler Mounting Bolts	—	1100 (95)
Driveline Midship and End Brackets	68 (50)	—
Driveplate Bolts	75 (55)	—
Main Support Crossmember Bolts/Nuts	68 (50)	—
Rear Support Bracket Bolts/Nuts	68 (50)	—
Torque Converter Bolts	31 (23)	—
Transmission Drain Plug	17 (13)	—
Transmission Flange Bolts	41 (30)	—
Transmission Oil Pan Bolts	17 (13)	—
Engine-to-Transmission Struts		
Engine-to-Strut Bolt	47 (35)	—
Transmission-to-Strut Bolt	102 (75)	—
Exhaust Lines		
Catalytic Converter Clamps	43 (32)	—
Exhaust Manifold Saddle Brackets	34 (25)	—
Starter		
Starter Mounting Bolts	68 (50)	—
Starter Mounting Nut	27 (20)	—
Starter Battery Lead Connector	—	800–1240 (70–110)
Starter Solenoid Lead Connector	—	500–740 (45–65)

Table 1, Fastener Torques

IMPORTANT: Before replacing the transmission you must call Aisin for approval and a Return Material Authorization (RMA) number. Call (734) 453-5551 to speak with an Aisin representative.

Transmission Replacement

1. Apply the parking brake, chock the tires, and disconnect the batteries.
2. Remove the transmission drain plug and drain the automatic transmission fluid. See **Fig. 1**. Install the drain plug and tighten it 27 to 36 lbf·ft (37 to 49 N·m).



A. Remove Drain Plug

Fig. 1, Draining the Transmission Fluid

NOTE: The ATF drained from the transmission can be used again if it is clean and if the container into which it was drained contained no ethylene glycol.

3. Support the driveline with a jack stand at the midship bearing.
4. Remove the bolts that hold the midship bearing bracket so the driveshaft can slide to the rear. See **Fig. 2**.
5. If the vehicle is equipped with a driveline parking brake, remove the nuts on the brake flange. See **Fig. 3**.

   If the vehicle is not equipped with a driveline parking brake, remove the transmission yoke U-joint bearing caps or bearing straps.

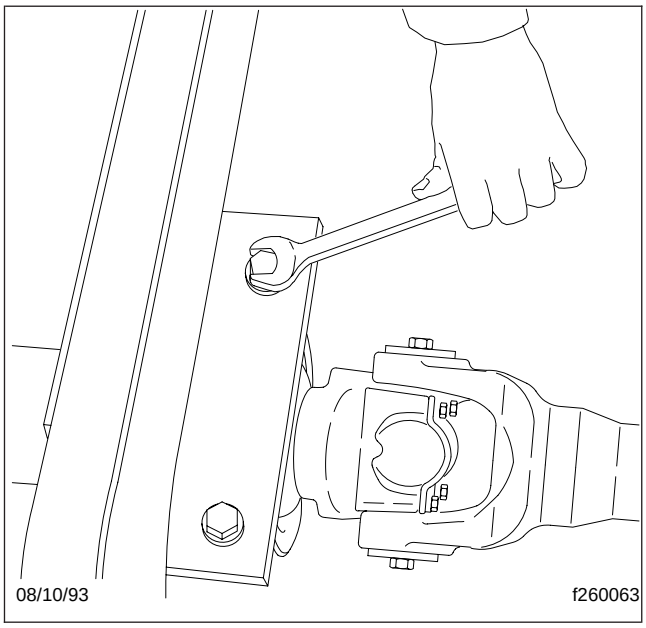


Fig. 2, Removing the Midship Bearing Bolts

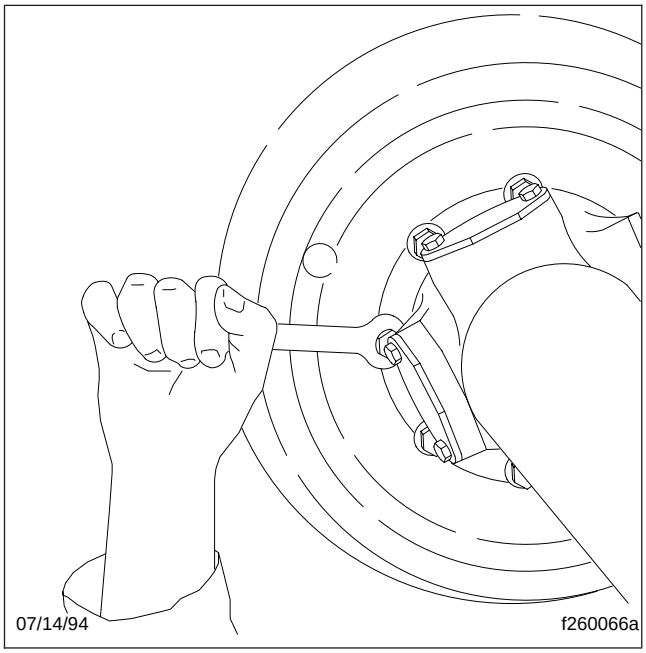
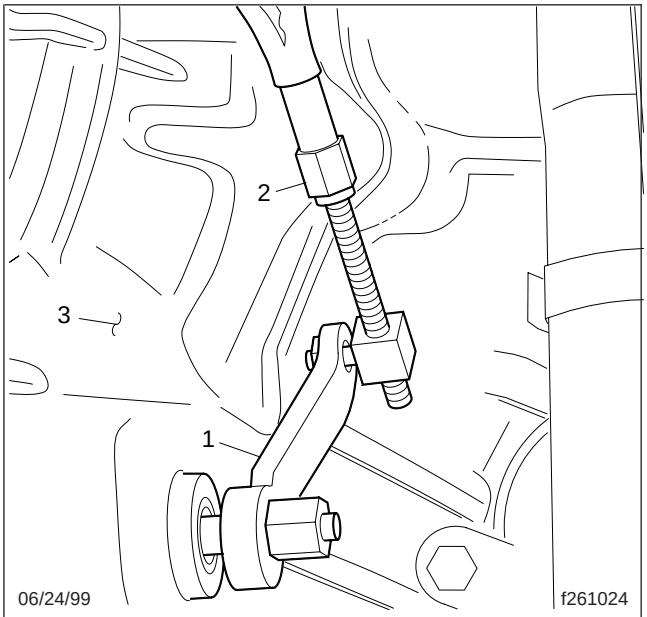


Fig. 3, Removing the Brake Flange Nuts

6. Slide the front of the driveshaft off the driveline brake flange or out of the transmission output yoke.

Transmission Replacement

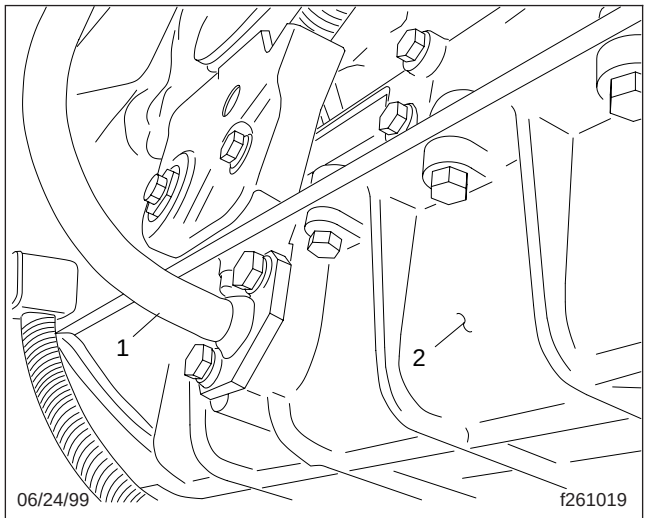
7. Support the disconnected driveshaft and tie it to the frame rail.
8. Remove the shift cable by pulling the cotter pin from the end of the shift assembly and disconnecting the shift lever. See **Fig. 4**.



1. Transmission Shift Arm
2. Shift Cable
3. Transmission

Fig. 4, Transmission Shift Lever

9. Disconnect the transmission cooler lines.
10. Remove the ATF fill/dipstick tube, as follows. See **Fig. 5**.
    - 10.1 Remove the U-bolt that holds the fill/dipstick tube to its support bracket.
    - 10.2 Remove the two bolts that secure the fill/dipstick tube to the transmission.
    - 10.3 Pull the fill/dipstick tube and O-ring from the transmission case.
    - 10.4 Plug the hole with a clean rag to prevent entry of foreign material.
11. Disconnect the flexplate from the transmission, as follows.
    - 11.1 Remove the capscrews that hold the ring gear access cover. Then, remove the cover.



1. Fill/Dipstick Tube
2. Transmission Oil Pan

Fig. 5, Fill/Dipstick Tube

    - 11.2 Using a screwdriver, turn the ring gear until one of the capscrews that hold the flexplate adapter to the torque converter can be removed.
    - 11.3 Continue turning the ring gear and removing the capscrews through the access hole until all six are removed.
12. Tilt the hood.
13. Under the hood, disconnect the five electrical harnesses for the transmission. They are bundled together and should be fed down to the transmission to be removed easily.
14. If necessary, place a piece of plywood on a transmission jack to support the transmission.
15. Remove all but the top two mounting bolts.
16. Slide the jack into place under the transmission. Secure the transmission with a chain. Anchor the chain with bolts at the front lifting bosses on the top of the transmission.
17. Remove the remaining transmission flange bolts.
18. Move the transmission jack to the rear. Lower the jack and lift the front of the vehicle, as needed, so the transmission clears the frame rail and any attached components.
19. If necessary, place jack stands under the raised front of the vehicle.

20. Roll the transmission jack backward and remove the transmission.

IMPORTANT: Before installing the new transmission, make sure the rear tires are chocked and the transmission is securely chained to the transmission jack.

21. If necessary, raise the front of the vehicle frame with a hydraulic jack to obtain adequate clearance for installing the new transmission. Place jack stands under the front of the vehicle.
22. With the transmission on a jack, roll the transmission into place behind the flexplate. Remove the jack stands and lower the front of the vehicle frame.
23. Raise the jack until the transmission lines up with the engine bell housing.
24. Push the transmission toward the engine until it seats squarely against the engine bell housing with the bolt holes in the transmission housing aligned with those in the flywheel housing.

NOTE: No force is required. If interference is encountered, move the transmission away from the engine and correct the problem.

25. Install all the transmission flange bolts finger tight. Once all bolts are in place tighten the bolts in a criss-cross pattern to 45 lbf·ft (61 N·m).
26. Remove the chain that was used to secure the transmission to the transmission jack.
27. Lower the transmission jack and remove it.
28. Connect the flexplate to the transmission, as follows.
    - 28.1 Remove the capscrews that hold the ring gear access cover. Then remove the cover.
    - 28.2 Using a screwdriver, turn the ring gear until a hole in the flexplate adaptor aligns with a hole in the torque converter. Install a capscrew. Continue turning the ring gear and installing the capscrews through the access hole until all six are installed.
    - 28.3 Tighten the six fasteners 32 to 43 lbf·ft (44 to 58 N·m).
    - 28.4 Install the ring gear access cover and capscrews.
29. Install the fill/dipstick tube. Tighten the two capscrews 11 lbf·ft (15 N·m).
30. Install the shift cable.
31. Feed the bundle of electrical cables up to the hood area and connect them where the old bundle was disconnected under the hood.
32. Install tie straps on all electric lines, at all locations where tie straps were previously installed.
33. If previously removed, connect the exhaust bracket.
34. Connect the driveshaft, as follows.
    - 34.1 Slide the front of the driveshaft into the transmission output yoke or onto the driveline parking brake flange, as equipped.
    - 34.2 On vehicles without a driveline parking brake, install the transmission yoke U-joint bearing caps or bearing straps, and tighten per **Table 1** or **Table 2**.

      On vehicles with a driveline parking brake, slide the driveshaft flange onto the studs in the parking brake. Install and tighten the nuts 40 lbf·ft (54 N·m).

Fastener Size	Torque: lbf·ft (N·m)
5/16–24	20 (27)
3/8–24	36 (49)

Table 1, Torque Values for Bearing Cap Bolts

Fastener Size	Torque: lbf·ft (N·m)
3/8–24	53 (72)
1/2–20	125 (169)

Table 2, Torque Values for Bearing Strap Bolts

    - 34.3 If the midship bearing bracket bolts and nuts were removed, install them.

      Whether removed, or just loosened, tighten the nuts 95 lbf·ft (129 N·m).
35. Connect the batteries and remove the chocks from the tires.
36. Check the ATF level. Add fluid as needed.
37. Start the engine and check for any leaks. Repair leaks as needed.

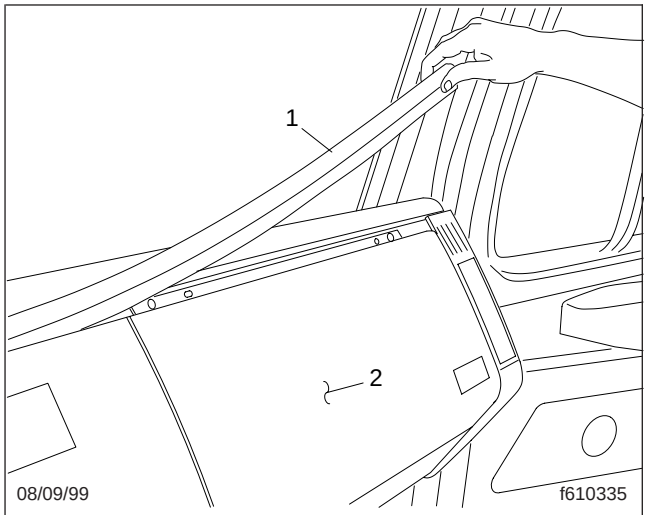
Transmission Replacement

38. Road test the vehicle and check for correct transmission operation.

ECU Replacement

The ECU is located inside the cab, behind the passenger-side upper dash panel. Follow the steps to replace the ECU.

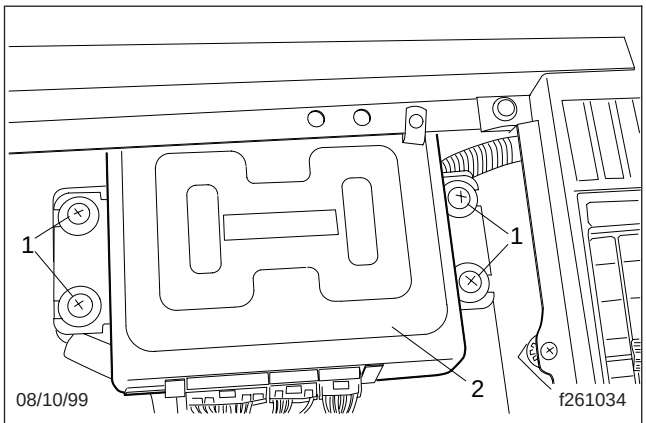
1. Remove the molding strip on the top end of the dash panel. See **Fig. 1**.



1. Molding Strip
2. Passenger-Side Dash Panel

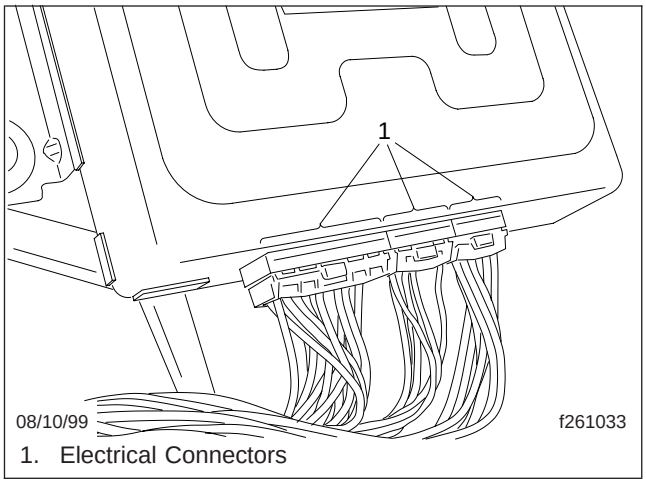
Fig. 1, Molding Strip on Dash

2. Under the molding strip are two screws securing the dash panel. Remove the two screws.
3. Remove the panel.
4. Remove the four screws securing the ECU to the mounting bracket. See **Fig. 2**.
5. Pull the ECU away from the mounting bracket.
6. Disconnect all three electrical connectors from the ECU. See **Fig. 3**.
7. Connect the electrical connectors to the new ECU.
8. Install the new ECU onto the bracket, and fasten it with the screws.
9. Install the dash panel.
10. Install the molding strip.



1. Mounting Screws
2. ECU

Fig. 2, ECU Installed



1. Electrical Connectors

Fig. 3, ECU Electrical Connectors

End-Yoke and End-Yoke Seal Replacement

Special Tools

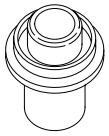
Special Tools			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580269	End-Yoke Seal Installation Tool	Kent-Moore	J-44434

Table 1, Special Tools

Replacement

1. Apply the parking brake, chock the tires, and disconnect the batteries.
2. Support the driveline with a jack stand at the midship bearing.
   - 2.1 Loosen the bolts holding the midship bearing bracket so the driveshaft can slide to the rear. See **Fig. 1**.

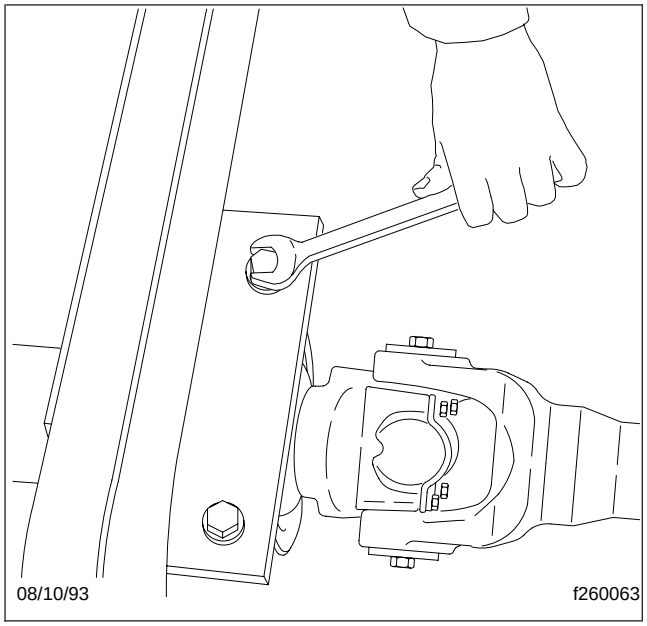
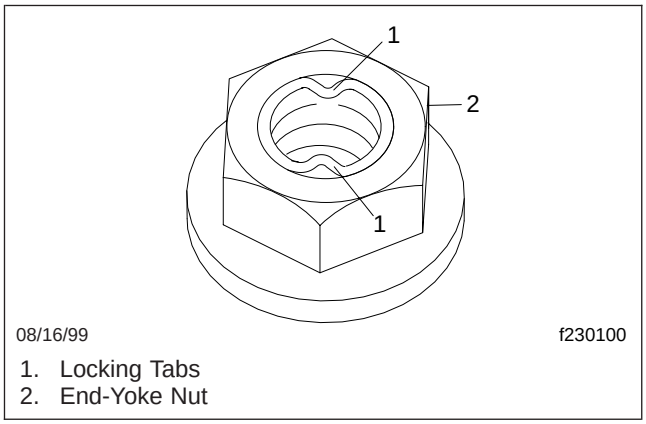


Fig. 1, Loosen the Midship Bearing Bolts

   - 2.2 Remove the transmission yoke U-joint end caps or lock straps
   - 2.3 Slide the front of the driveshaft off the driveline brake flange or out of the transmission output yoke.

NOTE: It may be necessary to remove the mounting bolts from the midship bearing bracket so the driveshaft can be moved far enough back.

   - 2.4 Support the disconnected driveshaft and tie it to the frame rail.
3. Pry open the locking tabs on the nut. See **Fig. 2**.



1. Locking Tabs
2. End-Yoke Nut

Fig. 2, End-Yoke Nut

4. Secure the end-yoke so it will not rotate and remove the end-yoke nut.

NOTE: Transmission fluid (ATF) may partially drain after removing the end yoke.

5. Slide the end yoke off the end of the output shaft. Discard the O-ring.
6. Remove the oil seal. See **Fig. 3**.

End-Yoke and End-Yoke Seal Replacement

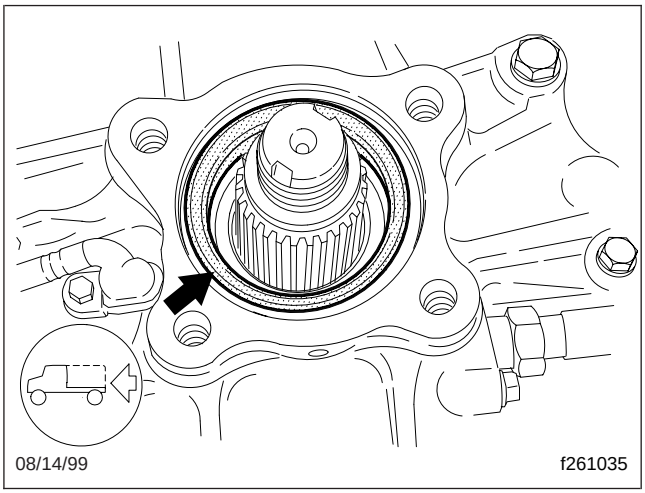


Fig. 3, End-Yoke Seal

7. Using the special oil seal installation tool (Kent Moore p/n J-44434), install the new oil seal. The tool will set the seal in the transmission. See **Fig. 4**.

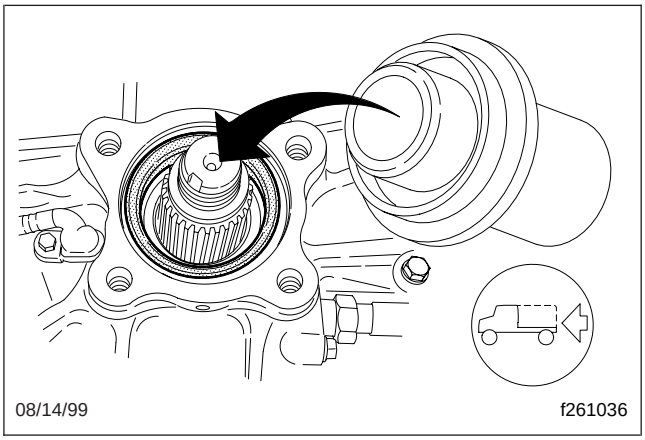


Fig. 4, Install the Seal with the Tool

8. Wipe away any loose particles at the opening point of the end yoke and lubricate it with grease or ATF.
9. Install the new end yoke (if replacing end-yoke, otherwise use the existing yoke) onto the output shaft slowly. Be careful not to damage the oil seal when installing.

IMPORTANT: The O-ring must be replaced each time the end yoke is removed.

10. Apply ATF to the new O-ring and install it into the groove between the end yoke and the output shaft.
11. Install the end yoke nut and tighten by hand.

⚠ CAUTION

Do not over tighten the end-yoke nut. Over torquing the nut could result in severe damage to the O-ring. O-ring damage can cause transmission fluid to leak.

12. Tighten the end yoke nut 181 to 214 lbf·ft (245 to 290 N·m).
13. Connect the driveshaft.
    - 13.1 Slide the front of the driveshaft into the transmission output yoke.
    - 13.2 Install the transmission yoke U-joint end caps or lock straps.
    - 13.3 If the midship bearing bracket bolts and nuts were removed, install them. Tighten the nuts 95 lbf·ft (129 N·m).
14. Remove the chocks from the tires.
15. Check the ATF level. Add fluid as needed.
16. Road test the vehicle, and check for correct transmission operation.

Troubleshooting

The oil temperature light on the instrument panel is the primary diagnostic tool for the Aisin automatic transmission. The light should remain off during normal operation but will either illuminate or flash to indicate a problem. See **Table 1** for troubleshooting symptoms, potential causes, and solutions.

IMPORTANT: If the vehicle is experiencing symptoms similar to those described in one of the diagnostic codes but the oil temperature light is not flashing, confirm that a light bulb was installed in the IL14 port of the instrument cluster. See **Fig. 1**. Vehicles built prior to April 2000 may be missing this bulb (reference Field Service Campaign SF206A/SC206A). If this bulb was installed, confirm that it is seated properly and that the circuit is complete.

If the oil temperature light is flashing:

1. The oil temperature light will flash in the generic pattern (1.2 seconds ON, 0.5 seconds OFF, 1.2 seconds ON, etc.).
2. Disconnect the diagnostic code connector at the ECU, as follows. See **Fig. 2**. The specific diagnostic codes will only flash when this diagnostic-code connector is disconnected.
   - 2.1 Open the lower dash panel on the passenger side.
   - 2.2 Follow the wiring from the bulkhead connector 14 inches (355 mm), or from the transmission ECU 36 inches (914 mm) to the looped diagnostic code connector.

   NOTE: Vehicles built prior to July 1, 1999, have a looped, 8-pin, combined options/diagnostic code connector. Vehicles built after July 1, 1999, have a looped, 4-pin diagnostic code connector and a separate 8-pin options connector.
3. Identify the specific diagnostic code. The specific codes will be displayed every 2.4 seconds.
   - The first digit will be illuminated for 0.3 seconds each, separated by 0.5 second off intervals.
   - The second digit (if any) will be illuminated for 1.3 seconds each, separated by 0.5 second off intervals.
   - The third digit (if any) will be illuminated for 0.3 seconds each, separated by 0.5 second off intervals.

   NOTE: If there is more than one diagnostic code to be displayed, the lowest number of the codes will be displayed first and then the higher number.

   See **Fig. 3** for a sample diagnostic code.
4. Locate the specific diagnostic codes in **Table 2**. Then, locate the troubleshooting guide for that particular diagnostic code in this subject (e.g. *Troubleshooting Diagnostic Code 143*).

IMPORTANT: The vehicle ignition must be left on to clear the fault codes. If the ignition is turned off prior to reconnecting the connector, the diagnosis will be stored within the memory and may reappear and cause confusion if a new problem arises.

5. Clear the diagnostic fault codes by reconnecting the diagnostic code connector at the ECU while the vehicle ignition is left on. See **Fig. 2**.

Troubleshooting

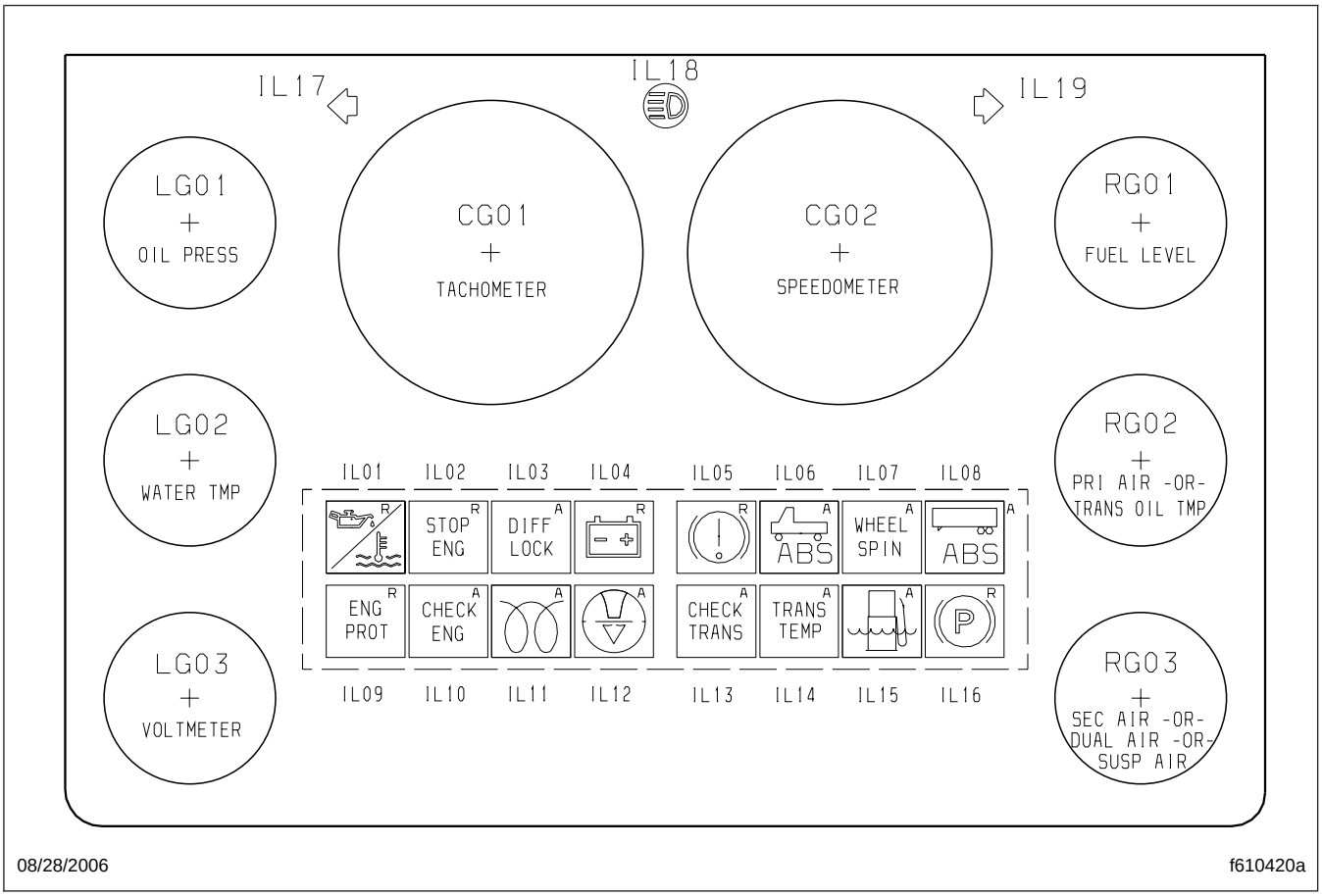
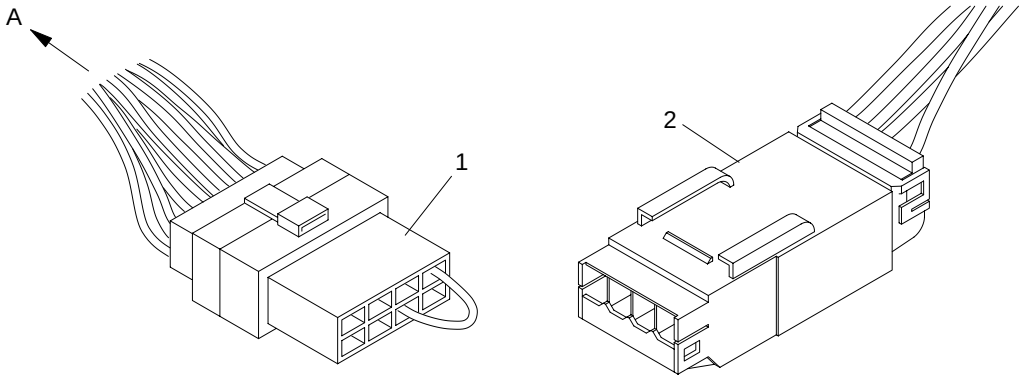
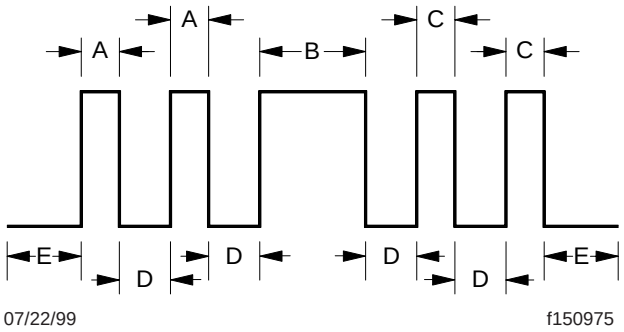


Fig. 1, Instrument Cluster



A. To ECU
1. Looped 8-Pin Options/Diagnostic Connector (before July 1, 1999)
2. Looped 4-Pin Diagnostic Connector (after July 1, 1999)

Fig. 2, Diagnostic Options Connector



A. 0.3 Seconds
B. 1.3 Seconds
C. 0.3 Seconds
D. 0.5 Seconds
E. 2.4 Seconds

Fig. 3, Example Fault Code 212

Oil Temperature Light Troubleshooting		
Condition	**Cause**	**Solution**
oil temperature light is off	normal operation	No fix needed.
oil temperature light is on	sharp rise in transmission oil temperature	Stop driving the vehicle and continue idling until the oil temperature drops to the normal level and the lamp goes out.
	short circuit of oil temperature lamp or the transmission system wiring	Inspect the wiring of the transmission oil temperature warning lamp. If a short circuit is found, repair the circuit.
	transmission oil temperature switch failure	Inspect the oil temperature switch. If defects are found, replace the switch.

Troubleshooting

Oil Temperature Light Troubleshooting		
Condition	**Cause**	**Solution**
oil temperature light is flashing	problem with the transmission system	Disconnect the diagnostic code terminal and identify the flash pattern, then begin troubleshooting to detect causes and locate defective parts. For diagnostic code troubleshooting, see **Table 2**.

Table 1, Oil Temperature Light Troubleshooting

Diagnostic Code Definition			
Diagnostic Code	**Problem**	**Potential Causes**	**Vehicle Status**
25	Speed Sensor	• open or short circuit in speed sensor system • speed sensor failure	• Ordinary running is possible. However, when the turbine revolution sensor is not functioning, the automatic speed change function does not work.
2	Turbine Revolution Sensor	• open or short circuit in turbine revolution sensor system • turbine revolution sensor failure	• Ordinary running is possible. However, when both the speed sensor and the turbine revolution sensor are out of order, the automatic speed change function does not work.
143	Neutral Start Switch	• open or short circuit in neutral switch system • the control of the shift lever does not conform with operation of the neutral start switch. • misplacement of switch • neutral start switch failure	• When the shift lever is set to the range 3, 2, and L by manual shift operation, automatic speed change is not performed. The shift to the range N and R indicates no problem.
24	Pulse Width Modulation Sensor	• throttle sensor failure • engine ECU failure • open or short circuit in throttle signal harness • transmission ECU failure • throttle sensor output does not conform to the throttle opening rate due to adjustment error.	• Severe shock during speed change. • During acceleration, forward shifting occurs too early (resulting in insufficient acceleration) or too late.
341	Solenoid #1	• open or short circuit in solenoid No. 1 system • solenoid No. 1 failure	• Abnormal speed shift (except when in drive range, 2nd gear shift is skipped).
342	Solenoid #2	• open or short circuit in solenoid No. 2 system • solenoid No. 2 failure	• Abnormal speed shift (except when in drive range, speed is shifted directly to fourth gear).

Diagnostic Code Definition			
Diagnostic Code	**Problem**	**Potential Causes**	**Vehicle Status**
343	Solenoid #3	• open or short circuit in solenoid No. 3 system • solenoid No. 3 failure	• Abnormal speed shift (except when in drive range, speed is shifted directly to the 3rd gear).
335	Lock-up Solenoid	• open or short circuit in lock-up solenoid system • lock-up solenoid failure	• No lock-up occurs, or, during low-speed driving, lock-up occurs immediately after the shift to 2nd gear; hence vibration occurs from T/C.
21	Oil Temperature Sensor	• open or short circuit in oil temperature sensor system • oil temperature sensor failure	• Despite A/T being sufficiently warmed up, gear change shock is severe for a while after driving.
347	Linear Solenoid Problem	• open or short circuit in linear solenoid system • linear solenoid failure	• Speed change caused shock is extremely severe during low throttle opening rate.

Table 2, Diagnostic Code Definition

Troubleshooting Diagnostic Codes 341, 342, 343, 335

1. Confirm that all transmission ECU connectors are properly connected, and conduct a visual inspection of the circuits.
2. Check item voltage or resistance, as follows. See **Table 3**.
   - 341 Diagnostic Code — Check item 26 (Solenoid #1)
   - 342 Diagnostic Code — Check item 27 (Solenoid #2)
   - 343 Diagnostic Code — Check item 28 (Solenoid #3)
   - 335 Diagnostic Code — Check item 25 (Lock-up Solenoid)

ECU Connector Check Item List							
Check Items		**Terminal No.***		**Measure**	**Style†**	**Measuring Conditions**	**Reference Values**
1	Ground 1	M2	Body	Resistance	A	Ignition OFF	5 ohms or less
2	Ground 2	M29	Body	Resistance	A	Ignition OFF	5 ohms or less
3	Power Source 1	M1	M2 or M29	Voltage	A	Ignition ON	Battery Voltage
						Ignition OFF	0.5 volts or less
4	Oil Temperature Switch	N40	M2 or M29	Voltage	A	Oil Temp = 284°F (140°C) or above	IG –3 volts or above
						Oil Temp = Less than 284°F (140°C)	3 volts or less
5	Exhaust Brake Switch	N7	M2 or M29	Voltage	A	Switch ON	IG –3 volts or above
						Switch OFF	3 volts or less

Troubleshooting

ECU Connector Check Item List							
Check Items		Terminal No.*		Measure	Style†	Measuring Conditions	Reference Values
6	Overdrive Switch	N12	M2 or M29	Voltage	A	Switch ON	3 volts or less
						Switch OFF	IG –3 volts or above
7	Shift Position Range 3	M5	M2 or M29	Voltage	A	Shift Position 3	IG –3 volts or above
						All other positions (except 3)	3 volts or less
8	Shift Position Range 2	M32	M2 or M29	Voltage	A	Shift Position 2	IG –3 volts or above
						All other positions (except 2)	3 volts or less
9	Shift Position Range L	M6	M2 or M29	Voltage	A	Shift Position L	IG –3 volts or above
						All other positions (except L)	3 volts or less
10	Shift Position Range N	M4	M2 or M29	Voltage	A	Shift Position N	IG –3 volts or above
						All other positions (except N)	3 volts or less
11	Shift Position Range D	M31	M2 or M29	Voltage	A	Shift Position D	IG –3 volts or above
						All other positions (except D)	3 volts or less
12	Shift Position Range R	M30	M2 or M29	Voltage	A	Shift Position R	IG –3 volts or above
						All other positions (except R)	3 volts or less
13	Pattern Selector Switch Power	N11	M2 or M29	Voltage	A	Power Switch ON	3 volts or less
						Power Switch OFF	IG –3 volts or above
14	Diagnostic Code Output Switch	N14	M2 or M29	Voltage	A	When connector is connected	3 volts or less
						When Circuit is Open	IG –3 volts or above
15	Turbine Revolution Sensor	O18	O45	Resistance	C	Atmosphere Temp., 86°F (30°C)	155 to 205 ohms
						Transmission Oil Temp., 176°F (80°C)	188 to 238 ohms
16	Turbine Revolution Sensor GND	O16	M2 or M29	Resistance	B	Ignition OFF	0.5 ohms or less
17	Speed Sensor	O17	O44	Resistance	C	Atmosphere Temp., 86°F (30°C)	180 ± 25 ohms
18	Speed Sensor GND	O43	M2 or M29	Resistance	B	Ignition OFF	0.5 ohms or less
19	Oil Temperature Sensor	O20	O48	Resistance	C	Oil Temp.: -40 to 284°F (-40 to 140°C)	70 to 45 kiloohms
20	Oil Temperature Sensor Ground	O48	M2 or M29	Resistance	B	Ignition OFF	0.5 ohms or less
21	Throttle Signal	O47	M2 or M29	Resistance	A	Ignition ON (idle)	0.5 to 1.5 volts
						Ignition ON (during WOT)	9.5 to 15.5 volts
22	Exhaust Brake Cut	O50	M2 or M29	Voltage	A	Exhaust Brake Switch ON	3 volts or less
						Exhaust Brake Switch OFF	IG -3 volts or above
23	Oil Temperature Lamp	O22	M2 or M29	Voltage	A	Lamp ON	3 volts or less
						Lamp OFF	IG volt
24	Idle-Up Output	O51	M2 or M29	Voltage	A	Idle UP Switch ON (Range N)	3 volts or less
						Idle UP Switch ON (Excluding Range N)	IG volt

ECU Connector Check Item List							
Check Items		Terminal No.*		Measure	Style†	Measuring Conditions	Reference Values
25	Lock-Up Solenoid	O52	M2 or M29	Resistance	C	Oil Temperature: 86° (30°C)	14 ± 3 ohms
26	Shift Solenoid No. 1	O27	M2 or M29	Resistance	C	Oil Temperature: 86° (30°C)	14 ± 3 ohms
27	Shift Solenoid No. 2	O26	M2 or M29	Resistance	C	Oil Temperature: 86° (30°C)	14 ± 3 ohms
28	Shift Solenoid No. 3	O25	M2 or M29	Resistance	C	Oil Temperature: 86° (30°C)	14 ± 3 ohms
29	Linear Solenoid	O54	O53	Resistance	C	Oil Temperature: 86° (30°C)	4.5 ± 1 ohms
30	Linear GND	O53	M2 or M29	Resistance	B	Ignitions OFF	0.5 ohms or less

* See **Fig. 4** for ECU measuring points. See **Fig. 5** for bulkhead and transmission connector measuring points.

† A=Measure from the rear of the connector (wire side) with the connector connected to the ECU; B=Measure at the ECU terminal with the connector removed; C=Measure at the vehicle harness terminal with the connector removed.

Table 3, ECU Connector Check Item List

3. Check the automatic transmission harness.
4. If steps 1 through 3 are all good, replace the transmission ECU. For instructions, see **Subject 150**.

   If the problem is not solved, go to the next step.

   If the problem is solved, skip to the last step under this heading.
5. Check the connectors, as follows.

   5.1 Remove all connectors and check for wire disconnection at the terminals caused by excessive harness tension, rust on the terminals, and contact failure on the terminals caused by foreign matter.

   5.2 Pull each wire to confirm that the terminals are securely connected. If the connector terminal stopper breaks, the terminal may slip off the connector even when the connector body is engaged with the harness.

   5.3 Remove corrosion and dust from the terminals.

   IMPORTANT: Do not use chlorine, petroleum detergent, or conductive detergent to clean terminals. Use a cleaning solvent that easily evaporates to prevent condensation inside connectors. Before attaching connectors to their counterparts or hardware, blow or shake off excess solvent to prevent deterioration of the connector seals.
6. Test drive the vehicle.

   If the problem is still present, continue on to the next step.

   If the problem is solved, skip to the last step under this heading.
7. Examine the wire harness for defects, as follows.

   7.1 Remove the connectors.

   7.2 At one side of the harness, connect the wire to be inspected to the appropriate terminal using a jumper, forming a circuit.

   7.3 At the other side of the harness, check the conductivity of the wire connected by the jumper.

   7.4 Measure the resistance. If the resistance is 0 or close to 0 ohms, there is no wire disconnection. If the resistance is infinite, there is a wire disconnection. Locate and repair the breakage.

   If the problem is still present, continue to the next step.

   If the problem is solved, skip to the last step under this heading.
8. Test for wire harness short circuits, as follows.

   8.1 Place one probe of the tester on one terminal of the circuit to be inspected. With the other test probe, make contact with each terminal of the connectors and chassis ground.

   8.2 Measure the resistance. If the resistance is close to 0 ohms, there is a short circuit. Locate and repair the short.

Troubleshooting

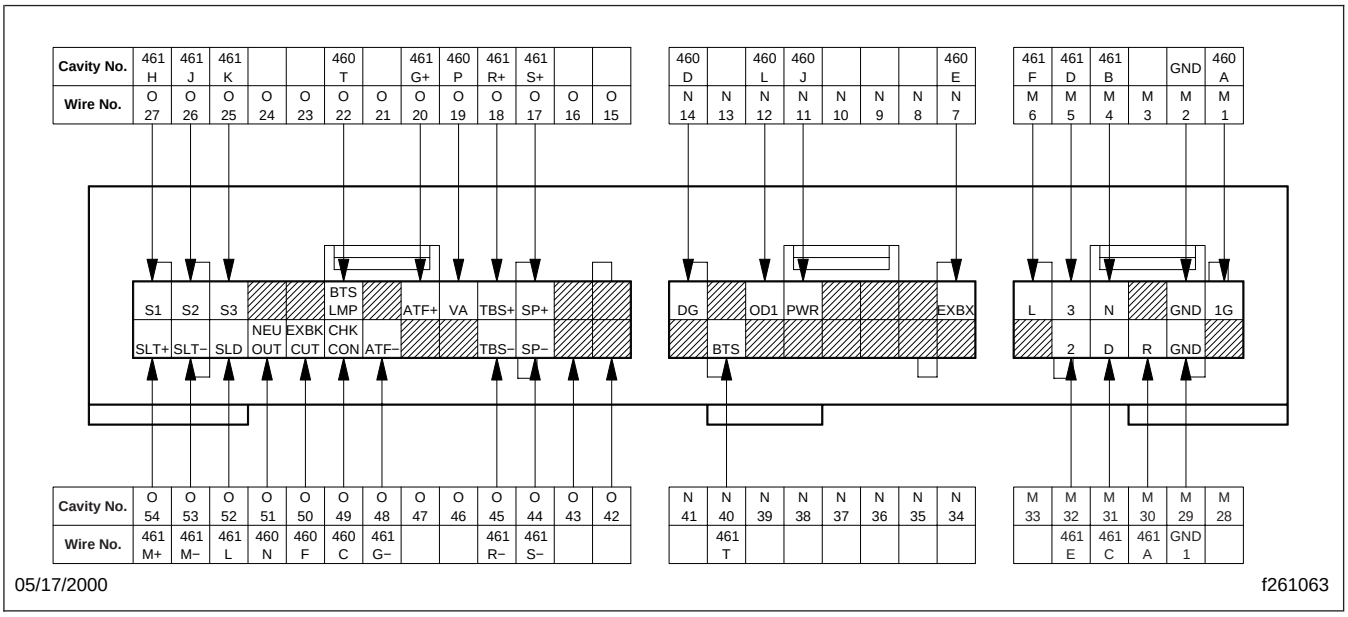


Fig. 4, ECU Terminal Number Locations

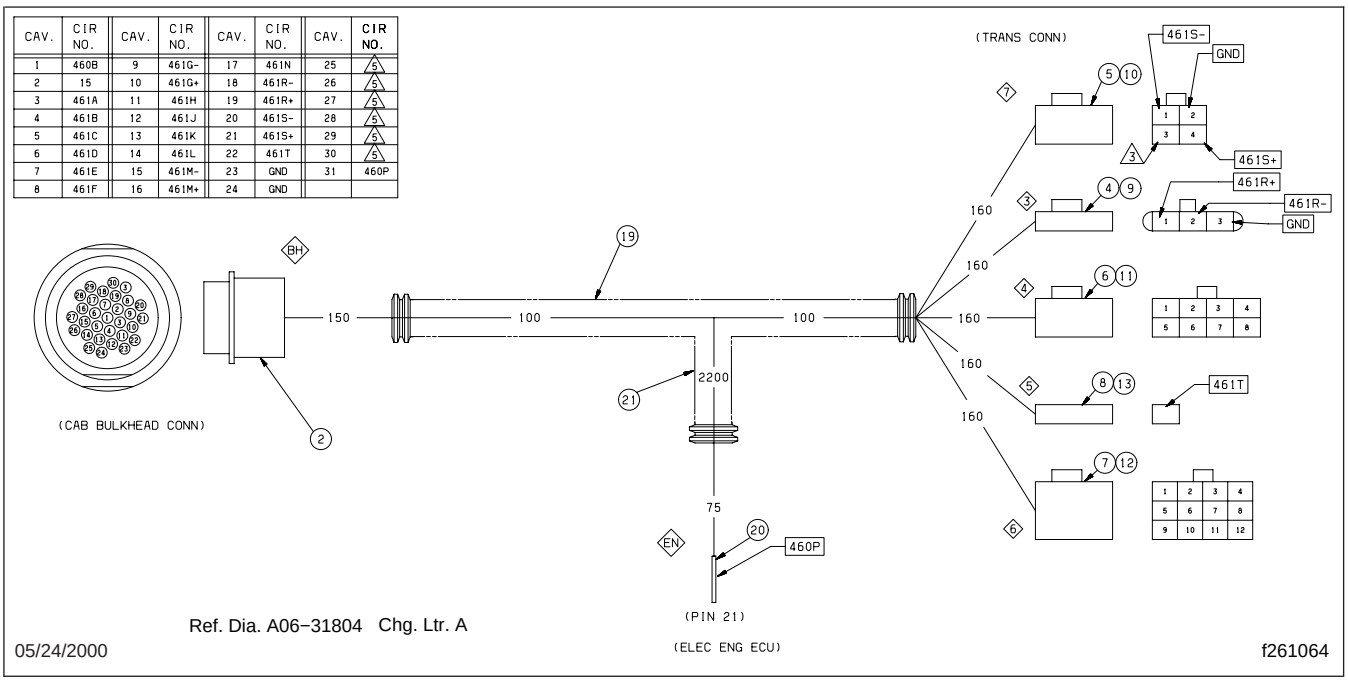


Fig. 5, Bulkhead Wiring Connector

9. Test drive the vehicle.
10. If the problem is not resolved, replace the harness assembly and test drive the vehicle again. If the problem is not solved, contact Aisin for approval to remove and replace the transmission.
11. Clear the diagnostic codes.

Troubleshooting Diagnostic Codes 2, 21, 25, 347

1. Confirm that all transmission ECU connectors are properly connected, and conduct a visual inspection of the circuits.
2. Check item voltage or resistance, as follows. See **Table 3**.
   - 2 Diagnostic Code — Check item 16 (Turbine Revolution Sensor Ground)
   - 21 Diagnostic Code — Check item 20 (Oil Temperature Sensor Ground)
   - 25 Diagnostic Code — Check item 18 (Speed Sensor Ground)
   - 347 Diagnostic Code — Check item 30 (Linear Ground)
3. If the above steps indicate no problems, go to the next step.

   If any of the previous steps show problems, replace the ECU. For instructions, see **Subject 110**.

   If the problem still exists after ECU replacement, go to the next step.

   If the problem is solved, skip to the last step under this heading.
4. Check item voltage or resistance, as follows. See **Table 3**.
   - 2 Diagnostic Code — Check item 15 (Turbine Revolution Sensor)
   - 21 Diagnostic Code — Check item 19 (Oil Temperature Sensor)
   - 25 Diagnostic Code — Check item 17 (Speed Sensor)
   - 347 Diagnostic Code — Check item 29 (Linear Solenoid)
5. If the voltage or resistance is acceptable, replace the ECU. For instructions, see **Subject 110**.

   If, after replacing the ECU, the problem is not solved continue to the next step.

   If, after replacing the ECU, the problem was solved, skip to the last step under this heading.
6. Check the connectors, as follows.

   6.1 Remove all connectors and check for: wire disconnection at the terminals caused by excessive harness tension; rust on the terminals; and contact failure on the terminals caused by foreign matter.

   6.2 Pull each wire to confirm that the terminals are securely connected. If the connector terminal stopper breaks, the terminal may slip off the connector even when the connector body is engaged with the harness.

   6.3 Remove corrosion and dust from the terminals.

   IMPORTANT: Do not use chlorine, petroleum detergent, or conductive detergent to clean terminals. Use a cleaning solvent that easily evaporates to prevent condensation inside connectors. Before attaching connectors to their counterparts or hardware, blow or shake off excess solvent to prevent deterioration of the connector seals.
7. Test drive the vehicle.

   If the problem was not solved, continue to the next step.

   If the problem was solved, skip to the last step under this heading.
8. Test for wire harness short circuits, as follows.

   8.1 Place one probe of the tester on one terminal of the circuit to be inspected. With the other test probe, make contact with each terminal of the connectors and chassis ground.

   8.2 Measure the resistance. If the resistance is close to 0 ohms, there is a short circuit. Locate and repair the short.
9. Test drive the vehicle.
10. If the problem is not solved, replace the harness assembly and test drive the vehicle again.

    If the problem was not solved, continue to the next step.

If the problem was resolved after replacing the harness, skip to the last step under this heading.

11. Complete the following.
    - 2 Diagnostic Code – Contact Aisin for approval to remove and replace the transmission.
    - 21 Diagnostic Code — Contact Aisin for approval to remove and replace the transmission.
    - 25 Diagnostic Code — Replace the speed sensor (part number located in service parts list).
    - 347 Diagnostic Code — Replace the linear solenoid (part number located in service parts list).
12. Clear the diagnostic codes.

Troubleshooting Diagnostic Code 143

1. Confirm that all transmission ECU connectors are properly connected, and conduct a visual inspection of the circuits.
2. Check items 7 through 12 in **Table 3**.
3. If the above procedures show no problems, replace the transmission ECU. For instructions, see **Subject 110**.

   If the problem is not solved, continue to the next step.

   If the problem was corrected, go to the last step under this heading.
4. Check the connectors, as follows.

   4.1 Remove all connectors and check for: wire disconnection at the terminals caused by excessive harness tension, rust on the terminals, and contact failure on the terminals caused by foreign matter.

   4.2 Pull each wire to confirm that the terminals are securely connected. If the connector terminal stopper breaks, the terminal may slip off the connector even when the connector body is engaged with the harness.

   4.3 Remove corrosion and dust from the terminals.

   IMPORTANT: Do not use chlorine, petroleum detergent, or conductive detergent to clean terminals. Use a cleaning solvent that easily evaporates to prevent condensation inside connectors. Before attaching connectors to their counterparts or hardware, blow or shake off excess solvent to prevent deterioration of the connector seals.
5. Test drive the vehicle.

   If the problem is still present, go to the next step.

   If the problem is solved, skip to the last step under this heading.
6. Examine the wire harness for defects, as follows.

   6.1 Remove the connectors.

   6.2 At one side of the harness, connect the wire to be inspected to the appropriate terminal using a jumper, forming a circuit.

   6.3 At the other side of the harness, check the conductivity of the wire connected by the jumper.

   6.4 Measure the resistance. If the resistance is 0 or close to 0 ohms, there is no wire disconnection. If the resistance is infinite, there is a wire disconnection. Locate and repair the breakage.
7. Test drive the vehicle.

   If the problem is not solved, continue to the next step.

   If the problem is solved, skip to the last step under this heading.
8. Test for wire harness short circuits, as follows.

   8.1 Place one probe of the tester on one terminal of the circuit to be inspected. With the other test probe, make contact with each terminal of the connectors and chassis ground.

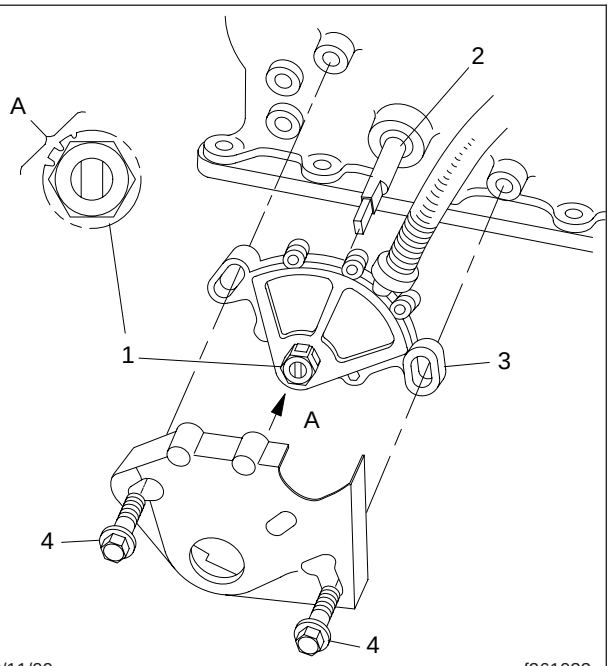
   8.2 Measure the resistance. If the resistance is close to 0 ohms, there is a short circuit. Locate and repair the short.
9. Test drive the vehicle.

   If the problem was not solved, replace the harness assembly and test drive the vehicle again.

   If the problem is not solved, go to the next step.

If the problem is solved, go to the last step under this heading.

10. Adjust the neutral start switch, as follows. See **Fig. 6**.



1. Manual Valve Shaft Nut
2. Manual Valve Shaft
3. Neutral Start Switch
4. Fixing Bolt

Fig. 6, Neutral Start Switch

10.1 Set the manual valve shaft to position N using the manual lever.

10.2 Loosen the fixing bolt to allow the neutral start switch to rotate in the rotating direction of the manual valve shaft.

10.3 Rotate the neutral start switch and visually align the baseline N with the centerline passing through the flats of the manual valve shaft.

10.4 Torque the fixing bolts to 8 to 11 lbf·ft (10 to 16 N·m).

10.5 Recheck by eye that the baseline N is aligned with the centerline passing though the flats of the manual valve shaft.

10.6 Repeat step 2. Check items 7 through 12 in **Table 3**.

11. Test drive the vehicle.

    If the problem is still present, contact Aisin for approval to remove and replace the transmission.

12. Clear the diagnostic codes.

Troubleshooting Diagnostic Code 24

1. Confirm that all transmission ECU connectors are properly connected, and conduct a visual inspection of the circuits.
2. Check item 21 in **Table 3**.
3. Confirm that the transmission ECU connector VA pin voltage is constant and at 9.5 to 15.5 volts.

   If the VA pin voltage is constant and correct, skip to the last step under this heading.

   If the VA pin voltage is constant but incorrect, go to the next step.

   If the VA pin voltage varies, replace the transmission ECU and drive test the vehicle. For instructions on ECU replacement, see **Subject 110**.

   If the problem is not solved, continue to the next step.

   If the problem is solved, skip to the last step under this heading.
4. Check the connectors, as follows.

   4.1 Remove all connectors and check for: wire disconnection at the terminals caused by excessive harness tension, rust on the terminals, and contact failure on the terminals caused by foreign matter.

   4.2 Pull each wire to confirm that the terminals are securely connected. If the connector terminal stopper breaks, the terminal may slip off the connector even when the connector body is engaged with the harness.

   4.3 Remove corrosion and dust from the terminals.

   IMPORTANT: Do not use chlorine, petroleum detergent, or conductive detergent to clean

terminals. Use a cleaning solvent that easily evaporates to prevent condensation inside connectors. Before attaching connectors to their counterparts or hardware, blow or shake off excess solvent to prevent deterioration of the connector seals.

5. Test drive the vehicle.

   If the problem is not solved, go to the next step.

   If the problem is solved, skip to the last step under this heading.

6. Examine the wire harness for defects, as follows.

   6.1 Remove the connectors.

   6.2 At one side of the harness connect the wire to be inspected to the appropriate terminal using a jumper, forming a circuit.

   6.3 At the other side of the harness, check the conductivity of the wire connected by the jumper.

   6.4 Measure the resistance. If the resistance is close to 0 ohms, there is no wire disconnection. If the resistance is anything but 0 ohms, there is a wire disconnection. Locate and repair the breakage.

7. Test drive the vehicle.

   If the problem did not go away, continue to the next step.

   If the problem is solved, skip to the last step under this heading.

8. Test for wire harness short circuits, as follows.

   8.1 Place one probe of the tester on one terminal of the circuit to be inspected. Make contact with each terminal of the connectors and chassis ground with the other test probe.

   8.2 Measure the resistance. If the resistance is close to 0 ohms, there is a short circuit. Locate and repair the short.

9. Test drive the vehicle.

   If the problem did not go away, replace the harness assembly and test drive the vehicle again.

   If the problem is not solved, continue to the next step.

   If the problem is solved, skip to the last step under this heading.

10. Check the engine ECU for fault codes.

    If the engine is not registering a TPS fault code, troubleshoot the engine ECU. See **Group 01**.

11. Test drive the vehicle.

12. Clear the diagnostic codes.

Special Tools

See **Table 1** for special tools.

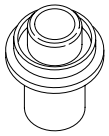
Special Tools			
Tool	**Description**	**Manufacturer**	**Part Number**
 f580269	End-Yoke Seal Installation Tool	Kent-Moore	J-44434

Table 1, Special Tools

Parts

See **Table 2** for service parts.

Part Number	Part Description
AIS 341000-52010	ATM Assembly with Torque Converter with SPL-90 (mounting bolts included)
AIS 341000-52011	ATM Assembly with Torque Converter without End-Yoke (mounting bolts included)
AIS 35168-8700	Oil Pan Gasket
AIS 351754-10010	Drain Plug
AIS 984511-18001	Drain Plug Gasket
AIS 983351-08001	Seal Plug
AIS 983111-06003	Seal Plug Gasket
AIS 33161-8700	PTO Cover
AIS 33162-8700	PTO Cover Gasket
AIS 984651-07005	Breather Hose
AIS 39395-8900	Cooler Union
AIS 39352-8623	Cooler Union O-Ring
AIS 33482-8900	Speed Meter Gear
AAM AA1700 16C	Speed Sensor
A06-30358-000	Speed Sensor Harness
AIS 33404-8900	Sleeve Sub-Assembly
AIS 39352-8632	Sleeve O-Ring
AIS 33485-30020	Speed Meter Lock Plate
AIS 33823-8900	Shift Cable Bracket
AIS 35161-8612	Oil Pan
AIS 86410-4680	ECU

Specifications

Part Number	Part Description
AIS 39358-8601	Rear Oil Seal
AIS 39128-8633	Bolt (engine x ATM)
AIS 39128-8632	Bolt (drive plate x torque converter)
AIS 991411-60825	Bolt (oil pan)
AIS 991411-40814	Bolt (speed meter)
AIS 39128-8606	Bolt (shift cable bracket)
AIS 39310-8600	Nut
AIS 39352-8620	O-Ring

Table 2, Aisin Parts List

General Description

Cummins B and C Series engines use a cable to connect the throttle pedal to the throttle lever on the engine. Vehicles built before June 1993 are equipped with a nonadjustable cable. From June 1993, the throttle cable can be adjusted at the throttle cable bracket. For examples see **Fig. 1**, **Fig. 2**, or **Fig. 3**. The cable runs from the pedal, through the frontwall, and directly to the engine throttle lever. Return springs return the throttle lever to the idle position when pressure on the throttle pedal is released.

Right-hand-drive vehicles with B-series engines use a deck-mounted throttle pedal with mechanical linkage. See **Fig. 4**. The cable runs across the top of the frontwall, and then down to the engine. See **Fig. 5**.

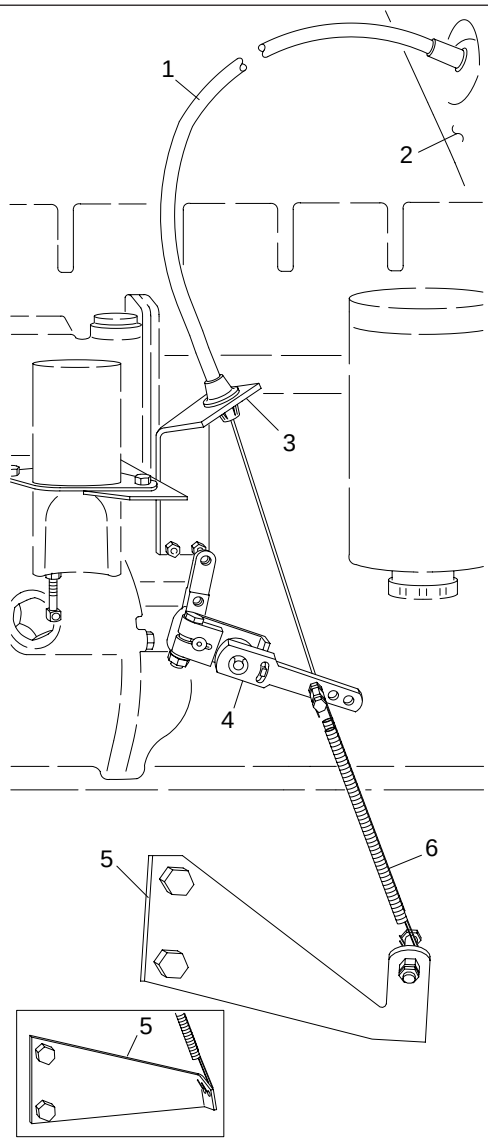
When depressed, the throttle pedal pulls the cable, and the cable pulls the engine throttle lever up to increase fuel delivery to the engine. The cable length enables the throttle pedal to operate the throttle lever through its full range, from idle to full throttle. The cable conduit prevents any interference with, or wear on, the throttle cable.

The throttle lever consists of two parts held in alignment by a breakover spring. See **Fig. 6** and **Fig. 7**. The rear half of the lever connects to the throttle cable. The forward half connects to a shaft which controls the fuel injection pump rack. As the throttle cable pulls the lever upward or releases it downward, the lever rotates the shaft to increase or decrease fuel delivery to the fuel injectors.

When the throttle cable pulls the rear half of the throttle lever as far upward as the injection pump shaft will rotate, additional force applied at the throttle pedal overcomes the breakover spring in the throttle lever. See **Fig. 8**. This allows the rear portion of the throttle lever to continue rotating upward as the throttle cable pulls, but the injection pump shaft is not forced to rotate beyond its rotation limit.

A throttle pedal stop prevents the cable from pulling the throttle lever beyond the breakover range.

Vehicles equipped with automatic transmissions have a throttle position sensor which is connected to the throttle lever by a cable. See **Fig. 9**, **Fig. 10**, **Fig. 11**, or **Fig. 12**.



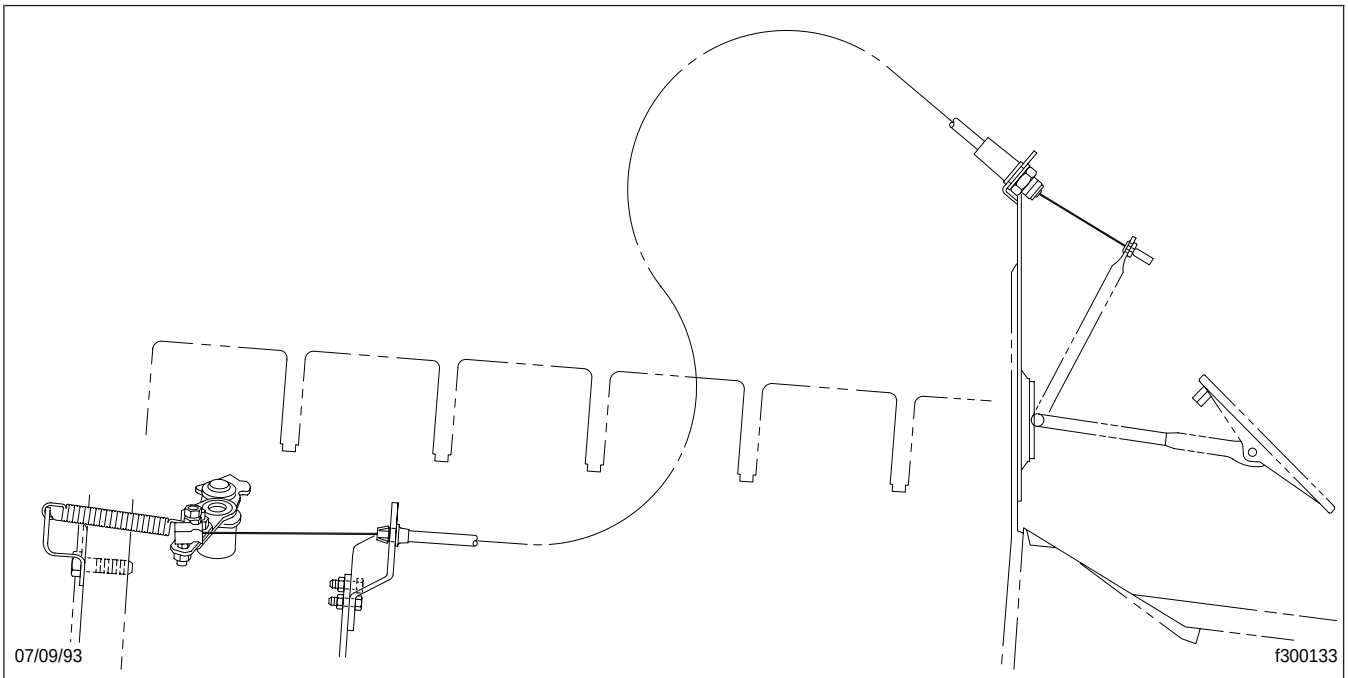
12/20/94 f300128a

NOTE: Nonadjustable throttle control cable shown for B Series engines, except the 160 horsepower engine.

1. Throttle Cable
2. Frontwall
3. Throttle Cable Bracket
4. Throttle Lever
5. Return Spring Bracket
6. Return Springs

Fig. 1, Nonadjustable Throttle Cable, Except the 160 Horsepower B Series Engine

General Information



NOTE: Nonadjustable throttle control cable shown for the 160 horsepower B Series engines installed prior to January 1993. From January 1993, 160 horsepower engines use the same throttle control installation as other B Series engines.

Fig. 2, Nonadjustable Throttle Cable, 160 Horsepower B Series Engine Only

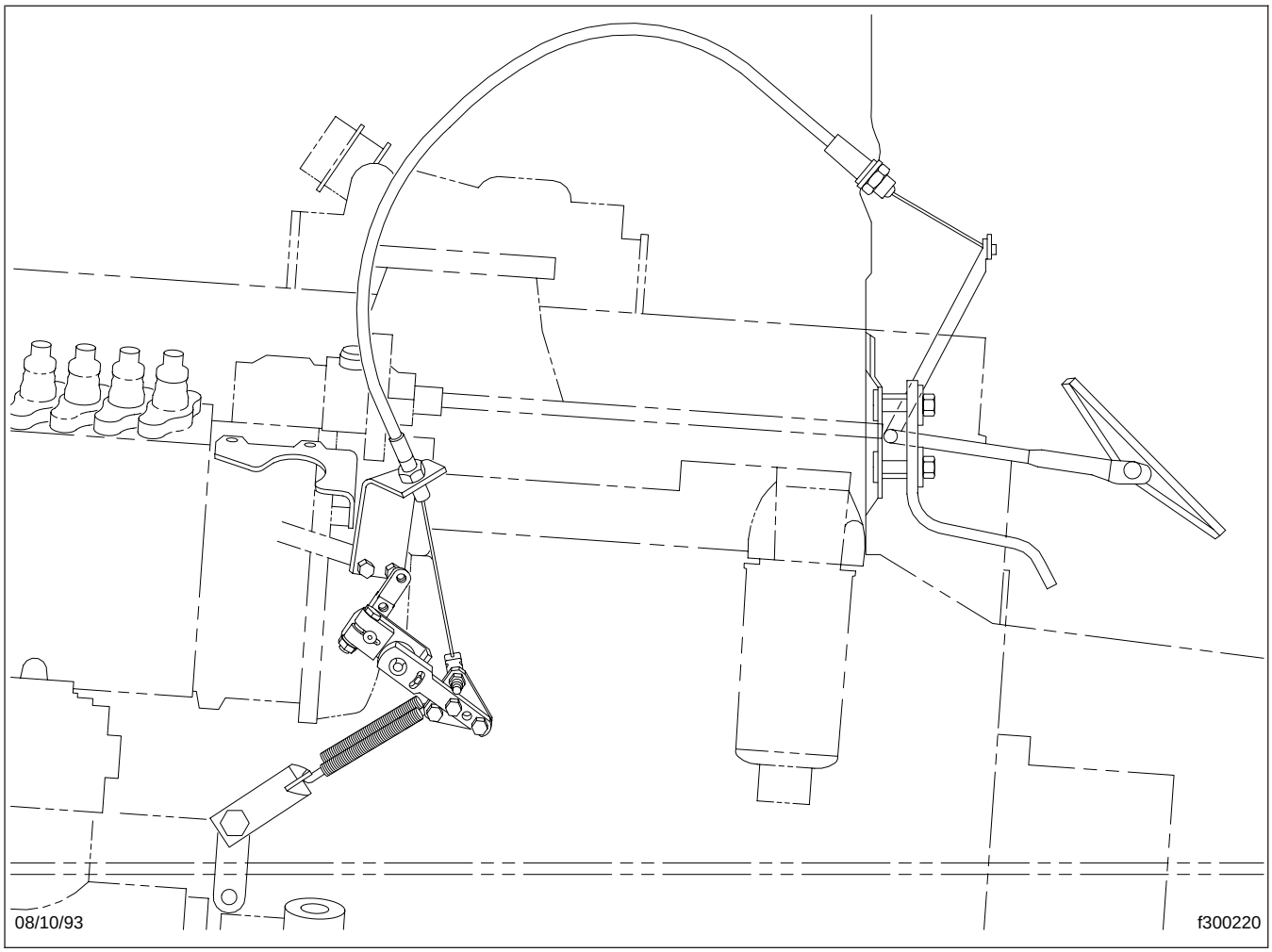


Fig. 3, Adjustable Throttle Cable, C Series Engine

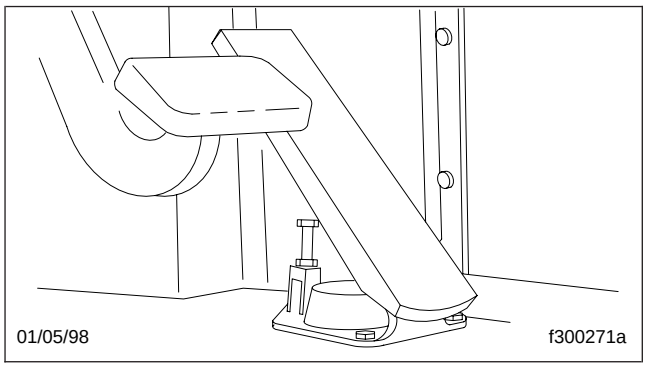
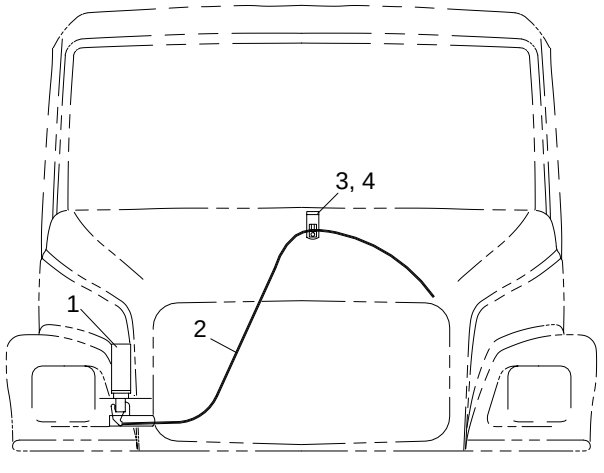


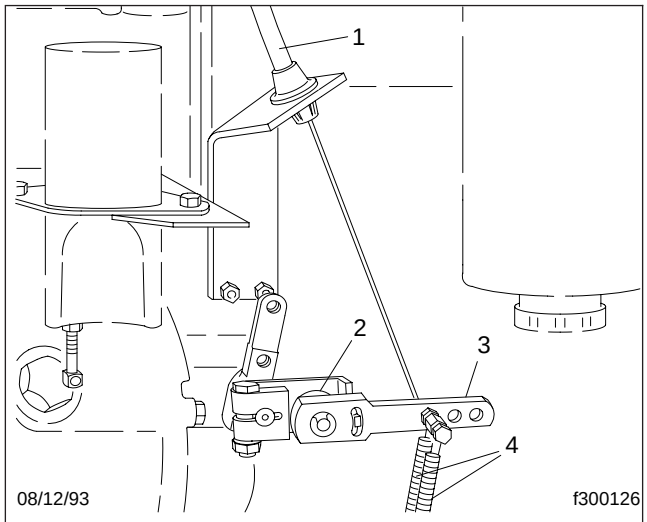
Fig. 4, Right-Hand Drive Throttle Pedal

General Information



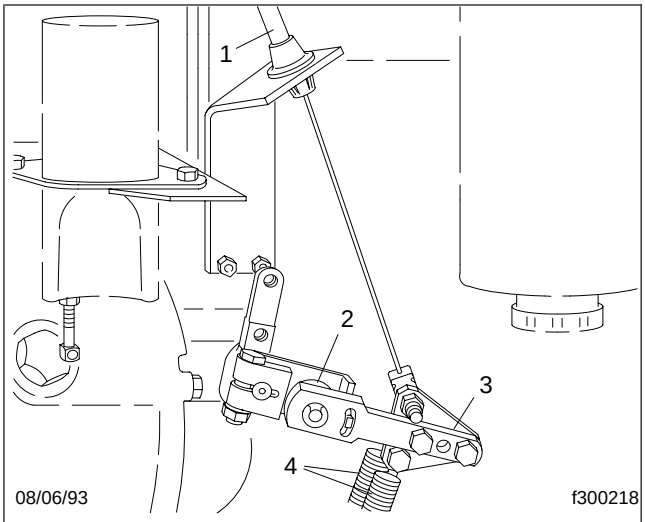
1. Throttle Pedal
2. Accelerator Cable
3. Standoff Bracket
4. Support Clamp

Fig. 5, Right-Hand Drive Throttle Control



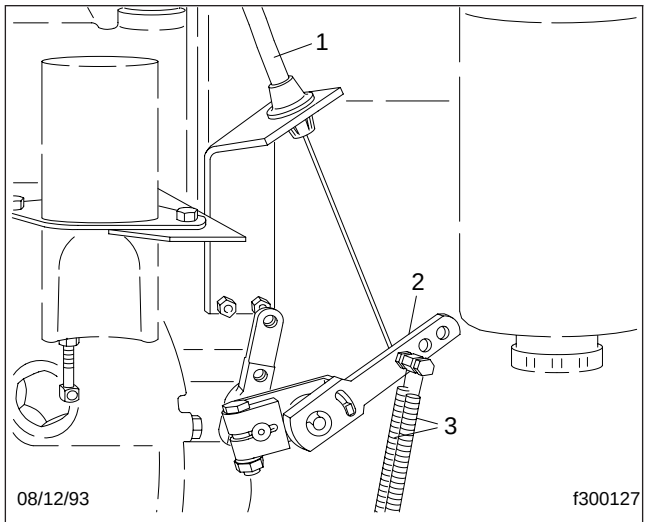
1. Throttle Cable
2. Breakover Spring
3. Throttle Lever
4. Return Springs

Fig. 7, Partial Throttle, B Series Engine



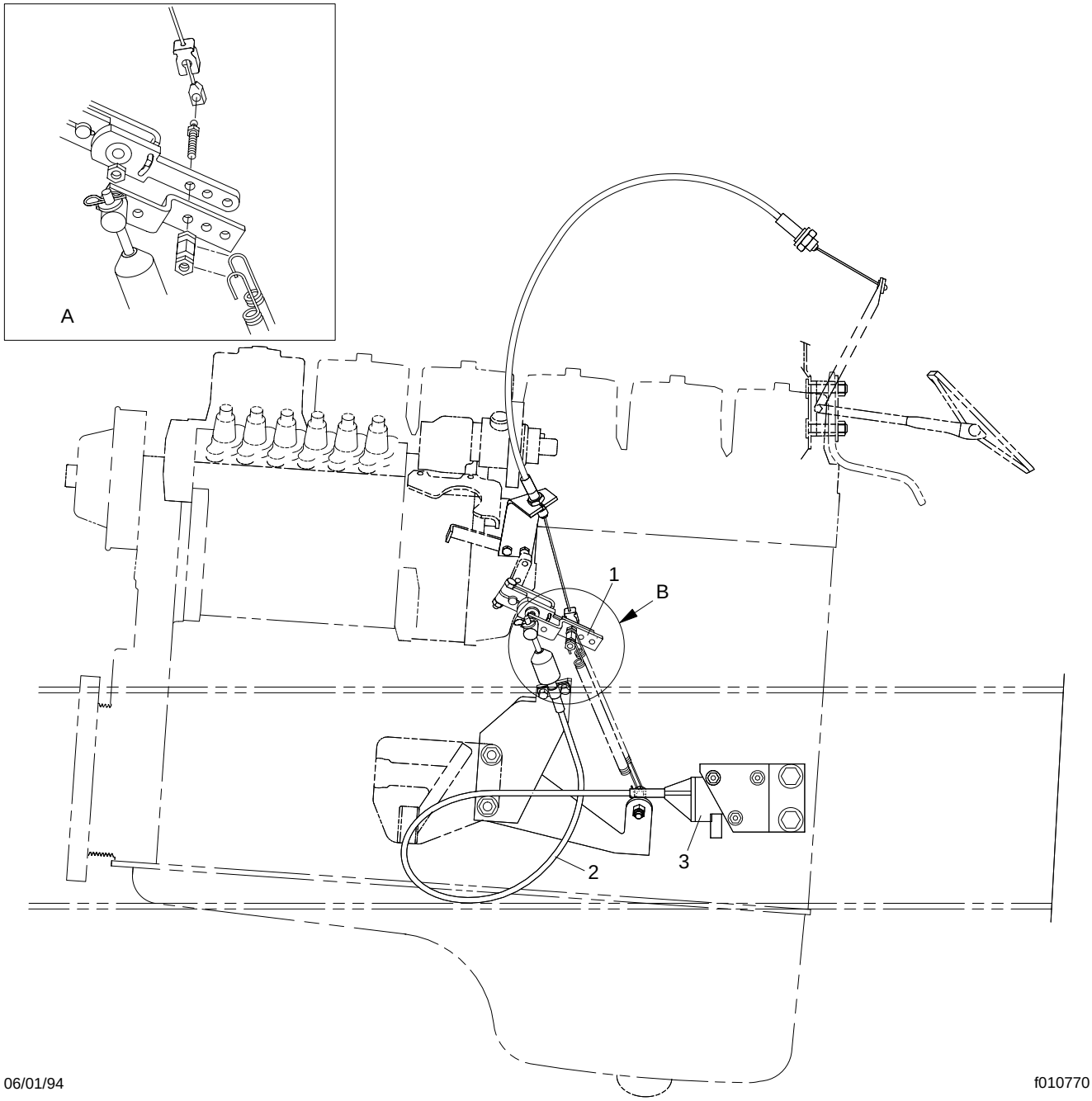
1. Throttle Cable
2. Breakover Spring
3. Throttle Lever
4. Return Springs

Fig. 6, Idle Position, C Series Engine



1. Throttle Cable
2. Throttle Lever
3. Return Springs

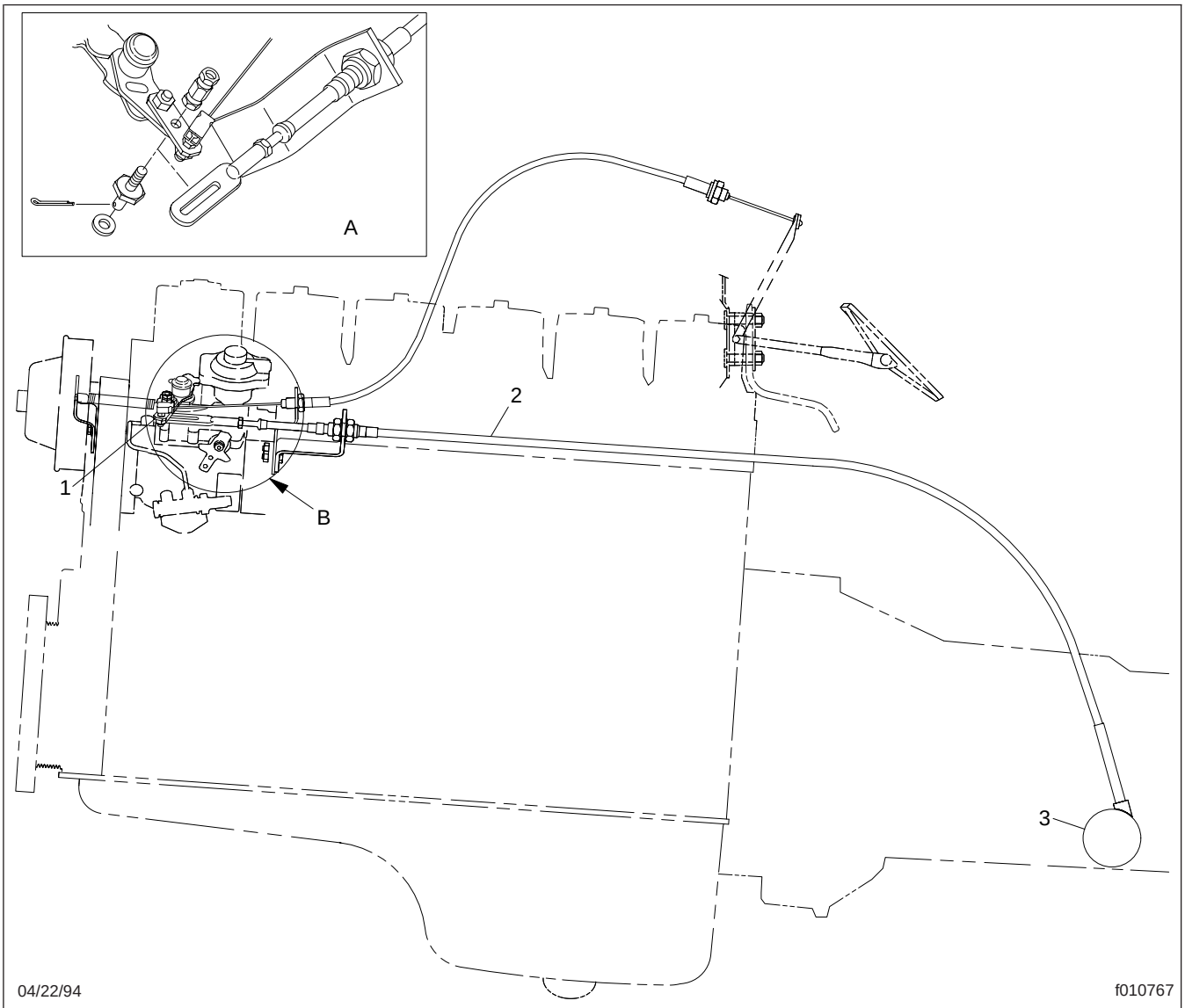
Fig. 8, Full Throttle, B Series Engine, Breakover Spring Overcome



A. Detail A
B. See Detail A
1. Throttle Lever
2. Throttle Position Sensor Cable
3. Throttle Position Sensor

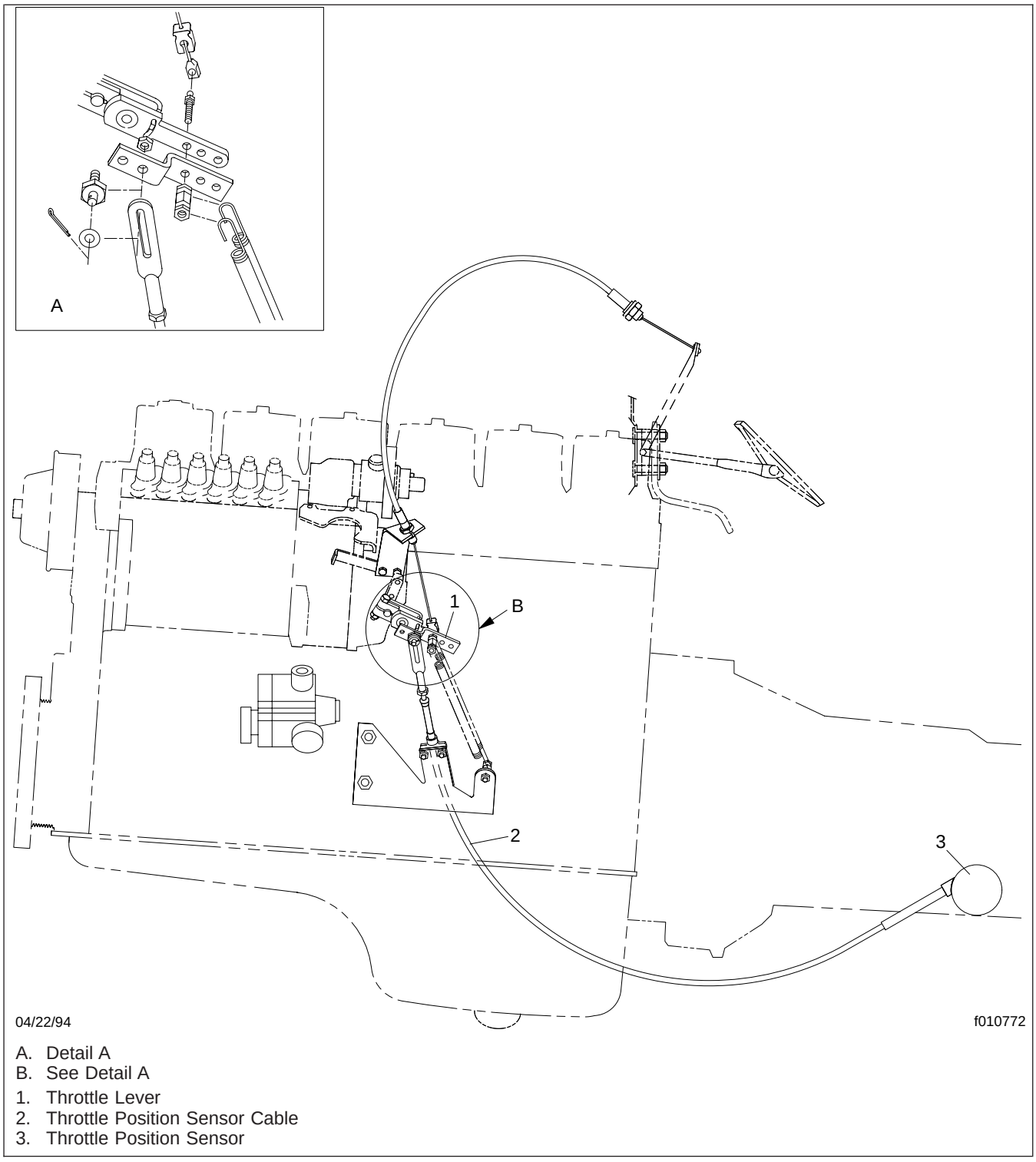
Fig. 9, B Series Engine with Allison MD Automatic Transmission

General Information



A. Detail A
B. See Detail A
1. Throttle Lever
2. Throttle Position Sensor Cable
3. Throttle Position Sensor

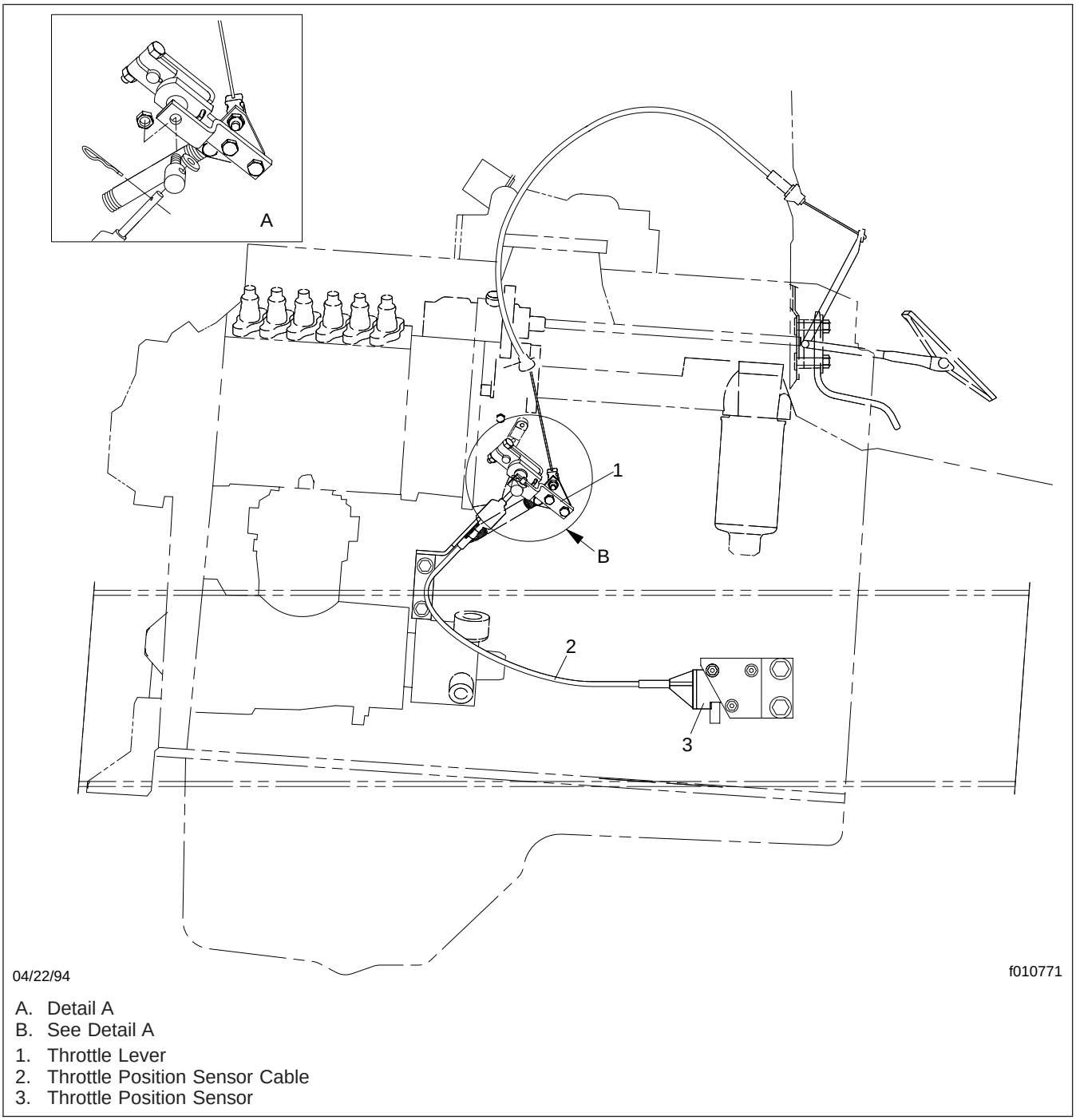
Fig. 10, 160-Horsepower B Series Engine with Allison MT or AT Automatic Transmission



A. Detail A
B. See Detail A
1. Throttle Lever
2. Throttle Position Sensor Cable
3. Throttle Position Sensor

Fig. 11, C Series Engine with Allison MT or AT Automatic Transmission

General Information



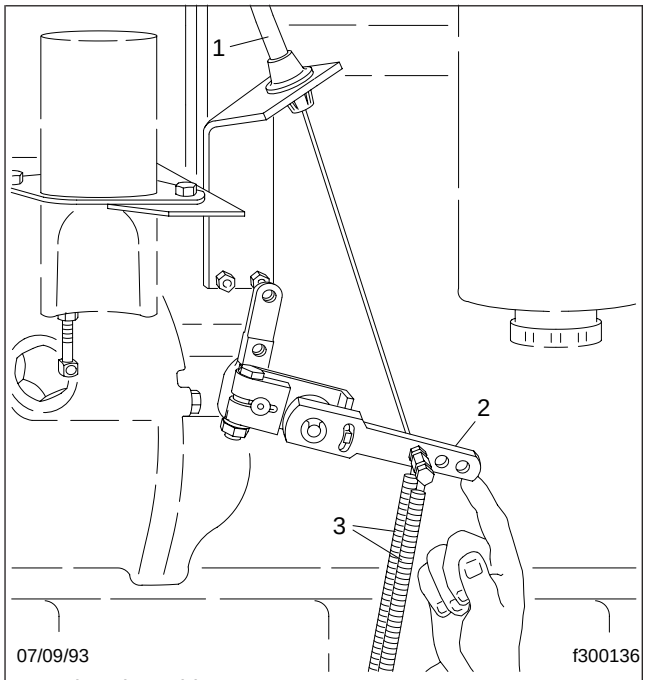
A. Detail A
B. See Detail A
1. Throttle Lever
2. Throttle Position Sensor Cable
3. Throttle Position Sensor

Fig. 12, C Series Engine with Allison MD Automatic Transmission

Nonadjustable Throttle Control Cable Operation Checking

Operation Checking

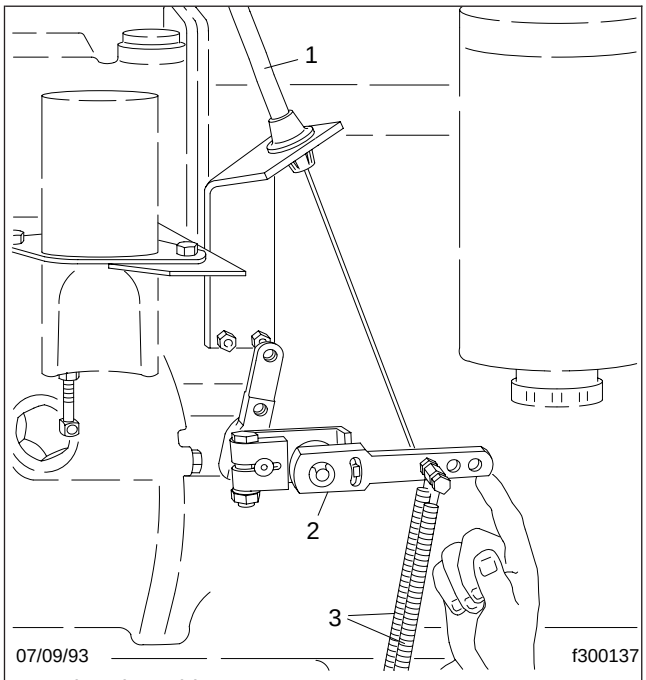
1. Shut down the engine, set the parking brake, and chock the tires. Tilt the hood.
2. Check the linkage attachment fasteners for tightness; tighten any that are loose.
3. Operate the throttle lever by hand, from idle to full throttle, while checking that nothing interferes with movement of the throttle lever or of the throttle pedal. Reposition any parts that interfere.
4. Operate the throttle lever by hand, from idle to full throttle, while checking that the return springs pull the throttle lever back to idle when the lever is released. See **Fig. 1** and **Fig. 2**.



1. Throttle Cable
2. Throttle Lever
3. Return Springs

Fig. 1, Idle Position

5. Inspect the return springs, as follows:
   - 5.1 Disconnect the anchor hook of each spring from the throttle lever, then disconnect each spring from the spring bracket.

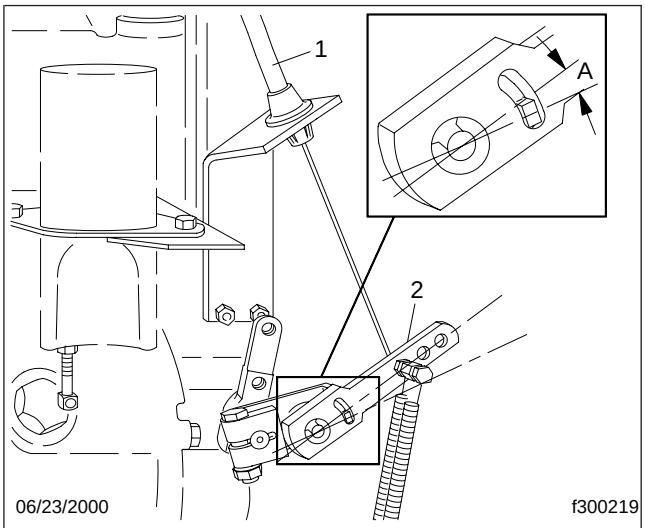


1. Throttle Cable
2. Throttle Lever
3. Return Springs

Fig. 2, Partial Throttle

   - 5.2 Inspect the springs, especially in the area of the anchor loops, for wear, nicks, or other damage that might cause breakage.
   - 5.3 Measure the springs for stretching. The relaxed spring should be no longer than 9.4 inches (238 mm), from the outside of one anchor loop to the outside of the opposite anchor loop.
   - 5.4 If the springs are worn, damaged, or stretched, install new springs.
   - 5.5 Install the springs by inserting one end of each spring into the holes, or around the bolt in the spring bracket. Then hook the opposite ends of the springs on the throttle lever.
6. Operate the pedal, from idle to the pedal stop, while checking that the throttle cable pulls the throttle lever into the breakover range. See **Fig. 3**.
7. Lower the hood. Remove the chocks from the tires.

Nonadjustable Throttle Control Cable Operation Checking



A. Breakover Range
1. Throttle Cable
2. Throttle Lever

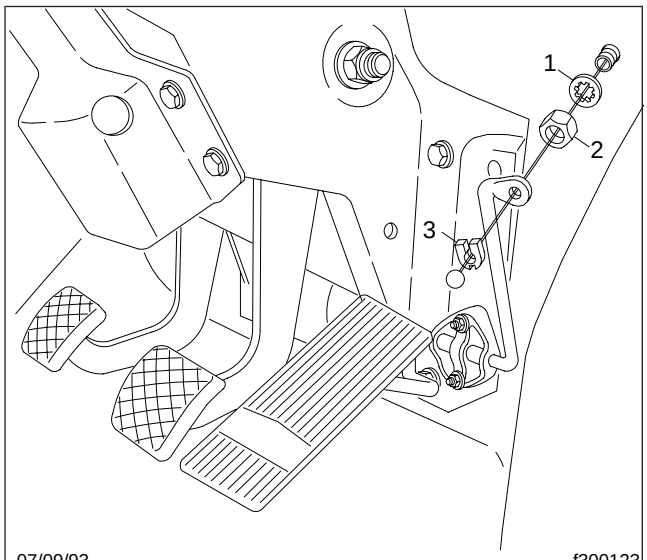
Fig. 3, Full Throttle (breakover spring overcome)

8. Test drive the vehicle and ensure that the throttle system operates properly.

Removal

1. Shut down the engine, set the parking brake, and chock the tires. Tilt the hood.
2. Lift the throttle pedal to get some slack in the throttle cable as it comes through the frontwall. See **Fig. 1**.

   For Right-Hand-Drive Vehicles: Remove the cable from the mounting bracket on the frontwall.



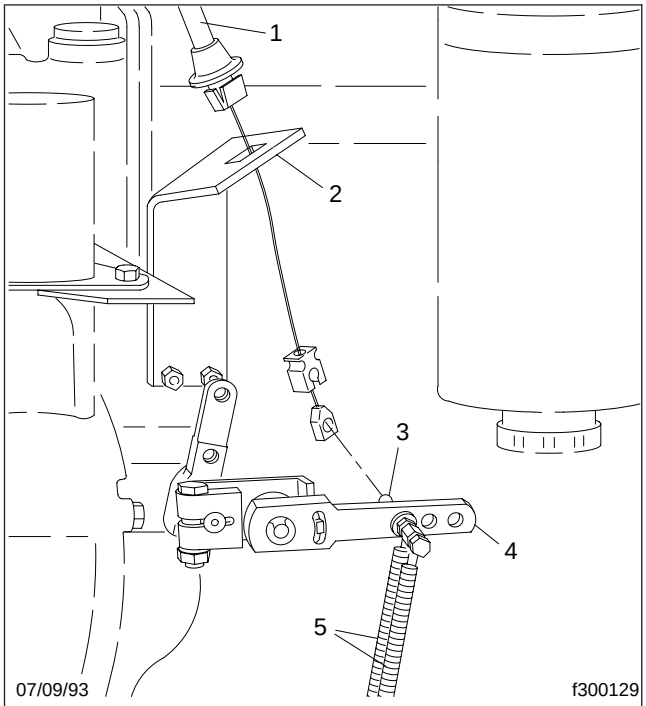
Note: Lift the pedal to get slack in the throttle cable.

1. Toothed Lock Washer
2. Cable Clamp Nut
3. Plastic Bushing

Fig. 1, Throttle Cable Connection to Throttle Pedal

3. Pry out the plastic bushing that holds the cable end in the throttle pedal lever. See **Fig. 1**. Take the bushing off of the cable, and remove the cable from the pedal lever.
4. Remove the cable clamp nut and toothed lock washer from the cable conduit at the frontwall, inside the cab. See **Fig. 1**.

   For Right-Hand-Drive Vehicles: Disconnect the yoke from the throttle pedal assembly, under the deck.
5. Pass the cable out through the frontwall.
6. Pull the plastic cover up, off of the cast-metal cable end, and remove the cable end from the ball stud in the throttle lever. See **Fig. 2** or **Fig. 3**.



1. Throttle Cable
2. Throttle Cable Bracket
3. Ball Stud
4. Throttle Lever
5. Return Springs

Fig. 2, Throttle Cable Connection to Throttle Lever

7. For nonadjustable throttle cables, slide the cable up through the hole in the throttle cable bracket.

Installation

1. Connect the throttle cable to the throttle pedal.
   - 1.1 Pass the cable through the frontwall into the cab. Make sure that the bulkhead seal washer is in place against the engine side of the frontwall.
   - 1.2 Secure the cable conduit at the frontwall with the toothed lock washer and the cable clamp nut. See **Fig. 1**. Tighten the nut 10 lbf·ft (13 N·m).

Throttle Cable Removal and Installation

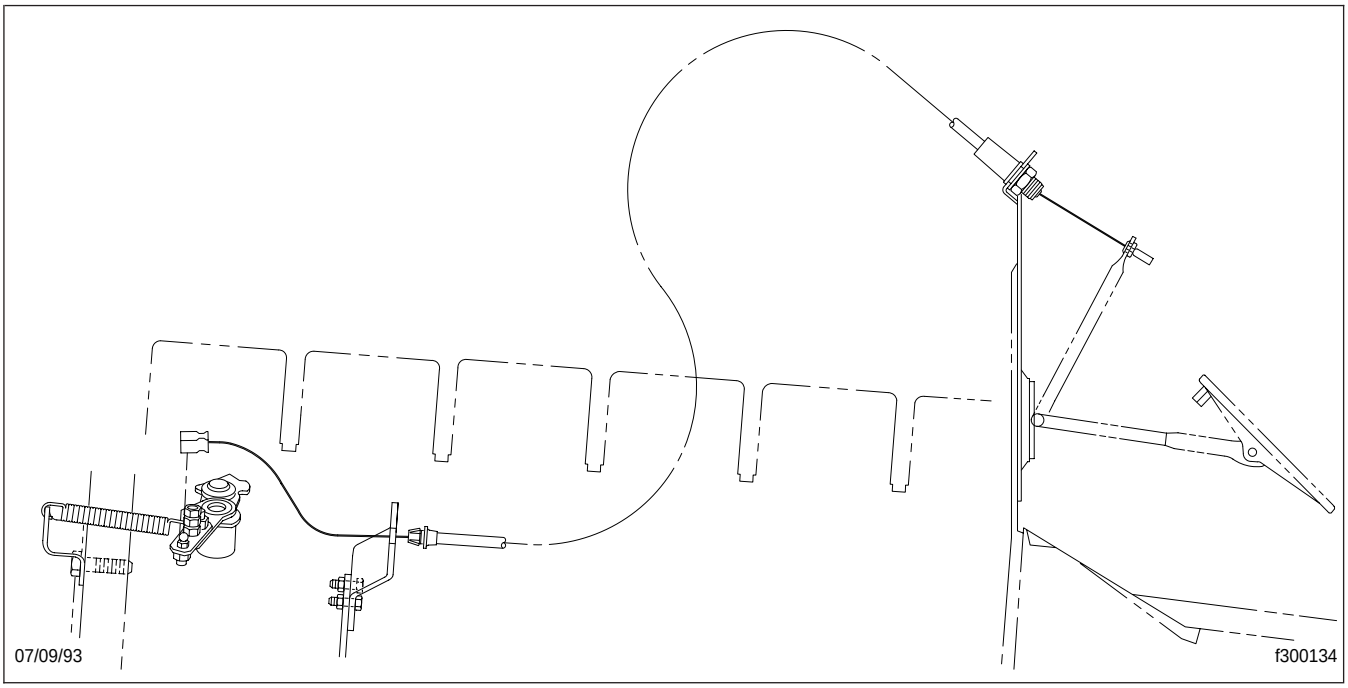


Fig. 3, Throttle Cable Connection to Throttle Lever

1.3 Thread the cable through the throttle pedal lever, and slip a new plastic bushing onto the cable (with the open slot of the bushing facing down) so that the cable end can't pass back through the lever. See **Fig. 1**.

1.4 Snap the bushing into the hole at the upper end of the throttle pedal lever.

For Right-Hand-Drive Vehicles: Connect the yoke to the throttle pedal assembly, then install the rubber boot.

Attach the cable to the standoff bracket on the frontwall.

2. Inspect the ball stud in the throttle lever for wear. Replace it if necessary. If replacing the ball stud, apply Perma-Lock® MM 115 sealant or the equivalent to the ball stud threads, and secure the stud to the throttle lever with the nut (a locknut on C Series and 160 horsepower B Series engines, or a grooved nut on any other B Series engine). Tighten the nut 10 lbf·ft (13 N·m).

3. For a nonadjustable cable, thread the cable through the cable bracket hole, and assemble the cast-metal cable end onto the ball stud. Secure the joint by sliding the plastic cover down onto it.

4. Position the cable in the throttle bracket. For nonadjustable cables, secure the cable with the push-snap fitting.

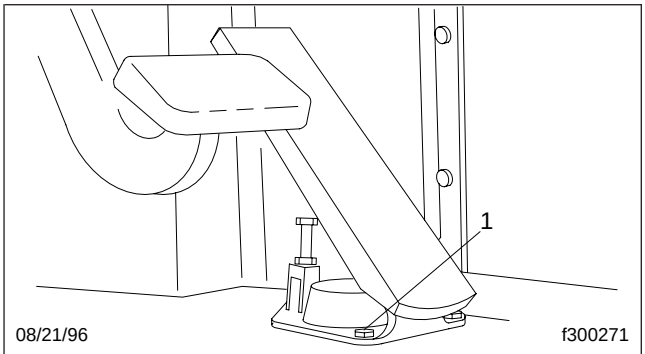
5. Lower the hood. Remove the chocks from the tires.

6. Test drive the vehicle and ensure that the throttle system operates properly.

Throttle Pedal Removal and Installation, Right-Hand Drive

Removal

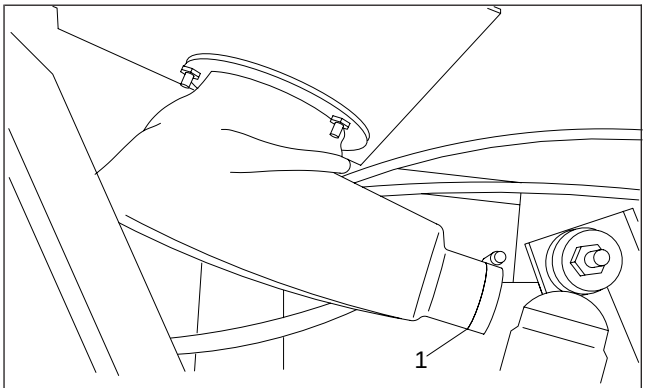
1. Shut down the engine, set the parking brake, and chock the tires.
2. Remove the three pedal assembly-to-floorboard capscrews, washers, and nuts. See **Fig. 1**.



1. Pedal Assembly-to-Floorboard Capscrew

Fig. 1, Pedal Mounting

3. Remove the clamp and slide the boot off of the pedal assembly. See **Fig. 2**.



1. Boot Clamp

Fig. 2, Pedal Boot

4. Disconnect the throttle cable clevis from the pedal assembly.
5. Remove the cable clamp.
6. Remove the pedal assembly from the interior of the vehicle.

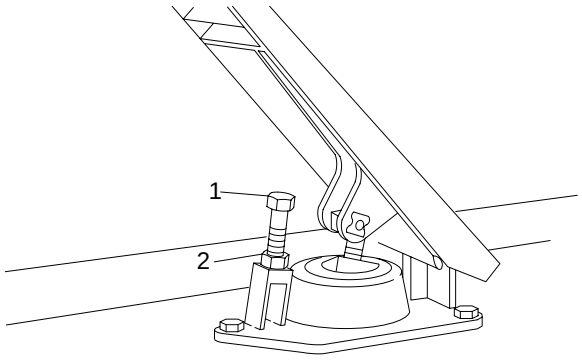
Installation

1. Position the pedal assembly on the deck, then install the three pedal assembly-to-floorboard capscrews, washers, and nuts. Tighten them securely.
2. From underneath the vehicle, connect the throttle cable clevis to the pedal assembly.
3. Install the boot and clamp onto the pedal assembly linkage.
4. Remove the chocks from the tires.
5. Test drive the vehicle and ensure that the throttle pedal operates properly.

Throttle Pedal Adjustments, Right-Hand Drive

Pedal Limit Stop Adjustment

1. Shut down the engine, set the parking brake, and chock the tires.
2. On the throttle pedal assembly, loosen the jam nut, and lower the limit stop screw. See **Fig. 1**.

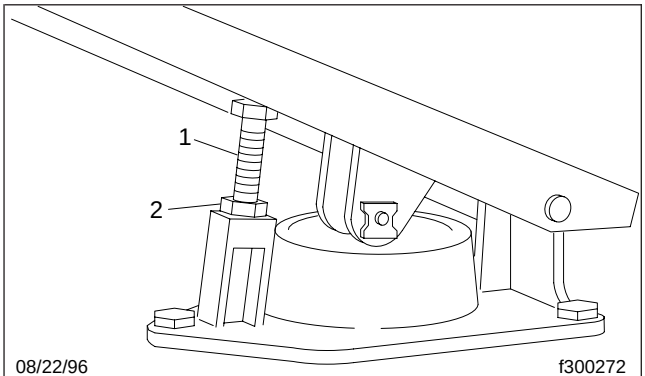


08/20/96 f300268

1. Limit Stop Screw
2. Jam Nut

Fig. 1, Limit Stop Adjustment

3. Lightly depress the pedal to the wide open throttle position. Raise the limit stop screw until it touches the foot pedal. Use the jam nut on the screw to lock the position. See **Fig. 2**. Tighten the jam nut securely.



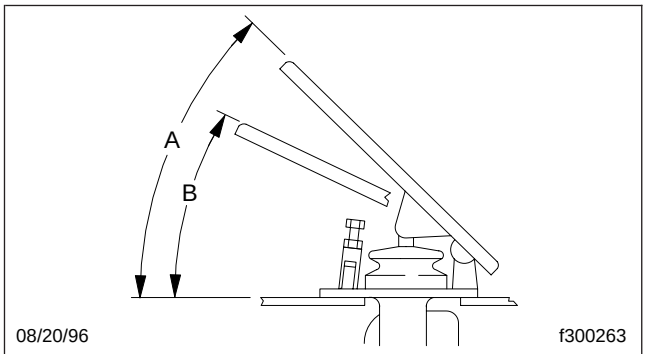
08/22/96 f300272

1. Limit Stop Screw
2. Jam Nut

Fig. 2, Pedal at Wide Open Throttle

Comfort Angle Adjustment

The comfort angle may be set between a range of 37 degrees and 53 degrees relative to the accelerator pedal base. See **Fig. 3**.

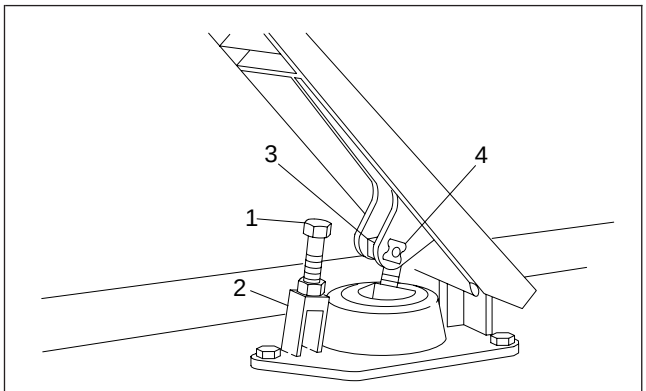


08/20/96 f300263

A. 53°
B. 37°

Fig. 3, Comfort Angles

1. Remove the pin retaining clip and cross pin. See **Fig. 4**.



08/20/96 f300264

1. Limit Stop Screw
2. Adjusting Block
3. Cross Pin
4. Pin Retaining Clip

Fig. 4, Pedal Comfort Angle Components

2. Disengage and turn the adjusting block down to decrease the angle in the idle position, or up to increase the angle.
3. Position the adjusting block in place and install the cross pin and the retaining clip.

Throttle Pedal Adjustments, Right-Hand Drive

4. Loosen the jam nut, and lower the limit stop screw.
5. Lightly depress the pedal to the wide open throttle position. Raise the limit stop screw until it touches the foot pedal. See **Fig. 2**.
6. Tighten the jam nut securely.
7. Remove the chocks from the tires.
8. Test drive the vehicle and ensure that the throttle pedal assembly operates properly.

Specifications

Torque Specifications			
Description	**Grade**	**Size**	**Torque lbf·ft (N·m)**
Cable Clamp Nut	8	9/16 inch	10 (13)
Throttle Lever Cable Clamp Nut	5	1/4 inch	10 (13)

Table 1, Torque Specifications

General Description

A non-adjustable cable connects the Mercedes-Benz OM 366LA engine to the throttle pedal. **See Fig. 1.** The cable runs from the pedal, through the firewall, and directly to the engine throttle lever. The throttle lever is spring-loaded to return to the idle position.

Principles of Operation

When depressed, the throttle pedal pulls the cable, and the cable pulls the engine throttle lever up to increase fuel delivery to the engine. The cable length enables the throttle pedal to operate the throttle lever through its full range, from idle to full throttle. The cable conduit prevents any interference with or wear on the throttle cable.

The Bosch throttle lever consists of two parts held in alignment by a breakover spring. **See Fig. 2 and Fig. 3.** The rear half of the lever connects to the throttle cable. The forward half connects to a shaft which controls the fuel injection pump rack. As the throttle cable pulls the lever up or releases it down, it rotates the shaft to increase or decrease fuel delivery to the fuel injectors.

When the throttle cable pulls the rear half of the throttle lever as far up as the injection pump shaft will rotate, additional force applied at the throttle pedal overcomes the breakover spring in the throttle lever. **See Fig. 4.** This allows the rear portion of the throttle lever to continue rotating upward as the throttle cable pulls, but the injection pump shaft is not forced to rotate beyond its rotation limit.

A throttle pedal stop prevents the cable pulling the throttle lever beyond the breakover spring range.

General Description and Principles of Operation

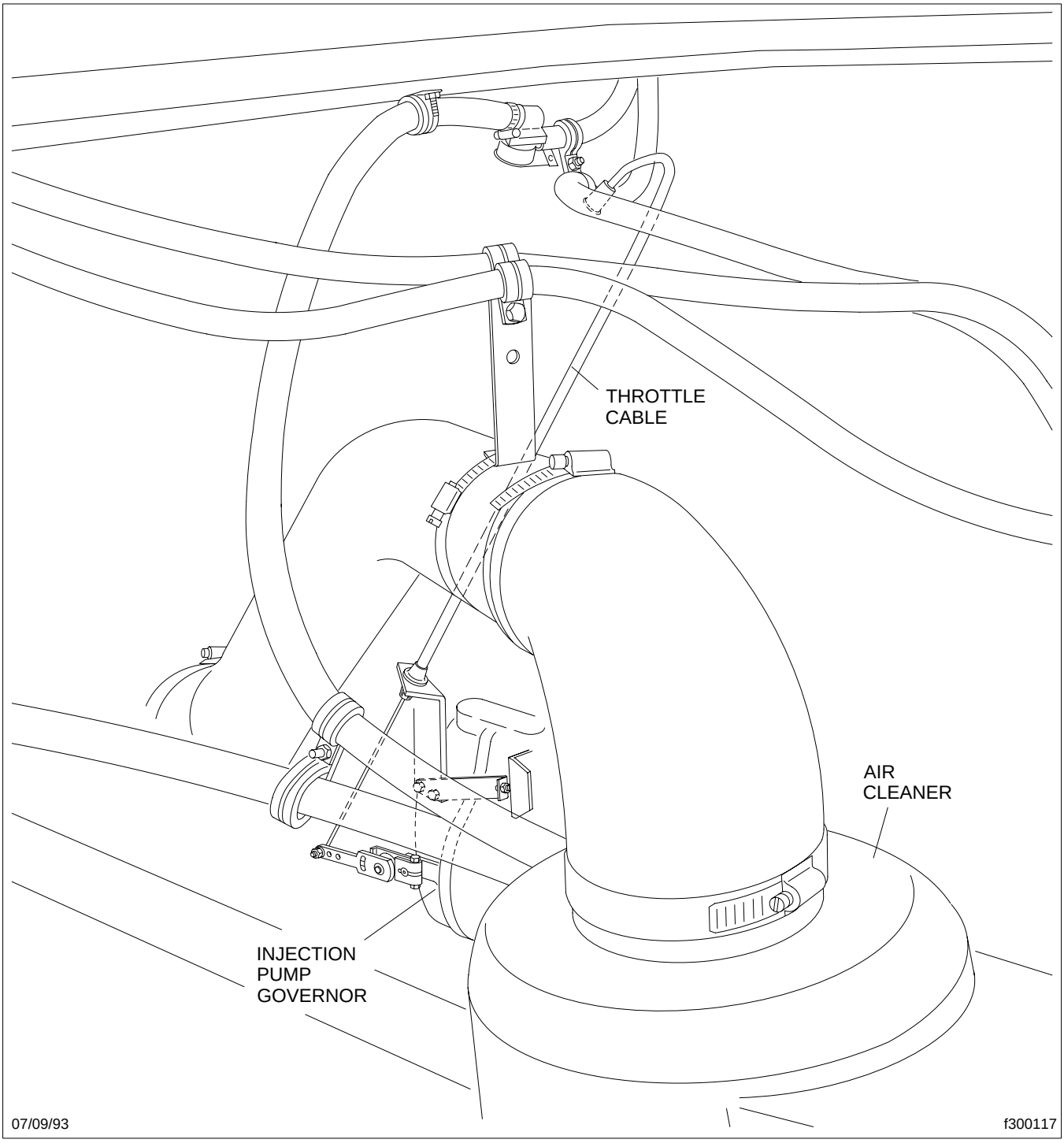


Fig. 1

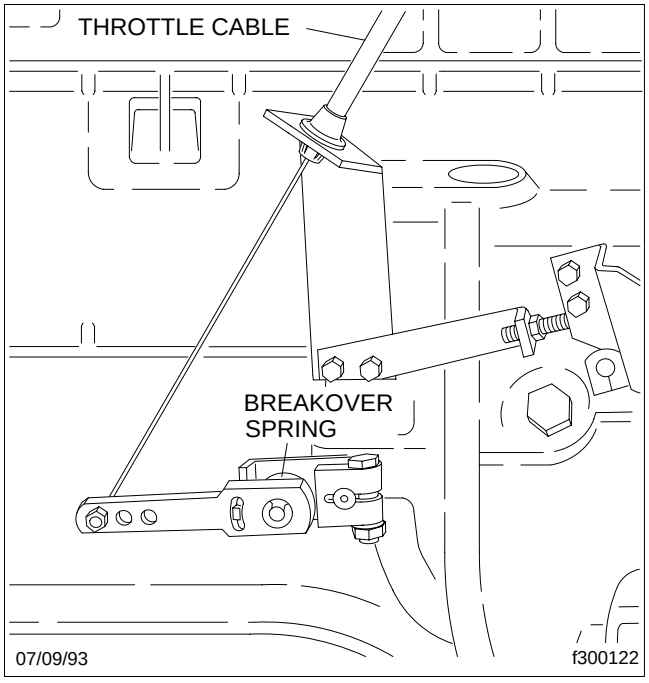


Fig. 2, Throttle Lever at Idle

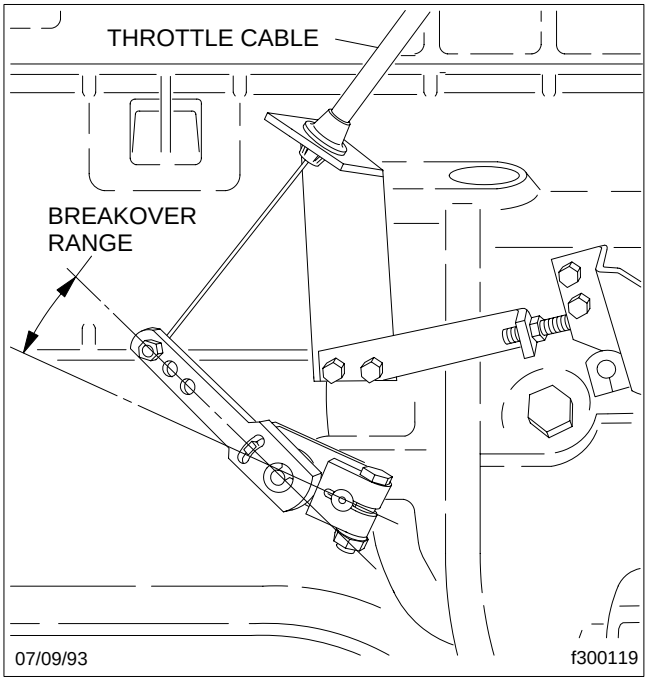


Fig. 4, Throttle Lever at Full Throttle

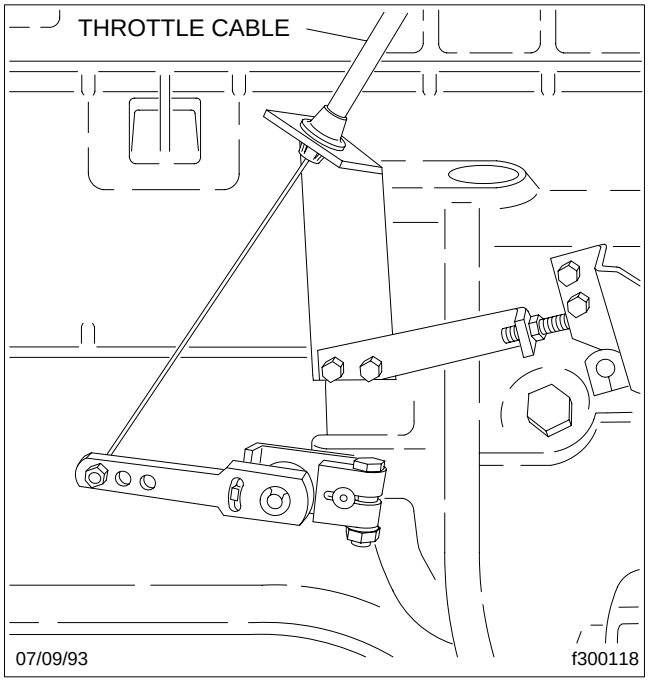


Fig. 3, Throttle Lever Partially Open

Checking

1. Check the linkage attachment fasteners (cap-screws, locknuts, and hexnuts) for tightness; tighten any that are loose.
2. Operate the throttle by hand, from idle to full throttle, while checking that nothing interferes with movement of the throttle lever or the throttle pedal. Reposition any parts that interfere.
3. Operate the throttle by hand, from idle to full throttle, while checking that the throttle lever returns to idle when released, and that the throttle lever pulls the throttle pedal back up. **Refer to Fig. 1 and Fig. 2.**
4. Operate the throttle pedal by hand, from idle to the pedal stop, while checking that the throttle cable pulls the throttle lever into the breakover range. **Refer to Fig. 3.**

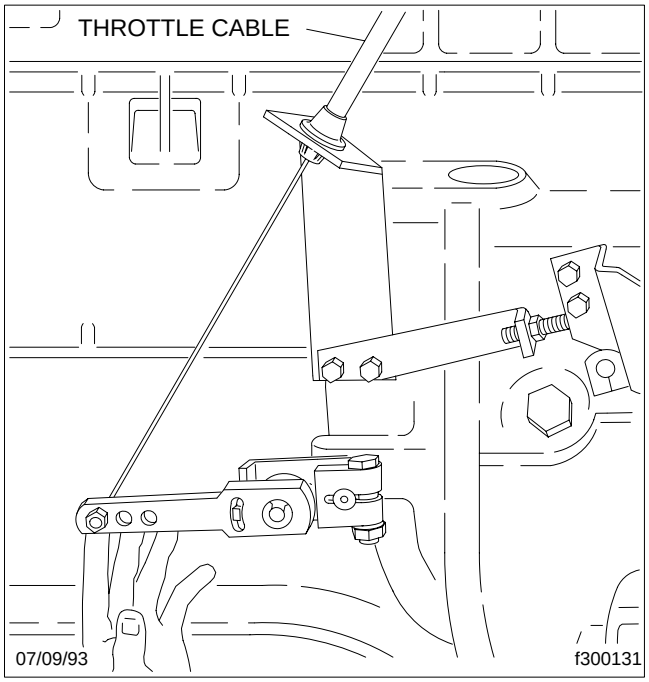


Fig. 1, Throttle Lever at Idle

NOTE: The breakover range begins at the point where the two parts of the throttle lever begin to have intersecting center lines.

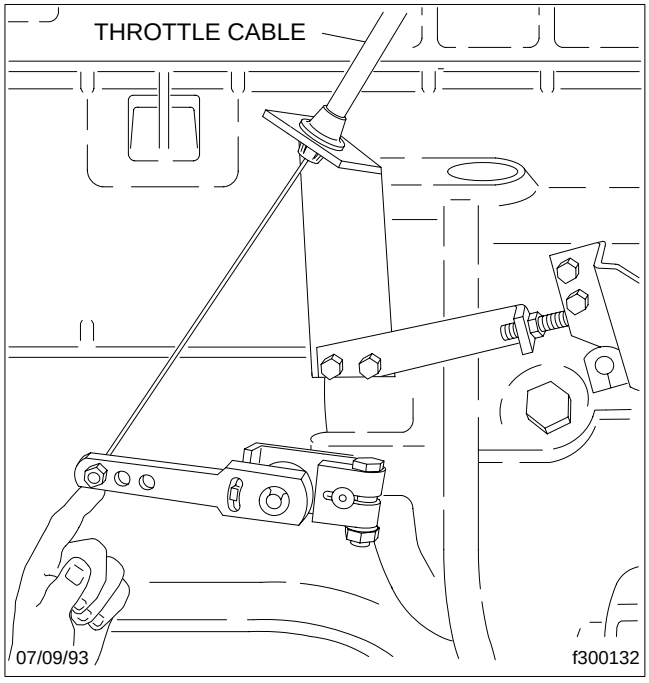


Fig. 2, Throttle Lever Partially Open

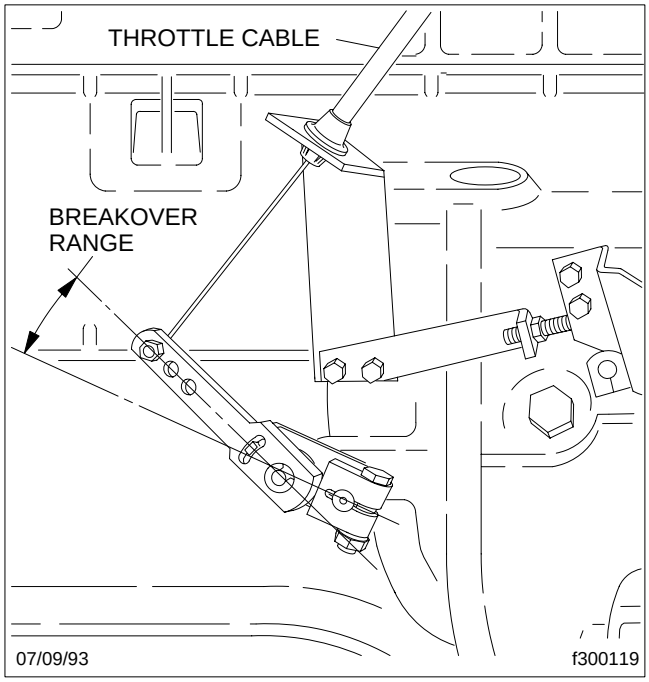


Fig. 3, Throttle Lever at Full Throttle

Throttle Cable Removal and Installation

Removal

1. Lift the throttle pedal to get some slack in the throttle cable as it comes through the firewall. **Refer to Fig. 1.**
2. Pry out the plastic bushing which holds the cable end in the throttle pedal lever. **Refer to Fig. 1.** Take the bushing off the cable, and remove the cable from the pedal lever.
3. Remove the cable clamp nut and toothed lockwasher from the cable conduit at the inside of the firewall. **See Fig. 1.**
4. Pass the cable out through the firewall.
5. Pull the plastic cover up, off the cast-metal cable end, and remove the cable end from the ball stud in the throttle lever. **Refer to Fig. 2.**
6. Remove the push-snap fitting from the throttle cable bracket. **Refer to Fig. 2.**
7. Slide the cable up through the hole in the cable bracket.

Installation

1. Pass the cable through the firewall into the cab. Make sure the bulkhead seal washer is in place against the engine side of the firewall.
2. Secure the cable conduit at the firewall with the toothed lockwasher and the cable clamp nut. **Refer to Fig. 1.** Tighten the clamp nut 14 N·m (10 lbf·ft).
3. Thread the cable through the throttle pedal lever, and slip a new plastic bushing onto the cable (with the open slot of the bushing facing up) so it can't pass back through the lever. **See Fig. 1.**
4. Snap the bushing into the hole at the upper end of the throttle pedal lever.
5. Inspect the ball stud in the throttle lever for wear, and replace if needed. If replacing the ball stud, apply Perma-Lock® MM 115 sealant or equivalent to the ball stud threads, and secure the stud to the throttle lever with the nut. Tighten the nut 13 N·m (10 lbf·ft).
6. Thread the cable through the cable bracket hole, and assemble the cast-metal cable end on the ball stud. Secure the joint by sliding the plastic cover down onto it.

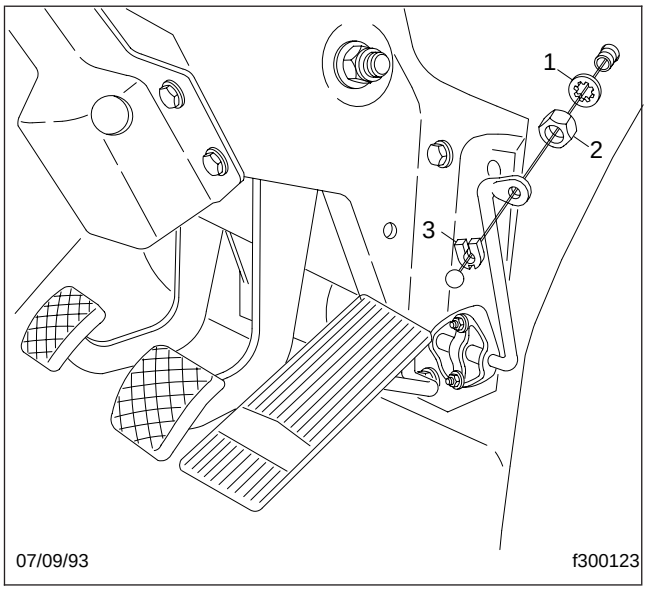


Fig. 1

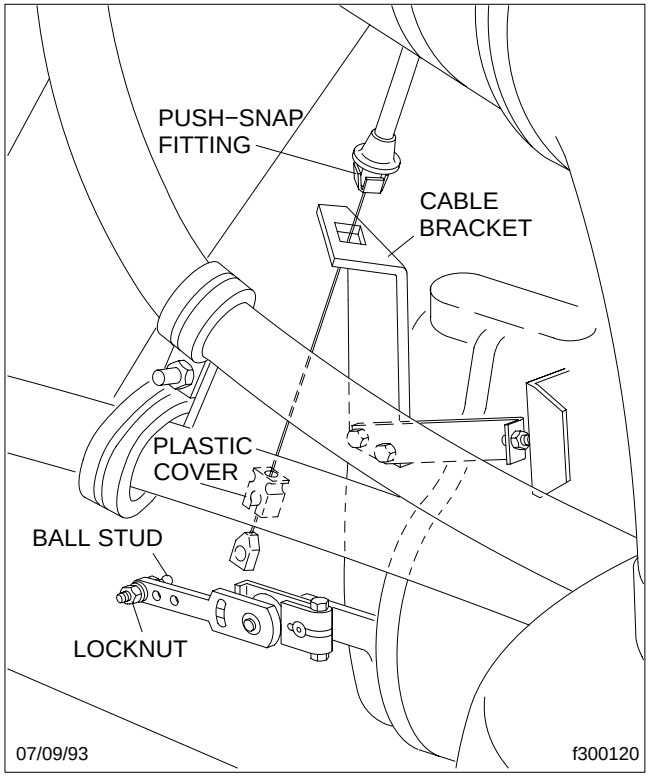


Fig. 2

Throttle Cable Removal and Installation

7. Position the cable in the cable bracket. **Refer to Fig. 2.** Secure the cable with the push-snap fitting.

Specifications

Description	Grade	Size	Torque N·m (lbf·ft)
Cable Clamp Nut	8	9/16 inch	14 (10)
Throttle Lever Cable Nut	5	1/4 inch	13 (10)

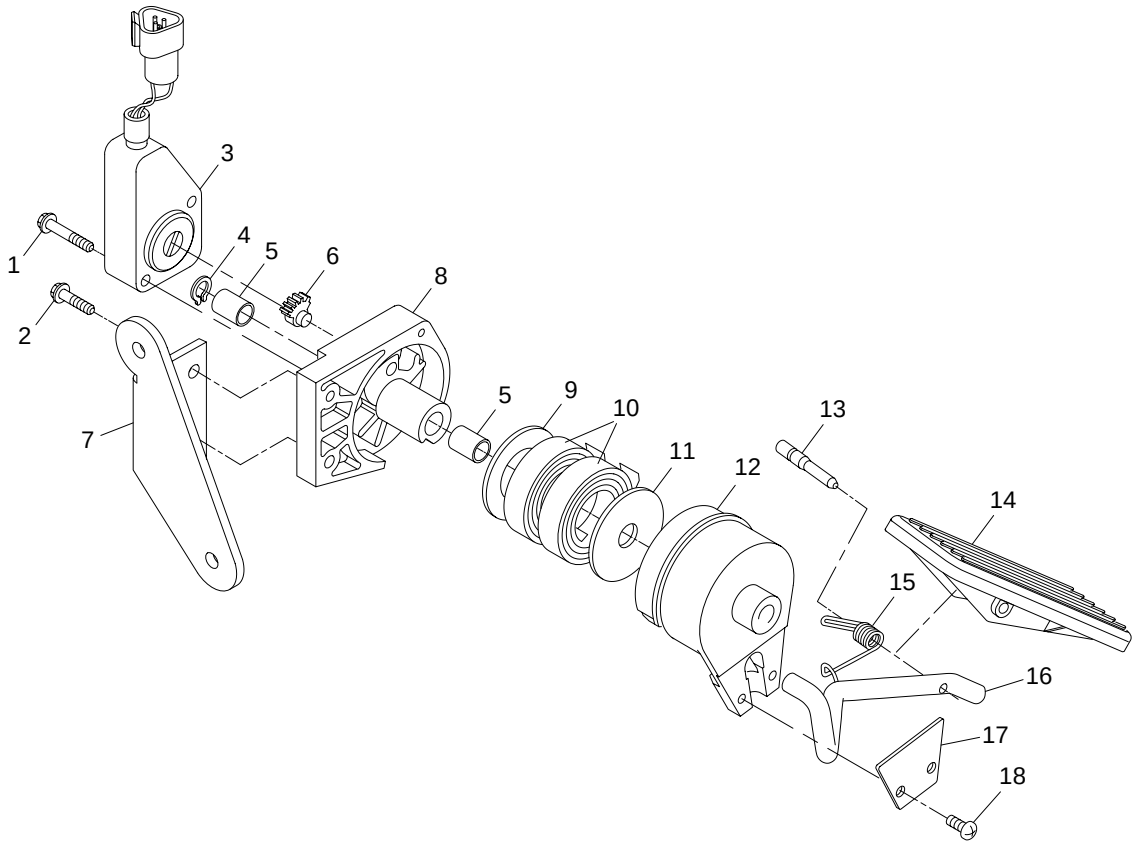
Table 1, Fastener Torques

Throttle Pedal Assembly

A Williams brand suspended, electronic throttle pedal is used in vehicles with Caterpillar, Cummins, and Detroit Diesel engines. See **Fig. 1**, **Fig. 2**, **Fig. 3**, and **Fig. 4**. The pedal is mounted to the inside of the frontwall and is connected by wiring to the engine control module.

NOTE: On vehicles with Detroit Diesel Series 50 engines, the pedal arm pulls an accelerator cable attached to the spring loaded spool assembly. The cable pulls the spool assembly and the assembly rotates. See **Fig. 4**.

The sensor, attached to the inboard side of the assembly, monitors how far the pinion gear (spool assembly on DDE Series 50 engines) rotates. Depending on how much the driver presses on the pedal, and the pedal rotates the pinion gear (or the cable rotates the spool assembly), the sensor signals the

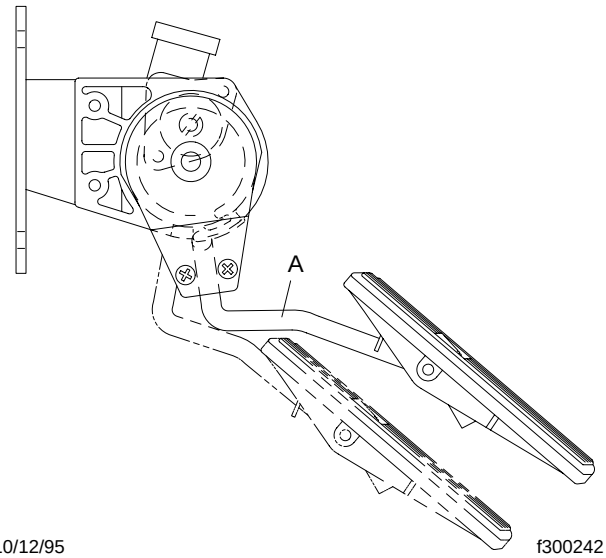


1. Screw, M10–32 x 1.25
2. Hex Screw, 1/4–20 x 0.75
3. Sensor
4. Grip Ring
5. Bushing
6. Pinion Gear
7. Mounting Plate
8. Throttle Base
9. Spacer Washer
10. Throttle Spring
11. Spacer Washer
12. Housing
13. Pedal Pin
14. Pedal
15. Pedal Return Spring
16. Pedal Lever
17. Saddle Clamp
18. Screw, M10–32 x 0.50

Fig. 1, Williams Suspended Electronic Throttle Pedal, Exploded View (Caterpillar CFE engine)

As the driver presses on the pedal, the pedal lever or pedal arm is forced downward, rotating the pinion gear which meshes with the pedal sensor, or potentiometer. See **Fig. 1**.

General Information



1. Idle Position

Fig. 2, Williams Suspended Electronic Throttle Pedal, Side View (Cummins M11, ISB, and ISC engines)

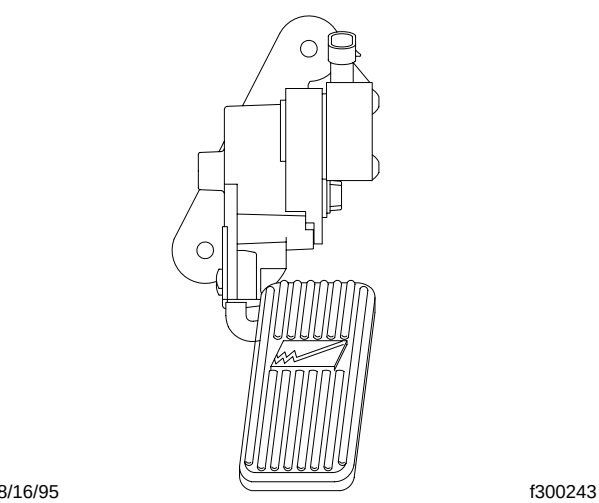


Fig. 3, Williams Suspended Electronic Throttle Pedal, Front View (Cummins M11, ISB, and ISC engines)

electronic engine control how much fuel to deliver to the engine.

When the driver stops pressing on the pedal, return springs within the pedal (or spool) assembly return the pedal to the original idle position. Only the pedal sensor is serviceable. If any other part of the pedal malfunctions, replace the entire pedal assembly.

Throttle Position Sensor

The throttle position sensor (TPS) is an electro-mechanical device that converts the mechanical input from the throttle pedal assembly into an electrical signal proportional to the input of the pedal. This electrical signal is fed to the engine ECU, which uses the signal to manage engine and engine accessory operations.

Two types of throttle position sensors are used on electronic engines:

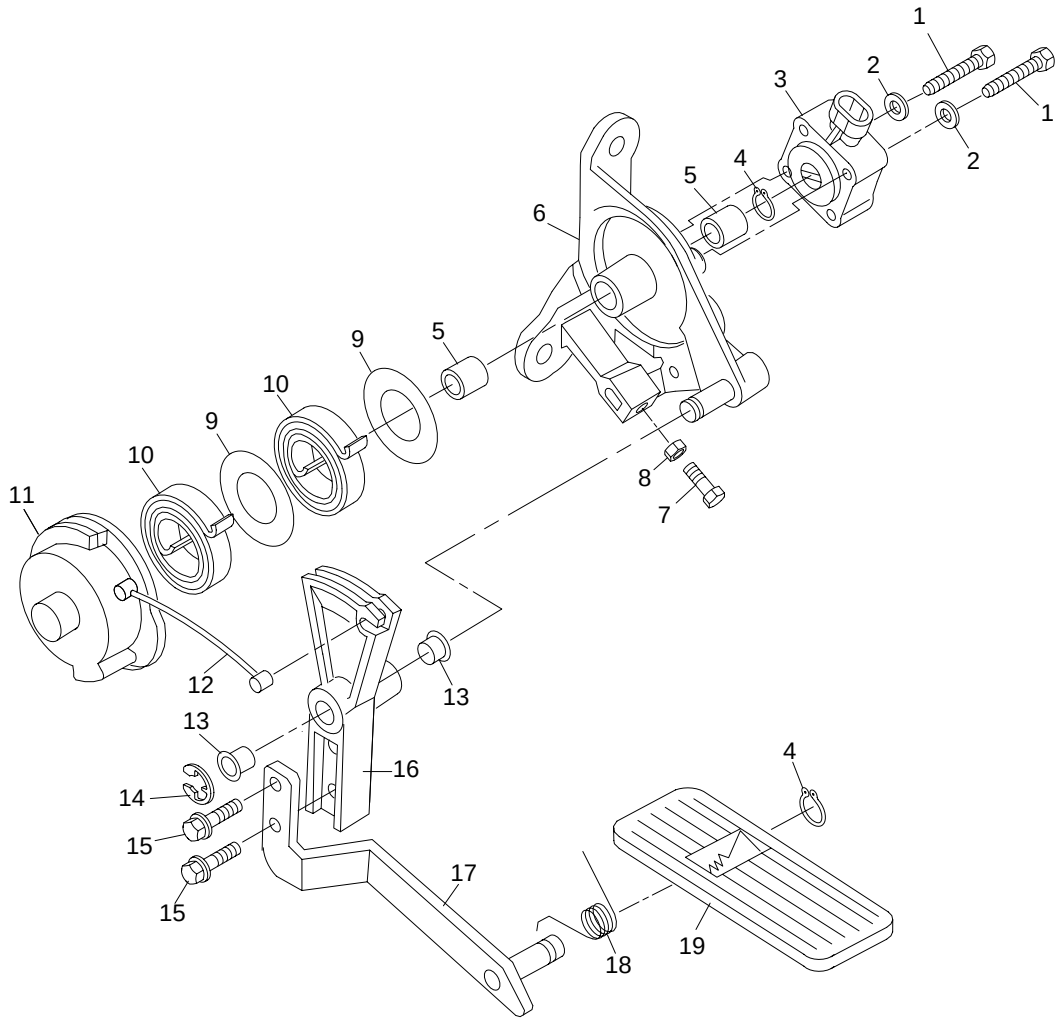
- The first type is a ratiometric sensor that produces a linear voltage output in proportion to pedal input. The engine ECU uses a converter circuit to turn the analog voltage into a digital "count."
- The second type is a pulse-width modulated (PWM) sensor that generates a series of discrete voltage pulses. The width of the pulses is proportional to the pedal position. A narrower pulse width indicates a smaller throttle pedal request and a wider pulse width indicates a larger pedal request. The pulse width is termed the "duty cycle" of the TPS.

The linear-type sensor is used on Cummins and Detroit Diesel engines. The PWM sensor is used on Caterpillar engines.

The TPS can also provide an idle validation signal (IVS). At present, an IVS is only available on vehicles equipped with Cummins electronic engines. The IVS is a single-pole, dual-throw switch integral with the TPS. When the throttle pedal returns to idle, the IVS moves to the "idle" position to tell the engine ECU that the pedal has returned to idle. When the throttle pedal is moved off of idle, the IVS moves to an "off idle" position to tell the engine ECU that the pedal is no longer in the idle position. Unlike a switch, there is a transition point on the TPS where a high resistance between the IVS common lead and either of the output leads may appear.

When properly installed, the TPS does not operate in either the lower or the upper 10 to 15 percent of the full range of travel. The output signal from the TPS can never be zero volts or equal the supply voltage from the engine. If such a condition should occur, the engine ECU will report a TPS problem.

The input signal from the TPS to the engine ECU is converted to binary data for engine management re-



03/19/93 f300207

1. Screw
2. Washer
3. Potentiometer
4. Retainer Ring
5. Needle Bearing
6. Bracket Base
7. Hex Screw
8. Hex Nut
9. Nylon Washer
10. Spring
11. Spool Assembly
12. Accelerator Cable
13. Nyliner
14. Snap Ring
15. Hex Screw
16. Pivot Arm
17. Pedal Arm
18. Pedal Spring
19. Pedal

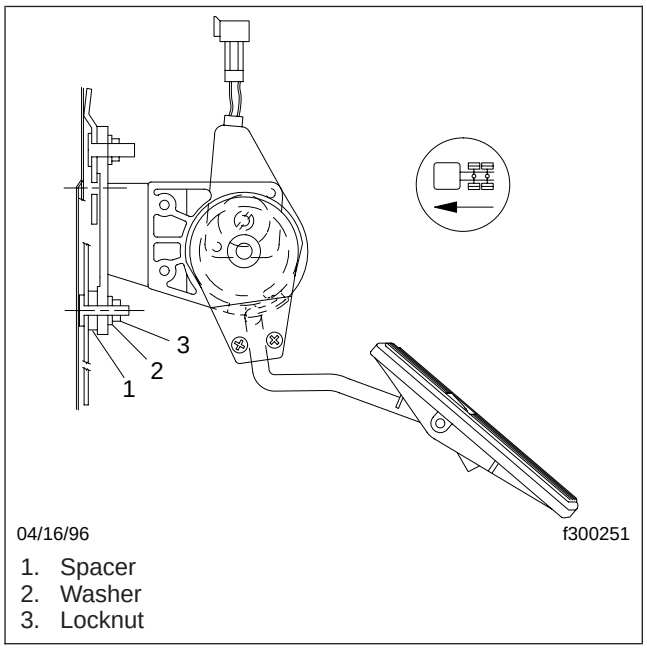
Fig. 4, Williams Suspended Electronic Throttle Pedal, Exploded View (DDE Series 50 engine)

quirements. Detroit Diesel engines report the input voltage as "counts," one "count" being equal to about 0.005 volt. Caterpillar and Cummins engines convert the actual TPS position to a percentage TPS value. The percentage TPS value is scaled so that the values represent the sensor position in the allowed range of travel. A 0 percent value (3 percent for Caterpillar engines) corresponds to idle. A 100 percent value corresponds to full throttle. Raw data may be available for diagnosis, but percentage TPS values are displayed by the diagnostic tools and appear in troubleshooting manuals.

Throttle Pedal Removal and Installation

Removal

1. Shut down the engine, set the parking brake, and chock the tires.
2. Disconnect the batteries.



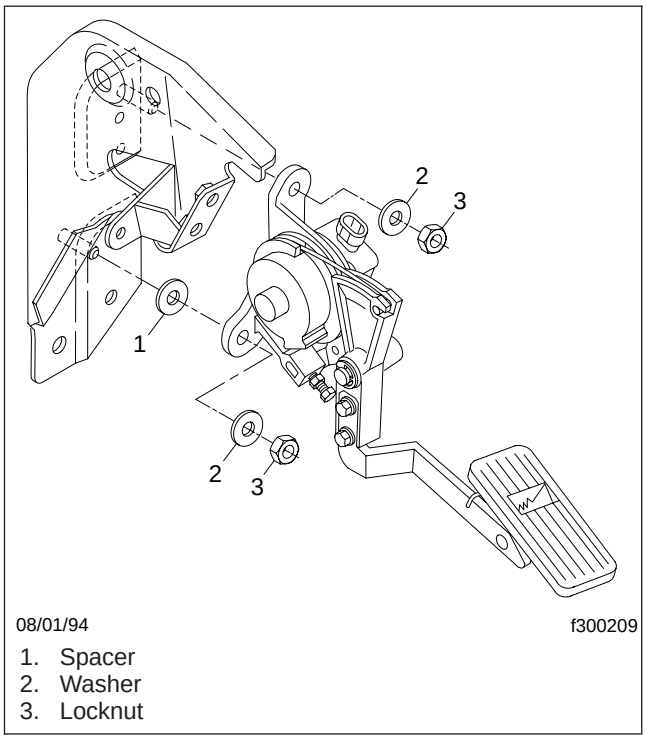
1. Spacer
2. Washer
3. Locknut

Fig. 1, Throttle Pedal Installation (typical)

⚠ WARNING

To prevent personal injury, always wear eye protection and use caution when servicing pedal assemblies. Springs under tension could release suddenly and cause personal injury.

3. Disconnect the wiring harness from the throttle pedal. See **Fig. 1** and **Fig. 2**.
4. Remove the throttle pedal assembly from the vehicle.
   - 4.1 Remove the two locknuts and washers that secure the mounting plate to the two studs on the cab frontwall.
   - 4.2 Lift the pedal assembly off of the studs.



1. Spacer
2. Washer
3. Locknut

Fig. 2, Williams Electronic Throttle Pedal (DDE Series 50 engine)

Installation

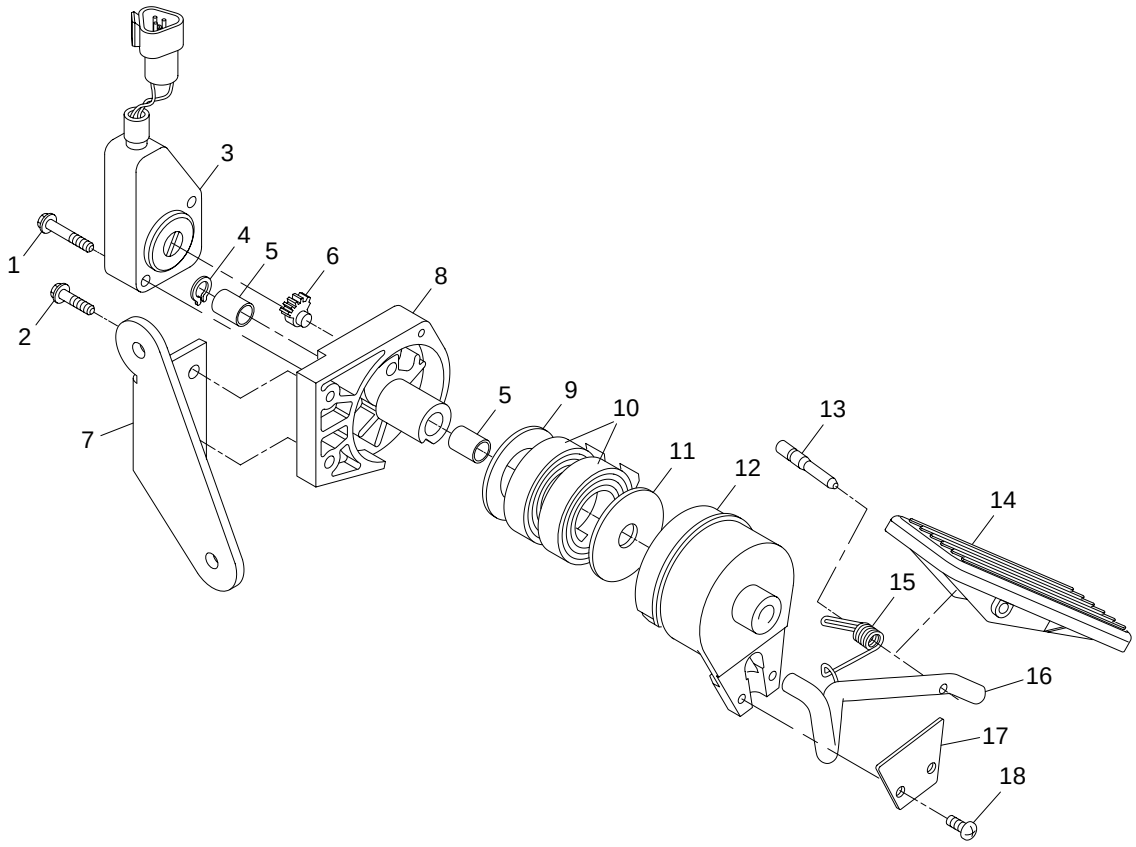
1. Install the throttle pedal assembly. See **Fig. 1** and **Fig. 2**.
   - 1.1 If applicable, make sure that the spacer is in place on the lower mounting stud, then position the mounting plate on the two studs on the inside of the cab frontwall.
   - 1.2 Secure the plate on the studs with two 5/16–18 locknuts, and tighten the locknuts securely.
2. Connect the wiring harness to the throttle pedal.
3. Connect the batteries.
4. Remove the chocks from the tires.
5. Test drive the vehicle and ensure that the throttle pedal operates properly.

Replacement

1. Shut down the engine, set the parking brakes, and chock the tires.
2. Disconnect the batteries.

NOTE: The sensor is not a serviceable part. If the sensor is malfunctioning, replace it.

3. Remove the sensor. See **Fig. 1**.
   - 3.1 Remove the two screws that hold the sensor to the throttle base.
   - 3.2 Disconnect the wiring harness from the throttle pedal sensor.
4. Install the sensor.
   - 4.1 Align the sensor with the pinion gear.
   - 4.2 Rotate the sensor so that the mounting holes line up, then secure the sensor with the mounting screws, and tighten the screws 15 to 20 lbf·in (160 to 220 N·cm).
   - 4.3 Connect the wiring harness to the sensor.
5. Connect the batteries and remove the chocks from the tires.



1. Screw, M10–32 x 1.25
2. Hex Screw, 1/4–20 x 0.75
3. Sensor
4. Grip Ring
5. Bushing
6. Pinion Gear
7. Mounting Plate
8. Throttle Base
9. Spacer Washer
10. Throttle Spring
11. Spacer Washer
12. Housing
13. Pedal Pin
14. Pedal
15. Pedal Return Spring
16. Pedal Lever
17. Saddle Clamp
18. Screw, M10–32 x 0.50

Fig. 1, Williams Electronic Throttle Pedal, Exploded View (typical)

Throttle Pedal Sensor Replacement

6. Test drive the vehicle and ensure that the throttle pedal sensor operates properly.

Throttle Pedal Sensor Timing (Caterpillar CFE Engine)

Sensor Timing

1. Shut down the engine, set the parking brake, and chock the tires.
2. Loosen the two screws that hold the sensor to the throttle base.
3. Connect the Caterpillar Digital Diagnostic Tool to the vehicle's electronic data link. With the pedal in the idle position, adjust the sensor by rotating the housing until the reader displays the correct output of 10 to 22 percent of duty cycle.

CAUTION

Do not overtighten the sensor screws. Overtightening the screws can damage the sensor.

4. After the sensor is adjusted to the correct specifications, tighten the two sensor screws 15 to 20 lbf·in (169 to 226 N·cm).
5. Tighten the wiring harness clamps.
6. Remove the chocks from the tires.

Troubleshooting Procedures

CAUTION

The throttle pedal assembly is designed so that the throttle position sensor (TPS) will not reach the internal stop points when it is mounted to the pedal assembly. Very little sensor rotational adjustment is available once the TPS is installed. Attempting to modify the TPS, in an effort to gain adjustment range, or forcing the TPS shaft beyond the internal stop points will result in severe damage to the TPS.

The TPS used with Caterpillar engines is a pulse-width modulated (PWM) sensor. It cannot be properly diagnosed with a digital multimeter set to measure voltage, resistance, or continuity. A multimeter capable of measuring "duty cycle" can be used to view the TPS output. Caterpillar engine diagnostic tools are recommended for viewing the percentage TPS reported by the engine ECU. Attempting to diagnose a PWM sensor assembly without the proper tools will result in damage to the TPS.

Common Problems and Indications

A number of symptoms may be reported which can indicate a problem with the throttle pedal, TPS, or wiring to the electronic engine, including:

- low power or poor acceleration
- the vehicle will not reach programmed top speed
- the engine is stuck at idle
- the engine brake or engine retarder does not function
- slow deceleration
- the check engine light comes on
- an engine fault code indicating a TPS problem appears

These symptoms do not always indicate a throttle pedal, TPS, or wiring problem. Symptoms can disappear when the TPS is replaced, however, the TPS may not be faulty. A thorough diagnosis of the entire TPS system must be performed to ensure that a TPS is faulty.

Preliminary Checks

1. Verify, by testing with the particular engine manufacturer's diagnostic software and tools, that the TPS is operating properly. For Cummins engines, also verify idle validation signal (IVS) inputs. See **Table 1**.

IMPORTANT: **Table 1** is a guide for common engine installations. It is necessary to verify the correct information for the specific engine installed in the vehicle.

2. If the engine manufacturer's diagnostic software and tools produce the readings shown in **Table 1**, the TPS is not at fault. If you are unable to produce the readings shown in **Table 1**, go to the next step.
3. Verify that the TPS is wired properly. See **Table 2**.

IMPORTANT: Reversing the TPS signal line and the ground line can result in a percentage TPS reading that does not change, and may also produce a fault code at the engine ECU. Reversing the TPS signal line and the +v supply line can prevent the TPS signal from reaching 100 percent. Reversing the +v supply line and the common line will result in the TPS providing "inverted" pedal information, or not working at all. Verify circuit positions and circuit designations in the engine ECU connector using the engine manufacturer's troubleshooting documentation.

NOTE: On Caterpillar engines, swapping any circuits may cause the TPS not to operate.

4. Check the voltage to the TPS. See **Table 3** for TPS connector pin locations.

IMPORTANT: The ignition key must be in the ON position. For Cummins and Detroit Diesel engines, disconnect the TPS connector at the TPS. For Caterpillar and Mercedes-Benz engines, use or fabricate a breakout harness. After diagnosis, clear any historical TPS fault codes to prevent misdiagnosis in the future.

NOTE: It is normal for the engine to report fault codes when the TPS connector is disconnected.

Troubleshooting

CAUTION

Do not perform the tests in steps 5, 6, and 7 on the PWM sensor used with Caterpillar engines. Doing so may result in serious damage to the TPS.

5. If you do not read the voltages shown in **Table 3**, test resistance on the +v supply and common circuits between the TPS and the engine connectors. Disconnect the OEM harness connector at the engine ECU.

IMPORTANT: For Caterpillar engines, also disconnect the TPS connector from the TPS. Ensure that the ignition key is in the OFF position before making any tests.

6. If a resistance greater than 10 ohms is read, there is a potential wiring problem. Correct any wiring problem before attempting further tests. If a wiring problem is discovered and repaired, go back and repeat step 1 to determine if this was the only problem.

NOTE: If circuit resistance is 10 ohms or less but the voltage is below that listed in **Table 3**, the engine ECU is probably faulty. If both voltage and circuit resistance are within spec, go to the next step.

7. For Cummins and Detroit Diesel TPS, check the resistance of the TPS at the OEM harness connector with a digital multimeter. Before making measurements, reconnect the TPS connector to the TPS. Leave the OEM harness connector disconnected. See **Table 4** for acceptable readings.

8. Inspect and ensure that all connector pins at the TPS sensor, frontwall, and engine ECU are free of corrosion and are not bent or damaged. Inspect and ensure that the connections between the pins and the wires are secure and also free of corrosion.

NOTE: If the TPS does not return to idle, one of two conditions exists. Either the IVS is faulty or the TPS signal voltage or PWM duty cycle, recorded by the engine ECU, is dropping significantly after the engine has calibrated the idle position.

9. On Cummins engines only, check and ensure that the IVS is working properly. If a problem is found with the IVS, replace the TPS with a new unit or one known to be good and continue testing. If no problem is found, go to the next step.

10. Remove the pedal assembly from the floor. Loosen (but do not remove) the TPS mounting screws. By hand, rotate the TPS sensor assembly as far as possible. Then, tighten the mounting screws securely. Check the operation of the TPS again.

NOTE: In some cases, it may be necessary to exchange the existing TPS with another because the TPS and pedal assembly tolerances result in an idle position too close to the edge of acceptable operation. In this situation, the TPS is probably not faulty and may perform acceptably in another pedal.

11. If the engine will not reach rated speed or recognize full throttle, the cause is something other than the TPS. Check the engine ECU parameters and reset them if necessary. Check and ensure that the TPS is wired correctly. Remove the TPS from the pedal assembly and move the pedal through the full range of operation. Watch the operation of the TPS actuator tab. Ensure that no parts are binding or broken.

12. If the TPS does not leave idle, check IVS operation (if so equipped) and ensure that the switch transitions from the idle to the off-idle state. Also, check for a signal on the appropriate wires at the engine ECU for both idle and off-idle states. On vehicles not equipped with an IVS, check and ensure that the TPS is connected correctly to the engine.

13. If the problem has still not been resolved, the problem is not with the TPS. See the engine manufacturer's service literature for further guidance.

Diagnostic Software/Tool Readings		
Engine	**Pedal Position**	**Reading**
Caterpillar *	Idle	3% TPS
	Full throttle	100% TPS
	Between idle/full throttle	Varies smoothly between 3% and 100%
Cummins *	Idle	0% TPS, IVS on-idle
	Full throttle	100% TPS, IVS off-idle
	Between idle/full throttle	Varies smoothly between 0% and 100%, IVS transitions between on-idle and off-idle at or before 15% TPS
Detroit Diesel	Idle	64 to 205 counts, (0% TPS)
	Full throttle	Less than 968 counts (100% TPS)
	Between idle/full throttle	Varies smoothly between idle and full throttle values
Mercedes-Benz	Idle	0% TPS
	Full throttle	100% TPS
	Between idle/full throttle	Varies smoothly between idle and full throttle values

* The ECM converts raw TPS data to % TPS.

Table 1, Diagnostic Software/Tool Readings

Throttle Position Sensor (TPS) Wiring				
Engine	**Engine Mfr. Circuit**	**TPS Connector Pin**	**Engine ECU Connector**	**See Drawing(s)**
Caterpillar CFE	C985 (+v supply)	A	35	D06–22104
	C993 (common)	B	29	–
	C986 (TPS signal)	C	37	–
Caterpillar C10/C12	C985 (+v supply)	A	4	D06–33424
	C993 (common)	B	5	*
	C986 (TPS signal)	C	66	D06–27057
Cummins ISB/ISC	N18 (+v supply)	C	29	D06–26882
	N19 (common)	B	19	–
	N11 (TPS signal)	A	30	–
Cummins ISM	N18 (+v supply)	C	18	D06–23965
	N19 (common)	B	19	–
	N11 (TPS signal)	A	11	–
Mercedes-Benz 906	440P + (+v supply)	C	9 (VCU)	–
	440P – (common)	B	14 (VCU)	–
	440T (TPS signal)	A	11 (VCU)	–

Troubleshooting

Throttle Position Sensor (TPS) Wiring				
Engine	**Engine Mfr. Circuit**	**TPS Connector Pin**	**Engine ECU Connector**	**See Drawing(s)**
Detroit Diesel 50	D916 (+v supply)	A	A3	–
	D952 (common)	C	C3	–
	D417 (TPS signal)	B	D2	–

* Wire C795 is replaced by wire C993.

Table 2, Throttle Position Sensor (TPS) Wiring

TPS Connector Pin Locations			
Engine	**TPS +V Supply**	**TPS Common (Ground)**	**Voltage**
Caterpillar	Pin A	Pin B	+8v ± 0.5v
Cummins	Pin C	Pin B	+5v ± 0.5v
Detroit Diesel	Pin A	Pin C	+5v ± 0.5v
Mercedes-Benz	Pin C	Pin B	+5v ± 0.5v

Table 3, TPS Connector Pin Locations

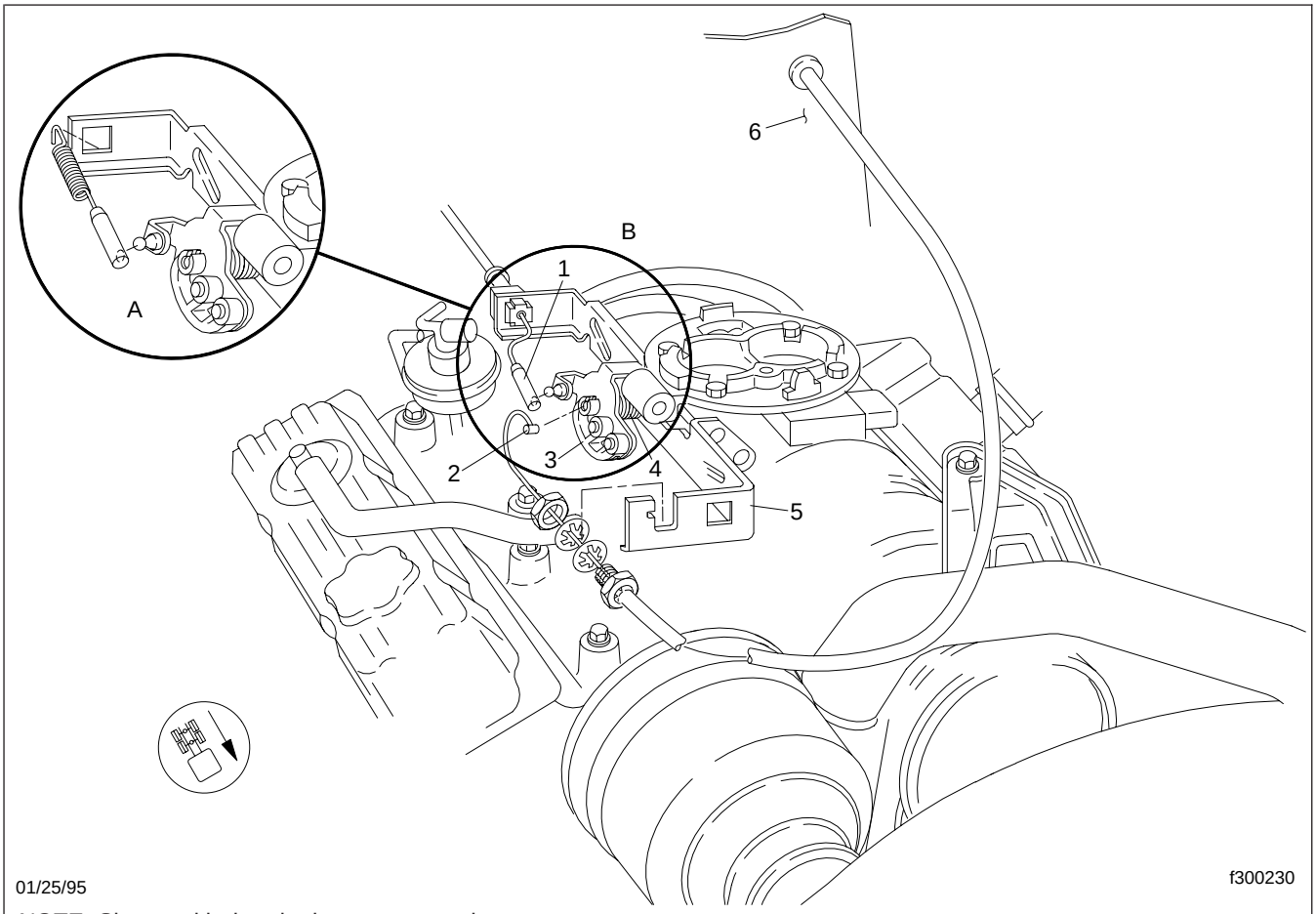
TPS Resistance at OEM Connector Harness (Cummins and Detroit Diesel engines only)			
Measurement	**From**	**To**	**Value**
TPS total resistance	+V supply	Common	2000 to 3000 ohms
TPS signal to common at idle	TPS signal	Common	200 to 500 ohms (13% ± 2% of TPS total resistance)
TPS signal to +v supply at idle	TPS signal	+V supply	1800 to 2500 ohms and less than TPS total resistance
TPS signal over pedal travel range	TPS signal	+V supply	Should change smoothly from high to low resistance values as the pedal moves from idle to wide-open throttle
	TPS signal	Common	Should change smoothly from low to high resistance values as the pedal moves from idle to wide-open throttle

Table 4, TPS Resistance at OEM Connector Harness (Cummins and Detroit Diesel engines only)

General Description

An adjustable cable connects the throttle pedal to the throttle body on the Dodge Magnum V-8 and V-10 engines. **See Fig. 1** and **Fig. 2**. The cable runs from the pedal, through the firewall, and directly to the engine throttle body. Return springs on the throttle body shaft will return the throttle lever to the idle position when pressure on the throttle pedal is released. Engines equipped with manual transmissions have an additional pedal return spring. **See Fig. 3.**

When depressed, the throttle pedal pulls the cable, and the cable pulls the engine throttle lever to increase fuel delivery to the engine. The cable length enables the throttle pedal to operate the throttle lever through its full range, from idle to full throttle. To adjust the cable length, reposition the threaded cable end in the throttle body mounting bracket, and secure the cable with the cable clamp nuts. The cable housing prevents any interference with, or wear on, the throttle cable.



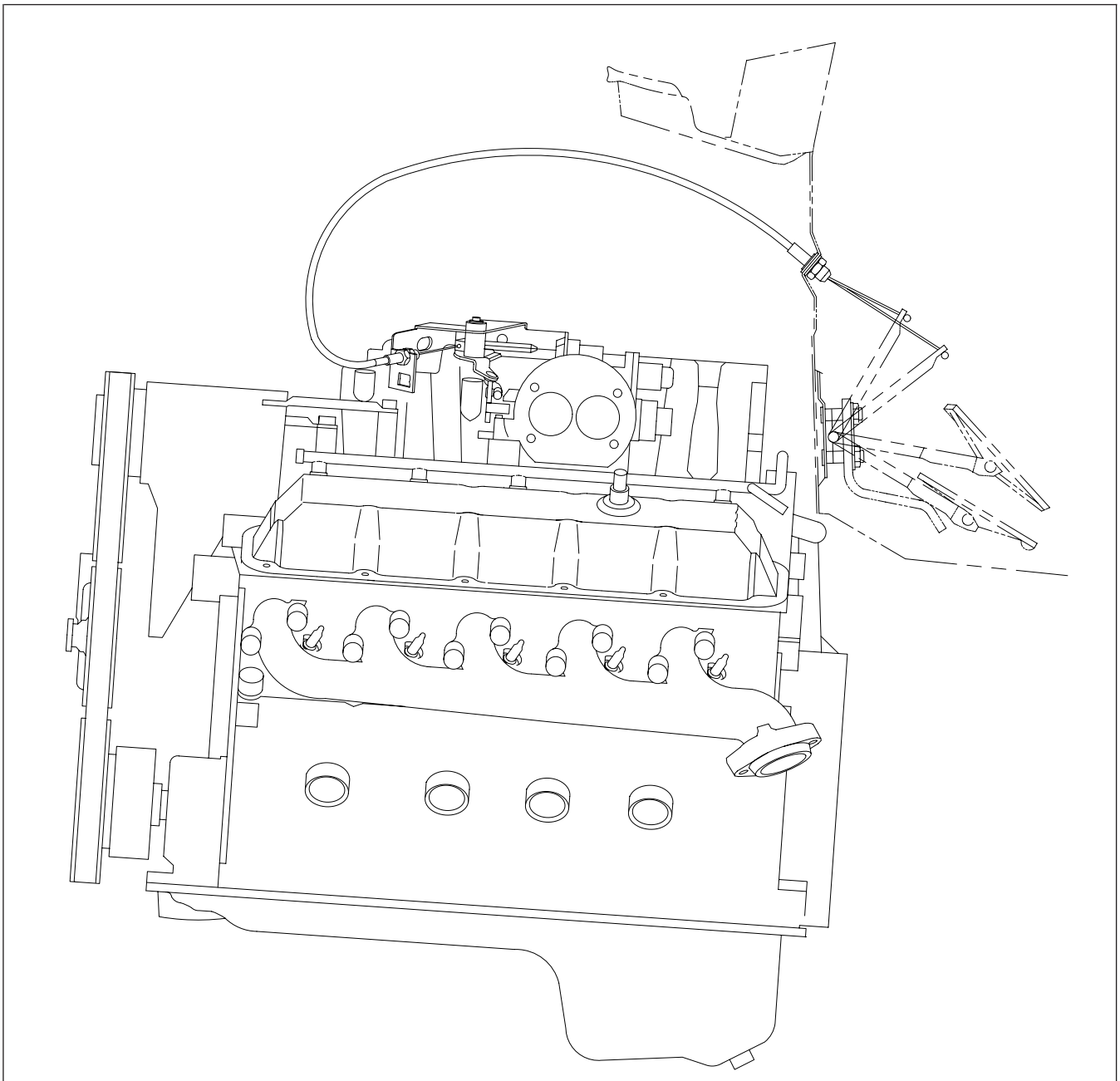
NOTE: Shown with the air cleaner removed.

A. Return spring used with manual transmission.
B. Transmission throttle valve cable used with automatic transmission.

1. Transmission Throttle Valve Cable
2. Throttle Cable
3. Throttle Body Cam
4. Throttle Pedal Return Spring
5. Throttle Body Mounting Bracket
6. Firewall

Fig. 1, Throttle Cable from Firewall To Throttle Body Lever, V-8 Engine

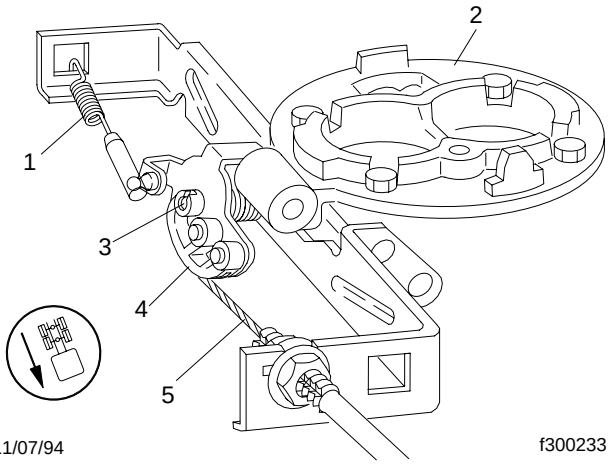
General Description



NOTE: Shown with the air cleaner removed.

Fig. 2, Throttle Cable from Firewall To Throttle Body Lever, V-10 Engine

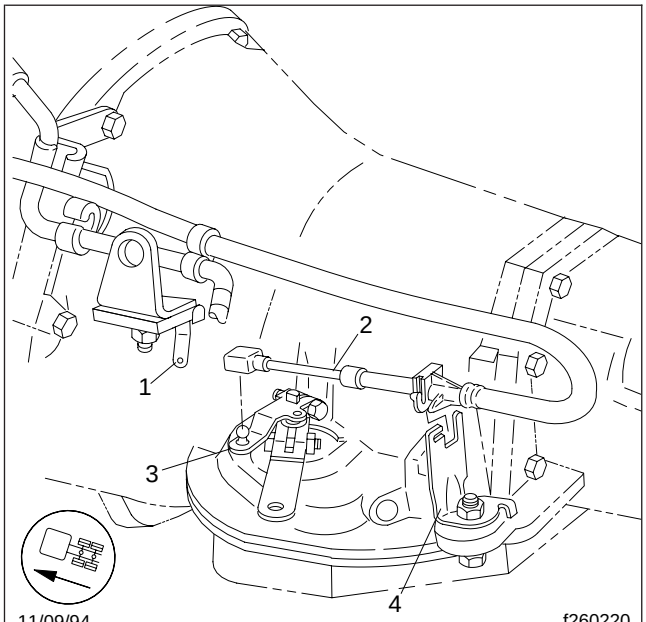
On vehicles equipped with automatic transmissions, a second cable runs from the throttle body to the transmission throttle valve lever. **See Fig. 4 .** The transmission throttle valve cable is adjustable at the



1. Throttle Pedal Return Spring (manual transmissions only)
2. Throttle Body
3. Cable Pin
4. Throttle Body Cam
5. Throttle Cable

Fig. 3, Return Spring Installation for Manual Transmission, V-8 Engine

engine, and when adjusted correctly, the cable will pull simultaneously with the cable from the throttle pedal.



1. Spring Bracket
2. Transmission Throttle Valve Cable
3. Transmission Throttle Valve Lever
4. Cable Bracket

Fig. 4, Transmission Throttle Valve Cable, Transmission End

Throttle Cable Removal and Installation

Removal

1. Park the vehicle, shut down the engine, and set the parking brakes. Tilt the hood.
2. To access the throttle body, remove the air cleaner housing. **See Fig. 1.** For complete removal instructions, refer to **Group 09**.

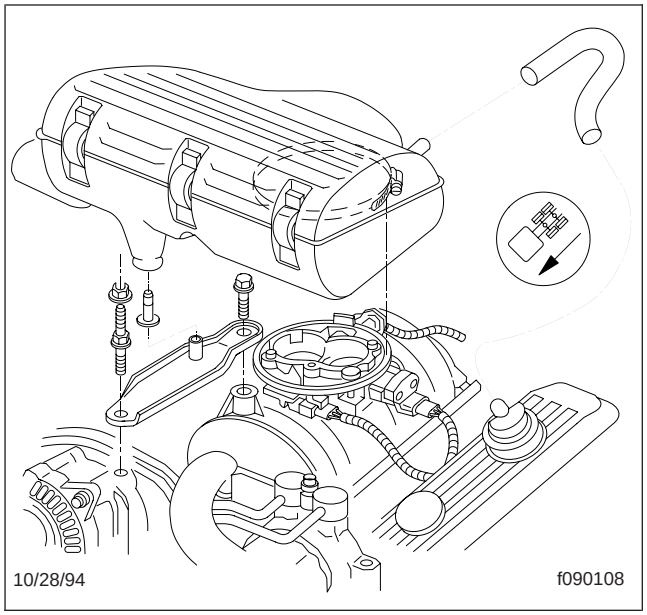
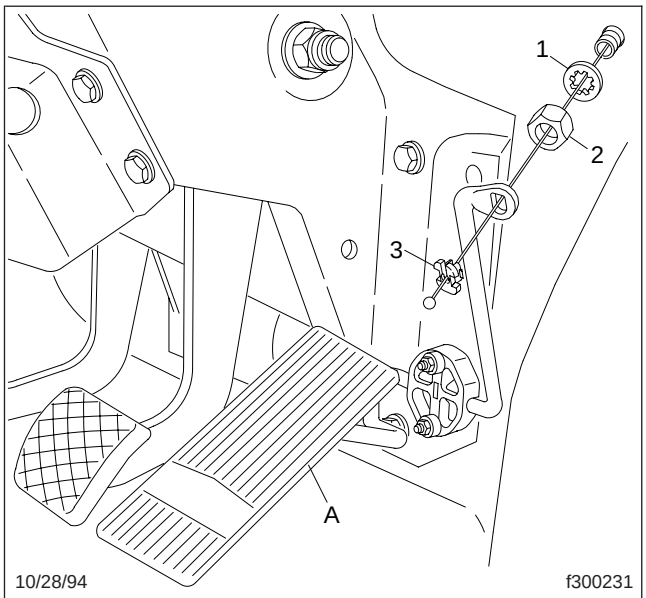


Fig. 1, Air Cleaner Removal, V-8 Engine

⚠ WARNING

WARNING: Be careful not to kink or damage the cable core wire (within the cable housing) while servicing the throttle pedal or cables. A damaged cable could cause loss of throttle control, possibly resulting in a vehicle crash and personal injury or property damage.

3. Lift the throttle pedal to get some slack in the throttle cable as it comes through the firewall. **See Fig. 2.**
4. Pry out the plastic bushing which holds the cable end in the throttle pedal lever. Take the bushing off the cable, and remove the cable from the pedal lever.
5. Remove the cable clamp nut and the toothed lockwasher from the cable housing at the firewall inside the cab. **See Fig. 2.**



A. Lift the pedal to get some slack in the throttle cable.
1. Toothed Lockwasher
2. Cable Clamp Nut
3. Plastic Bushing

Fig. 2, Throttle Cable Connection at the Throttle Pedal

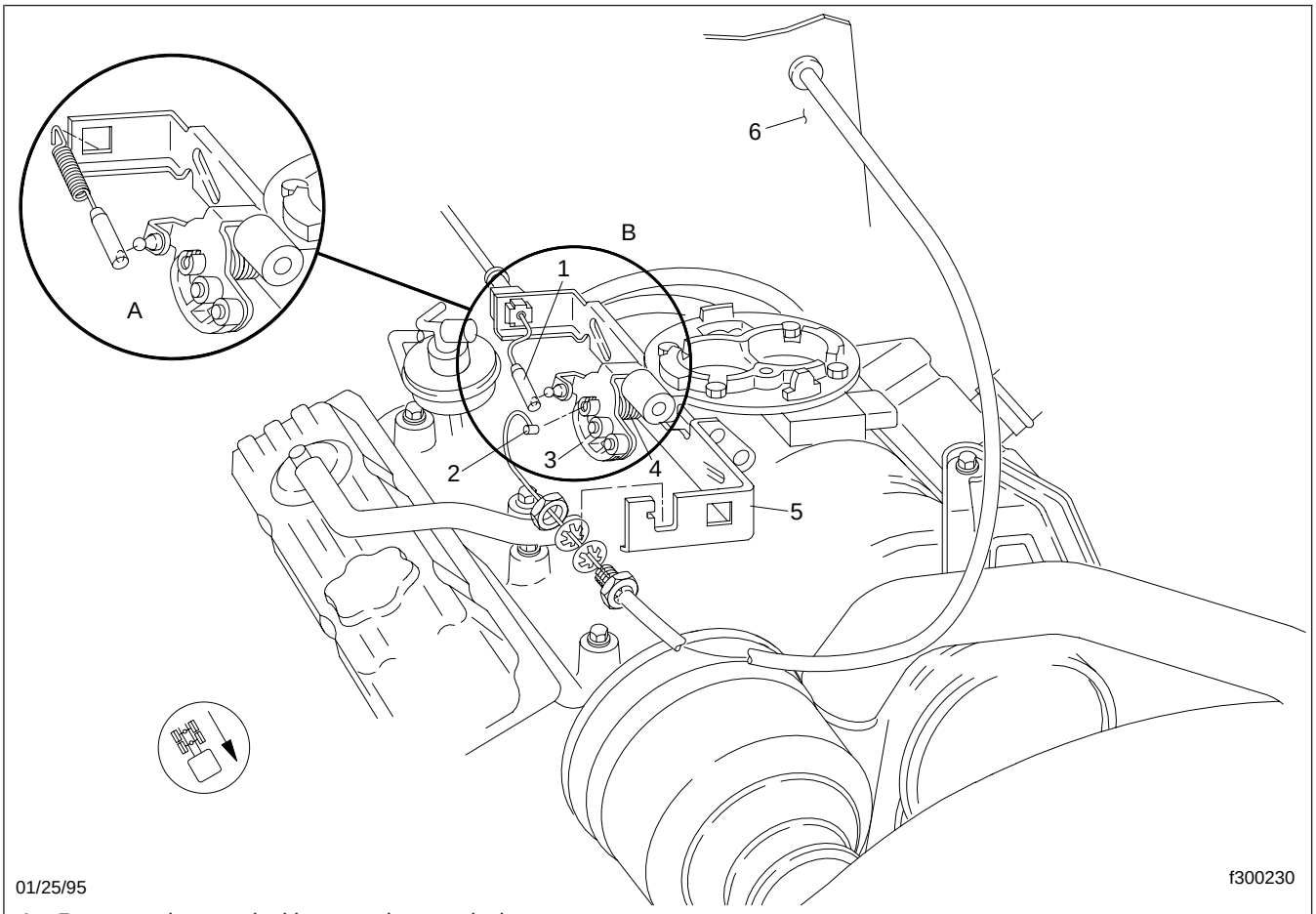
6. Pass the cable out through the firewall.
7. If applicable, loosen the camp that holds the cable housing to the radiator inlet pipe, and draw the cable and cable housing through and free of the clamp. **See Fig. 3.**
8. *For V-8 engines,* roll the throttle body cam, by hand, from idle to full throttle. Slip the pin on the end of the cable from the hole in the throttle body cam, and remove the cable from the cam. **See Fig. 4.**

   For V-10 engines, pull the plastic cap back and off the metal cable socket that mounts on the ball on the throttle body lever. **See Fig. 5.** Then, lift the cable socket off the ball. **See Fig. 6.**
9. Loosen the cable clamp nuts on either side of the throttle body mounting bracket. **See Fig. 7.** Slide the cable out of the bracket.

Installation

1. *For V-8 engines,* by hand, rotate the throttle cam to the full throttle position. **See Fig. 4.** Fit the pin

Throttle Cable Removal and Installation



A. Return spring used with manual transmission.
B. Transmission throttle valve cable used with automatic transmission.

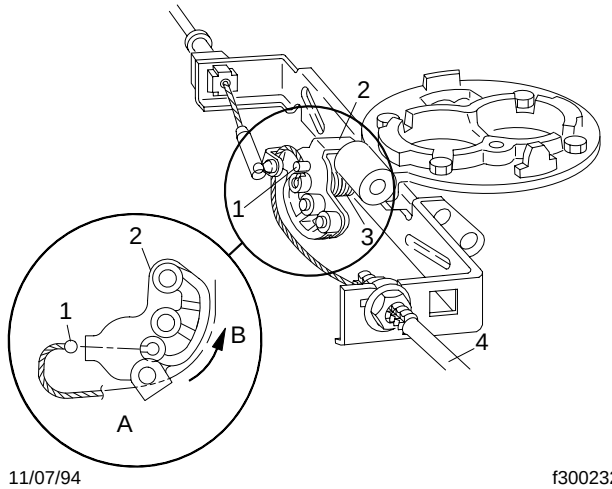
1. Transmission Throttle Valve Cable
2. Throttle Cable
3. Throttle Body Cam
4. Throttle Pedal Return Spring
5. Throttle Body Mounting Bracket
6. Firewall

Fig. 3, Throttle Cable from Firewall To Throttle Body Lever, V-8 Engine

on the end of the cable into the hole on the throttle body cam.

For V-10 engines, fit the throttle cable socket over the lever ball on the throttle body lever. **See Fig. 6.** Then, slide the plastic cap onto the metal cable socket to lock it on the lever ball.

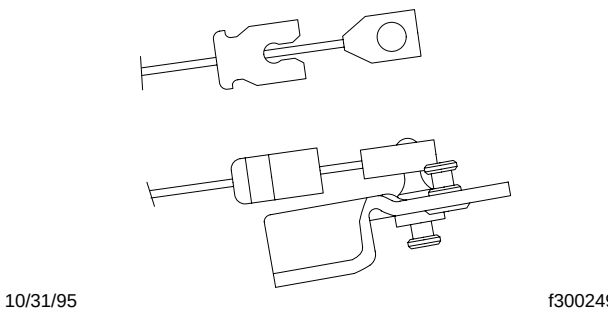
2. Turn the threaded cable housing so the two grooves in the housing align with the two points in the throttle body mounting bracket notch. **See Fig. 8.** Install the housing in the notch, and tighten a lockwasher and a cable clamp nut fingertight against each side of the bracket.
3. If applicable, route the throttle cable through the clamp on the radiator inlet tube and around the engine to the throttle body. **See Fig. 3.**
4. Thread the cable from the engine compartment, through the hole in the firewall and into the cab. Make sure the bulkhead seal washer is in place against the engine side of the firewall. Secure the cable housing at the firewall with the toothed



11/07/94 f300232

A. View of Wide-Open Throttle
B. Rotate to full throttle.
1. Cable Pin
2. Throttle Body Cam
3. Throttle Pedal Return Spring
4. Throttle Cable

Fig. 4, Cable Removal, V-8 Engine

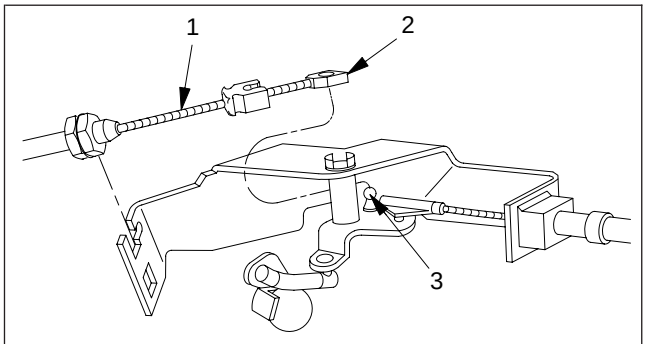


10/31/95 f300249

Fig. 5, Throttle Cable End and Plastic Locking Cap, V-10 Engine

lockwasher and the cable clamp nut. **See Fig. 2.** Tighten the nut 13 N·m (10 lbf·ft).

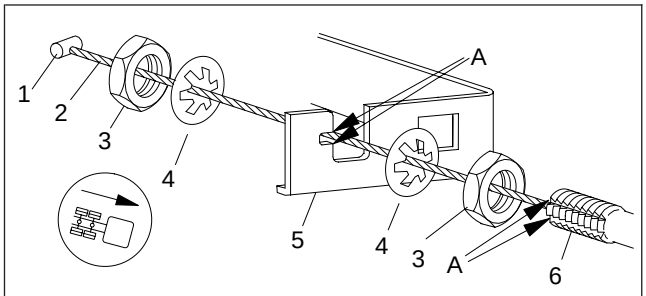
5. Thread the cable end through the throttle pedal lever, and place the plastic bushing onto the end of the throttle cable. Snap the bushing (with the notch in the bushing pointing up) into the hole at the upper end of the throttle pedal lever.
6. Use the cable clamp nuts to adjust the throttle cable in the throttle body mounting bracket until the throttle pedal can pull the throttle body lever from idle to full throttle and then return to idle. When the cable is adjusted, tighten the clamp nuts 13 N·m (10 lbf·ft).



01/11/96 f300248

1. Throttle Cable
2. Cable Socket
3. Lever Ball

Fig. 6, Throttle Cable Connection to Throttle Body, V-10 Engine



10/28/94 f300235

A. Turn the grooves in the cable housing outboard to align with the bracket points.
1. Throttle Cable Pin
2. Throttle Cable
3. Cable Clamp Nut
4. Toothed Lockwasher
5. Throttle Body Mounting Bracket
6. Threaded Cable Housing

Fig. 7, Throttle Cable Installation, V-8 Engine

⚠ WARNING

WARNING: Do not allow the throttle cable to rub against other components. A rubbing cable can wear and break resulting in loss of throttle control and possible property damage or personal injury.

Throttle Cable Removal and Installation

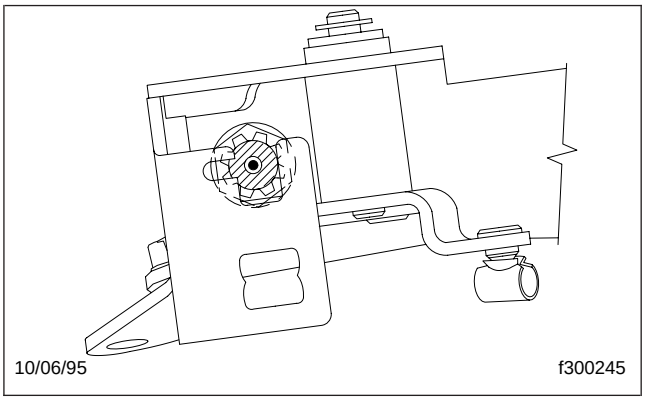


Fig. 8, Cable Positioning, V-10 Engine

7. Make sure the cable routing clamp(s) is tight enough to prevent motion between the parts.
8. Install the air cleaner housing and tighten the mounting band 400 N·cm (35 lbf·in). For complete installation instructions, refer to **Group 09**.
9. Lower the hood, and test drive the vehicle.

Transmission Throttle Valve Cable Replacement, Checking and Adjustment

Removal

1. Park the vehicle, shut down the engine, and set the parking brakes. Tilt the hood.
2. To access the throttle body, remove the air cleaner housing. **See Fig. 1.** For complete removal instructions, refer to **Group 09**.

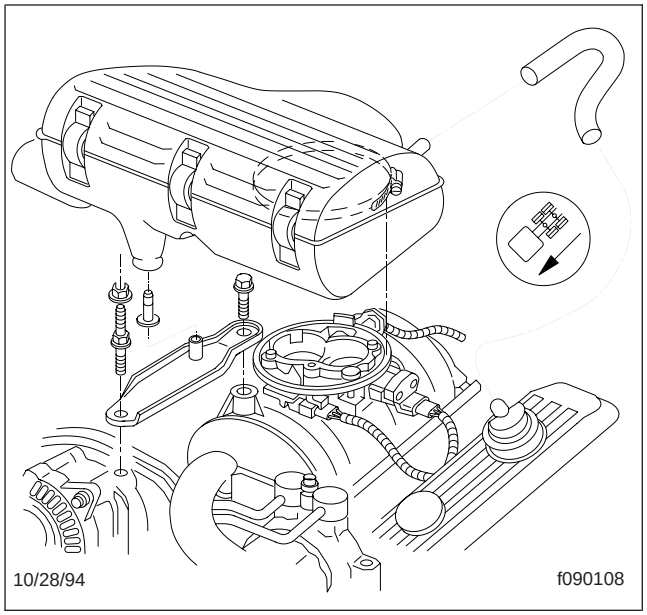
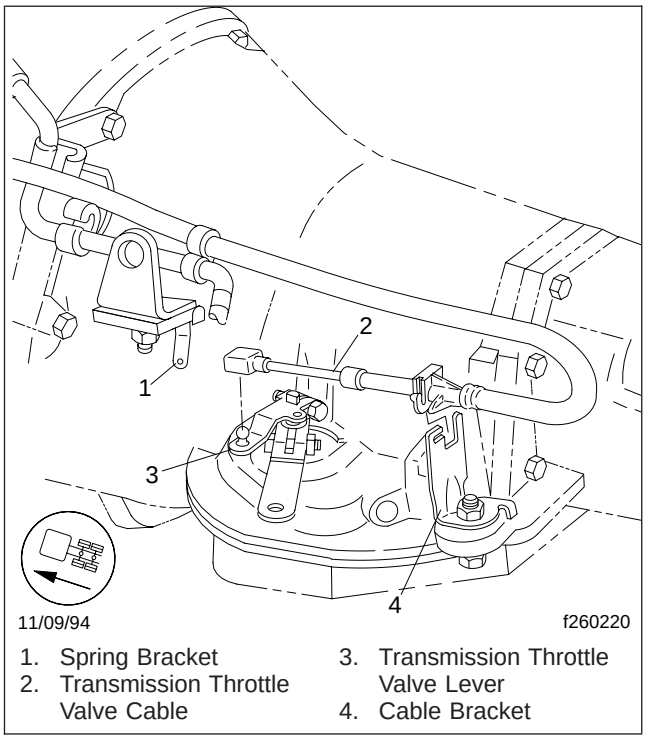


Fig. 1, Air Cleaner Removal, V-8 Engine

3. Pull the transmission end of the transmission throttle valve cable straight up and off the stud on the throttle valve lever. **See Fig. 2.**
4. Rotate the cable housing out of the cable bracket on the transmission.
5. Loosen the clamps that route the cable from the transmission to the engine.
6. Pull the engine end of the transmission throttle valve cable slightly forward until it snaps off the stud on the throttle body cam. **See Fig. 3.**
7. At the throttle body, pinch the tabs on the sides of the plastic cable housing retainer, and pull the cable backwards out of the throttle body mounting bracket. **See Fig. 4.**
8. Pull the cable and cable housing free of the vehicle.



1. Spring Bracket
2. Transmission Throttle Valve Cable
3. Transmission Throttle Valve Lever
4. Cable Bracket

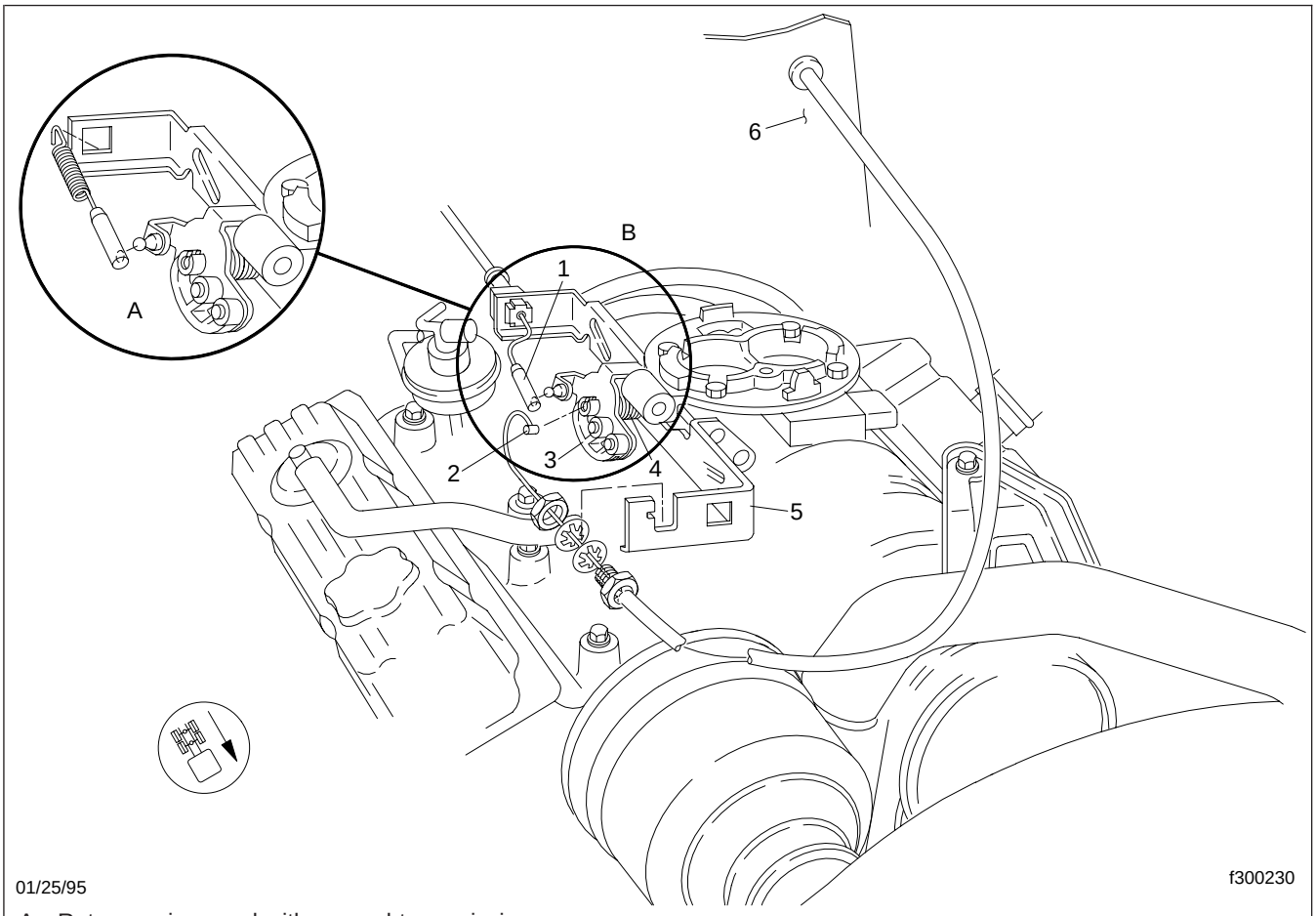
Fig. 2, Transmission Throttle Valve Cable Installation at the Transmission

9. To install the transmission throttle valve cable, at the throttle body, pinch the tabs on the sides of the plastic cable housing retainer, and push the cable forward through the hole in the throttle body mounting bracket. **See Fig. 3.** Release the tabs and let the retainer lock the cable housing into the mounting bracket.
10. Route the cable through the clamps to the transmission, and attach the cable to the transmission throttle valve lever.
11. Make sure the transmission throttle valve lever return spring is attached. The transmission will not shift correctly if the return spring is not attached. **See Fig. 5.**
12. Use the following procedures to check and adjust the transmission throttle valve cable.

Checking

1. If not already done, park the vehicle, shut down the engine, and set the parking brakes. Tilt the hood.

Transmission Throttle Valve Cable Replacement, Checking and Adjustment



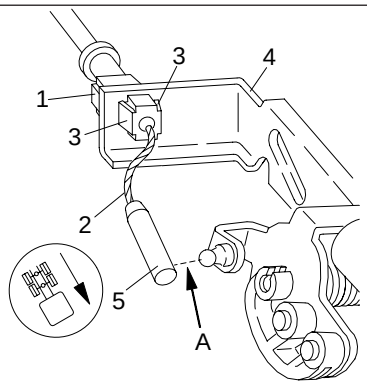
A. Return spring used with manual transmission.
B. Transmission throttle valve cable used with automatic transmission.

1. Transmission Throttle Valve Cable
2. Throttle Cable
3. Throttle Body Cam
4. Throttle Pedal Return Spring
5. Throttle Body Mounting Bracket
6. Firewall

Fig. 3, Transmission Throttle Valve Cable Installation at the Engine, V-8 Engine

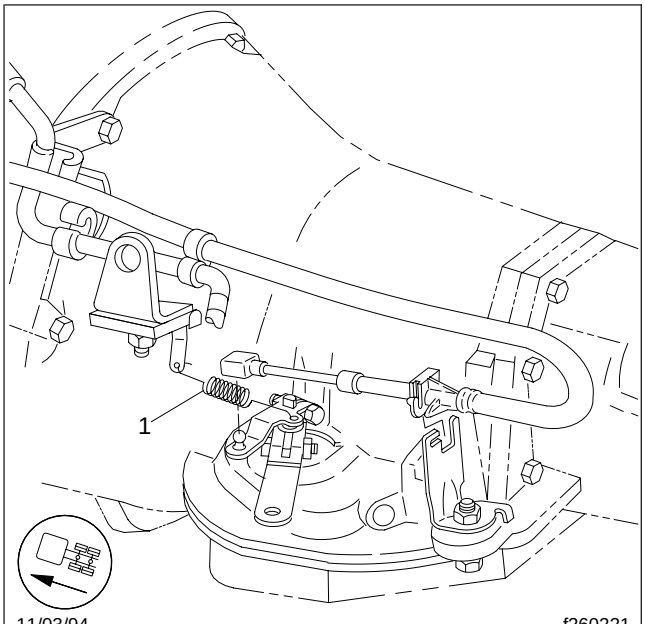
2. To access the throttle body, remove the air cleaner housing. **See Fig. 1.** For complete removal instructions, refer to **Group 09**.
3. Make sure the throttle body cam and the transmission throttle control valve lever are both in the idle position.
4. If not already disconnected, pull the engine end of the transmission throttle valve cable slightly forward until it snaps off the stud on the throttle body cam. **See Fig. 3.**
5. Compare the position of the cable end and the attachment stud. **See Fig. 4.** The cable end and the stud must be aligned within 1 mm in either direction.
6. If the cable end and the cam stud are not aligned, the cable will have to be adjusted. Go to the adjustment procedure that follows.
7. With an assistant, watch the movement of the transmission throttle lever and the throttle body cam. If the lever and the cam move simultaneously from idle to half-throttle and back to idle,

Transmission Throttle Valve Cable Replacement, Checking and Adjustment



A. To adjust the cable, align the cable and stud to within 1 mm of center.
1. Cable Lock Button
2. Transmission Throttle Control Valve Cable (Engine End)
3. Cable Housing Retainer Tabs
4. Throttle Body Mounting Bracket.
5. Throttle Body Cam Stud

Fig. 4, Transmission Throttle Valve Cable Adjustment, V-8 Engine



1. Transmission Throttle Control Valve Lever Return Spring

Fig. 5, Return Spring Installation

the cable adjustment is correct. If the transmission lever moves ahead of or lags behind the throttle body cam, adjust the cable. If the throttle body cam prevents the transmission lever from returning to the closed position, adjust the cable. Refer to the cable adjustment procedure that follows.

8. If the alignment is correct and the transmission lever and throttle cam move simultaneously, connect the engine end of the cable to the stud on the throttle body cam. Go to the last three steps in the Adjustment procedure.

Adjustment

1. If not already done, park the vehicle, shut down the engine, and set the parking brakes. Tilt the hood.
2. To access the throttle body, remove the air cleaner housing. **See Fig. 1.** For complete removal instructions, refer to **Group 09**.
3. Disconnect the cable end from the stud on the throttle body cam.
4. Make sure the transmission throttle control valve lever is in the fully closed position. Then, make sure the throttle body cam is in the idle position.
5. Find the cable lock button. **See Fig. 4.** The button is part of the cable retainer at the engine end of the cable.
6. Press the cable lock button to release the cable. The button only has to move about 2 mm to release the cable.

   Center the cable end on the attachment stud to within 1 mm and release the cable lock button.
7. Attach the cable end to the throttle body cam, and check that the transmission throttle control valve lever and the throttle body cam move simultaneously as described in the checking procedure, above.
8. Make sure all cable routing clamps are tight, and that the cable is securely connected to the transmission throttle control valve lever and the throttle body cam.
9. Install the air cleaner housing and tighten the mounting band 400 N·cm (35 lbf·in). For complete installation instructions, refer to **Group 09**.
10. Lower the hood, and test drive the vehicle.

General Information

IMPORTANT: This service manual *does not cover* the procedures and calculations necessary to perform frame modifications. For basic information, see the *Freightliner Body Builder's Manual*; for more extensive frame modifications, be sure to consult with the Freightliner Engineering Department.

The main body of the frame is two non-heat-treated steel frame rails secured together by crossmembers. See **Fig. 1**. The frame assembly is supported on the front and rear axles, and supports the rest of the chassis and body.

Both frame rails have identical specifications. Each has an upper flange, lower flange, and web (the surface area between the flanges). The inside area of the frame rail is called the channel. See **Fig. 2**.

Crossmembers control axial rotation and longitudinal motion of the rails, and reduce torsional stress transmitted from one rail to the other. Crossmembers are also used for vehicle component mounting, and for protection of the wires and tubing that are routed from one side of the vehicle to the other.

FRAME STATIONS

A frame station is a reference point along each frame rail from which the location of each component

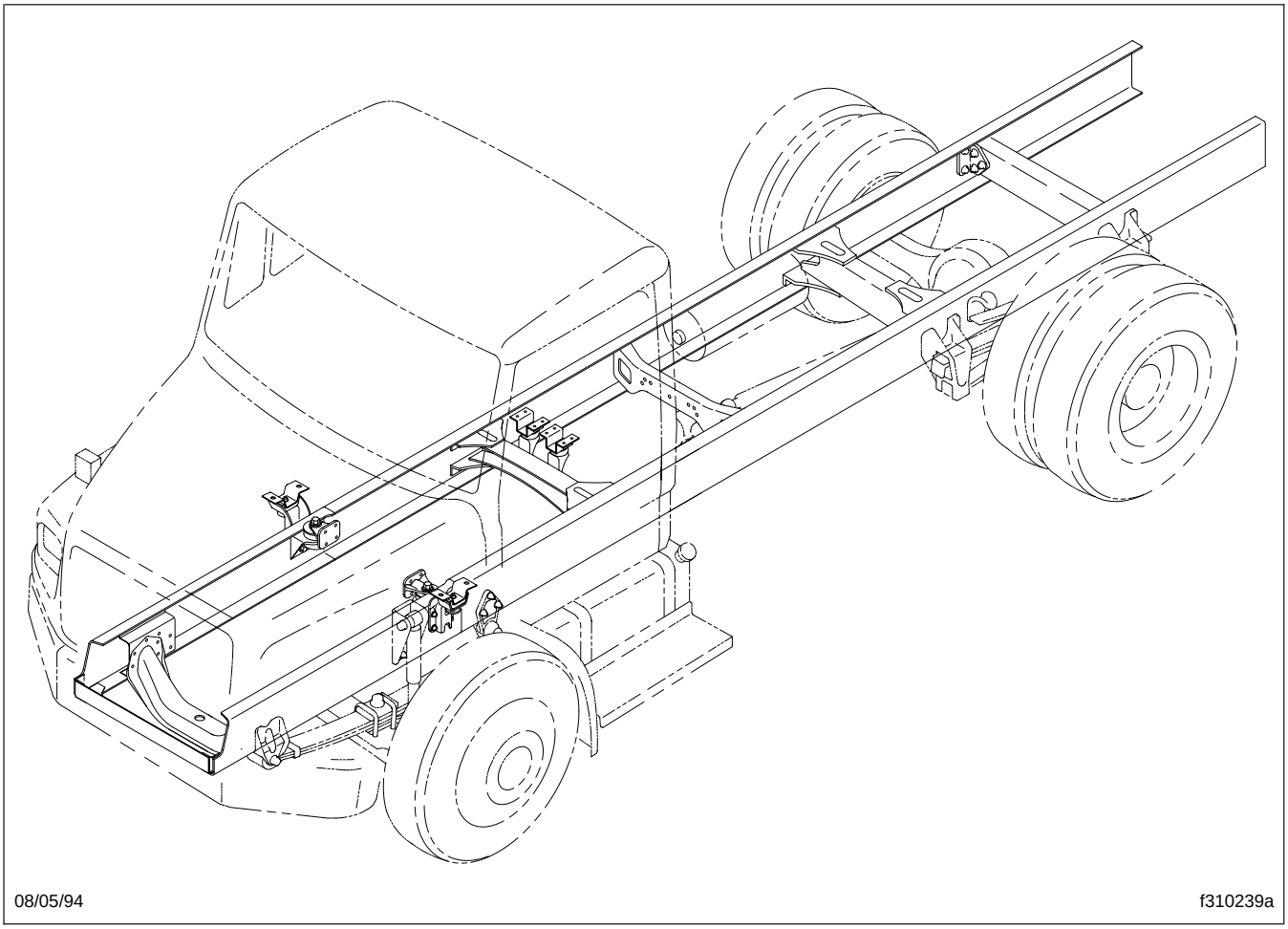
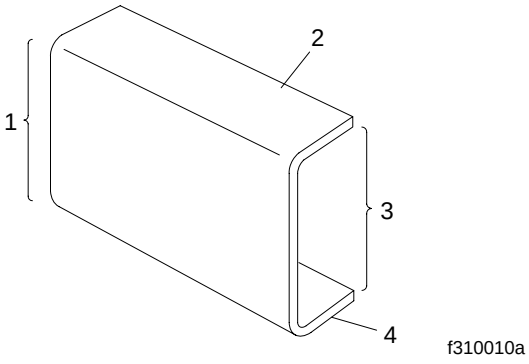


Fig. 1, Frame Assembly

(mounted on that frame rail) is measured. There are

General Information



1. Web
2. Upper Flange
3. Channel
4. Lower Flange

Fig. 2, Frame Terminology

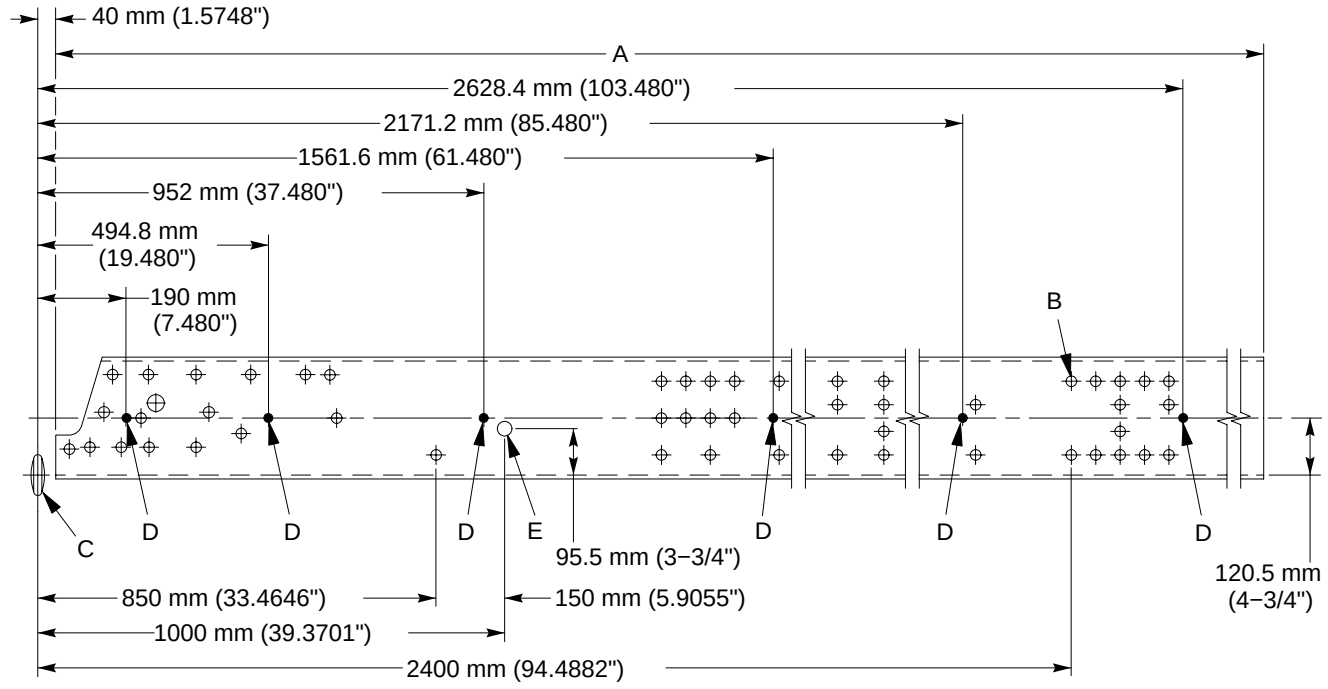
two frame stations along the frame rails: station zero and station 1000. See **Fig. 3**.

There is no identifying mark for station zero; it is located 40 mm (about 1.6 inches) forward of the forward end of the frame rail, and 290 mm (about 11.4 inches) forward of the centerline of the front suspension's forward spring pin. Station 1000 is located 1000 mm (about 39.4 inches) to the rear of station zero, and is directly above the centerline of the front axle.

Station 1000 is used when station zero is not accessible because of vehicle assembly. Station 1000 is identified by a 27 mm (1-1/16 inch) diameter hole near the bottom third of the frame rail web. A bulkhead fitting for the air or hydraulic brake lines is installed in the hole.

The vehicle's frame drilling chart lists the location of each frame rail component. For example: if a component is given a location of 850, then that component is installed on the frame rail 850 mm (33-15/32 inches) aft of station zero, or 150 mm (5-29/32 inches) forward of station 1000.

In addition to frame stations zero and 1000, each frame rail has six manufacturing holes along the centerline of the frame rail web. All six holes are 16-mm (5/8-inch) diameter. See **Fig. 3**. These holes can be used for location and measurement in the same manner as the hole at frame station 1000.



NOTE: Left-hand frame rail shown; Right-hand is symmetrical.

A. Frame Length ± 5 mm (± 0.197")
B. Component Mounting Hole
C. Frame Station Zero
D. 16 mm (5/8") Diameter Manufacturing Holes (6)
E. 27 mm (1-1/16") Diameter Hole at Frame Station 1000

Fig. 3, Frame Stations

General Handling

Whenever the frame rails are lifted or moved, take care to avoid anything that may scratch, cut, or damage the exposed frame assembly. Cushion all chain hoists or cable slings with a section of heavy hose. If the frame rail is raised with a jack, place a block of wood between the jack and the frame rail.

Never heat the frame rails for straightening purposes; such work should be done cold.

⚠ CAUTION

CAUTION: Heating the frame rail for straightening purposes will reduce the strength of the rail in localized areas, which can result in structural failure of the frame rail.

Use pencil lines or soapstone marking for any work that requires marking of the frame rail. High visibility can be obtained by first chalking the surface of the frame rail, then making the pencil marks.

⚠ CAUTION

CAUTION: Before performing any electric welding on a vehicle, disconnect the battery power and ground cables and any electronic control units (ECUs) installed on the vehicle. Electric currents produced during electric welding can damage various electrical components on the vehicle, such as alternator diodes and ECUs.

Freightliner vehicle components that typically use ECUs include electronic engine, electronic automatic transmission, and ABS (antilock braking system).

For any ECU with a battery power harness, disconnect its ground terminal from the chassis ground, and disconnect its power terminal from the battery positive post. Or else disconnect the main connection at the ECU.

Apply Alumilastic® Compound or a paintable, air-cured synthetic rubber or moisture-cured polyurethane, flexible weather-sealant between any dissimilar metal surfaces that contact each other (except nuts, bolts, and zinc or cadmium plated washers), regardless of whether the surfaces are primed or painted.

Repairing Cracks, Filling Unused Holes, and Drilling Holes

Repairing Cracks

IMPORTANT: In most cases cracked or damaged frame rails should be replaced. In some cases it may be necessary to repair minor damage; before attempting any repairs, contact your regional service representative for approval.

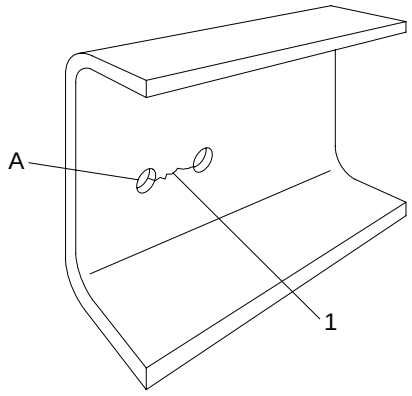
CAUTION

Before performing any electric welding on a vehicle, disconnect the battery power and ground cables and any electronic control units (ECUs) installed on the vehicle. Electric currents produced during electric welding can damage various electrical components on the vehicle, such as alternator diodes and ECUs.

Vehicle components that typically use ECUs include electronic engine, electronic automatic transmission, and ABS (antilock braking system).

For any ECU with a battery power harness, disconnect its ground terminal from the chassis ground, and disconnect its power terminal from the battery positive post, or disconnect the main connection at the ECU.

1. Drill a 1/8-inch (3-mm) diameter hole at each end of the crack to prevent it from spreading further. See **Fig. 1**.

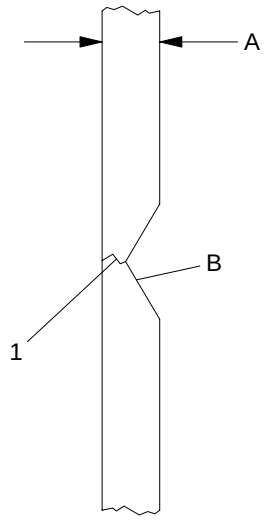


09/19/2003 f310012c

A. 1/8-inch (3-mm) Diameter Hole
1. Crack

Fig. 1, Preventing Cracks from Spreading

2. Vee out the crack to a depth of two thirds of the stock thickness. See **Fig. 2**.



08/14/95 f310013a

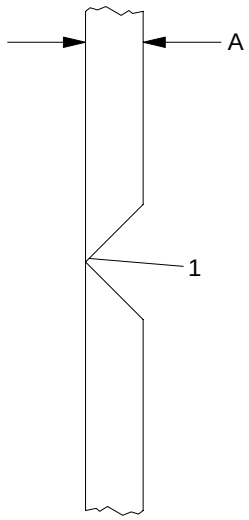
A. Frame Rail Thickness
B. Grind a vee groove two thirds the depth of the stock thickness.
1. Crack

Fig. 2, Cross-Section View

NOTE: If it will not be possible to grind both sides of the frame rail, then grind the vee groove on one side to the full depth of the stock thickness. See **Fig. 3**.

3. Clamp a copper or aluminum bar on the opposite side of the groove. The bar will act as a "chill" strip, keeping the heat from spreading to the surrounding area of the frame rail. See **Fig. 4**. Deposit the weld material using the applicable welding method described in this section.
4. Grind the weld flush with the frame rail. See **Fig. 5**.
5. Cut a deep enough vee groove on the opposite side of the frame rail to reach the weld metal. See **Fig. 6**.
6. Clamp the "chill" strip on the opposite side of the groove. See **Fig. 7**. Weld the vee groove, as instructed above. Make full penetration of the weld.
7. Grind the weld flush with the frame rail. See **Fig. 8**.

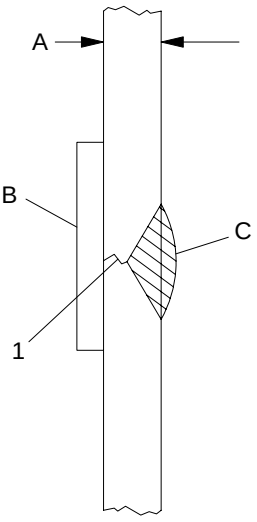
Repairing Cracks, Filling Unused Holes, and Drilling Holes



08/14/95 f310014a

A. Frame Rail Thickness
1. Vee Groove (Full Depth)

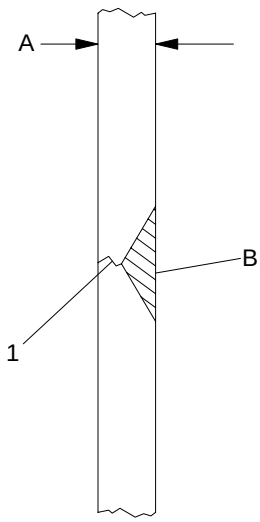
Fig. 3, Full Depth Groove



08/14/95 f310015a

A. Frame Rail Thickness
B. Clamp the "chill" strip on opposite side of groove.
C. Deposit weld material.
1. Crack

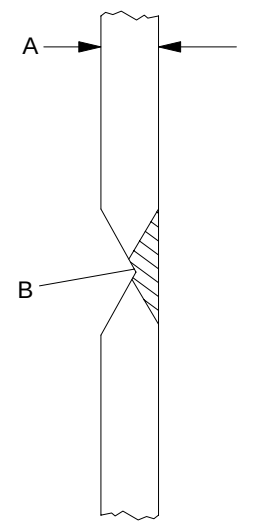
Fig. 4, Using a Chill Strip



08/15/95 f310016a

A. Frame Rail Thickness
B. Grind the weld flush with frame rail.
1. Crack

Fig. 5, Weld Ground Flush

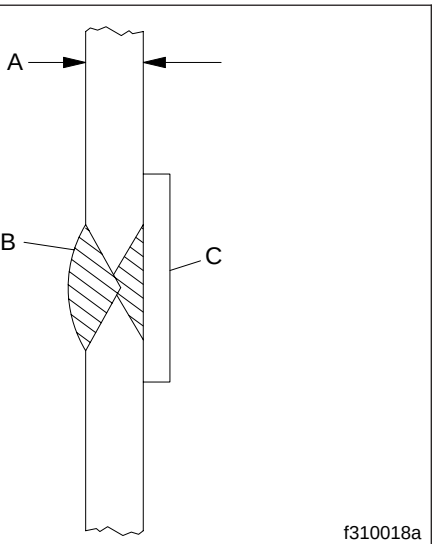


08/15/95 f310017a

A. Frame Rail Thickness
B. Grind the vee groove deep enough to reach the weld.

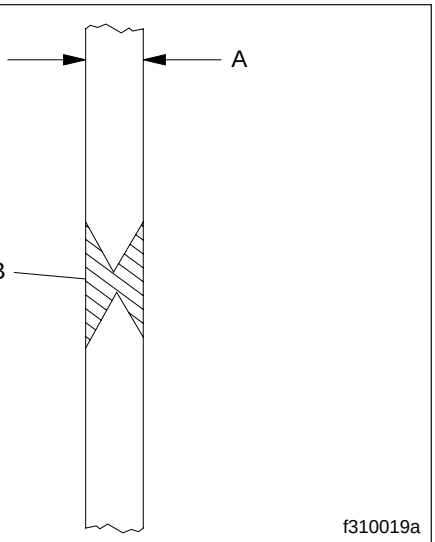
Fig. 6, Cross-Section View

Repairing Cracks, Filling Unused Holes, and Drilling Holes



A. Frame Rail Thickness
B. Deposit weld material to penetrate opposite weld.
C. Clamp the "chill" strip on opposite side of groove.

Fig. 7, Second Weld



A. Frame Rail Thickness
B. Grind the weld flush with the frame rail.

Fig. 8, Second Weld Ground Flush

Filling Unused Holes

1. Fill all unused holes in the frame assembly with the applicable nut, washer, and bolt combination.
2. If the diameter of a hole is less than 3/8 inch (9.5 mm), enlarge it to 3/8 inch (9.5 mm), and fill it with the applicable nut, washer, and bolt combination.
3. Tighten the fasteners to the applicable torque value. For proper frame fastening instructions, refer elsewhere in this group.

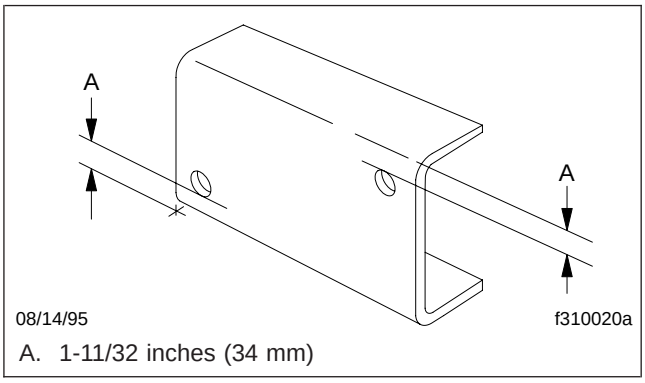
Drilling Holes

During vehicle manufacture, holes are drilled or punched in the frame rail only as specified on the vehicle frame drilling chart. If any additional holes need to be drilled, contact your regional service representative for approval.

A single exception to this rule is that holes may be drilled for tubing clips and the like through the web portion of the channel only, with the following restrictions:

- The *edge* (not the center) of the hole must be no closer than 1-11/32 inches (34 mm) from the outer face of the flange. See **Fig. 9** for the minimum distance to the flanges that holes can be placed on the web.
- Material between the centerline of the hole and the outside of the upper or lower flange must be at least 2-13/32 inches (60 mm).
- Minimum material between hole centerlines must be 2 inches (50 mm).
- All attaching fasteners must be Grade 8. Flat washers must be made with high strength steel.
- The minimum material between the rear suspension bracket and the end of the frame must be at least 2 inches (50 mm).
- Holes between the front axle centerline and the rear axle centerline cannot exceed 3/4 inches (19 mm).

Repairing Cracks, Filling Unused Holes, and Drilling Holes



A. 1-11/32 inches (34 mm)

Fig. 9, Minimum Distance for Drilling Holes

Frame Fasteners

Either Huckbolts® or grade 8 hexhead bolts and grade C prevailing torque locknuts are used for frame attachments. **See Fig. 1 and Fig. 2**. For attachments where clearance is minimal, low-profile hexhead bolts and grade C prevailing torque locknuts are used. For some components, grade 8.2 flanged hexhead bolts and grade G prevailing torque locknuts are used for frame attachments. **See Fig. 3** . Prevailing torque locknuts of all three bolt types have distorted sections of threads to provide torque retention.

When nonflanged hexhead bolts and locknuts are used on an attached aluminum part, a hardened flatwasher is required to prevent the bolt head or nut from embedding in the part. In general, hardened washers are used to distribute the load, and to prevent localized overstressing of the frame rails, brackets, and other parts. They are placed directly against the part, under the nut or bolt head. These special hardened washers are used on frame rails, and for the engine rear supports, rear suspension brackets, and fifth wheel mountings. They are cadmium-or zinc-plated, and have a hardness rating of 38 to 45 HRC.

Flanged hexhead bolts and locknuts have integral flanges which eliminate the need for washers on steel and aluminum surfaces. The fasteners are placed directly against the frame where the part is attached.

HEXHEAD BOLT REPLACEMENT

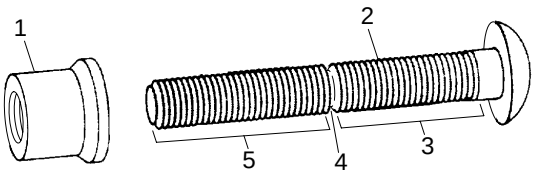
Replace hexhead bolts and locknuts with identical fasteners. Refer to the Freightliner *Parts Book* for fastener specifications.

Apply Alumilastic® compound, or an equivalent, to all bolts, nuts, and washers that contact aluminum parts.

CAUTION

CAUTION: Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the frame or parts.

Never hammer or screw bolts into place. Align the holes of the frame and the part being attached to it, so that the nut and bolt surfaces are flush against the frame and the part. For bolts 4 inches (102 mm) or less in length, make sure that at least 1-1/2 threads and no more than 5/8-inch (16 mm) bolt length extend through the self-locking nut after it has been tightened. For bolts longer than four inches (102 mm), allow a minimum of 3 threads and a maximum of 3/4-inch (19 mm) bolt length.



04/23/93 f230018

1. Collar
2. Huckbolt
3. Locking Grooves
4. Breakneck
5. Pulling Grooves

Fig. 1, Huckbolt Fastener

HUCKBOLT REMOVAL

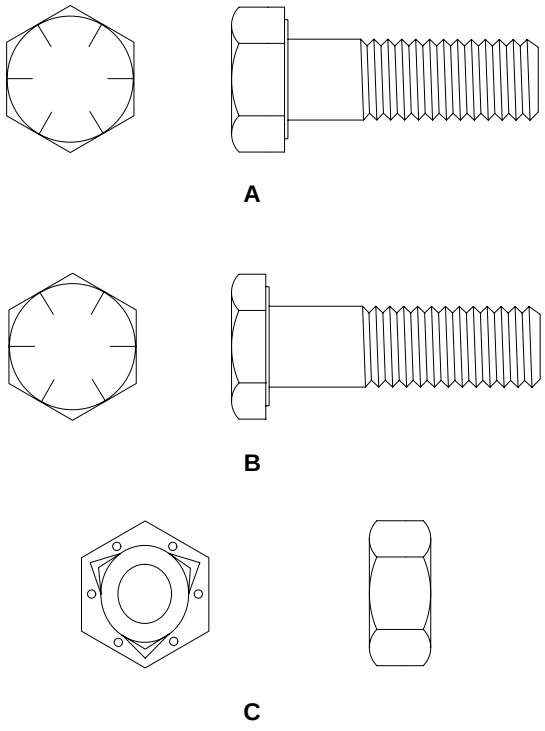
Huckbolt HP 8® frame fasteners **(see Fig. 1)**have parallel locking grooves on the lockbolt pintail. The swaged collar cannot be unscrewed. Use the Huck Collar Cutter to remove HP8 fasteners. If the Collar Cutter isn't available, split the collar with an air chisel while supporting the opposite side of the collar with an anvil. **Refer to Fig. 4**. Then, drive out the lockbolt with a punch. Discard the fastener after removing it.

HUCK-FIT® frame fasteners have locking threads instead of grooves; the collar can be removed using a standard impact wrench and sockets. Discard the fastener after removing it.

CAUTION

CAUTION: Never attempt to reuse any Huck fastener that has been removed. Even though HUCK-FIT fasteners can be removed with a socket wrench, they cannot be correctly installed again. Reusing any Huck frame fastener can result in damage to the vehicle frame or components attached to the frame.

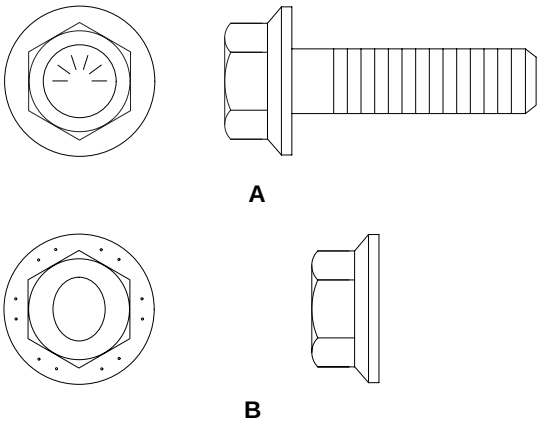
Frame Fasteners



10/19/93 f310006

A. Grade 8 Hexbolt
B. Grade 8 Low-Profile Hexbolt
C. Grade C Prevailing Torque Locknut

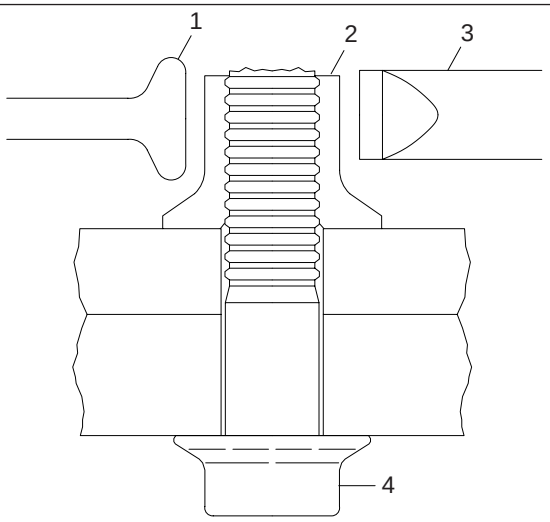
Fig. 2, Hexhead Fasteners



02/22/93 f310007

A. Grade 8.2 Flanged Bolt
B. Grade G Prevailing Torque Locknut

Fig. 3, Flanged Hexhead Fasteners



02/21/94 f310081a

1. Anvil
2. Lockbolt Collar
3. Chisel
4. Lockbolt

Fig. 4, Huckbolt Removal

HUCKBOLT INSTALLATION

NOTE: Huckbolts cannot be installed without the proper Huckbolt installation equipment.

1. Insert the pintail through the prepared hole in the frame or other component. **Refer to Fig. 5**.
2. Place the collar over the pintail.
3. Place the Huck installation tool nose assembly over the pintail. **Refer to Fig. 6**. The pintail pulling grooves ratchet into the chuck jaws, which securely grip the pintail.
4. As the installation tool trigger is pulled, the tool piston and chuck jaws move rearward, pulling on the pintail, seating the bolt head, and closing the gap between the work surfaces. As pulling on the pintail continues, the collar is swaged into the locking grooves on the pintail; and the collar is lengthened, developing clamping force. **Refer to Fig. 7**.
5. The pintail breaks (**see Fig. 8**), freeing the nose assembly anvil from the swaged collar.

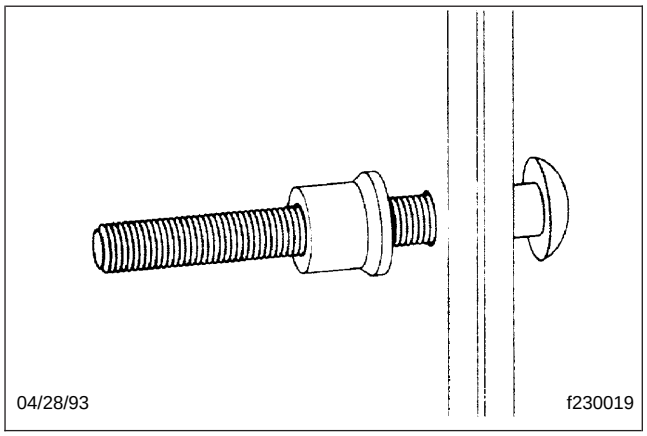


Fig. 5

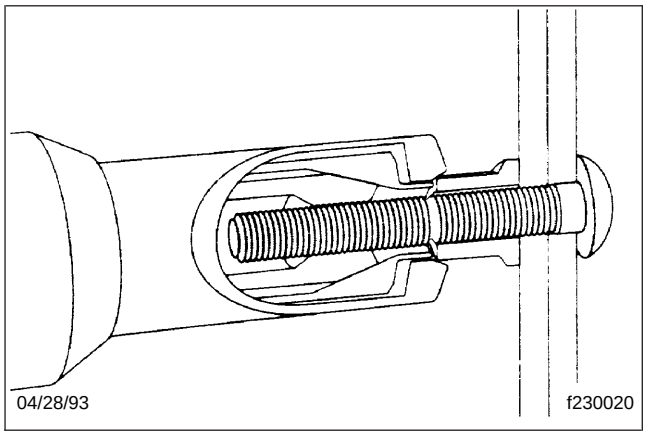


Fig. 6

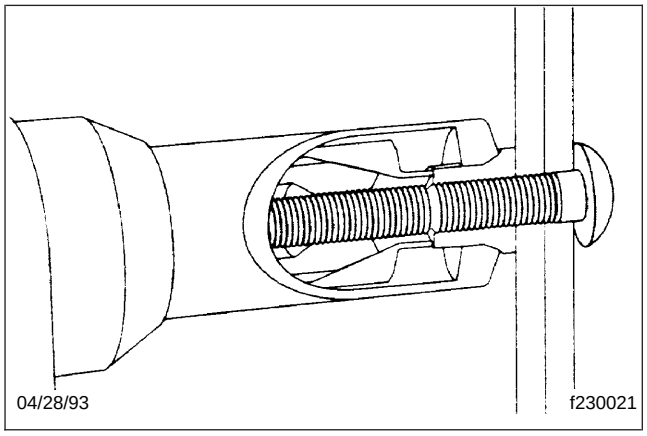


Fig. 7

NOTE: Most Huck fasteners have a constriction, the breakneck (Fig. 1), which determines the point where the pintail breaks free. MAGNA-GRIP® fasteners do not have this breakneck; the pintail should break flush with the top of the collar. No more than two grooves should be visible on the collar after installation. **Refer to Fig. 9** for examples of acceptable and unacceptable MAGNA-GRIP pintail breaks.

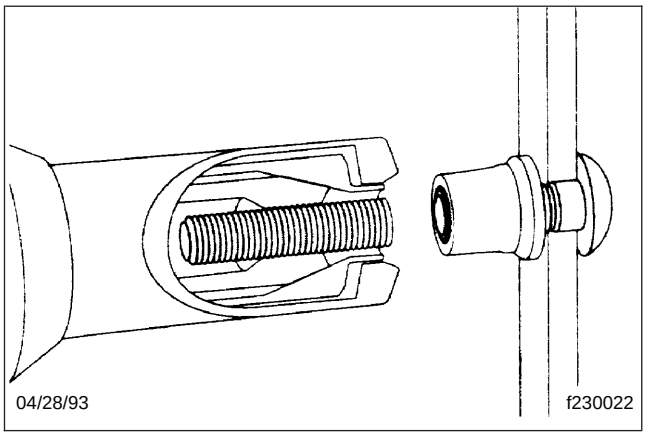


Fig. 8

FRAME FASTENER TIGHTENING

⚠ CAUTION

CAUTION: Continued vehicle operation with loose fasteners could result in component, bracket, and frame damage.

Tighten hexhead bolts and locknuts periodically to offset the effects of "bedding in" (seating). Refer to the Maintenance Schedule and the frame section in the vehicle maintenance manual for intervals.

When tightening the fasteners, tighten the nut, not the bolt head. This will give a true torque reading by eliminating bolt body friction. For torque specifications, refer to the general information section in the vehicle maintenance manual.

NOTE: Huck fasteners do not require periodic tightening.

Frame Fasteners

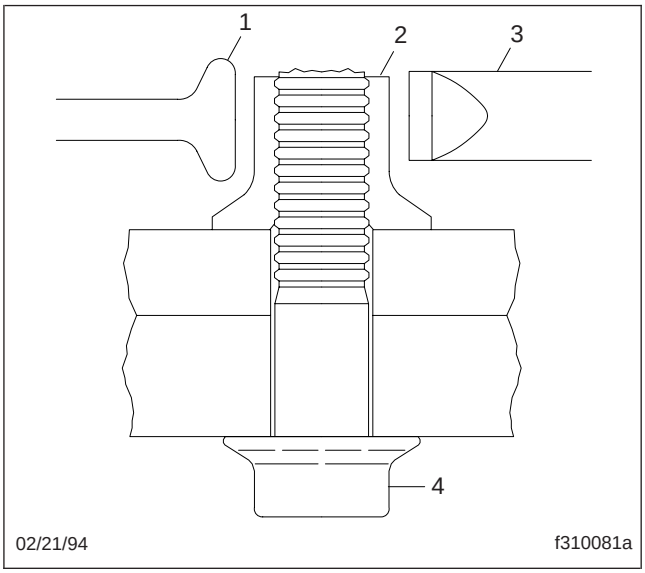


Fig. 9

Crossmember Removal and Installation

Removal

The placement of crossmembers affects the overall stability of the frame. If a crossmember is being eliminated, added, or relocated, Freightliner dealers must contact their Regional Service Office for instructions and approval. All others must contact a Freightliner dealership, which will contact the Regional Service Office for approval.

IMPORTANT: Before removing any crossmember, note the direction, size, and type, of all fasteners that attach the crossmember to the frame rail, and that attach other parts to the crossmember. Also note which direction the open channel of the crossmember is facing, for installation reference.

NOTE: If a 5-piece (welded) crossmember (**Fig. 1**) must be removed, it must be cut in two, removed, then replaced with a 5-piece crossmember having upper and lower gussets that bolt in place (**Fig. 2**).

5-PIECE (WELDED) CROSSMEMBER (Removal for replacement with a 5-piece bolted crossmember) **(See Fig. 1)**

1. Apply the parking brakes, then chock the tires on both the front and rear axles.
2. If any air brake valve is attached to the crossmember, drain the air reservoirs, then remove the valve(s) from the crossmember.

   Remove any clamps that attach air lines or wiring to the crossmember. Secure the lines or wires away from the crossmember.
3. If the back-of-cab crossmember is being removed, support the cab (at its normal ride height), the fuel tank(s), and the cab-access steps, as applicable. Remove the fasteners that attach the rear cab support brackets to the crossmember. See **Fig. 3**.
4. If rear suspension brackets are attached to the frame rails with the same fasteners that attach the crossmember, support the rear of the frame at its normal ride height, using safety stands.
5. Using a cutting torch, cut the crossmember channel in two. A 76 mm (3-inch) cut will make removal easier.
6. Remove the fasteners that attach the crossmember halves to the frame rails, and remove the crossmember.

REAR-CLOSING CROSSMEMBER **(See Fig. 4)**

1. Apply the parking brakes, then chock the tires on both the front and rear axles.
2. If so equipped, remove the backup alarm from the crossmember.

   If any air brake valve is attached to the crossmember, drain the air reservoirs, then remove the valve(s) from the crossmember.

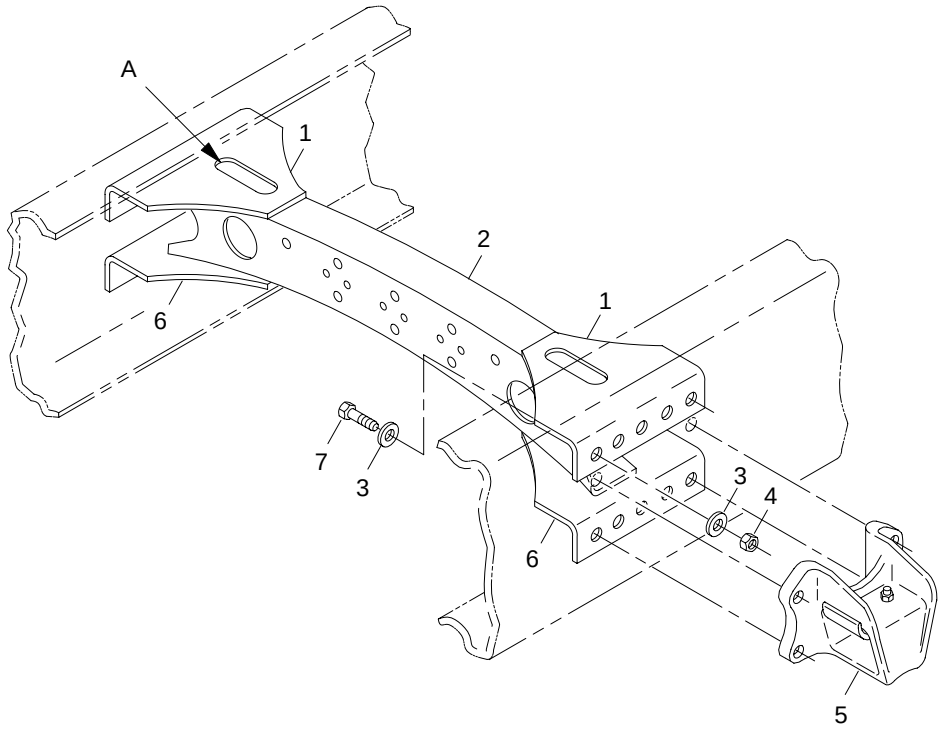
   Remove any clamps that attach air lines or wiring to the crossmember.

   If the leveling valve for an AirLiner suspension is attached to the crossmember, remove the valve. For instructions, refer to **Group 32** in this manual.
3. Remove the fasteners that attach the crossmember to the front angle brackets.
4. If rear suspension brackets are attached to the frame rails with the same fasteners that attach the angle brackets, support the rear of the frame at its normal ride height, using safety stands.
5. Remove the fasteners that attach the rear angle brackets to each frame rail; then remove, as an assembly, the rear brackets and the crossmember.
6. If needed, remove the front angle brackets and their fasteners. If applicable, after removing the fasteners, remove the rear suspension brackets from the springs.

SPLAYED CROSSMEMBER **(See Fig. 5)**

1. Apply the parking brakes, then chock the tires.
2. If removing a midship bearing crossmember, support the driveline on a safety stand, then remove the fasteners that attach the midship bearing bracket to the crossmember.
3. Unbolt the crossmember from both frame rails.

Crossmember Removal and Installation



A. Welded (typical at all 4 gussets)
1. Upper Gusset
2. Channel
3. Hardened Steel Flatwasher
4. 5/8–11 Locknut
5. Rear Suspension Bracket
6. Lower Gusset
7. 5/8–11 Grade 8 Bolt

Fig. 1, Welded 5-Piece Crossmember Assembly

4. At one end of the crossmember, use a deadblow hammer to tap against its curved side (the closed side of the channel), until the crossmember is no longer wedged in the frame. Remove the crossmember.

Overslung Crossmember (See Fig. 6)

1. Apply the parking brakes, then chock the tires on both the front and rear axles.
2. Remove the half-fender from the left side of the vehicle.
3. Provide support underneath both fuel tanks.
4. From underneath the chassis, remove the two 5/8–11 fasteners that attach each side of the crossmember to its mounting brackets.
5. Remove the overslung crossmember by rotating it down and outward on the left side of the vehicle.

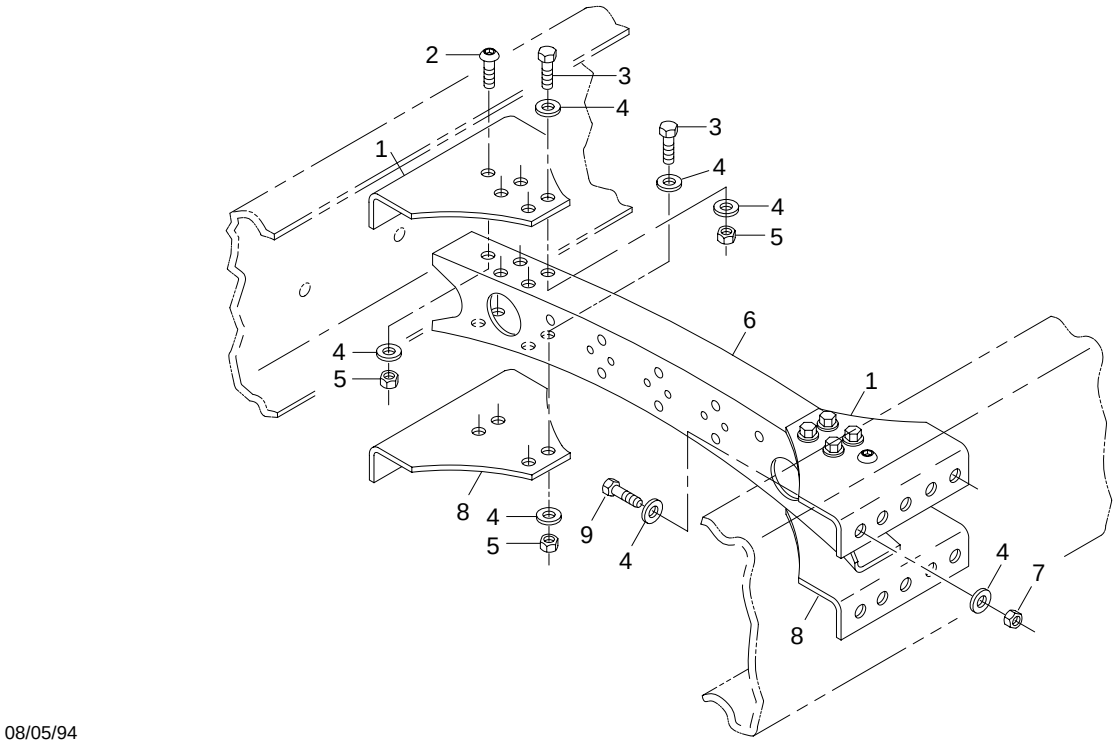
Installation

5-PIECE (BOLTED) CROSSMEMBER (Installation for replacement of a 5-piece welded crossmember)

(See Fig. 2)

1. Attach one upper gusset to the crossmember channel; tighten the fasteners snug, but not to their final torque value.
2. Install the crossmember channel and gusset in the frame rails with its open channel facing the same direction that was noted during removal.

Crossmember Removal and Installation



1. Upper Gusset
2. 1/2–13 Button-Head Capscrew
3. 1/2–13 Grade 8 Hexbolt
4. Hardened Steel Flatwasher
5. 1/2–13 Locknut
6. Crossmember Channel
7. 5/8–11 Locknut
8. Lower Gusset
9. 5/8–11 Grade 8 Hexbolt

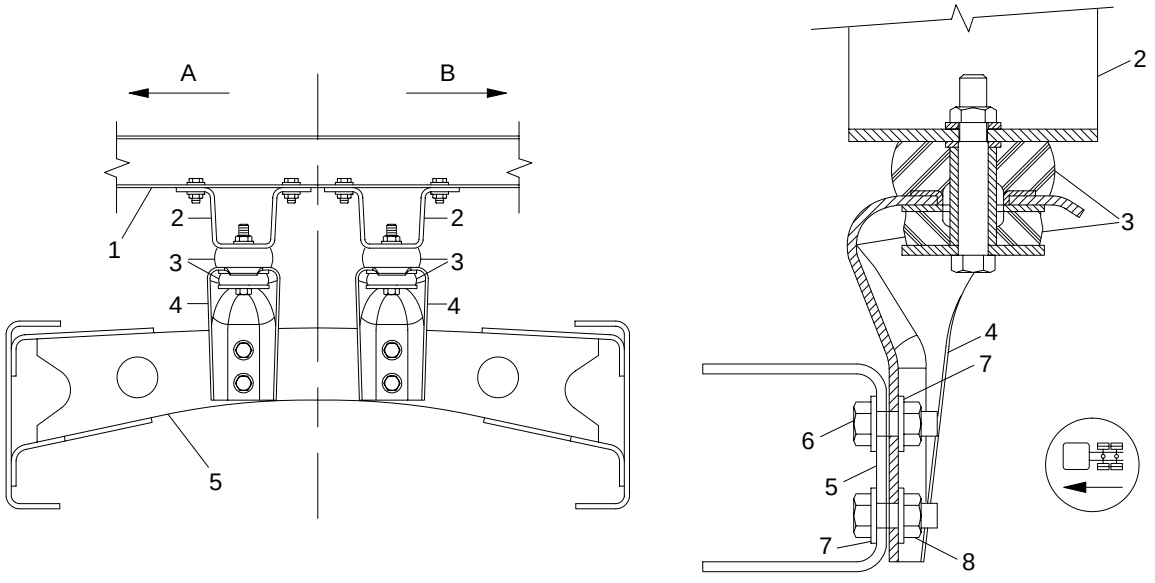
Fig. 2, Bolted 5-Piece Crossmember Assembly

Position the crossmember so its channel is supported on the lower flanges of both frame rails.

3. Attach the other upper gusset to the crossmember channel; tighten the fasteners snug, but not to their final torque value.
4. Tighten the locknuts on the button-head capscrews at the outboard end of both upper gussets 92 N·m (68 lbf·ft).
5. Using a deadblow hammer, tap the crossmember up into place. Align the mounting holes of the upper gussets with the holes in the frame rails. Install the fasteners, but don't tighten them.
6. Install the lower gussets on the crossmember channel, but don't tighten the fasteners at this time. Install the fasteners that attach the lower gussets to the frame rails.
7. Tighten the fasteners that attach the gussets to the frame rails 184 N·m (136 lbf·ft). Then, tighten the fasteners that attach the gussets to the crossmember channel 92 N·m (68 lbf·ft).
8. If any air brake valve was attached to the crossmember, install the valve(s) on the crossmember.

   Install any clamps that attach air lines or wiring to the crossmember.
9. If the back-of-cab crossmember was replaced, install the fasteners that attach the rear cab support brackets to the crossmember. See **Fig. 3**. Tighten the cab support bracket fasteners 92 N·m (68 lbf·ft). Remove the supports from under the cab, fuel tanks, and cab-access steps.
10. Remove the chocks.

Crossmember Removal and Installation



A. Left Side
B. Right Side

1. Back-of-Cab Reinforcement
2. Cab Mounting Bracket
3. Isolators
4. Cab Support Bracket
5. Back of Cab Crossmember
6. 1/2–13 Grade 8 Bolt
7. Hardened Steel Flatwasher
8. 1/2–13 Locknut

Fig. 3, Remove the Rear Cab Support Bracket Fasteners

REAR-CLOSING CROSSMEMBER

(See Fig. 4)

1. If they were removed, install the front angle brackets and their fasteners, but don't tighten the fasteners at this time. If applicable, install the rear suspension brackets on the springs.
2. Slide the crossmember into the opening at the rear of the frame rails, then turn it upright, to position it against the front angle brackets.
3. Attach the rear angle brackets to the frame rails, but don't tighten the fasteners at this time.
4. Install but do not tighten the fasteners that attach the crossmember to the front angle brackets.
5. If they were removed from the rear-closing crossmember, install any air brake valves, and securely tighten the fasteners.

   If so equipped, install the backup alarm.

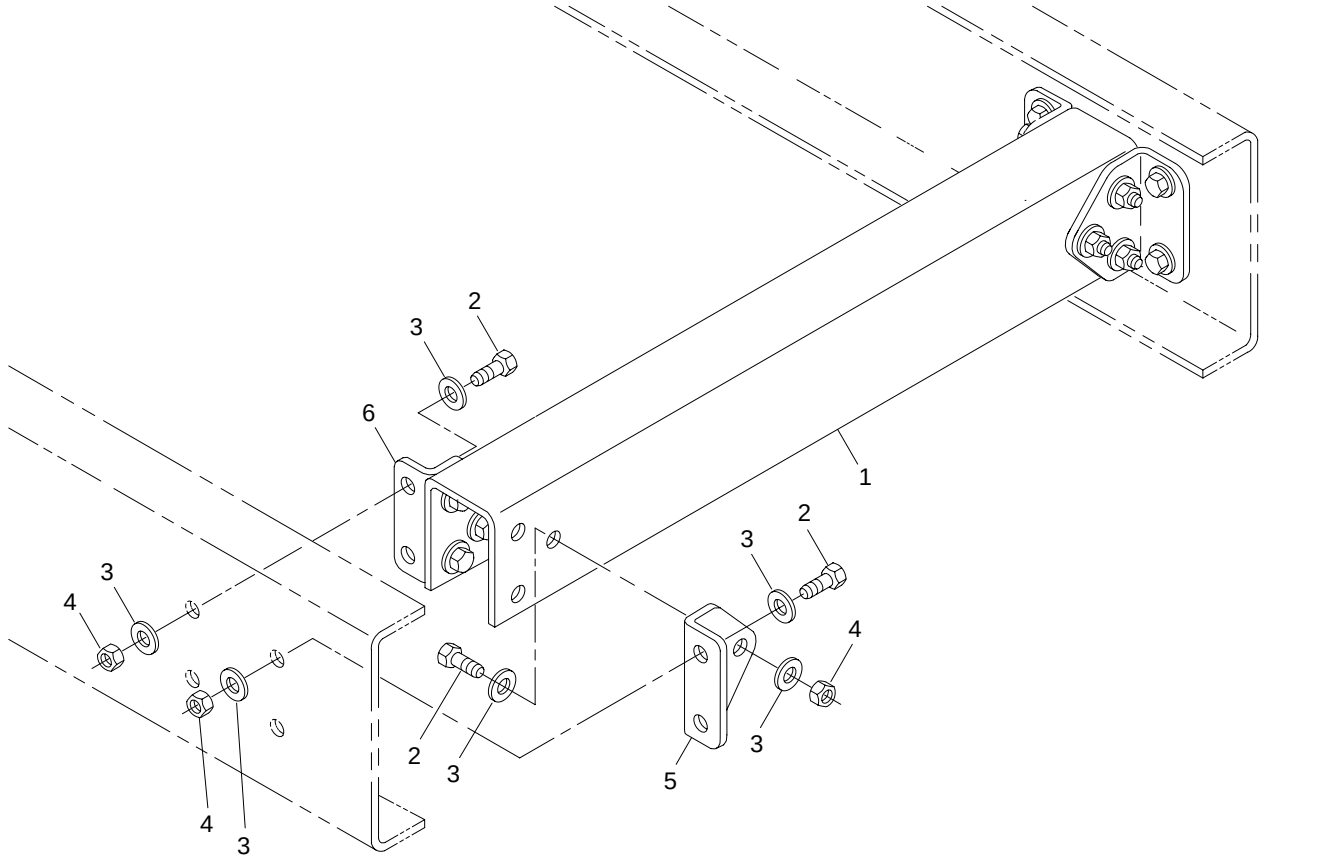
   Install any clamps that attach air lines or wiring to the crossmember.

   If the leveling valve for an AirLiner suspension was removed from the crossmember, install the leveling valve. For instructions, refer to **Group 32** in this manual.
6. Tighten the fasteners that attach the angle brackets to the frame rails, then tighten the fasteners that attach the crossmember to the angle brackets. Tighten all fasteners 184 N·m (136 lbf·ft).
7. Remove the chocks.

SPLAYED CROSSMEMBER **(See Fig. 5)**

1. Install the crossmember in the frame rails with its open channel facing the same direction that was noted during removal. Align the mounting holes at one end of the crossmember with the holes in the frame rail.

NOTE: With the crossmember not straight across in the frame rails, and the holes not aligned on the opposite end, the holes at that end will be in approximate alignment.



1. Rear Closing Crossmember
2. 5/8–11 Grade 8 Bolt
3. Hardened Steel Flatwasher
4. 5/8–11 Locknut
5. Rear Angle Bracket
6. Front Angle Bracket

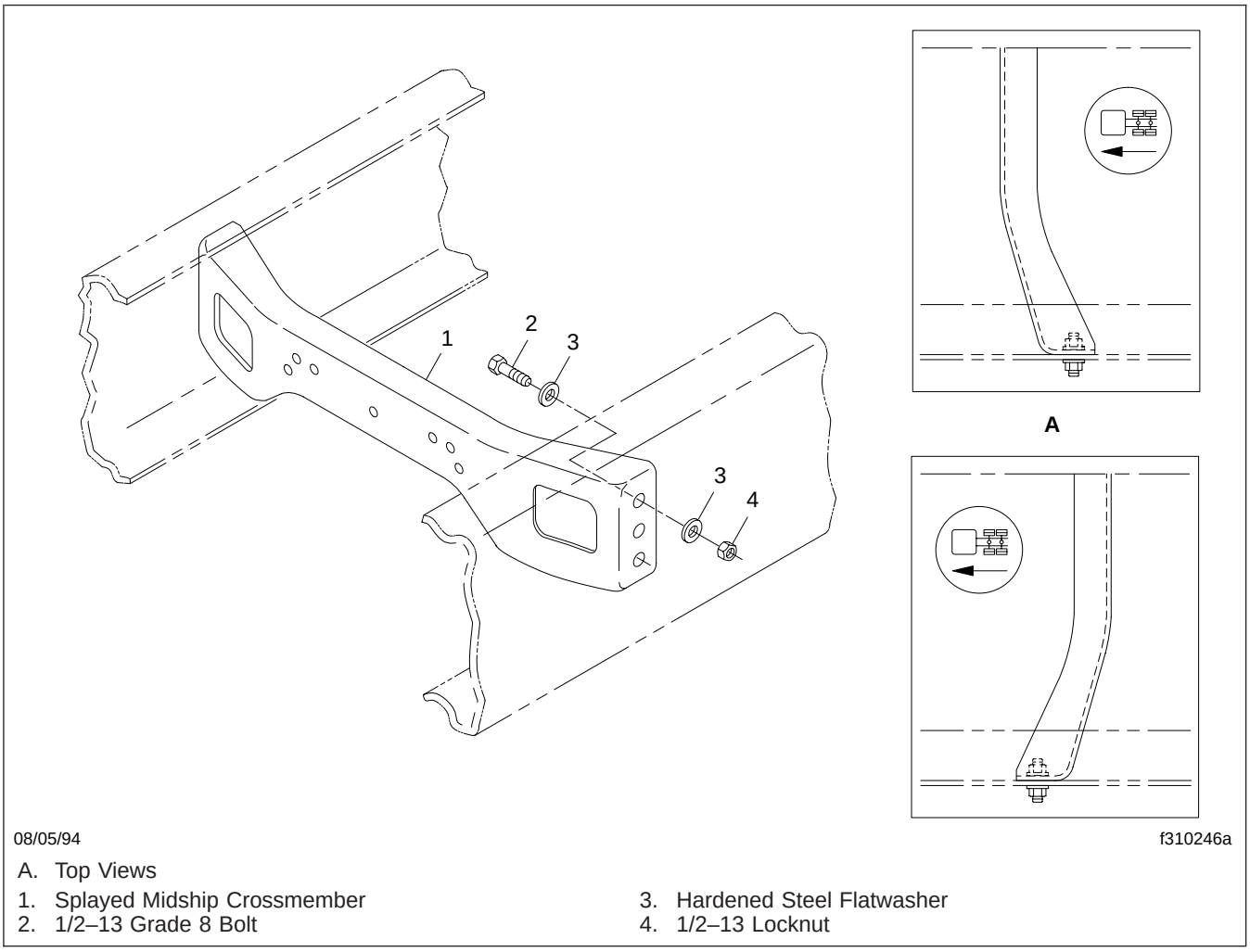
Fig. 4, Rear Closing Crossmember Installation

2. Install the fasteners in that end of the crossmember and frame rail, but tighten the locknuts finger-tight only.
3. At the other end of the crossmember, use a deadblow hammer to tap against its straight side, until the crossmember is straight across in the frame rails, and the mounting holes at both ends are in alignment with the holes in the frame rails.
4. If a midship bearing crossmember is being installed, install the fasteners that attach the midship bearing bracket to the crossmember. Remove the safety stands that supported the driveline.
5. Tighten all of the fasteners to their applicable torque values; refer to **Section 00.04.**
6. Remove the chocks.

Overslung Crossmember **(See Fig. 6)**

1. Rotate the new crossmember into place from the left side.
2. Place the crossmember on the rear surface of the mounting brackets.
3. Install the 5/8–11 mounting fasteners (bolt heads facing forward). Tighten the fasteners 184 N·m (136 lbf·ft).
4. Install the half-fender on the left side of the vehicle. Tighten the fasteners 16 N·m (12 lbf·ft).
5. Remove the chocks.

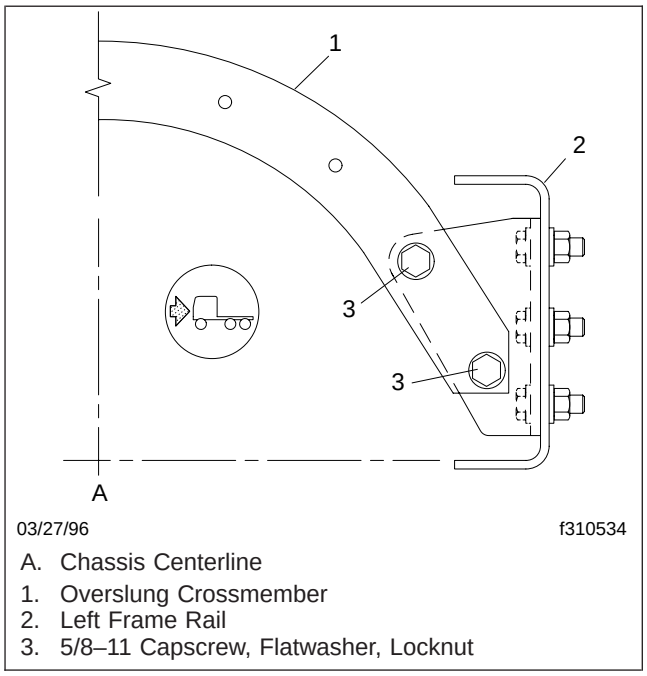
Crossmember Removal and Installation



08/05/94 f310246a

A. Top Views
1. Splayed Midship Crossmember
2. 1/2–13 Grade 8 Bolt
3. Hardened Steel Flatwasher
4. 1/2–13 Locknut

Fig. 5, Splayed Crossmember



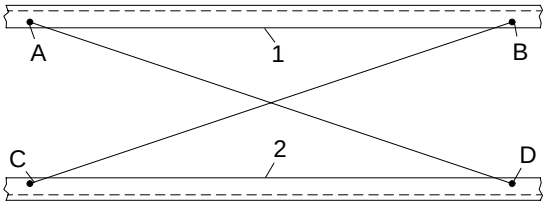
A. Chassis Centerline
1. Overslung Crossmember
2. Left Frame Rail
3. 5/8–11 Capscrew, Flatwasher, Locknut

Fig. 6, Overslung Crossmember, FL112 Installation

Alignment

Frame rail alignment is checked by measuring the distances from two sets of points on the upper (or lower) flanges of the frame rails. See **Fig. 1**. The rear set of points must be as far back as possible from the forward set of points. There must be no interference, along or between the frame rails, that would prevent measuring from any one of the four points to the other three points. If the upper flanges are being used for the measurements, the fifth wheel and deck plate (as equipped) must be removed.

There are no marks or bolt holes in the upper or lower flanges of the frame rails. Therefore, the points must be projected from the frame station marks, manufacturing holes, or component attachment holes in the frame rail webs. See **Fig. 2**.



12/20/1999 f310247

A. Right Forward Point
B. Right Rear Point
C. Left Forward Point
D. Left Rear Point
1. Right Frame Rail
2. Left Frame Rail

Fig. 1, Alignment Points

IMPORTANT: Use a pencil or soapstone to make all lines, points, or other marks. Do not use any marker or tool that will scratch the surface of the frame rail. Use a machinist's square to project all points from the webs to the upper (or lower) flanges, and to measure inboard from the outside face of the frame rails.

1. Apply the parking brakes and chock all the tires.
2. For each frame rail, project the exact vertical centerline of the 5/8-inch (16-mm) manufacturing hole at frame station 2628.4, from the frame web to the upper (or lower) flange, and mark it with a line across the flange.

   If, because of interference, the manufacturing hole at frame station 2628.4 cannot be used, choose and mark another matched set of points.

   2.1 Determine how far forward that the upper (or lower) flanges of both frame rails are clear.

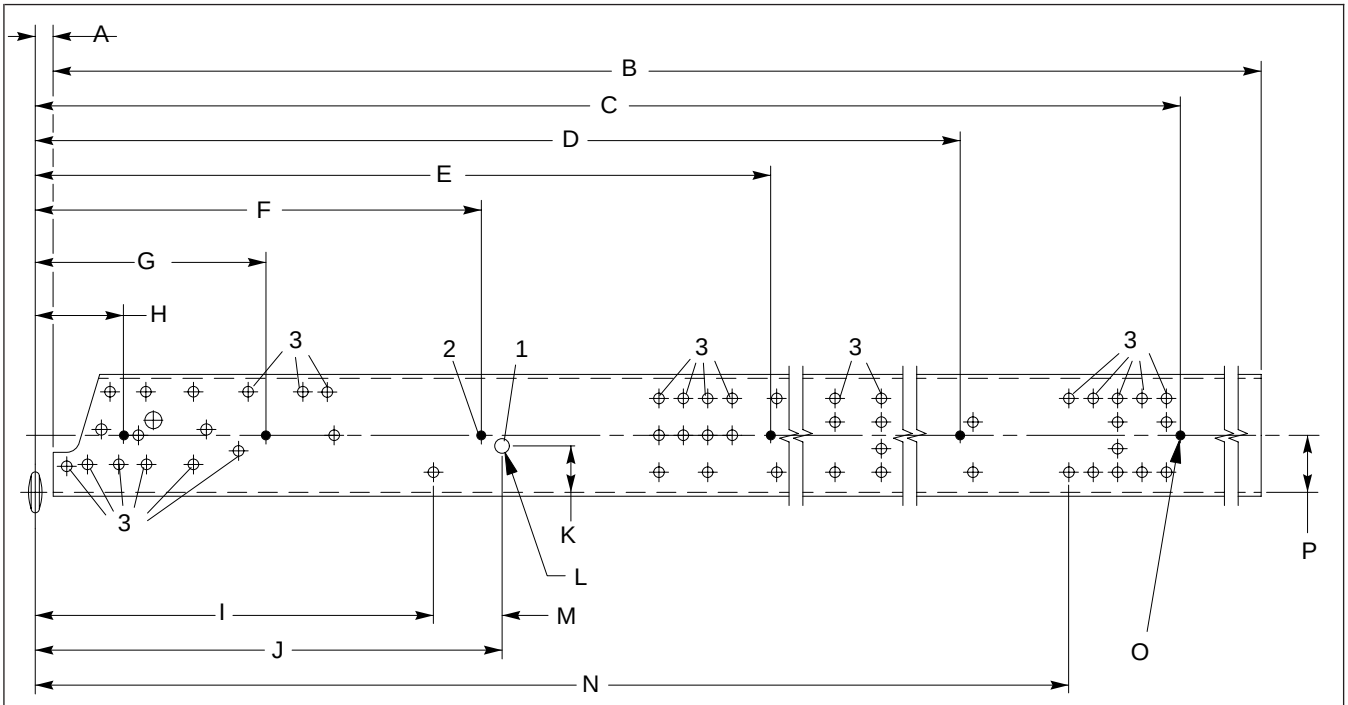
   2.2 Find a matched set of bolt holes on the frame rail webs, that are aligned with, or just rearward of, the front of the clear area on the flanges. The bolt holes must be in exactly the same location in each frame rail.

   2.3 Project the exact vertical centerline of each bolt hole, and mark a line across the upper (or lower) flange of its respective frame rail.
3. Find the exact center of the width of each flange, and mark the point on each projected line. This will be the forward set of points. The forward points must be in identical locations on both frame rails.
4. If needed and as equipped, remove the fifth wheel and deck plate; refer to the applicable section in this Group for instructions.
5. Measure along each frame rail, to find a set of holes *at least* 72 inches (180 cm) rearward from the forward set of points. The holes must be in exactly the same location in each frame rail.

IMPORTANT: If, because of interference, the distance must be less than 72 inches (180 cm), the distance must be the maximum that is possible.

6. Project the exact vertical centerline of each bolt hole, and mark a line across the upper (or lower) flange of its respective frame rail.
7. Along each line, measure and mark a point 2 inches (5 cm) inboard from the outside face of its respective frame rail. The rear points must be in identical locations on both frame rails.
8. Measure the distance from the forward point on one frame rail to the rear point on the opposite frame rail. See **Fig. 1**. Then measure the distance from the other forward point to the rear point on its opposite frame rail. Compare the two measurements.

Frame Rail Alignment



A. 1.6 Inches (40 mm)
B. Total Length ±0.2 Inches (5 mm)
C. 103.48 Inches (2628.4 mm)
D. 85.48 Inches (2171.2 mm)
E. 61.48 Inches (1561.6 mm)
F. 37.48 Inches (952.0 mm)
G. 19.48 Inches (494.8 mm)
H. 7.48 Inches (190.0 mm)
I. 33.5 Inches (850 mm)
J. 39.4 Inches (1000 mm)
K. 3-3/4 Inches (95.5 mm)
L. 1-1/16 Inches (27.0 mm) In Diameter
M. 5.9 Inches (150 mm)
N. 94.5 Inches (2400 mm)
O. 5/8 Inches (16.0 mm) In Diameter
P. 4-3/4 Inches (120.5 mm)

1. Hole At Frame Station 1000
2. Manufacturing Hole, 5/8-Inch (16 mm)
3. Component Mounting Holes

Fig. 2, Critical Dimensions, Frame Rails

If the values differ by more than 1/8 inch (3 mm), proceed with the next step.

If the measurements are within 1/8 inch (3 mm) of each other, the frame rails do not need to be aligned; go to the step for fifth wheel and deck installation.

9. Loosen *all* of the frame fasteners enough to allow movement of the parts when force is applied.

IMPORTANT: To align the frame rails, the frame must have all of the crossmembers in place, but the attachment fasteners should *not* be tightened.

10. Using a large hammer and a large wooden block, place the block against the rear end of the frame rail that had its rear point the greater distance from its opposite rail's front point. Tap the block until the measurements are within 1/8 inch (3 mm) of each other.
11. Tighten all of the frame fasteners, starting at the middle of the frame and working alternately toward both ends. Tighten all fasteners to their applicable torque values; refer to the Specifications in **Section 00.04**.
12. Again, check the frame rail alignment.
13. When the measurements are within specifications, install the fifth wheel and deck plate (as

equipped); refer to the applicable section in this Group for instructions.

14. If the frame rails needed aligning, check the axle alignment; refer to the appropriate suspension section in **Group 32** for instructions.
15. Remove the chocks from the tires.

General Information

NOTE: The Holland 3500 series XA–3501 model fifth wheel top plate has been replaced by the XA–351 model. All 3500 series fifth wheel top plates which are marked with a manufactured date after June 1, 1996 are XA–351 models.

NOTE: Service operations for the Holland 3500 series slide mounts (FW2535/FW35) are covered in **Section 31.05** in this group.

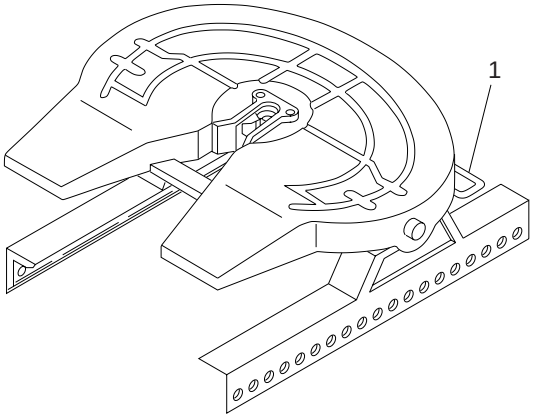
MODEL XA–3501 TOP PLATE

NOTE: The part number prefix for the stationary fifth wheel is FW3500 and the part number prefix for the sliding fifth wheel is FW2535.

Holland 3500 series XA–3501 fifth wheels are used for pulling trailers having the standard SAE kingpin. When installed as stationary fifth wheels, they are bracket-mounted to the trailer frame in a position that best distributes the trailer load over the tractor axles. When installed as sliding fifth wheels, they are mounted on the Holland 3500 series sliding mount. These fifth wheels have a capacity of 150,000 lbf (667 000 N) maximum drawbar pull and 40,000 to 50,000 lbf (178 000 to 222 000 N) maximum vertical load. The fifth wheel (**Fig. 1**) has a cast steel top plate, and is equipped with a split type "B" mechanical spring lock. This steel kingpin lock system requires a 300 lbf (1330 N) push (force) to couple, and also includes a slack adjustment and the Holland lockguard (which prevents high kingpin coupling).

The two spring-loaded lock halves separate as the kingpin enters the lock mechanism. See **Fig. 2**. The final forward motion of the kingpin forces the lock to close in a 360 degree grip around the shoulder and neck of the kingpin, and moves the yoke between the lock halves and the tapered rib members of the fifth wheel understructure. The kingpin can be released only by manually operating the kingpin lock control handle. See **Fig. 1**. An adjustment nut compensates for wear on the lock or kingpin, if necessary.

See Chapter 10 of the *Business Class Trucks Driver's Manual* for complete operating instructions.



1. Kingpin Lock Control Handle

Fig. 1, XA-3501 Fifth Wheel

MODEL XA–351 TOP PLATE

NOTE: The part number prefix for the stationary fifth wheel and the sliding fifth wheel is FW35.

The Holland 3500 series XA–351 fifth wheels are applicable for general over-the-road use. They are designed to pull trailers having a 2 inch (5 cm) SAE J700b kingpin. They have a capacity of 150,000 lbf (667 000 N) maximum drawbar pull and 55,000 lbf (244 652 N) maximum vertical load. These fifth wheels are available in three different mounting assemblies: the Kompensator®; the slide mount; and the stationary mount.

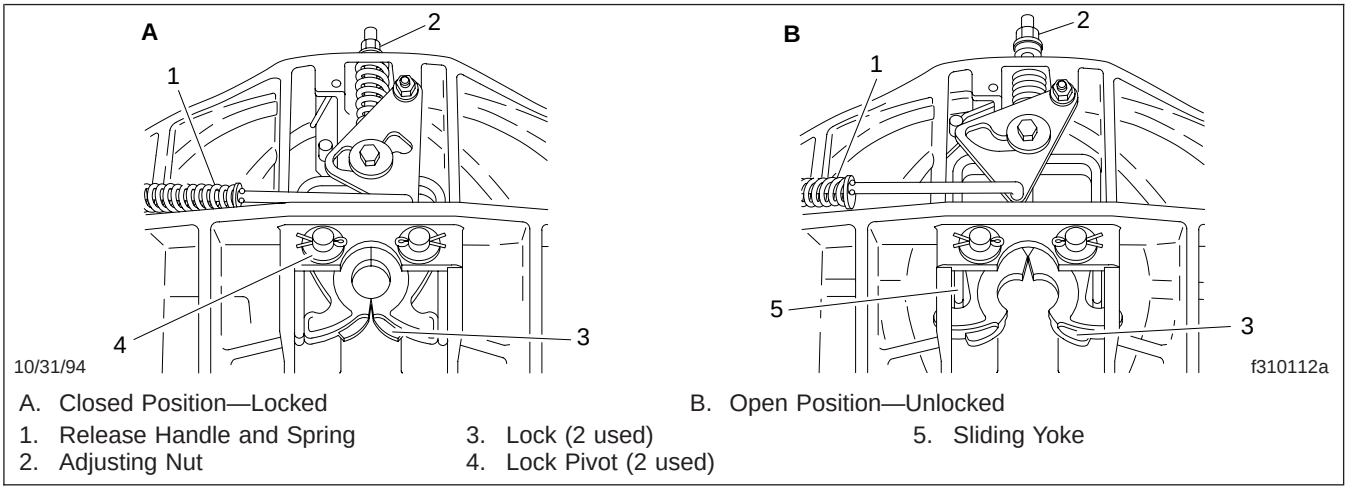
The stationary mount fifth wheels are available with four different mounting bracket styles, which include:

- a bracket with a mounting base for over-the-frame mounting;
- a bracket with a mounting angle for over-the-frame mounting;
- a bracket for angle mounting (designed to be welded to the angle) for over-the-frame mounting;
- and, a bracket for outboard angle mounting.

The mounting brackets use nylon-lined "up-shock" bushings. These fifth wheels come in a variety of heights to accommodate many applications.

The sliding fifth wheels are available with either an over-the-frame mounting bracket or an outboard angle mounting bracket. These mounting brackets

General Information



A. Closed Position—Locked
B. Open Position—Unlocked
1. Release Handle and Spring
2. Adjusting Nut
3. Lock (2 used)
4. Lock Pivot (2 used)
5. Sliding Yoke

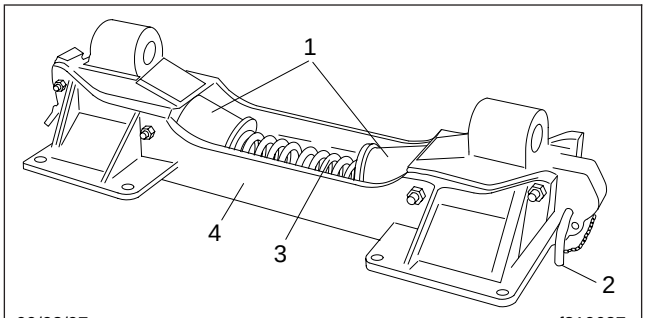
Fig. 2, Type B Kingpin Lock Mechanism (bottom view)

are either equipped with a manual slide release or an air slide release mechanism. These sliding mounts have a position adjustment that gives the fifth wheel top plate the ability to be released, incrementally moved (by 1.5 inch [3.8 cm] displacements) and locked in alternate positions. The position adjustment feature allows the fifth wheel position to vary combination length and tractor axle load distribution for maximum equipment utilization. The mounting brackets use nylon-lined "up-shock" bushings. The sliding fifth wheels are available in a variety of heights and slide travel lengths.

The Kompensator® fifth wheel is equipped with either a stationary or sliding mounting bracket. This fifth wheel is designed for rigid trailers that don't flex during torsional loading. It provides torsional stress relief and promotes vehicle stability with trailers that have an unusually high center of gravity (where the center of gravity is up to 44 inches [111 cm] above the top plate surface). This fifth wheels unique cradle design provides side-to-side movement to help relieve the torque and twist of the trailer. Spring cushions act as a restoring force to provide stability after absorbing the strain and pressure of the load. Additionally, it keeps the center of compensation above the fifth wheel bearing surface and centered between the frame rails. All models are available with an optional "lock-out" feature to restrict compensation for applications that do not require compensation. See **Fig. 3**.

The 3500 series top plate consists of:

- the cast steel top plate;
- the bracket pin mount;



1. Urethane Cushions
2. Optional Lockout
3. Compression Springs
4. Kompensator® Cradle Design Mounting Bracket

Fig. 3, The Kompensator®Cradle

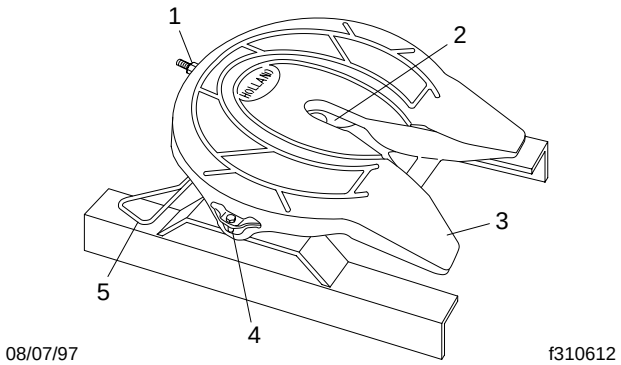
- the release handle;
- the infinite lock adjustment nut;
- and the kingpin lock mechanism.

See **Fig. 4**.

The kingpin lock mechanism consists of:

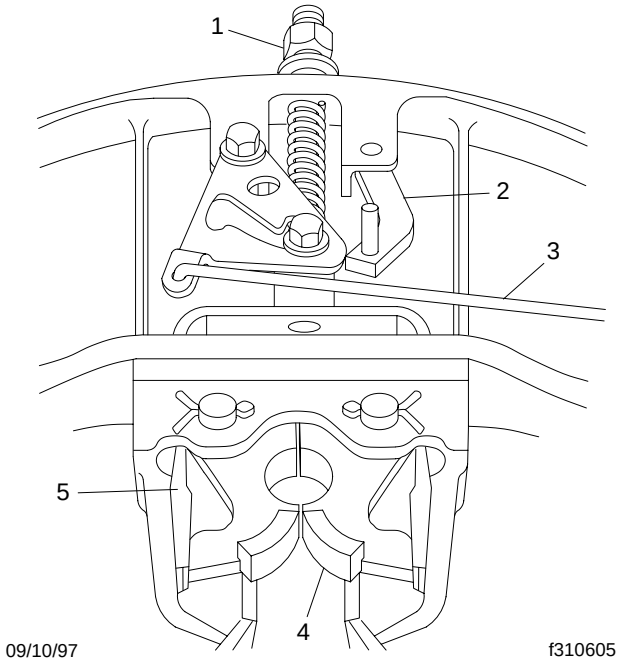
- the infinite lock adjustment nut;
- the secondary lock;
- the release handle;
- the type "B" forged steel split lock;
- and, the yoke.

See **Fig. 5**.



1. Infinite Lock Adjustment Nut
2. Kingpin Lock
3. Cast Steel Top Plate
4. Bracket Pin Mount
5. Release Handle

Fig. 4, XA-351 Fifth Wheel



1. Infinite Lock Adjustment Nut
2. Secondary Lock (Automatic Shown)
3. Release Handle
4. Kingpin Guide
5. Yoke

Fig. 5, Kingpin Lock Mechanism (bottom view)

When the yoke is retracted, the two spring-loaded lock halves separate as the kingpin enters the lock mechanism. When the yoke engages, the final forward motion of the kingpin forces the lock to close in a 360 degree grip around the shoulder and neck of the kingpin. After the yoke is engaged (positioned between the lock halves and the tapered rib members of the top plate casting), the secondary lock moves behind the yoke. For fifth wheels with an automatic secondary lock, the kingpin is released by manually operating the release handle. For fifth wheels with a manual secondary lock, the fifth wheel is released by pulling the secondary release handle, then hooking the secondary release handle to the top plate casting, and finally manually operating the primary release handle. For high coupling protection, a one step rear lock is incorporated into the split lock. For increased durability of the kingpin lock mechanism, the infinite lock adjustment positions are available to compensate for wear of both the kingpin and the lock jaws.

See Chapter 10 of the *Business Class Trucks Driver's Manual* for complete operating instructions.

Model XA–3501 Top Plate Removal and Disassembly

Removal and Disassembly

(See Fig. 1)

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

A fifth wheel rebuild kit is available for servicing the 3500 series XA–3501 fifth wheel (part number RK–63501 [left release] and RK–63500 [right release]). The kit contains all replacement parts for the fifth wheel, except the fifth wheel plate, slide mount assembly, rubber bushings, bushing pins, and roll pins.

Review the troubleshooting section before rebuilding the fifth wheel. Rebuilding may be unnecessary.

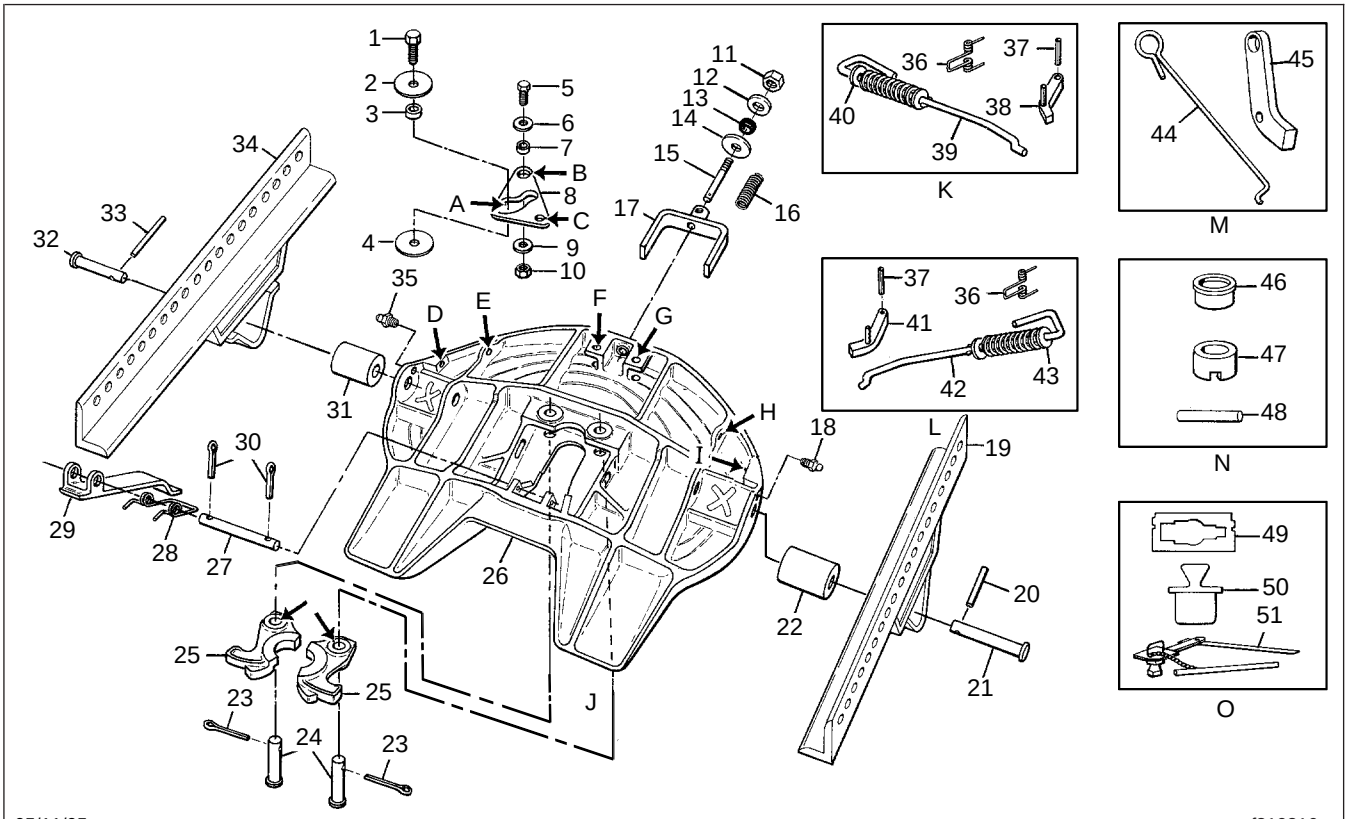
1. Steam clean the top plate. Remove it from the slide mounts (**Fig. 1**) by removing the roll pins from the bushing pins; then, remove the bushing pins from the mounting brackets. Use an overhead hoist to lift the fifth wheel from the mounting brackets and tractor frame.
2. Turn the fifth wheel upside down with the locks open.
3. While disassembling the fifth wheel, check it for cracks and for missing or damaged parts.
   - 3.1 Remove the lockguard, the lockguard torsion spring, the lockguard pin, and the lockguard cotter pins.
   - 3.2 On fifth wheels with a right-hand release, remove the secondary lock roll pin from hole F. Then, remove the right-hand secondary lock from under hole F.

     On fifth wheels with a left-hand release, remove the secondary lock roll pin from hole G. Then, remove the left-hand secondary lock with the secondary lock spring from under hole G.
   - 3.3 Remove the attaching release arm capscrew, capscrew washer, and roller from hole A of the release arm and yoke subassembly.
   - 3.4 Remove the release arm capscrew, release arm capscrew washer, and release arm roller from hole G for models with right-hand release or from hole F for models with left-hand release.
   - 3.5 Remove the release handle from the fifth wheel top plate. Remove the washer, release handle spring, and release handle washer from the release handle.
   - 3.6 Remove the yoke shaft locknut, yoke shaft washer, and rubber block from the yoke shank. Then, remove the yoke shank and the yoke shank spring from the yoke subassembly.
   - 3.7 Remove the yoke from the fifth wheel top plate.
   - 3.8 Remove the lock cotter pins, lockpins, and the lock jaws from the fifth wheel top plate.
   - 3.9 If the top plate is cracked, discard it. If the lockpin hole is worn, the top plate can be returned for a factory rebuild.

⚠ WARNING

Do not attempt to repair or rebuild the top plate if it is cracked or if the lockpin does not fit tightly. The top plate could fail or the locks could malfunction. This could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

Model XA–3501 Top Plate Removal and Disassembly



A. Release Arm Cam Profile
B. Release Arm Pivot Hole
C. Hole for Attachment of Release Handle
D. Guide Hole for Right-Hand Release
E. Hole for Left-Hand Manual Secondary Lock Handle
F. Right-Hand Secondary Lock Anchor Hole
G. Left-Hand Secondary Lock Anchor Hole
H. Hole for Right-Hand Manual Secondary Lock Handle
I. Guide Hole for Left-Hand Release
J. Lockpin Holes
K. For Right-Hand Release
L. For Left-Hand Release
M. For Models With Secondary Lock
N. For Models With Lockpin Bushings
O. Accessories

1. Capscrew, 5/8–18 x 1-3/4
2. Flatwasher, 5/8" i.d.
3. Roller
4. Washer, 5/8" i.d.
5. Capscrew, 1/2–20
6. Washer, 1-3/4" o.d. x 9/16" i.d.
7. Roller
8. Release Arm (Cam Plate)
9. Washer, 1-3/4" o.d. x 13/16" i.d.
10. Locknut, 1/2–20
11. Locknut, 3/4–16
12. Washer, 1-1/2" o.d. x 13/16" i.d.
13. Rubber Block
14. Lock Adjustment Tag
15. Yoke Shank
16. Yoke Shank Spring
17. Yoke Subassembly
18. Grease Fitting
19. Mounting Bracket
20. Roll Pin
21. Bracket Pin
22. Rubber Bushing
23. Cotter Pins, 1/4" x 2"
24. Lockpins
25. Lock Jaws
26. Fifth Wheel Top Plate
27. Lockguard Pin
28. Lockguard Torsion Spring
29. Lockguard
30. Cotter Pins, 1/8" x 1"
31. Rubber Bushing
32. Bracket Pin
33. Roll Pin
34. Mounting Bracket
35. Grease Fitting
36. Secondary Lock Torsion Spring
37. Roll Pin
38. Right-Hand Secondary Lock
39. Right-Hand Release Handle
40. Washer, 1-3/4" o.d. x 9/16" i.d.
41. Left-Hand Secondary Lock
42. Left-Hand Release Handle
43. Washer, 1-3/4" o.d. x 9/16" i.d.
44. Manual Secondary Lock Handle
45. Manual Secondary Lock
46. Lockpin Bushings, 2
47. Lockpin Bushing, 2
48. Roll Pin, 2
49. Kingpin Gauge
50. Plug, 2"
51. Kingpin Lock Tester

Fig. 1, Holland 3500 Series XA-3501 Fifth Wheel and Accessories (bottom view)

Model XA–3501 Top Plate Assembly and Installation

Assembly and Installation

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

A fifth wheel rebuild kit is available for servicing the 3500 series XA–3501 fifth wheel (part numbers RK–63501 [left release] and RK–63500 [right release]). The kit contains all replacement parts for the fifth wheel, except the fifth wheel plate, slide mount assembly, rubber bushings, bushing pins, and roll pins.

Review the troubleshooting section before rebuilding the fifth wheel. Rebuilding may be unnecessary.

IMPORTANT: Use only Holland rebuilding kits. Replace all roll pins, cotter pins, springs, capscrews, nuts, and washers.

1. Clean all moving parts with no. 2 diesel fuel before assembly.
2. Before installing the lock jaws (**Fig. 1**), lubricate the lockpin holes (Ref. J) with Never-Seez®.

⚠ CAUTION

Use only Never-Seez®. Other lubricants can damage the lockpin holes.

3. Place the lock jaws in the top plate with the 2-7/8 inch bore toward the face of the top plate. See **Fig. 2**.
4. Drive the lockpins (**Fig. 1**) through the top plate and lockpin holes (Ref. J) in the lock jaws until the head of the pins are flush with the top plate.
5. If the top plate is equipped with lockpin bushings, use roll pins instead of cotter pins. See **Fig. 3**.
6. Check that the lock jaws move freely.

⚠ WARNING

Use only Holland part number TF–0237 or a precision plug machined to 2.000 ± 0.005 inch (5.08 ± 0.0127 cm) to adjust the locking mechanism. Failure to do so may cause locking mechanism malfunction. This could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

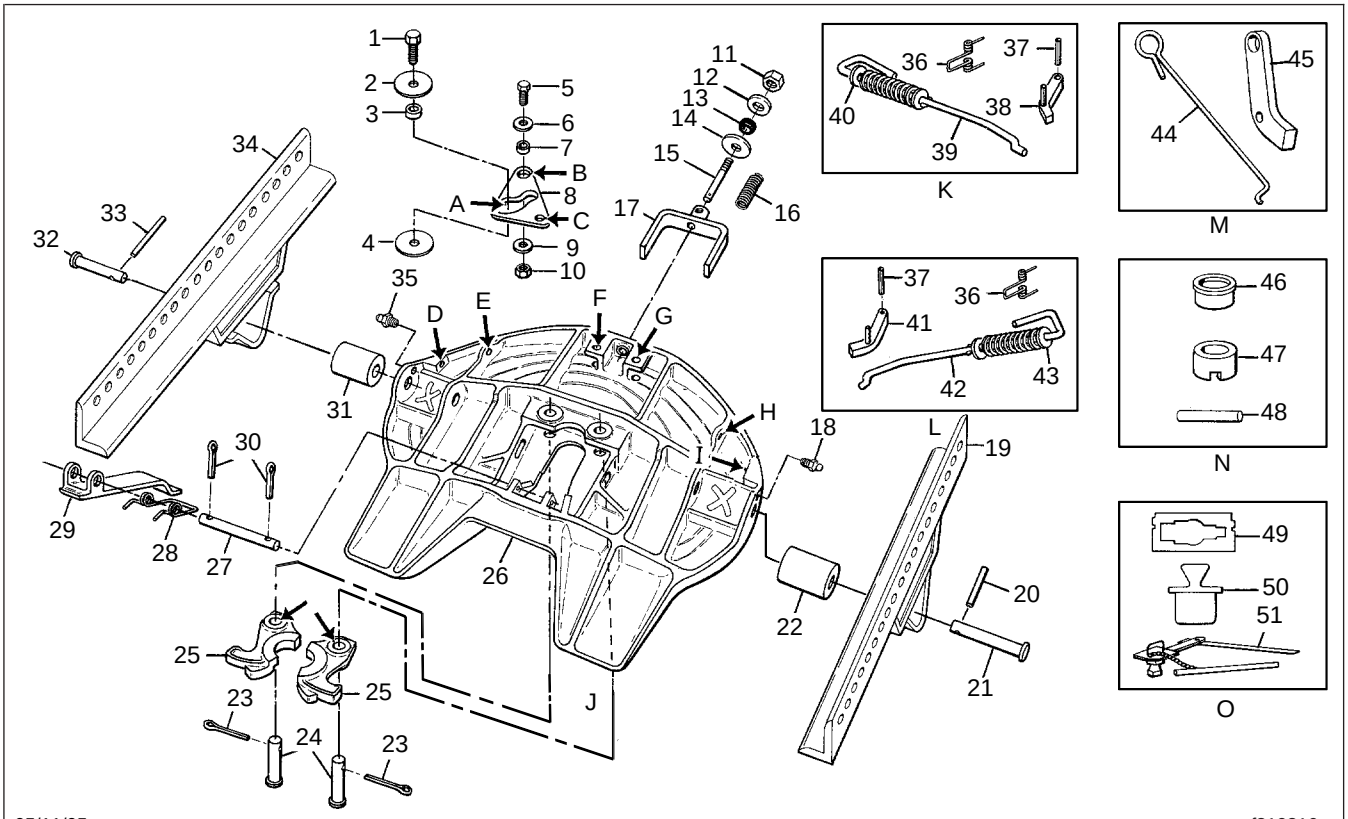
7. Install a 2-inch (5.08 cm) diameter plug (Holland part number TF–0237) in the lock jaws. See **Fig. 4**.
8. Strike the yoke with a mallet to bend the yoke tips outward slightly. See **Fig. 5**.
9. Slide the yoke into the top plate with the threaded hole facing up, and tap the yoke into position.

⚠ WARNING

Never grind on the inside of the yoke or on the locks. This can weaken the yoke structure, possibly causing the kingpin to fit loosely. This could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

10. Inspect the yoke tips. The tips must be flush with the ends of the locks, or extend no more than 1/32 inch (0.8 mm) beyond. See **Fig. 6**.
    - 10.1 If the yoke tips fall short (**Fig. 7**), use a belt sander or disk grinder to grind the outside surfaces of the yoke until it fits precisely into place. See **Fig. 8**.
    - 10.2 If the yoke tips extend beyond the ends of the locks, build up the outer surfaces of the yoke using a low hydrogen E70XX welding rod. See **Fig. 9**. After welding, grind the beads smooth.
11. The outside of each yoke tip has two contact areas. Check that all four surfaces have full area contact with the top plate ribs (**Fig. 10**) after welding and grinding.
12. Continue welding, grinding, and fitting until the yoke has full contact and the yoke tips are flush with the ends of the locks.
13. Apply a coat of light grease to both the inside and outside friction surfaces of the yoke, then slide the yoke into the top plate with the threaded hole facing up.
14. Install the spring (**Fig. 1**) between the yoke and the top plate. Insert the yoke shank through the top plate and spring, then into the yoke. Make

Model XA–3501 Top Plate Assembly and Installation



A. Release Arm Cam Profile
B. Release Arm Pivot Hole
C. Hole for Attachment of Release Handle
D. Guide Hole for Right-Hand Release
E. Hole for Left-Hand Manual Secondary Lock Handle
F. Right-Hand Secondary Lock Anchor Hole
G. Left-Hand Secondary Lock Anchor Hole
H. Hole for Right-Hand Manual Secondary Lock Handle
I. Guide Hole for Left-Hand Release
J. Lockpin Holes
K. For Right-Hand Release
L. For Left-Hand Release
M. For Models With Secondary Lock
N. For Models With Lockpin Bushings
O. Accessories

1. Capscrew, 5/8–18 x 1-3/4
2. Flatwasher, 5/8" i.d.
3. Roller
4. Washer, 5/8" i.d.
5. Capscrew, 1/2–20
6. Washer, 1-3/4" o.d. x 9/16" i.d.
7. Roller
8. Release Arm (Cam Plate)
9. Washer, 1-3/4" o.d. x 13/16" i.d.
10. Locknut, 1/2–20
11. Locknut, 3/4–16
12. Washer, 1-1/2" o.d. x 13/16" i.d.
13. Rubber Block
14. Lock Adjustment Tag
15. Yoke Shank
16. Yoke Shank Spring
17. Yoke Subassembly
18. Grease Fitting
19. Mounting Bracket
20. Roll Pin
21. Bracket Pin
22. Rubber Bushing
23. Cotter Pins, 1/4" x 2"
24. Lockpins
25. Lock Jaws
26. Fifth Wheel Top Plate
27. Lockguard Pin
28. Lockguard Torsion Spring
29. Lockguard
30. Cotter Pins, 1/8" x 1"
31. Rubber Bushing
32. Bracket Pin
33. Roll Pin
34. Mounting Bracket
35. Grease Fitting
36. Secondary Lock Torsion Spring
37. Roll Pin
38. Right-Hand Secondary Lock
39. Right-Hand Release Handle
40. Washer, 1-3/4" o.d. x 9/16" i.d.
41. Left-Hand Secondary Lock
42. Left-Hand Release Handle
43. Washer, 1-3/4" o.d. x 9/16" i.d.
44. Manual Secondary Lock Handle
45. Manual Secondary Lock
46. Lockpin Bushings, 2
47. Lockpin Bushing, 2
48. Roll Pin, 2
49. Kingpin Gauge
50. Plug, 2"
51. Kingpin Lock Tester

Fig. 1, Holland 3500 Series XA-3501 Fifth Wheel and Accessories (bottom view)

Model XA–3501 Top Plate Assembly and Installation

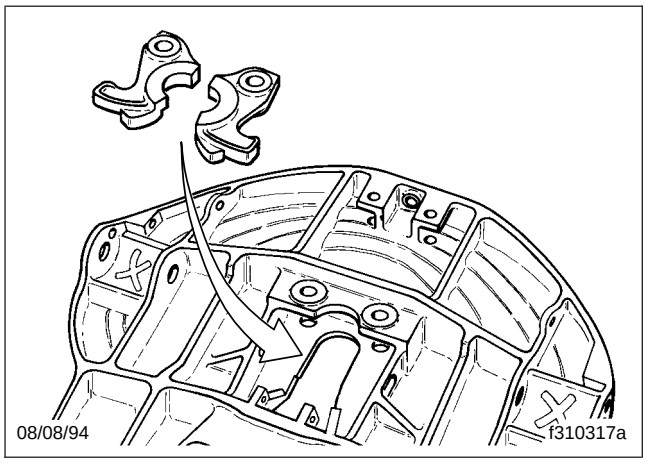


Fig. 2, Place the Lock Jaws

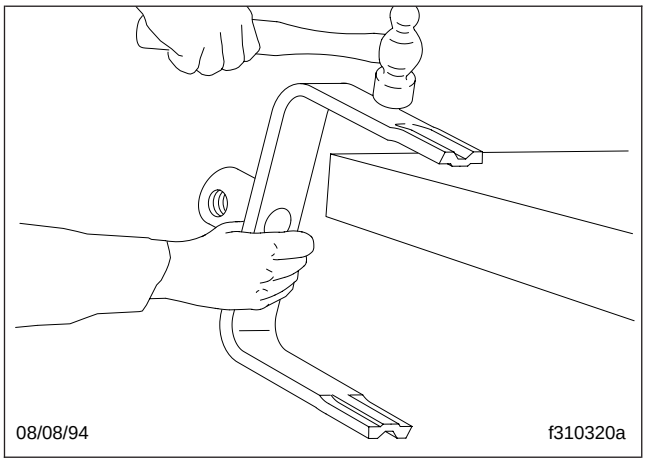


Fig. 5, Strike the Yoke

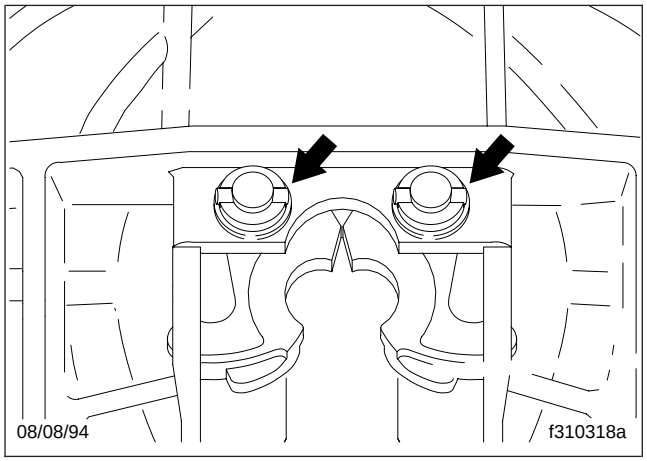


Fig. 3, Roll Pins Used

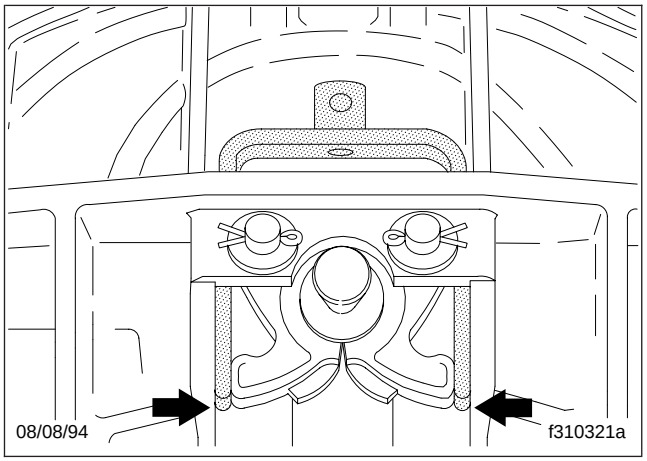


Fig. 6, Inspect the Tips

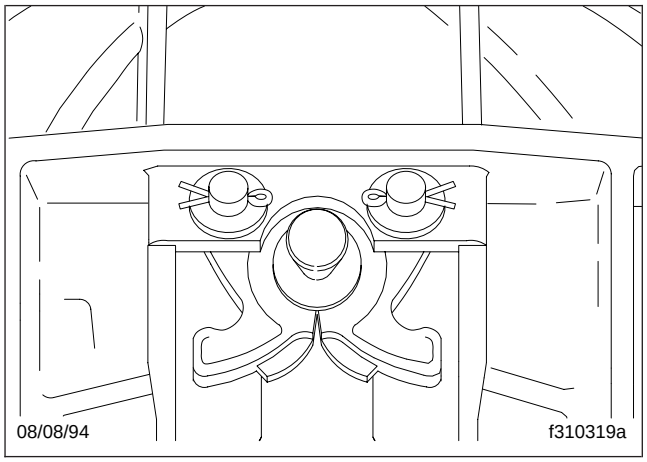


Fig. 4, Plug in the Lock Jaws

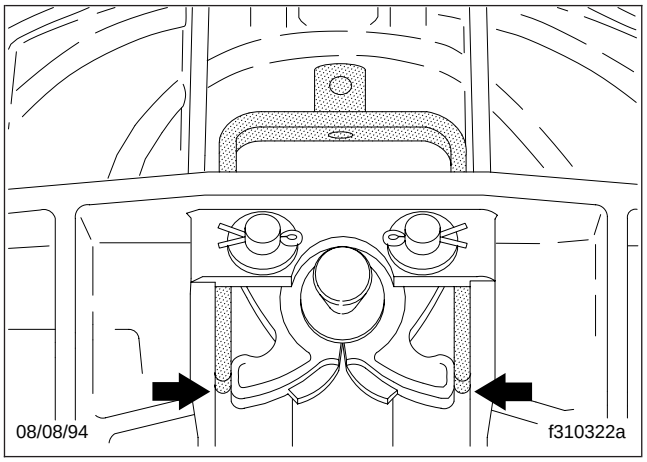
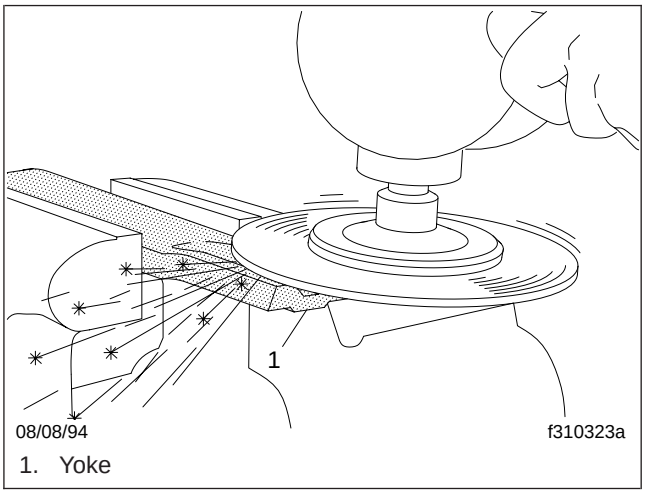


Fig. 7, Yoke Tips Fall Short

Model XA–3501 Top Plate Assembly and Installation



1. Yoke

Fig. 8, Grind the Yoke

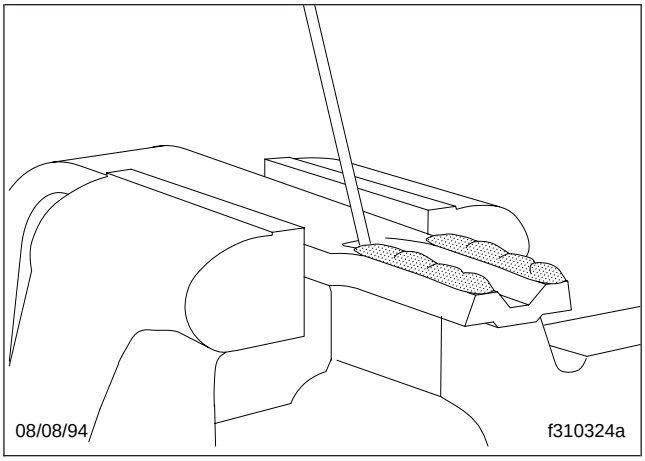


Fig. 9, Build Up the Yoke

sure that the predrilled recess in the yoke shank aligns with the threaded hole in the yoke.

15. Install the lock adjustment tag, the rubber block, a 13/16-inch i.d. steel washer, and the 3/4-inch locknut in the order stated.
16. Install the 9/16-inch i.d. washer on the release handle as shown in **Fig. 1**.
17. Pass the open end of the release handle through the guide hole (Ref. D for models with right-hand release, Ref. I for models with left-hand release) toward the outside of the top plate.
18. Inspect the release arm (cam plate) for burrs or rough edges in the cam profile (Ref. A). Remove any burrs or rough edges.

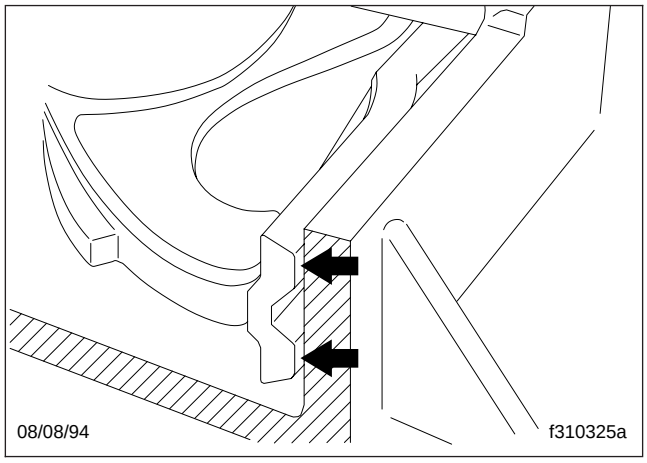


Fig. 10, Contact with Top Plate

19. Apply a light coat of grease to the cam profile and pivot holes.
20. Insert the "S" end of the release handle through the small hole in the release arm (cam plate).
21. Place the release arm (cam plate) on the top plate so that the cam profile (**Fig. 11**, Ref. A) is over the hole in the yoke and the large hole (Ref. B) is over the lug in the top plate opposite the release handle.

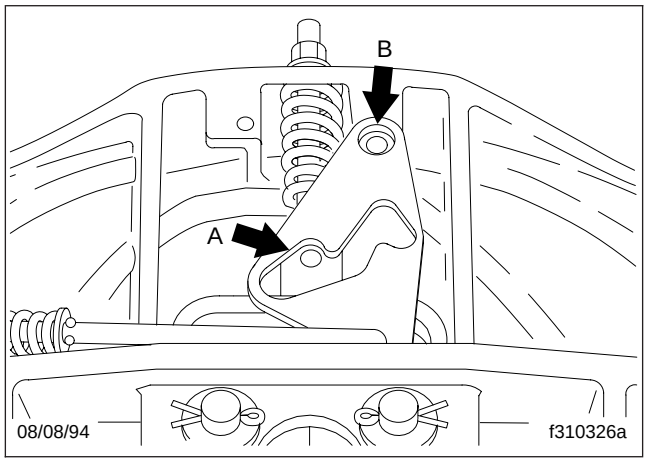


Fig. 11, Place the Release Arm

22. Slide a 9/16-inch i.d. flatwasher between the plate lug and the release arm with the rounded edge towards the cam. See **Fig. 12**.
23. Install the 1/2-inch i.d. roller (**Fig. 1**) in the large hole of the release arm.

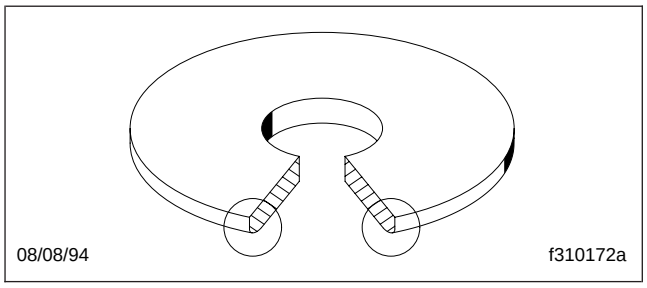


Fig. 12, Rounded Edge

24. Place a second 9/16-inch i.d. flatwasher over the release arm. Make sure the rounded edge of the washer faces the cam.
25. Install the 1/2-inch diameter capscrew through the washers, roller, and hole in the top plate lug (Ref. G for right-hand release models, Ref. F for left-hand release models).
26. Secure the capscrew with a 1/2-inch locknut. Tighten the locknut; then, check that the release arm moves freely.
27. Place a 5/8-inch i.d. washer between the yoke and the release arm. Make sure that the rounded edge of the washer faces the release arm.
28. Insert the 5/8-inch i.d. roller in the release arm opening.
29. Install the second 5/8-inch i.d. washer on top of the release arm.
30. Pass the 5/8-inch diameter capscrew through the assembly. Be certain that the bolt passes through the yoke and into the recess in the yoke shank.
31. Tighten the capscrew securely, but make sure the top washer turns freely.
32. Turn the nut on the yoke shank clockwise until the yoke just begins to move.
33. Check the plug (Holland part number TF–0237). It should fit snugly in the locks, but you should be able to turn it with some force.
34. On models with an automatic secondary lock assembly, Install the secondary lock.
    - 34.1 Start the roll pin into the hole in the top plate lug opposite the release arm anchor capscrew.
    - 34.2 Install the torsion spring on the secondary lock, and position them on the lug. Be sure the open end of the spring faces toward the rib of the lug. See **Fig. 13**.

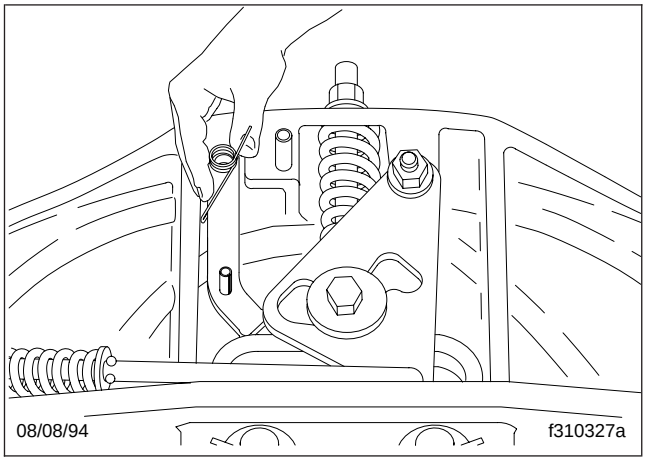


Fig. 13, Torsion Spring Installation

    - 34.3 While holding the parts in place, drive the roll pin until it is flush with the lug.
    - 34.4 Check the spring tension on the secondary lock. Check that the lock moves freely.
35. On models with a manual secondary lock assembly, install the manual secondary lock.
    - 35.1 Pass the end of the manual secondary lock handle (**Fig. 1**) through the hole (Ref. E for right-hand release, Ref. H for left-hand release).
    - 35.2 Attach the handle to the secondary lock.
    - 35.3 Start the roll pin into the hole in the top plate lug opposite the release arm anchor capscrew.
    - 35.4 Install the torsion spring on the secondary lock, and place them in position on the lug. Be sure the open end of the spring faces toward the rib of the lug. See **Fig. 13**.
    - 35.5 While holding the parts in place, drive the roll pin until it is flush with the lug.
    - 35.6 Check the spring tension on the secondary lock. Check that the lock moves freely.

Model XA–3501 Top Plate Assembly and Installation

36. Pull the release handle, remove the plug, and pry open the lock jaws.
37. Assemble the lockguard and the torsion spring.
38. Mount the lockguard using the lockguard pin and cotter pins. See **Fig. 14**.

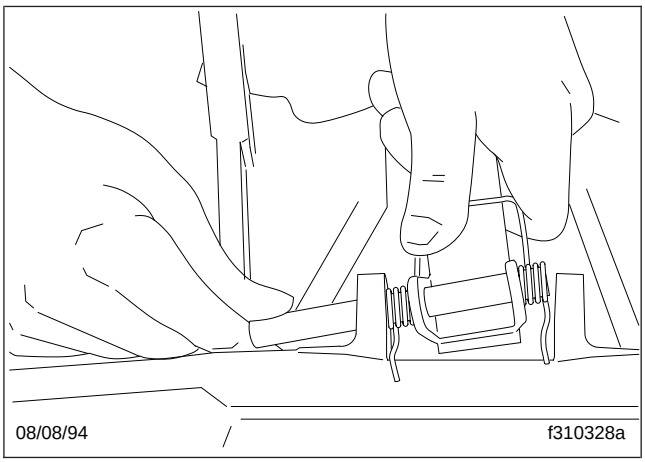


Fig. 14, Mount the Lockguard

39. Check the spring tension on the lockguard. Check that the lockguard moves freely.
40. Check the adjustment. The tip of the guard should be even with the edge of the 2-inch bore in the lock jaw. See **Fig. 15**.

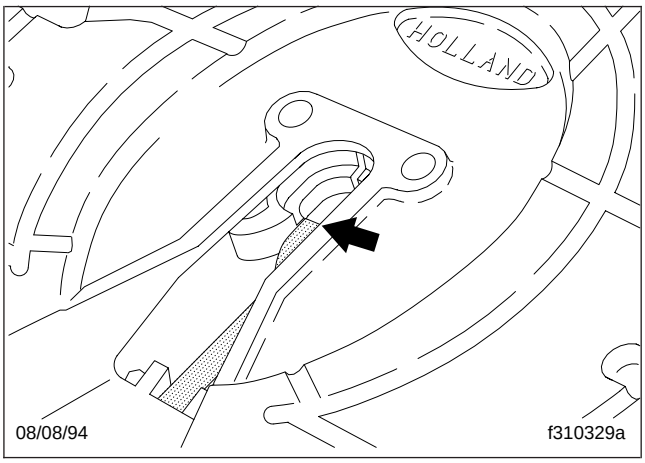


Fig. 15, Check the Guard

41. Adjust the lockguard position by supporting the end of the guard with a short piece of steel placed between the locks and the lock-guard. Tap the center of the guard to adjust it. See **Fig. 16**.

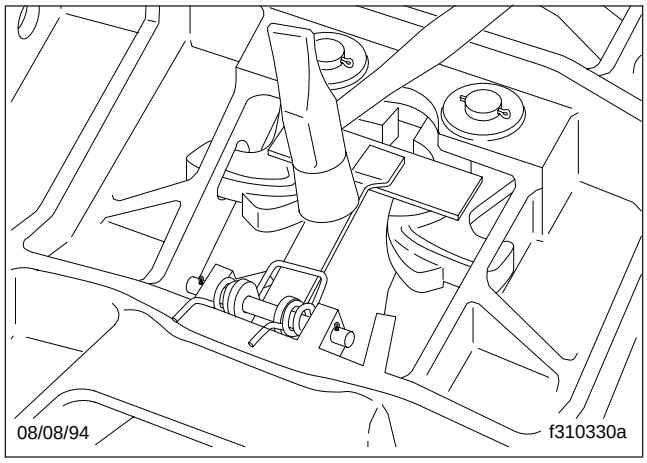


Fig. 16, Adjust the Guard

42. Using a Holland Lock Tester, close the locks. For instructions, refer to Holland Publication FW 130. Make sure that the locking mechanism functions properly. See **Fig. 17**. If the fifth wheel does not operate properly, repeat the above procedures or contact your local Holland representative for assistance.

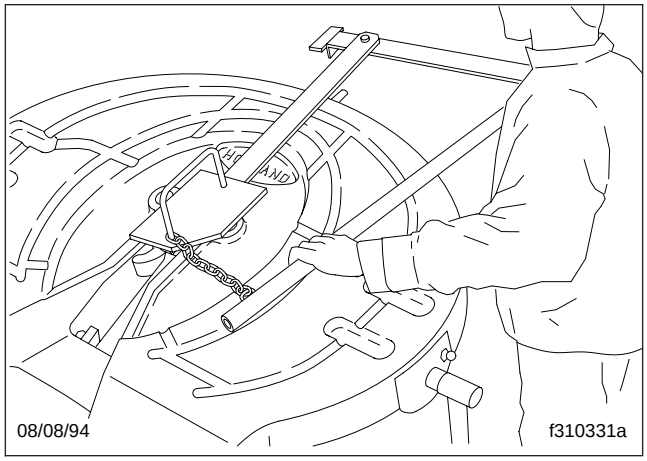


Fig. 17, Using the Lock Tester

IMPORTANT: The fifth wheel must be well lubricated to operate correctly. See Group 31 of the *Business Class Trucks Maintenance Manual*, for complete maintenance and lubrication instructions of the fifth wheel assembly.

Model XA–3501 Top Plate Assembly and Installation

⚠ WARNING

If the fifth wheel does not operate properly, do not use it. The fifth wheel could malfunction, resulting in bodily injury or property damage due to possible separation of the trailer from the tractor.

43. Using an overhead hoist, position the fifth wheel on the sliding mount assembly. Insert the bushing pins. Then install the roll pins.

Model XA–351 Top Plate Removal and Disassembly

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

Fifth wheel rebuild kits are available for servicing the 3500 series XA–351 fifth wheels. For the rebuild kits, the part numbers include:

- RK–351AL (left release with automatic secondary lock);
- RK–351A02L (left release with manual secondary lock);
- RK–351A (right release with automatic secondary lock);
- RK–351A02 (right release with manual secondary lock).

These fifth wheel rebuild kits contain all the replacement parts, except: the fifth wheel top plate; the bracket assembly rubber bushings; the bracket assembly bushing pins; and the bracket assembly bushing pin capscrews and locknuts.

Rebuilding the fifth wheel may be unnecessary. Review the troubleshooting section before rebuilding the fifth wheel. If the troubleshooting section does not correct the problem, then the fifth wheel may need rebuilding.

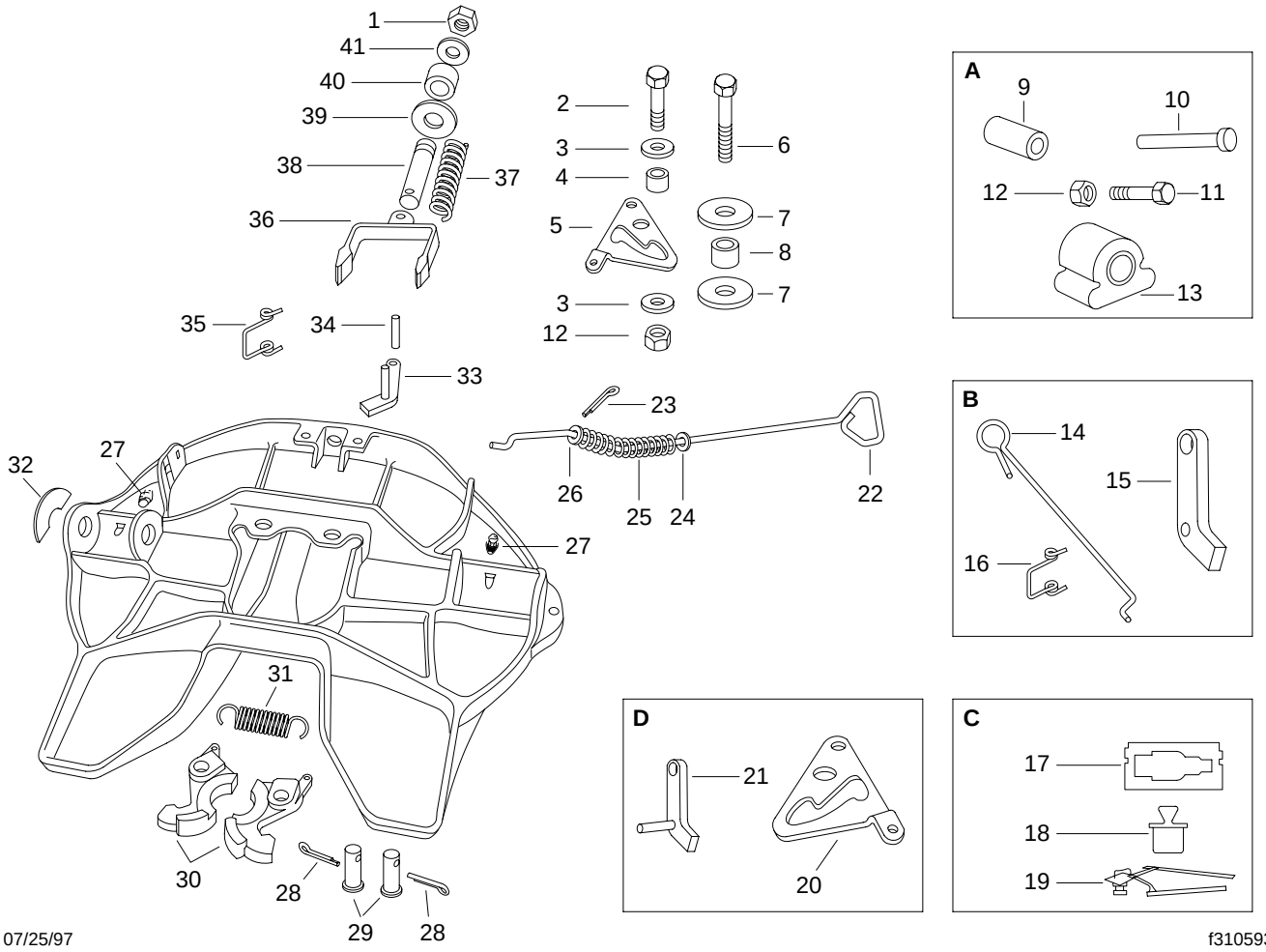
While disassembling the fifth wheel, Check it for cracks and for missing or damaged parts. Discard all used components.

Removal and Disassembly

(See Fig. 1)

1. Steam clean the top plate.
2. Remove the top plate from the bracket assembly.
   - 2.1 Loosen and remove the 1/2–20 bushing pin capscrews and locknuts from the top plate.
   - 2.2 Remove the bushing pins from the bracket assembly. See **Fig. 2**.
   - 2.3 Using an overhead hoist, lift the fifth wheel from the bracket assembly and tractor frame.
3. Disassemble the secondary lock.
   - 3.1 Turn the fifth wheel upside down with the locks open.
   - 3.2 Using a suitable driver and hammer, drive the 1/2-inch by 2-3/4 inch roll pin from the top plate and the secondary lock. See **Fig. 3**.
   - 3.3 If the fifth wheel has an automatic secondary lock, proceed to the next substep, otherwise, remove the manual secondary release handle by passing the "S" bend of the release handle through the large hole in the secondary lock and then through the guide hole. See **Fig. 4**.
   - 3.4 Remove the secondary lock.
4. Disassemble the cam plate.
   - 4.1 Loosen and remove the 5/8-inch capscrew from the threaded hole in the yoke. Remove the washers, and the roller from the cam plate. See **Fig. 5**.
   - 4.2 Loosen and remove the 1/2-inch capscrew and nut from the top plate lug. Remove the washers, and the roller from the cam plate. See **Fig. 6**.
   - 4.3 Remove the release handle by passing the "S" bend of the release handle through the large hole in the raised tab of the cam plate and through the top plate casting hole. See **Fig. 6**.
5. Disassemble the yoke.
   - 5.1 Slide the yoke shaft assembly away from the yoke, through the compression spring, and out of the top plate casting. See **Fig. 7**.
   - 5.2 Remove the compression spring and remove the yoke.
6. Disassemble the lock.
   - 6.1 Remove the cotter pins from the lockpins.
   - 6.2 Using a suitable driver and hammer, drive the lockpins out of the casting. See

Model XA–351 Top Plate Removal and Disassembly

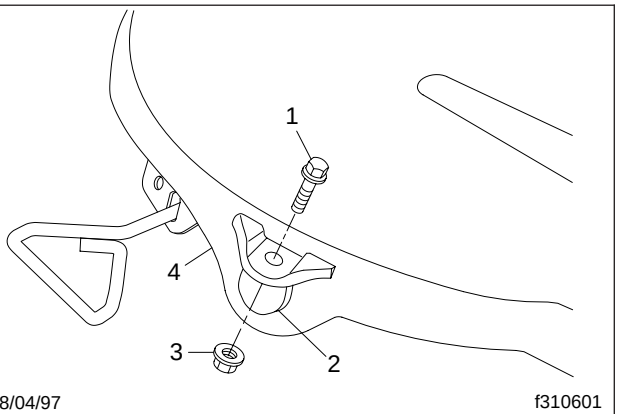


A. Bushing Pin Assembly
B. Manual Secondary Lock Assembly
C. Fifth Wheel Accessories
D. Right Hand Secondary Lock Assembly

1. Locknut, 3/4–16
2. Capscrew, 1/2–20 x 1–3/4)
3. Washer, 1–3/4" o.d. x 9/16" i.d.
4. Roller, 1/2" i.d.
5. Cam Plate (left-hand)
6. Capscrew, 5/8–18 x 3/4
7. Washer, 2–5/8 x 21/32
8. Roller, 5/8" i.d.
9. Rubber Bushing (brackets manufactured prior to 5/82)
10. Bracket Bushing Pin
11. Capscrew, 1/2–20 x 1–1/4
12. Locknut, 1/2–20
13. Rubber Bushing (brackets manufactured after 5/82)
14. Manual Secondary Lock Release Handle
15. Manual Secondary Lock
16. Torsion Spring
17. Kingpin Gauge
18. 2" Lock Gauge (Plug)
19. Kingpin Lock Tester
20. Cam Plate (right-hand)
21. Secondary Lock (right-hand)
22. Release Handle
23. Cotter Pin, 1/8 x 1–1/4
24. Washer, 1–3/8" o.d. x 9/16" i.d.
25. Compression Spring
26. Washer, 1–1/16" o.d. x 5/8" i.d.
27. Grease Zerk
28. Cotter Pin, 1/4 x 2
29. Lockpin
30. Lock Jaw Set
31. Extension Spring
32. Operation Tag
33. Secondary Lock (left-hand)
34. Roll Pin, 1/2 x 2–3/4
35. Torsion Spring
36. Yoke
37. Compression Spring
38. Yoke Shaft
39. Lock Adjustment Tag
40. Rubber Washer
41. Washer 1–1/2" o.d. x 13/16" i.d.

Fig. 1, Holland 3500 Series XA-351 Fifth Wheel and Accessories (bottom view)

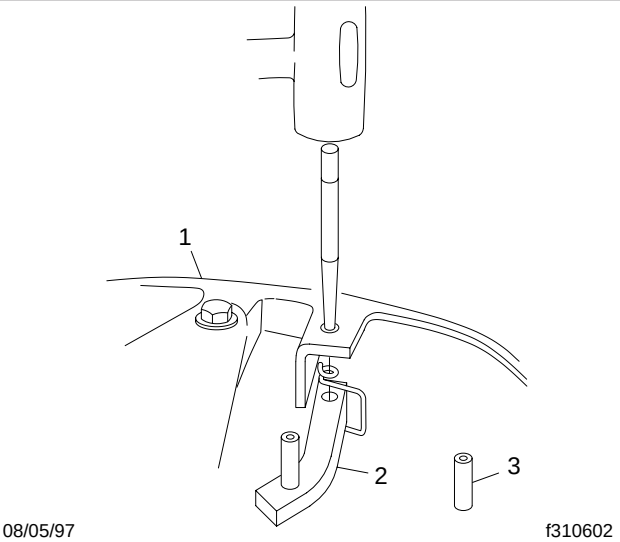
Model XA–351 Top Plate Removal and Disassembly



08/04/97 f310601

1. Capscrew
2. Bushing Pin
3. Locknut
4. Top Plate

Fig. 2, Remove the Bushing Pin

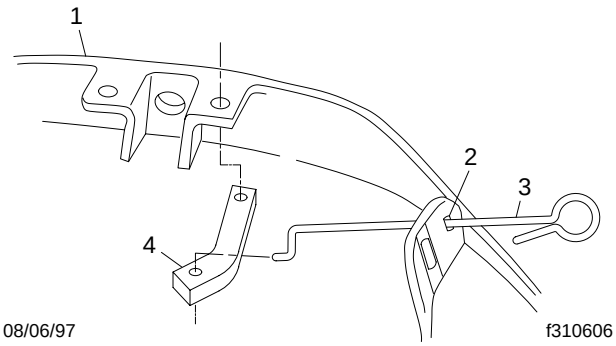


08/05/97 f310602

1. Top Plate
2. Secondary Lock
3. Roll Pin

Fig. 3, Disassemble the Secondary Lock

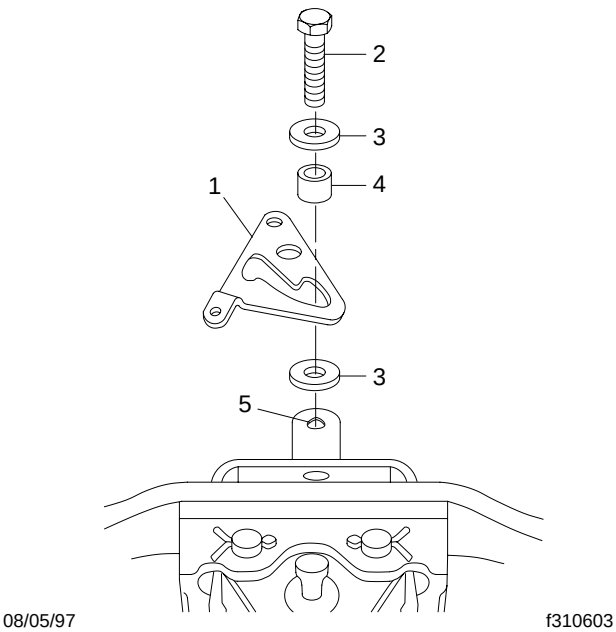
Fig. 8. This will free the lock jaws assembly. Remove the lock jaws and lock spring.



08/06/97 f310606

1. Top Plate
2. Guide Hole
3. Release Handle
4. Secondary Lock

Fig. 4, Remove the Release Handle

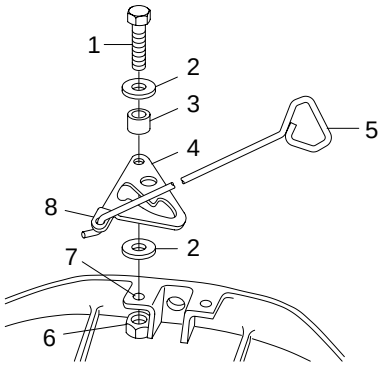


08/05/97 f310603

1. Cam Plate
2. Capscrew, 5/8–20
3. Washer
4. Roller
5. Threaded Hole In Yoke

Fig. 5, Remove the Capscrew From the Yoke

Model XA–351 Top Plate Removal and Disassembly



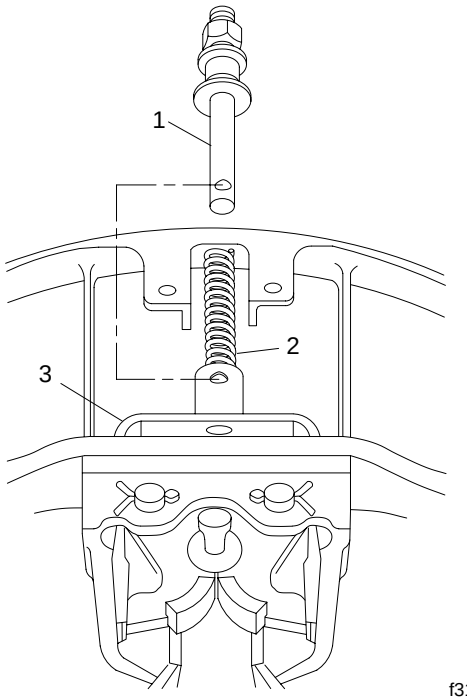
08/05/97 f310604

1. Capscrew, 1/2–20
2. Washer
3. Roller
4. Cam Plate
5. Release Handle
6. Nut, 1/2–20
7. Top Plate Lug
8. Raised Tab

Fig. 6, Disassemble the Cam Plate

⚠ WARNING

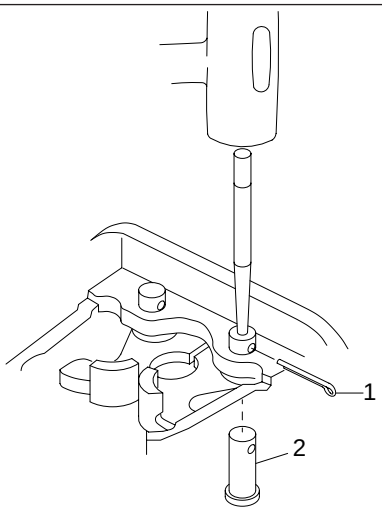
Do not attempt to repair or rebuild the top plate if it is cracked or if the lockpin does not fit tightly. The top plate could fail or the locks could malfunction. This could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.



08/04/97 f310600

1. Yoke Shaft Assembly
2. Compression Spring
3. Yoke

Fig. 7, Remove the Yoke Shaft Assembly



08/06/97 f310608

1. Cotter Pin
2. Lockpin

Fig. 8, Remove the Lockpins

Model XA–351 Top Plate Assembly and Installation

WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

Fifth wheel rebuild kits are available for servicing the 3500 series XA–351 fifth wheels. For the rebuild kits, the part numbers include:

- RK–351AL (left release with automatic secondary lock);
- RK–351A (right release with automatic secondary lock);
- RK–351A02L (left release with manual secondary lock);
- RK–351A02 (right release with manual secondary lock).

These fifth wheel rebuild kits contain all the replacement parts, except: the fifth wheel top plate; the bracket assembly rubber bushings; the bracket assembly bushing pins; and the bracket assembly bushing pin capscrews and locknuts.

Review the troubleshooting section before rebuilding the fifth wheel. Rebuilding may be unnecessary.

IMPORTANT: Use only Holland rebuilding kits. Replace all roll pins, springs, capscrews, nuts, and washers that are included in the kit. Do not reuse all parts.

WARNING

Use only genuine Holland parts and do not modify, change or add to the product. Any alterations to the fifth wheel assembly could compromise its performance. This could result in the loss of the trailer connection during vehicle travel, possibly causing bodily injury and property damage.

Assembly and Installation

(See Fig. 1)

WARNING

Do not attempt to repair or rebuild the top plate if it is cracked or distorted or if the lockpin does not fit tightly. The top plate could fail or the locks could malfunction. This could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

1. Inspect the top plate.
   - 1.1 If necessary, turn the fifth wheel upside down.
   - 1.2 Inspect the front lock surface for burrs or cracks. See **Fig. 2**. The front lock surface must be free of any burrs or cracks.
2. Install the lock.
   - 2.1 Lubricate the lockpin holes of the lock jaws with Never-Seez (provided in the kit). See **Fig. 3**.

CAUTION

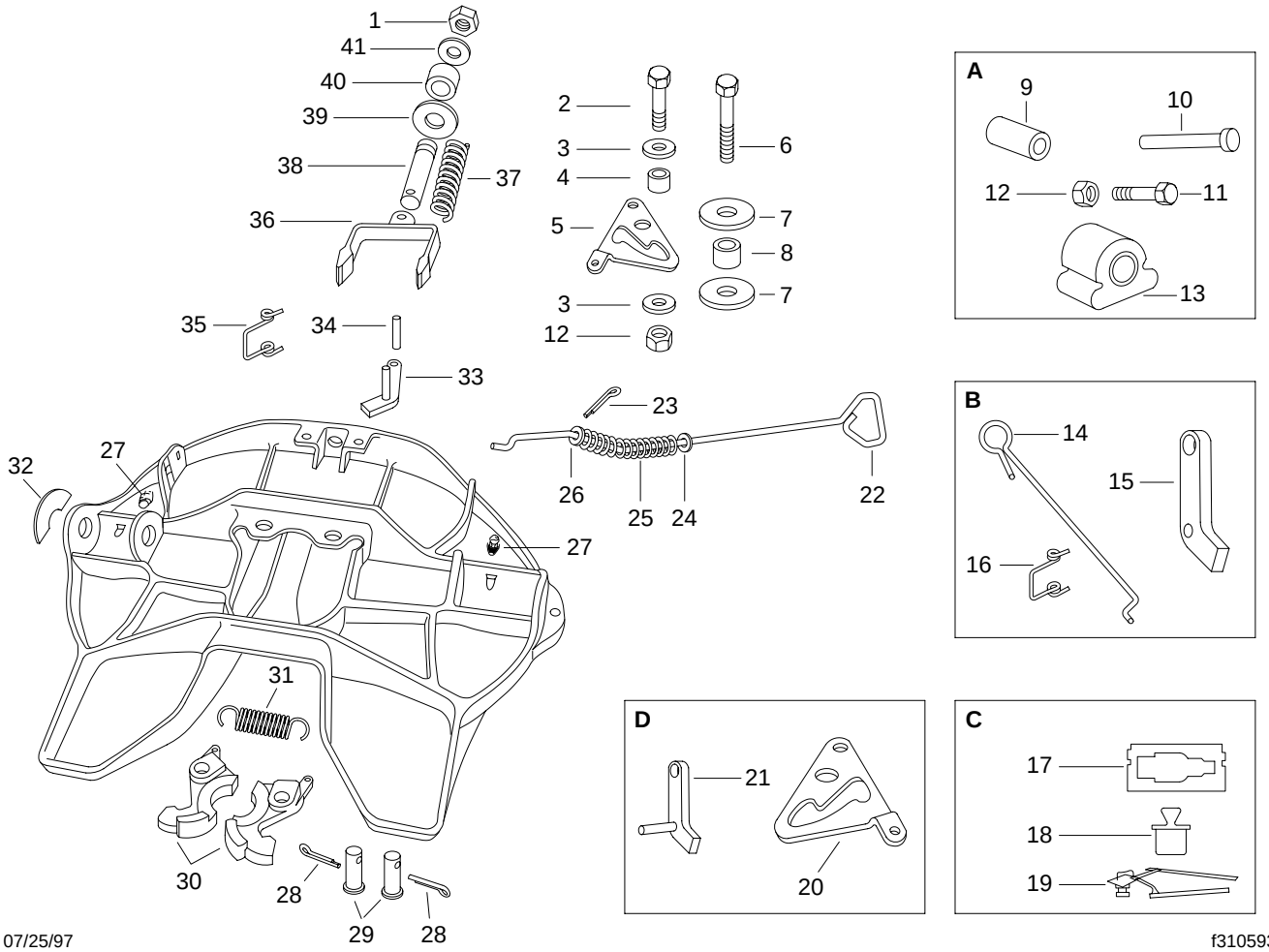
Use only Never-Seez. Other lubricants can damage the lockpin holes.

   - 2.2 Align the lock jaws in the casting and position the lock jaws so that the raised edge of the kingpin guides are facing up. See **Fig. 4**.
   - 2.3 Align the holes in the lockpins so that the cotter pins can be inserted. Insert the lockpins into the casting and through the lock jaws. Using a suitable hammer, drive the lockpins into the casting until the heads are flush with the casting. See **Fig. 5**.
   - 2.4 Insert the cotter pins and spread.
   - 2.5 Check that the lock jaws move freely.

WARNING

You must use a Holland lock gauge (TF–0237) or a precision plug that is 2.000 ± 0.005 inch (5.08 ± 0.0127 cm) for proper installation of the locking

Model XA–351 Top Plate Assembly and Installation



A. Bushing Pin Assembly
B. Manual Secondary Lock Assembly
C. Fifth Wheel Accessories
D. Right Hand Secondary Lock Assembly

1. Locknut, 3/4–16
2. Capscrew, 1/2–20 x 1–3/4
3. Washer, 1–3/4" o.d. x 9/16" i.d.
4. Roller, 1/2" i.d.
5. Cam Plate (left-hand)
6. Capscrew, 5/8–18 x 3/4
7. Washer, 2–5/8 x 21/32
8. Roller, 5/8" i.d.
9. Rubber Bushing (brackets manufactured prior to 5/82)
10. Bracket Bushing Pin
11. Capscrew, 1/2–20 x 1–1/4
12. Locknut, 1/2–20
13. Rubber Bushing (brackets manufactured after 5/82)
14. Manual Secondary Lock Release Handle
15. Manual Secondary Lock
16. Torsion Spring
17. Kingpin Gauge
18. 2" Lock Gauge (Plug)
19. Kingpin Lock Tester
20. Cam Plate (right-hand)
21. Secondary Lock (right-hand)
22. Release Handle
23. Cotter Pin, 1/8 x 1–1/4
24. Washer, 1–3/8" o.d. x 9/16" i.d.
25. Compression Spring
26. Washer, 1–1/16" o.d. x 5/8" i.d.
27. Grease Zerk
28. Cotter Pin, 1/4 x 2
29. Lockpin
30. Lock Jaw Set
31. Extension Spring
32. Operation Tag
33. Secondary Lock (left-hand)
34. Roll Pin, 1/2 x 2–3/4
35. Torsion Spring
36. Yoke
37. Compression Spring
38. Yoke Shaft
39. Lock Adjustment Tag
40. Rubber Washer
41. Washer, 1–1/2" o.d. x 13/16" i.d.

Fig. 1, Holland 3500 Series XA-351 Fifth Wheel and Accessories (bottom view)

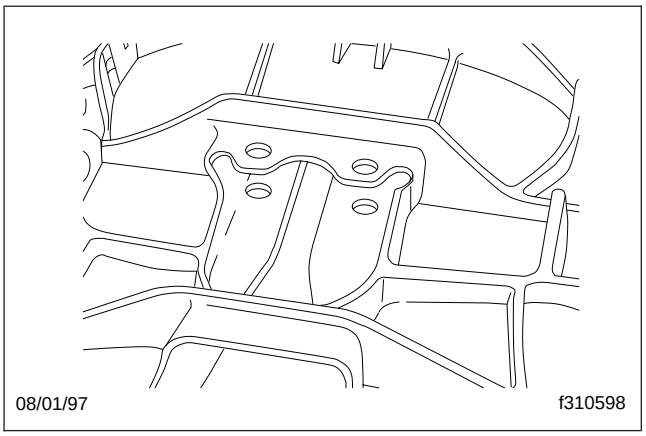
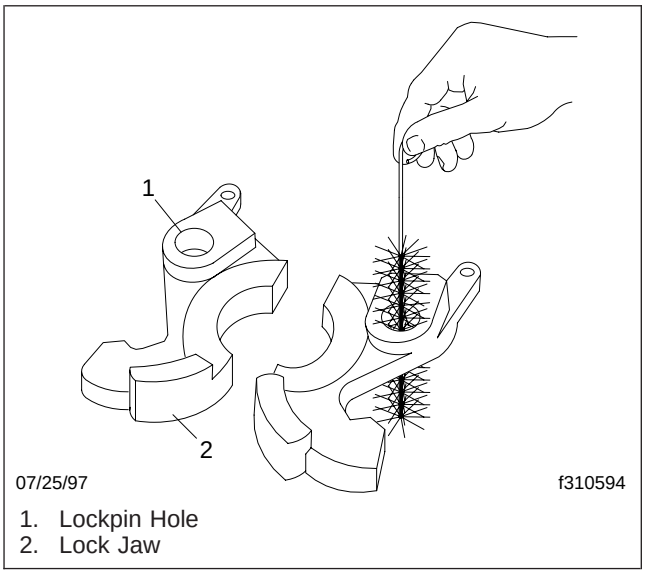


Fig. 2, Front Lock Surface Inspection



1. Lockpin Hole
2. Lock Jaw

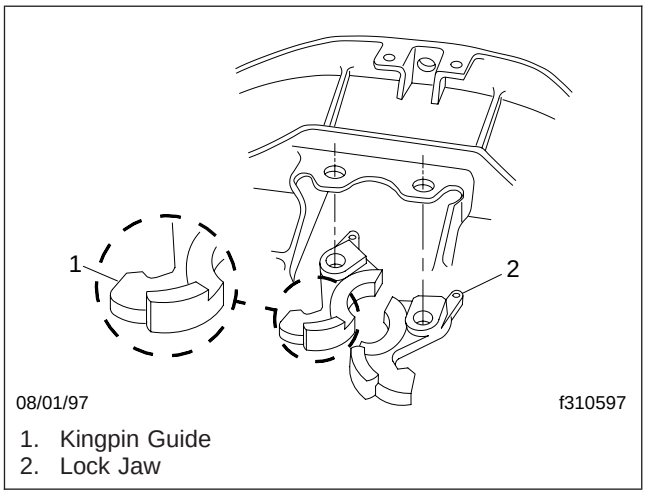
Fig. 3, Lubricate the Lockpin Holes

mechanism. If the proper plug is not used, the lock could malfunction or fail. This could result in the loss of the trailer connection during vehicle travel, possibly causing personal injury and property damage.

2.6 Position a 2-inch (5.08 cm) diameter "plug" into the lock jaws. See **Fig. 6**. A lock gauge, Holland part number TF–0237 is available at a Holland distributor.

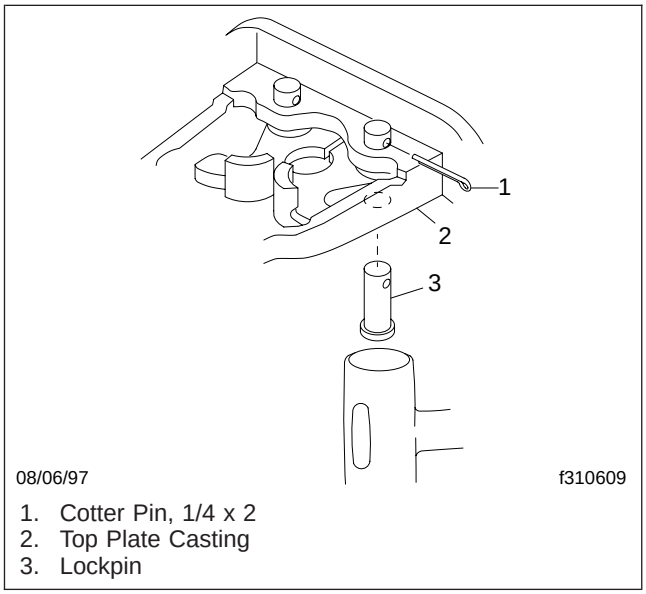
3. Install the yoke.

3.1 Lubricate the surface area of the yoke tips with light grease. With the threaded



1. Kingpin Guide
2. Lock Jaw

Fig. 4, Align the Lock Jaws



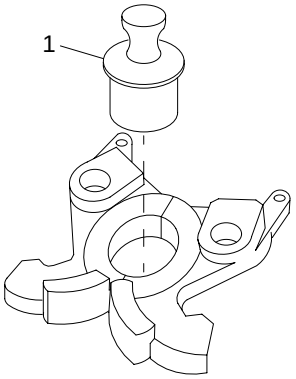
1. Cotter Pin, 1/4 x 2
2. Top Plate Casting
3. Lockpin

Fig. 5, Install the Lockpins

hole facing up, slide the yoke into the casting and seat it around the locks. See **Fig. 7**.

3.2 Inspect the amount of yoke tip engagement. Yoke tips must extend flush with the end of the locks and no more then 1/2 inch (12.7 mm) past the locks. See **Fig. 8**. If the new yoke extends more than 1/2 inch (12.7 mm) past the locks, *do not use it*. Discard it and order part number

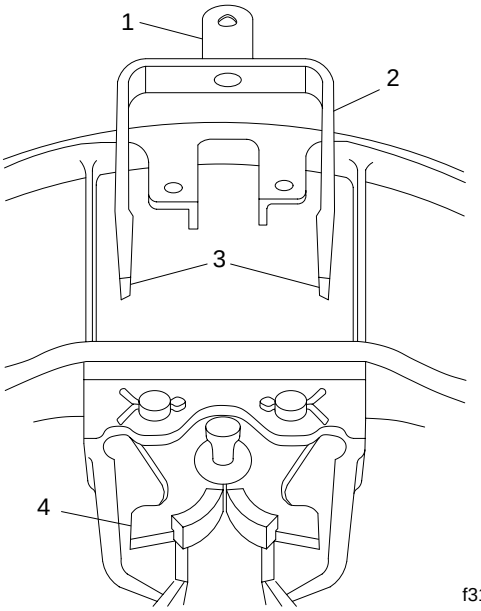
Model XA–351 Top Plate Assembly and Installation



08/01/97 f310599

1. Lock Gauge (Plug)

Fig. 6, Install the Lock Gauge



08/06/97 f310610

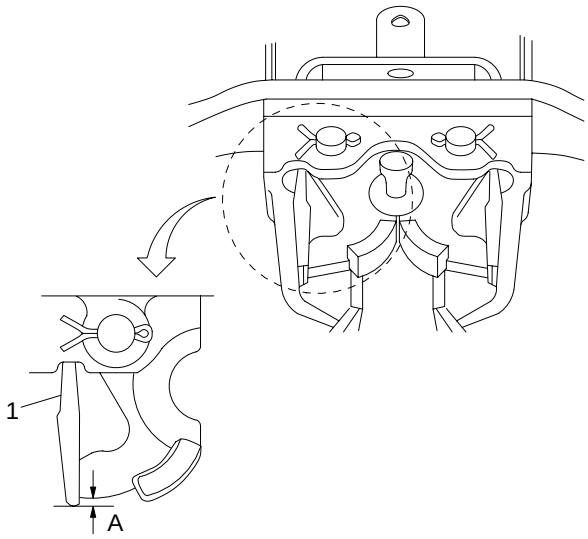
1. Threaded hole
2. Yoke
3. Yoke Tips
4. Lock

Fig. 7, Install the Yoke

XA–07295–THK from your nearest Holland distributor.

3.3 Install the lock spring. See **Fig. 9**.

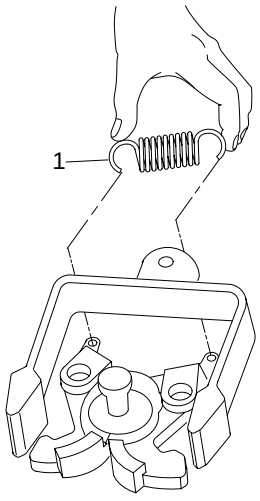
3.4 Install the yoke spring. Slide the yoke shaft into the casting, through the yoke spring and into the yoke. Align the re-



08/06/97 f310611

A. Measurement: 1/2" (12.7 mm) Maximum
1. Yoke Tip

Fig. 8, Measure the Yoke Tip Engagement



08/13/97 f310623

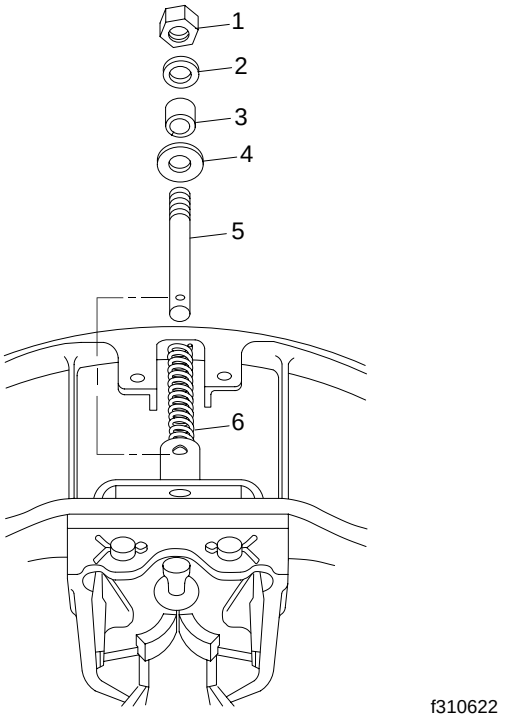
1. Lock Spring

Fig. 9, Install the Lock Spring

cessed hole in the yoke shaft with the threaded hole in the yoke. See **Fig. 10**.

3.5 In this order, slide the lock adjustment tag, rubber washer, and 1-1/2 inch

Model XA–351 Top Plate Assembly and Installation



1. Locknut, 3/4–16
2. Washer, 1–1/2" o.d. x 13/16" i.d.
3. Rubber Washer
4. Lock Adjustment Tag
5. Yoke Shaft
6. Yoke Spring

Fig. 10, Install and Assemble the Yoke Shaft

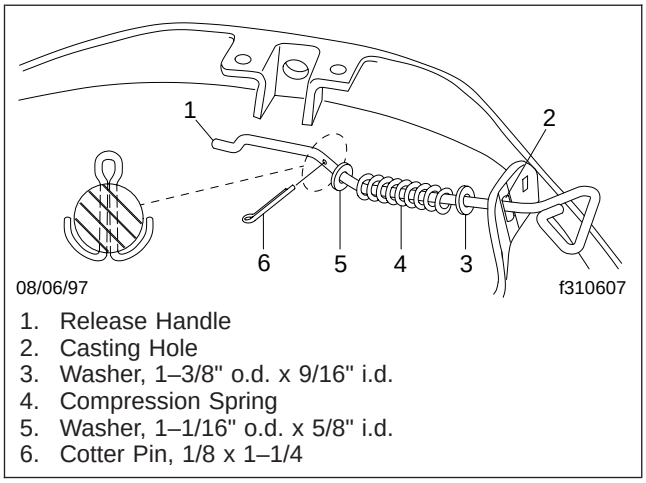
washer onto the yoke shaft. Then, start the locknut and turn it finger tight. See **Fig. 10**.

4. Install the release handle.

   4.1 Slide the release handle through the hole in the casting (on the left side for left release or on the right side for right release). See **Fig. 11**.

   4.2 In this order, slide the 1-3/4 inch washer, compression spring, and 1-1/16 inch washer over the "S" bend of the release handle.

   4.3 Compress the spring using the 1-1/16 inch washer until the cotter pin hole is exposed.



1. Release Handle
2. Casting Hole
3. Washer, 1–3/8" o.d. x 9/16" i.d.
4. Compression Spring
5. Washer, 1–1/16" o.d. x 5/8" i.d.
6. Cotter Pin, 1/8 x 1–1/4

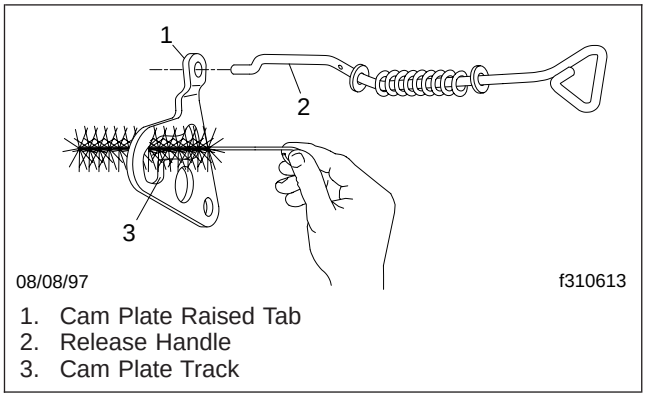
Fig. 11, Install the Release Handle

   4.4 Insert the cotter pin; spread it and wrap it completely around the release handle. See **Fig. 11**.

5. Install the cam plate.

   5.1 Inspect the cam plate for burrs and remove as required.

   5.2 Lubricate the cam plate track and pivot hole with light grease. Then connect the raised tab in the cam plate to the "S" bend in the release handle. See **Fig. 12**.



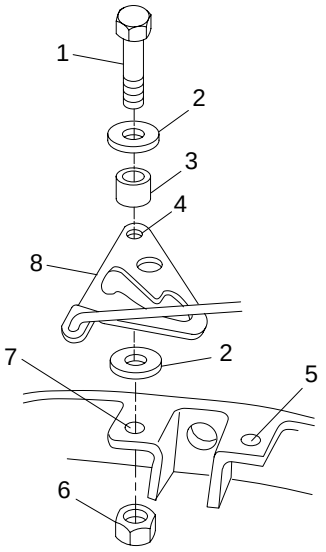
1. Cam Plate Raised Tab
2. Release Handle
3. Cam Plate Track

Fig. 12, Lubricate the Cam Plate

   5.3 Position the cam plate attachment hole over the proper casting lug hole. Then, slide the 1-3/4 inch washer between the cam plate and casting lug hole with the rounded side of the washer facing the cam plate. Then install the 1/2-inch roller

Model XA–351 Top Plate Assembly and Installation

into the cam plate and place the second 1-3/4 inch washer on top of the roller with the rounded side facing the cam plate. See **Fig. 13**.



08/14/97 f310624

1. Capscrew, 1/2–20 x 1–3/4
2. Washer, 1–3/4" o.d. x 9/16" i.d.
3. Roller, 1/2" i.d.
4. Cam Plate Attachment Pivot Hole
5. Hole for Right Release
6. Locknut, 1/2–20
7. Hole for Left Release
8. Cam Plate

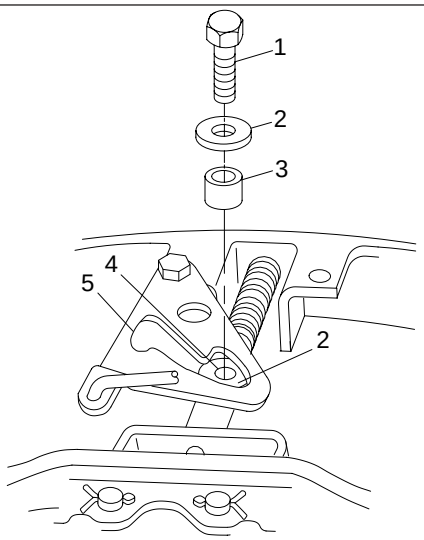
Fig. 13, Install the Cam Plate

5.4 Install the 1/2-inch capscrew through the washers, roller, and top plate lug. Then, secure the capscrew with the 1/2-inch locknut and tighten securely. See **Fig. 13**.

5.5 Check for free movement of the cam plate.

NOTE: When installing the washers, the rounded edge of the washers *must* always face the cam plate.

5.6 Align the cam plate track over the threaded hole in the yoke. Then slide a 2-5/8 inch o.d. washer between the yoke and the cam plate with the rounded side of the washer facing the cam plate. Then place the 5/8-inch roller into the cam plate track and place the second 2-5/8 inch o.d. washer over the roller with the rounded side of the washer facing the cam plate. See **Fig. 14**.



08/14/97 f310625

1. Capscrew (5/8–18 x 1–3/4")
2. Washer (2-5/8 x 21/32")
3. Roller (5/8" i.d.)
4. Threaded Hole in Yoke
5. Cam Plate Track

Fig. 14, Install the Capscrew Into the Yoke

5.7 Check the alignment of the recessed hole in the yoke shaft. Then, install the 5/8-inch capscrew through the washers, roller, and cam plate and into the threaded hole in the yoke. Make sure the capscrew enters the recessed hole in the yoke shaft. Then, tighten the capscrew securely. See **Fig. 14**.

5.8 Check for free movement of the cam plate.

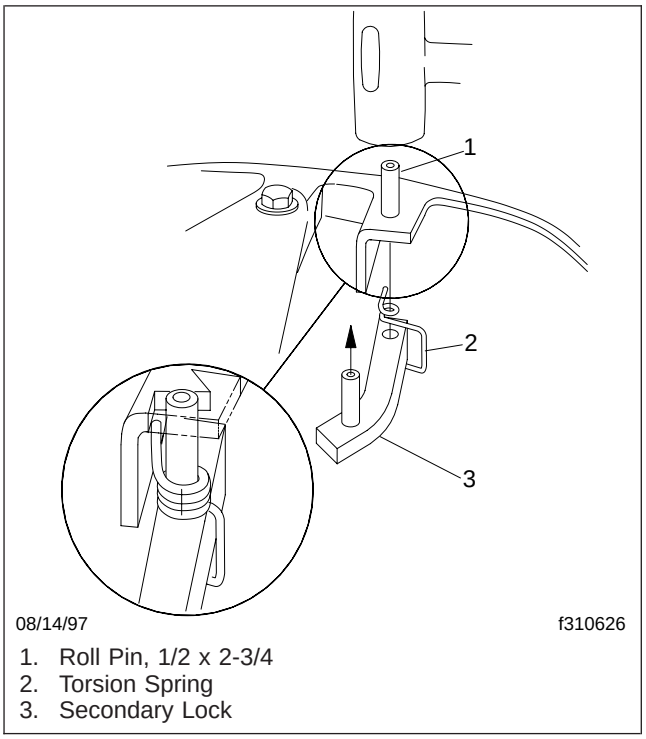
6. Install the secondary lock.

6.1 If equipped with the automatic version, start the roll pin into the hole in the top plate opposite the cam attachment capscrew. Then, assemble and install the secondary lock and torsion spring. Make sure the flats of the torsion spring are resting against the casting. See **Fig. 15**.

With a suitable hammer, drive the roll pin through the torsion spring and secondary

lock until the roll pin is flush with the casting. See **Fig. 15**.

Check the lock spring for tension and lock for free movement.



1. Roll Pin, 1/2 x 2-3/4
2. Torsion Spring
3. Secondary Lock

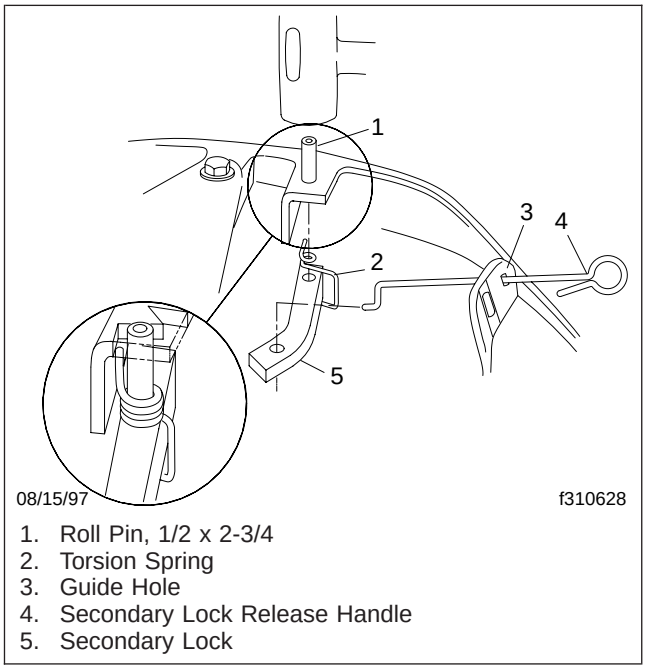
Fig. 15, Install the Secondary Lock

6.2 Pass the "S" bend of the manual secondary release handle through the casting guide hole (if equipped with the manual version). Then, pass the "S" bend of the release handle through the large hole in the secondary lock. See **Fig. 16**.

6.3 Start the roll pin into the hole in the top plate opposite the cam attachment capscrew (if equipped with the manual version). Then, assemble and install the secondary lock and torsion spring. Make sure the flats of the torsion spring are resting against the casting. See **Fig. 16**.

6.4 With a suitable hammer, drive the roll pin through the torsion spring and secondary lock until the roll pin is flush with the casting (if equipped with the manual version). See **Fig. 16**.

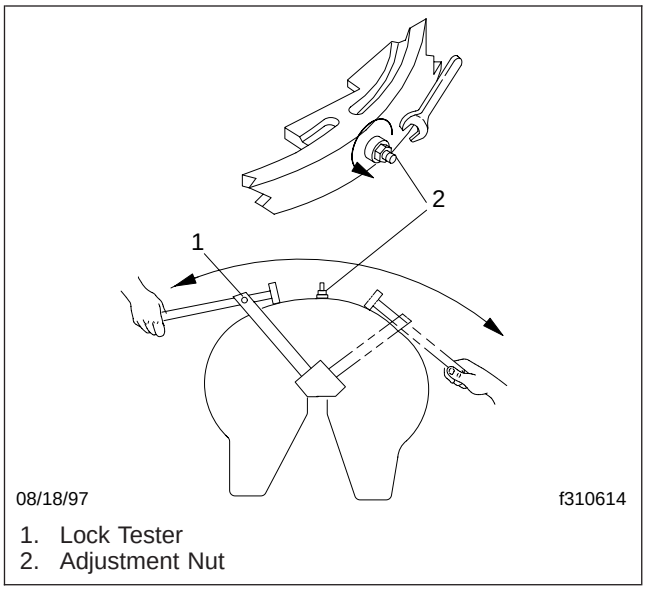
6.5 Check the lock spring for tension and lock for free movement.



1. Roll Pin, 1/2 x 2-3/4
2. Torsion Spring
3. Guide Hole
4. Secondary Lock Release Handle
5. Secondary Lock

Fig. 16, Install the Secondary Lock

7. Adjust the lock. See **Fig. 17**.



1. Lock Tester
2. Adjustment Nut

Fig. 17, Adjusting the Lock

Model XA–351 Top Plate Assembly and Installation

7.1 If equipped, pull the secondary release handle and hook it on the casting. Next, pull the primary release handle to open the locks. Now, remove the 2-inch plug.

7.2 Turn the fifth wheel right side up and close the locks using a Holland Lock tester (see Holland publication FW130 for operating instructions for the lock tester).

7.3 Verify that the locks are completely closed around the kingpin. The lock halves should be seated against each other.

7.4 Alternate tightening the adjustment nut and attempting to turn the lock tester back and forth. Continue tightening the adjustment nut until there is some resistance felt in the lock tester (as it is turned back and forth).

The fifth wheel is properly adjusted when there is resistance between locks and the lock tester, but the lock tester can still be turned by hand.

7.5 Pull the release handle and remove the lock tester.

8. Check the fifth wheel for proper operation.

8.1 Using the Holland lock tester, open and close the fifth wheel at least three times.

Each time you close the locks, verify that the locks have closed completely around the kingpin and that the adjustment nut and rubber bushing are seated snug against the casting.

8.2 Check for resistance between the locks and the lock tester one final time, and adjust as needed.

⚠ WARNING

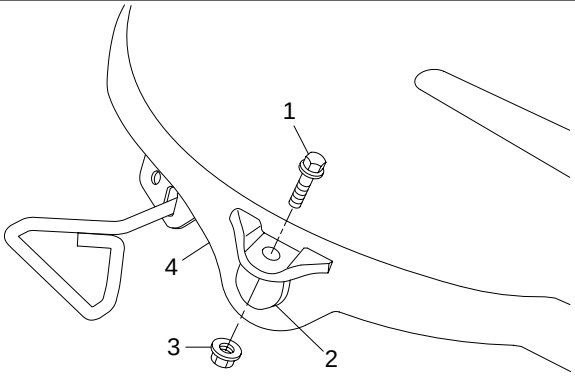
If the fifth wheel does not operate properly, do not use it. Either disassemble it and repeat the rebuilding procedure or contact your nearest Holland representative for assistance. Never use a fifth wheel that does not operate properly. The fifth wheel could malfunction, resulting in bodily injury or property damage due to a possible separation of the trailer from the tractor.

8.3 The fifth wheel is now ready for operation.

9. Install the top plate.

9.1 Using an overhead hoist, lift and position the fifth wheel over the bracket assembly.

9.2 Install the bushing pins through the fifth wheel and into the bracket assembly. Then, install and tighten securely the 1/2–20 bushing pin capscrews and locknuts. See **Fig. 18**. Remove the overhead hoist.



1. Capscrew
2. Bushing Pin
3. Locknut
4. Top Plate

Fig. 18, Install the Bushing Pin

9.3 Lubricate the fifth wheel. For instructions, see Group 31 of the *Business Class Trucks Maintenance Manual*.

Troubleshooting Tables

Problem—The Fifth Wheel Is Hard to Hook Up to the Trailer

Problem—The Fifth Wheel Is Hard to Hook Up to the Trailer	
Possible Cause	**Remedy**
The trailer may be too high; the kingpin is not entering the locks properly.	Lower the trailer landing gear until the bolster plate contacts the fifth wheel
The locks are closed.	Pull the release handle and pry open the locks.
Rust or grime is interfering with the lock operation.	Spray a light lubricant or diesel fuel on all moving parts including the release handle. Operate the release mechanism several times.
The fifth wheel locks are too tight.	Check the lock adjustment. Correct as needed.
A bent release handle, bent kingpin, or damaged bolster plate is interfering with the lock movement.	Check the release handle, kingpin, and bolster plate. Replace parts as required.
The locks are damaged.	Inspect the locks and replace parts as required.
The fifth wheel needs rebuilding.	Rebuild the fifth wheel, using the parts in the appropriate rebuilding kit.

Problem—The Fifth Wheel Is Hard to Unhook from the Trailer

Problem—The Fifth Wheel Is Hard to Unhook from the Trailer	
Possible Cause	**Remedy**
The secondary lock is not released.	If equipped with a manual secondary lock, pull the release handle and lock it open by resting it against the top plate. If equipped with an automatic secondary lock, inspect the lock for missing or broken parts, and repair or replace as required.
The tractor is putting pressure against the locks.	Set trailer brakes. Back the tractor into the trailer to relieve pressure and lock the tractor brakes before pulling the release handle.
There is rust or grime on the locking mechanism.	Spray a light lubricant or diesel fuel on all moving parts including the release handle. Operate the release mechanism several times.
The kingpin is bent or the bolster plate is damaged.	Check the kingpin, using a Holland TF–0110 Kingpin Gauge. Check the bolster plate, using a 48-inch (122 cm) straight edge. Repair or replace parts as required.
The fifth wheel locks are too tight.	Check the lock adjustment. Correct as needed.
The release handle will not stay out or must be held out when unlocking.	Replace the cam or release arm and the release handle spring.

General Description

Fontaine 5000 series fifth wheels are used for pulling trailers having a standard kingpin. When installed as a stationary fifth wheel, it is bracket-mounted to the tractor frame in a position that best distributes the trailer load over the tractor axles **(Fig. 1).**

The Fontaine fifth wheel lock mechanism for the trailer kingpin consists of a spring-loaded jaw and a sliding wedge. Kingpin release is accomplished by activating a manual lock control handle located on the left side (roadside) of the fifth wheel. Kingpin lockup occurs when the kingpin is forced into the jaws and the lock control handle moves to the locked position.

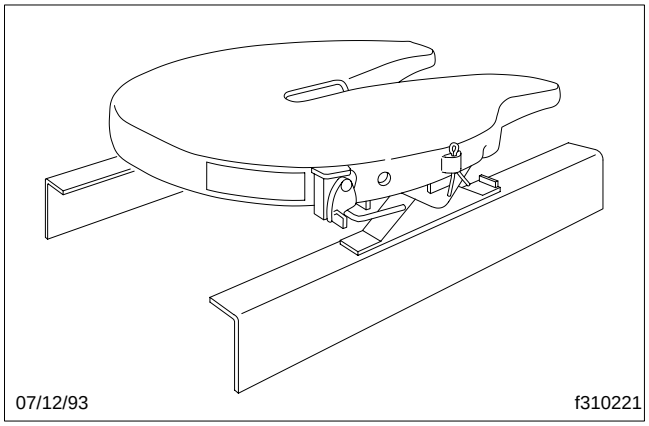


Fig. 1, Fontaine 5000 Series Fifth Wheel and Angle Mount

Principles of Operation

As the kingpin enters the lock mechanism, the jaw is moved first with the spring-loaded wedge sliding in place against the jaw. **See Fig. 2.** The jaw will move behind the kingpin, followed by the wedge. The wedge reinforces the jaw and takes up slack around the kingpin.

Placing the lock control handle in the unlocked position moves the wedge and jaw out from behind the kingpin. This action unlocks the fifth wheel, allowing freedom of movement underneath the trailer when the tractor is moved.

Refer to the vehicle driver's manual for complete operating instructions.

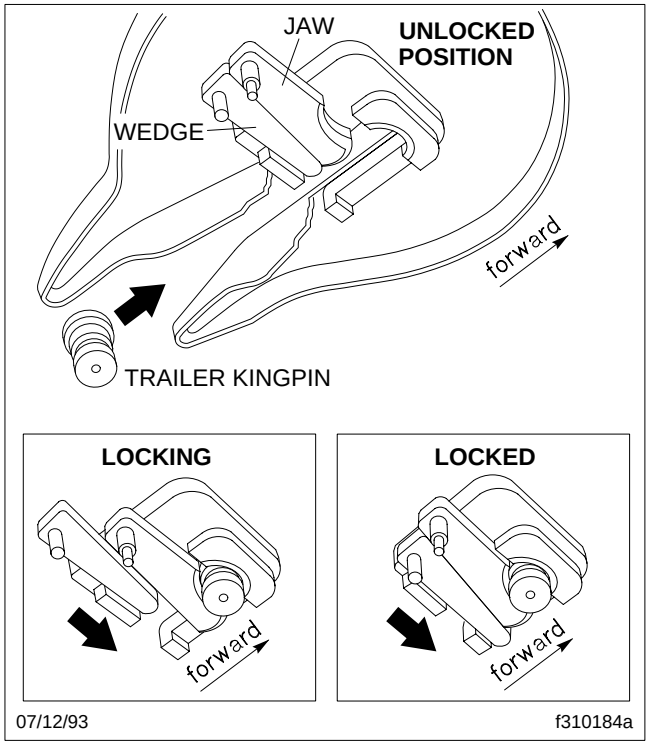
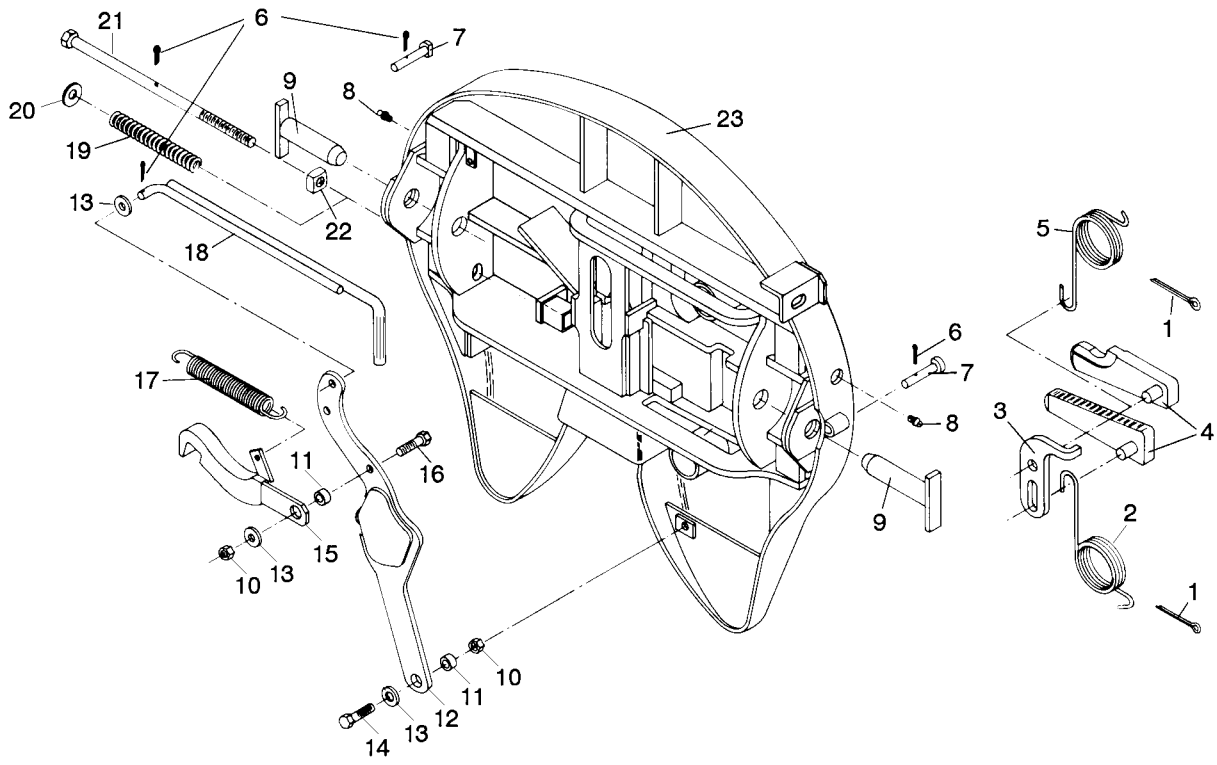


Fig. 2, Fontaine Kingpin Lock Mechanism

Removal and Disassembly

(See Fig. 1)



1. 3−Inch Cotter Pin
2. Wedge Spring
3. Timer
4. Jaw and Wedge
5. Jaw Spring
6. 1−Inch Cotter Pin
7. Retaining Pin
8. Grease Fitting
9. Bushing Pin
10. 1/2−13 Locknut
11. Pivot Bushing
12. Operating Handle
13. 1/2−Inch Flatwasher
14. 1/2−13 x 2−Inch Hexhead Capscrew
15. Bumper
16. 1/2−13 x 1−1/2 Inch Hexhead Capscrew
17. Bumper Spring
18. Release Handle
19. Wedge Stoprod Spring
20. 5/8−Inch Flatwasher
21. Wedge Stoprof
22. 5/8−11 Square Nut
23. Fifth Wheel Top Plate

07/12/93 f310220

Fig. 1, Fontaine 5000 Series Fifth Wheel (Left-Side Release Shown)

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in a hazardous operating condition due to a possible disengagement of the trailer from the tractor.

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.

1. Steam clean the top plate. Remove it from the sliding mount by removing the cotter pins (Ref. 6) from the retaining pins (Ref. 7). Remove the retaining pins and bushing pins (Ref. 9) from both sides of the top plate.

Removal and Disassembly

2. Using an overhead hoist, lift the fifth wheel off the angle mount and tractor frame.
3. Turn the fifth wheel upside down.

⚠ WARNING

Do not attempt to repair or rebuild the top plate if it is cracked or if parts are damaged. The top plate or parts could malfunction. This could result in disengagement of the trailer during vehicle travel, possibly causing personal injury and property damage.

NOTE: While disassembling the fifth wheel, check it for cracks and for missing or damaged parts.

4. Unhook the bumper spring (Ref. 17) from its clasp. See **Fig. 2**.
5. Remove the two hexhead capscrews (Refs. 14 and 16) from the operating handle (Ref. 12). See **Fig. 3**.
6. Remove the bumper (Ref. 15). See **Fig. 4**.
7. Remove the cotter pin (Ref. 6) and flatwasher (Ref. 13) that attach the release handle (Ref. 18) to the operating handle.

   Slide the release handle out through the side of the fifth wheel. See **Fig. 5**.
8. Slide the operating handle over to the side of the fifth wheel. See **Fig. 6**.

NOTE: Slide the bottom part of the operating handle first. This will allow the handle to clear the studs under the handle.

9. Lift the timer (Ref. 3) off the studs. See **Fig. 7**.
10. Slide the operating handle out through the slot at the top or bottom of the fifth wheel. See **Fig. 8**.
11. Using pliers or a screwdriver, pry the wedge and jaw springs (Refs. 2 and 5) over the studs. See **Fig. 9**.
12. Remove the jaw and wedge (Ref. 4). See **Fig. 10**.
13. Remove the jaw and wedge springs as follows:

    13.1 Remove the cotter pin **(Fig. 11)**.

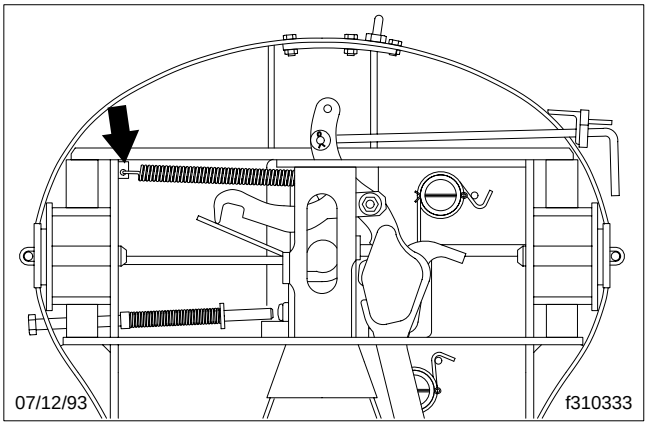


Fig. 2

13.2 Using a screwdriver, pry up on the spring to relieve tension and remove it. See **Fig. 12**.

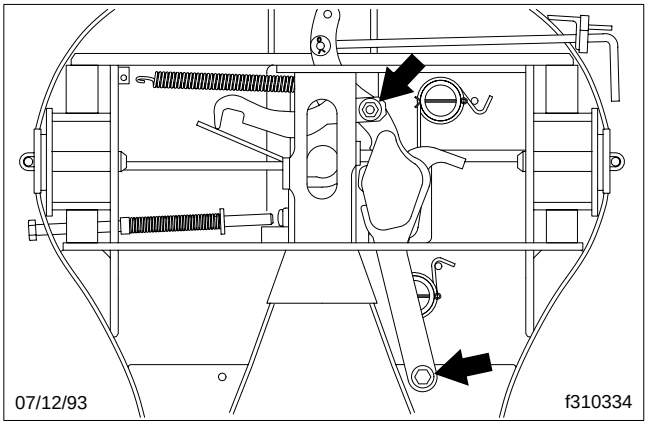


Fig. 3

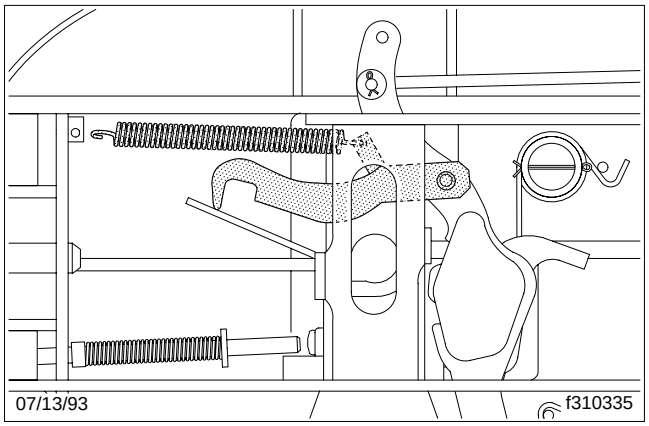


Fig. 4

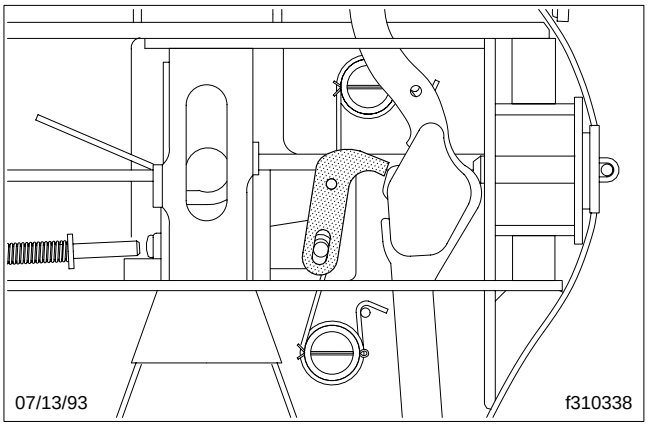


Fig. 7

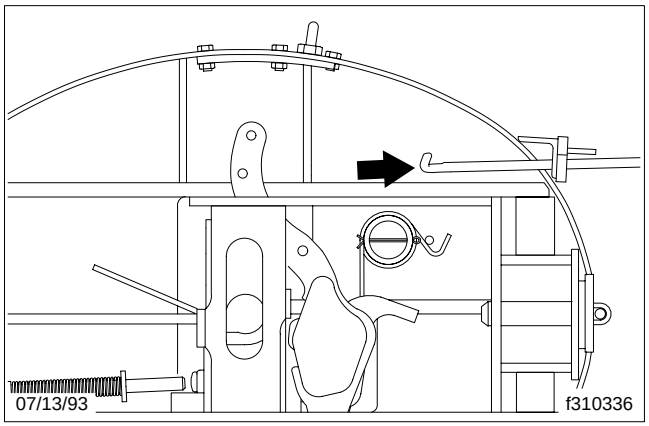


Fig. 5

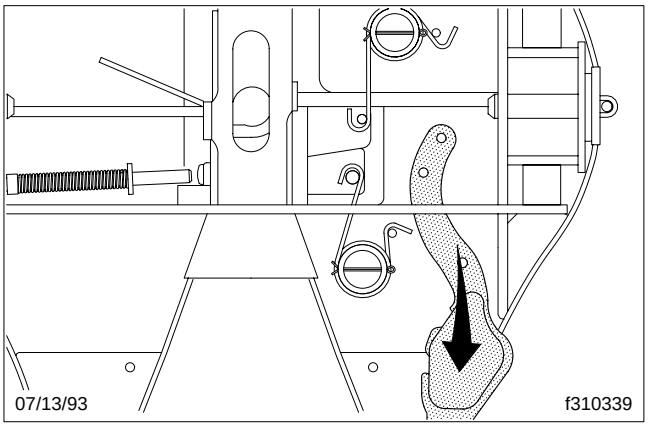


Fig. 8

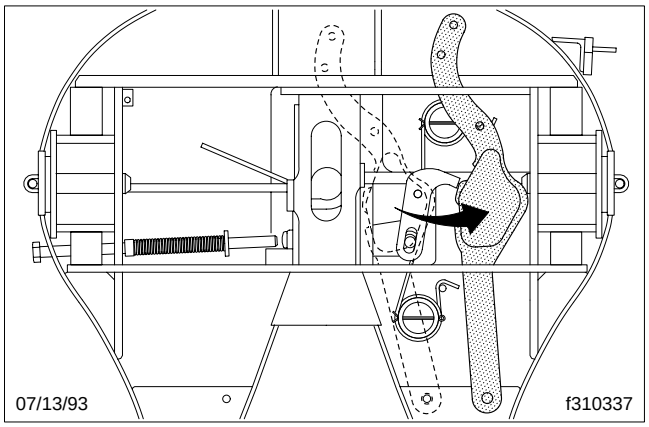


Fig. 6

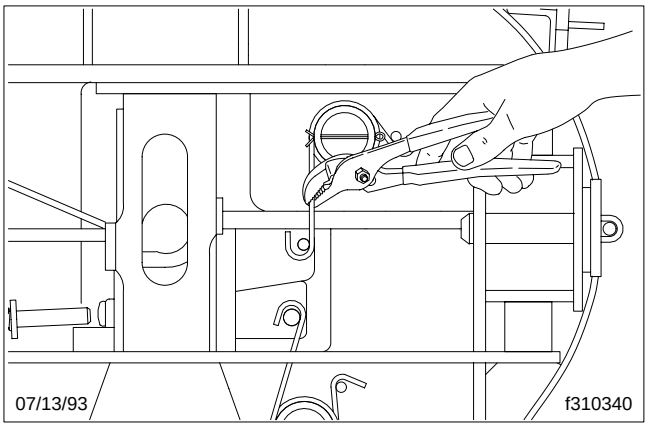


Fig. 9

Removal and Disassembly

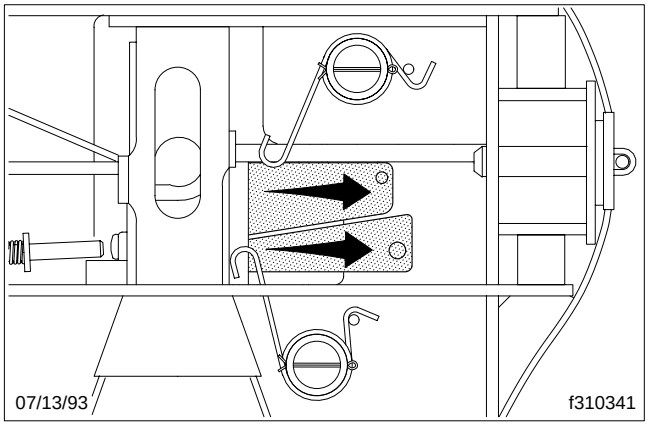


Fig. 10

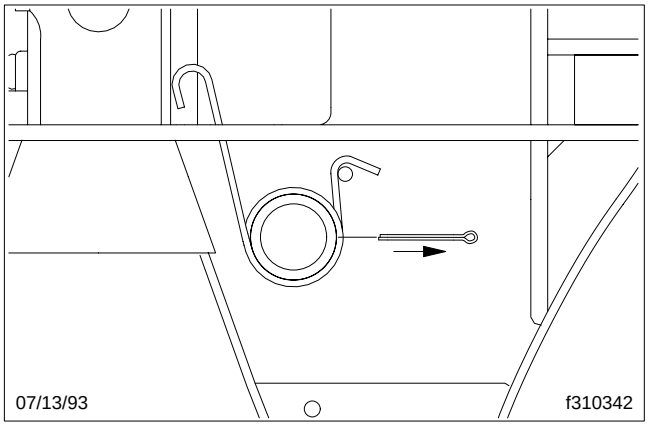


Fig. 11

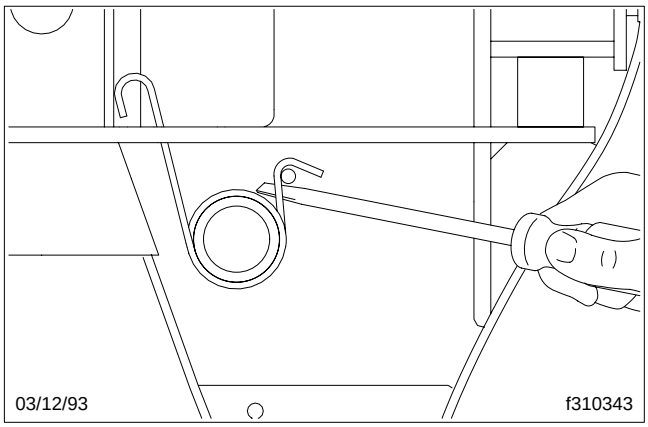
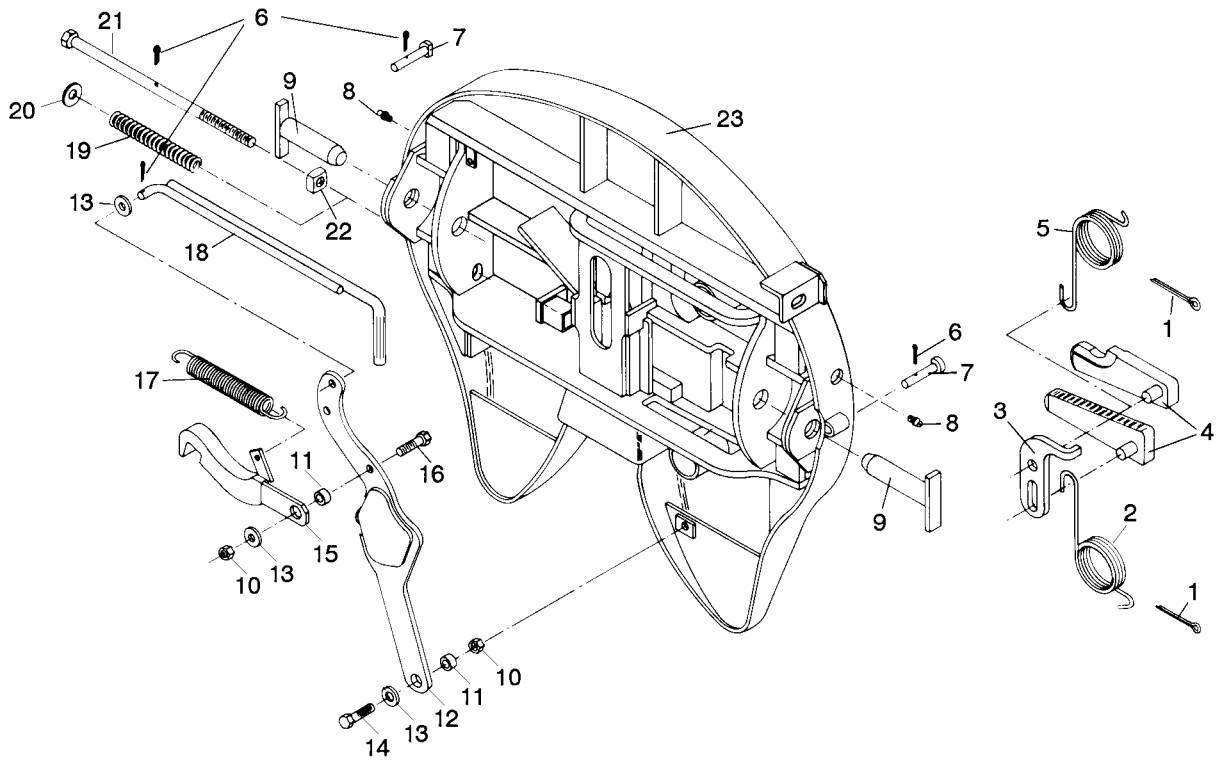


Fig. 12

Assembly and Installation

(See Fig. 1)



1. 3−Inch Cotter Pin
2. Wedge Spring
3. Timer
4. Jaw and Wedge
5. Jaw Spring
6. 1−Inch Cotter Pin
7. Retaining Pin
8. Grease Fitting
9. Bushing Pin
10. 1/2−13 Locknut
11. Pivot Bushing
12. Operating Handle
13. 1/2−Inch Flatwasher
14. 1/2−13 x 2−Inch Hexhead Capscrew
15. Bumper
16. 1/2−13 x 1−1/2 Inch Hexhead Capscrew
17. Bumper Spring
18. Release Handle
19. Wedge Stoprod Spring
20. 5/8−Inch Flatwasher
21. Wedge Stoprof
22. 5/8−11 Square Nut
23. Fifth Wheel Top Plate

07/12/93 f310220

Fig. 1, Fontaine 5000 Series Fifth Wheel (Left-Side Release Shown)

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in a hazardous operating condition due to a possible disengagement of the trailer from the tractor.

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.

IMPORTANT: Replace any parts that show signs of wear, damage, or deterioration.

Assembly and Installation

⚠ WARNING

When cleaning parts with no. 2 diesel fuel, do not smoke or use an open flame near the area. To do so could result in a possible fire.

1. Clean all moving parts with no. 2 diesel fuel before assembly.
2. Insert the wedge spring through the slot and lay the spring coil over the spring bracket. See **Fig. 2**.

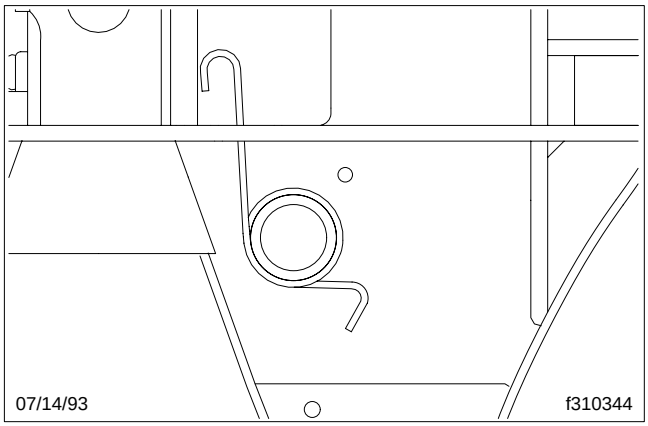


Fig. 2

3. Insert the spring tool part number 710 into the spring bracket (**Fig. 3**). Engage the small hooked tail and wind it around until it is directly over the small stud at the back of the bracket.

   Using a hammer, tap down on the spring until it catches on the stud. Install the cotter pin (**Fig. 4**).

NOTE: Order the spring tool part number 710 from: Fontaine Fifth Wheel Company 125 Cleage Drive Birmingham, Alabama 35217

4. The jaw spring has very little tension; install it by hand.
5. Install a 2-inch diameter shaft where the kingpin will engage in the fifth wheel.
6. Apply a moderate amount of a multipurpose chassis grease to the sides and serrated edges of the jaw and wedge (**Fig. 1**, Ref. 4), and also the stationary jaw in the throat of the fifth wheel.
7. Install the wedge and jaw.
8. Using pliers or a screwdriver, pry the jaw and wedge springs over the studs. See **Fig. 5**.
9. Insert the operating handle (Ref. 12) and move it over to the side of the wheel. Apply a moderate amount of multipurpose chassis grease to the grooved middle section of the operating handle.

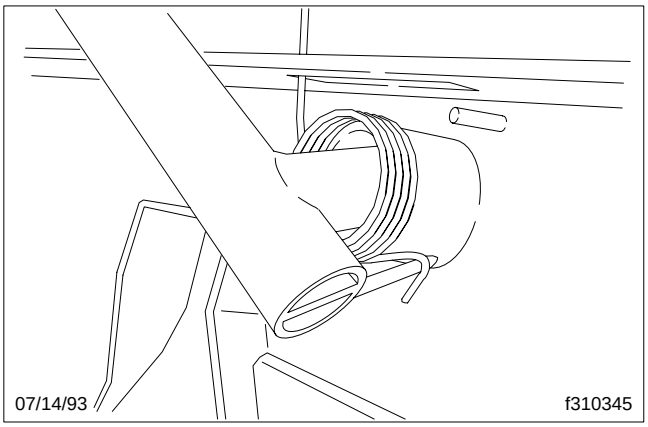


Fig. 3

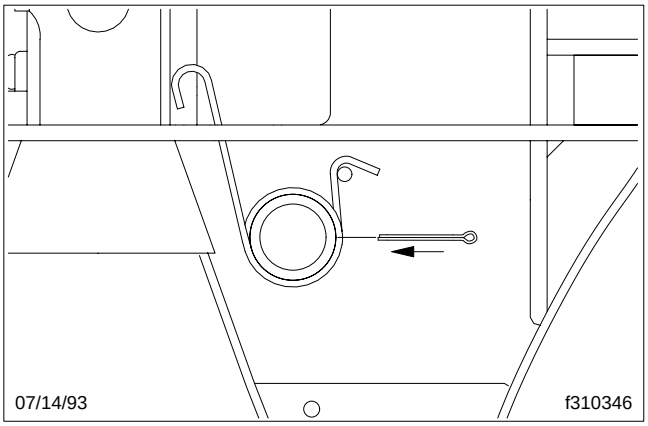


Fig. 4

10. Install the timer (Ref. 3) over the studs.

NOTE: The small hole on the timer fits over the top stud. Make sure the small bent arm of the timer is facing down.

11. Slide the operating handle (top part first) over to the side. Make sure that the handle is in a vertical position once it goes over the studs. See **Fig. 6**.
12. Slide the release handle (Ref. 18) in through the safety lock. Using a flatwasher (Ref. 13) and cot-

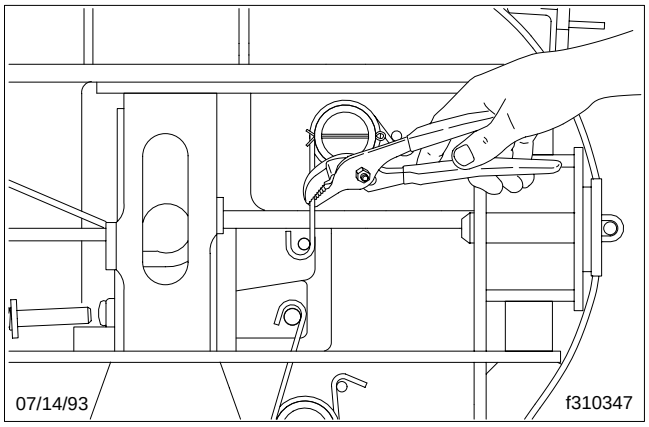


Fig. 5

ter pin (Ref. 6), attach the release handle to the second hole from the top on the operating handle.

13. Position the bumper (Ref. 15), then attach it to the operating handle with a new 1/2–13 x 1-1/2 inch capscrew (Ref. 16), bushing, washer, and locknut.
14. On the other end of the operating handle, install a new 1/2–13 x 2-inch capscrew (Ref. 14), washer, bushing, and locknut.
15. Apply multipurpose chassis grease to the operating handle, and to other fifth wheel parts that may come into contact with the handle during operation.
16. Connect the bumper spring.
17. Using multipurpose chassis grease, grease the top plate and the zerk fittings on the side of the fifth wheel.

    On heavy-duty oscillating fifth wheels, grease the top of the rocker bearing bushing.
18. Measure the distance from the wedge to the end of the wedge stoprod (**Fig. 7**). The correct measurement should be 3 mm (3/8 inch). Turn the wedge stoprod clockwise if the measurement is more than 3 mm (3/8 inch), or turn it counterclockwise if the measurement is less than 3 mm (3/8 inch).

⚠ WARNING

If the fifth wheel does not operate properly, do not use it. The fifth wheel could malfunction, resulting in personal injury or property damage due to possible disengagement of the trailer from the tractor.

IMPORTANT: The fifth wheel must be well lubricated to operate correctly. Refer to the frame and fifth wheel section of the vehicle maintenance manual for complete maintenance and lubrication instructions of the fifth wheel assembly.

19. Using an overhead hoist, position the fifth wheel on the sliding mount assembly. Insert the bushing pins. Install the retaining pins and the 1-inch long cotter pins.

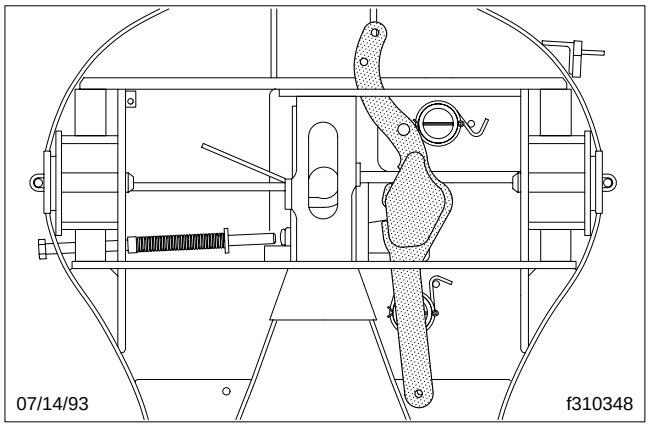
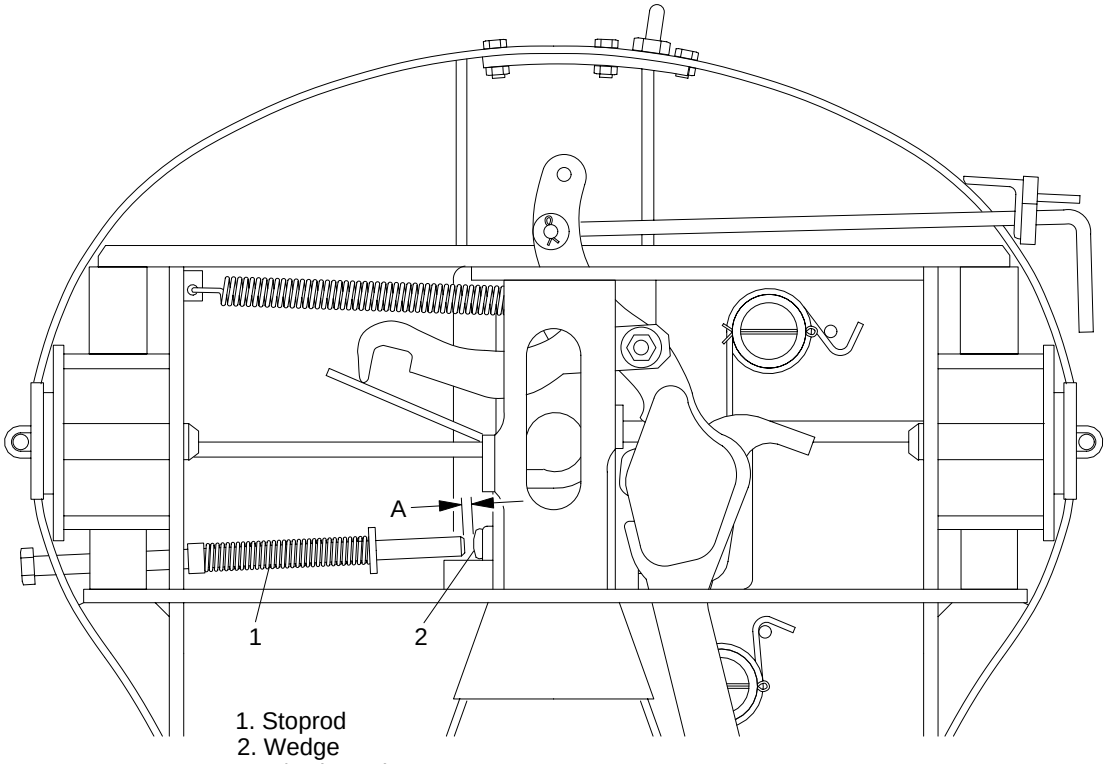


Fig. 6

Assembly and Installation



1. Stoprod
2. Wedge
A. 3/8" (3 mm)

07/14/93 f310185

Fig. 7

Problem—The Fifth Wheel Is Hard to Hook Up to the Trailer

Possible Cause	Remedy
The trailer may be too high; the kingpin is not entering the locks correctly.	Lower the trailer landing gear until the trailer plate contacts the fifth wheel.
Bent kingpin, or damaged trailer plate is interfering with the lock movement.	Check the kingpin and trailer plate. Replace parts as needed.

Problem—The Fifth Wheel Is Hard to Unhook from the Trailer

Possible Cause	Remedy
The tractor is putting pressure against the locks.	Back the tractor into the trailer; set the tractor brakes. Strike the wedge stoprod to release pressure.
Too much slack in the fifth wheel locks.	Check that the wedge stoprod is 3 mm (3/8 inch) from the end of the wedge. Adjust as needed.
	Check the kingpin diameter; it should not be worn more than 3 mm (3/8 inch). Replace if needed.
	Check the jaw and wedge for excessive wear. Replace if needed.

Bumper and Air Dam Removal and Installation

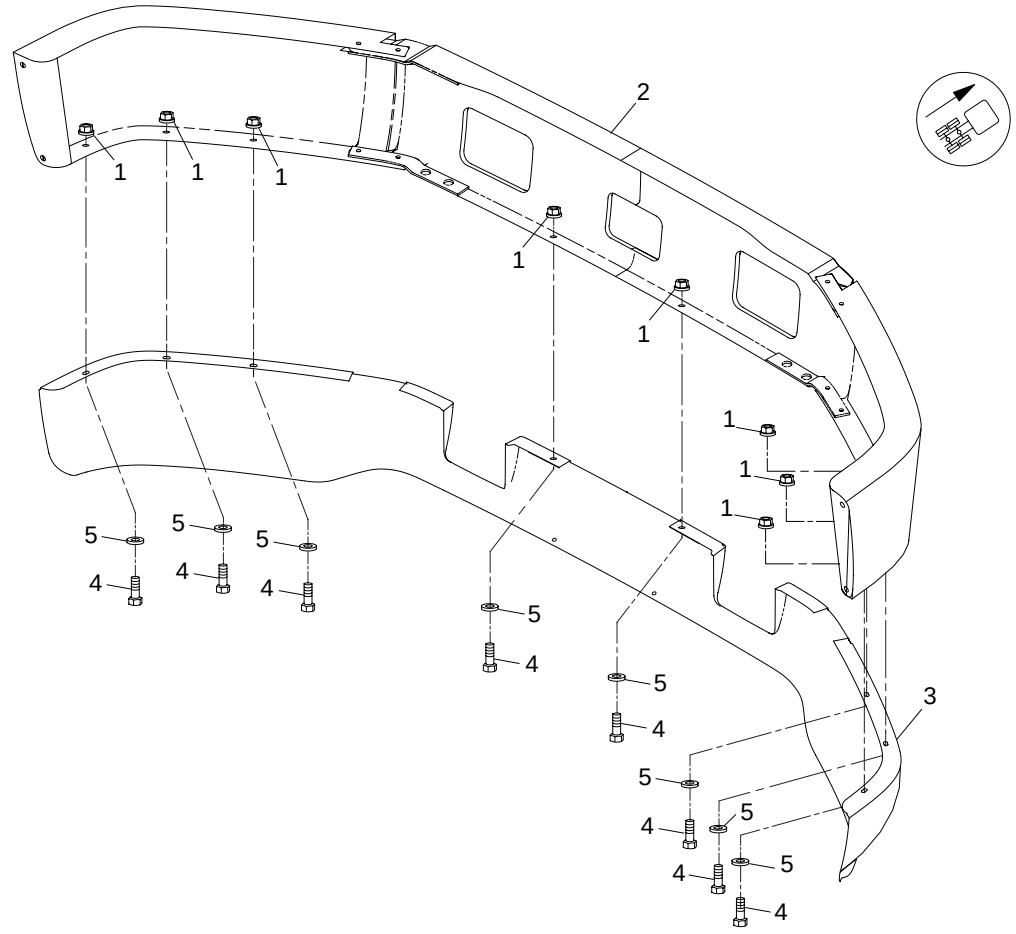
Removal

1. Park the vehicle on a level surface; then apply the parking brakes. Chock the tires.
2. If equipped with road lights, remove them from the bottom of the bumper.
   - 2.1 Disconnect the wiring from each road light.
   - 2.2 Remove the fasteners that attach the road light mounting bracket to the bottom of the bumper; then remove the road light and its mounting bracket.
3. Remove the air dam from the bumper.
   - 3.1 Remove the 1/4–20 fasteners that attach the air dam to the bottom of the bumper. **See Fig. 1.**
   - 3.2 Remove the air dam from the bumper. Set it aside.
4. Remove the bumper.
   - 4.1 On each side of the vehicle, remove the upper and lower outboard fasteners holding the bumper extension to the bumper. **See Fig. 2.**
   - 4.2 Loosen the upper and lower inboard bumper extension fasteners enough so you can swing the bumper extension out of the way. This will provide easier access to the upper bumper fasteners.
   - 4.3 Support the bumper. On one side of the vehicle, remove first the lower, then the upper 1/2–13 fasteners that attach the bumper to the frame rail bracket. **See Fig. 2.**
   - 4.4 Repeat the procedure on the other side of the vehicle.
   - 4.5 Remove the bumper assembly from the vehicle.

Installation

1. Support the bumper on the frame rail brackets.
2. Install the 1/2–13 fasteners.
   - 2.1 Install the 1-1/4 inch-long bolts in the upper edge of the bumper and through the upper part of the bracket. Install the washers and nuts.
   - 2.2 Install the 1-1/2 inch-long bolts in the lower edge of the bumper and through the lower part of the bracket. Install the washers and nuts.
   - 2.3 Tighten the nuts 68 lbf·ft (92 N·m).
3. On one side of the vehicle, swing the bumper extension back into place; then install the outboard fasteners. Tighten both the inboard and outboard fasteners 68 lbf·ft (92 N·m).
4. Repeat the above procedure on the other side of the vehicle.
5. Install the road lights onto the bumper.
   - 5.1 Line up the hole in the road light mounting bracket with that in the bottom edge of the bumper.
   - 5.2 Install the fasteners; then tighten them finger tight.
   - 5.3 Turn the light to correctly align it; then tighten the mounting bracket fasteners firmly.
   - 5.4 Connect the wiring.
   - 5.5 Repeat the procedure on the other side of the vehicle.
6. Install the air dam.
   - 6.1 Put the air dam in position under the bumper, aligning the holes in the bumper with those in the air dam.
   - 6.2 Install the 1/4–20 fasteners. Tighten them 8 lbf·ft (11 N·m).
7. Remove the chocks from the tires.

Bumper and Air Dam Removal and Installation

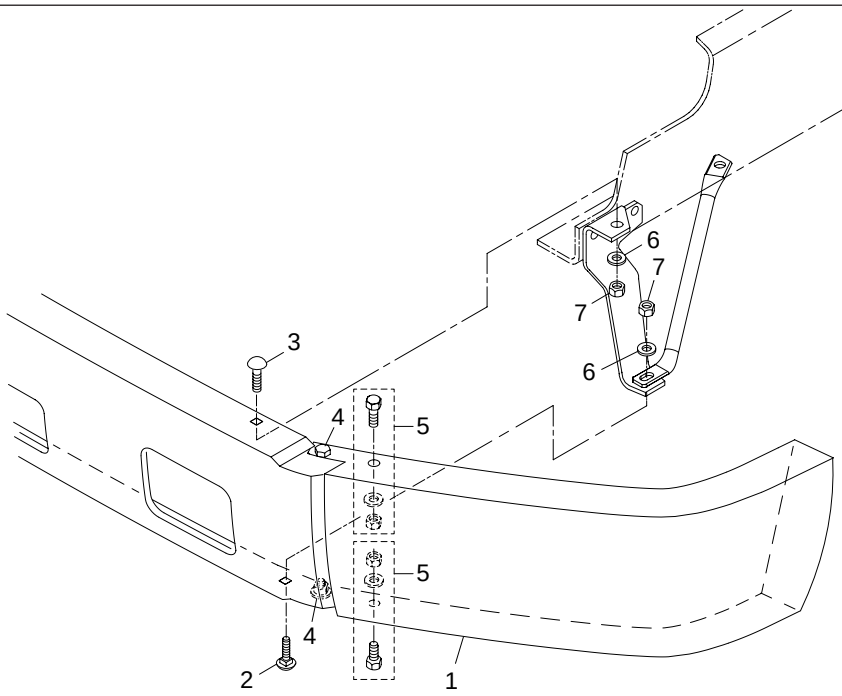


NOTE: Road lights not shown.

1. 1/4–20 Hexnut
2. Bumper
3. Air Dam
4. 1/4–20 Hexbolt
5. 1/4-inch Washer

Fig. 1, Bumper and Air Dam

Bumper and Air Dam Removal and Installation



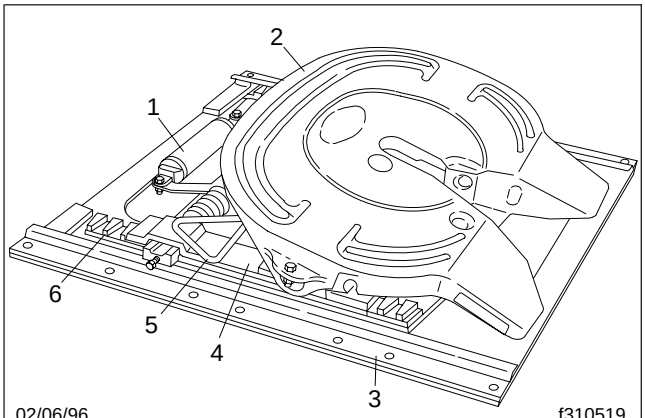
05/31/95 f310461

1. Bumper Extension
2. Bolt, Round-Head, 1/2–13 x 1-1/2"
3. Bolt, Round-Head, 1/2–13 x 1-1/4"
4. Inboard Fasteners, Bumper Extension
5. Outboard Fasteners, Bumper Extension
6. 1/2" Washer
7. 1/2–13 Hexnut

Fig. 2, Bumper Installation

General Description (See Fig. 1)

The Holland Fleetmaster fifth wheel is used for pulling trailers having the standard 2-inch diameter kingpin. When installed as a stationary fifth wheel, it is bracket-mounted to the tractor frame in a position that best distributes the trailer load over the tractor axles. When used as a sliding fifth wheel, it is mounted to a slide bracket and plate assembly (air-operated or manual release).



02/06/96 f310519

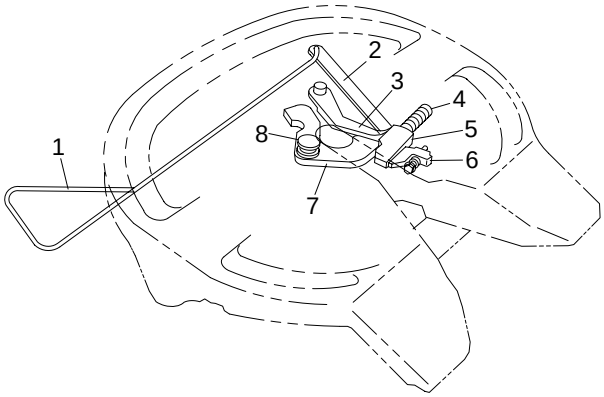
1. Air Cylinder
2. Top Plate
3. Outboard Mounting Plate
4. Slide Plate
5. Release Handle
6. Track

Fig. 1, Holland Fleetmaster Fifth Wheel Assembly

Principles of Operation

The fifth wheel lock mechanism for the trailer kingpin consists of a hinged lock, locking plunger, plunger spring, cam arm, release arm, and operating rod. The lock rotates on a lock pin during coupling and uncoupling operations. During coupling the hinged lock and cam arm pivot against the kingpin and are secured by the locking plunger (See **Fig. 2**).

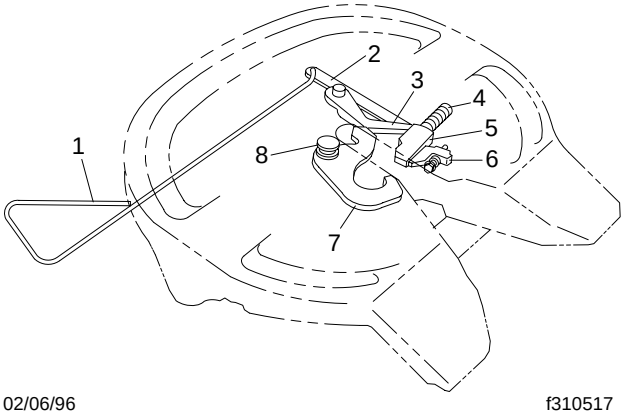
Uncoupling is accomplished by pulling the release handle using 60–70 lbs. (27–32 kg) of force. The release arm pivots and forces the locking plunger against the plunger spring. The hinged lock is released and the trailer kingpin can be removed (See **Fig. 3**).



02/06/96 f310518

1. Release Handle
2. Release Arm
3. Cam Arm
4. Plunger Spring
5. Locking Plunger
6. Adjusting Wedge
7. Hinged Lock
8. Lock Pin

Fig. 2, Fifth Wheel in Locked Position



02/06/96 f310517

1. Release Handle
2. Release Arm
3. Cam Arm
4. Plunger Spring
5. Locking Plunger
6. Adjusting Wedge
7. Hinged Lock
8. Lock Pin

Fig. 3, Fifth Wheel in Unlocked Position

Removal (See Fig. 1)

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in a hazardous operating condition due to possible disengagement of the trailer from the tractor.

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.

1. Steam clean the top plate. Remove the cotter pins from the bracket pins. Remove the bracket pins. Discard the cotter pins and remove the top plate.
2. Using an overhead hoist, lift the fifth wheel off the mount and tractor frame.

Disassembly (See Fig. 1)

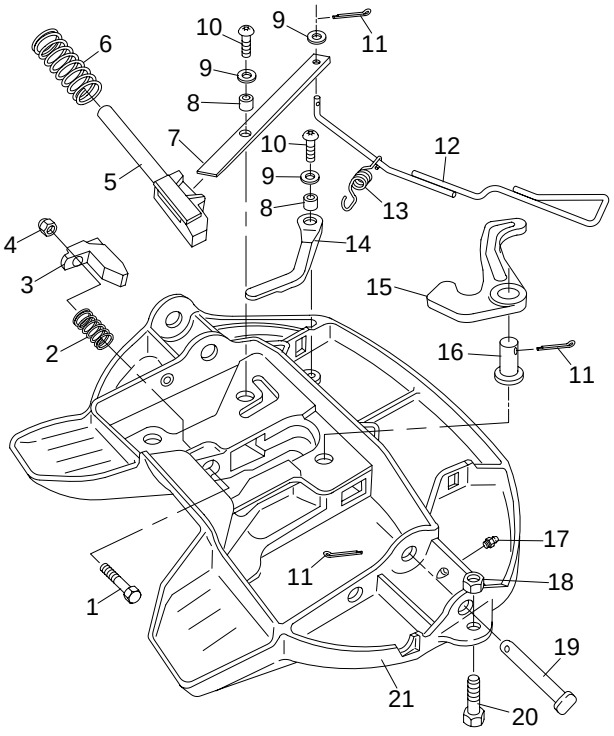
1. Turn the fifth wheel upside down.

⚠ WARNING

Do not attempt repair or rebuilding if the top plate is cracked or distorted or if the lock pin is sloppy in the top plate. These conditions could result in top plate failure or malfunction of the locks.

NOTE: While disassembling the fifth wheel, check it for cracks and for missing or damaged parts.

2. Pull the release handle out, slide it forward and hook the handle to the unlock notch of the casting.
3. With the plunger in the unlocked position, remove and discard the cotter pin. Remove the lock pin.
4. Slide the hinged lock away from the locking plunger and remove it from the top plate.



02/07/96 f310521

NOTE: Bottom view shown.

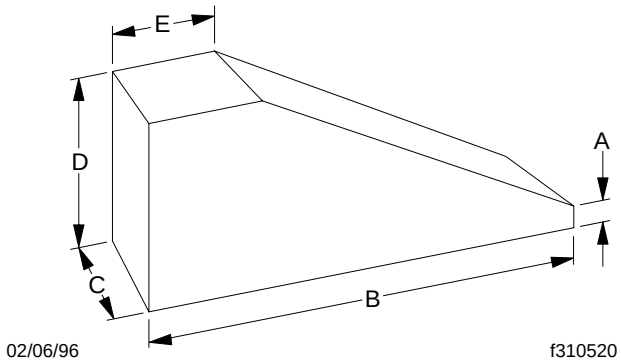
1. Hex Head Capscrew
2. Spring
3. Adjusting Wedge
4. Locking Nut
5. Locking Plunger
6. Plunger Spring
7. Release Arm
8. Roller
9. Washer
10. Torx Screw
11. Cotter Pin
12. Release Handle
13. Extension Spring
14. Cam Arm
15. Hinged Lock
16. Lock Pin
17. Grease Fitting
18. Locknut
19. Bracket Pin
20. Hex Head Capscrew
21. Top Plate

Fig. 1, Fifth Wheel Assembly Components (with left-hand release)

NOTE: It may be necessary to fabricate a wedge to hold the plunger in the unlocked position during the disassembly and assembly procedure.

5. Insert the fabricated wedge, see **Fig. 2**.
6. Pull the release handle and slide it rearward to unhook it from the notch in the casting.

Removal and Disassembly

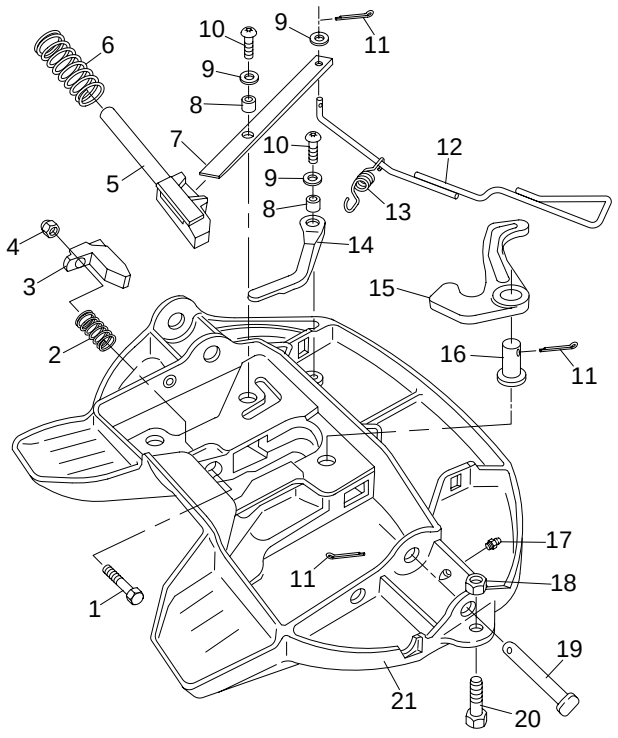


A. 0.3 inch (7.6 mm)
B. 8 inches (203.2 mm)
C. 1.5 inches (38.1 mm)
D. 3 inches (76.2 mm)
E. 2.5 inches (63.5 mm)

Fig. 2, Fabricated Wedge Dimensions

7. Remove the cotter pin and washer. Discard the cotter pin. Disconnect and pull the release handle away from the release arm.
8. Remove the release arm Torx screw, washer, and roller. Remove the release arm.
9. Slowly remove the fabricated wedge. Guide the locking plunger from the left throat of the fifth wheel to the right throat. Pull the plunger out of the right throat of the fifth wheel. Remove the plunger spring and adjusting wedge.
10. Remove the Torx screw, washer, and roller. Remove the cam arm.
11. Remove the extension spring and the release handle.
12. Remove the grease fittings.

Assembly (See Fig. 1)



02/07/96 f310521

NOTE: Bottom view shown.

1. Capscrew
2. Spring
3. Adjusting Wedge
4. Locking Nut
5. Locking Plunger
6. Plunger Spring
7. Release Arm
8. Roller
9. Washer
10. Torx Screw
11. Cotter Pin
12. Release Handle
13. Extension Spring
14. Cam Arm
15. Hinged Lock
16. Lock Pin
17. Grease Fitting
18. Locknut
19. Bracket Pin
20. Capscrew
21. Top Plate

Fig. 1, Fifth Wheel Assembly Components (with left-hand release)

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in a hazardous operating condition due to possible disengagement of the trailer from the tractor.

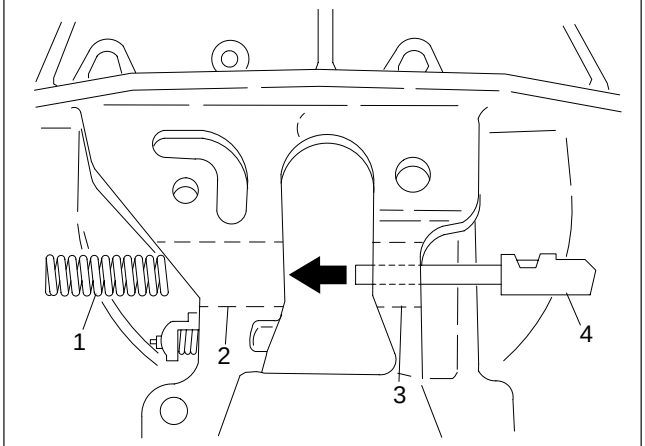
Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.

IMPORTANT: When rebuilding use only Holland rebuilding kits. Replace all roll pins, cotter pins, springs, bolts, nuts, and washers. Inspect the rebuild kit to verify that all parts are present.

IMPORTANT: Check the lock pin holes. If the holes are elongated the top plate must be replaced. Replace any parts that show signs of wear, damage, or deterioration. Brackets, bracket bushings, bracket pins, and bracket shoes should be replaced in pairs.

1. Clean all moving parts with no. 2 diesel fuel before assembly.
2. Replace the grease fittings.
3. Apply a thin film of multipurpose chassis grease to the release arm, release arm roller, hinged lock, lock pin, cam arm and roller, adjusting wedge, and locking plunger.
4. Install a 5/8-inch capscrew through the hole in the right side of the throat of the fifth wheel.
5. Slide the wedge spring, and wedge over the capscrew. Thread a 5/8-inch locknut onto the capscrew. Hand tighten the locknut.
6. Install the plunger through the opening in the right throat of the fifth wheel, through the left throat into the plunger spring, and through the hole in the rib of the casting. See **Fig. 2**.
7. Compress the plunger spring by inserting the fabricated block into the throat until the plunger is flush with the throat of the casting. See **Fig. 3**.
8. Insert the cam arm tail into the pocket in the plunger. Align the cam arm hole with the bolt hole in the casting. See **Fig. 4**.
9. Install the roller, washer (rounded edge towards roller), and torx bolt. Tighten the torx bolt 85 to 120 lbf·ft (115 to 163 N·m).
10. Insert the tapered end of the release arm through the main rib of the casting into the

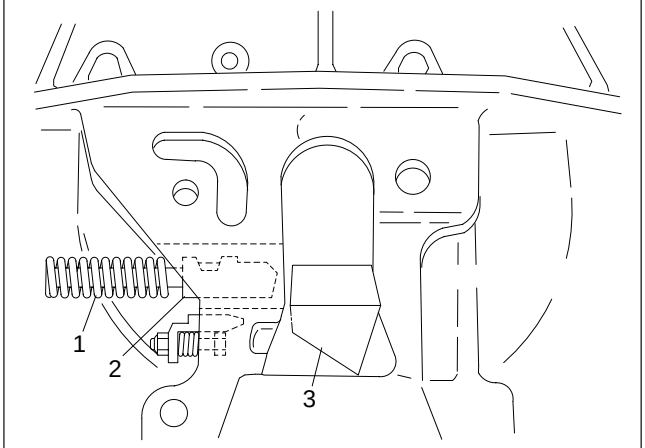
Assembly and Installation



02/08/96 f310523

1. Plunger Spring
2. Left Throat
3. Right Throat
4. Locking Plunger

Fig. 2, Plunger Installation



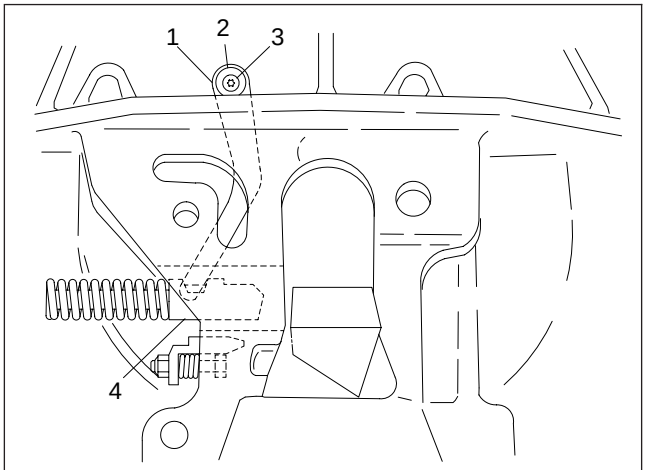
02/08/96 f310524

1. Plunger Spring
2. Locking Plunger
3. Fabricated Wedge

Fig. 3, Inserting Fabricated Wedge

plunger. The tapered end of the release arm must face down next to the cam arm. Align the release arm hole with the bolt hole in the casting.

The following step applies only to fifth wheels equipped with a left-hand (road side) release. Fifth wheels equipped with a right-hand (curb-



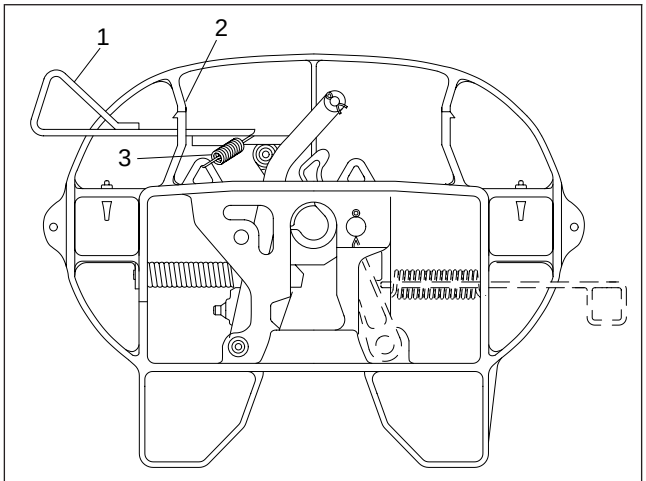
02/08/96 f310525

1. Cam Arm
2. Washer
3. Torx Screw
4. Locking Plunger

Fig. 4, Cam Arm Installation

side) release (see **Fig. 5**) do not require a roller, washer, and torx bolt to install the release arm.

11. Install the roller, washer (rounded edge towards roller), and torx bolt. Tighten the torx bolt 85 to 120 lbf·ft (115 to 163 N·m).



09/09/96 f310543

1. Release Handle
2. Main Rib
3. Release Handle Spring

Fig. 5, Right-Hand (curb-side) Release

12. Feed the release handle through the hole in the casting, through the closed end of the release

handle spring, and up through the bottom of the release arm.

13. Install the washer and cotter pin.
14. Lubricate the release handle spring contact areas with a light grease. Attach the release handle spring to the casting ear.
15. Pull the release handle and hook it on the unlock notch of the casting.
16. Remove the fabricated block. Keep hands and fingers clear.
17. Grease the lock pin hole and lock contact areas. Slide the hinged lock through the opening in the right-hand side of the throat of the fifth wheel. Align the lock pin hole with the hole in the casting.
18. Slide the lock pin through the casting from the face of the top plate through the lock, then through the bottom of the casting. Install the cotter pin.
19. Unhook the release handle from the notch in the casting.

Installation

NOTE: Before remounting the top plate, inspect the rubber bushings and bracket pins for wear. Replace as necessary. If bushing replacement is required, be sure to use the correct diameter bushing.

1. Using an overhead hoist, position the fifth wheel on the sliding or stationary mount brackets. Clamp the fifth wheel in place to compress the bracket rubbers.
2. Insert the bracket pins and new cotter pins. Lock the cotter pins.

Lock Adjustment

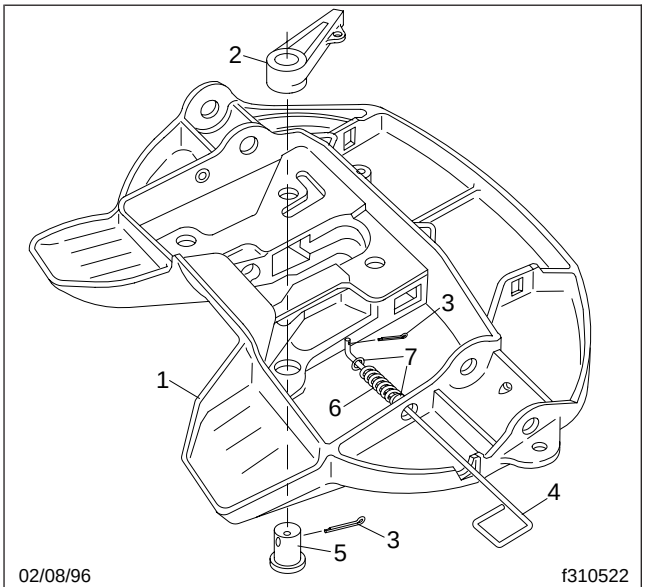
1. Open the hinged lock by pulling the release handle and putting pressure against the hinged lock, moving it towards the open position.
2. Close the fifth wheel using a Holland lock tester. Tighten the adjustment bolt while attempting to rotate the lock tester back and forth.
3. Slowly tighten the bolt until the lock tester just stops rotating. Loosen the adjustment bolt two full turns.
4. Verify proper operation by locking and unlocking the fifth wheel several times using the tester.

⚠ WARNING

If the fifth wheel top plate does not operate properly, do not use it. An improperly functioning fifth wheel could cause loss of vehicle or trailer control, resulting in personal injury. Repeat the above procedure or call your local Holland representative for assistance.

Secondary Lock Installation

1. Using the Holland lock tester, close the fifth wheel lock. See **Fig. 1**.



NOTE: Bottom view shown.

1. Top Plate
2. Secondary Lock Arm
3. Cotter Pin
4. Secondary Lock Release Handle
5. Secondary Lock Pin
6. Spring
7. 7/16-inch Washer

Fig. 1, Optional Secondary Lock Assembly

2. Lubricate the secondary lock arm pin hole with Never Seez grease.
3. Slide the lock arm into the right side of the casting with the lock arm ear facing the outside of the casting.
4. Align the pin holes of the secondary lock arm and the casting. Drive the lock pin through the casting from the top plate, through the secondary lock. Install the cotter pin through the secondary lock.
5. Install a 45-degree lube fitting into the secondary lock pin.
6. Grasp the secondary lock handle handhold, and slide the other end of the handle through the rib of the casting, through the 7/16-inch washer, through the handle spring, through another 7/16-inch washer, and up through the bottom of the loop on the secondary lock arm.
7. Compress the release handle spring and secure the release handle using a cotter pin. Lock the cotter pin.
8. Check the secondary release handle for proper operation.

Troubleshooting

Problem—Hard to Hook Up the Fifth Wheel to the Trailer

Problem—Hard to Hook Up the Fifth Wheel to the Trailer	
Possible Cause	**Remedy**
The trailer may be too high; the kingpin is not entering the lock correctly.	Lower the trailer landing gear until the trailer plate contacts the fifth wheel.
A bent kingpin or damaged trailer plate is interfering with the hinged lock movement.	Check the kingpin and trailer plate. Replace parts as needed.
The hinged lock has not been adjusted correctly.	Check the clearance between the lock and the kingpin. Adjust as described in this section.
Attempting to couple too quickly.	Pick up the trailer with the fifth wheel. Stop. Continue backing up until the fifth wheel locks firmly to the kingpin. Stopping helps prevent hitting the kingpin too hard.
The locks are closed.	Pull the release handle. Hook the handle on the notch in the casting and pry the hinged lock open.
Accumulated rust or grime is interfering with lock operation.	Spray a light lubricant or diesel fuel on all moving parts, including the release handle. Operate the unit several times.
The locks are damaged.	Inspect and replace components as described in this section.
The fifth wheel requires rebuilding	Follow the procedures contained in this section using the appropriate rebuilding kit.
Using a lube plate with the wrong kingpin length.	See Holland Service Bulletins 4 and 4A.

Problem—Hard to Unhook the Fifth Wheel from the Trailer

Problem—Hard to Unhook the Fifth Wheel from the Trailer	
Possible Cause	**Remedy**
The tractor is putting pressure against the locks.	Back the tractor up a little to relieve kingpin load against the fifth wheel lock. Lock the tractor brakes before pulling the release handle and hooking it on the notch in the top of the plate casting.
The optional secondary lock (if equipped) is not released.	Pull out the secondary release handle and move it forward to secure it on the top plate casting.
The release handle will not stay out or must be held out when unlocking.	Follow the procedures contained in this section using the appropriate rebuilding kit.
The primary release handle is not pulled out completely and locked on the notch in the casting.	Slide the primary release handle out and pull it forward. Slide the handle forward, hooking it on the notch on the top plate casting.
Rust or grime is on the locking mechanism.	Spray a light lubricant or diesel fuel on all moving parts including the release handle. Operate the unit several times.
Bent kingpin or damaged bolster plate.	Check the kingpin with a Holland TF–0110 Kingpin Gage and bolster plate with a 48 inch straightedge. Repair or replace as required.
Fifth wheel locks are adjusted too tight.	Check the clearance between the lock and the kingpin. Adjust as described in this section.

Troubleshooting

NOTE: After the fifth wheel is unlocked and moves freely from the kingpin, it is normal for the release handle to disengage from the notch in the casting to return to a position between locked and unlocked.

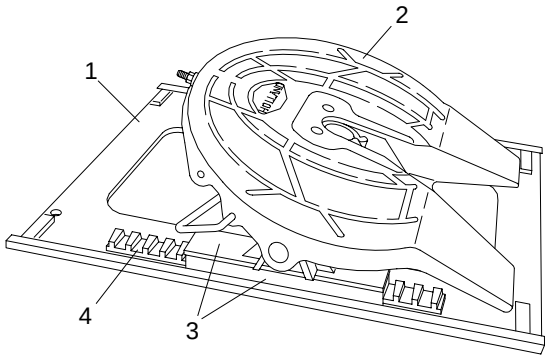
General Information

NOTE: For Holland 3500 series fifth wheel service operations, see **Section 31.01**.

NOTE: Prior to June 1, 1996, the Holland sliding fifth wheel mount carried a part number prefix FW2535. Since June 1,1996, the Holland sliding fifth wheel mount part number prefix has been replaced by FW35.

The Holland sliding fifth wheel mount is designed to provide maximum tractor use for different lengths and types of trailers. The FW2535/FW35 sliding fifth wheel mount is used with the Holland 3500 series fifth wheel, and is equipped with either a manually operated or an air-operated release slider.

Sliding fifth wheel assemblies are mounted on a baseplate with notched rails. See **Fig. 1**. Plungers are meshed into teeth on the baseplate to lock the fifth wheel. This assembly allows forward or rearward movement of the fifth wheel along the notched rails for optimum weight distribution over the tractor axles. The mounting baseplate is bolted to the tractor frame.



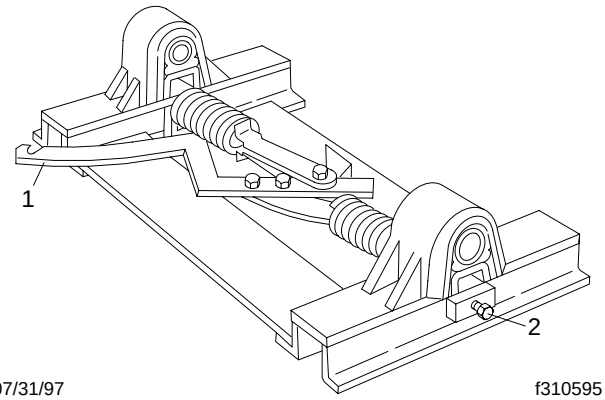
05/04/93 f310370

1. Baseplate
2. Fifth Wheel Top Plate (XA–3500)
3. Slide Mount
4. Baseplate Rail

Fig. 1, XA-3500 Sliding Fifth Wheel

When the fifth wheel is in the desired position, it is locked in place by wedge-shaped plungers that engage in the notched rails under the sliding mount. To release the fifth wheel, the plungers are withdrawn.

The manually operated release slider contains a release lever (**Fig. 2**), which when manually pulled or released, unlocks or locks both sides of the sliding mount at the same time.



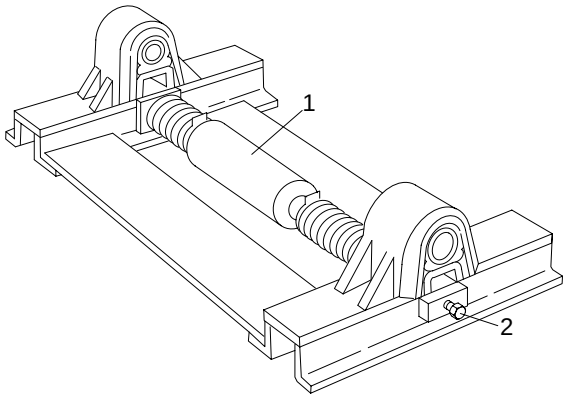
07/31/97 f310595

NOTE: Baseplate rails not shown.

1. Release Lever
2. Slider Plunger Release

Fig. 2, Manual Release Slider Assembly

The air-operated release slider contains a double-ended air cylinder (**Fig. 3**), which locks and unlocks both sides of the sliding mount at the same time. The air cylinder is activated by a two-position air-control valve in the tractor cab. See **Fig. 4**.



07/31/97 f310596

NOTE: Baseplate rails not shown.

1. Double-Ended Air Cylinder
2. Slider Plunger Release

Fig. 3, Air Valve Release Slider Assembly

General Information

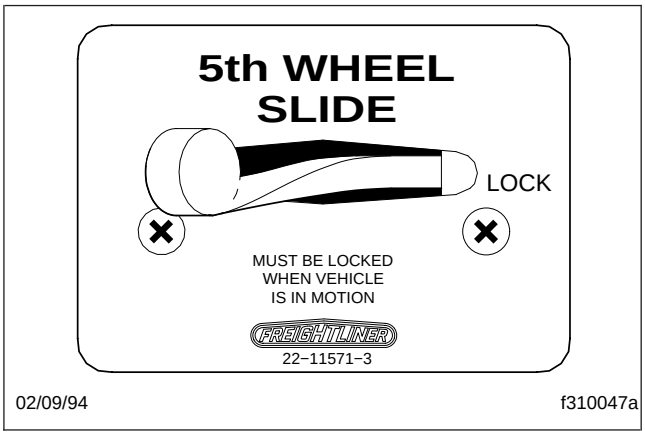


Fig. 4, Control Valve

See Chapter 10 of the *Business Class Trucks Driver's Manual* for complete operating instructions.

Disassembly

⚠ WARNING

Fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Incorrect or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

1. Remove the top plate.
   - 1.1 If equipped with model XA–3501 top plate, remove the roll pins (**Fig. 1**) from both the right and left side of the top plate. Then, remove the bushing pins.

     Using an overhead hoist, lift the fifth wheel off the slide mount assembly.
   - 1.2 If equipped with model XA–351 top plate, loosen and remove the 1/2–20 bushing pin capscrews and locknuts from both the left and right sides of the top plate. Then, remove the bushing pins (**Fig. 1**) from the bracket assembly.

     Using an overhead hoist, lift the fifth wheel off the slide mount assembly.

⚠ WARNING

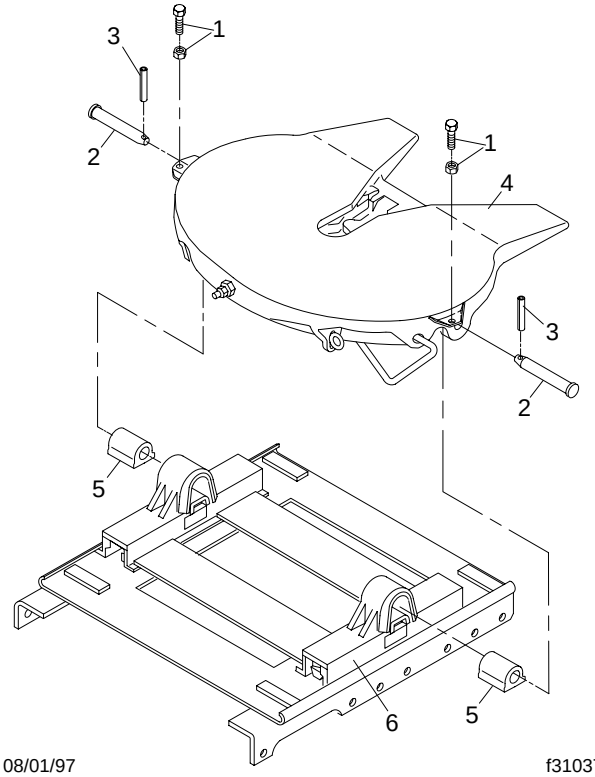
When draining the air reservoir, do not look into the air jets, or direct them toward anyone. Dirt or sludge particles may be in the airstream, and could cause injury if ejected.

2. If the fifth wheel has a manual release sliding mount, then go to the next step. Otherwise, drain the air reservoir; then disconnect and plug the air line from the air cylinder.

⚠ WARNING

Parts are under spring compression. Wear safety goggles during disassembly and assembly, and keep fingers away from possible pinch points at the ends of springs. Failure to do so can result in bodily injury, due to parts ejecting with force.

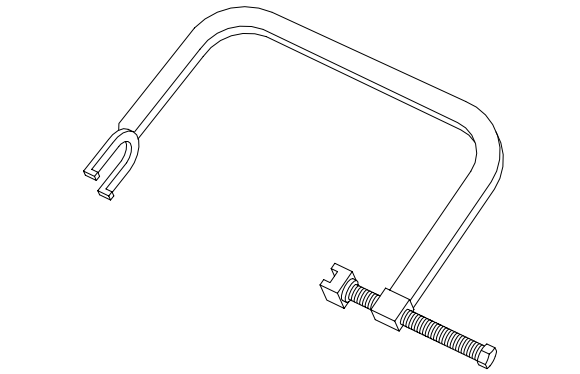
3. Using a Holland TF–TN 2500 spring compressor (**Fig. 2**), compress one of the plunger return springs (**Fig. 3**).



08/01/97 f310373

1. Capscrew and Locknut (XA–351 only)
2. Bushing Pin
3. Roll Pin (XA–3501 only)
4. Fifth Wheel Top Plate
5. Rubber Bushing
6. Slide Mount Assembly

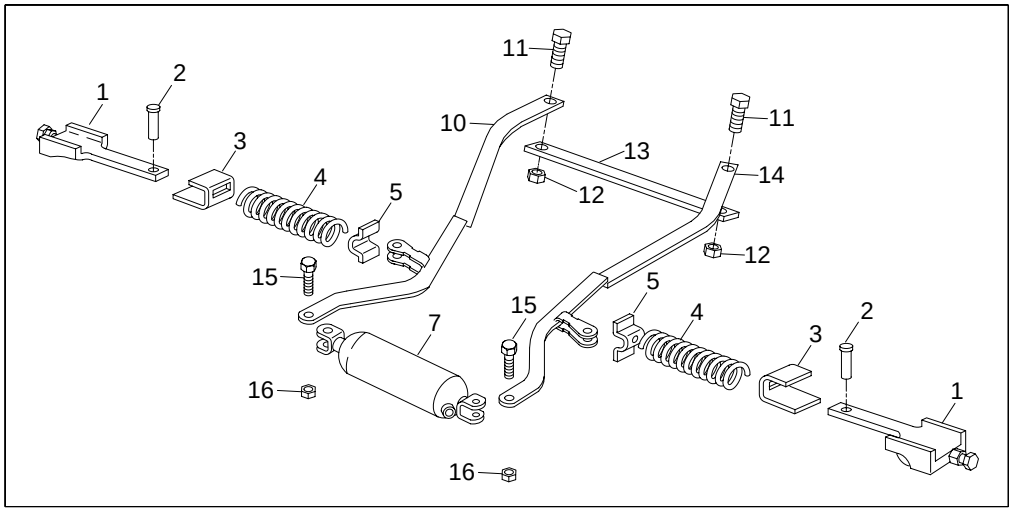
Fig. 1, Sliding Mount Components



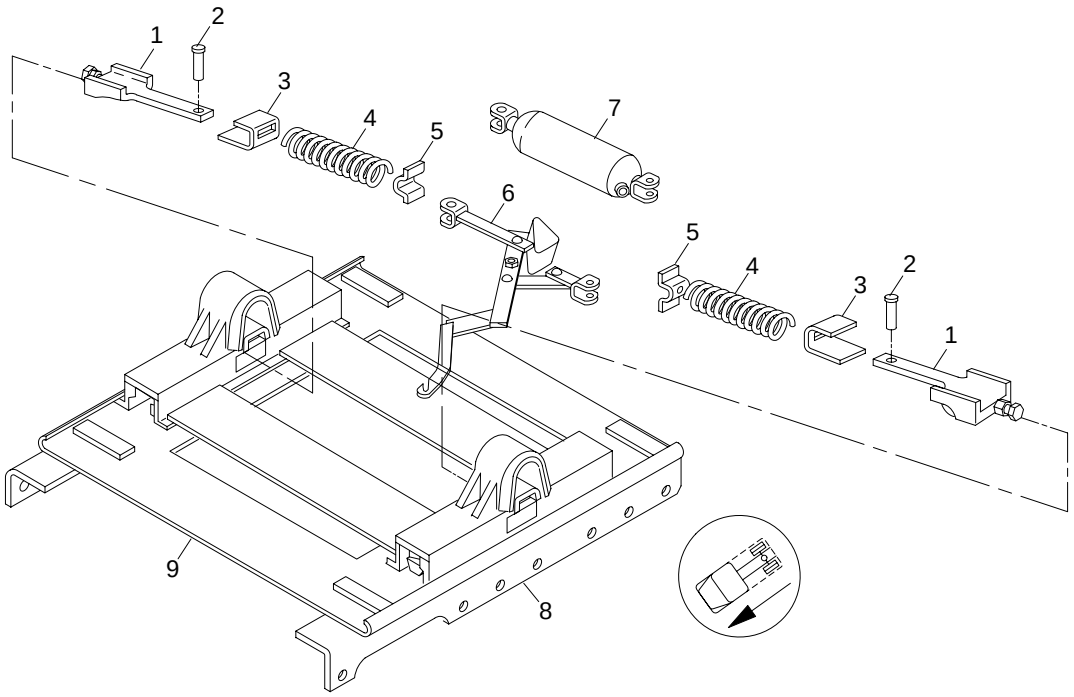
05/06/93 f310374

Fig. 2, Spring Compressor

Sliding Mount Disassembly and Assembly



A



09/29/97 f310375

A. Spring assembly for 6.62 and 8.12 inch (16.8 and 20.6 cm) fifth wheel heights

1. Plunger
2. Retaining Pin
3. Spring Compression Stop
4. Plunger Return Spring
5. Spring Retainer
6. Manual Release Lever
7. Air-Release Cylinder
8. Slide Mount Assembly
9. Baseplate
10. Right Release Lever
11. Capscrew, 3/8–16
12. Locknut, 3/8–16
13. Tie Bar
14. Left Release Lever
15. Capscrew, 1/2–20
16. Locknut, 1/2–20

Fig. 3, Spring Assemblies

4. Remove the plunger retaining pin (**Fig. 3**) from the plunger end, and either the air-release cylinder or manual release lever clevis. Then remove the plunger.

   If equipped with a fifth wheel height of 6.62 or 8.12 inches (16.8 or 20.6 cm), remove the plunger retaining pin from the release lever, then remove the plunger.

5. Carefully remove the spring compressor; then remove the plunger return spring, the spring compression stop, and the spring retainer (**Fig. 3**).

   Repeat the procedure for the other plunger.

6. Remove the air-release cylinder or the manual release lever.

   If equipped with a fifth wheel height of 6.62 or 8.12 inches (16.8 or 20.6 cm), remove the air-release cylinder or the manual release lever along with the right and left release levers (**Fig. 3**). Disconnect the release levers from the air-release cylinder or manual release lever.

⚠ WARNING

Wear protective eye and facial gear when grinding to remove the rear stops. Failure to do so could result in personal injury due to flying metal debris from the grinding.

7. If the slide mount assembly (**Fig. 3**) is damaged, dismantle it from the baseplate (Ref. 9).

   7.1 Grind down the welded area to remove the rear stops.

   7.2 Remove the slide mount assembly from the baseplate by sliding it off the rear of the tracks.

8. Remove all dirt and grease from the parts. Replace any parts that show signs of wear or damage.

NOTE: If the rubber bushings (**Fig. 1**) are damaged, or if they allow movement of more than 1/8 inch (3 mm), replace them.

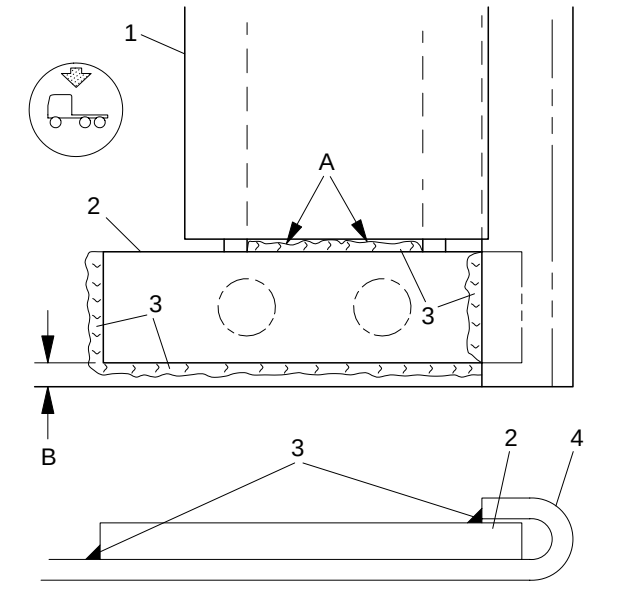
Assembly

⚠ WARNING

Fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Incorrect or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

1. Using a rubber lubricant or a waterless hand cleaner, lubricate the outer surfaces of the new rubber bushings.
2. Install the rubber bushings (**Fig. 1**) into the slide mount assembly until they are flush with the outboard ends of the assembly.
3. Using a multipurpose chassis grease, lubricate the flanges on the slide mount assembly. Then slide the assembly onto the tracks of the baseplate.
4. Move the slide mount assembly to the rearmost position. Install the plungers into the outboard ends of the slide mount. Engage the plungers in the rail teeth.
5. Install the rear stops under the curled edge of the baseplate. Allow a clearance of about 1/8 inch (3 mm) from the rear stops to the slide mount (when it's in the full rear position). The stops should be about 1/4 to 1/2 inch (6 to 13 mm) from the rear edge of the baseplate. See **Fig. 4**.
6. Clamp the rear stops in place, then move the slide mount assembly forward and out of the way.
7. Weld the stops in place. The welds should be 1/4-inch (6-mm) fillet. On the forward edge, weld only the center area; not the area where the slide mount assembly contacts the stop. See **Fig. 4**.
8. Move the slide mount assembly to the rearmost position and check for clearance. Make sure the plungers seat into the rail with all teeth engaged.
9. If equipped with a fifth wheel height of 6.62 or 8.12 inches (16.8 or 20.6 cm), and if new release levers are being installed, attach the right and left release levers to the tie bar (**Fig. 3**). Install

Sliding Mount Disassembly and Assembly



A. Weld carefully to avoid slide mount.
B. 1/4 to 1/2 inch (6 to 13 mm)

1. Slide Mount
2. Rear Stop
3. Weld
4. Baseplate

Fig. 4, Slide Stop Installation

3/8–16 capscrews and locknuts and tighten them firmly, but make sure the parts are not binding.

Using the 1/2–20 capscrews and locknuts, attach the air-release cylinder or the manual release lever to the ends of the release levers, tighten the nuts firmly, but make sure the parts are not binding.

10. Install the spring compression stops and the plunger return springs on the inboard ends of the plungers. Then install the spring retainers.

⚠ WARNING

Parts are under spring compression. Wear safety goggles during disassembly and assembly, and keep fingers away from possible pinch points at the ends of springs. Failure to do so can result in bodily injury, due to parts ejecting with force.

11. Using a Holland TF–TN 2500 spring compressor, compress one of the plunger return springs and its spring retainer enough to access the hole through the end of the plunger shaft.

12. If equipped with a standard fifth wheel, position the air-release cylinder or the manual release lever so that the holes in its clevis line up with the hole through the end of the plunger shaft. Install the retaining pin.

    If equipped with a fifth wheel height of 6.62 or 8.12 inches (16.8 or 20.6 cm), line up the holes in the clevis of one of the release levers (**Fig. 3**) with the hole in the end of the plunger shaft. Install the retaining pin.

13. Carefully remove the spring compressor.

14. Repeat the procedure on the other side of the vehicle.

15. If the fifth wheel has a manual release sliding mount, then go to the next step, otherwise connect the air lines.

    15.1 Remove the plugs from the air line.

    15.2 Connect the air line to the inlet on the air-release cylinder.

    15.3 Start the engine to build air pressure, then check the operation of the slide mechanism.

16. Adjust the plungers, following the procedure in **Subject 110**.

17. Install the top plate.

    17.1 If equipped with model XA–3501 top plate, using an overhead hoist, lift the fifth wheel onto the slide mount assembly.

    From both the right and left side of the top plate, install the bushing pins and the roll pins (**Fig. 1**).

    17.2 If equipped with model XA–351 top plate, using an overhead hoist, lift the fifth wheel onto the slide mount assembly.

    From both the right and left side of the top plate, Install the bushing pins. Then, install and tighten snugly the 1/2–20 bushing pin capscrews and locknuts (**Fig. 1**).

Adjustment

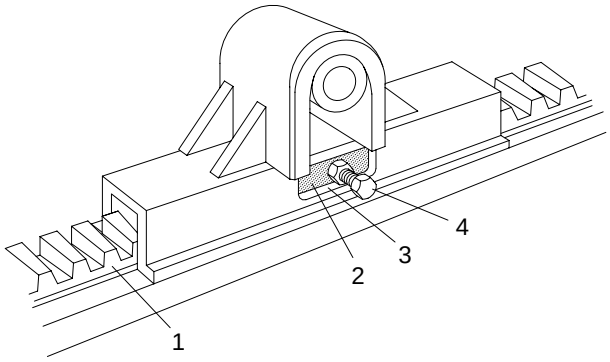
⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Incorrect or incomplete procedures could result in loss of trailer connection during vehicle travel, possibly causing bodily injury and property damage.

NOTE: The locking plungers are adjusted at installation and again after one month of operation. Make additional adjustments as needed.

1. The plungers should seat in the pocket with a small amount of play when locked (engaged). See **Fig. 1**. If they wedge or bind, turn the adjusting bolt clockwise or counterclockwise as needed.

   Turning the adjusting bolt clockwise moves the plunger out of the pocket; turning it counterclockwise moves the plunger further into the pocket.



11/21/95 f310371

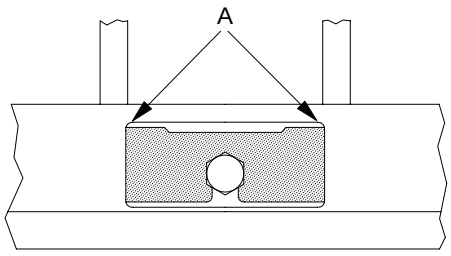
1. Plunger Adjusting Bolt
2. Pocket
3. Plunger
4. Rack

Fig. 1, Plunger Position

2. If the plungers don't unlock (release), check the air-release cylinder or the manual release lever for correct operation. Replace it if needed. See **Subject 100** for removal and installation instructions.

3. If the adjusted plunger binds on the bottom of the pocket, remove it; then grind the plunger top edges 1/16 inch (2 mm). See **Fig. 2**. Install the plunger. See **Subject 100** for plunger removal and installation instructions.

   Adjust the plunger, following the instructions above.



05/06/93 f310372

A. Check for interference here.

Fig. 2, Plunger Checking

4. If the plungers are too loose, check the tension of the plunger return springs. If the springs are damaged or worn, replace them, following the instructions in **Subject 100**.

   If the plungers are still too loose, replace the plungers, following the instructions in **Subject 100**.

General Information

Fontaine H5092 series fifth wheels couple to trailers having a standard 2-inch kingpin. When installed as a stationary mount, the fifth wheel is bracket-mounted to the tractor frame in a position that best distributes the trailer load over the tractor axles. Sliding fifth wheels (**Fig. 1**), are mounted on the Fontaine HAWB or HMWS (previously called 5AWB and 5MWS) model slide mounts.

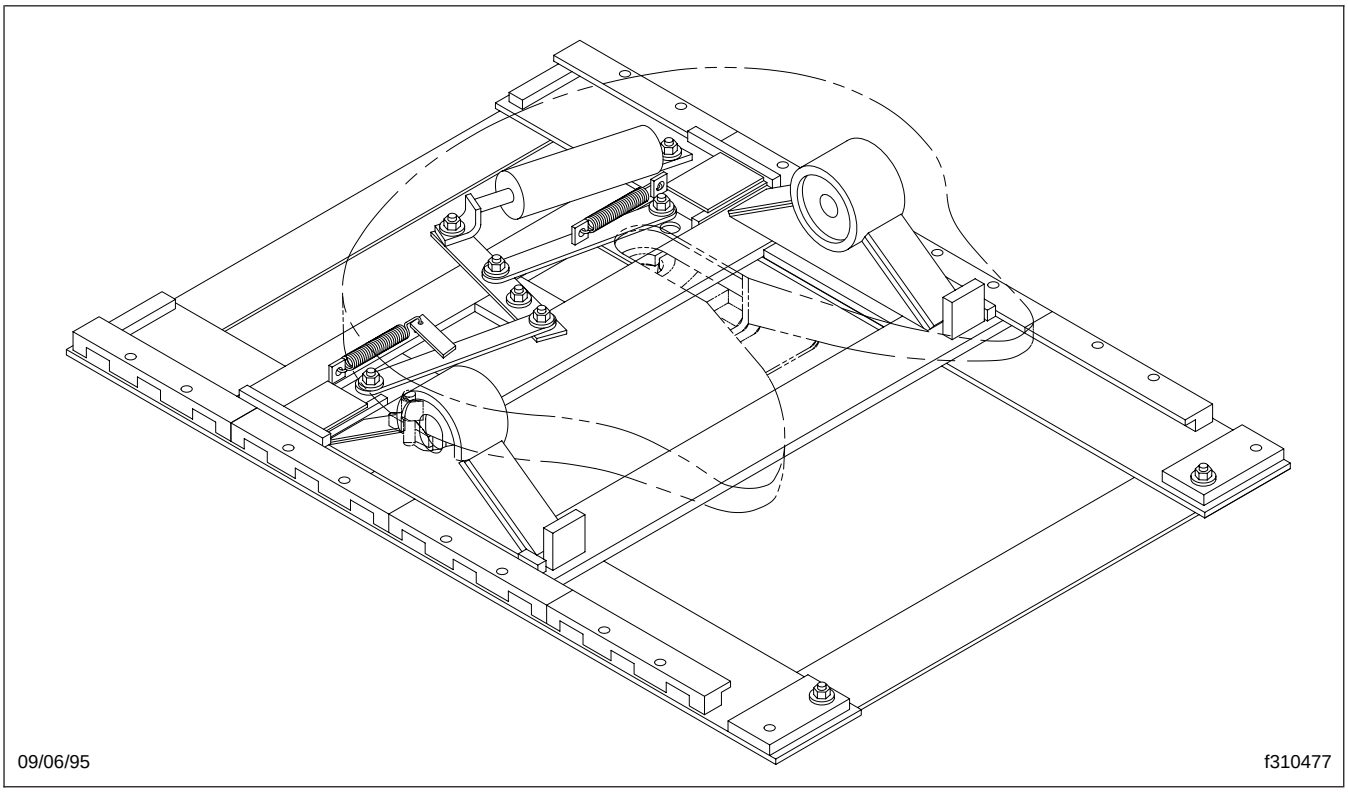


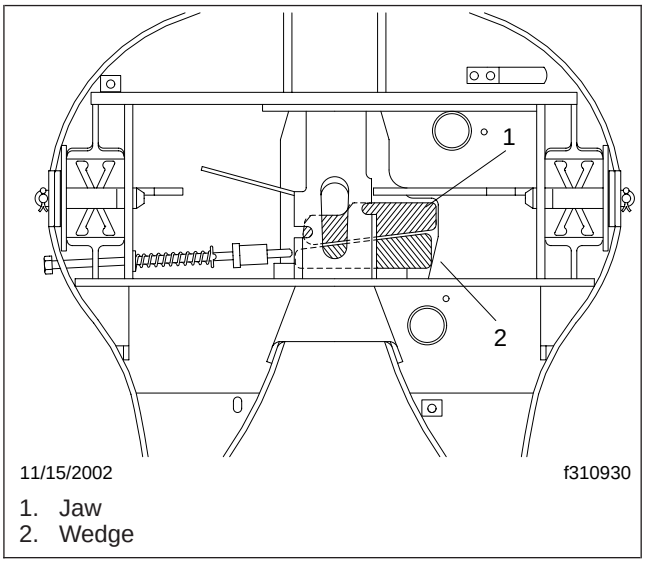
Fig. 1, Fontaine H5092 Series Air Slide Fifth Wheel

The Fontaine fifth wheel lock mechanism for the trailer kingpin consists of a spring-loaded jaw and sliding wedge. Kingpin release is accomplished by pulling a manual lock control handle located on either the right side (curbside) or left side (roadside) of the fifth wheel. Kingpin coupling occurs when the kingpin enters the throat of the fifth wheel, triggers the jaw and wedge to slide into place behind the kingpin, and moves the lock control handle into the locked position.

As the kingpin enters the lock mechanism, the jaw is moved first with the spring-loaded wedge sliding in place against the jaw. The jaw will move behind the kingpin, followed by the wedge. The wedge reinforces the jaw and automatically adjusts for slack around the kingpin. See **Fig. 2** for an illustration of the jaw and wedge in the locked position.

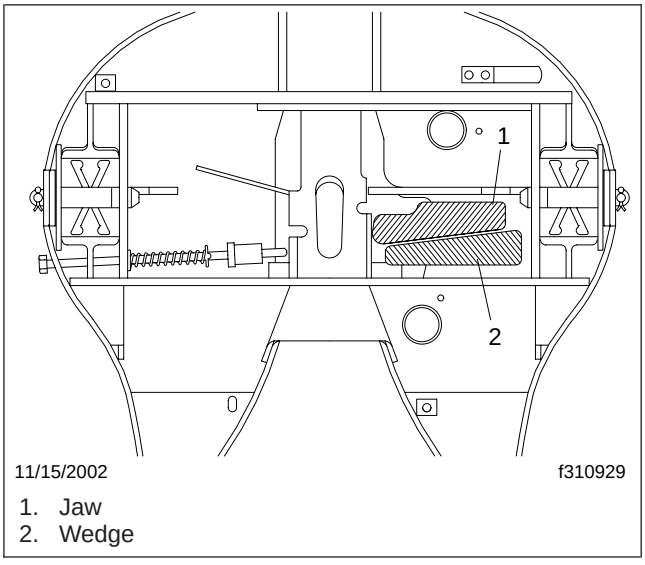
Placing the lock control handle in the unlocked position moves the wedge and jaw out from behind the kingpin and unlocks the fifth wheel. See **Fig. 3** for an illustration of the jaw and wedge in the unlocked position.

General Information



1. Jaw
2. Wedge

Fig. 2, Locked Position



1. Jaw
2. Wedge

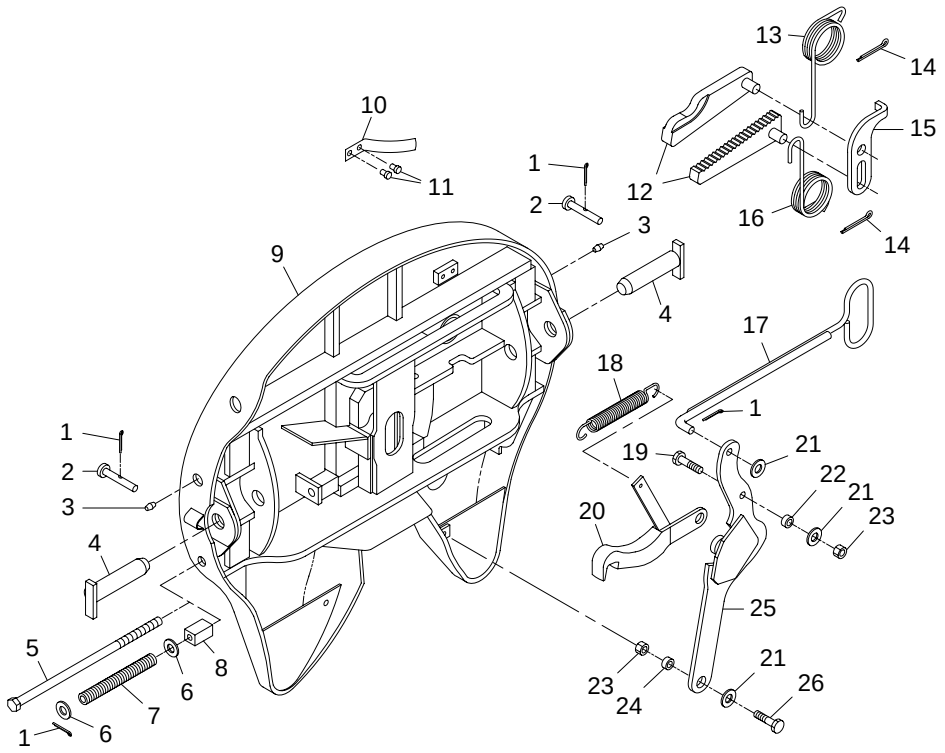
Fig. 3, Unlocked Position

Fifth Wheel Removal and Disassembly

See **Fig. 1** for an exploded view of the Fontaine® H5092 fifth wheel.

result in disengagement of the trailer from the tractor, leading to personal injury or property damage.

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Fail-



09/18/95 f310476

1. Cotter Pin, 3/16" x 1"
2. Lower Bracket Retainer Pin
3. Grease Fitting
4. Lower Bracket Pin
5. Wedge Stop Rod
6. Flatwasher
7. Wedge Stop Rod Spring
8. Nut, Wedge Stop Rod
9. Upper Assembly, Side Release
10. Leaf Spring
11. Thread-Cutting Screw, 1/4–20 x 3/8"
12. Step Jaw and Wedge
13. Jaw Spring
14. Cotter Pin, 1/4" x 3"
15. Timer
16. Wedge Spring
17. Pull Handle
18. Bumper Handle Spring
19. Hexhead Bolt, 1/2–13 x 2", Bumper Pivot
20. Bumper
21. Flatwasher
22. Bushing, 5/16", Bumper Pivot
23. Hex Locknut, 1/2–13
24. Bushing, 7/16", Handle Pivot
25. Operating Handle, Side Release Only
26. Hexhead Bolt, 1/2–13 x 2", Handle Pivot

Fig. 1, Fontaine H5092 Series Fifth Wheel (left-side release shown)

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could

ure to do so can result in personal injury, due to parts ejecting with force.

1. Steam clean the top plate. Remove it from the sliding mount by removing the cotter pins from

Removal and Disassembly

the retaining pins. Remove the retaining pins and bushing pins from both sides of the top plate.

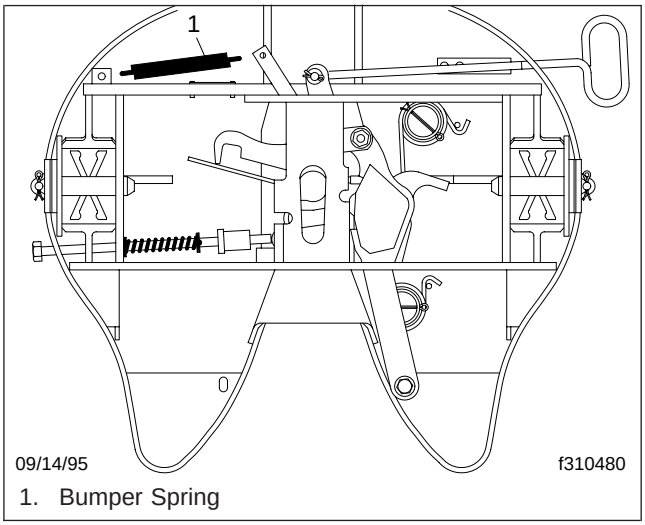
2. Using an overhead hoist, lift the fifth wheel off the sliding mount and tractor frame.
3. Turn the fifth wheel upside down.

NOTE: While disassembling the fifth wheel, check it for cracks and for missing or damaged parts.

⚠ WARNING

Do not attempt to repair or rebuild the top plate if it is cracked or if parts are damaged. The top plate or parts could malfunction. This could result in disengagement of the trailer during vehicle travel, possibly causing personal injury and property damage.

4. Set the fifth wheel in a locked position, then unhook the bumper spring from the bumper tang and the tab on the side of the fifth wheel substructure. See **Fig. 2**. Remove the bumper spring.



1. Bumper Spring

Fig. 2, Bumper Spring Removal

5. Remove the two bolts on the operating handle. **Fig. 3.** Each bolt has a nut, washer, and bushing. Discard the bushings.
6. Remove the cotter pin and washer that holds the pull handle to the operating handle. Slide the pull handle out through the side of the fifth wheel. See **Fig. 4**.

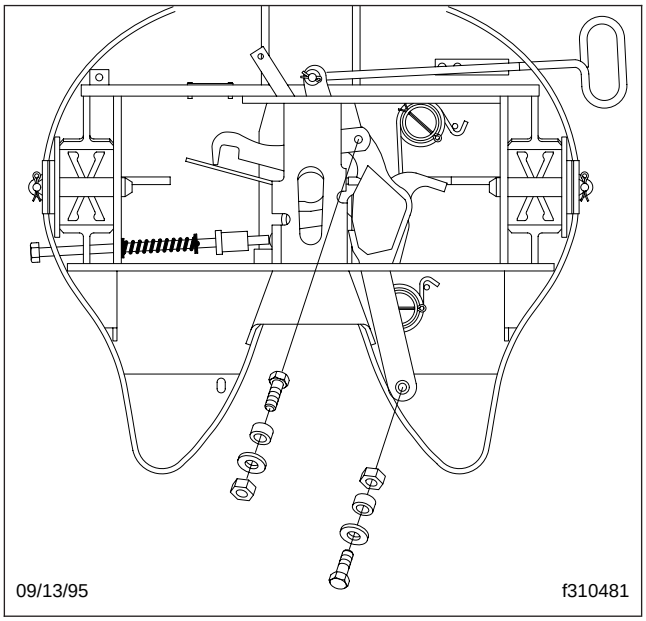


Fig. 3, Bolt Removal

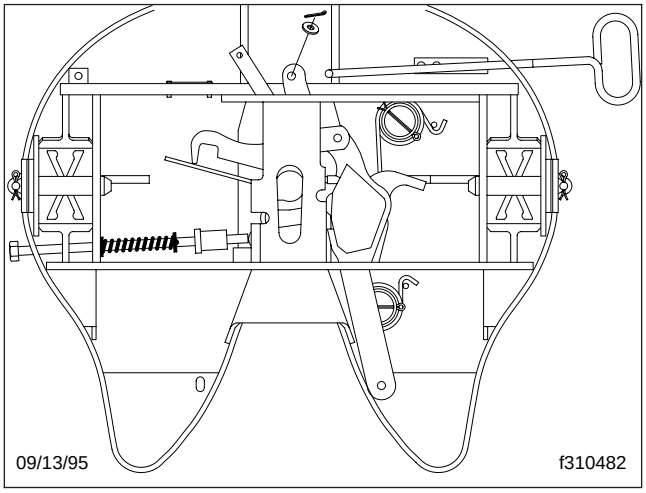
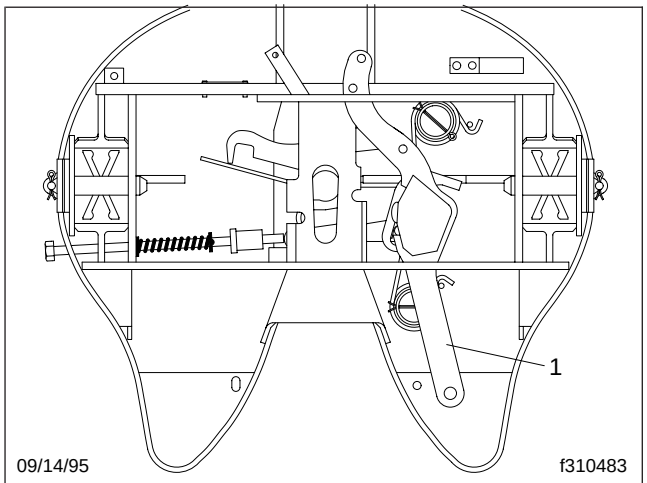


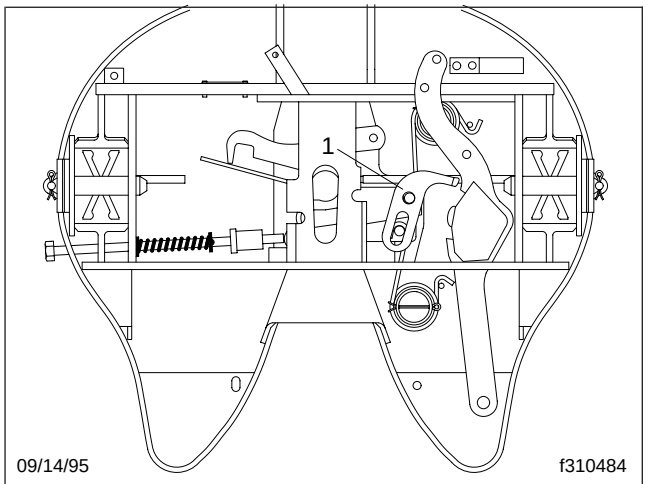
Fig. 4, Pull Handle Removal

7. Slide the operating handle over to the side of the fifth wheel. Slide the bottom part first. This will allow the handle to clear the jaw and wedge studs on the underside and clear the timer. See **Fig. 5**.
8. Remove the timer by lifting upward. See **Fig. 6**.



1. Operating Handle

Fig. 5, Operating Handle Positioning



1. Timer

Fig. 6, Timer Removal

9. Slide the operating handle out through the slot in the rear crossmember of the fifthwheel. See **Fig. 7**.

10. Slide the bumper toward the operating handle slot and to the rear of the fifth wheel until the bumper tang clears the operating handle slot. Lift upward and remove. See **Fig. 8**.

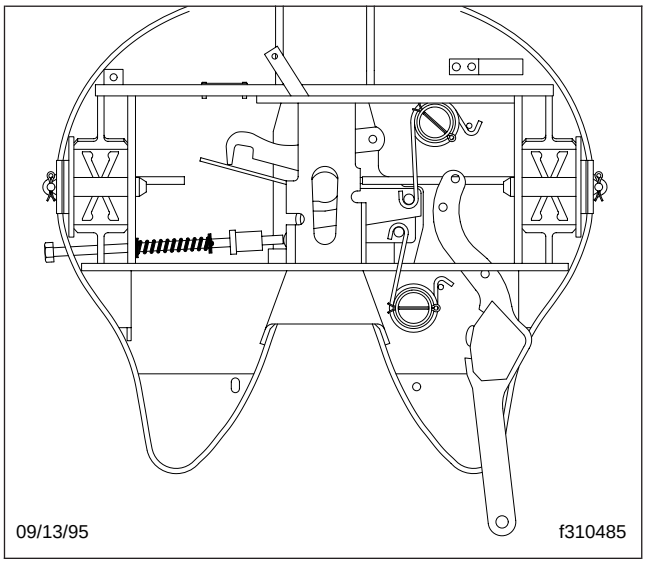
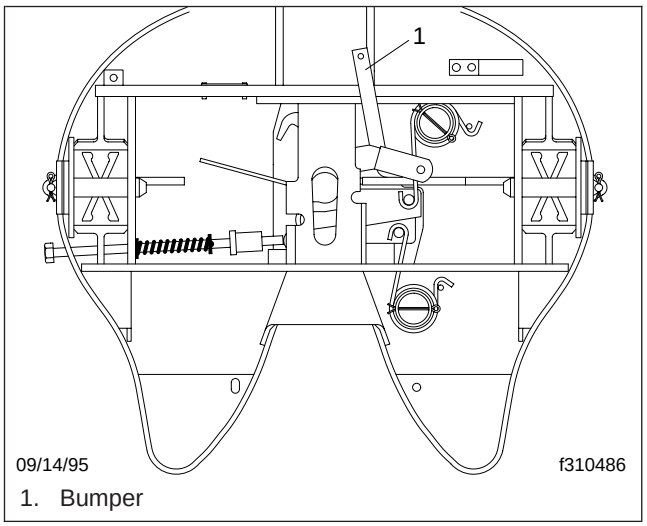


Fig. 7, Operating Handle Removal



1. Bumper

Fig. 8, Bumper Removal

⚠ WARNING

The wedge spring is under extreme tension. Always wear safety glasses. Do not stand directly over the springs. A flying spring could cause personal injury.

11. Remove the cotter pins from the jaw and wedge springs. Discard the cotter pins, and pry the small hooked tail of the jaw and wedge spring up

Removal and Disassembly

over the jaw and wedge studs. Remove and discard both springs. See **Fig. 9**.

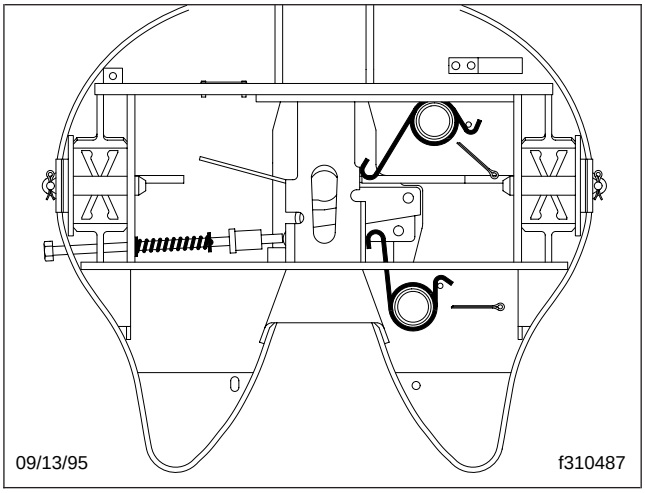


Fig. 9, Spring Removal

12. Remove the wedge first, and then the jaw. Discard the jaw and wedge. See **Fig. 10**.

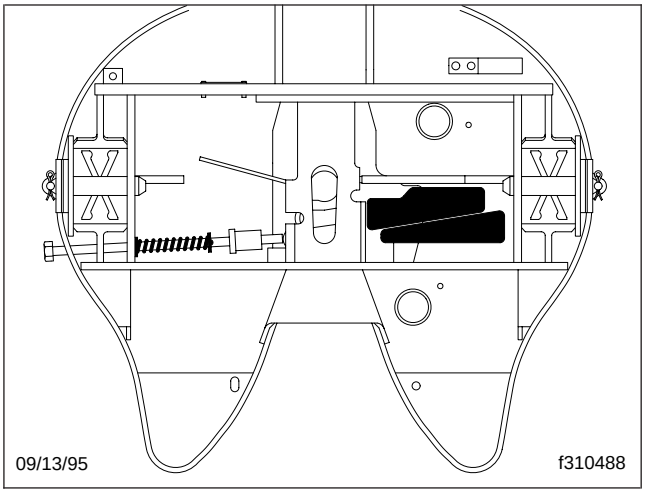


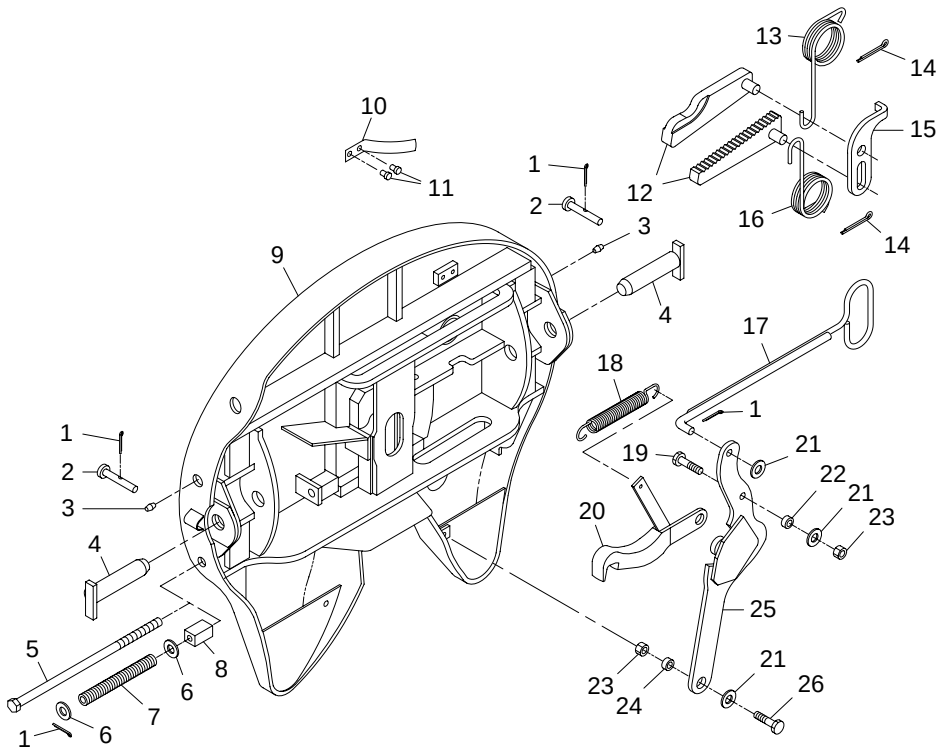
Fig. 10, Jaw and Wedge Removal

Assembly and Installation

See **Fig. 1** for an exploded view of a Fontaine® H5092 fifth wheel.

from the tractor, leading to personal injury and property damage.

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.



1. Cotter Pin, 3/16" x 1"
2. Lower Bracket Retainer Pin
3. Grease Fitting
4. Lower Bracket Pin
5. Wedge Stop Rod
6. Flatwasher
7. Wedge Stop Rod Spring
8. Nut, Wedge Stop Rod
9. Upper Assembly, Side Release
10. Leaf Spring
11. Thread-Cutting Screw, 1/4–20 x 3/8"
12. Step Jaw and Wedge
13. Jaw Spring
14. Cotter Pin, 1/4" x 3"
15. Timer
16. Wedge Spring
17. Pull Handle
18. Bumper Handle Spring
19. Hexhead Bolt, 1/2–13 x 2", Bumper Pivot
20. Bumper
21. Flatwasher
22. Bushing, 5/16", Bumper Pivot
23. Hex Locknut, 1/2–13
24. Bushing, 7/16", Handle Pivot
25. Operating Handle, Side Release Only
26. Hexhead Bolt, 1/2–13 x 2", Handle Pivot

Fig. 1, Fontaine H5092 Series Fifth Wheel (left-side release shown)

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in possible disengagement of the trailer

IMPORTANT: Replace any parts that show signs of wear, damage, or deterioration.

Fifth Wheel Assembly and Installation

1. Clean all moving parts with no. 2 diesel fuel before assembly.
2. Always assemble the parts around a 2-inch kingpin or a shaft with a 2-inch diameter. Insert the jaw first and then the new wedge below it. Apply a moderate amount of grease having EP (extra pressure) additives to the sides and serrated edges of the jaw and wedge. Also apply grease to the stationary jaw in the throat of the fifth wheel. See **Fig. 2**.

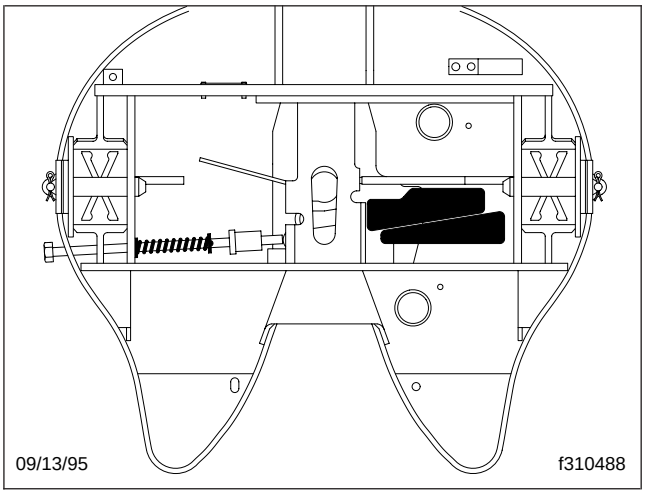


Fig. 2, Wedge and Jaw Installation

3. Insert the new wedge spring through the slot in the rear crossmember and lay the coil over the spring boss. Using a spring tool, engage the small hooked tail of the wedge spring and wind it around until it is directly over the small stud at the back of the bracket. Using a hammer, nudge the spring downward allowing it to catch on the stud. Insert a new cotter pin. See **Fig. 3**.

   Repeat these steps to replace the jaw spring.

NOTE: The jaw spring has minimal tension and can be replaced by hand.

4. Place the bumper back in position, sliding the bumper tang through the operating handle guide slot and toward the tab on the side of the fifth wheel substructure. See **Fig. 4**.
5. Apply a liberal amount of grease to the grooved middle section of the operating handle, then insert the operating handle and move it over to the side of the wheel. See **Fig. 5**.

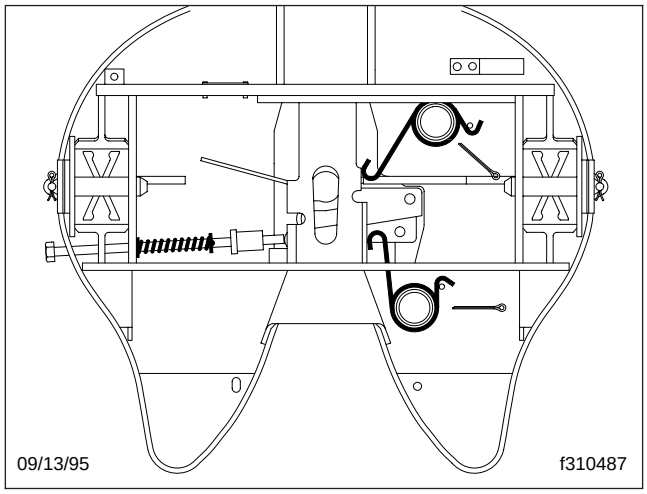
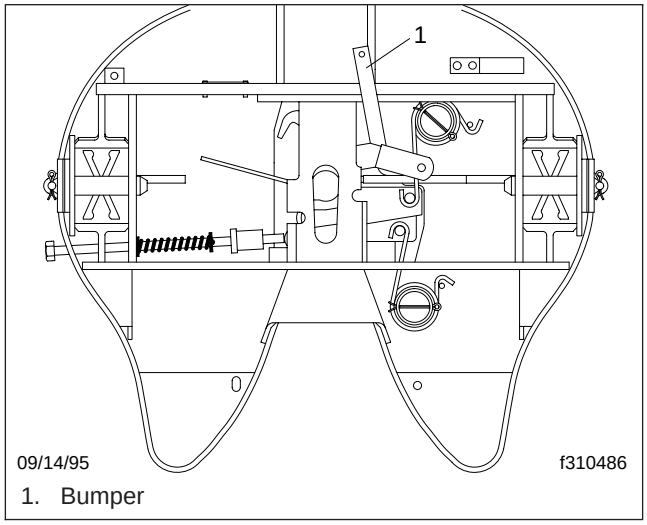


Fig. 3, Spring Installation



1. Bumper

Fig. 4, Bumper Installation

6. Insert the timer over the jaw and wedge studs. the small hole on the timer fits over the jaw stud and the slotted hole fits over the wedge stud. Be certain the small bent arm of the timer is facing downward. See **Fig. 6**.
7. Slide the operating handle toward the center of the wheel to engage the handle with the studs on the jaw and wedge. Slide the top part first. This will ensure that the grooves on the operating handle are aligned with the studs. A correctly aligned operating handle should be in a vertical position once it goes over the studs. See **Fig. 7**.

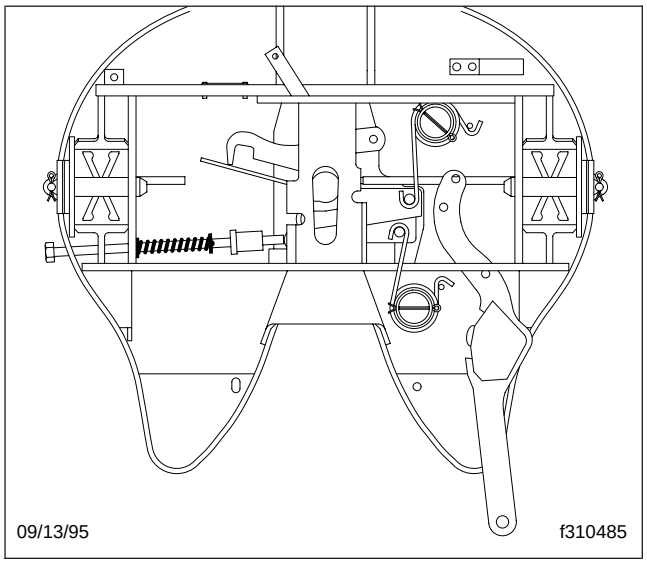


Fig. 5, Operating Handle Installation

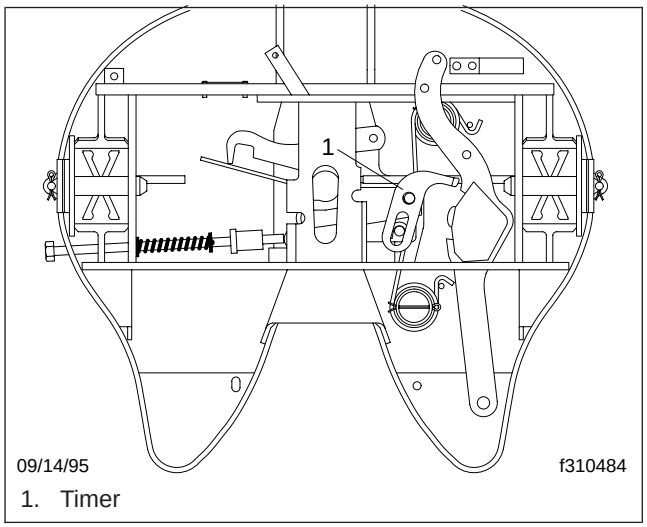


Fig. 6, Timer Installation

8. Slide the pull handle in through the safety lock and using the cotter pin and washer, fasten it in the top hole of the operating handle. See **Fig. 8**.
9. Align the bumper hole with the hole in the operating handle. Replace the bolts on the operating handle. The bolt which fastens the operating handle to the bumper must be inserted with the threads facing toward you to prevent interference with the jaw springs. The other bolt should be positioned with the threads facing downward. Each bolt has a nut, washer, and new bushings.

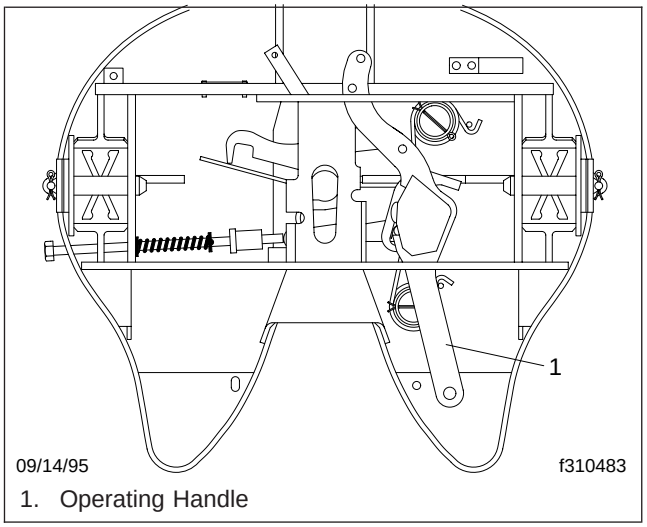


Fig. 7, Operating Handle Positioning

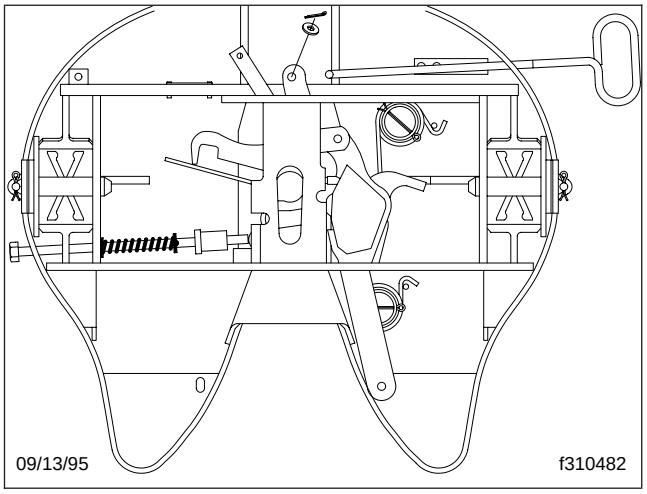


Fig. 8, Pull Handle Installation

Apply grease to the bolt parts and where there is metal to metal contact with the operating handle. See **Fig. 9**. Do not overtighten the bolts. Lubricate all pivot points.

IMPORTANT: The fifth wheel must be well lubricated to operate correctly. Refer to Group 31 of the *Business Class®: Maintenance Manual* for complete maintenance and lubrication instructions for the fifth wheel assembly.

10. Connect the bumper spring to its clasp. Apply grease to the bracket pockets and to the grease fittings on the side of the fifth wheel until grease

Fifth Wheel Assembly and Installation

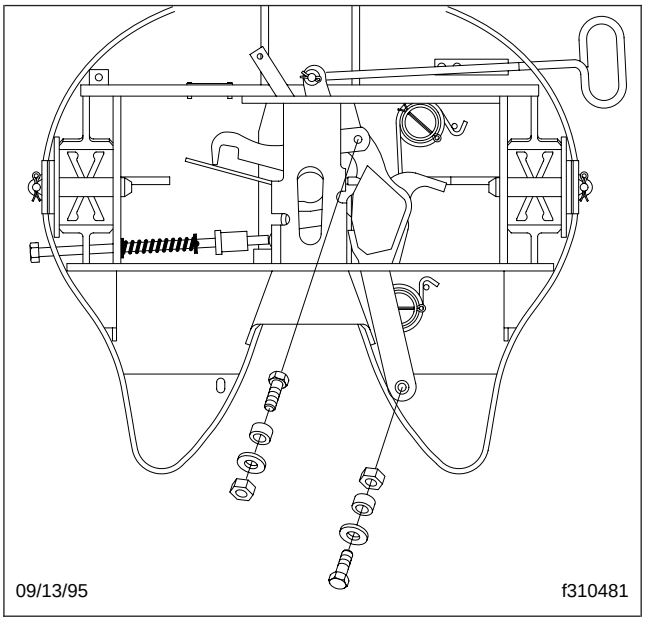
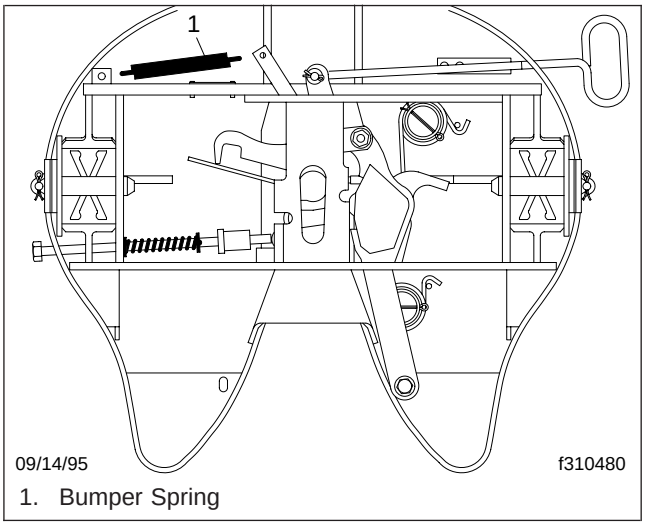


Fig. 9, Bolt Installation

flows into the upper brackets. Also apply a liberal amount of grease to the top plate. See **Fig. 10**.



1. Bumper Spring

Fig. 10, Spring Installation

WARNING

If the fifth wheel does not operate properly, do not use it. The fifth wheel could malfunction, resulting in personal injury or property damage due to possible disengagement of the trailer from the tractor.

11. Using an overhead hoist, position the fifth wheel on the sliding mount assembly. Insert the bushing pins. Install the retaining pins and the 1-inch-long cotter pins.

Troubleshooting Tables

Problem—Difficulty Coupling

Possible Cause	Remedy
The kingpin is too high to trip the latch	Lower the landing gear.
The trailer plate or kingpin is damaged.	Check the trailer plate for flatness. Check the kingpin for squareness with the trailer plate.

Problem—Excessive Wear on the Fifth Wheel Top Plate

Possible Cause	Remedy
Damaged trailer plate	If the trailer plate is not flat, replace it.

Problem—Difficulty Uncoupling

Possible Cause	Remedy
Pressure on the locking mechanism caused by truck drifting apart from the trailer putting excess pressure on the lock	Back up the trailer and set the brakes. Strike the wedge stop rod which protrudes through the side of the fifth wheel. This spring-loaded rod will release the pressure on the locking mechanism.
Oval-shaped kingpin	Lower the landing gear.
Debris build-up in the grease	

Problem—Slack

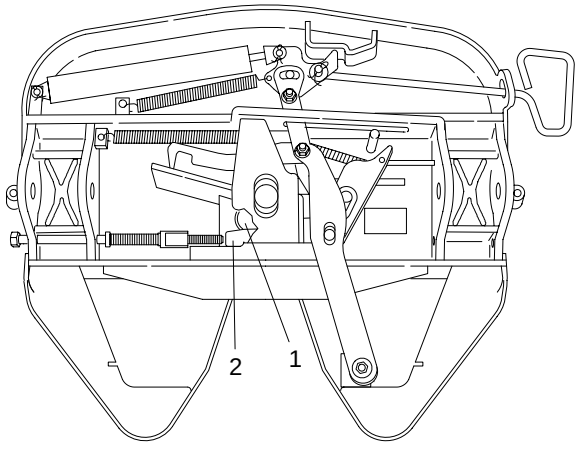
Possible Cause	Remedy
Undersized kingpin	Replace the kingpin if worn greater than 1/8 inch (3 mm) at the 2-inch (5-cm) diameter.
Worn jaw and wedge	Jaw and wedge could have excessive wear. Replace them.

General Information

Fontaine 6000 and 7000 series fifth wheels couple to trailers having a standard 2-inch kingpin. When installed as a stationary mount, the fifth wheel is bracket-mounted to the tractor frame in a position that best distributes the trailer load over the tractor axles. Sliding fifth wheels are mounted on the Fontaine AWB or MWS model slide mounts.

The Fontaine fifth wheel lock mechanism for the trailer kingpin consists of a spring-loaded jaw and sliding wedge. Kingpin release is accomplished by pulling a manual lock control handle located on either the right side (curbside) or left side (roadside) of the fifth wheel. Kingpin coupling occurs when the kingpin enters the throat of the fifth wheel, triggers the jaw and wedge to slide into place behind the kingpin, and moves the lock control handle into the locked position.

As the kingpin enters the lock mechanism, the jaw is moved first with the spring-loaded wedge sliding in place against the jaw. The jaw will move behind the kingpin, followed by the wedge. The wedge reinforces the jaw and automatically adjusts for slack around the kingpin. See **Fig. 1** for an illustration of the jaw and wedge in the locked position.

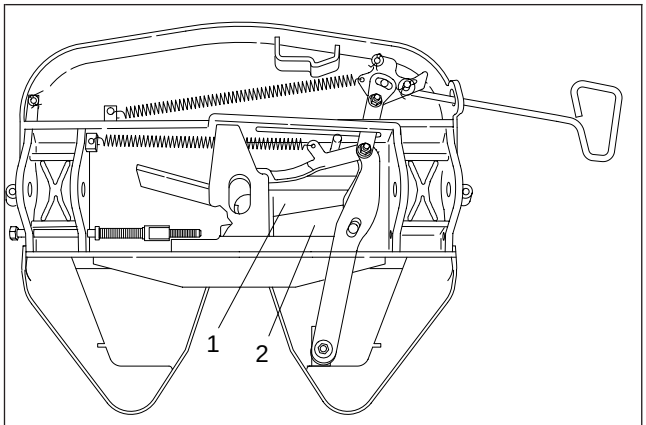


11/18/2002 f310931

1. Jaw
2. Wedge

Fig. 1, Locked Position

Placing the lock control handle in the unlocked position moves the wedge and jaw out from behind the kingpin and unlocks the fifth wheel. See **Fig. 2** for an illustration of the jaw and wedge in the unlocked position.



11/18/2002 f310932

1. Jaw
2. Wedge

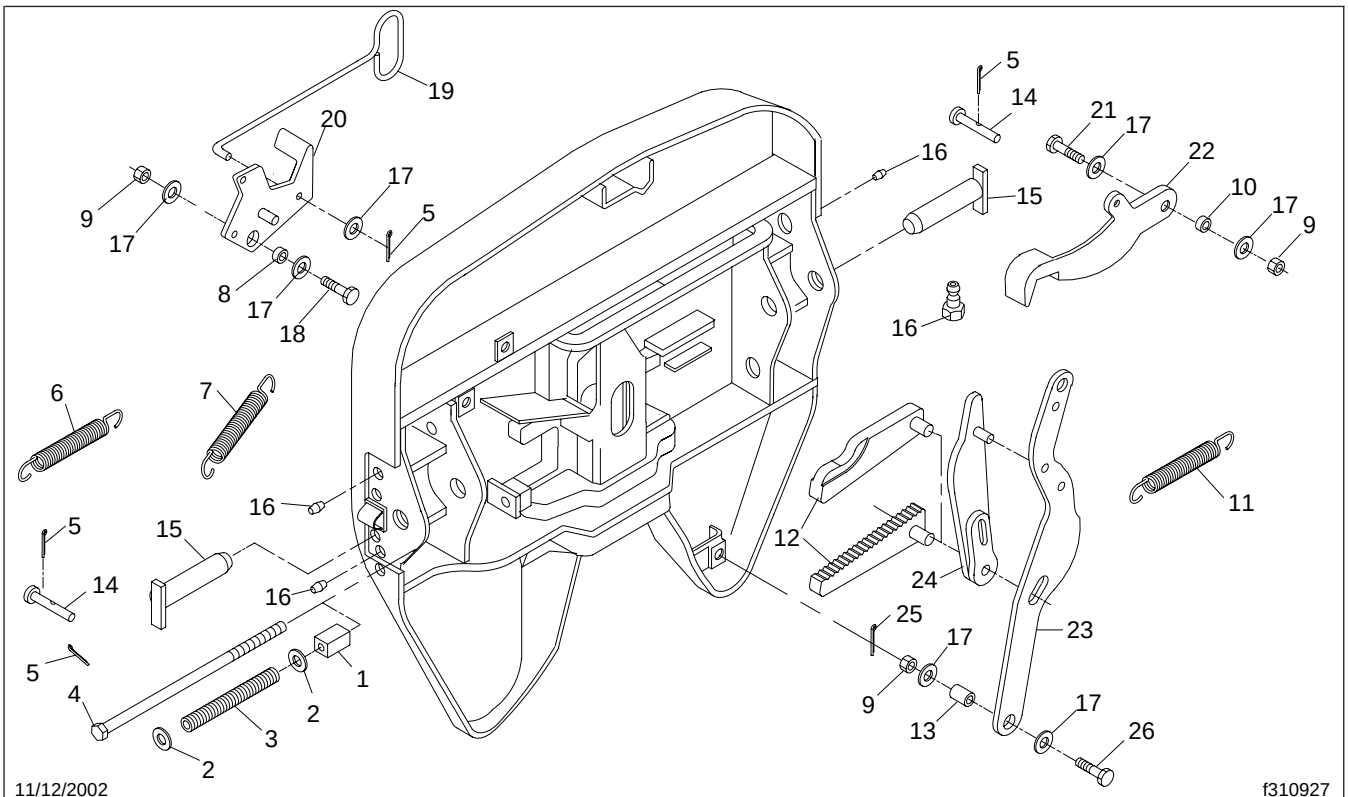
Fig. 2, Unlocked Position

Fifth Wheel Removal and Disassembly

See **Fig. 1** for an exploded view of a Fontaine® 6000 or 7000 No-Slack II series fifth wheel.

result in disengagement of the trailer from the tractor, leading to personal injury or property damage.

Parts are under spring compression. Wear safety goggles during disassembly and assembly. Fail-



1. Wedge Stop Rod Nut
2. Flatwasher, 5/8", Plain
3. Wedge Stop Rod Spring
4. Wedge Stop Rod
5. Cotter Pin, 3/16 x 1"
6. Bumper Spring
7. Handle Spring
8. Bushing, 7/16"
9. Hex Locknut, 1/2–13
10. Bushing, 5/16"
11. Timer Spring
12. Step Jaw and Wedge Set
13. Bushing
14. Bracket Retainer Pin
15. Bracket Pin
16. Grease Fitting
17. Flatwasher, 1/2" I.D. x 1-3/4" O.D., Plain
18. Hexhead Bolt, 1/2–13 x 1-1/2", Grade 5
19. Pull Handle
20. Secondary Lock
21. Hexhead Bolt, 1/2–13 x 1-3/4", Grade 5
22. Bumper
23. Operating Handle
24. Timer
25. Hairpin Cotter Pin
26. Hexhead Bolt, 1/2–13 x 2-3/4", Grade 5

Fig. 1, Fontaine 6000 and 7000 No-slack II Series Fifth Wheel (left side release shown)

⚠ WARNING

All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could

ure to do so can result in personal injury, due to parts ejecting with force.

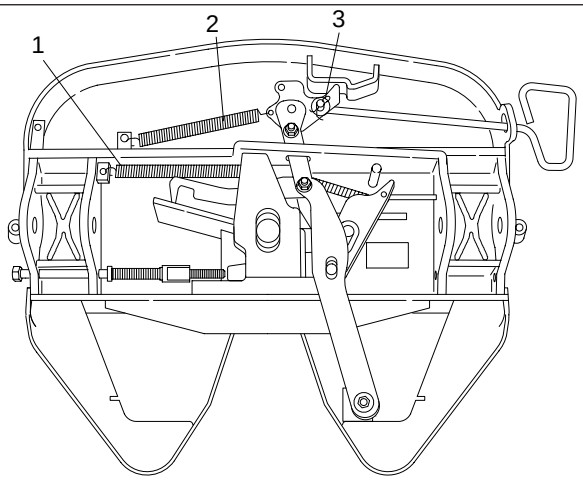
1. Steam clean the top plate. Remove it from the sliding mount by removing the cotter pins from the retaining pins. Remove the retaining pins and bushing pins from both sides of the top plate.

Removal and Disassembly

2. Using an overhead hoist, lift the fifth wheel off the sliding mount and tractor frame.
3. Turn the fifth wheel upside down.

NOTE: While disassembling the fifth wheel, check it for cracks and for missing or damaged parts.

4. Remove the secondary lock spring and bumper spring. See **Fig. 2**. Remove the pull handle cotter pin and washer, then slide out the pull handle.

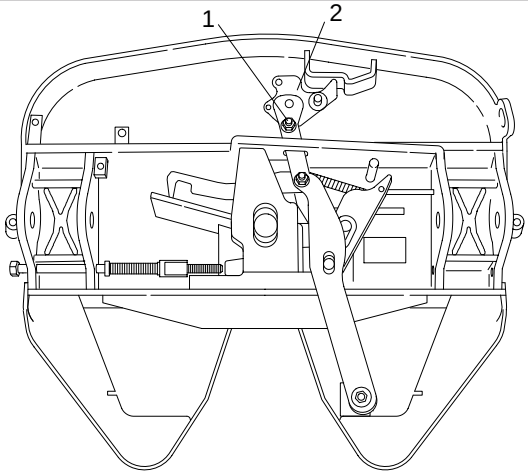


11/12/2002 f310920

1. Bumper Spring
2. Secondary Lock Spring
3. Pull Handle Cotter Pin

Fig. 2, Pull Handle

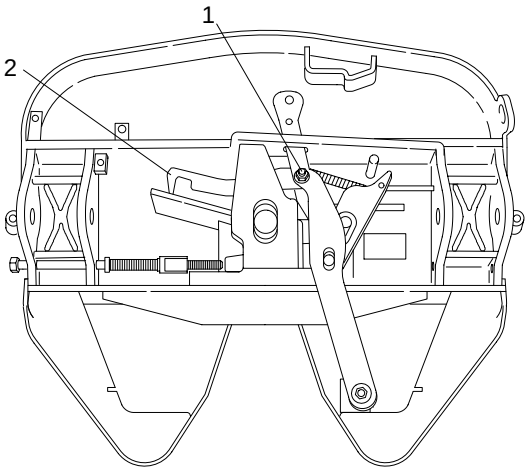
5. Unbolt and remove the secondary lock from the operating handle. Discard the locknut and bushing. See **Fig. 3**.
6. Unbolt and remove the bumper from the operating handle. Discard the locknut and bushing. See **Fig. 4**.
7. Unbolt the operating handle from the pivot mount and remove. Discard the locknut. See **Fig. 5**.
8. Remove the timer spring and timer. See **Fig. 6**.
9. Remove the jaw and wedge. See **Fig. 7**.



11/12/2002 f310921

1. Bolt
2. Secondary Lock

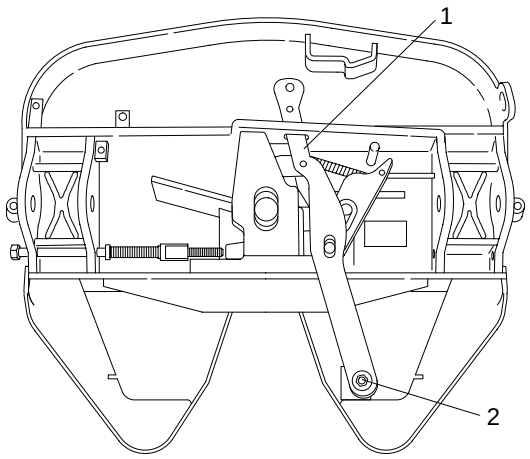
Fig. 3, Secondary Lock



11/12/2002 f310922

1. Bolt
2. Bumper

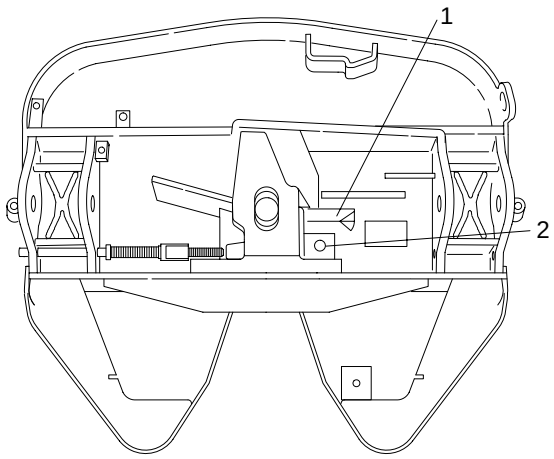
Fig. 4, Bumper



11/12/2002 f310923

1. Operating Handle
2. Bolt

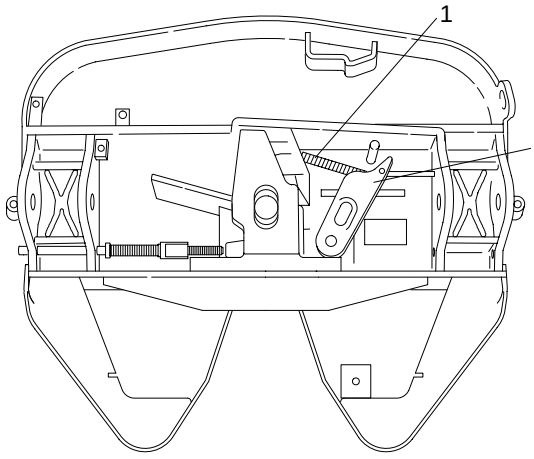
Fig. 5, Operating Handle



11/12/2002 f310925

1. Jaw
2. Wedge

Fig. 7, Jaw and Wedge



11/12/2002 f310924

1. Timer Spring
2. Timer

Fig. 6, Timer Spring and Timer

Assembly and Installation

⚠ WARNING

Before rebuilding the assembly, check to make sure that there are no cracks in the crossmembers or other components. Also check the bracket pin holes to ensure they are not worn oversize (pins should fit snugly). Under no circumstances should a fifth wheel be repaired or used if any component (crossmember, saddle bearing, etc.) is cracked. Operating a fifth wheel with damaged components could result in disengagement of the trailer from the tractor, leading to personal injury or property damage.

Use a Moly-based lubricant such as Mobil grease Moly 50 or equivalent when applying lubricant to the locking jaw and wedge. Lightly oil other moving parts in the fifth wheel.

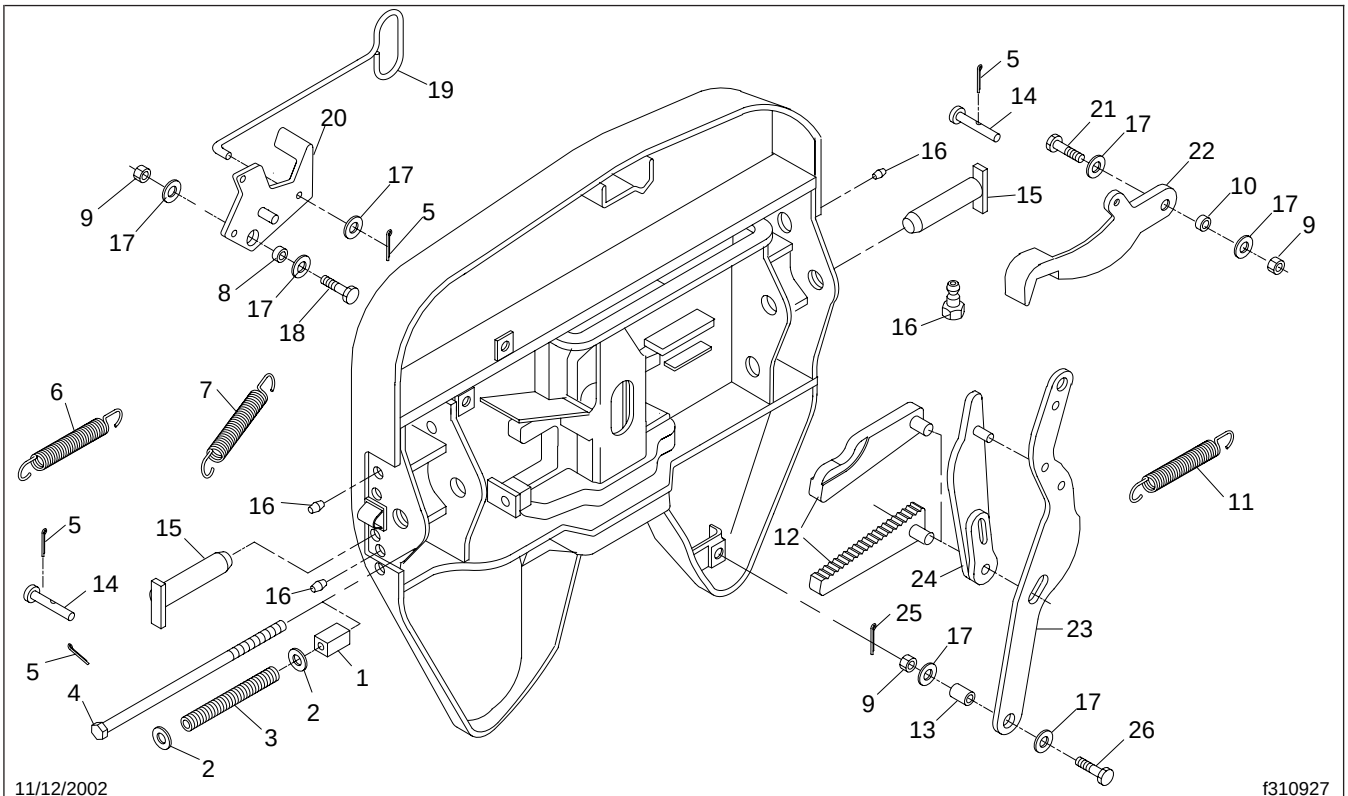
See **Fig. 1** for an exploded view of a Fontaine® 6000 or 7000 No-Slack II series fifth wheel.

1. Always assemble parts around a 2-inch kingpin or a 2-inch-diameter shaft. Insert the jaw first, then the wedge below it. See **Fig. 2**. Grease the jaw and wedge on the top and bottom.
2. Install the timer and the timer spring. See **Fig. 3**.
3. Install the operating handle and bolt to the pivot mount. See **Fig. 4**. Use the existing bolt, washer, hairpin cotter pin and bushing. Inspect the bushing for wear before using it and replace it if necessary. Use the new locknut that is supplied in the repair kit. Note the orientation of the bolt (**Fig. 1**).
4. Install the bumper and bolt it to the operating handle. See **Fig. 5**. Use the existing bolt and washers (inspect for wear before using and replace if necessary). Use the new locknut and bushing that is supplied in the repair kit. Note the orientation of the bolt (**Fig. 1**). After installing the bumper, check to make sure that it can pivot freely.
5. Insert the secondary lock and bolt it to the operating handle. See **Fig. 6**. Use the existing bolt and washers (inspect for wear before using and replace if necessary). Use the new locknut and bushing that is supplied in the repair kit. Note the orientation of the bolt (**Fig. 1**).
6. Install the pull handle. See **Fig. 7**. Use the existing washer and cotter pin (inspect for wear before using and replace if necessary). Attach the new secondary lock/bumper spring that is supplied in the repair kit. Open and close the fifth wheel to ensure that it works properly. The fifth wheel must be properly lubricated before opening and closing the wheel.

Use a Moly-based lubricant such as Mobil grease Moly 50 or equivalent when applying lubricant to the locking jaw and wedge. Lightly oil other moving parts in the fifth wheel.

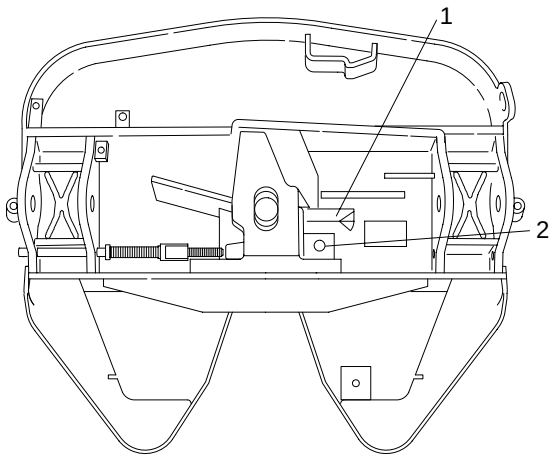
7. Close the fifth wheel several times with a standard 2-inch kingpin tool. With the lock closed, adjust the wedge stop rod so that the end is 1/4-inch (6 mm) from the wedge. See **Fig. 8**.
8. Using an overhead hoist, position the fifth wheel on the sliding mount assembly. Insert the bushing pins. Install the retaining pins and the 1-inch-long cotter pins.

Assembly and Installation



1. Wedge Stop Rod Nut
2. Flatwasher, 5/8", Plain
3. Wedge Stop Rod Spring
4. Wedge Stop Rod
5. Cotter Pin, 3/16 x 1"
6. Bumper Spring
7. Handle Spring
8. Bushing, 7/16"
9. Hex Locknut, 1/2–13
10. Bushing, 5/16"
11. Timer Spring
12. Step Jaw and Wedge Set
13. Bushing
14. Bracket Retainer Pin
15. Bracket Pin
16. Grease Fitting
17. Flatwasher, 1/2" I.D. x 1-3/4" O.D., Plain
18. Hexhead Bolt, 1/2–13 x 1-1/2", Grade 5
19. Pull Handle
20. Secondary Lock
21. Hexhead Bolt, 1/2–13 x 1-3/4", Grade 5
22. Bumper
23. Operating Handle
24. Timer
25. Hairpin Cotter Pin
26. Hexhead Bolt, 1/2–13 x 2-3/4", Grade 5

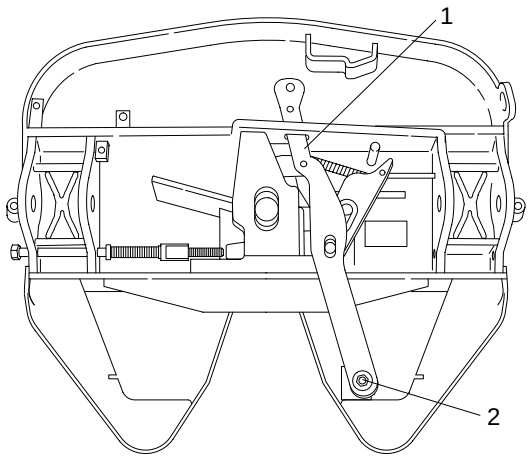
Fig. 1, Fontaine 6000 and 7000 No-slack II Series (left side release shown)



11/12/2002 f310925

1. Jaw
2. Wedge

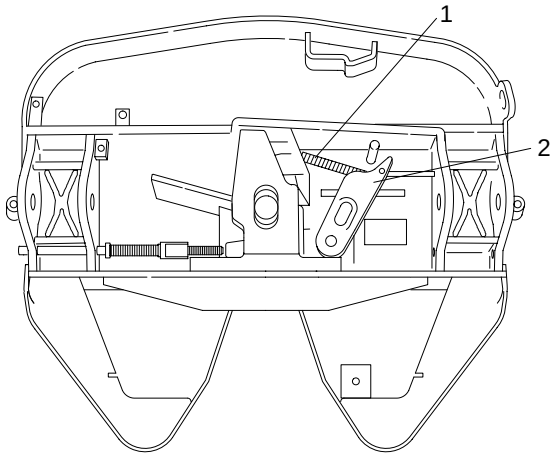
Fig. 2, Jaw and Wedge



11/12/2002 f310923

1. Operating Handle
2. Bolt

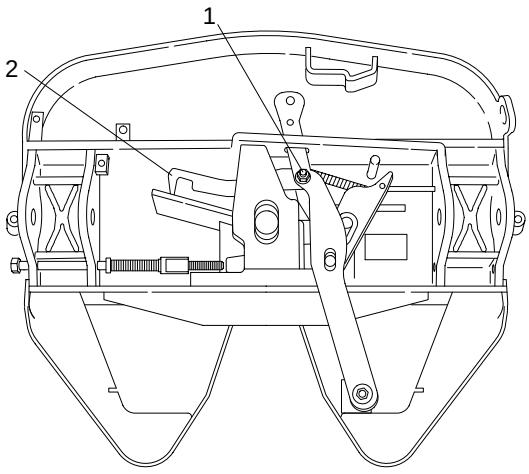
Fig. 4, Operating Handle



11/12/2002 f310924

1. Timer Spring
2. Timer

Fig. 3, Timer Spring and Timer

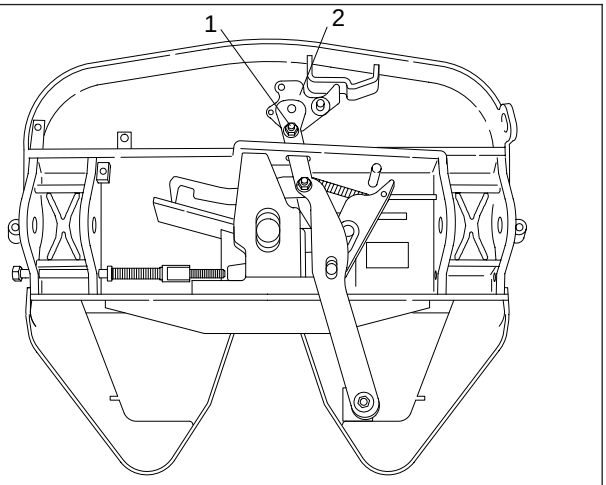


11/12/2002 f310922

1. Bolt
2. Bumper

Fig. 5, Bumper

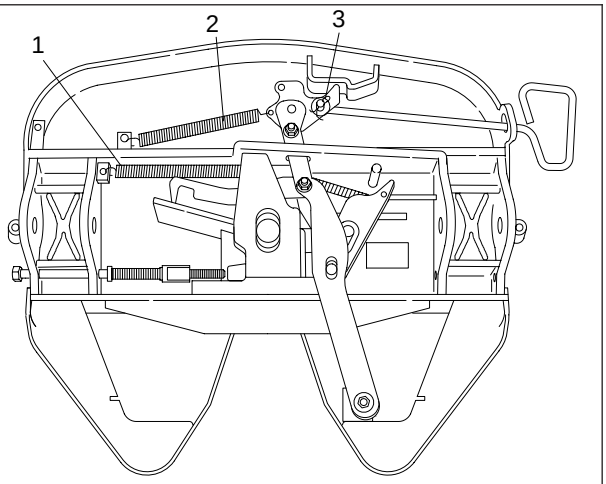
Assembly and Installation



11/12/2002 f310921

1. Bolt
2. Secondary Lock

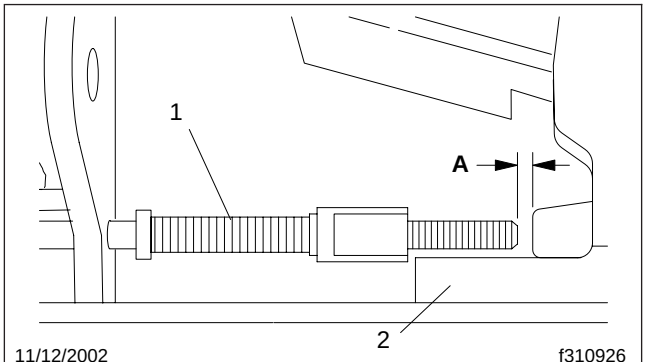
Fig. 6, Secondary Lock



11/12/2002 f310920

1. Bumper Spring
2. Secondary Lock Spring
3. Pull Handle Cotter Pin

Fig. 7, Pull Handle



11/12/2002 f310926

A. 1/4 inch (6 mm)
1. Stop Rod
2. Wedge

Fig. 8, Wedge Stop Rod Adjustment

Troubleshooting Tables

Problem—Difficulty Coupling

Possible Cause	Remedy
The kingpin is too high to trip the latch.	Lower the landing gear.
The trailer plate or kingpin is damaged.	Check the trailer plate for flatness. Check the kingpin for squareness with the trailer plate.

Problem—Excessive Wear on the Fifth Wheel Top Plate

Possible Cause	Remedy
Damaged trailer plate.	If the trailer plate is not flat, replace it.

Problem—Difficulty Uncoupling

Possible Cause	Remedy
Pressure on the locking mechanism caused by truck drifting apart from the trailer putting excess pressure on the lock.	Back up the trailer and set the brakes. Strike the wedge stop rod which protrudes through the side of the fifth wheel. This spring-loaded rod will release the pressure on the locking mechanism.
Oval-shaped kingpin.	Lower the landing gear.
Debris build-up in the grease.	

Problem—Slack

Possible Cause	Remedy
Undersized kingpin.	Replace the kingpin if worn greater than 1/8 inch (3 mm) at the 2-inch (5-cm) diameter.
Worn jaw and wedge	Jaw and wedge could have excessive wear. Replace them.

General Description

Freightliner front suspensions use either a taperleaf or a flatleaf assembly. The taperleaf suspensions are available in varying capacities from 6,000-pound (2 722 kg) to 14,000-pound (6 350 kg). Shock absorbers are standard. The flatleaf suspensions are available in varying capacities from 12,000-pound (5 543 kg) to 18,000-pound (8 165 kg), and shock absorbers are optional.

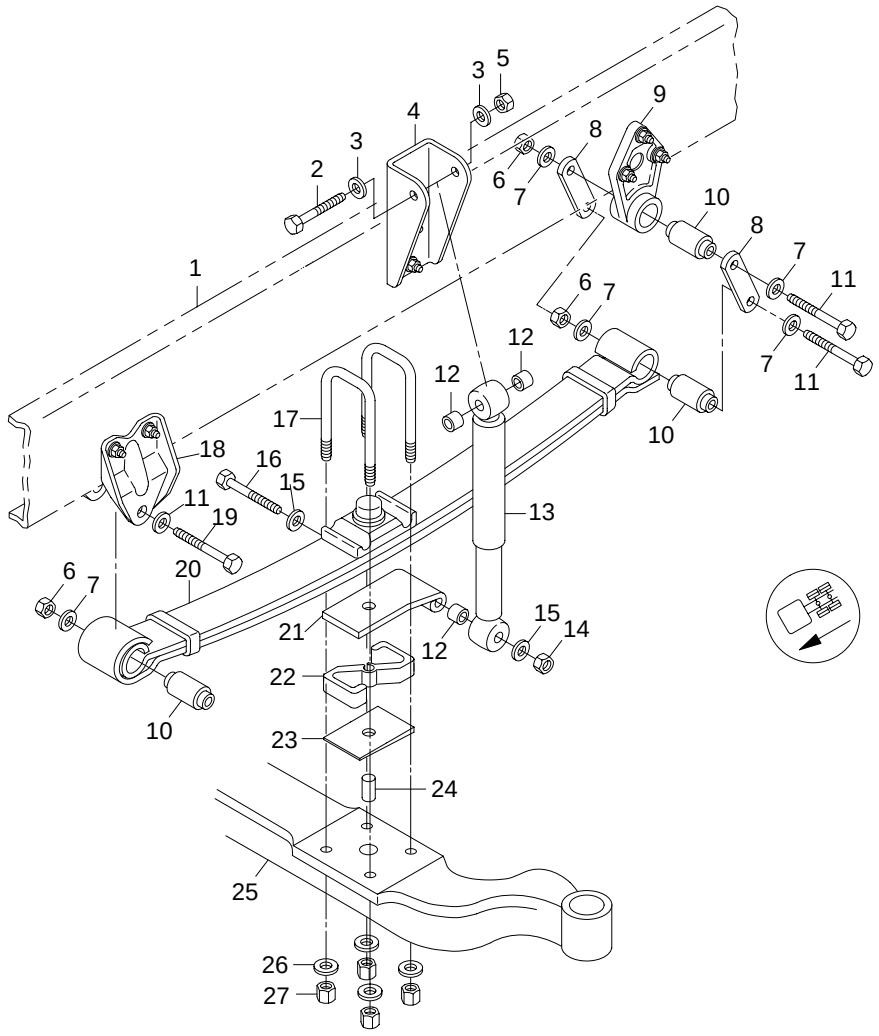
The spring assemblies are attached to the axle with U-bolts, hardened washers, and high nuts. See **Fig. 1**, **Fig. 2**, **Fig. 3**, and **Fig. 4**. The forward end of each spring mounts to a stationary front spring bracket. The rear of each spring mounts to a spring shackle suspended from a frame-mounted bracket. The shackle allows for variations in spring length as the spring flexes.

The leaf spring assembly absorbs and stores energy over bumps, releasing it at a controlled rate to smooth the ride. Individual spring leaves are held together by a center bolt. Alignment clips limit the sideways spread and vertical separation of the individual leaves.

A design change implemented in March 1999 combines the axle pad and the shock absorber lower mounting bracket into one part. See **Fig. 5**.

The all-wheel-drive front suspension (see **Fig. 6**) is nearly identical to the standard front suspension, except the U-bolts are longer and there is a thicker steel spacer between the leaf springs and the top of the front axle. See **Subject 130** for information about the all-wheel-drive front suspension.

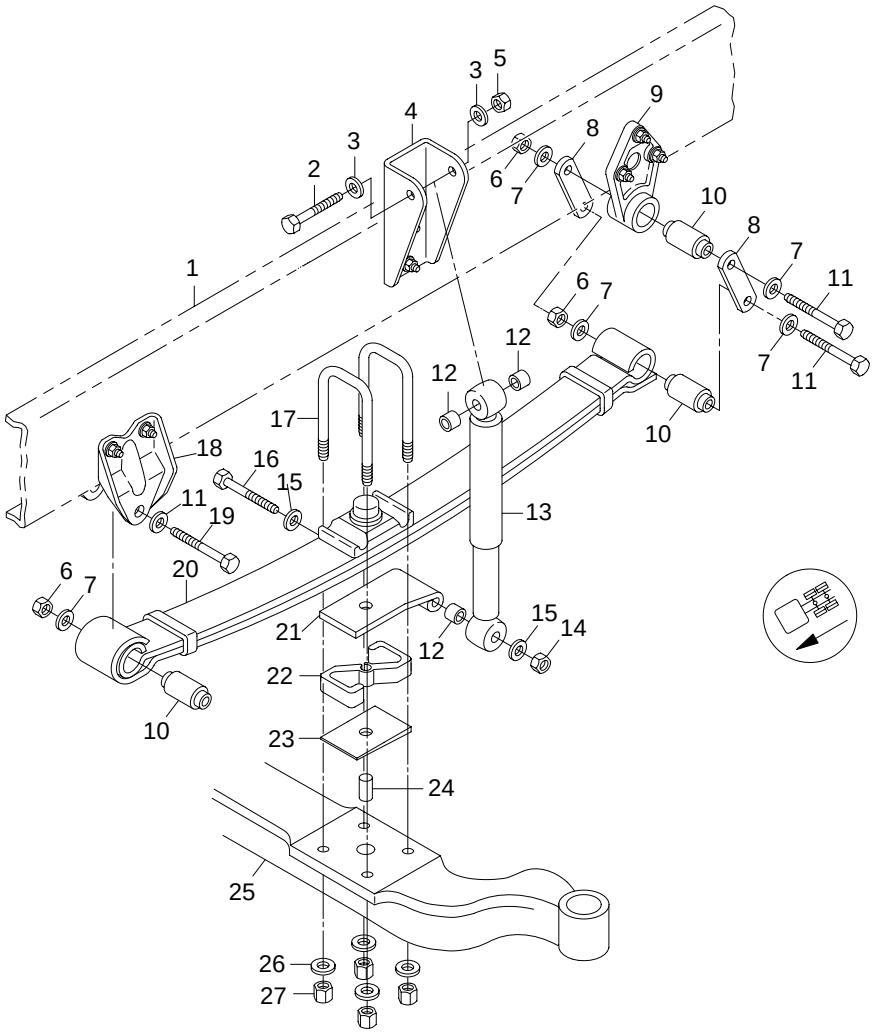
General Information



03/25/96 f320253a

1. Frame Rail
2. Shock Absorber Upper Mounting Bolt
3. Hardened Washer
4. Shock Absorber Upper Mounting Bracket
5. Hexnut
6. Hexnut, 3/4–10, Grade C
7. Hardened Washer
8. Spring Shackle
9. Shackle Bracket
10. Bushing
11. Spring Shackle Bolt, 3/4–10 x 6.5
12. Spacer
13. Shock Absorber
14. Hexnut
15. Hardened Washer
16. Shock Absorber Lower Mounting Bolt
17. U-Bolt, 5/8–18
18. Front Spring Bracket
19. Front Spring Mounting Eye Bolt, 3/4–10 x 6
20. Spring Assembly
21. Shock Absorber Lower Mounting Bracket
22. Spacer
23. Caster Adjustment Shim
24. Dowel Pin
25. Axle
26. Hardened Washer
27. High Hexnut, 5/8–18

Fig. 1, 6,000-Pound Taperleaf Front Suspension

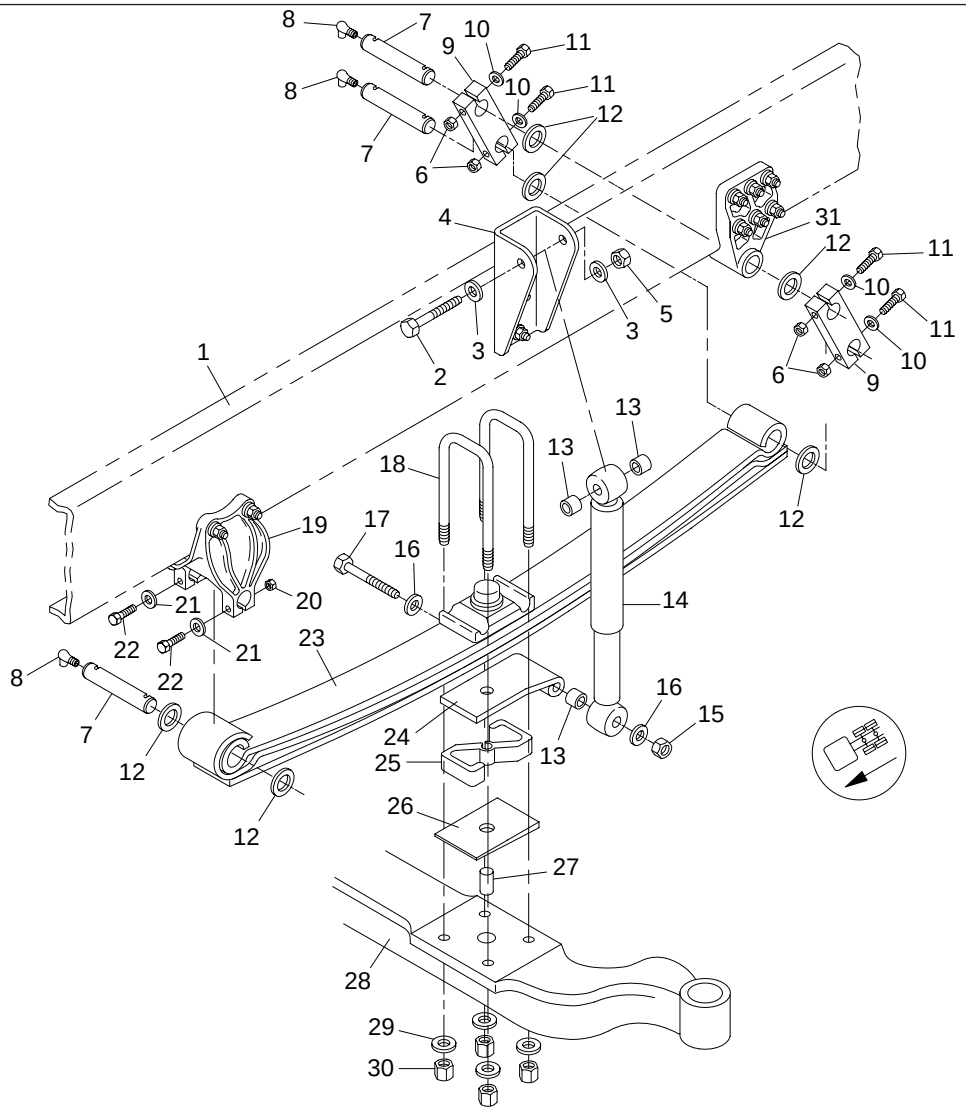


03/25/96 f320253a

1. Frame Rail
2. Shock Absorber Upper Mounting Bolt
3. Hardened Washer
4. Shock Absorber Upper Mounting Bracket
5. Hexnut
6. Hexnut, 3/4–10, Grade C
7. Hardened Washer
8. Spring Shackle
9. Shackle Bracket
10. Bushing
11. Spring Shackle Bolt, 3/4–10 x 6.5
12. Spacer
13. Shock Absorber
14. Hexnut
15. Hardened Washer
16. Shock Absorber Lower Mounting Bolt
17. U-Bolt, 3/4–16
18. Front Spring Bracket
19. Front Spring Mounting Eye Bolt, 3/4–10 x 6
20. Spring Assembly
21. Shock Absorber Lower Mounting Bracket
22. Spacer
23. Caster Adjustment Shim
24. Dowel Pin
25. Axle
26. Hardened Washer
27. High Hexnut, 3/4–16, Grade C

Fig. 2, 12,000-Pound Taperleaf Front Suspension

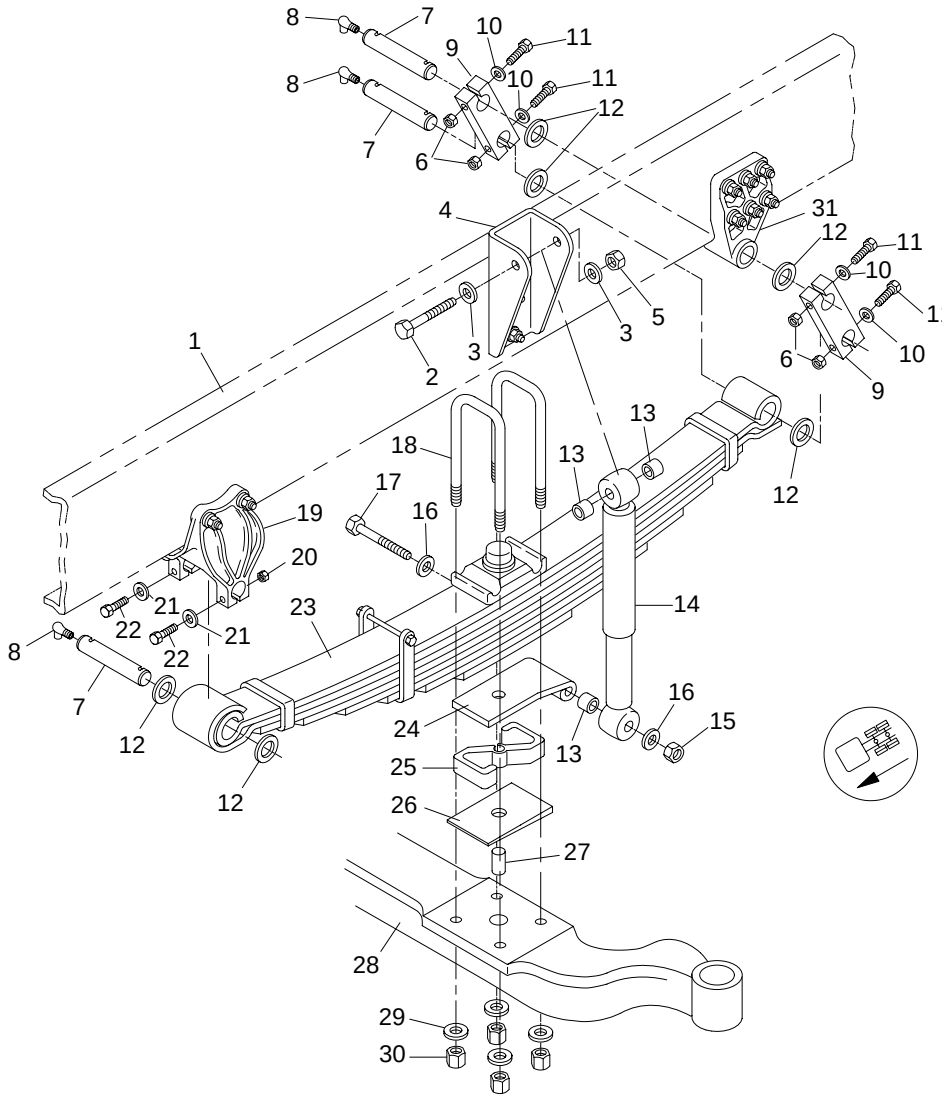
General Information



03/25/96 f320460

1. Frame Rail
2. Shock Absorber Upper Mounting Bolt
3. Hardened Washer
4. Shock Absorber Upper Mounting Bracket
5. Hexnut
6. Hexnut, 1/2–13
7. Spring Pin
8. Zerk Fitting
9. Shackle Bracket
10. Bearing Washer
11. Spring Shackle Bolt, 1/2–13 x 3.25
12. Spring Shim Washer
13. Spacer
14. Shock Absorber
15. Hexnut
16. Hardened Washer
17. Shock Absorber Lower Mounting Bolt
18. U-bolt, 7/8–14
19. Front Spring Bracket
20. Hexnut, 1/2–13
21. Bearing Washer
22. Front Spring Bracket Bolt, 1/2–13 x 3.25
23. Spring Assembly
24. Shock Absorber Lower Mounting Bracket
25. Spacer
26. Caster Adjustment Shim
27. Dowel Pin
28. Axle
29. Hardened Washer
30. High Hexnut, 7/8–14, Class C
31. Rear Shackle Bracket

Fig. 3, 14,000-Pound (6 350 kg) Taperleaf Suspension

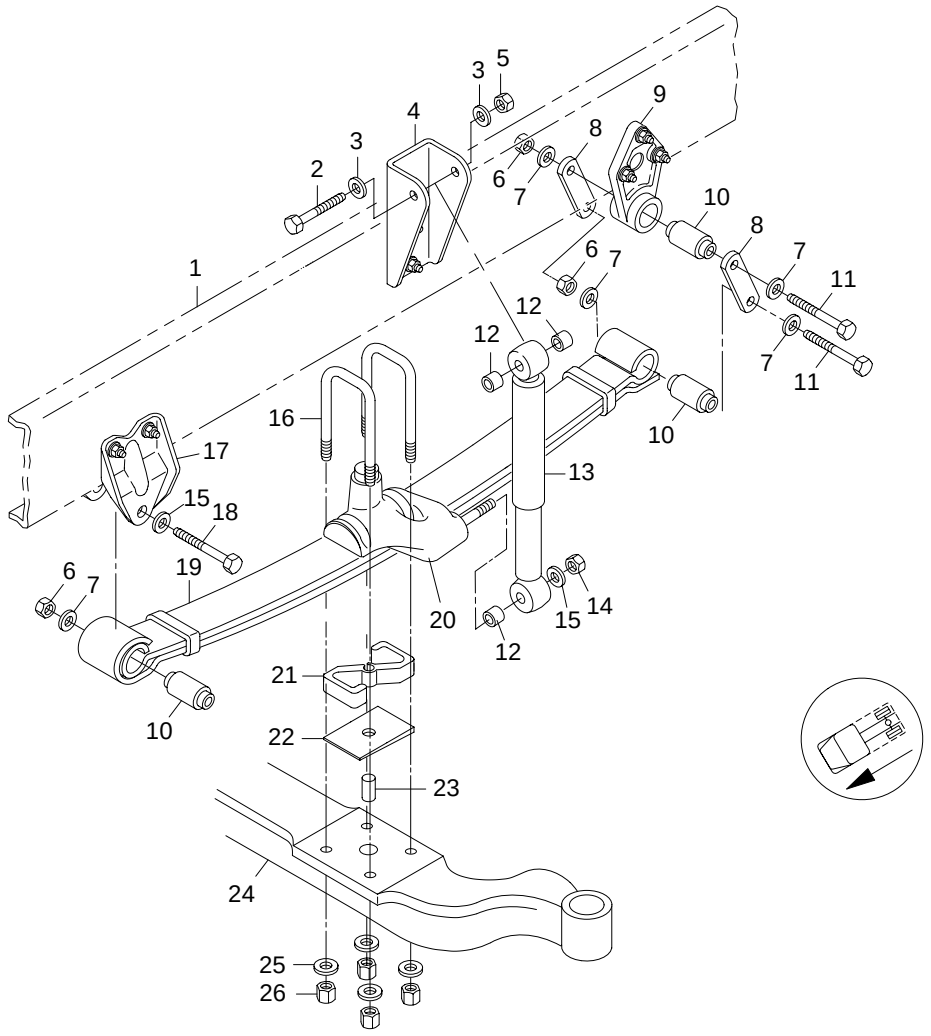


03/25/96 f320461

1. Frame Rail
2. Shock Absorber Upper Mounting Bolt
3. Hardened Washer
4. Shock Absorber Upper Mounting Bracket
5. Hexnut
6. Hexnut, 1/2–13, Class C
7. Spring Pin
8. Zerk Fitting
9. Spring Shackle
10. Bearing Washer
11. Spring Shackle Bolt, 1/2–13 x 3.25
12. Spring Shim Washer
13. Spacer
14. Shock Absorber
15. Hexnut
16. Hardened Washer
17. Shock Absorber Lower Mounting Bolt
18. U-bolt, 7/8–14
19. Front Spring Bracket
20. Hexnut, 1/2–13
21. Bearing Washer
22. Front Spring Bracket Bolt, 1/2–13 x 3.25
23. Spring Assembly
24. Shock Absorber Lower Mounting Bracket
25. Spacer
26. Caster Adjustment Shim
27. Dowel Pin
28. Axle
29. Hardened Washer
30. High Hexnut, 7/8–14, Class C
31. Rear Shackle Bracket

Fig. 4, Flatleaf Front Suspension

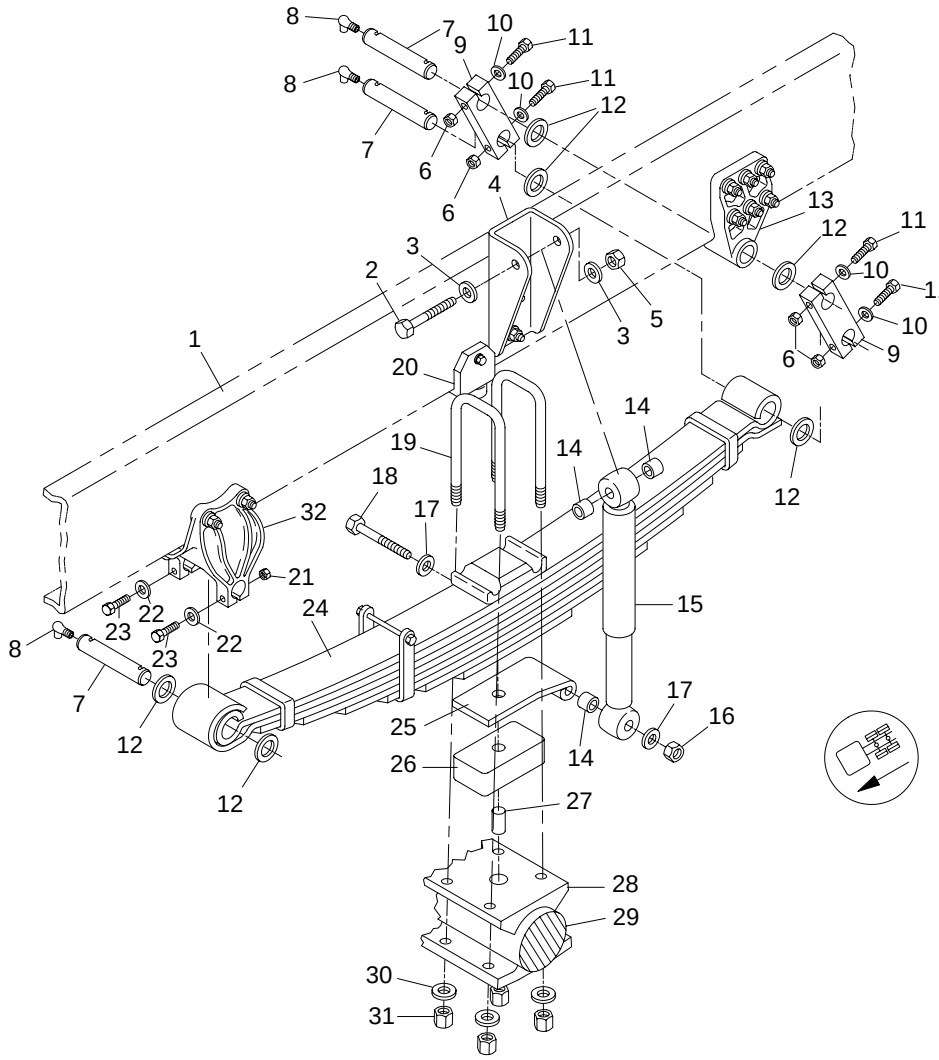
General Information



11/09/2001 f320839

1. Frame Rail
2. Shock Absorber Upper Mounting Bolt
3. Hardened Washer
4. Shock Absorber Upper Mounting Bracket
5. Hexnut
6. Hexnut, 3/4–10, Grade C
7. Hardened Washer
8. Spring Shackle
9. Shackle Bracket
10. Bushing
11. Spring Shackle Bolt, 3/4–10 x 6.5
12. Spacer
13. Shock Absorber
14. Hexnut
15. Hardened Washer
16. U-Bolt
17. Front Spring Bracket
18. Front Spring Eye Mounting Bolt
19. Spring Assembly
20. Shock Absorber Lower Mounting Bracket
21. Spacer
22. Caster Adjustment Shim
23. Dowel Pin
24. Axle
25. Hardened Washer
26. High Hexnut

Fig. 5, Axle Stop and Shock Absorber Lower Mounting Bracket After March 1999 (12,000-pound taperleaf shown)



03/25/96 f320516

1. Frame Rail
2. Shock Absorber Upper Mounting Bolt
3. Hardened Washer
4. Shock Absorber Upper Mounting Bracket
5. Hexnut
6. Hexnut, 1/2–13, Class C
7. Spring Pin
8. Zerk Fitting
9. Spring Shackle
10. Bearing Washer
11. Spring Shackle Bolt, 1/2–13 x 3.5
12. Spring Shim Washer
13. Rear Shackle Bracket
14. Spacer
15. Shock Absorber
16. Hexnut
17. Hardened Washer
18. Shock Absorber Lower Mounting Bolt
19. U-Bolt, 7/8–14
20. Axle Stop
21. Hexnut, 1/2–13, Class C
22. Bearing Washer
23. Front Spring Bracket Bolt, 1/2–13 x 3.5
24. Spring Assembly
25. Shock Absorber Lower Mounting Bracket
26. Spacer
27. Dowel Pin
28. Axle Mounting Bracket
29. Axle
30. Hardened Washer
31. High Hexnut, 7/8–14
32. Front Spring Bracket

Fig. 6, All-Wheel-Drive Front Suspension (exploded view)

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Remove the front bumper. For instructions, see **Group 31**.
4. Remove the wheel and tire for access to the leaf spring. For instructions, see **Group 40**.
5. Remove the half-fender. For instructions, see **Group 88**.

⚠ WARNING

Use safety stands to securely support all axle and frame weight during suspension repairs. Unsecured components may drop when fasteners are loosened or removed, causing component damage and serious personal injury.

IMPORTANT: Make sure the frame rails are level and an equal distance off the ground.

6. Raise the front of the vehicle until both wheels are off the ground and the frame and axle are supported with safety stands. The axle and leaf springs can then be manipulated with the floor jack.
7. Remove the leaf spring assembly.

   NOTE: Leaf spring assemblies on vehicles with suspensions manufactured at 14,000-pound (6 350 kg) and 18,000-pound (8 165 kg) weight ratings have multiple leaf springs, heavy duty brackets, U-bolts, and other components.

   7.1 Remove the U-bolt high nuts and washers. Remove the U-bolts. See **Fig. 1**.

   7.2 Loosen the shock absorber upper mounting bolt. Swing the shock absorber and attached lower mounting bracket out of the way. See **Fig. 2** or **Fig. 3**.

   7.3 Remove the spring shackle lower bolt. See **Fig. 4**.

   7.4 Remove the front spring mounting eye bolt. See **Fig. 5**.

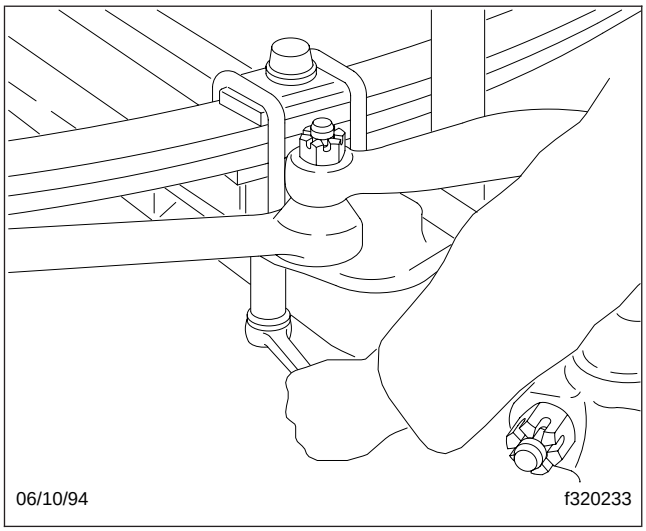
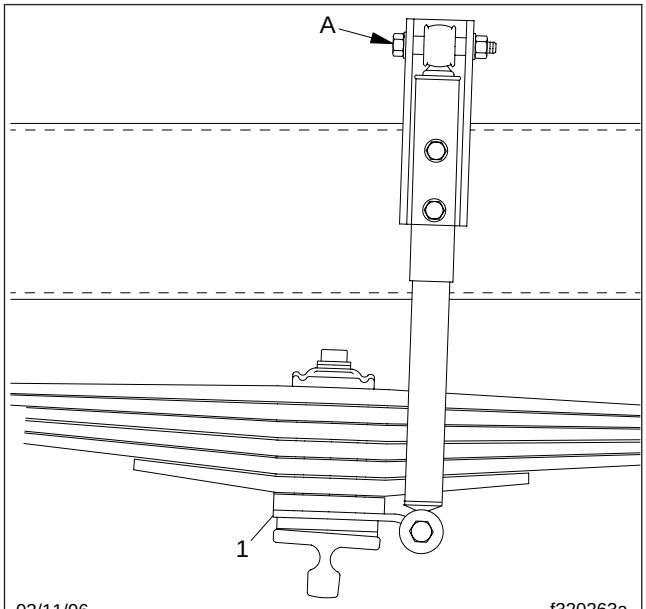


Fig. 1, U-Bolt Removal



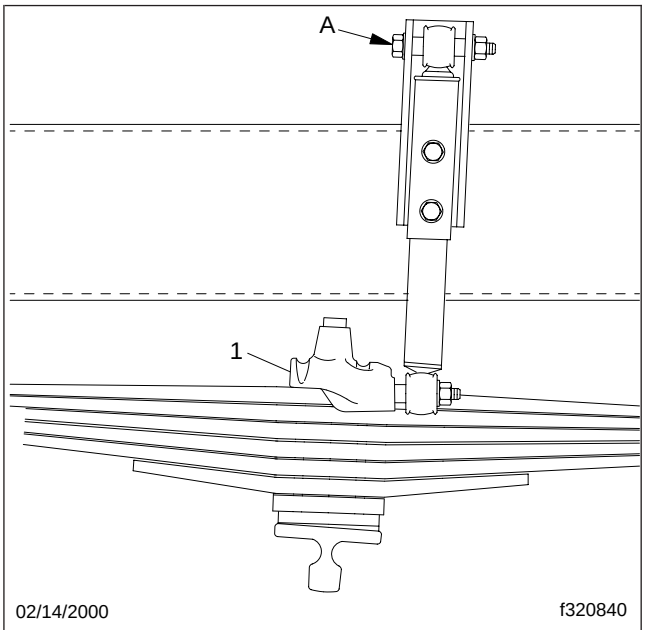
A. Loosen the shock absorber upper mounting bolt.
1. Shock Absorber Lower Mounting Bracket

Fig. 2, Shock Absorber Lower Mounting Bracket Before March 1999

NOTE: If removing the driver's side spring, the steering must be at right full-lock so the bolt can clear the drag link.

7.5 Support the front axle with a jack. Remove the safety stand and lower the front

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation



A. Loosen the shock absorber upper mounting bolt.
1. Shock Absorber Lower Mounting Bracket

Fig. 3, Shock Absorber Lower Mounting Bracket After March 1999

axle enough to allow removal of the spring. Note the location of the spring spacer and any caster adjustment shims.

WARNING

The spring assembly is heavy. To prevent bodily injury, always use two people to remove it.

7.6 Remove the spring by sliding it toward the front of the vehicle. See **Fig. 6**.

8. Remove the shackle upper bolt and nut. See **Fig. 7**. Press out the bushing. Remove the fasteners that hold the shackle bracket to the frame and remove the bracket. See **Fig. 8**.

Cleaning and Inspection

1. Using a wire brush and solvent or steam cleaning equipment, wash all parts to remove dirt, grease, and scale.
2. Inspect all components for damage.

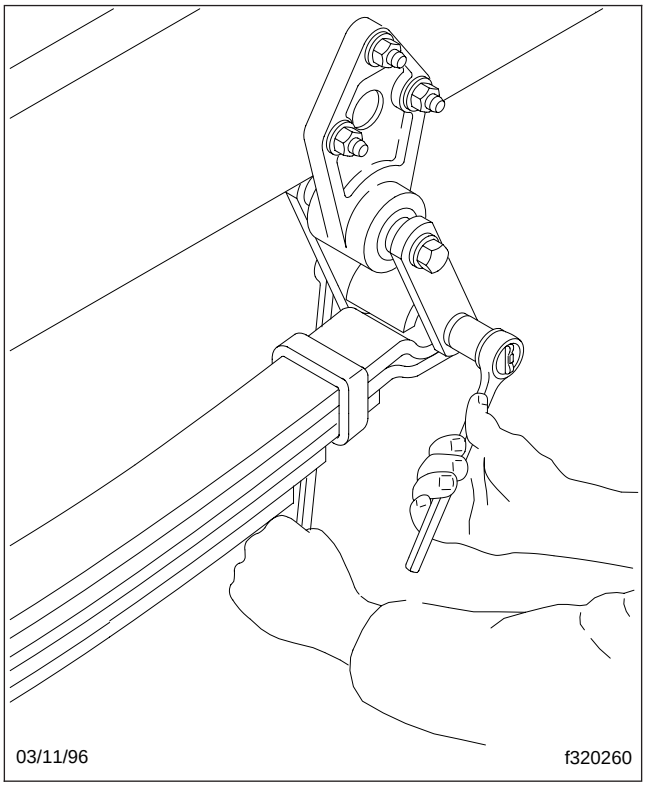


Fig. 4, Spring Shackle Lower Bolt Removal/Installation

2.1 Inspect the spring shackles and the shackle bracket for cracks, wear, and other damage. Replace any damaged parts.

2.2 Inspect the leaf spring assembly for cracks or corrosion. If any leaves are cracked or broken, replace the *entire spring assembly.*

WARNING

Do not replace individual leaves of a leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. On front spring assemblies, if cracks or breaks exist in the two top leaves, a loss of vehicle control could occur. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

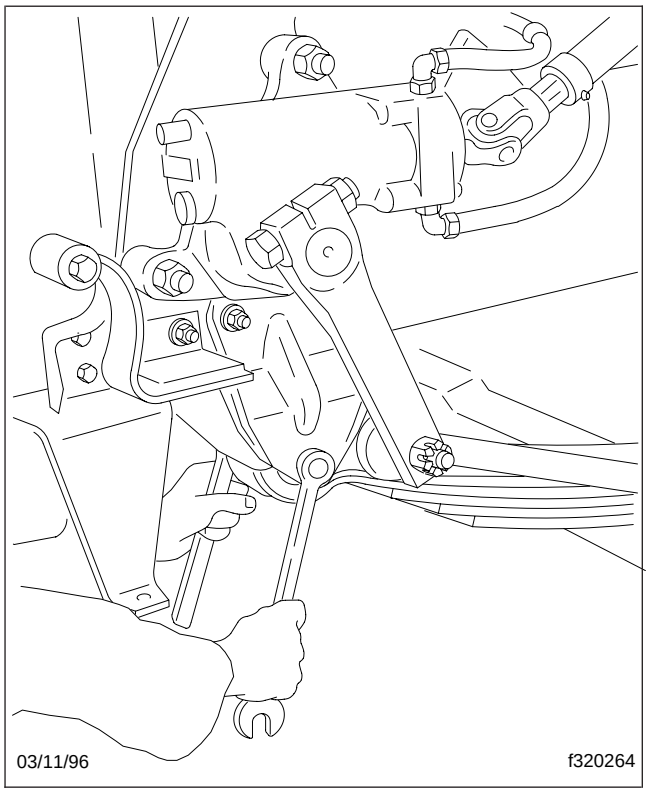


Fig. 5, Spring Eye Bolt Removal/Installation

2.3 If the protective coating is gone from some areas of the spring, the cleaned areas can be painted with a rust-inhibiting paint. If rusting or corrosion is severe, replace the spring assembly.

Installation

IMPORTANT: For normal highway operation do not install springs of two different designs or load capacities on the front axle. In order to maintain a balanced front suspension system, install identical spring assemblies.

1. If the shackle bracket was removed, install it. See **Fig. 8**. Tighten the mounting bolts 135 lbf·ft (183 N·m).

NOTE: All suspension bracket (frame) fasteners require periodic retightening. See Group 00 of the *Business Class® Trucks Maintenance Manual* for the recommended intervals.

2. If the spring shackle was removed, install it. Do not tighten the upper bolt in the shackle at this time. See **Fig. 7**.

⚠ WARNING

The spring assembly is heavy. To prevent bodily injury, always use two people to install it.

3. Install the spring assembly.

   NOTE: Leaf spring assemblies on vehicles with suspensions manufactured at 14,000-pound (6 350 kg) and 18,000-pound (8 165 kg) weight ratings have multiple leaf springs, heavy duty brackets, U-bolts, and other components.

   3.1 Lift the spring into position. See **Fig. 6**. Install the spring eye bolt at the front of the spring (see **Fig. 5**) and the lower bolt in the shackle at the rear of the spring (see **Fig. 4**).

   3.2 Tighten the spring eye bolt and the bolts at the top and bottom of the shackle 240 lbf·ft (325 N·m).

   3.3 Apply Alumilastic® or a similar compound to the top and bottom of the spring spacer and any caster adjustment shims.

⚠ CAUTION

Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to suspension parts.

   3.4 Place the caster adjustment shim and spring spacer on the axle. See **Fig. 9** or **Fig. 10**.

   3.5 Place the U-bolt pad (and shock absorber lower mounting bracket, if equipped, for vehicles built after March 1999) in position on the leaf spring.

   3.6 Using a jack, lift the axle into position.

   3.7 For vehicles so equipped (and built before March 1999), position the shock absorber lower mounting bracket between

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

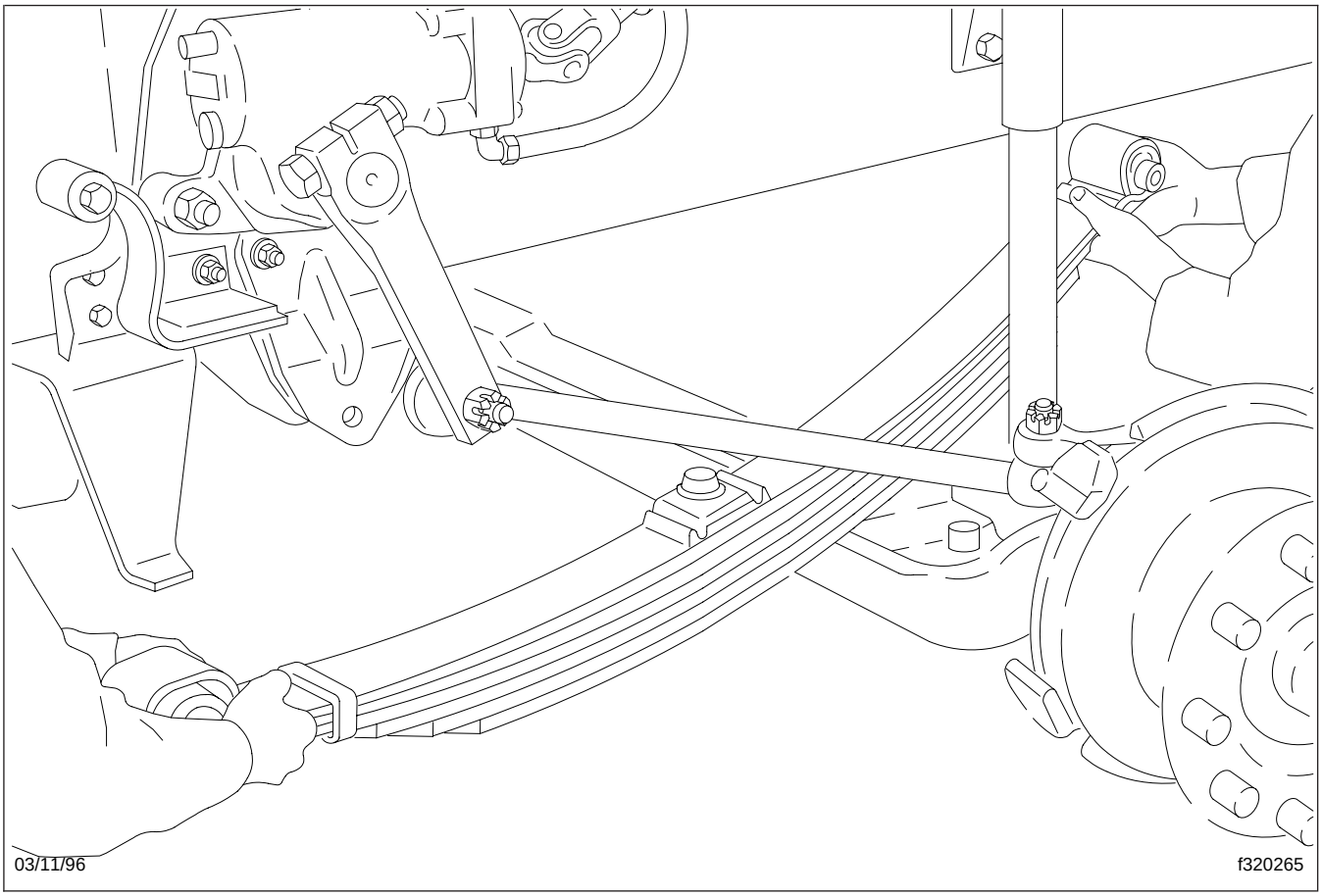


Fig. 6, Spring Removal/Installation

the spring spacer and the caster adjustment shims.

3.8 Install the U-bolts over the spring leaves, spring spacer, shock absorber lower mounting bracket, caster adjustment shims, and through the front axle.

3.9 Install the high nuts on the U-bolts and tighten them as described in **Specifications 400**.

4. Remove the floor jack and safety stands.
5. Install the half-fender. See **Group 88** for instructions.
6. Install the wheel and tire. See **Group 40** for instructions.
7. Install the front bumper. For instructions, see **Group 31**.
8. Close and latch the hood.
9. Remove the chocks from the tires.

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

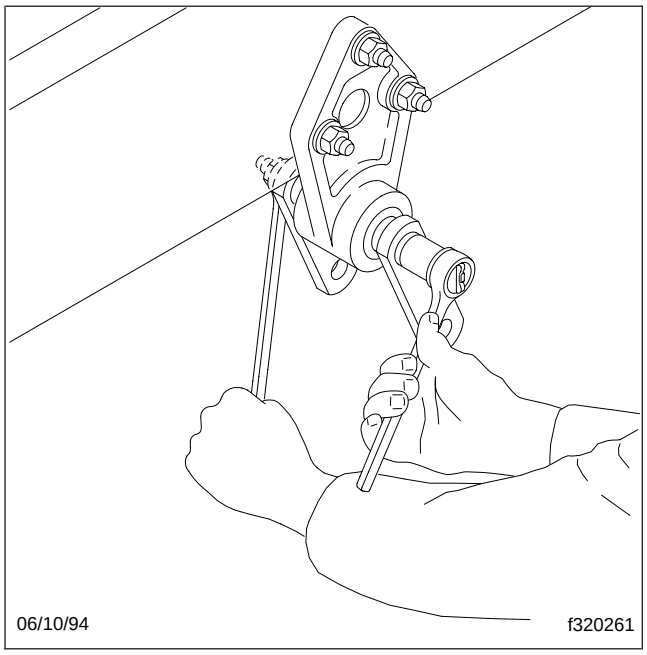


Fig. 7, Spring Shackle Removal/Installation

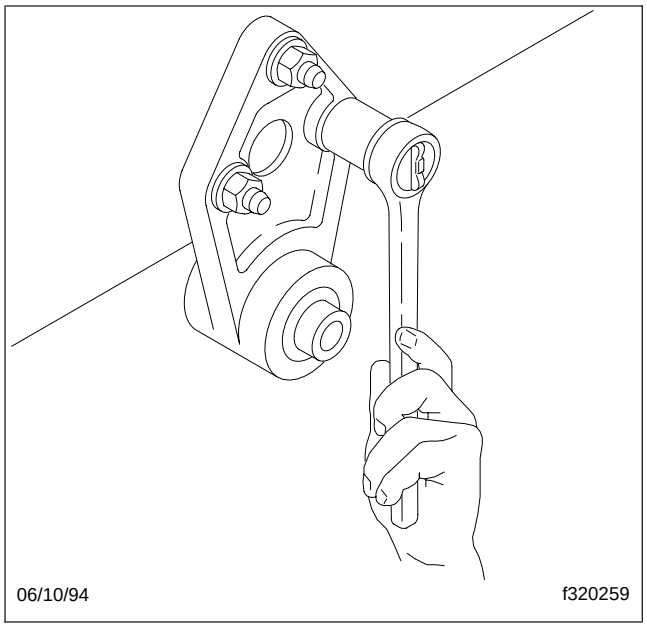
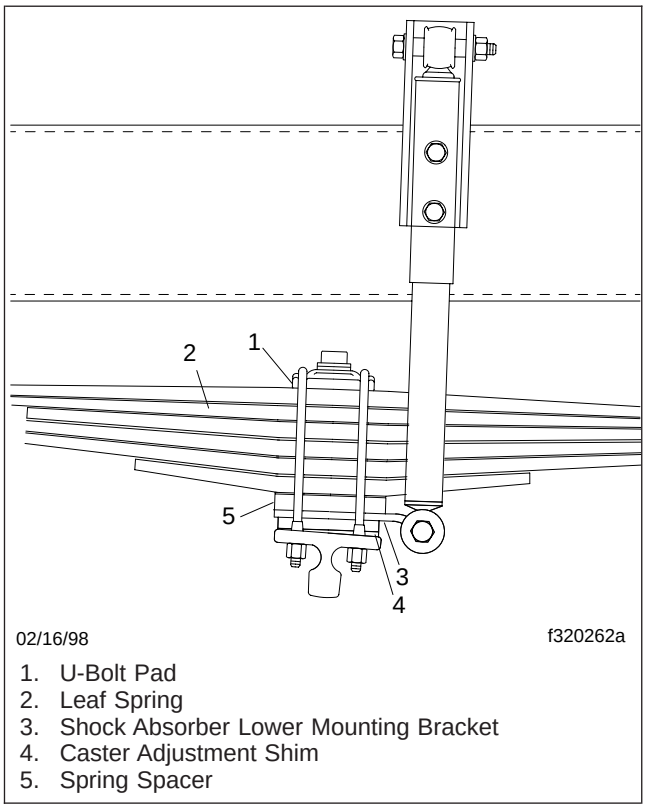


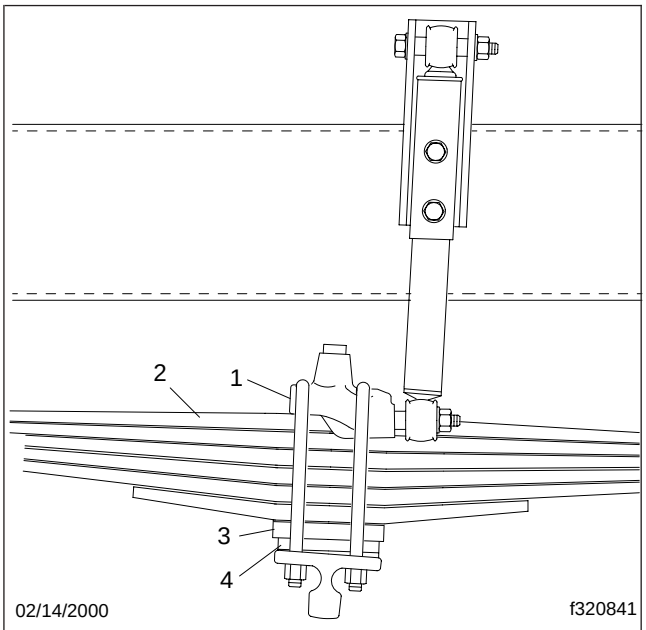
Fig. 8, Shackle Bracket Removal/Installation



1. U-Bolt Pad
2. Leaf Spring
3. Shock Absorber Lower Mounting Bracket
4. Caster Adjustment Shim
5. Spring Spacer

Fig. 9, Caster Adjustment Shim Location Before March 1999

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation



1. U-Bolt Pad
2. Leaf Spring
3. Shock Absorber Lower Mounting Bracket
4. Caster Adjustment Shim
5. Spring Spacer

Fig. 10, Caster Adjustment Shim Location After March 1999

Shackle Bracket Bushing Replacement

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Remove the front bumper. For instructions, see **Group 31**.
4. Remove the wheel and tire for access to the leaf spring. For instructions, see **Group 40**.
5. Remove the half-fender. For instructions, see **Group 88**.
6. Remove the shackle bracket from the vehicle. See **Fig. 1** or **Fig. 2**.
   - 6.1 Jack up the frame until the shackle lower bolt can be removed. Remove the bolt.
   - 6.2 Remove the shackle upper bolt and the spring shackle.
   - 6.3 Remove the shackle bracket from the frame.
7. Using a press, remove the bushing from the shackle bracket.
8. Inspect the shackle bracket and new bushing.
   - 8.1 With an inside micrometer or bore gauge, check whether the bracket bore is out-of-round. Replace the bracket if the bushing bore is out-of-round.
   - 8.2 Before installing the new bushing, check the shackle bracket bolt for ease of fit in the bushing. There should be an easy slip fit without wobble between the bolt and the bushing.
9. Using a press, insert the new bushing into the bracket until the bushing is centered in the bracket.

IMPORTANT: Do not press in the bushing by the center sleeve. This could damage the bushing.

10. Check the shackle bracket bolt again for ease of fit in the bushing. It should still fit easily without wobble between the bolt and the bushing. If it binds, the bushing may have been distorted during installation. Replace the bushing and check again for proper fit.
11. Install the shackle bracket. Install the fasteners and tighten them 183 N·m (135 lbf·ft).
12. Connect the leaf spring.
    - 12.1 Install the spring shackle and the shackle upper bolt.
    - 12.2 Adjust the height of the jack supporting the frame until the bushing at the rear of the leaf spring lines up with the hole for the shackle lower bolt.
    - 12.3 Install the shackle lower bolt. Tighten it 325 N·m (240 lbf·ft).
13. Install the half-fender. For instructions, see **Group 88**.
14. Install the wheel and tire. For instructions, see **Group 40**.
15. Install the front bumper. For instructions, see **Group 31**.
16. Close and latch the hood.
17. Remove the chocks from the tires.

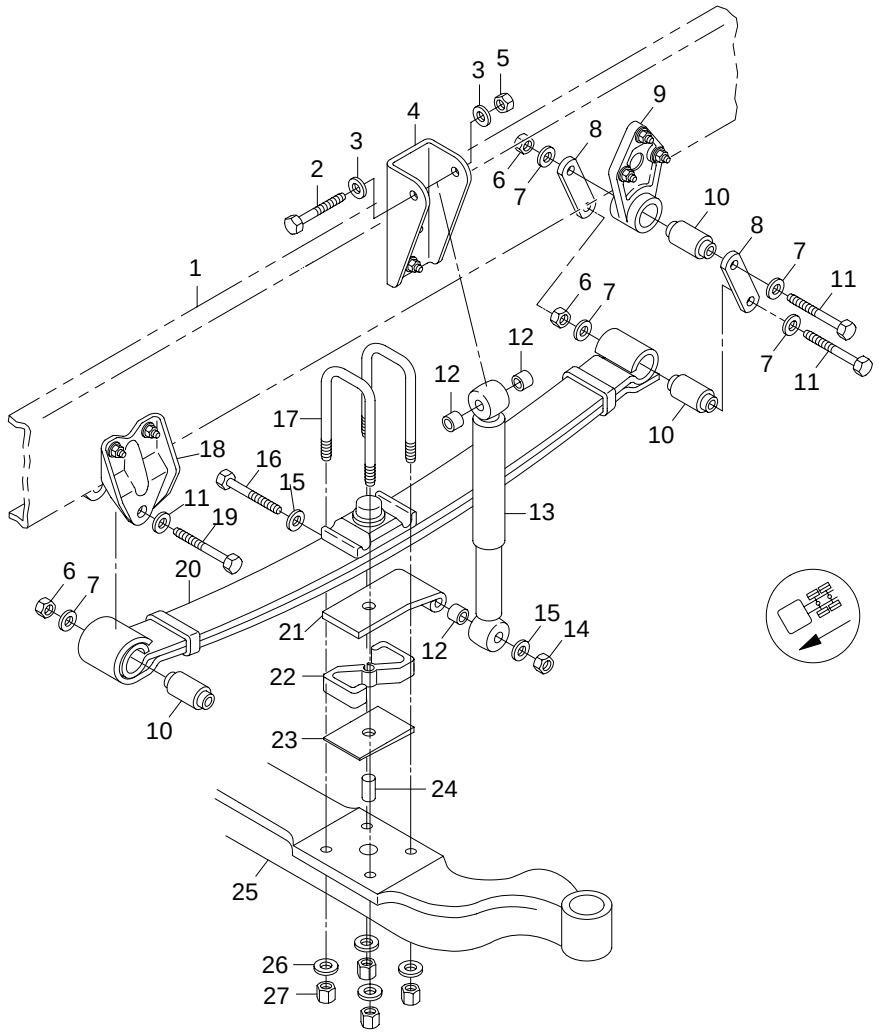
Spring Bushing Replacement

1. Remove the leaf spring from the vehicle. For instructions, see **Subject 100**.
2. Using a press, remove the worn or damaged bushing.
3. Using a press, insert the new bushing into the spring eye until the bushing is flush with the edges of the spring eye.

IMPORTANT: Do not press in the bushing by the center sleeve. This could damage the bushing.

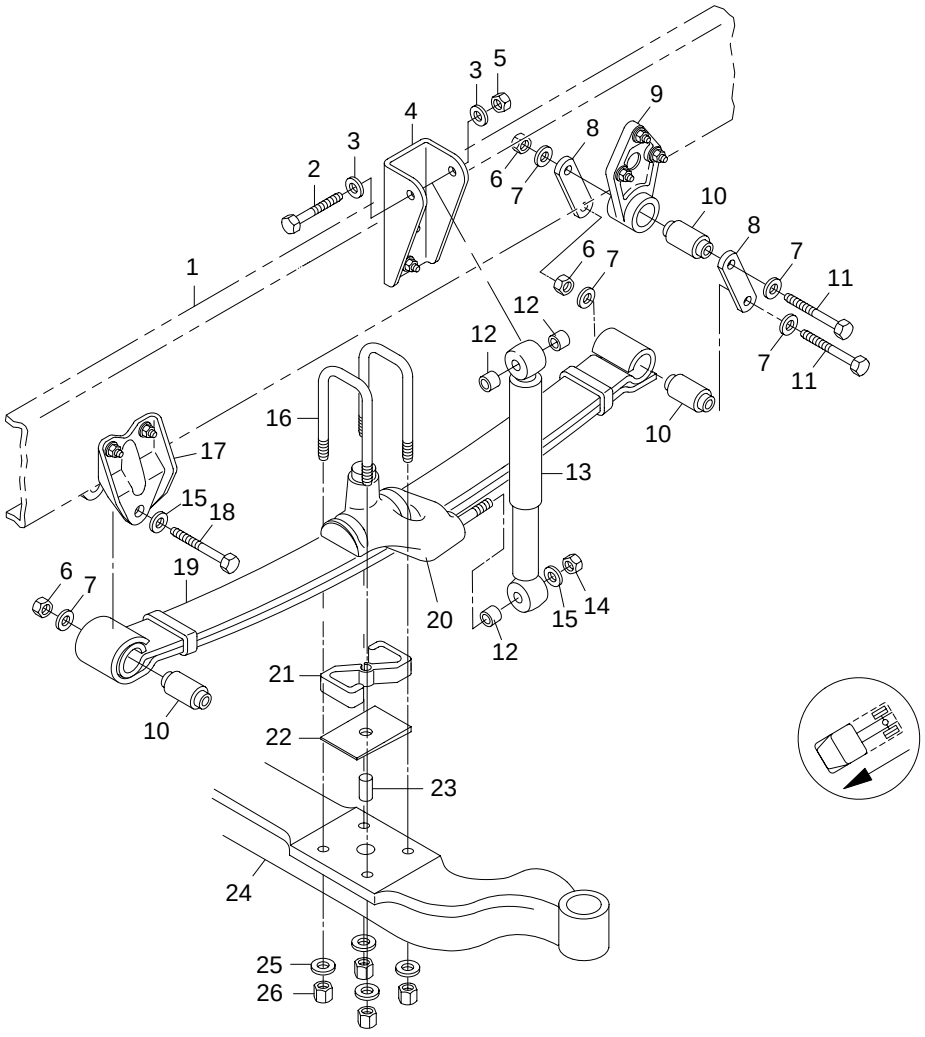
4. Install the leaf spring. For instructions, see **Subject 100**.

Bushing Replacement



1. Frame Rail
2. Shock Absorber Upper Mounting Bolt
3. Hardened Washer
4. Shock Absorber Upper Mounting Bracket
5. Hexnut
6. Hexnut, 3/4–10, Grade C
7. Hardened Washer
8. Spring Shackle
9. Shackle Bracket
10. Bushing
11. Spring Shackle Bolt, 3/4–10 x 6.5
12. Spacer
13. Shock Absorber
14. Hexnut
15. Hardened Washer
16. Shock Absorber Lower Mounting Bolt
17. U-Bolt, 5/8–18
18. Front Spring Bracket
19. Front Spring Mounting Eye Bolt, 3/4–10 x 6
20. Spring Assembly
21. Shock Absorber Lower Mounting Bracket
22. Spacer
23. Caster Adjustment Shim
24. Dowel Pin
25. Axle
26. Hardened Washer
27. High Hexnut, 5/8–18

Fig. 1, Front Suspension Before March 1999



11/09/2001 f320839

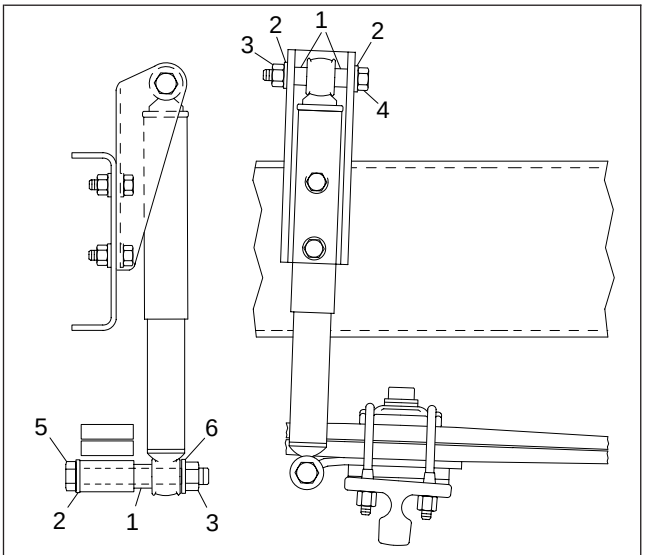
1. Frame Rail
2. Shock Absorber Upper Mounting Bolt
3. Hardened Washer
4. Shock Absorber Upper Mounting Bracket
5. Hexnut
6. Hexnut, 3/4–10, Grade C
7. Hardened Washer
8. Spring Shackle
9. Shackle Bracket
10. Bushing
11. Spring Shackle Bolt, 3/4–10 x 6.5
12. Spacer
13. Shock Absorber
14. Hexnut
15. Hardened Washer
16. U-Bolt
17. Front Spring Bracket
18. Front Spring Eye Mounting Bolt
19. Spring Assembly
20. Shock Absorber Lower Mounting Bracket
21. Spacer
22. Caster Adjustment Shim
23. Dowel Pin
24. Axle
25. Hardened Washer
26. High Hexnut

Fig. 2, Front Suspension After March 1999

Shock Absorber Replacement

Replacement

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Remove the shock absorber.
   - 3.1 Remove the locknut from the shock absorber upper mount. Remove the capscrew, washers, and spacers.
   - 3.2 Remove the locknut from the shock absorber lower mount. Remove the capscrew, washers, and spacers.
   - 3.3 Remove the shock absorber.
4. Install the new shock absorber. Make sure the washer is on the lower shock absorber mounting bushing and toward the outside. Tighten the locknuts 149 N·m (110 lbf·ft). See **Fig. 1** or **Fig. 2**.
5. Close and latch the hood.
6. Remove the chocks from the tires.

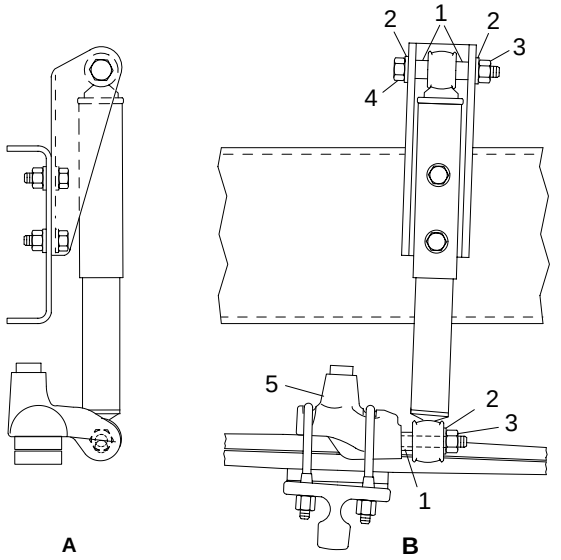


A. Front View
1. Spacer
2. 3/4-Inch Washer
3. 3/4-Inch Locknut
4. 3/4–10 x 5.5 Capscrew

B. Side View
5. 3/4–10 x 7 Capscrew
6. Washer

Fig. 1, Shock Absorber Mounting Before March 1999

Shock Absorber Replacement



A. Front View
B. Side View
1. Spacer
2. 3/4-Inch Washer
3. 3/4-Inch Locknut
4. 3/4–10 x 5.5 Capscrew
5. Lower Shock Absorber Mounting Bracket

Fig. 2, Shock Absorber Mounting After March 1999

All-Wheel-Drive Components Removal, Cleaning and Inspection, and Installation

Removal

1. Apply the parking brakes, chock the rear tires, and tilt the hood.
2. Remove the front bumper. Remove the wheel and tire for access to the leaf spring. For instructions, see **Group 40**.
3. Remove the half-fender. For instructions, see **Group 88**.
4. Using a floor jack, lift the front of the vehicle by the frame until all weight is off the spring being removed.
5. Support the frame and axle with safety stands.

⚠ WARNING

Use safety stands to securely support all axle and frame weight during suspension repairs. Unsecured components may drop when fasteners are loosened or removed, causing serious personal injury and component damage.

6. Remove the leaf spring assembly.
   - 6.1 Remove the U-bolt high nuts and washers; then, remove the U-bolts. See **Fig. 1**.
   - 6.2 Loosen the shock absorber upper mounting bolt. Swing the shock absorber and attached lower mounting bracket out of the way. See **Fig. 2**.
   - 6.3 Remove the lower spring shackle bolt.

   NOTE: All-wheel-drive suspensions use either spring pins or bolts in the leaf spring assembly to attach the leaf spring to the shackle and front spring bracket.

   - 6.4 Remove the spring front eye bolt or spring pin. See **Fig. 3**.

   NOTE: If removing the driver's side spring, the steering must be at right full-lock so the bolt or spring pin can clear the drag link.

   - 6.5 Support the front axle with a jack. Remove the safety stand; then, lower the front axle enough to allow removal of the spring. Note the location of the spring spacer.
   - 6.6 Remove the spring by sliding it toward the front of the vehicle. See **Fig. 4**.
7. Remove the upper shackle. If necessary, press out the spring pin. Remove the fasteners that hold the shackle bracket to the frame. Then, remove the bracket.

Cleaning and Inspection

1. Using a wire brush and solvent or steam cleaning equipment, wash all parts to remove dirt, grease, and scale.
2. Inspect all components for damage.
   - 2.1 Inspect the spring shackles and the shackle bracket for cracks, wear, and other damage. Replace any damaged parts.
   - 2.2 Inspect the leaf spring assembly for cracks or corrosion. If any leaves are cracked or broken, replace the *entire spring assembly.*

⚠ WARNING

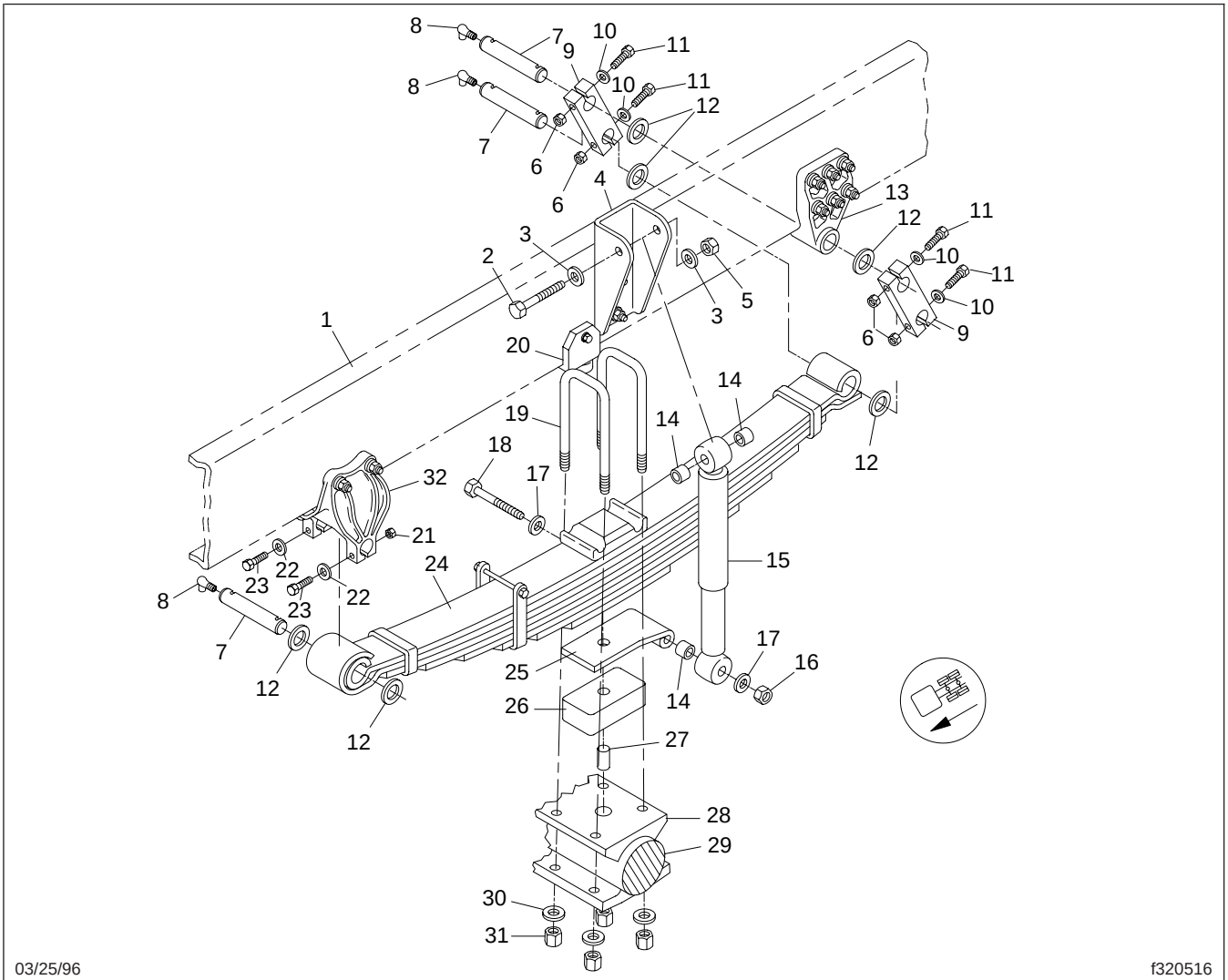
Do not replace individual leaves of a leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. On front spring assemblies, if cracks or breaks exist in the two top leaves, a loss of vehicle control could occur. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

   - 2.3 If the protective coating is gone from some areas of the spring, the cleaned areas can be painted with a rust-inhibiting paint. If rusting or corrosion is severe, replace the spring assembly.

Installation

IMPORTANT: For normal highway operation do not install springs of two different designs or load capacities on the front axle. In order to maintain a balanced front suspension system, install identical spring assemblies.

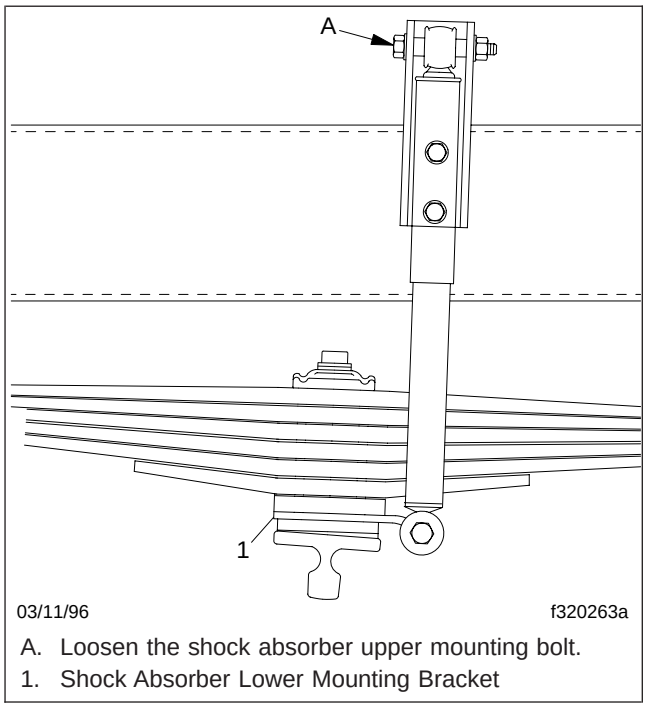
All-Wheel-Drive Components Removal, Cleaning and Inspection, and Installation



1. Frame Rail
2. Shock Absorber Upper Mounting Bolt
3. Hardened Washer
4. Shock Absorber Upper Mounting Bracket
5. Hexnut
6. Hexnut, 1/2–13, Class C
7. Spring Pin
8. Zerk Fitting
9. Spring Shackle
10. Bearing Washer
11. Spring Shackle Bolt, 1/2–13 x 3.5
12. Spring Shim Washer
13. Rear Shackle Bracket
14. Spacer
15. Shock Absorber
16. Hexnut
17. Hardened Washer
18. Shock Absorber Lower Mounting Bolt
19. U-Bolt, 7/8–14
20. Axle Stop
21. Hexnut, 1/2–13, Class C
22. Bearing Washer
23. Front Spring Bracket Bolt, 1/2–13 x 3.5
24. Spring Assembly
25. Shock Absorber Lower Mounting Bracket
26. Spacer
27. Dowel Pin
28. Axle Mounting Bracket
29. Axle
30. Hardened Washer
31. High Hexnut, 7/8–14
32. Front Spring Bracket

Fig. 1, All-Wheel-Drive Front Suspension (exploded)

All-Wheel-Drive Components Removal, Cleaning and Inspection, and Installation



A. Loosen the shock absorber upper mounting bolt.
1. Shock Absorber Lower Mounting Bracket

Fig. 2, Shock Absorber Lower Mounting Bracket Removal

1. If the shackle bracket and spring pin or bolt were removed, install them. If necessary, tighten the mounting bolts 135 lbf·ft (183 N·m).

NOTE: All suspension bracket (frame) fasteners require periodic retightening. Refer to the vehicle maintenance manual for the recommended intervals.

2. If the spring shackle was removed, install it. Don't tighten the upper bolt in the shackle at this time.
3. Install the spring assembly.
   - 3.1 Lift the spring into position. See **Fig. 4**. Install the spring eye bolt or spring pin at the front of the spring (see **Fig. 3**) and the lower bolt or spring pin in the shackle at the rear of the spring.
   - 3.2 If necessary, tighten the spring eye bolt and the bolts at the top and bottom of the shackle 240 lbf·ft (325 N·m).
   - 3.3 Apply Alumilastic® or a similar compound to the top and bottom of the spring spacer and any caster adjustment shims.

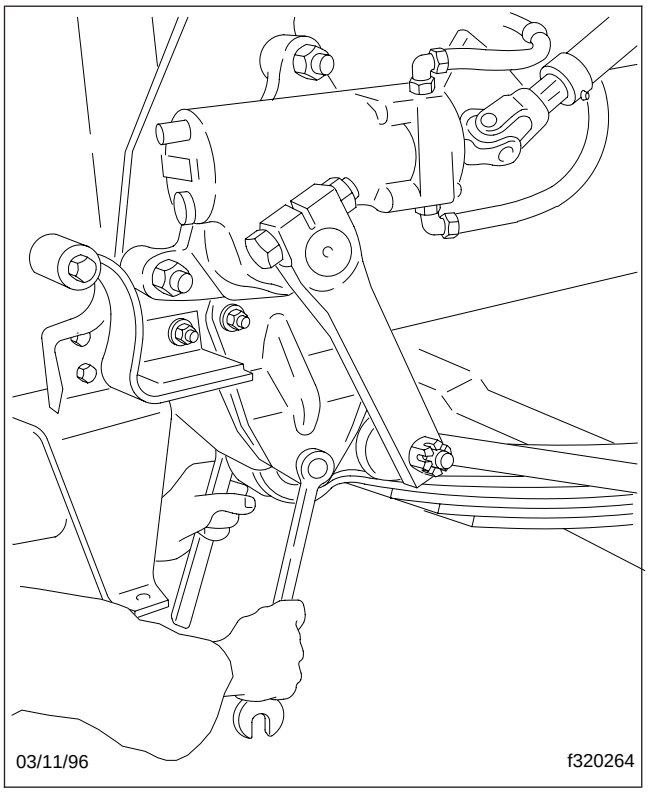


Fig. 3, Spring Eye Fastener Removal/Installation (bolt shown)

⚠ CAUTION

Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to suspension parts.

- 3.4 Place the spring spacer on the axle.
- 3.5 Place the U-bolt pad in position on the leaf spring.
- 3.6 Using a jack, lift the axle into position.
- 3.7 If so equipped, position the shock absorber lower mounting bracket between the leaf spring and the spring spacer.

IMPORTANT: Use new U-bolts when installing the all-wheel-drive assembly.

- 3.8 Install the new U-bolts over the spring leaves, shock absorber lower mounting

All-Wheel-Drive Components Removal, Cleaning and Inspection, and Installation

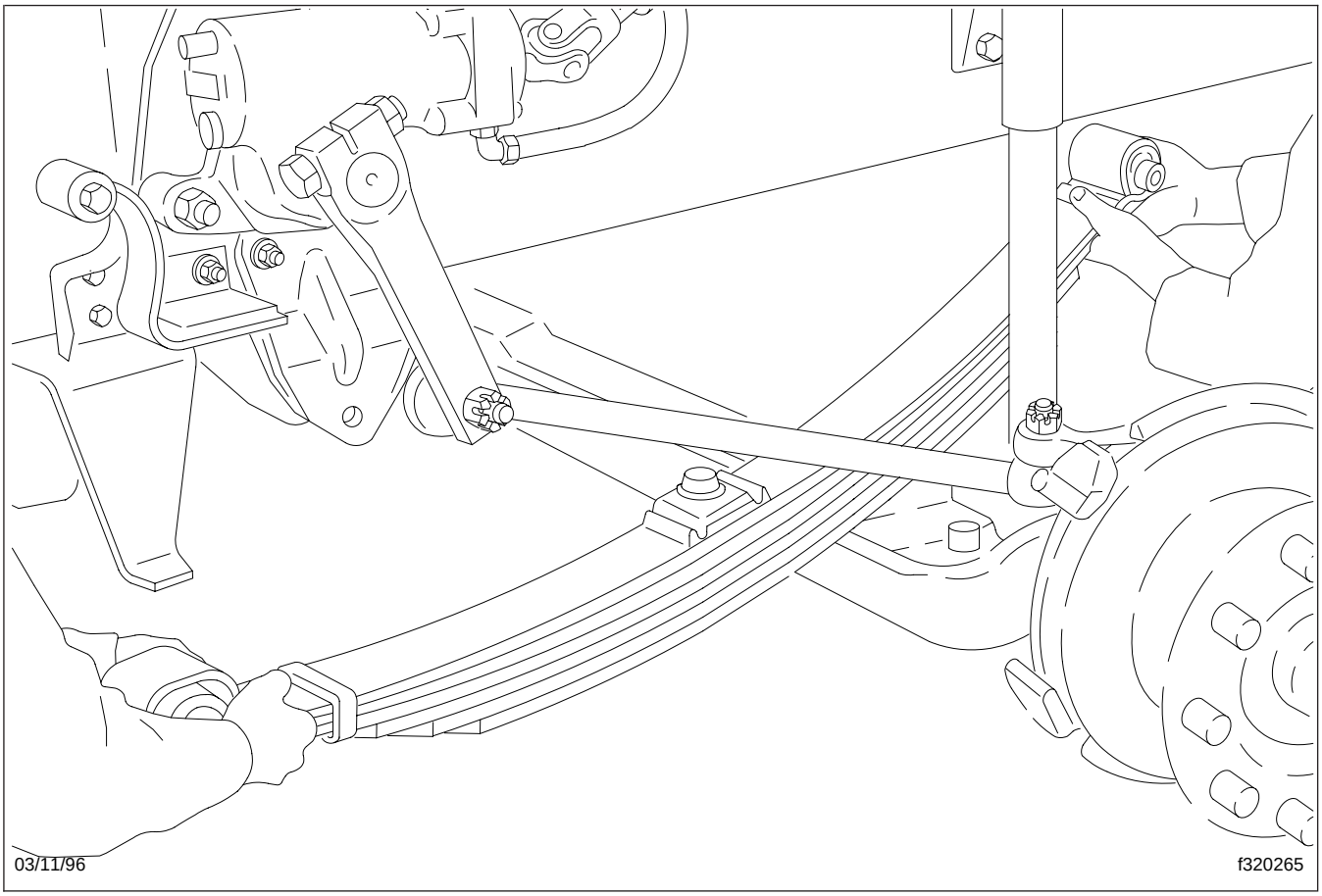


Fig. 4, Spring Removal/Installation

bracket, spring spacer, and through the front axle.

3.9 Install the high-nuts on the new U-bolts and tighten them as described in **Specifications 400**.

4. Remove the floor jack and safety stands.
5. Install the half-fender. See **Group 88** for instructions.
6. Install the wheel and tire. See **Group 40** for instructions. Install the front bumper.
7. Lower the hood, and remove the chocks from the tires.

Troubleshooting

This subject contains the following troubleshooting tables:

- Vehicle Leans to One Side
- Vehicle Wanders
- Vehicle Bottoms Out
- Frequent Spring Breakage
- Noisy Spring
- Rough Ride

Problem—Vehicle Leans to One Side

Possible Cause	Remedy
One or more spring leaves are broken.	Replace the spring assembly.
The spring assembly is weak or fatigued.	Replace the spring assembly.
Unmatched spring-design/load-capacity spring assemblies are installed.	Install the correct spring assemblies as originally specified for the vehicle.
A frame rail is bent or twisted.	Check the frame rails for bends and twists. Correct as needed.

Problem—Vehicle Wanders

Possible Cause	Remedy
One or more spring leaves are broken.	Replace the spring assembly.
The wheels are out of alignment.	Adjust the wheel alignment using the instructions in the **front axle group.**
Caster is incorrect.	Install correct caster shims. Refer to the **front axle group** for specifications.
Steering gear is not centered.	Adjust steering using the instructions in the **steering group.**
Drive axle is out of alignment.	Align the drive axle using the instructions in the **rear axle group.**

Problem—Vehicle Bottoms Out

Possible Cause	Remedy
Excessive weight on the vehicle is causing an overload.	Reduce the loaded vehicle weight to the maximum spring capacities.
One or more spring leaves are broken.	Replace the spring assembly.
The spring assembly is weak or fatigued.	Replace the spring assembly.

Problem—Frequent Spring Breakage

Possible Cause	Remedy
The vehicle is overloaded or operated under severe conditions.	Reduce the loaded vehicle weight to the maximum spring capacities. Caution the driver on improper vehicle handling.
There is insufficient torque on the U-bolt high nuts.	Torque the U-bolt high nuts to the value listed in the torque table in **"Specifications, 400."**
A loose center bolt is allowing the spring leaves to slip.	Check the spring leaves for damage. If damaged, replace the spring assembly. If not, tighten the center-bolt nut to the value listed in the torque table in **"Specifications, 400."**
Worn or damaged spring bushings are allowing spring end-play.	Replace the spring bolt and bushing.

Troubleshooting

Possible Cause	Remedy
A loose spring bolt is allowing spring end-play.	Replace the spring bolt and bushing.

Problem—Noisy Spring

Possible Cause	Remedy
A loose U-bolt nut or center bolt is allowing spring leaf slippage.	Inspect the components for damage. Replace damaged components as necessary. Torque all fasteners to the values listed in the torque table in **"Specifications, 400."**
A loose, bent, or broken spring shackle or front suspension bracket is impairing the spring flex.	Inspect the shackles and brackets for damage. Replace damaged components as necessary. Torque the fasteners to the values listed in the torque table in **"Specifications, 400."**
Worn or damaged spring bolts are allowing spring end-play.	Replace any worn or damaged spring bolts.
Worn or damaged spring bushings are allowing spring end-play.	Replace the spring bolt and bushing.

Problem—Rough Ride

Possible Cause	Remedy
Refer to the applicable section in this group.	

Specifications

Description	Size	Torque: lbf·ft (N·m)
Shackle Bracket Bolt	3/4–10	135 (183)
Shackle Bracket Mounting Bolt	5/8–11	135 (183)
Spring Eye Bolt	3/4–10	135 (183)
Shock Absorber Mounting Capscrews	3/4–10	110 (149)
U-Bolt High Nut (Tighten in a diagonal pattern as shown in **Fig. 1**.)	5/8–18	Stage 1: Hand tighten Stage 2: 60 (80) Stage 3: 200 (271) Stage 4: 180–230 (245–313)
	3/4–16	Stage 1: Hand tighten Stage 2: 60 (80) Stage 3: 200 (271) Stage 4: 270–330 (367–449)
	7/8–14	Stage 1: Hand tighten Stage 2: 60 (80) Stage 3: 200 (271) Stage 4: 420–500 (571–680)

Table 1

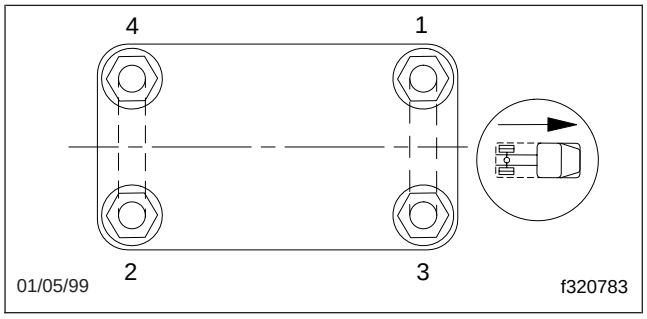


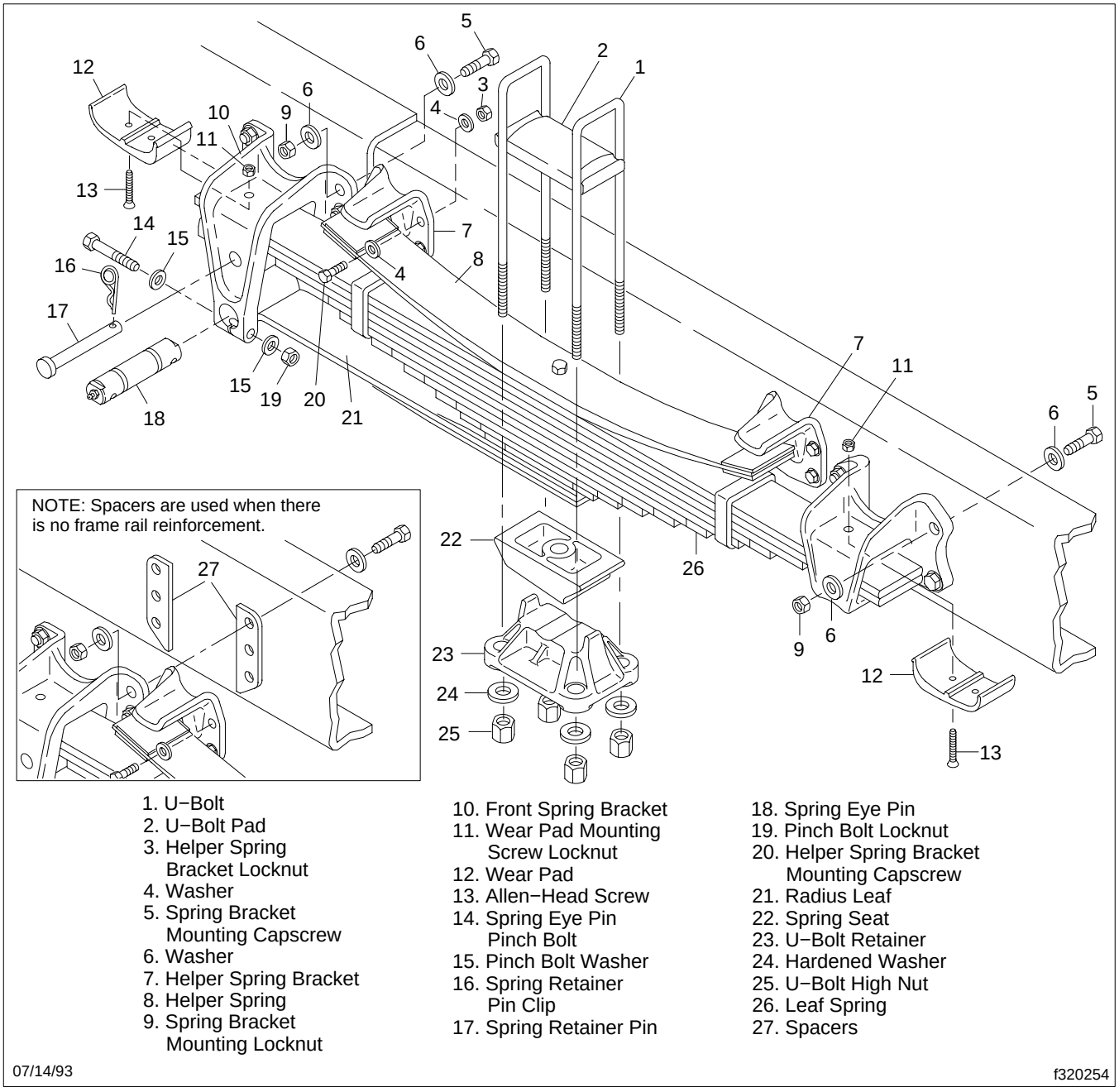
Fig. 1, Tightening Pattern for U-bolt High Nuts

General Description

The rear leaf spring suspension **(Fig. 1)** uses a slip spring design with varying capacities. Optional helper leaves provide a progressive spring rate and additional roll stability. The spring ends ride in cast iron brackets mounted on the frame rails. Each spring bracket holds a replaceable wear pad. The spring assemblies are attached to the axle with U-bolt assemblies. A radius leaf attaches each spring assembly to its forward spring bracket and holds the axle in alignment.

Shock absorbers are optional with all suspension capacities.

General Description



1. U−Bolt
2. U−Bolt Pad
3. Helper Spring Bracket Locknut
4. Washer
5. Spring Bracket Mounting Capscrew
6. Washer
7. Helper Spring Bracket
8. Helper Spring
9. Spring Bracket Mounting Locknut
10. Front Spring Bracket
11. Wear Pad Mounting Screw Locknut
12. Wear Pad
13. Allen−Head Screw
14. Spring Eye Pin Pinch Bolt
15. Pinch Bolt Washer
16. Spring Retainer Pin Clip
17. Spring Retainer Pin
18. Spring Eye Pin
19. Pinch Bolt Locknut
20. Helper Spring Bracket Mounting Capscrew
21. Radius Leaf
22. Spring Seat
23. U−Bolt Retainer
24. Hardened Washer
25. U−Bolt High Nut
26. Leaf Spring
27. Spacers

Fig. 1, Leaf Spring Suspension

Replacement

1. Lift the rear axle and support it with safety stands. Lift the vehicle frame to take weight off the rear springs.
2. Remove the U-bolt high nuts; then, remove the U-bolts. See **Fig. 1**.

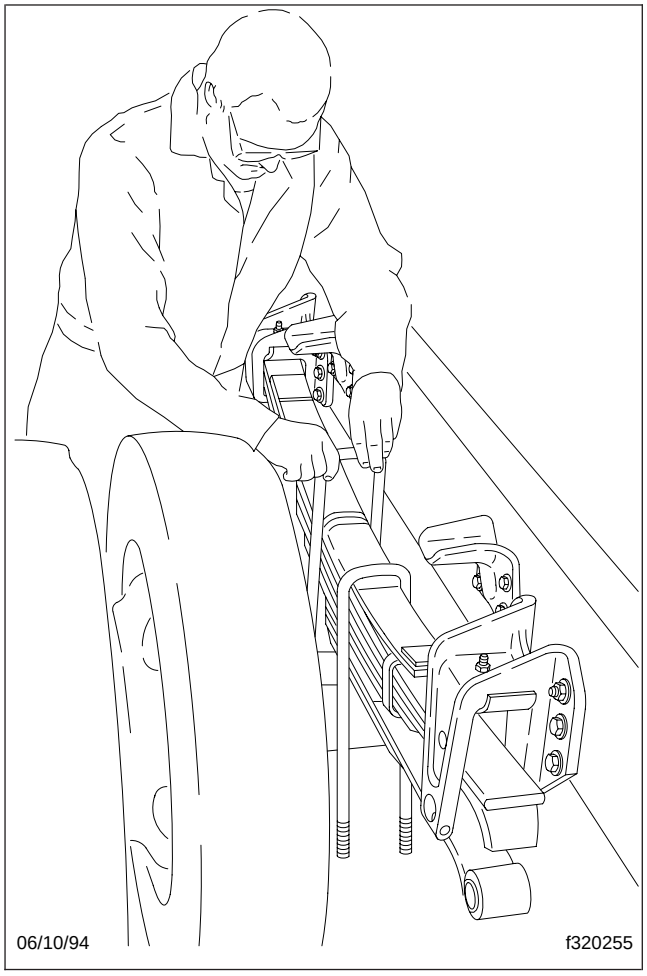


Fig. 1, Removing the U-bolts

3. Remove the spring eye pin that attaches the radius leaf to the front spring bracket.
   - 3.1 Using a C-clamp, take the load off the radius leaf. See **Fig. 2**.

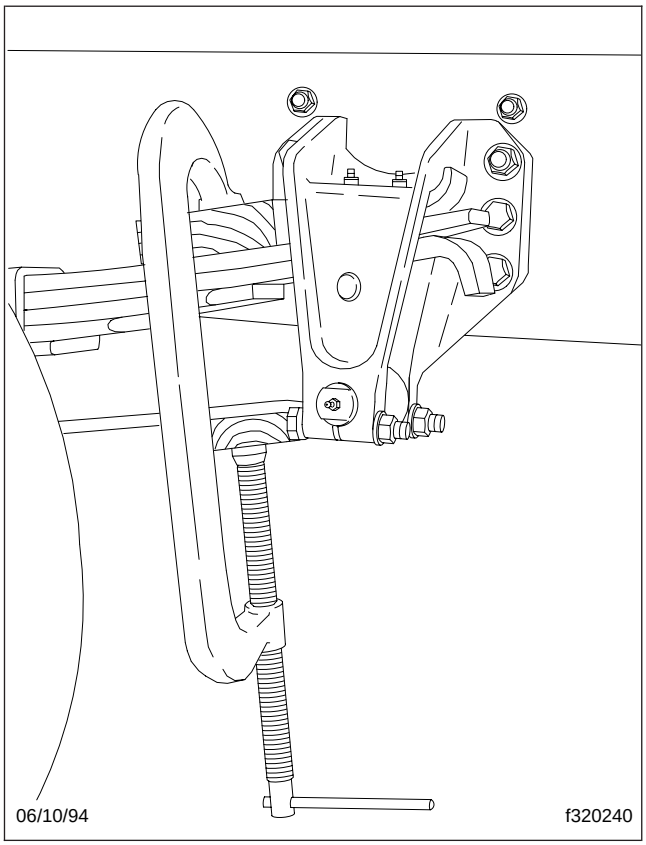


Fig. 2, Compress Springs to Remove Eye Pin

WARNING

Failure to use a C-clamp may cause components to be forcibly ejected, possibly causing serious personal injury.

   - 3.2 Remove the pinch bolts. See **Fig. 3**.
   - 3.3 Using a brass hammer and drift, tap the eye pin out. See **Fig. 4**.

4. Remove the clip (**Fig. 5**) and the spring retainer pin (**Fig. 6**).

WARNING

The leaf spring assembly is heavy. Always use two people when moving it, to avoid personal injury.

5. Remove the spring assembly.

Spring Assembly Replacement

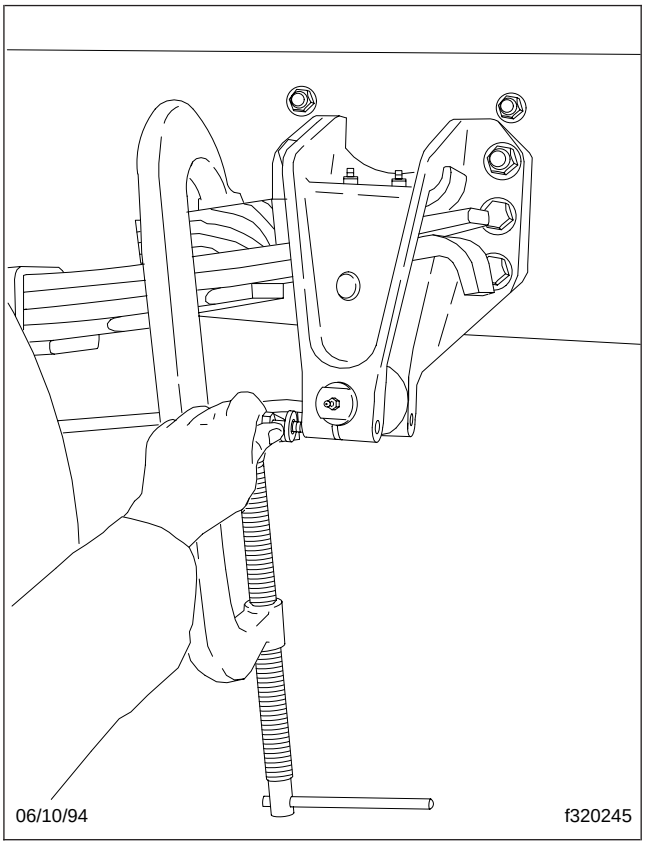


Fig. 3, Removing/Installing the Pinch Bolts

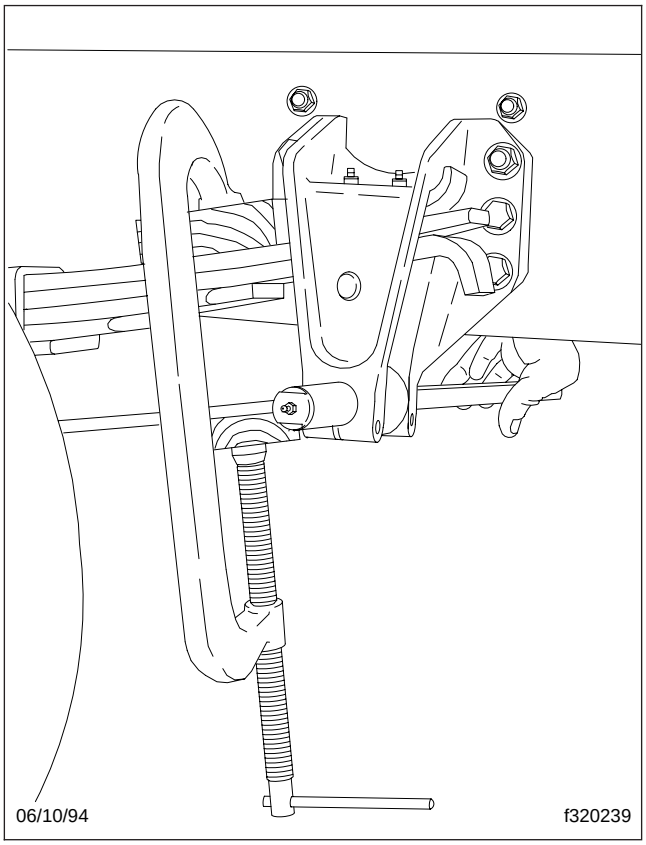


Fig. 4, Removing Eye Pin from Radius Leaf

5.1 If the vehicle is equipped with the optional helper spring, lift it off. See **Fig. 7**.

5.2 Slide the leaf spring assembly forward and remove it from the vehicle. See **Fig. 8**.

6. Inspect the wear pads for wear. Replace them if needed. For instructions, see **Subject 130**.

7. Install the new spring assembly.

7.1 Position the new spring on the axle seat.

NOTE: It may be necessary to raise the frame slightly.

7.2 Lower the frame until the spring is properly located between the spring brackets.

7.3 If equipped with the optional auxiliary spring, place it on the main spring.

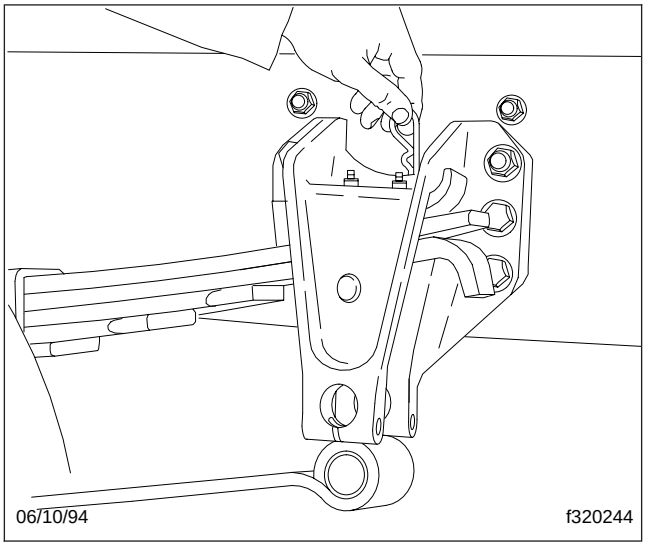


Fig. 5, Removing/Installing Retainer Pin Clip

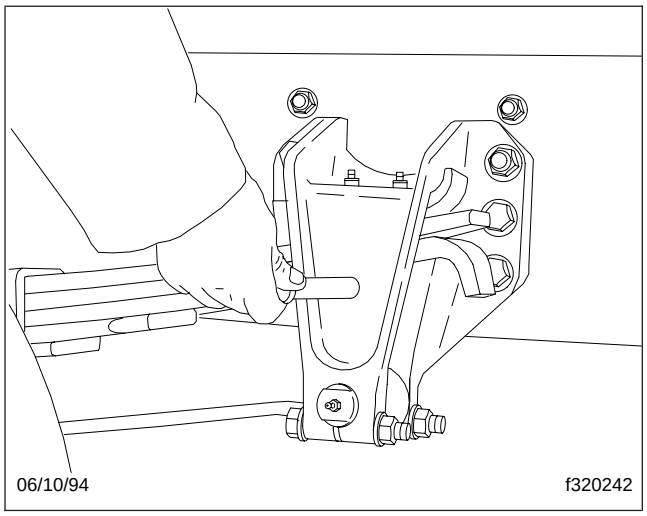


Fig. 6, Removing the Retainer Pin

8. Install the U-bolts and the U-bolt retainer. The taller end of the retainer must be towards the front of the vehicle. See **Fig. 9**.
9. Install the U-bolt high nuts (**Fig. 10**), but don't tighten them now.
10. Lift the spring above the hole for the spring retainer pin in the front spring bracket; then, insert the retainer pin. See **Fig. 11**.
11. Install the clip on the pin. See **Fig. 5**.
12. Install the spring eye pin.
    - 12.1 Using a C-clamp, compress the spring until the front spring eye pin can be installed. See **Fig. 12**.
    - 12.2 Inspect the pin for wear or damage. Replace it with a new pin if necessary.
    - 12.3 Using a brass hammer, tap the pin into position. See **Fig. 12**.
    - 12.4 Install the pinch bolts and nuts. See **Fig. 3**. Tighten the nuts to 32 lbf·ft (43 N·m).
    - 12.5 Remove the C-clamp.
13. Tighten the U-bolt high nuts as described in **Specifications 400**.
14. Remove the jack or safety stands from the rear axle and the frame.

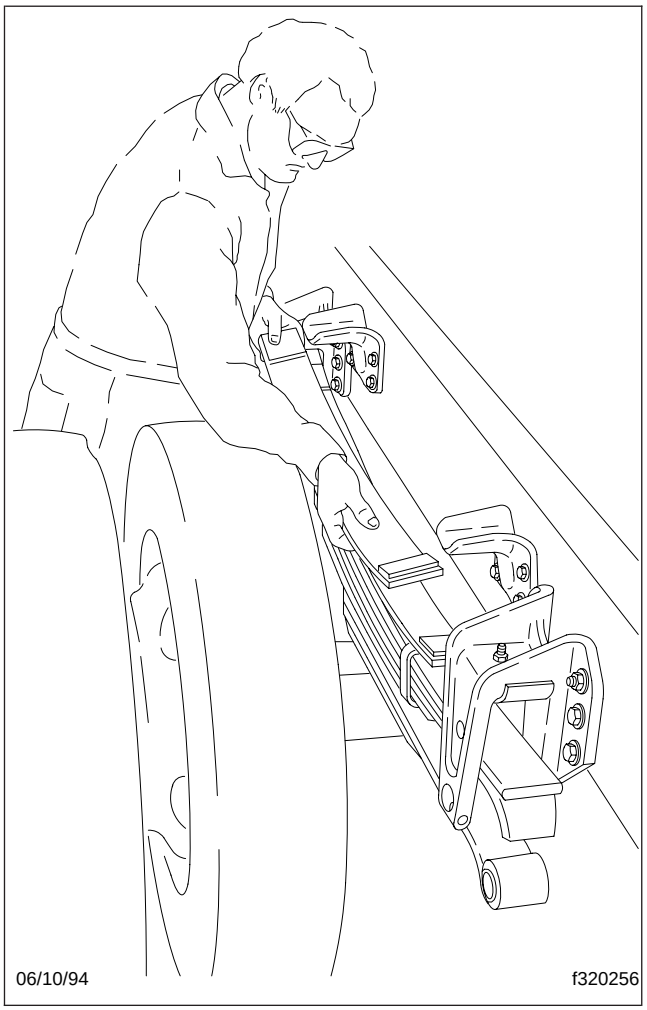


Fig. 7, Removing the Optional Helper Spring

Spring Assembly Replacement

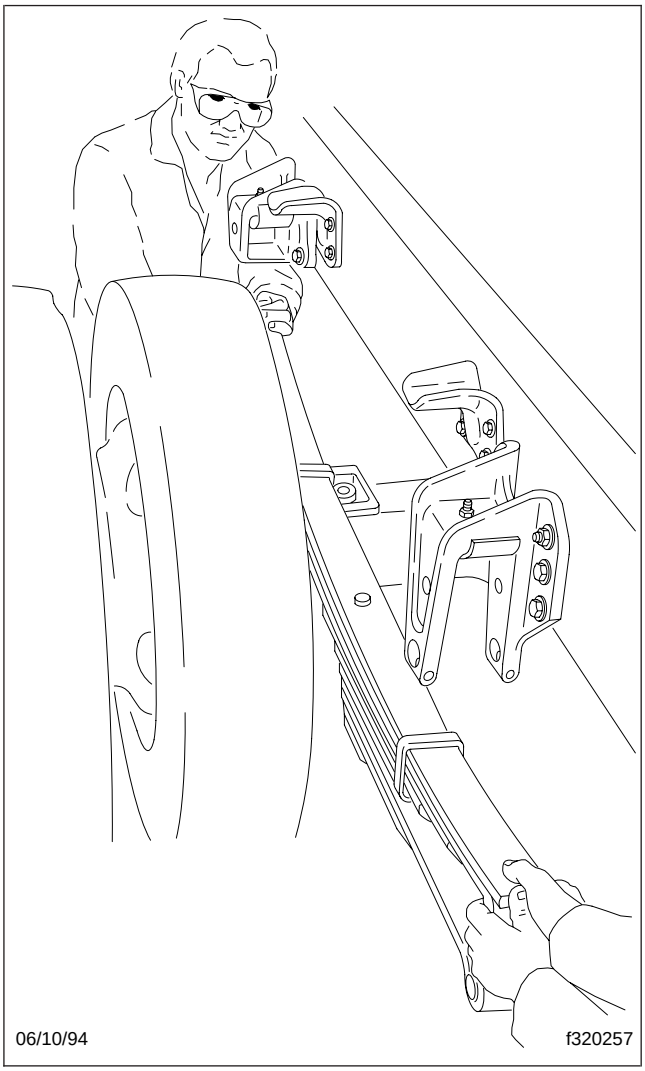
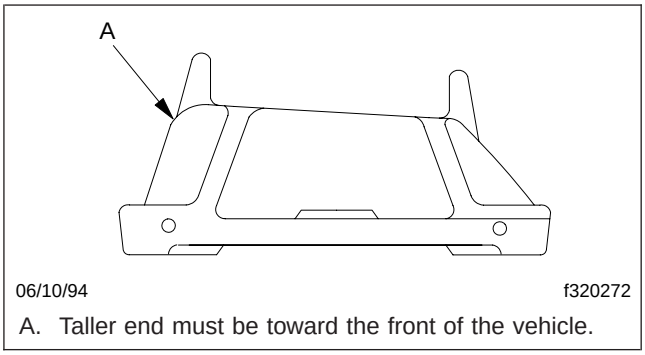


Fig. 8, Removing the Leaf Spring Assembly



A. Taller end must be toward the front of the vehicle.

Fig. 9, Alignment of the U-bolt Retainer

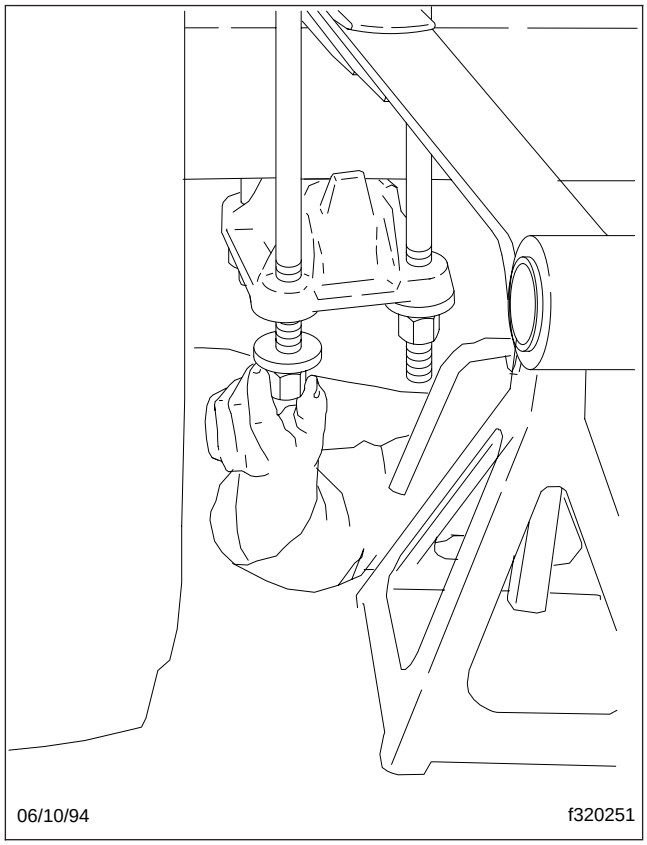


Fig. 10, Installing the U-bolt High Nuts

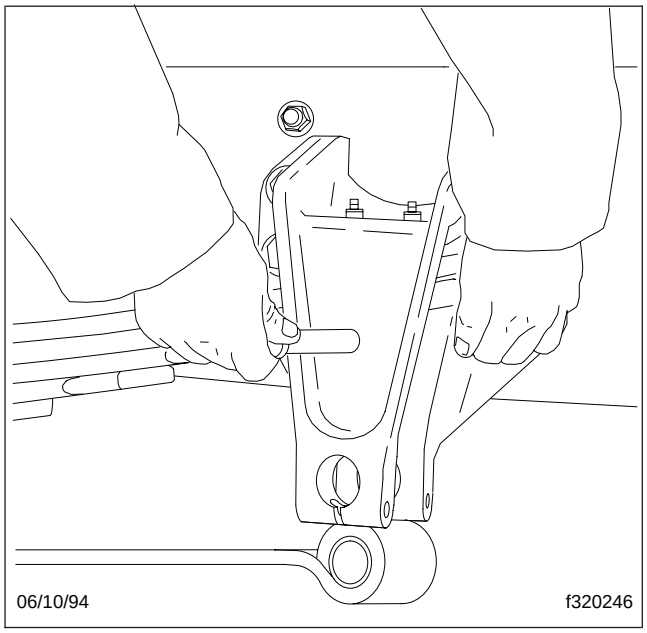


Fig. 11, Installing the Retainer Pin

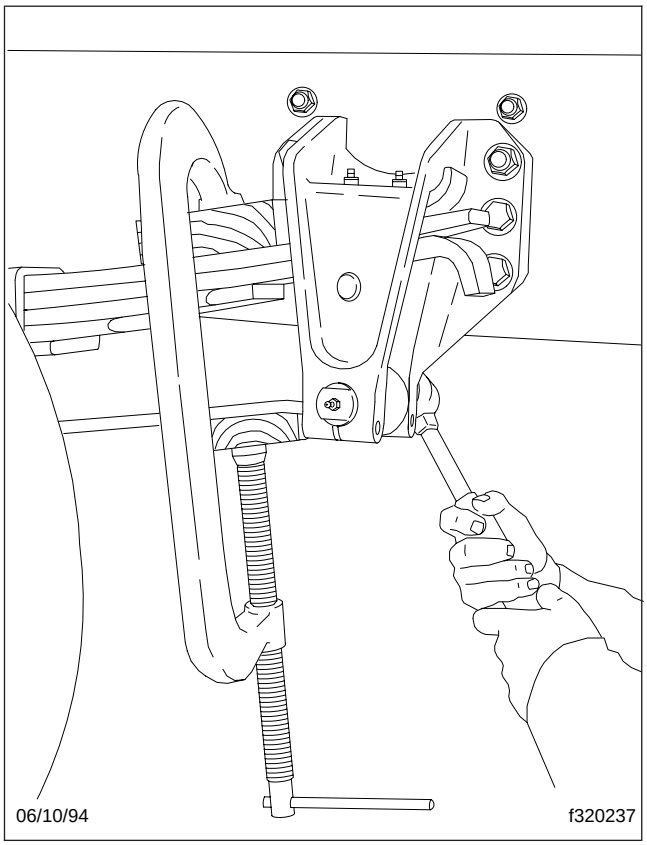


Fig. 12, Installing the Spring Eye Pin

Rear Spring Bracket Replacement

1. Park the vehicle and chock the front tires.
2. Jack up the frame rail at the rear of the vehicle until the leaf spring is floating free in the rear spring bracket.
3. Remove the fasteners holding the rear spring bracket to the frame rail. See **Fig. 1**.
4. Slide the spring bracket off the end of the leaf spring assembly. See **Fig. 2**.
5. Check the wear pad for wear. Replace it if needed. For instructions, refer to **Wear Pad Replacement, 130**.
6. Slide the new spring bracket into position.
7. Install the fasteners and tighten them 184 N·m (135 lbf·ft).
8. Lower the frame rail and remove the chocks from the tires.

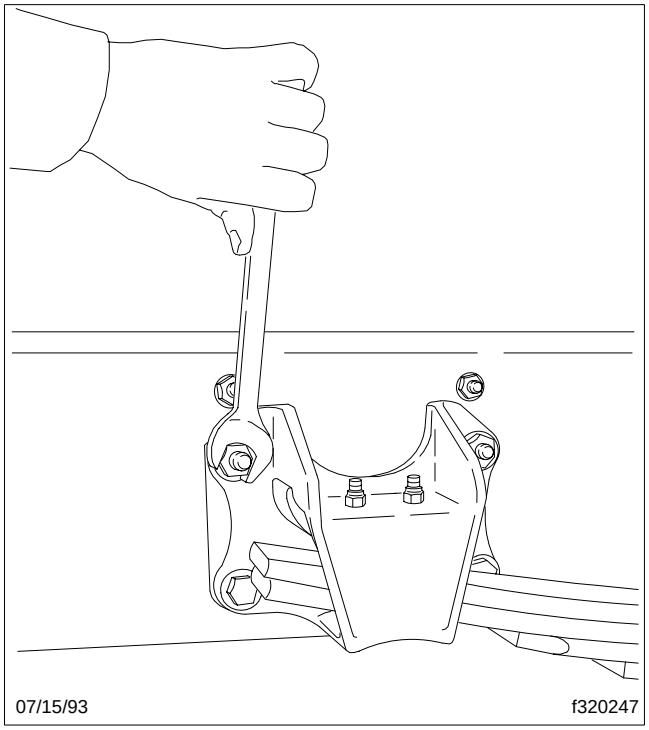


Fig. 1, Rear Spring Bracket Fastener Removal

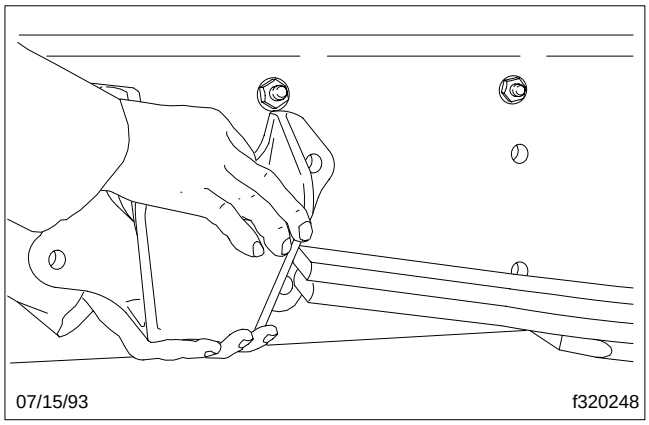


Fig. 2, Sliding Bracket From Leaf Spring Assembly

Forward Spring Bracket Replacement

1. Park the vehicle and chock the front tires.
2. Jack up the frame rail at the rear of the vehicle until the weight is removed from the leaf spring.
3. Remove the spring bracket.
   - 3.1 Using a C-clamp, take the load off the radius leaf. See **Fig. 3**.
   - 3.2 Remove the pinch bolts holding the spring eye pin. See **Fig. 4**.
   - 3.3 Using a brass hammer, tap out the spring eye pin. See **Fig. 5**.
   - 3.4 Remove the clip (see **Fig. 6**) and the spring retainer pin (see **Fig. 7**).
   - 3.5 Remove the fasteners holding the front spring bracket to the frame rail.
   - 3.6 Slide the spring bracket off the front of the leaf spring assembly.
4. Install a new spring bracket.
   - 4.1 Slide a new spring bracket into position.
   - 4.2 Install the fasteners and tighten them 325 N·m (240 lbf·ft).
   - 4.3 While lifting the spring, install the spring retainer pin and clip. See **Fig. 7**.
   - 4.4 Using a hammer, drive in the spring eye pin. See **Fig. 8**.

Spring Bracket Replacement

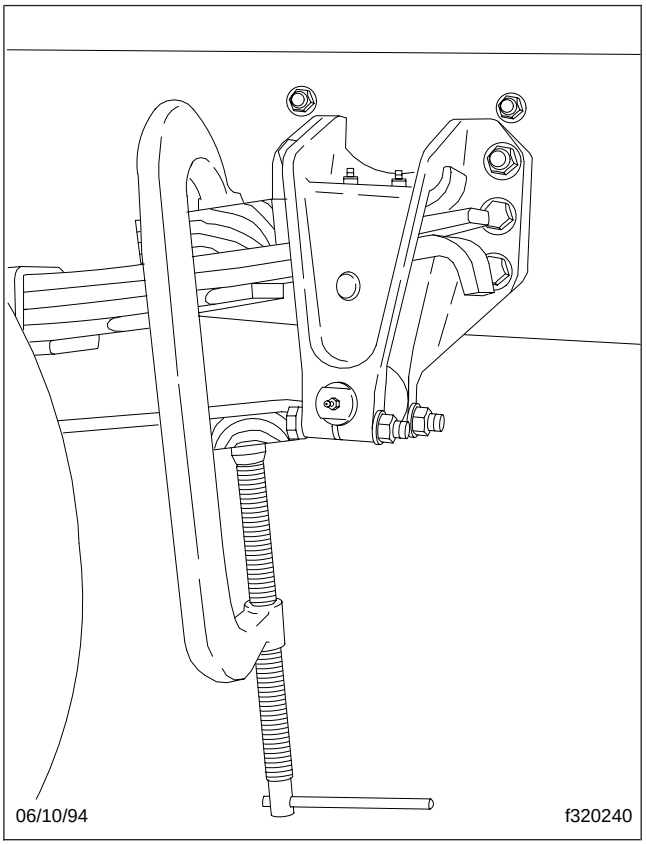


Fig. 3, C-Clamping Radius Leaf

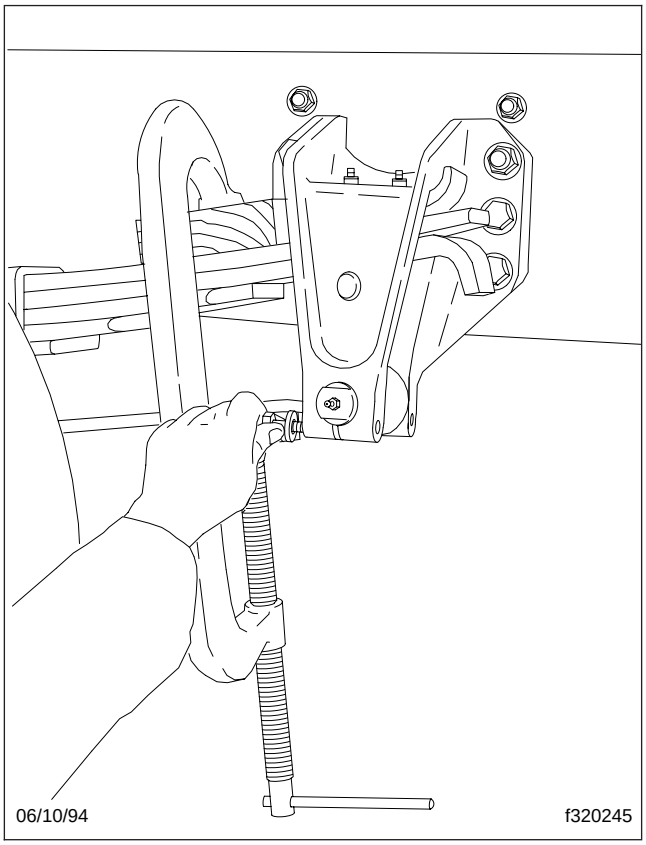


Fig. 4, Removing Pinch Bolts

4.5 Install the pinch bolts and nuts. Tighten the nuts 43 N·m (32 lbf·ft).

5. Lower the frame rail and remove the chocks from the tires.

Spring Bracket Replacement

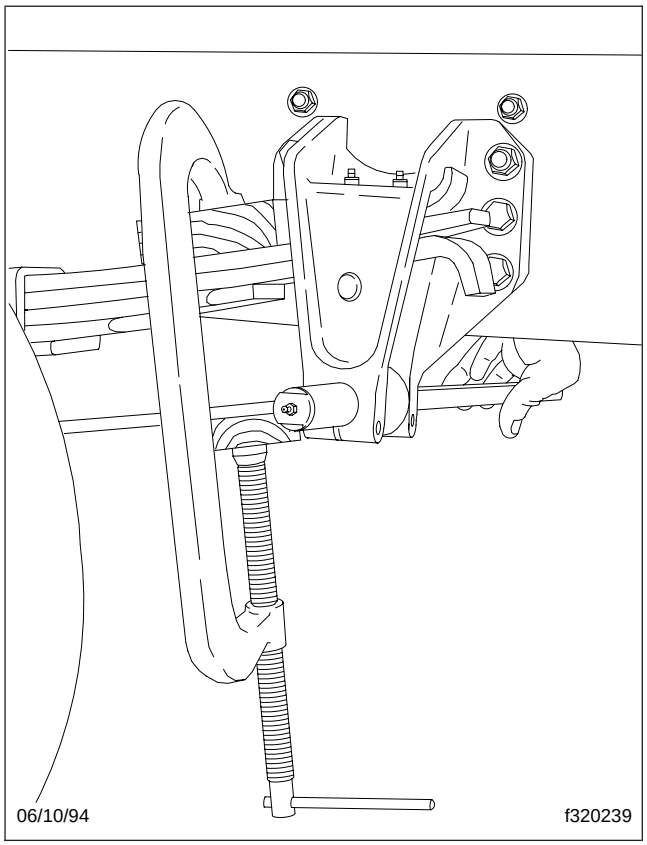


Fig. 5, Tap Out Spring Eye Pin

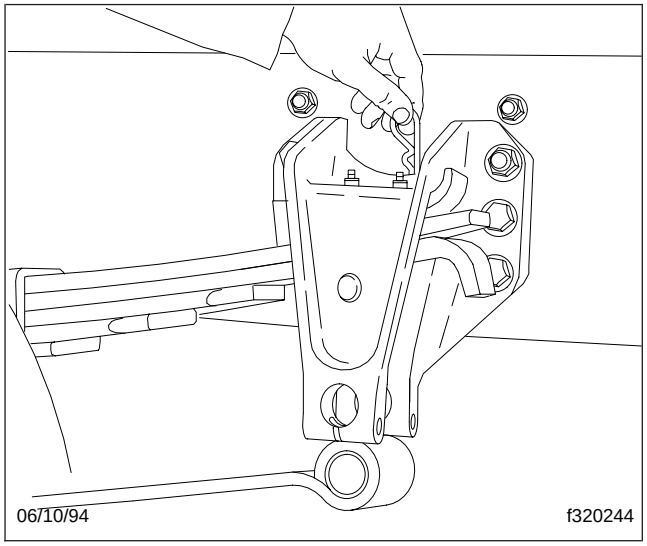


Fig. 6, Clip Removal

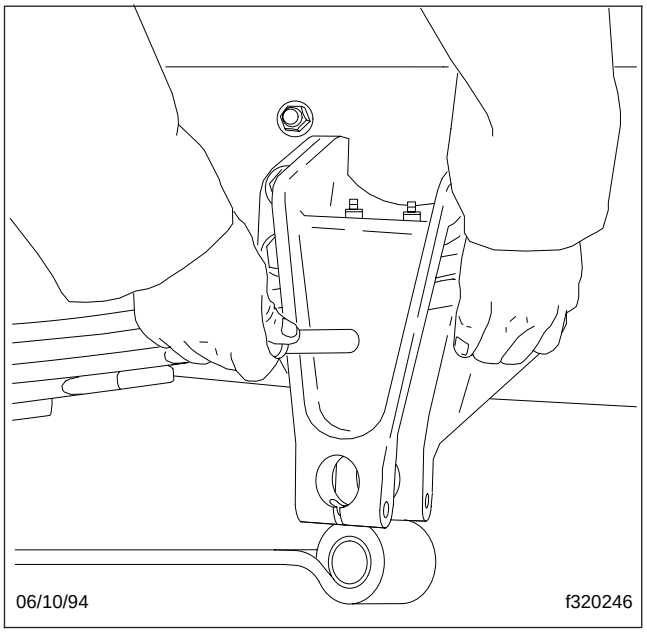


Fig. 7, Spring Retainer Pin Removal

Spring Bracket Replacement

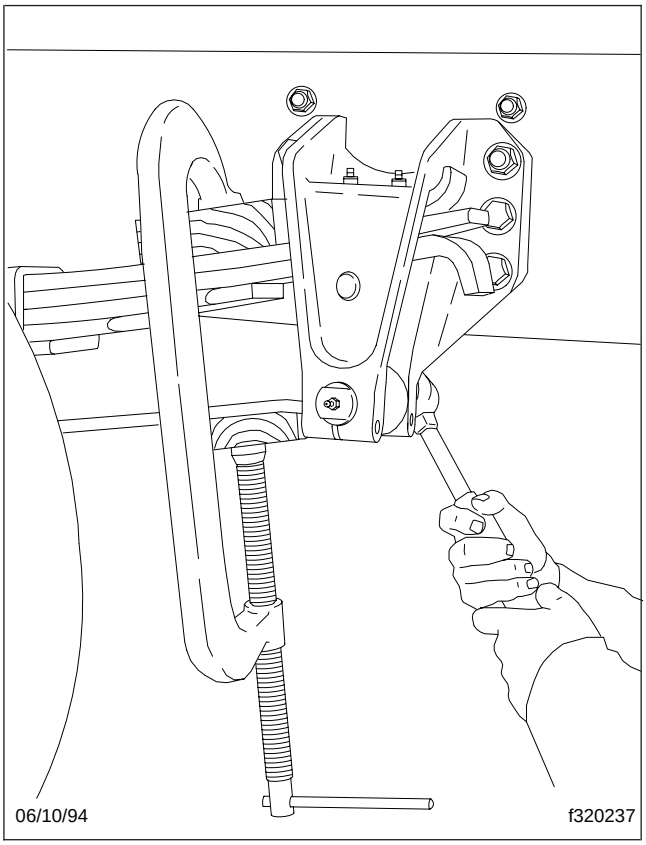


Fig. 8, Spring Eye Pin Installation

Replacement

1. Using a floor jack, lift the frame rail to take weight off the spring.
2. Using a C-clamp, take the load off the radius leaf. **See Fig. 1.**

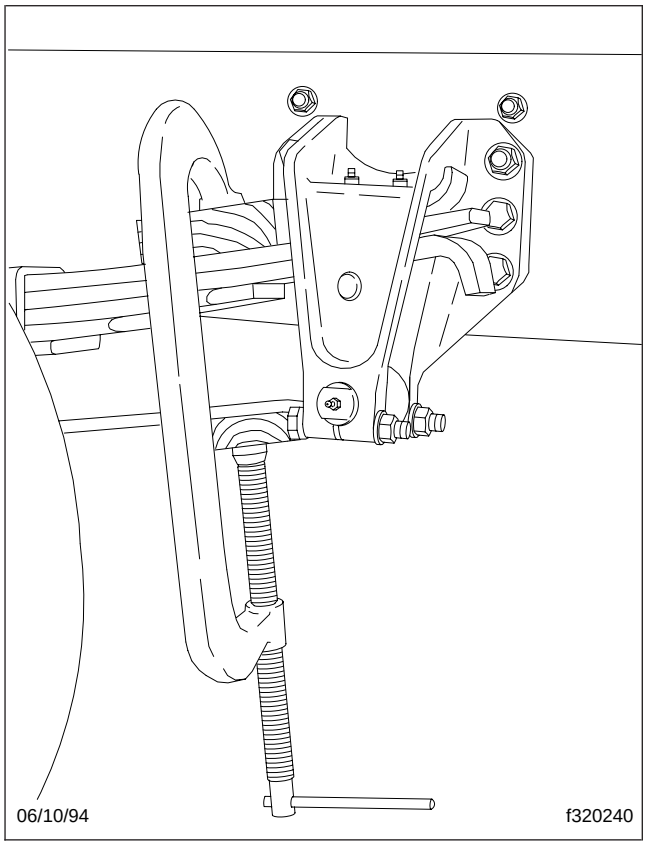


Fig. 1

3. Loosen and remove the pinch bolts. **See Fig. 2.**
4. Using a brass hammer and a drift, tap the pin out. **See Fig. 3.**
5. Grease the outer surface of a new pin and insert it **(Fig. 4).** Drive it in using a hammer. **See Fig. 5.**
6. Install the pinch bolts **(Fig. 2)** and nuts. Tighten the nuts 43 N·m (32 lbf·ft)
7. Install a new zerk fitting and the spring eye pin.
8. Remove the C-clamp and lower the jack.

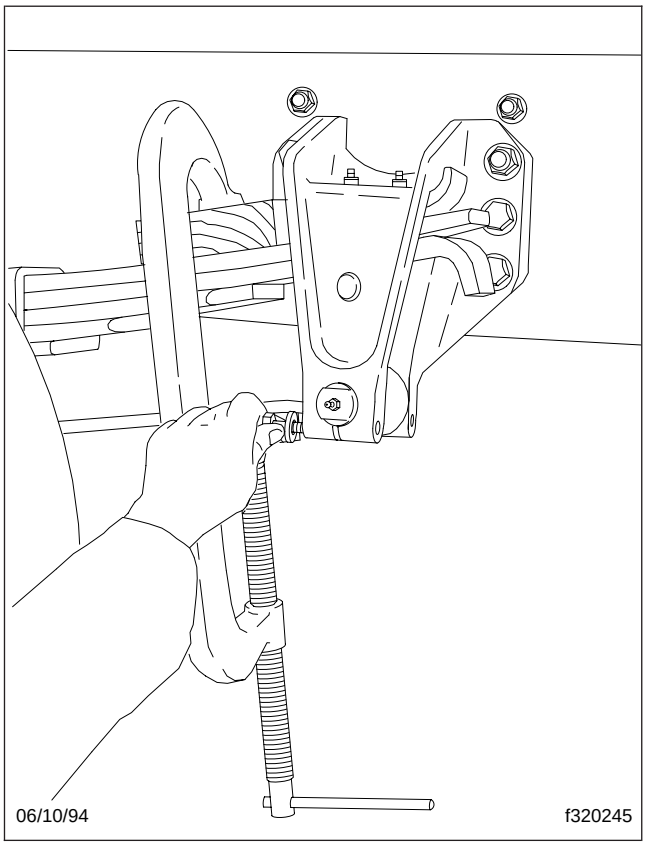


Fig. 2

NOTE: When replacing the pin, if the spring has shifted, loosen the U-bolt nuts so the spring can be shifted fore and aft.

Spring Eye Pin Replacement

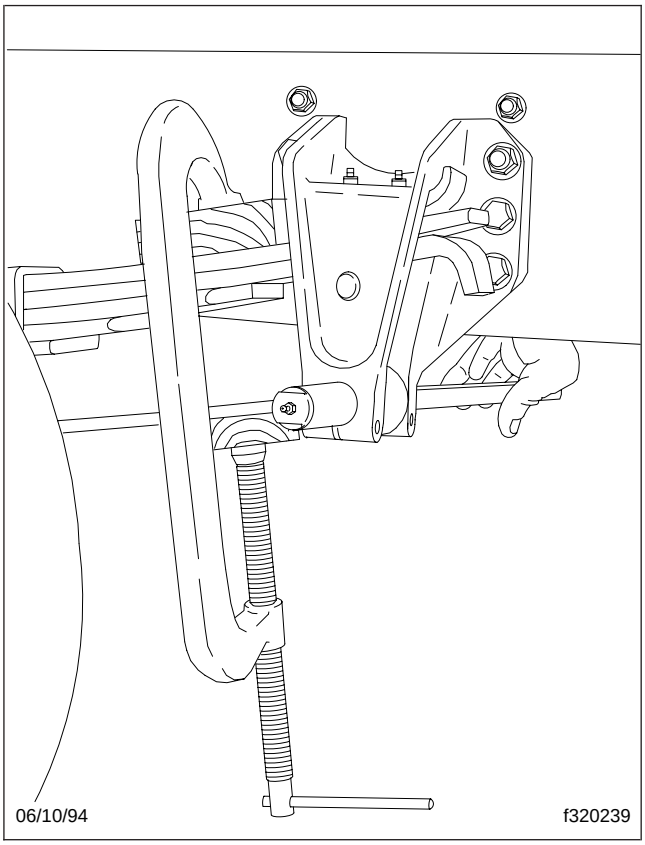


Fig. 3

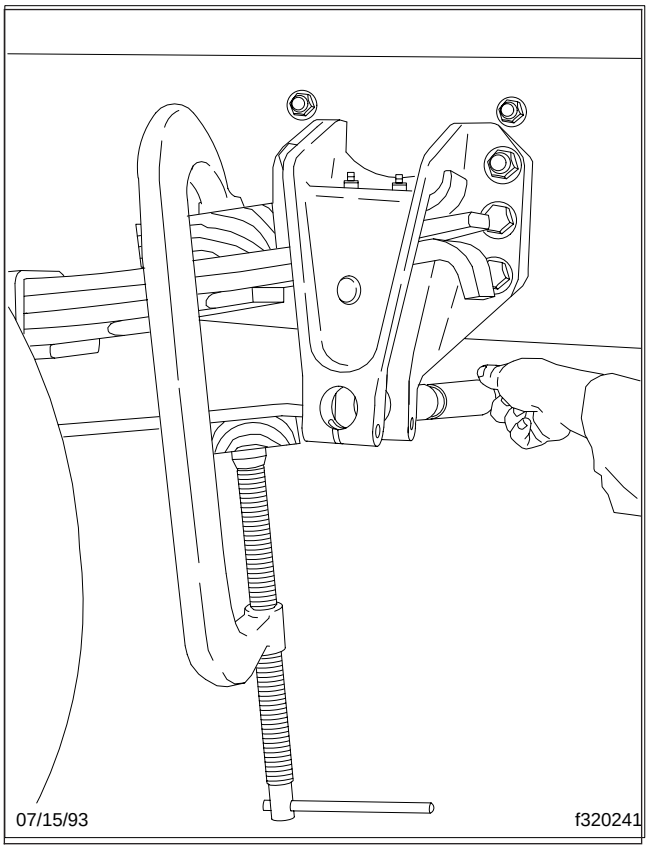


Fig. 4

Spring Eye Pin Replacement

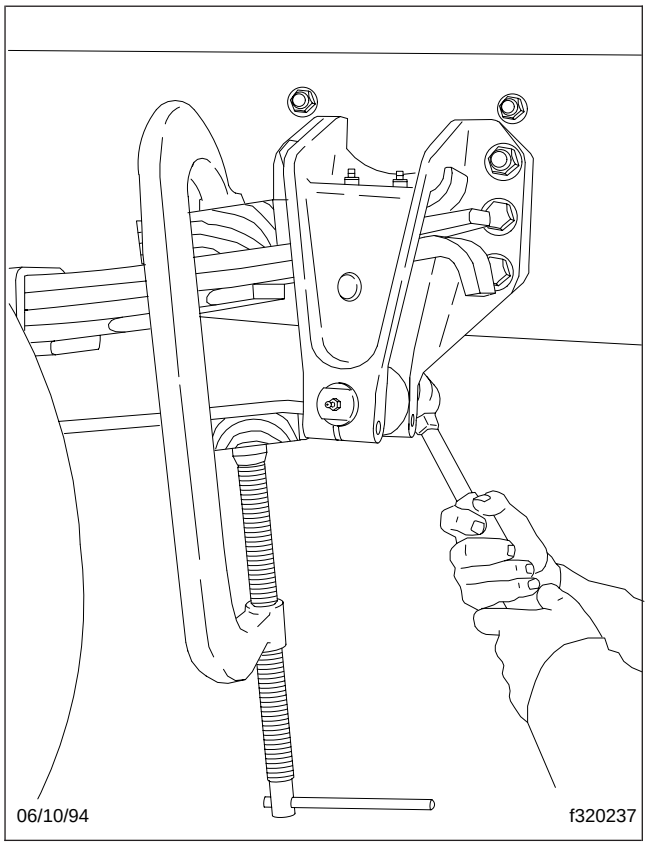


Fig. 5

Replacement

NOTE: Wear pads can be replaced without removing the leaf spring assemblies.

1. Park the vehicle and chock the front tires.
2. For front wear pad replacement, remove the clip **(Fig. 1)** and the spring retainer pin **(Fig. 2).**
3. Using a floor jack or a crane, take the weight off the frame rail so there is no contact between the spring and the wear pad.
4. Remove the allen-head screws attaching the wear pad to the spring bracket. **See Fig. 3** for the front wear pad, **Fig. 4** for the rear wear pad. Remove and discard the wear pad.
5. Install the new wear pad so that the thicker portion of the pad is toward the axle. **See Fig. 5** for the front wear pad. While holding it in place, install and tighten the allen-head screws until snug.
6. If removed, install the spring retainer pin and its clip.
7. Lower the frame rail.

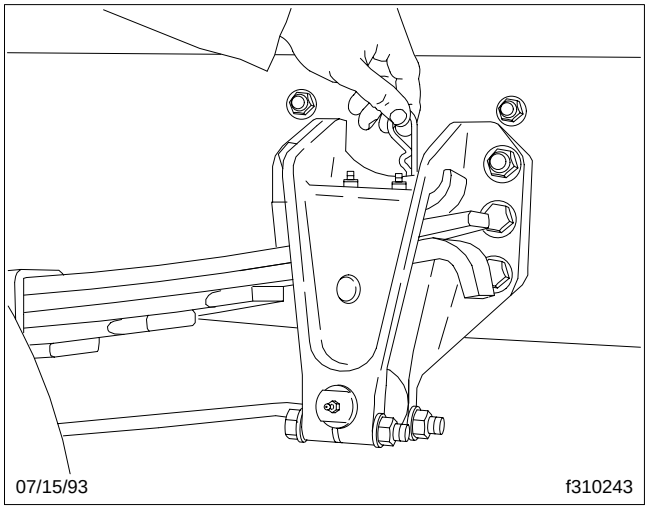


Fig. 1

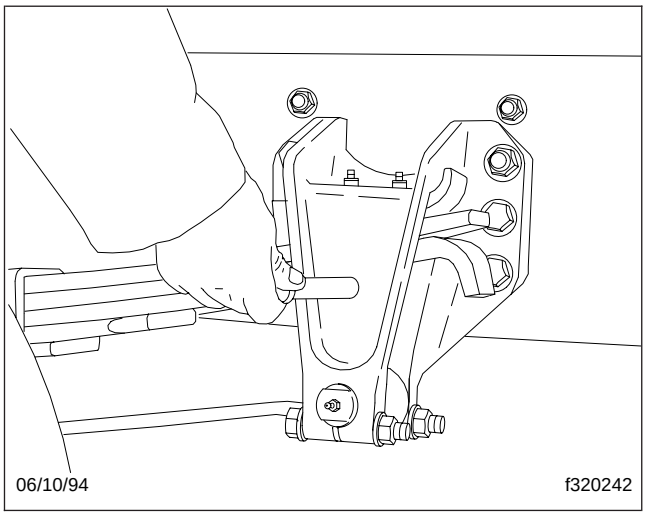


Fig. 2

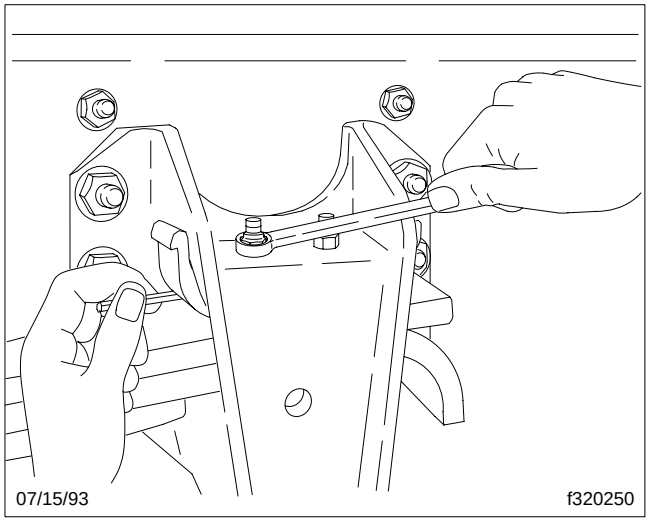


Fig. 3

Wear Pad Replacement

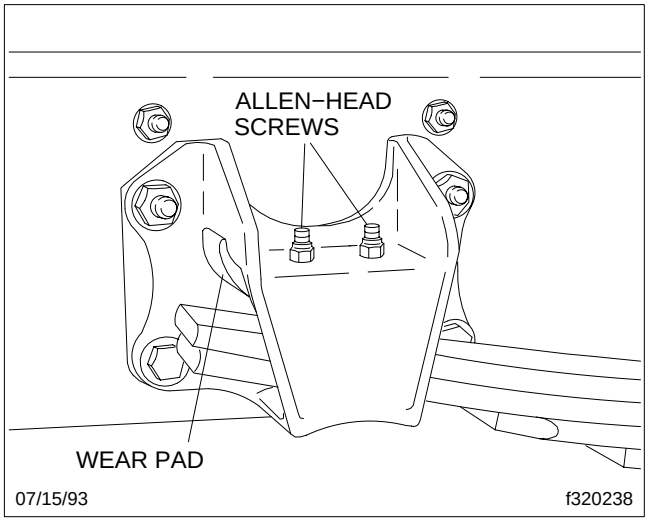


Fig. 4

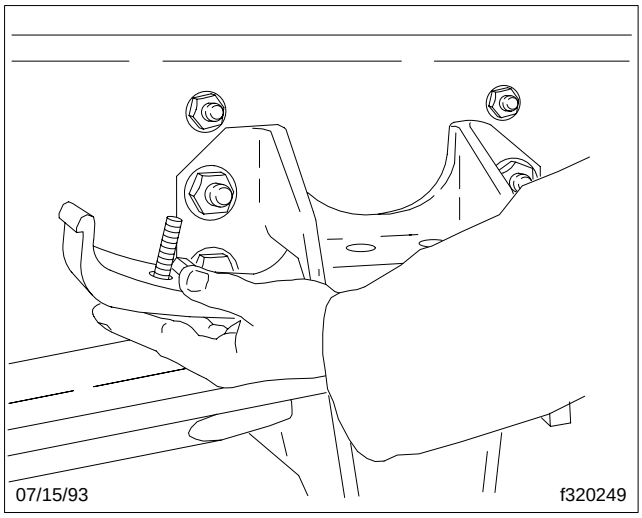


Fig. 5

Replacement (See Fig. 1)

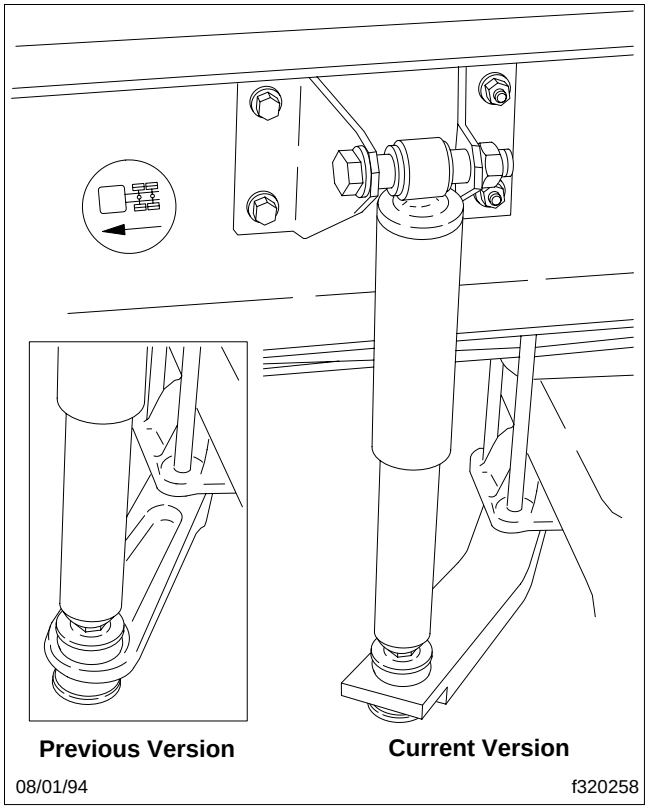


Fig. 1

1. Chock the tires and apply the parking brakes.
2. Remove the locknut, retainers, and bushings from the shock absorber lower mount.
3. Remove the locknut, capscrew, and washers from the shock absorber upper mount.
4. Remove the shock absorber.
5. Install the replacement shock absorber.
6. Install the capscrew and locknut in the upper mount. Hand tighten them at this time.
7. Install the replacement bushings, retainers, and locknut as shown in **Fig. 2**.

⚠ WARNING

Use only the retainers included with the replacement shock absorber. Do not use washers. They can be pushed over the nut and be ejected violently, possibly causing personal injury and property damage.

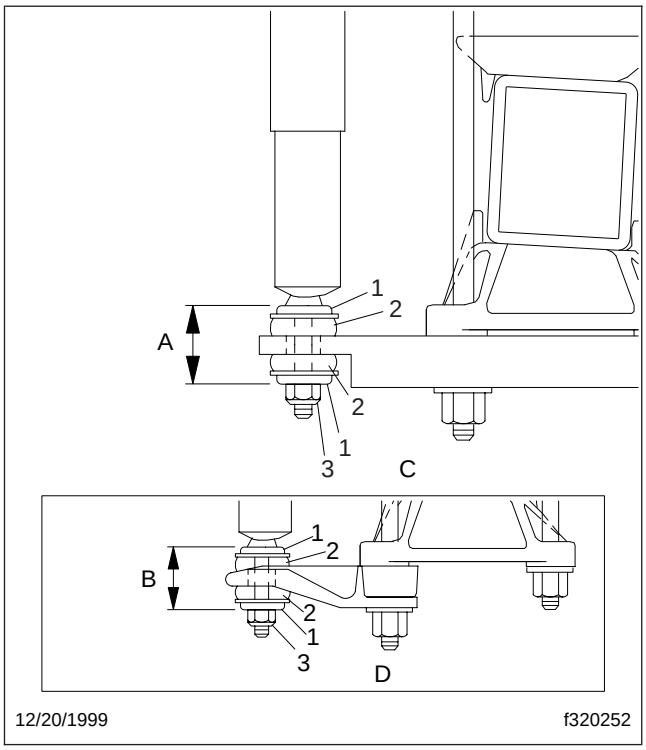


Fig. 2

8. Tighten the shock absorber upper mounting locknut 226 N·m (167 lbf·ft).
9. Tighten the shock absorber lower mounting nut to compress the bushings to the dimension shown in **Fig. 2**.

Specifications

Torque Values			
Description	**Size**	**IFI Grade**	**Torque lbf·ft (N·m)**
Forward Spring Bracket-to-Frame Rail Locknut *	3/4–10	C	240 (325)
Rear Spring Bracket-to-Frame Rail Locknut *	5/8–11	C	135 (184)
Axle U-Bolt High Nuts	5/8–18	C	Stage 1: Hand tighten Stage 2: 60 (81) † Stage 3: 200 (271) † Stage 4: 180 to 230 (245 to 313) †
	3/4–16	C	Stage 1: Hand tighten Stage 2: 60 (81) † Stage 3: 200 (271) † Stage 4: 270 to 330 (367 to 449) †
Spring Eye Pin Pinch Bolts	7/16—14	C	37 (50)
Shock Absorber Upper Locknut	—	C	167 (226)

* Cadmium-plated, wax-coated nuts, and grade 8 hexbolts with phosphate- and oil-coated threads; both used with hardened washers.
† Tighten in a diagonal pattern as shown in **Fig. 1**.

Table 1, Torque Values

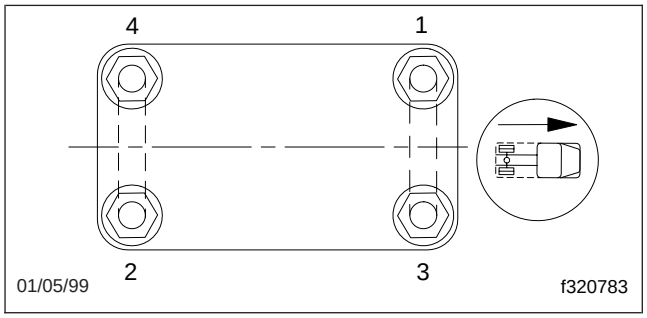


Fig. 1, Tightening Pattern for U-bolt High Nuts

General Information

The Freightliner AirLiner Suspension is a single axle or tandem axle suspension that uses a combination of air and leaf springs. The suspension is manufactured at numerous weight ratings up to 46,000 pounds (20 865 kg). The top of the air spring is bolted to a bracket on the frame rail or through the bottom flange of the frame rail; the bottom is bolted to the rear end of the tapered leaf spring assembly or, for the 23,000-pound (10 433 kg) and 46,000-pound suspensions, to a cross bar. The axle housing is fastened to the leaf spring assembly by U-bolts. A control rod, mounted between the axle housing and the frame rail, can be used to help locate the assembly laterally.

The air springs compensate for changes in road conditions and vehicle load, maintaining constant vehicle height. The air springs also absorb road shock.

A height control valve regulates the air flow into or out of the air springs. **See Fig. 1.** Changes in the clearance between the vehicle frame and the differential housing activate the height control valve. Then, the height control valve adjusts the frame height by compression or expansion of the air springs.

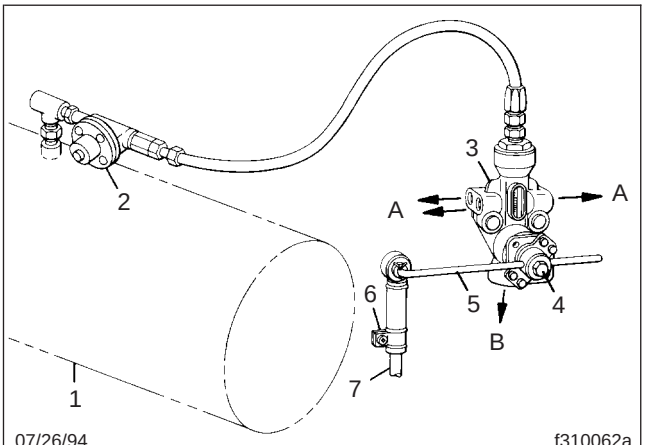
The pressure holding valve (**Fig. 1**, Ref. 2), located in the air line to the height control valve, is preset to maintain a minimum pressure of 448 kPa (65 psi) in the vehicle secondary air system if a leak should occur in the air suspension system.

Principles of Operation

The height control valve controls the air suspension system. All of the air in the system is admitted through or exhausted from this valve.

The height control valve is mounted on a frame crossmember. An overtravel lever extends horizontally from the end of the height control valve control shaft to a linkage arm that connects to the height control valve linkage bracket welded to the differential housing. **See Fig. 2.**

When the load changes, the overtravel lever turns the height control valve control shaft, activating either the intake or exhaust valve section of the height control valve. This adjusts the volume of air in the air springs, until the frame returns to the normal ride height, and the overtravel lever returns to the (horizontal) neutral position.



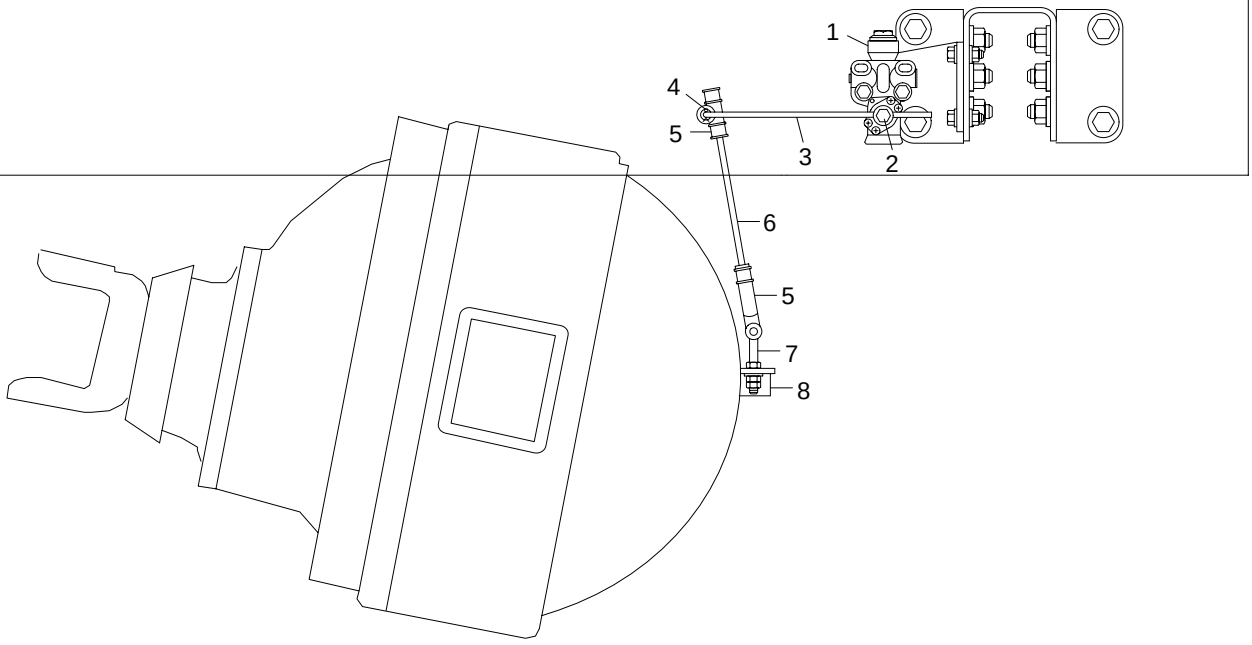
A. To Air Springs
B. To Atmosphere
1. Secondary Air Reservoir
2. Pressure Holding Valve
3. Height Control Valve
4. Adjusting Locknut
5. Overtravel Lever
6. Linkage Adjustment Clamp
7. Height Control Valve Linkage

Fig. 1, Height Control Valve Assembly

A 9-second time delay is built into the height control valve to prevent rapid suspension height changes due to bumps. This also reduces the air consumption of the suspension.

A side-to-side restriction valve inside the height control valve maintains vehicle roll stability by preventing inflation of the air spring on one side and deflation on the other side during curves.

General Information and Principles of Operation



08/02/94 f320282a

1. Height Control Valve
2. Adjustment Locknut
3. Overtravel Lever
4. Cotter Pin
5. Linkage Adjustment Clamp
6. Height Control Valve Linkage Rod
7. L-Rod
8. Height Control Valve Linkage Bracket

Fig. 2, Height Control Valve Assembly

General Guidelines

1. To keep the air suspension system operating reliably, the air system must be kept free of any oil, moisture, or foreign material. Inspect and maintain the air system components regularly. Refer to the applicable group of the vehicle maintenance manual for maintenance operations.

⚠ CAUTION

CAUTION: Failure to take precautions against the entry of moisture, oil, or other foreign material into the air suspension system could eventually lead to sludge forming in the air system. Sludge could adversely affect the operation of the air suspension system and other air system components.

2. Use only SAE grade 8 bolts, grade C prevailing torque locknuts, and hardened washers to attach spring hangers and brackets to the frame.
3. For suspension component inspecting, lubricating, and fastener torque checking intervals and instructions, refer to the maintenance schedule and the suspension group in the vehicle maintenance manual.

General Information

CAUTION

Failure to adjust the suspension ride height could adversely affect driveline angles. Also, if the air springs are set too high, the driver may have difficulty (or be prevented from) backing the vehicle under a trailer. If the air springs are set too low, rapid wear of suspension parts will result.

Use the applicable procedure to adjust the suspension height.

- Ride Height Adjustment, Vehicle with a Meritor WABCO Valve Adjustable Installation
- Ride Height Adjustment, Vehicle with a Meritor WABCO Valve Fixed Installation
- Ride Height Adjustment, Vehicle with a Barksdale Valve

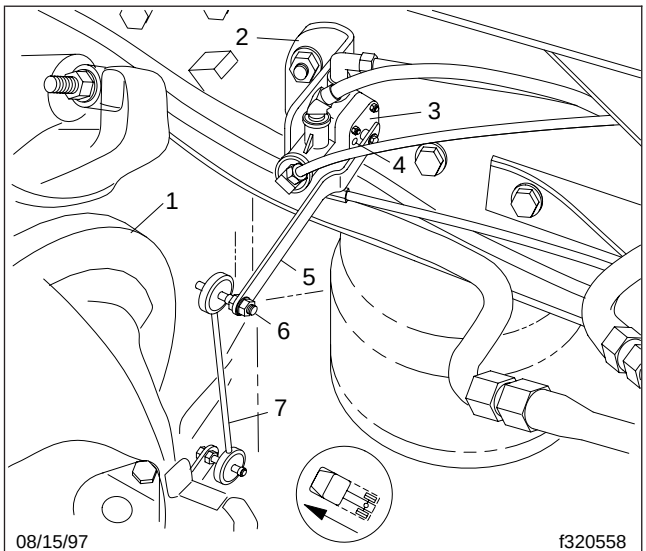
The Barksdale height-control valve replaced the Meritor WABCO valve after July 25, 1997. On vehicles with tandem-axle AirLiner rear suspensions, the Barksdale valve linkage rod is attached to the forward drive axle instead of the rearmost drive axle, and the valve is mounted on the frame rail. See **Fig. 1**.

There are two types of WABCO height-control valve installations: adjustable and fixed. See **Fig. 2**. On adjustable installations, the suspension height is changed by tilting the height-control valve up or down. On fixed installations, the suspension height is changed by adjusting the length of the vertical linkage rod.

Ride Height Adjustment, Vehicle with a Meritor WABCO Valve Adjustable Installation

IMPORTANT: Before checking the AirLiner suspension height, make sure there is no load on the chassis. For tractors, unhitch the trailer. Trucks must be empty.

1. Park the vehicle on a level surface, using a light application of the brakes. Do not apply the parking brakes. Put the transmission in neutral. Build the secondary air pressure to at least 100 psi (690 kPa). Shut down the engine.



1. Forward Drive Axle
2. Valve Mounting Bracket
3. Height-Control Valve
4. Pilot Hole
5. Lever Arm
6. Stud Bolt
7. Vertical Linkage Rod

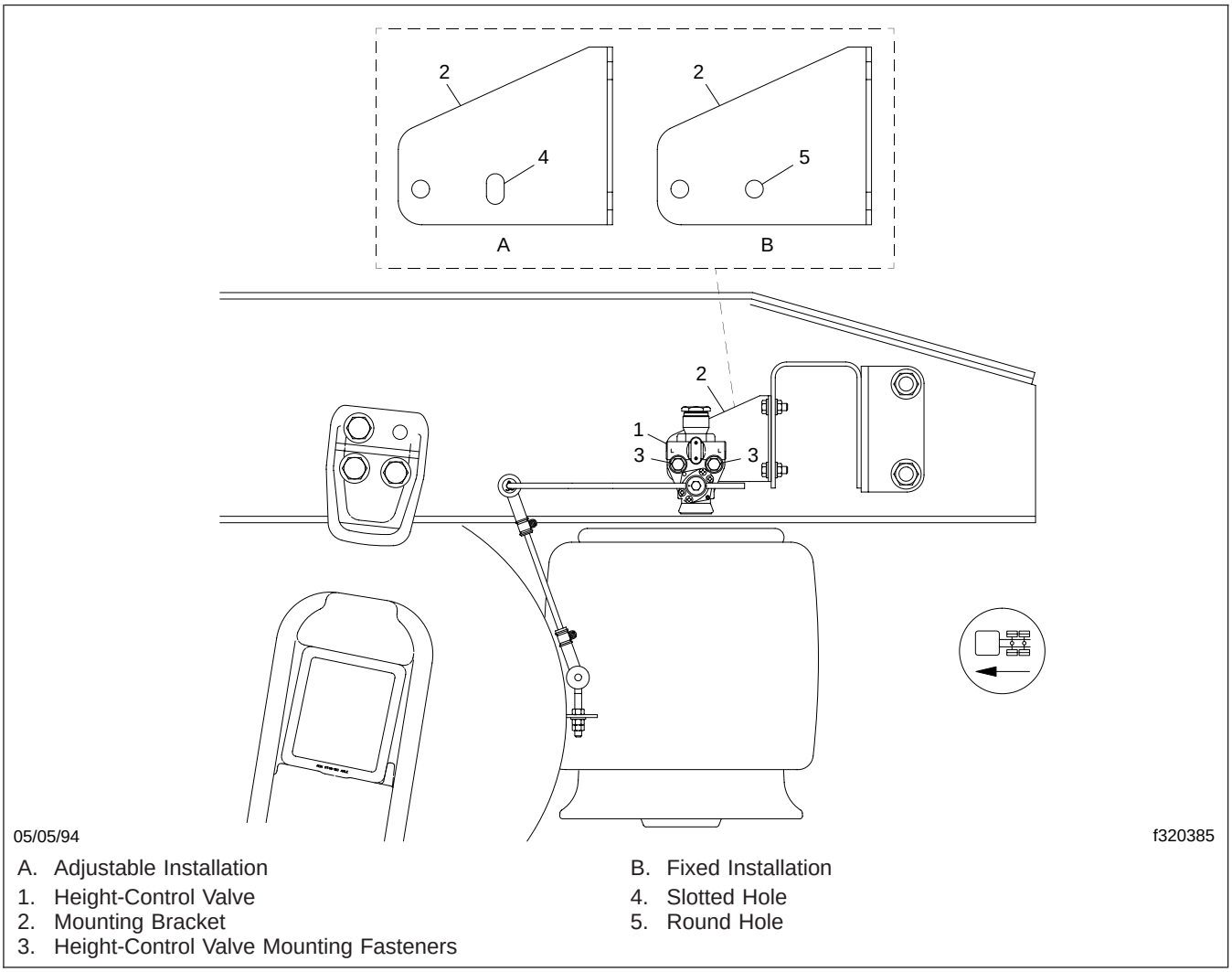
Fig. 1, Barksdale Height-Control Valve Installation

2. Mark the location of the front and rear tires on the floor, then chock the tires on one axle only.
3. Check the length of the over-travel lever between its pivot points. See **Fig. 3**. The length should be 8 inches (203 mm). If needed, adjust the length of the over-travel lever.
   - 3.1 Loosen the adjustment locknut on the control shaft.
   - 3.2 Move the over-travel lever fore or aft until the length between the pivot points is 8 inches (203 mm).
   - 3.3 Tighten the adjustment locknut 62 lbf·in (700 N·cm).
4. AirLiner suspensions may have one of three types of axle seats. See **Fig. 4**.

   The three styles are:

   - a one-piece, cast axle seat, that is *not* welded to the axle housing;
   - a one-piece, cast axle seat, that *is* welded to the axle housing;

Suspension Ride Height Adjustment



A. Adjustable Installation
1. Height-Control Valve
2. Mounting Bracket
3. Height-Control Valve Mounting Fasteners

B. Fixed Installation
4. Slotted Hole
5. Round Hole

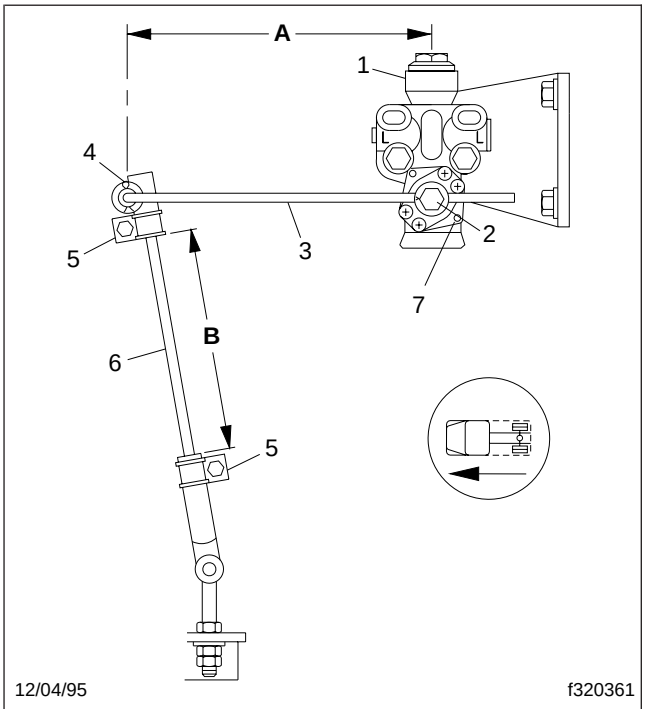
Fig. 2, Meritor WABCO Height-Control Valve Installation

- a two-piece, fabricated axle seat that is welded to the axle housing.

IMPORTANT If the axle seat is a two-piece welded type, subtract 1/4 inch (6 mm) from the minimum, target, and maximum heights when adjusting the suspension height.

5. Measure the distance from the bottom of the left forwardmost axle stop to the top of the axle U-bolt. See *Suspension Ride Height Measurement*, **Table 3**, **Table 4**, **Table 5**, **Table 6**, and **Table 7** for an acceptable range of heights for each suspension.
6. If the distance is within the acceptable range, apply the parking brakes, then remove the chocks from the tires.

   If the distance is not within the acceptable range, go to the next step.
7. Loosen the two fasteners that attach the height-control valve to the mounting bracket.
8. Rotate the height-control valve clockwise (as you are facing it from the driver's side of the vehicle). Let the air exhaust from the valve until the distance from the bottom of the left forwardmost



A. Measure the length of the over-travel lever between these two points.
B. Measure the length of the linkage rod between these two points.

1. Height-Control Valve
2. Adjustment Locknut
3. Over-Travel Lever
4. Cotter Pin
5. Adjustment Clamp
6. Linkage Rod
7. Valve Centering Hole

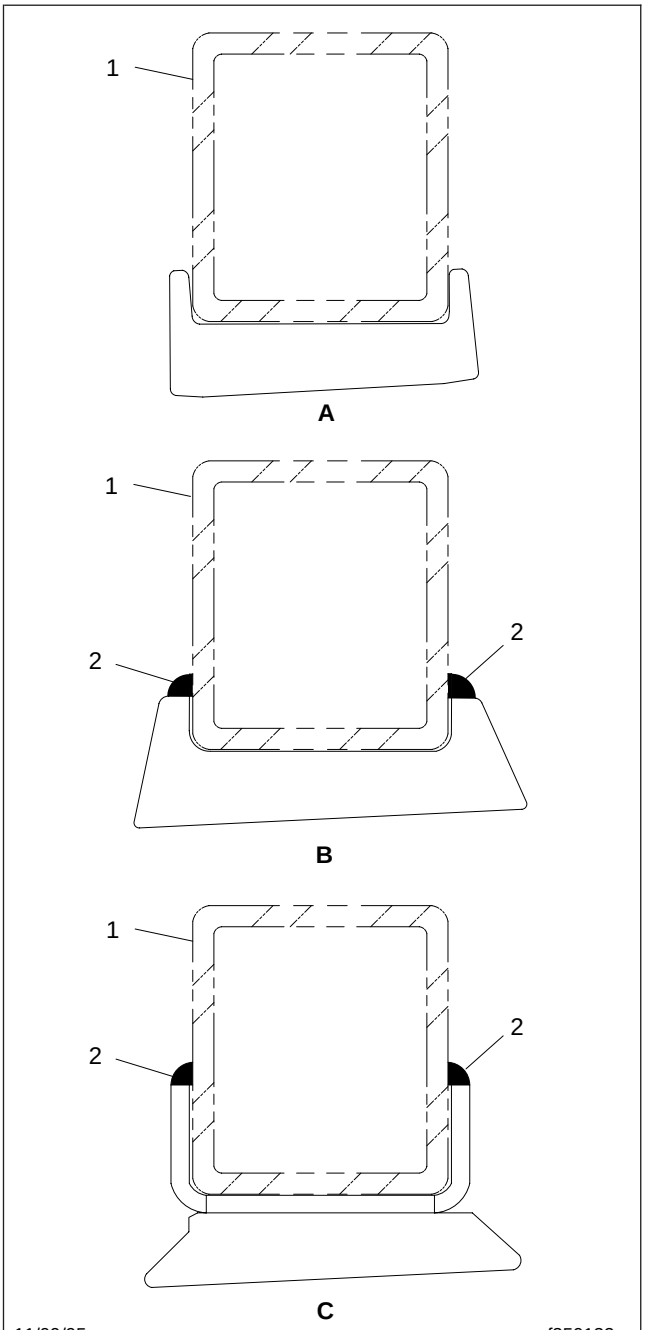
Fig. 3, Meritor WABCO Height-Control Valve Over-Travel Lever and Linkage Rod Measurement

axle stop to the top of the axle U-bolt is 2 inches (51 mm) or less.

9. Rotate the height-control valve counterclockwise, and raise the suspension height to the target height (previously noted from the appropriate table). Stop the air flow to the air bag by rotating the height-control valve clockwise.

10. Center the height-control valve.

    10.1 Rotate the valve very slightly clockwise and counterclockwise until you can insert a 4-mm pin, or drill bit, into the valve centering hole. Don't rotate the valve too much, or you will change the suspension height.



A. One-Piece Cast Axle Seat, Not Welded
B. One-Piece Cast Axle Seat, Welded
C. Two-Piece Fabricated Axle Seat, Welded

1. Axle Housing
2. Welds

Fig. 4, Axle Seats

10.2 Tighten the height-control valve mounting fasteners firmly.

11. Drive the vehicle unloaded for about 1/4 mile (1/2 km), then stop the vehicle in the exact location (as previously marked) of the original measurement.

    Park the vehicle using a light brake application. Chock the tires on one axle only, and put the transmission in neutral. Do not apply the parking brakes.

12. Check the adjusted distance between the bottom of the left forwardmost axle stop and the top of the axle U-bolt. It should be within the acceptable range for the applicable suspension previously noted.

13. If the distance is not within the acceptable range, repeat the adjustment procedure.

    If the distance is within the acceptable range, apply the parking brakes, then remove the chocks from the tires.

Ride Height Adjustment, Vehicle With a Meritor WABCO Valve Fixed Installation

IMPORTANT: Before checking the AirLiner suspension height, make sure there is no load on the chassis. For tractors, unhitch the trailer. Trucks must be empty. In order to adjust the suspension height, you must change the length of the linkage rod using the following procedure.

1. Park the vehicle on a level surface, using a light application of the brakes. Do not apply the parking brakes. Put the transmission in neutral. Build the secondary air pressure to at least 100 psi (690 kPa). Shut down the engine.

2. Mark the location of the front and rear tires on the floor, then chock the tires on one axle only.

3. Check the length of the height-control valve over-travel lever. See **Fig. 3**. See **Table 1** for the correct length.

   If the length is acceptable, go to the next step.

   If the length is not acceptable, adjust the length of the over-travel lever as follows.

Over-Travel Lever Length	
Axle Designation	**Over-Travel Lever Length: inches (mm)**
Meritor RS23–161	8 (203)
Meritor 23–180	7-3/8 (187)
Meritor SQ100	9-1/4 (235)
Meritor SSHD	9 (229)
Meritor RT40–145	9-3/4 (248)
Meritor RT44–145	9-3/4 (248)
Meritor RT46–160	8-1/8 (206)
Eaton 23105 SC	7-1/4 (184)
Eaton 402	8-3/8 (213)
Eaton 404	8-3/8 (213)
Eaton 461	8-3/8 (213)

Table 1, Over-Travel Lever Length

3.1 Loosen the adjustment locknut on the control shaft.

3.2 Move the over-travel lever fore or aft until it is the correct length.

3.3 Tighten the adjustment locknut 62 lbf·in (700 N·cm).

4. Measure the distance from the bottom of the left forwardmost axle stop to the top of the axle U-bolt. See *Suspension Ride Height Measurement*, **Table 3**, **Table 4**, **Table 5**, **Table 6**, and **Table 7** for an acceptable range of heights for each suspension.

   If the distance is within the acceptable range, apply the parking brakes, then remove the chocks from the tires.

   If the distance is not within the acceptable range, go to the next step.

5. Determine how much the suspension height needs to be adjusted so the distance matches the target height in the applicable table. Then, using **Table 2**, find the amount the length of the linkage rod needs to be changed. See **Fig. 3**.

Vertical Linkage Length Changes	
Suspension Height Correction: inches (mm)	**Vertical Linkage Length Correction: inches (mm)**
1/16 (2)	1/16 (2)
1/8 (3)	3/16 (5)
3/16 (5)	1/4 (6)
1/4 (6)	5/16 (8)
5/16 (8)	3/8 (10)
3/8 (10)	1/2 (13)
7/16 (11)	9/16 (14)
1/2 (13)	5/8 (16)
9/16 (14)	3/4 (19)
5/8 (16)	13/16 (21)
11/16 (17)	7/8 (22)
3/4 (19)	1 (25)
13/16 (21)	1-1/16 (27)
7/8 (22)	1-3/16 (30)
15/16 (24)	1-1/4 (32)
1 (25)	1-5/16 (33)

Table 2, Vertical Linkage Lengths

6. Adjust the length of the linkage rod as needed, adding or subtracting the amount shown in **Table 2**.

   NOTE: If the linkage rod is too short, replace it with a new rod, part number 16–13485–000. The linkage rod should be long enough so that at least 1/2 inch (13 mm) of it fits into both flexible end-sections of the linkage.

   6.1 Mark the existing length of the linkage rod between the upper and lower flexible end-sections of the linkage. See **Fig. 3**.

   6.2 Loosen both linkage adjustment clamps.

   6.3 Slide the flexible end-sections of the linkage over the linkage rod until the rod is the correct length.

   To increase the suspension height, lengthen the linkage rod; to decrease the suspension height, shorten the rod.

   6.4 Tighten the adjustment clamps.

7. Drive the vehicle unloaded for about 1/4 mile (1/2 km), then stop the vehicle in the exact location (as previously marked) of the original measurement.

   Park the vehicle using a light brake application. Chock the tires on one axle only, and put the transmission in neutral. Don't apply the parking brakes.

8. Check the distance between the bottom of the left forwardmost axle stop and the top of the axle U-bolt.

9. If the distance is within the acceptable range, apply the parking brakes, then remove the chocks from the tires.

   If the distance is not within the acceptable range, repeat the adjustment procedure.

Ride Height Adjustment, Vehicle with a Barksdale Valve

IMPORTANT: Before checking the suspension height, make sure there is no load on the chassis. For tractors, unhitch the trailer. Trucks must be empty.

1. Park the vehicle on a level surface, using a light application of the brakes. Do not apply the parking brakes. Put the transmission in neutral. Build the secondary air pressure to at least 100 psi (690 kPa). Shut down the engine.

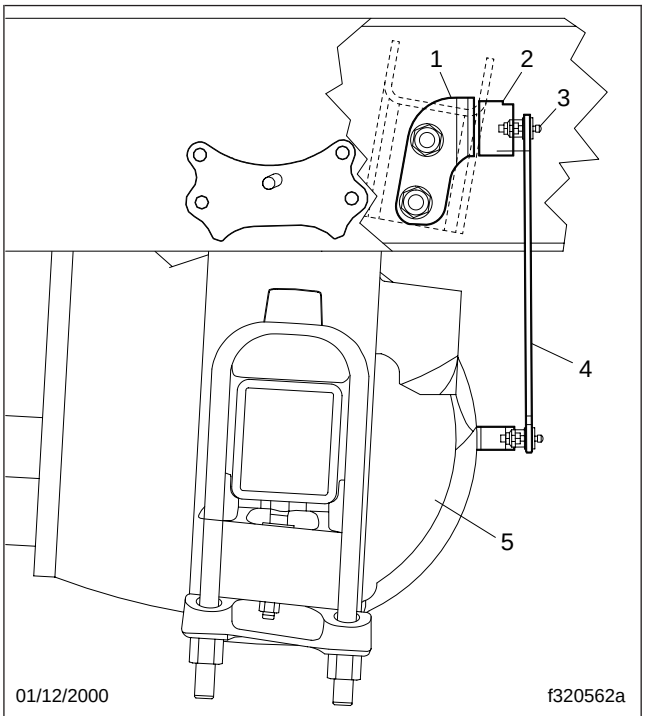
2. Mark the location of the front and rear tires on the floor, then chock the tires on one axle only.

NOTE: The stud bolt that fastens the lever arm to the linkage rod is oriented correctly when the linkage rod is vertical as viewed from the side of the vehicle. See **Fig. 5**.

3. Measure the distance between the left forward most axle stop and the suspension as indicated; see **Table 3**, **Table 4**, **Table 5**, **Table 6**, and **Table 7** for an acceptable range of heights for each suspension.

IMPORTANT: **Suspensions with Dual-Leaf Springs, and all Vehicles built before August 24, 2001:** Measure between the top of the U-bolt and the bottom of the axle stop (distance A).

Suspension Ride Height Adjustment



1. Valve Mounting Bracket
2. Height-Control Valve
3. Stud Bolt
4. Linkage Rod
5. Axle

Fig. 5, Barksdale Height-Control Valve Installation (side view)

Suspensions with Single-Leaf Springs, built after August 24, 2001: Measure between the top of the U-bolt **pad** and the bottom of the axle stop (distance B).

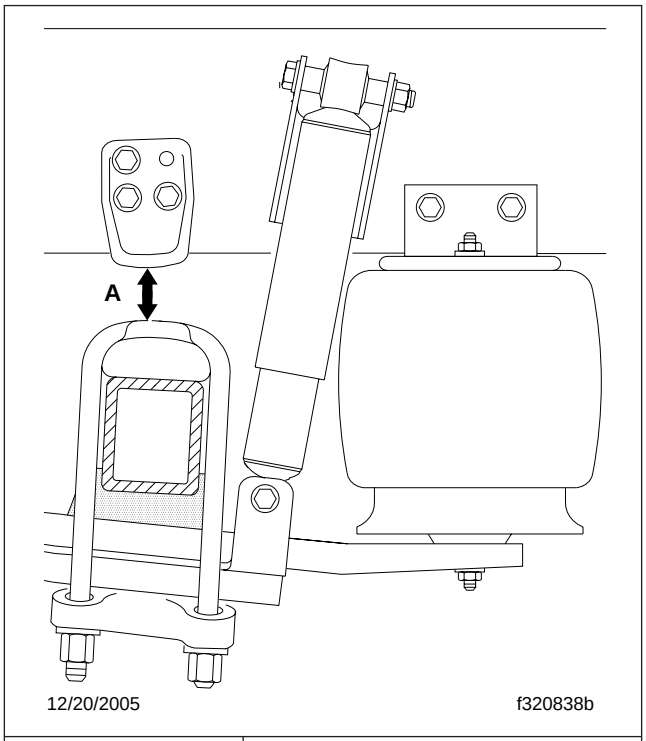
4. If the distance is within the acceptable range, apply the parking brakes, then remove the chocks from the tires.

   If the measurement is not within the acceptable range, go to the next step.

5. Adjust the suspension height.

   5.1 Loosen the two fasteners that attach the valve to the valve mounting bracket.

   5.2 Adjust the position of the valve body, until the distance from the bottom of the left axle stop to the top of the U-bolt or U-bolt pad is the target measurement from the applicable *Suspension Ride Height Measurement* table.



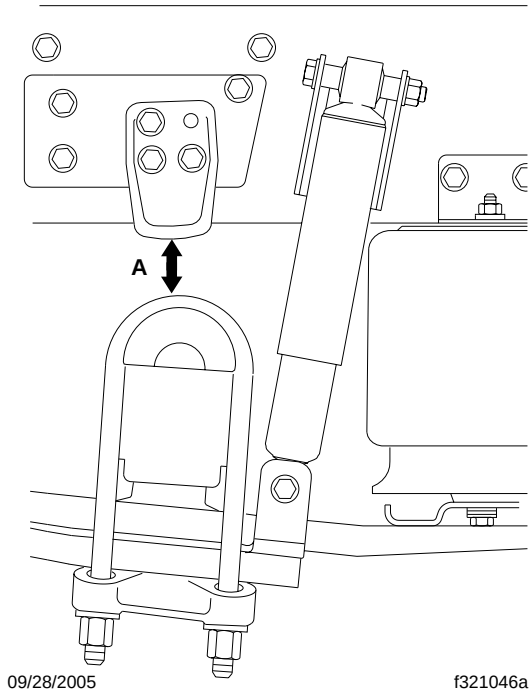
Measure Point	Suspension Height Measurement (A)		
	Min	Target	Max
A = Measure Here	2-3/8 inch (60 mm)	2-5/8 inch (67 mm)	2-7/8 inch (73 mm)

Table 3, Suspension Ride Height Measurement, Dual-Leaf Spring, 20k/40k High Ride

   5.3 Center the lever arm on the valve by inserting a 4-mm pin, or drill bit, into the hole in the lever arm and aligning the pilot hole with the valve body.

   5.4 Tighten the two fasteners that attach the valve to the mounting bracket.

   5.5 Remove the pin from the hole in the lever arm.



Measure Point	Suspension Height Measurement (A)		
	Min	Target	Max
A = Measure Here	2-3/4 inch (70 mm)	3 inch (76 mm)	3-1/4 inch (83 mm)

Table 4, Suspension Ride Height Measurement, Dual-Leaf Spring, 23k/46k/69k High Ride

6. Drive the vehicle unloaded for about 1/4 mile (1/2 km), then stop the vehicle in the exact location (as previously marked) of the original measurement.

   Park the vehicle using a light brake application. Chock the tires on one axle only, and put the transmission in neutral. Do not apply the parking brakes.

7. Check the distance between the bottom of the left axle stop and the top of the axle U-bolt or U-bolt pad.

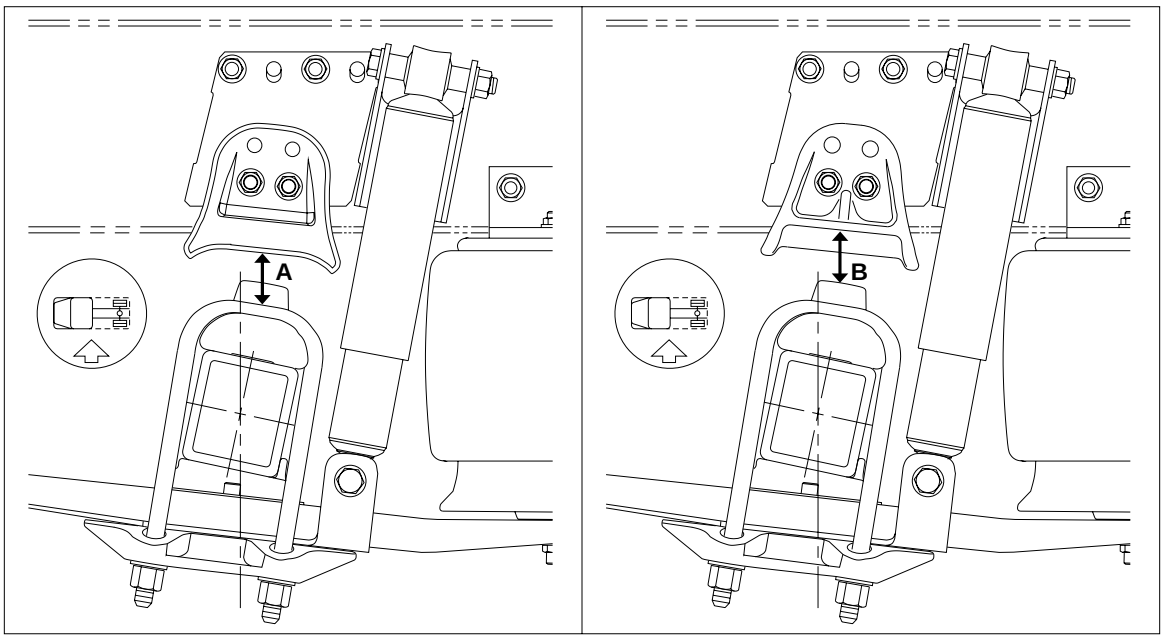
IMPORTANT: **Suspensions with Dual-Leaf Springs, and all Vehicles built before August 24, 2001:** Measure between the top of the U-bolt and the bottom of the axle stop (distance A).

Suspensions with Single-Leaf Springs, built after August 24, 2001: Measure between the top of the U-bolt *pad* and the bottom of the axle stop (distance B).

8. If the distance is within the acceptable range, apply the parking brakes, then remove the chocks from the tires.

   If the distance is not within the acceptable range, repeat the adjustment procedure.

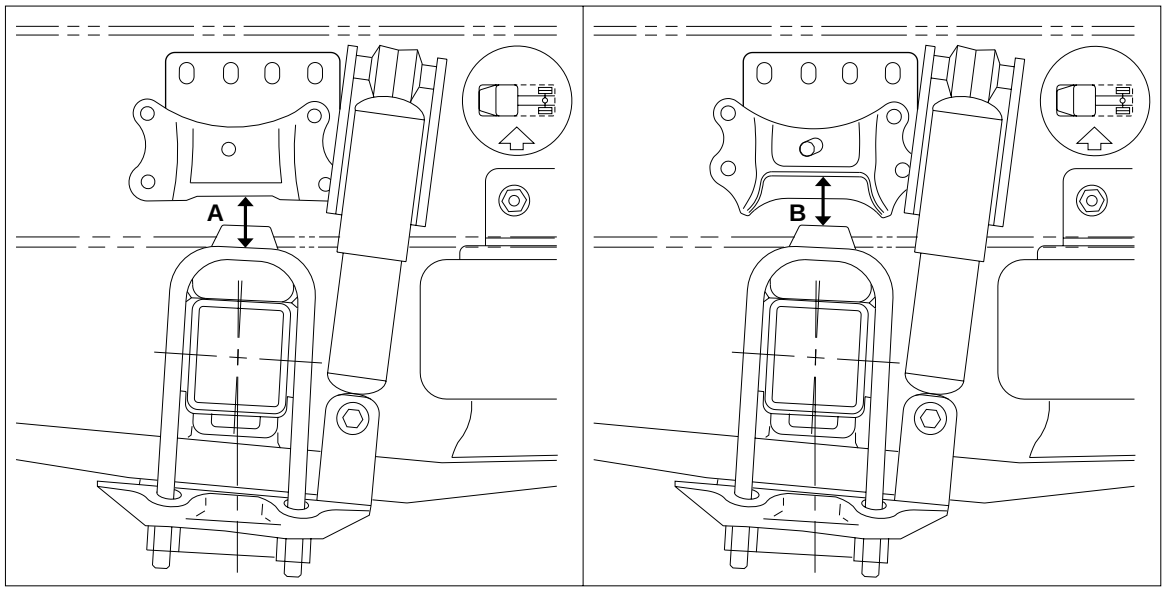
Suspension Ride Height Adjustment



09/27/2005 f320933a

Measure Point	Suspension Height Measurement (A or B)		
	Min	Target	Max
A = Measure Here if Built Before August 24, 2001 B = Measure Here if Built After August 24, 2001	2-3/8 inch (60 mm)	2-5/8 inch (67 mm)	2-7/8 inch (73 mm)

Table 5, Suspension Ride Height Measurement, Single-Leaf Spring, 20k/40k, High Ride Height

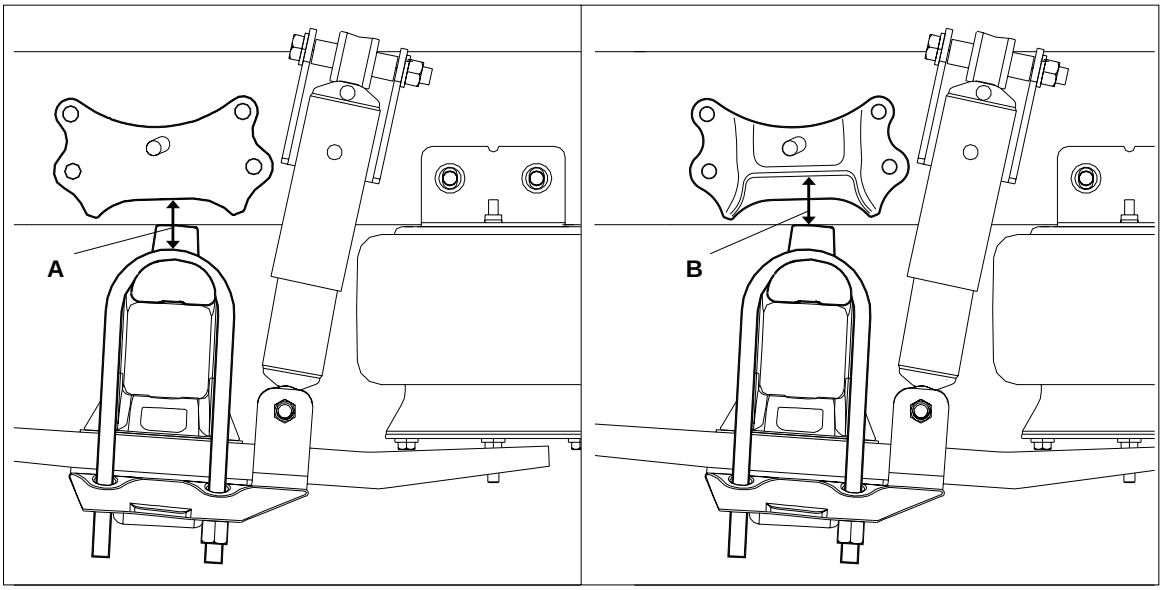


09/27/2005 f320934a

Measure Point	Suspension Height Measurement (A or B)		
	Min	Target	Max
A = Measure Here if Built Before August 24, 2001 B = Measure Here if Built After August 24, 2001	2-3/8 inch (60 mm)	2-1/2 inch (64 mm)	2-7/8 inch (73 mm)

Table 6, Suspension Ride Height Measurement, Single-Leaf Spring, 10k/12k/15k/18k Mid Ride Height and 40k Low and Mid Ride Height

Suspension Ride Height Adjustment



11/11/2005 f320932a

Measure Point	Suspension Height Measurement (A or B)		
	Min	Target	Max
A = Measure Here if Built Before August 24, 2001 B = Measure Here if Built After August 24, 2001	2-1/8 inch (54 mm)	2-9/32 inch (58 mm)	2-5/8 inch (67 mm)

Table 7, Suspension Ride Height Measurement, Single-Leaf Spring, 10k/12k/15k Low or Extra Low Ride Height

Checking

The leveling valve is the control center of any air suspension system and responds to changes in height. When correctly adjusted, it maintains the correct suspension ride height.

Carefully check the valve before replacing it. Do the following steps to see if a valve is working correctly.

1. Disconnect the leveling valve linkage from the overtravel lever. **Refer to Fig. 1.**
2. Pull the overtravel lever up about 45 degrees. **See Fig. 2**, Ref. A. If air passes through the valve, that section of the valve is working.
3. Return the valve to the neutral position. **See Fig. 2**, Ref. B. Air should stop flowing. If so, that section of the valve is working.
4. Push the overtravel lever down about 45 degrees. **See Fig. 2**, Ref. C. If air exhausts from the valve, that section of the valve is working.
5. Return the valve to the neutral position. If the air stops again in the neutral position, the valve is working correctly.
6. If the valve works as stated in all of the above steps, then no further checking is necessary. Connect the leveling valve linkage to the overtravel lever. Secure the linkage with a cotter pin.

   If the valve needs adjusting, refer to **"Leveling Valve Adjustment, 110."** If the valve needs replacing, refer to **"Leveling Valve Replacement, 130."**

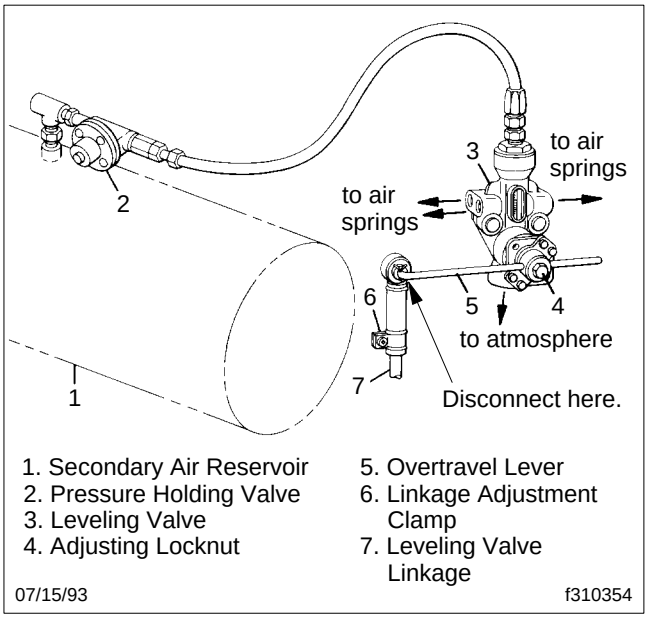


Fig. 1

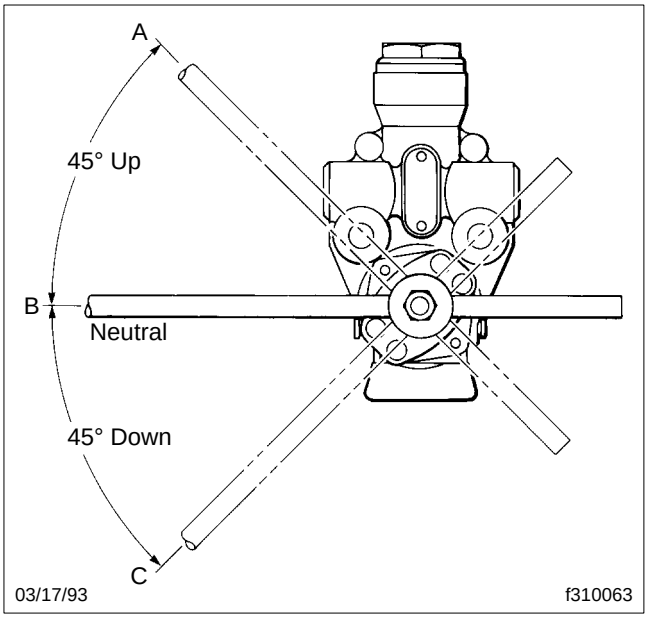


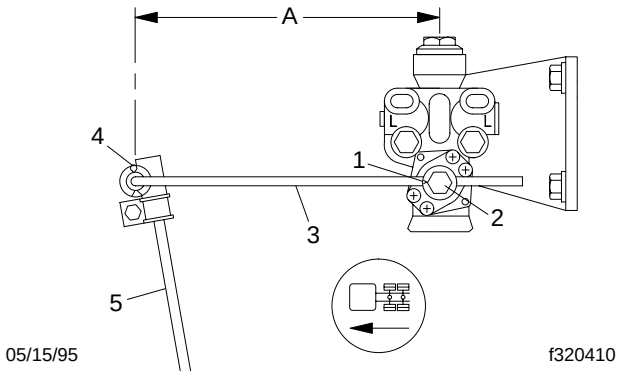
Fig. 2

Replacement

NOTE: A new type of height control valve (manufactured by Barksdale Inc.) replaced the Meritor WABCO valve. On vehicles with tandem-axle AirLiner rear suspensions, the Barksdale valve linkage rod is attached to the forward drive axle instead of the rearmost drive axle, and the valve is mounted on the frame rail. The Barksdale valves are installed on Business Class vehicles built after July 25, 1997.

Meritor WABCO

1. Park the vehicle on a level surface. Shut down the engine and apply the parking brake. Chock the front tires.
2. Drain the air reservoirs.
3. Disconnect the linkage from the overtravel lever. See **Fig. 1**. Exhaust all air from the air springs by moving the overtravel lever down.



A. Measure the length of the overtravel level between these two points.
1. V-Shaped Mark
2. Adjustment Locknut
3. Overtravel Lever
4. Cotter Pin
5. Linkage Rod

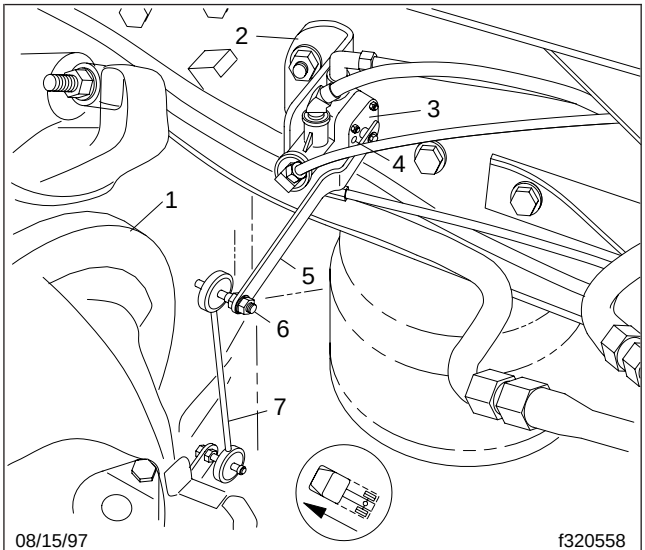
Fig. 1, Meritor Height Control Valve Linkage Measurement

4. Disconnect the air lines at the height control valve, and mark the lines for later reference. Using tape, cover the open ends of the air lines and fittings to prevent dirt or foreign material from entering.
5. Remove the height control valve mounting bolts and nuts, and remove the height control valve from the bracket.
6. Remove the overtravel lever from the height control valve.
7. Attach the new height control valve to the bracket. Tighten the valve mounting bolt nuts 14 lbf·ft (19 N·m).
8. Remove the tape from the air lines and fittings, and connect the air lines to the height control valve as marked earlier. Tighten nylon tube air fittings until only two threads show on the fitting. On wire-braid hose fittings, tighten the nut with a wrench until there is firm resistance, then tighten one-sixth turn more.
9. Connect the height control valve linkage to the overtravel lever. Secure the linkage with a cotter pin.
10. Connect the overtravel lever to the height control valve. Insert the overtravel lever into the valve at the hole with the V-shaped mark. See **Fig. 1**. Be sure the length between pivot points is 8 inches (20.3 cm). See **Fig. 1**, Ref. A.
11. Close the drain cocks on all reservoirs.
12. Build up normal operating pressure in the air system. Check all air lines and connections for leaks. Eliminate all leaks.
13. Remove the chocks from the tires.
14. Adjust the height control valve. For instructions, see **Subject 110**.

Barksdale Inc.

1. Park the vehicle on a level surface. Shut down the engine and apply the parking brake. Chock the front tires.
2. Drain the air reservoirs.
3. Disconnect the linkage from the overtravel lever. See **Fig. 2**. Exhaust all air from the air springs by moving the overtravel lever down.
4. Disconnect the air lines at the height control valve, and mark the lines for later reference. Using tape, cover the open ends of the air lines and fittings to prevent dirt or foreign material from entering.

Height Control Valve Replacement



1. Forward Drive Axle
2. Valve Mounting Bracket
3. Height Control Valve
4. Pilot Hole
5. Overtravel Lever
6. Stud Bolt
7. Linkage Rod

Fig. 2, Barksdale Height Control Valve Installation

5. Remove the height control valve mounting bolts and nuts, and remove the height control valve from the bracket.
6. Attach the new height control valve to the bracket. Tighten the valve mounting bolt nuts 14 lbf·ft (19 N·m).
7. Remove the tape from the air lines and fittings, and connect the air lines to the height control valve as marked earlier. Tighten nylon tube air fittings until only two threads show on the fitting. On wire-braid hose fittings, tighten the nut with a wrench until there is firm resistance, then tighten one-sixth turn more.
8. Connect the height control valve linkage to the overtravel lever.
9. Close the drain cocks on all reservoirs.
10. Build up normal operating pressure in the air system. Check all air lines and connections for leaks. Eliminate all leaks.
11. Remove the chocks from the tires.
12. Adjust the height control valve. For instructions, see **Subject 110**.

Replacement (See Fig. 1)

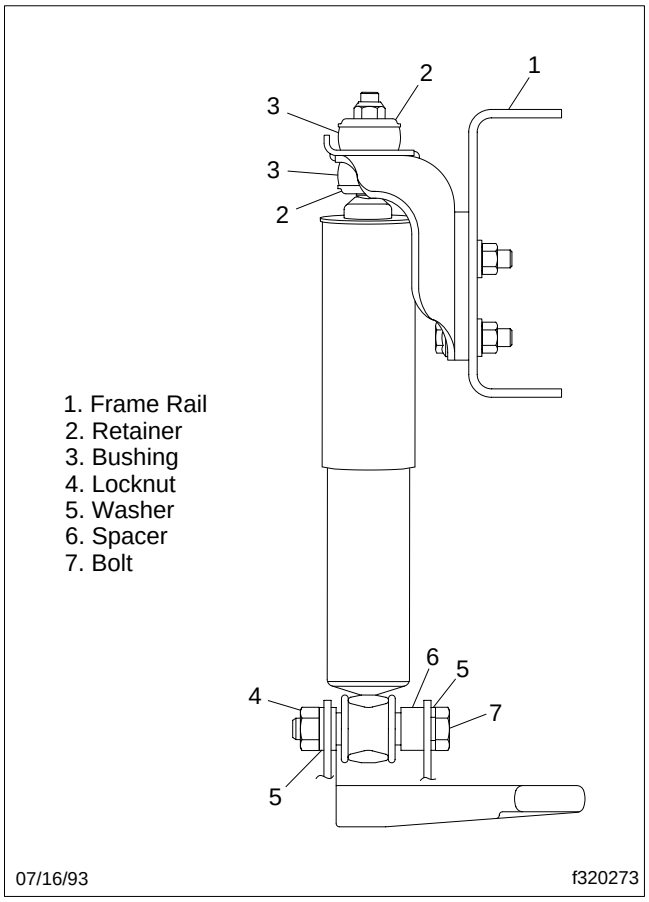


Fig. 1, Shock Absorber Mounting

1. Chock the tires.
2. Remove the locknut, bolt, washers, and spacer from the shock absorber lower mounting bracket.
3. Remove the nut, upper retainer, and upper bushing from the top of the shock absorber.
4. Pull the shock absorber out of the upper mounting bracket, and remove the retainer and bushing.
5. Install the replacement shock absorber, making sure the new bushings and retainers are positioned as shown in **Fig. 2**.

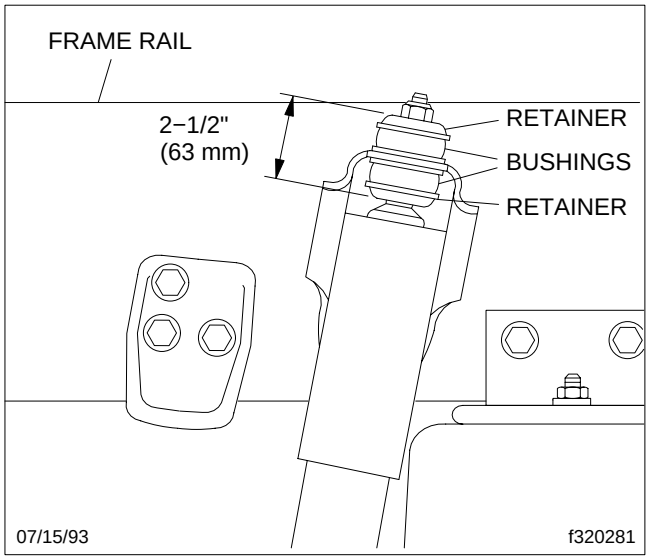


Fig. 2

WARNING

WARNING: Use only the retainers included with the replacement shock absorber. Do not use washers. They can be pushed over the nut and be ejected violently, possibly causing personal injury and property damage.

6. Tighten the shock absorber lower mounting locknut 230 N·m (170 lbf·ft).
7. Tighten the shock absorber upper mounting nut to compress the bushings to the dimension shown in **Fig. 2**.

Air Spring Bag Replacement

Replacement

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires. Raise the vehicle frame and support it with safety stands to remove all weight from the air springs.
2. Disconnect the leveling valve and exhaust all air from the air springs.
3. Using a dull instrument, pry the air spring bead off the piston lip. Be careful not to damage the piston.
4. Disconnect the air supply line, including the brass tee, from the air spring. Using tape, cover the ends of the air supply line and the fitting to prevent dirt or foreign material from entering.
5. Remove the locknuts and washers that connect the air spring bag to the upper mounting bracket.
6. Remove the air spring bag.
7. Check the piston for residue, and remove any, if found.

NOTE: When space is limited (such as at the forward axle of tandem axles), it may be easier to remove the piston from the leaf spring and assemble the bag and piston on a workbench. Secure the air spring mounting bracket, which is attached to the bag, in a vise. Fully extend the air bag and plug the air supply port. Apply a soap-and-water solution to the piston lip and air bag bead, and, using a twisting motion, push the piston onto the airbag until the piston is fully seated. Inspect the circumference of the bag-to-piston connection to make sure there is less than 1/8 inch (3.2 mm) of clearance between the air bag and the piston shoulder. The gap should be uniform around the assembly. After inspecting, remove the plug in the air supply port and push the piston into the air bag so that it rolls over the piston. Then, install on the vehicle.

⚠ WARNING

Do not add air pressure to the air spring assembly when it is not mounted on a vehicle.Doing so could cause components to eject from the assembly, which could cause serious personal injury or property damage.

8. Attach the new air spring bag to the upper mounting bracket, using the 1/2–13 locknut on the outsideof the frame rail and the 3/4–16 locknut on the inside. Tighten 3/4–16 locknuts 61 N·m (45 lbf·ft);tighten 1/2–13 locknuts 31 N·m (23 lbf·ft).
9. Remove the tape from the ends of the air supply line, the fitting, and the brass tee. Connect the air supply line to the air spring. Tighten nylon tube air fittings until only two threads show on the fitting. Onwire-braid hose fittings, tighten the nut with a wrench until there is firm resistance, then tighten one-sixth turnmore.
10. Make sure the air spring bag is fully extended alongside the piston so there are no folds in thebag near the bead. See **Fig. 1.**
11. Fold the air spring bag so the bead is fully parallel with the piston lip. See **Fig. 2.**
12. Apply a soap-and-water solution to the bead and piston lip.
13. Pull the rear of the air spring bag over the piston lip making sure the bead is the lowest part of thebag— none of the bag should droop over the piston. Then, work the front of the bag over the piston lip like a button in a button hole. See **Fig. 3.**
14. Feeling the bead through the folds of the air spring bag, snap the bead over the piston lip so itseats fully. A snapping sound confirms correct seating of the bead.
15. Inspect the circumference of the bag-to-piston connection to make sure there is less than 1/8 inch (3.2 mm) of clearance between the air bag and the piston shoulder. The gap should be uniform around the assembly.
16. Connect the leveling valve and inflate the air spring bag. As it's inflating, the bag shouldroll into position over the piston. See **Fig. 4.**
17. Remove the safety stands, and lower the vehicle. Remove the chocks from the tires.

Air Spring Bag Replacement

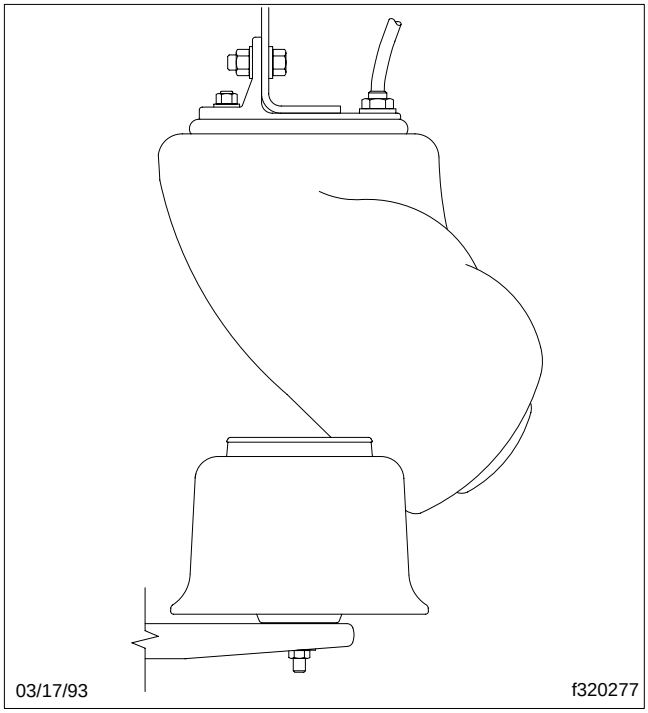


Fig. 1, Air Spring Bag Extended

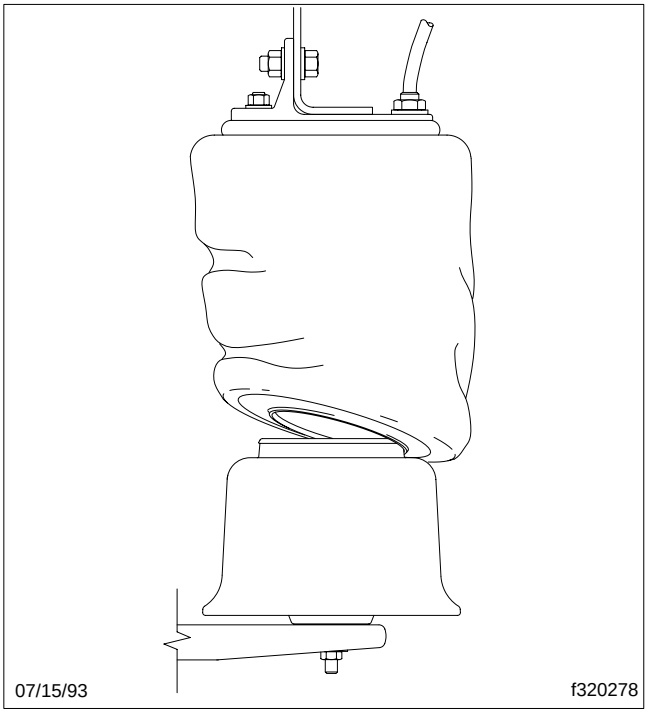


Fig. 3, Air Spring Bag Aligned with Piston

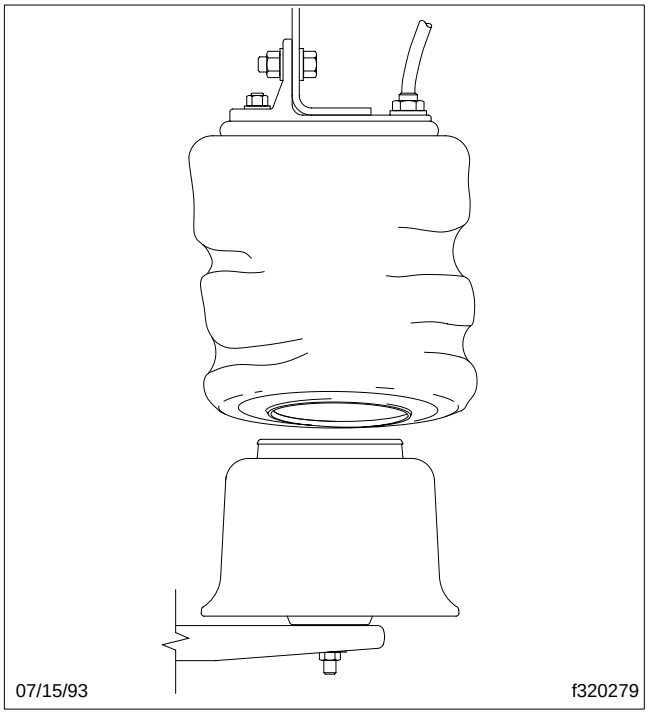


Fig. 2, Air Spring Bag Folded

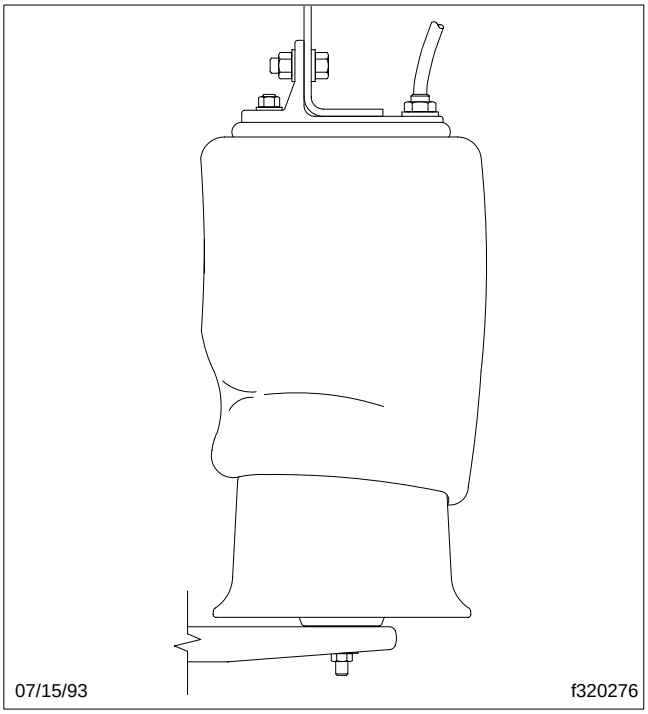
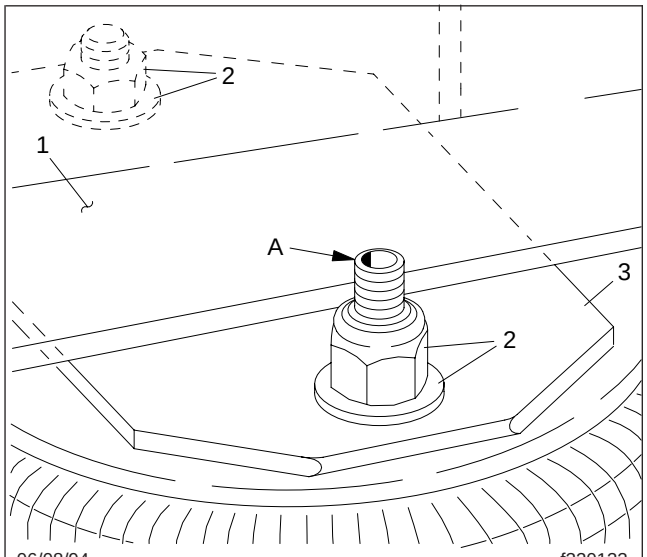


Fig. 4, Air Spring Bag Rolling Onto Piston

Air Spring Replacement

1. Chock the front tires. Raise the vehicle frame and support it with safety stands to remove all weight from the air springs. The leveling valve automatically releases air from the air springs when all weight is removed from the suspension.
2. Disconnect the air supply line,including the brass tee, from the air spring. Using tape, cover the ends of the air supply line and the fitting to prevent dirt or foreign material from entering.
3. Remove the locknuts and washers that connect the air spring to the upper mounting bracket, or to the frame rail flange. See **Fig. 1** and **Fig. 2.**

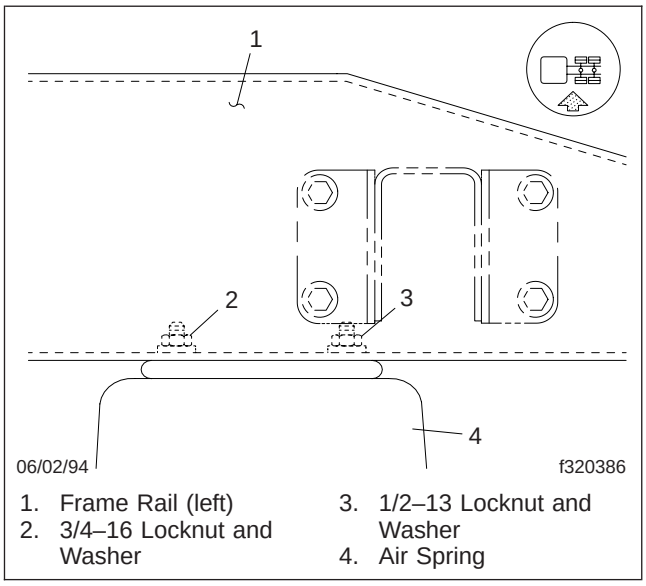


A. Air line connects here.
1. Right Frame Rail Flange
2. Locknut and Washer
3. Upper Mounting Bracket

Fig. 1, Bracket-Mounted Air Spring

4. Remove the capscrews and lockwashers that connect the air spring to the rear of the leaf spring. Remove the air spring. **See Fig. 3.**

NOTE: Suspensions manufactured to a 46,000-pound (20 865 kg) or 23,000-pound (10 433 kg) weight rating have a different leaf spring, and an additional cross bar attached between the air spring and rear of the leaf spring. **See Fig. 4.**



1. Frame Rail (left)
2. 3/4–16 Locknut and Washer
3. 1/2–13 Locknut and Washer
4. Air Spring

Fig. 2, Flange-Mounted Air Spring

5. Place the new air spring on the rear of the leaf spring (or the cross bar on the 23,000- and 46,000-pound suspensions), and install the washer and locknut that hold the air spring (and cross bar) in place. **See Fig. 3.** Tighten the locknut 55 lbf·ft (75 N·m).
6. *For bracket-mounted air springs:* Attach the air spring to the upper mounting bracket, using the 1/2–13 locknut on the outside of the frame rail and the 3/4–16 locknut on the inside. **See Fig. 1.** Tighten the 3/4–16 locknut 45 lbf·ft (61 N·m); tighten the 1/2–13 locknut 23 lbf·ft (31 N·m).

   For flange-mounted air springs: Attach the air spring to the frame rail flange, using the 3/4–16 locknut on the forward stud of the air spring, and the 1/2–13 locknut on the rear stud. **See Fig. 2.** Tighten the 3/4–16 locknut 45 lbf·ft (61 N·m); tighten the 1/2–13 locknut 23 lbf·ft (31 N·m).
7. Remove the tape from the ends of the air supply line, the fitting, and the brass tee. Connect the air supply line to the air spring. Tighten nylon tube air fittings until only two threads show on the fitting. On wire-braid hose fittings, tighten the nut with a wrench until there is firm resistance, then tighten one-sixth turn more.
8. Remove the safety stands, and lower the vehicle. Remove the chocks from the tires.

Air Spring Replacement

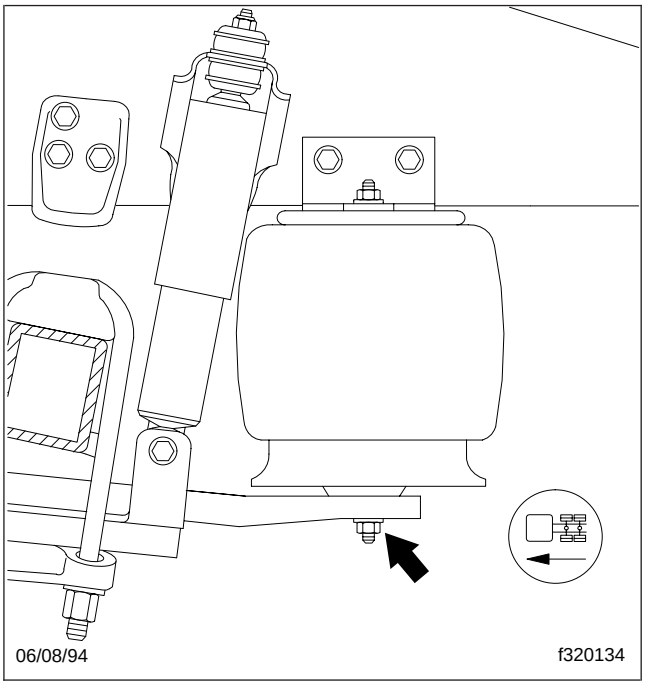
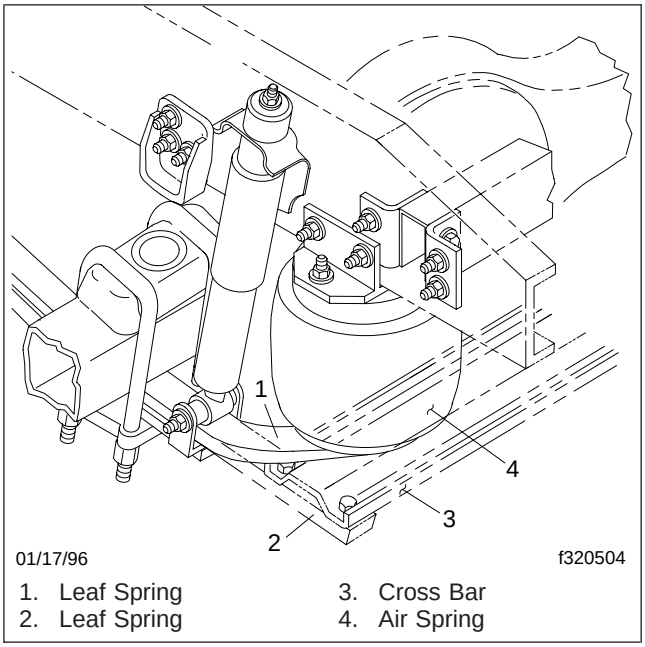


Fig. 3, Capscrew Connecting Leaf Spring and Air Spring



1. Leaf Spring
2. Leaf Spring
3. Cross Bar
4. Air Spring

Fig. 4, Leaf Spring and Air Spring Assembly (23,000- and 46,000-pound suspensions)

Leaf Spring Replacement

(See Fig. 1)

WARNING

Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

1. Chock the front tires.
2. Raise the rear of the vehicle, and support the rear axle(s) with safety stands. Raise the vehicle so that all weight is removed from the leaf springs, then securely support the frame with safety stands. Remove the wheel and tire assembly to easily access the suspension. Refer to the wheels and tires section in this manual for instructions.
3. Remove the nut, bolt, and washers from the shock absorber lower mounting bracket. Remove the high nuts, flatwashers, and axle clamp from each U-bolt. Support the leaf spring assembly with a jack.
4. If the air spring mounts to the leaf spring, disconnect the bottom of the air spring from the leaf spring.

   If the air spring mounts to a cross bar, disconnect the cross bar from the leaf spring by removing the capscrews, nuts, and washers. See Fig. 2.
5. Note the number and position of the alignment shims (See Fig. 1) on the spring mounting bolt.
6. Remove the hexnut, washers, alignment shim(s), spring mounting bolt, and wear shoe clip from the spring hanger. See Fig. 1.

WARNING

The leaf spring assembly is heavy. Use care when handling it to prevent injury.

7. Remove and discard the leaf spring assembly.
8. While supporting a new leaf spring assembly with a jack, position the assembly on the spring hanger. Install the bolts, wear shoe clips, washers, alignment shims, and hexnuts. Tighten the bolts just enough to hold the leaf spring assembly in place.
9. If the air spring mounts to the leaf spring, attach the air spring to the leaf spring assembly. Install the washer and locknut. Tighten the locknut 55 lbf·ft (75 N·m).

   If the air spring mounts to a cross bar, attach the cross bar to the leaf spring assembly. The longer capscrews attach in the forwardmost holes; the shorter capscrews attach in the aft holes.
10. Making sure that the U-bolt pads are in place on the top of the axle, fasten the leaf spring assembly to the axle using the U-bolts, axle clamp, washers, and high nuts making sure the U-bolt pads and axle clamps are positioned correctly.

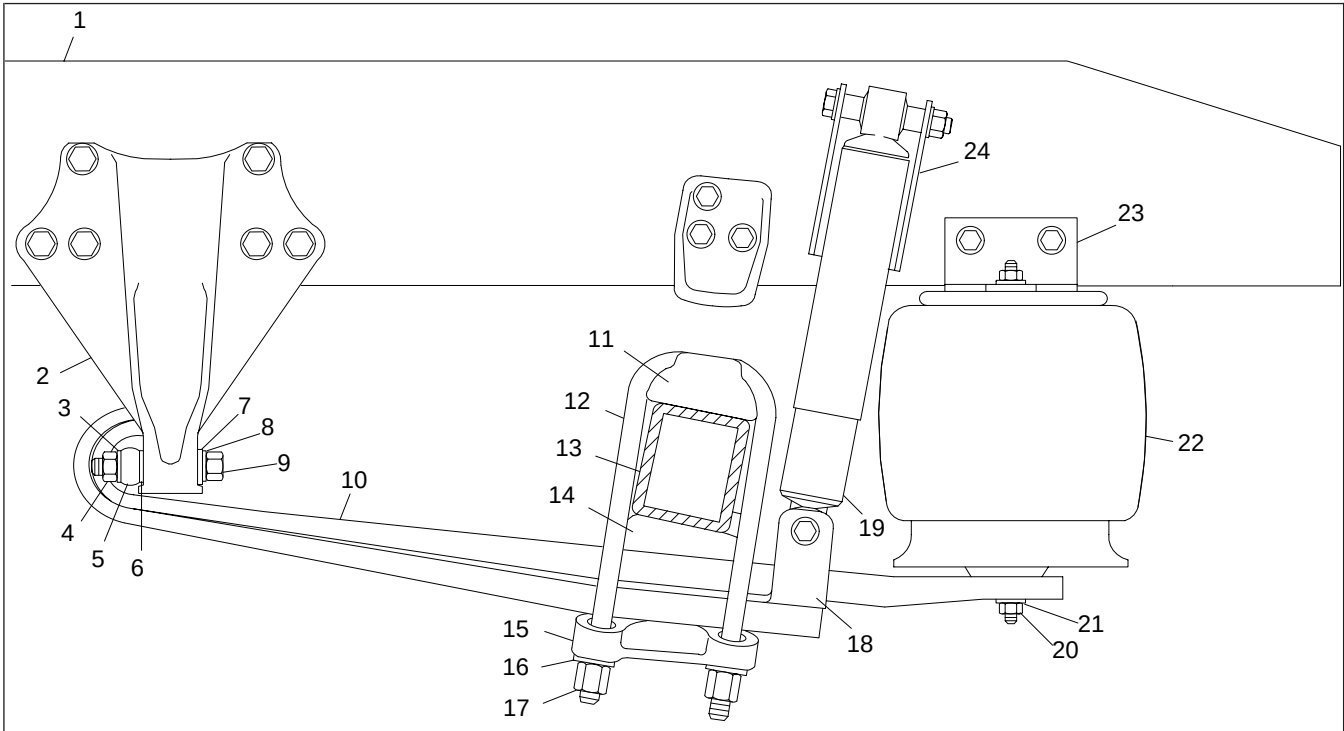
NOTE: On single-drive axles angled 5 degrees, the arrow on the U-bolt pads must point to the front of the axle housing. See Fig. 3. On single-drive axles angled 3 degrees, there is no arrow. Make sure that the axle bump stop on the U-bolt pad is positioned toward the vehicle centerline. See Fig. 4 .

With both 5- and 3-degree single-drive axle angles, the arrow on the bottom of the axle clamp (see Fig. 1) must point toward the rear of the vehicle.

On tandem axle suspensions, refer to Table 1 for U-bolt pad orientation. The arrow on the bottom of the axle clamp must point toward the rear of the vehicle on the forward rear axle and toward the front of the vehicle on the rearmost axle.

11. Tighten the U-bolt high nuts as described in Specifications 400.
12. Install the bolt, washers, and hexnut to connect the shock absorber to its lower mounting bracket. Tighten the hexnut 170 lbf·ft (230 N·m).
13. Tighten the locknut on the bottom of the air spring 55 lbf·ft (75 N·m).

Leaf Spring Replacement



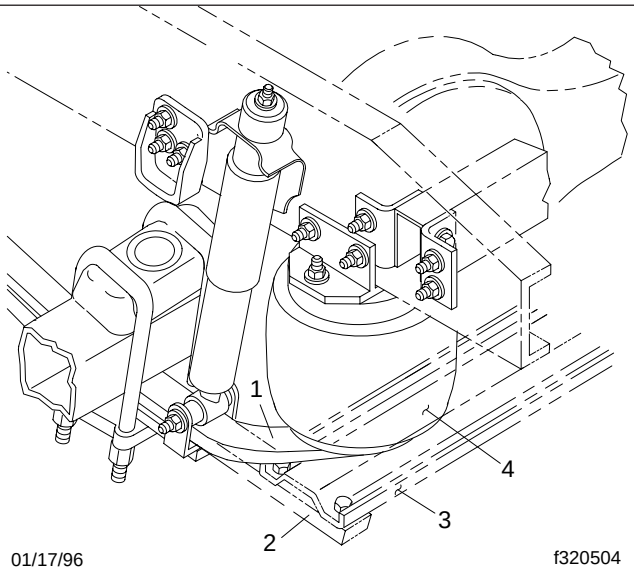
11/17/95 f320462

1. Frame Rail
2. Spring Hanger
3. Washer
4. Hexnut
5. Spring Mounting Eye Pin
6. Alignment Shim
7. Wear Shoe Clip
8. Washer
9. Spring Mounting Bolt
10. Leaf Spring Assembly
11. U-Bolt Pad
12. U-Bolt
13. Axle
14. Axle Seat
15. Axle Clamp
16. Flatwasher
17. High Nut
18. Shock Absorber Lower Mounting Bracket
19. Shock Absorber
20. Nylon Locknut
21. Washer
22. Air Spring
23. Air Spring Mounting Bracket
24. Shock Absorber Upper Mounting Bracket

Fig. 1, AirLiner Leaf Spring Assembly

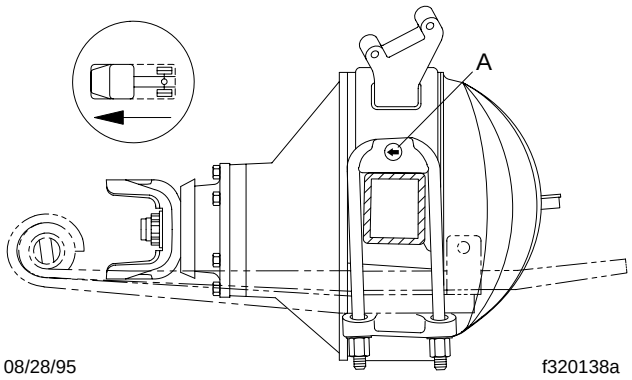
On 23,000-pound and 46,000-pound suspensions, tighten the locknuts on the bottom of the cross bar 241 lbf·ft (327 N·m).

14. Tighten the hexnuts at the front of the leaf spring 170 lbf·ft (230 N·m).
15. Install the wheel and tire assembly. For instructions, refer to **Group 40**. Remove the safety stands, and lower the vehicle.
16. Check the rear axle alignment. For instructions, refer to the rear axle section in this manual. If necessary, adjust the rear axle alignment using the instructions in **Subject 180**.



1. Leaf Spring
2. Leaf Spring
3. Cross Bar
4. Air Spring

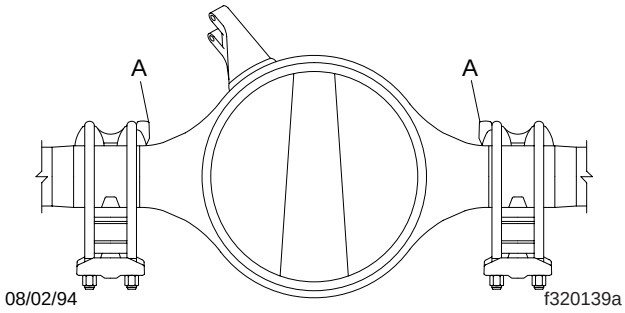
Fig. 2, Leaf Spring and Air Spring Assembly (23,000- and 46,000-pound suspensions)



A. Arrow on U-Bolt Pad

Fig. 3, U-bolt Pad Arrow Positioning

Leaf Spring Replacement



A. Axle Bump Stop

Fig. 4, Axle Bump Stop Positioning

U-Bolt Pad Orientation for Axles		
Axle Designation	**U-Bolt Pad Orientation**	
Meritor SQ 100, SSHD	Forward Rear Axle	No arrow; axle bump stop toward vehicle centerline.
	Rearmost Axle	No arrow; axle bump stop toward vehicle centerline.
Meritor RT40-145, RT44-145, RT46-160	Forward Rear Axle	No arrow; axle bump stop toward vehicle centerline.
	Rearmost Axle	Arrow toward front of vehicle.
Eaton 402, 461	Forward Rear Axle	No arrow; axle bump stop toward vehicle centerline.
	Rearmost Axle	No arrow; axle bump stop toward vehicle centerline.

Table 1, U-Bolt Pad Orientation for Axles

Replacement

WARNING

Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.
2. Raise the rear of the vehicle, and support the rear axle(s) with safety stands. Raise the vehicle so that all weight is removed from the leaf springs, then securely support the frame with safety stands.
3. Remove the wheel and tire assembly to easily access the suspension. For instructions, see the information in **Group 40**.
4. Remove the leaf spring assembly. See removal information in **Subject 170**.

WARNING

The leaf spring assembly is heavy. Use care when handling it to prevent injury.

5. Remove the bushing from the leaf spring eye.

WARNING

Do not use a cutting torch to remove the outer metal of the bushing from the spring eye. Welding, torching or cutting the leaf spring assembly can damage the leaf spring material, which may result in the failure of the components and cause serious personal injury, death, or property damage.

   5.1 Using a shop press with a capacity of at least 10 tons (9 072 kg), place the spring assembly in the shop press with the spring assembly squarely supported on the press bed for safety and to avoid bending the spring assembly.

   5.2 Center the bushing tool on the outer metal of the bushing and push the bushing from the spring eye.

   5.3 Remove any burrs or material left behind by the old bushing.

6. Install the new bushing in the leaf spring eye.

   6.1 Position the bushing on the shop press.

   6.2 Apply a bonding agent, either Permabond HM–160 or Loctite RC–609 or 680, liberally around the outside surface of the bushing.

   6.3 Press the bushing into place.

   6.4 Allow the bonding agent to cure for 24 hours.

   NOTE: After the curing time, the bushing must resist a minimum 7,700 lb (3 490 kg) pushout force.

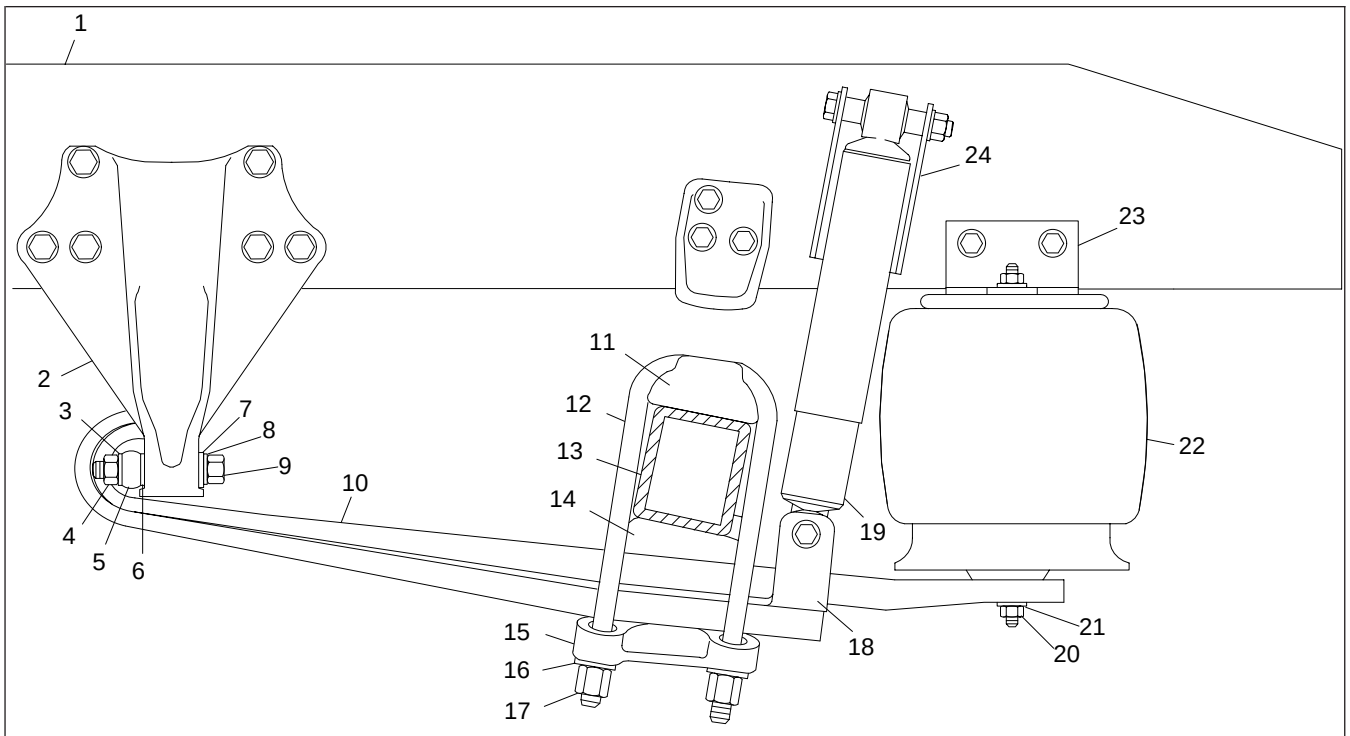
7. Install the leaf spring assembly. See the information in **Subject 170**.
8. Install the wheel and tire assembly. For instructions, see **Group 40**. Remove the safety stands, and lower the vehicle.
9. Check the rear axle alignment. For instructions, refer to **Group 35** in this manual. If necessary, adjust the rear axle alignment using the instructions in **Group 35**.
10. Remove the chocks from the tires.

Adjusting

See **Fig. 1**.

Follow the instructions in the rear axle alignment checking section of this manual to see if rear axle alignment adjustment is needed. If it is needed, proceed as follows:

2. Move the axle forward or backward until it is aligned within the tolerances in the rear axle section of this manual.
3. When the axle is in alignment, install alignment shim(s) to take up the slack between the spring hanger and the spring mounting eye pin.



1. Frame Rail
2. Spring Hanger
3. Washer
4. Hexnut
5. Spring Pin
6. Alignment Shim
7. Wear Shoe Clip
8. Washer
9. Spring Pinch Bolt
10. Leaf Spring Assembly
11. U-Bolt Pad
12. U-Bolt
13. Axle
14. Axle Seat
15. Axle Clamp
16. Flatwasher
17. High Nut
18. Shock Absorber Lower Mounting Bracket
19. Shock Absorber
20. Nylon Locknut
21. Washer
22. Air Spring
23. Air Spring Mounting Bracket
24. Shock Absorber Upper Mounting Bracket

Fig. 1, Rear Axle Suspension

1. Loosen the spring mounting eye bolts so that the forward end of the leaf spring can slide fore and aft in the spring hanger.

IMPORTANT: Make sure the same number of shims is installed on both ends of the spring mounting eye pin.

4. Tighten the spring mounting eye bolts 230 N·m (170 lbf·ft).

Rear Axle Alignment Adjusting

5. Check the axle alignment again. If necessary, repeat the above procedure until the alignment is within tolerances.

Rear Axle Tracking Adjustment

Single Axle

1. At the forward edge of the right rear tire, measure the distance from the inner side of the tire to the outer side of the right frame rail. See **Fig. 2**.

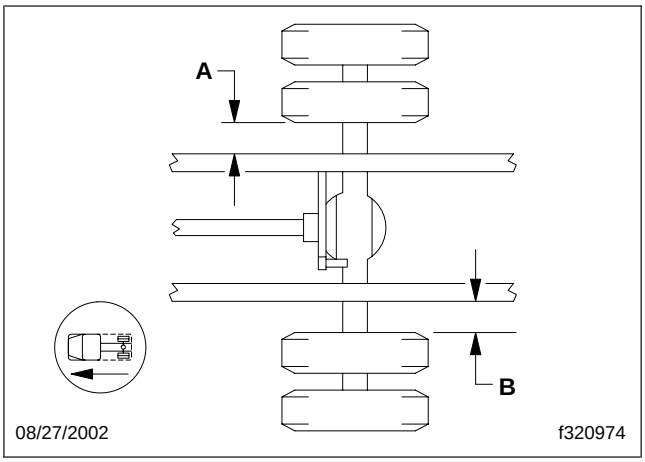


Fig. 2, Rear Axle Tracking Measurements (single axle)

2. At the rear edge of the left rear tire, measure the distance from the inner side of the tire to the outer side of the left frame rail. See **Fig. 2**.

IMPORTANT: Measurement "A" should not vary by more than 1/4-inch (6 mm) from measurement "B."

3. If measurements "A" and "B" vary by more than 1/4-inch (6 mm), loosen the fasteners holding the lateral torque rod to the frame rail. Add or remove torque-rod shims as needed.
4. For bar-pin style torque rods, tighten the fasteners 136 lbf·ft.

   For taper-pin style torque rods, tighten the fasteners 165 lbf·ft (224 N·m). See **Fig. 3**.

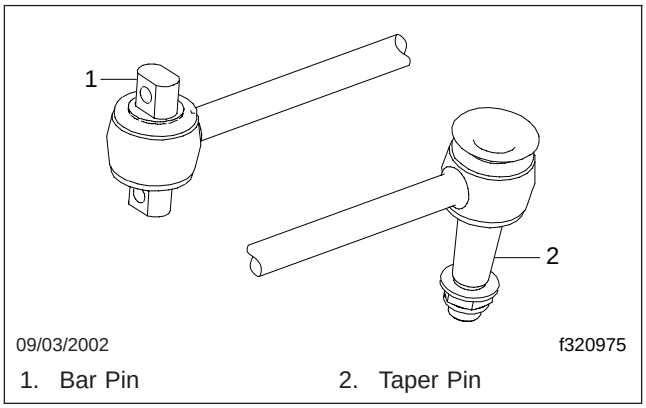


Fig. 3, Torque Rod Types

Tandem Axles

1. Check the tracking of the forward-rear axle. For instructions, see "Single Axle" in this subject. Adjust the tracking if needed.
2. At the forward-rear drive axle, measure the distance from the inner side of the right rear tire to the outer side of the right frame rail. Measure at the forward edge of the tire. See **Fig. 4**.

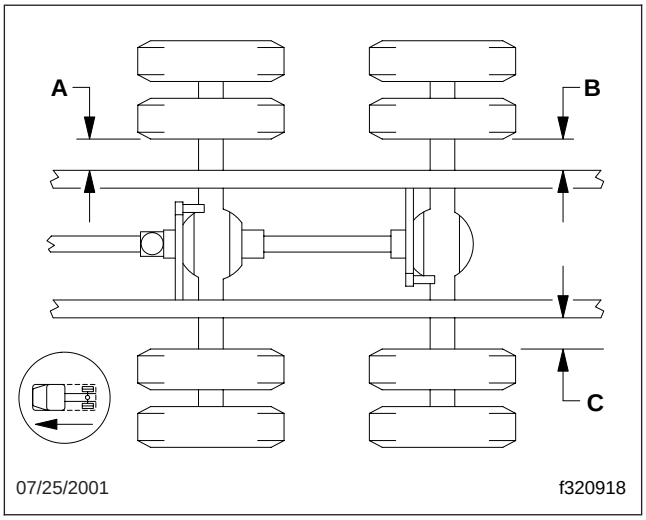


Fig. 4, Rear Axle Tracking Measurements (tandem axles)

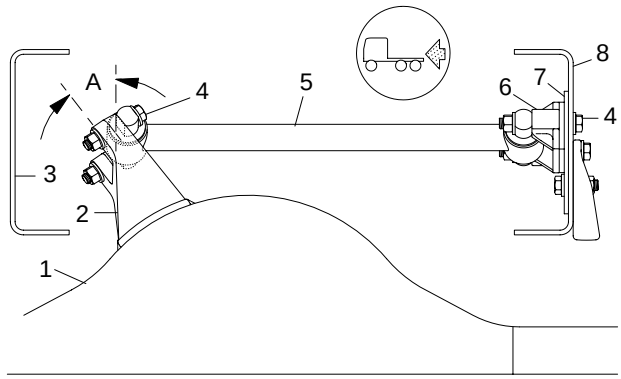
3. At both sides of the rear-rear drive axle, measure the distance from the inner side of the rear tires to the outer side of each frame rail. Measure at the rear edge of each tire. See **Fig. 4**.

IMPORTANT: Measurements "B" and "C" should not vary by more than 1/4-inch (6 mm) from measurement "A."

4. If measurements "B" and "C" vary by more than 1/4-inch (6 mm) from measurement "A," loosen the fasteners holding the axle lateral torque rod at the rear-rear drive axle to the frame rail. Add or remove torque-rod shims as needed.
5. For bar-pin style torque rods, tighten the fasteners 136 lbf·ft. For taper-pin style torque rods, tighten the fasteners 165 lbf·ft (224 N·m). See **Fig. 3**.

Replacement

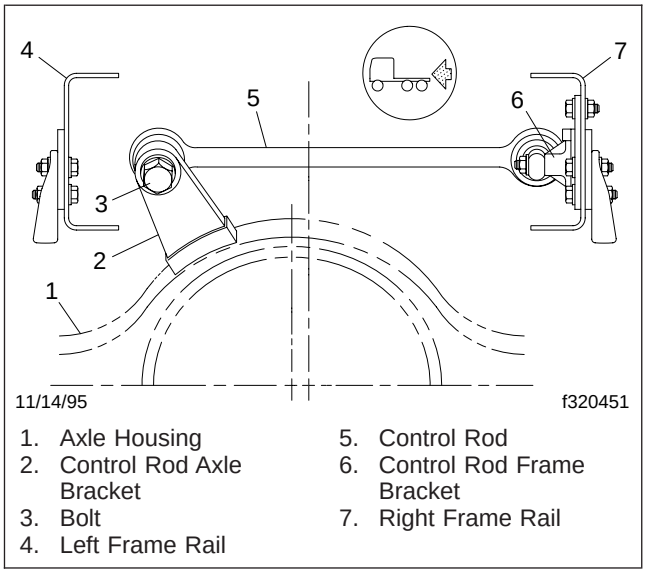
1. Park the vehicle. Shut down the engine, and apply the brakes.
2. Chock the tires. Raise the vehicle. Support the frame rails with jack stands.
3. Remove the fasteners holding the control rod to the frame rail bracket. Remove the shims, and set the shims aside.
4. Remove the control rod.
5. Position the new control rod so that the end with the fasteners angled up at 35 degrees is installed in the axle housing bracket. **See Fig. 1.**



A. Angle: 35 degrees
1. Axle Housing
2. Control Rod Axle Bracket
3. Left Frame Rail
4. Bolt
5. Control Rod
6. Control Rod Frame Bracket
7. Shim
8. Right Frame Rail

Fig. 1, AirLiner Control Rod Installation

6. Install the fasteners with the bolt heads facing up. Tighten the fasteners enough to hold the control rod in place.
7. Install the shims that were previously removed.
8. Install the other end of the control rod in the frame rail bracket; then, install the fasteners. Tighten the fasteners enough to hold the control rod in place.
9. Tighten all the fasteners 136 lbf·ft (184 N·m).
10. Remove the jack stands. Lower the vehicle. Remove chocks.



1. Axle Housing
2. Control Rod Axle Bracket
3. Bolt
4. Left Frame Rail
5. Control Rod
6. Control Rod Frame Bracket
7. Right Frame Rail

Fig. 2, Control Rod Installation on 23,000-pound and 46,000-pound AirLiner Suspensions

NOTE: Control rods on suspensions manufactured to a 23,000-pound (10 433 kg) and 46,000-pound (20 865 kg) weight rating are larger and are attached to the axle bracket with a single bolt. Tighten the fasteners attaching the control rod frame bracket to the frame rail 160 to 170 lbf·ft (217 to 230 N·m), and the bolt connecting the control rod to the axle housing 175 to 225 lbf·ft (237 to 305 N·m). **See Fig. 2.**

Specifications

Torque Values			
Description	**Size**	**Torque**	
		lbf·ft (N·m)	**lbf·in (N·cm)**
Air Spring Lower Mounting Locknuts	1/2–13	55 (75)	—
Air Spring Upper Mounting Bracket	5/8–11	125 (170)	—
Air Spring Upper Mounting Locknuts	3/4–16	45 (61)	—
	1/2–13	23 (31)	—
Axle U-Bolt High Nuts	7/8–14	Stage 1: Hand-tighten	—
		Stage 2: 60 (80) *	—
		Stage 3: 200 (270) *	—
		Stage 4: 420 to 500 (571 to 680) *	—
Lateral Control Rod Mounting Bolt Nuts	5/8–11	136 (184)	—
Leaf Spring Mounting Eye Bolt Locknuts	5/8–11	170 (230)	—
Leveling Valve Adjustment Nut	1/4–20	—	62 (700)
Leveling Valve Mounting Bolt Nuts	5/16–18	14 (19)	—
Shock Absorber Lower Mounting Nuts	3/4–10	170 (230)	—
Shock Absorber Upper Bracket Mounting Locknuts	5/8–11	125 (170)	—
Shock Absorber Upper Mounting Locknuts (vehicles built before September 1994)	—	Compress bushings to specified dimension. †	—
Shock Absorber Upper Mounting Nuts (vehicles built from September 1994)	3/4–10	170 (230)	—
Spring Hanger Mounting Locknuts	3/4–10	210 (285)	—

* Tighten in a diagonal pattern as shown in **Fig. 1**.
† See **Subject 140**.

Table 1, Torque Values

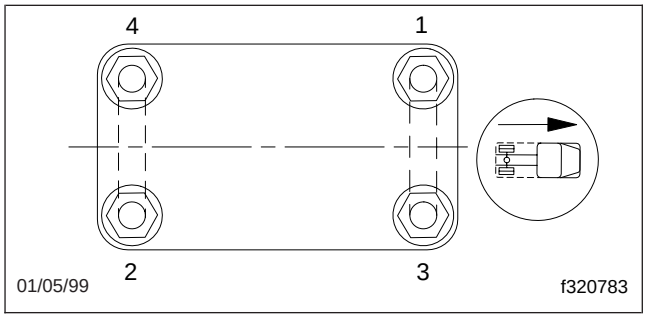


Fig. 1, Tightening Pattern for U-bolt High Nuts

General Description

Ride quality is determined by a complex interaction of several factors including the vehicle specifications, installed equipment, vehicle speed, suspension loading, and the roughness of the road. An unusual combination of these factors may result in a rough ride.

There are two terms used to describe rough ride conditions: harmonic and harsh. Harmonic ride problems are those in which the once-per-revolution energy input from such things as bent or imbalanced wheels matches the natural frequency of the frame flexing. This produces a fore-and-aft motion in the cab, which continues as long as the critical road speed is maintained. Harmonic ride problems can occur on smooth roads.

Harsh ride problems are those in which the suspension transfers, rather than absorbs, the momentary energy inputs produced when the tires hit bumps or holes in the road. Wavy asphalt, or a series of bumps, may cause repetition of the harsh, jarring motion in the cab, but the motion stops after the tires pass over the bumps. Harsh ride problems occur on rough roads.

This section is designed for use as an aid in locating and correcting rough ride problems. It is not intended for use as a replacement for the detailed service information located in the applicable sections in this manual, or in the component manufacturer's service manuals.

Harmonic Ride Checks

1. Visually check the vehicle for signs of damaged or missing suspension components. Repair or replace the components using the instructions **in the suspension group, the front axle group, or the rear axle group .**
2. Test drive the vehicle.

NOTE: When test driving the vehicle, duplicate as closely as possible the conditions under which the problem occurs. Note the area of the vehicle where the problem seems to be coming from. Pay special attention to this area during the service operations.

3. Chock the tires and apply the parking brakes.
4. Raise the vehicle until the tires are off the ground, and all of the weight is removed from the leaf springs. Block the axle and frame with safety stands. Perform the remedies **under "Troubleshooting, 300: Harmonic Ride, Tires Off the Ground."**

⚠ WARNING

WARNING: Serious personal injury, property damage, or component damage may occur when fasteners are loosened or removed causing unsecured components to drop.

5. Remove the safety stands from under the frame and axle, then lower the vehicle. Perform the remedies **under "Troubleshooting, 300: Harmonic Ride, Tires On the Ground."**

Harsh Ride Checks

1. Visually check the vehicle for signs of damaged or missing suspension components. Repair or replace the components using the instructions **in the suspension group, the front axle group, or the rear axle group .**
2. Test drive the vehicle.

NOTE: When test driving the vehicle, duplicate as closely as possible the conditions under which the problem occurs. Note the area of the vehicle where the problem seems to be coming from. Pay special attention to this area during the service operations.

3. Perform the corrections under **"Troubleshooting, 300: Harsh Ride, Tires On the Ground."**
4. If the problem persists, perform the harmonic ride checks in this subject. Occasionally, ride problems associated with rough roads are harmonic ride problems masked by the road conditions.

Problem—Harmonic Ride, Tires Off the Ground

Possible Cause	Remedy
Bent, distorted, or out-of-round wheels or rims are causing a rough ride.	Inspect and repair the assemblies using the instructions in the **wheels and tires group.**
Bent, distorted, or out-of-round brake drums or hubs are causing a rough ride.	Replace damaged components using the instructions in the **front axle group** or the **rear axle group.**
An improperly seated tire-to-rim bead is causing an out-of-round assembly.	Inspect the tires and rims for proper bead seating. Correct the problem using the instructions in the **wheels and tires group.**
A tire and rim assembly on spoke wheels is improperly installed, causing an out-of-round assembly.	Remove and install the tire and rim assembly using the instructions in the **wheels and tires group.**
Worn or distorted rim spacers are causing an out-of-round assembly.	Replace damaged spacers using the instructions in the **wheels and tires group.**
The wheels, brake drums, or hub assemblies are out of balance.	Inspect the components for missing balance weights. Balance, as necessary.
Radial force variations in the tires are causing a rough ride.	Exchange the tires and wheels with a set that is known to cause no ride problems. If this corrects the problem, discard the old tires. For instructions, **refer to the wheels and tires group.**

Problem—Harmonic Ride, Tires On the Ground

Possible Cause	Remedy
Worn or loose cab mounts allow the cab to bounce.	With a long bar, lever the cab legs up and down. If there is looseness, replace or tighten the mounts, as necessary.
Forces from the trailer suspension are pushing on the tractor fifth wheel.	Review the ride problems in this subject that apply to the trailer suspension. Perform the corrections, as necessary.

Problem—Harsh Ride, Tires Off the Ground

Possible Cause	Remedy
Seized front spring shackle pins are not allowing the springs to flex.	Replace the seized shackle pins. For instructions, refer to the applicable front suspension section in this service manual group.

Problem—Harsh Ride, Tires On the Ground

Possible Cause	Remedy
The tires are improperly inflated.	Adjust the tire pressure using the instructions in the wheels and tires group of the maintenance manual.
The frame is bottoming out against the suspension.	Check the suspension for weak or damaged springs or components. Inspect the springs for "gull-winging" when the vehicle is loaded. Replace the spring assembly, as necessary, using the instructions in the **suspension group.**
	Reduce the overall loaded weight on each axle to conform with the maximum spring load capacities on the vehicle specification sheet. Do not exceed the maximum spring load capacities.
	Adjust the air spring height using the instructions in the **suspension group.**

Troubleshooting

Possible Cause	Remedy
The vehicle normal loaded weight is markedly below the spring load capacity.	Customers should contact a Freightliner dealer for the correct application of a lower rated spring. Replace the spring assembly using the instructions in the **suspension group.**
When the vehicle is loaded, the front axle spring shackle angle is not within the rearward 3 to 18 degree angle.	Customers should contact a Freightliner dealer for shackle angle corrective measures. **Refer to the suspension group** for service instructions.
The weight on the tractor fifth wheel is causing overloading on the front axle springs.	Change the loading pattern on the trailer.
Forces from the trailer suspension are pushing on the tractor fifth wheel causing a rough ride condition.	Review the ride problems in this subject that apply to the trailer suspension. Perform the corrections, as necessary.

General Description

Hendrickson RT and U series suspensions **(Fig. 1 and Fig. 2)** use leaf springs to absorb road shock. The forward and rear ends of each spring assembly ride in hangers attached to the frame rails, and the spring assembly rests on a saddle connected to an equalizing beam. Each end of the beam is secured to beam hangers welded on the vehicle axles.

NOTE: No alignment adjustments are needed for RT and U suspensions; alignment is determined by the placement of the spring hangers on the frame rails, and the beam hangers on the axle housings.

To allow for spring length change caused by spring deflection, the forward end of each spring assembly is secured to the number one hanger by a pin that runs through the legs of the hanger and through the spring eye. The spring eye contains a bronze bushing, and the pin that runs through the eye and the spring hanger legs is hardened steel with lubrication channels. The pin is also notched to allow two bolts to pass through the spring hanger legs and lock the pin in place.

The rear end of the spring assembly isn't fastened to the number two spring hanger; instead, the spring rests against the rounded underside (or cam) of the hanger and is free to rub against the hanger as the spring assembly changes length due to deflection caused by vehicle weight and road shock.

A spacer runs between the legs of the number two spring hanger to prevent the spring assembly from moving out of position against the hanger.

U series suspensions are light-weight versions of the RT suspensions, and use U-bolts to hold the spring assembly on the saddle. RT suspensions use four bolts that run down through the spring top pad to hold the spring assembly on the saddle.

Hendrickson RT suspensions also feature a "pilot cup" (similar to a raised disk), forged upward in the main spring leaf around the center bolt. This cup fits into the spring top pad to ensure the spring assembly is positioned correctly in the saddle. U suspensions feature similar pilot cups **(see Fig. 3),** but the U pilot cups are forged downward, around the center bolt to ensure the spring assembly is positioned correctly in the saddle.

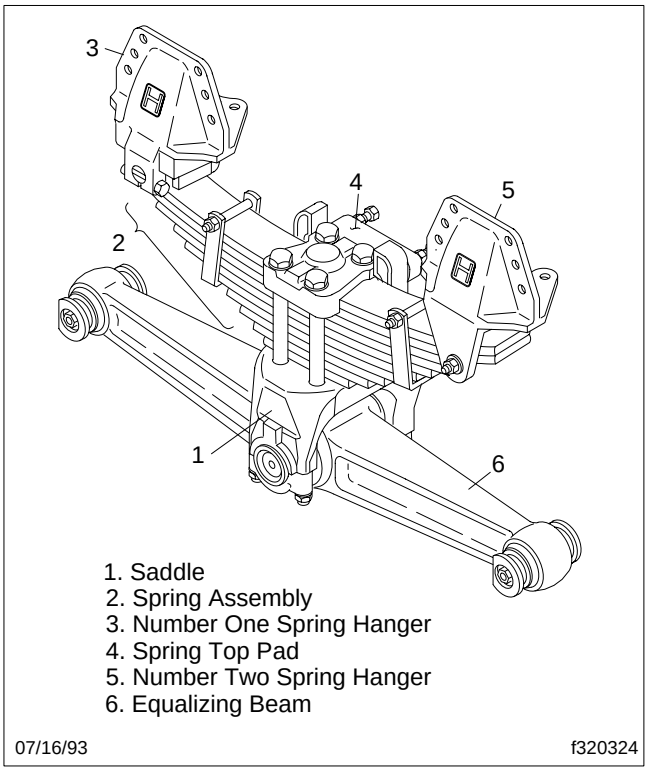


Fig. 1, RT Suspension

Because of this difference in pilot cups, springs for the two types of suspensions are not interchangeable.

RTE and UE series suspensions **(Fig. 4 and Fig. 5)** are basically the same as the RT and U suspensions, but feature longer spring assemblies that require a third spring hanger. This design provides a two-stage spring rate, depending on the vehicle load. When the vehicle is unloaded, there should be a 3/8-inch gap between the top spring and the number two spring hanger, and the rear end of the spring assembly should rest against the number three spring hanger.

Loaded **(see Fig. 5),** the springs deflect until the spring assembly rests against all three spring hangers.

On all models of RT and U suspensions, torque rods— mounted between the axle housings and the frame rails— prevent the axles from twisting or shifting side-to-side as the vehicle accelerates, stops, or corners.

General Description

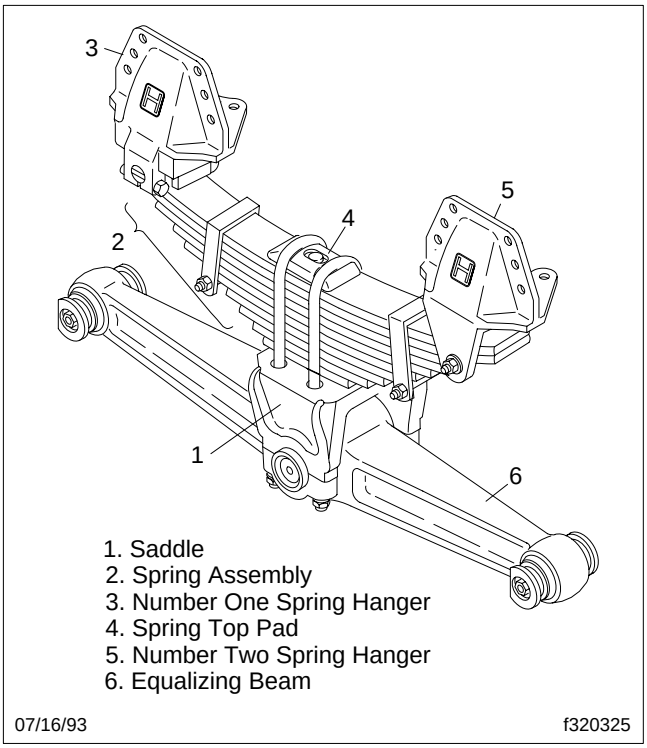


Fig. 2, U Suspension

All suspension fasteners require periodic tightening. For suspension inspecting, lubricating, and fastener torque checking instructions, refer to the suspension section in the vehicle maintenance manual.

⚠ WARNING

WARNING: Failure to periodically torque the suspension fasteners could result in damage to the frame hangers or separation of components. This could cause a loss of vehicle control, resulting in injury or property damage.

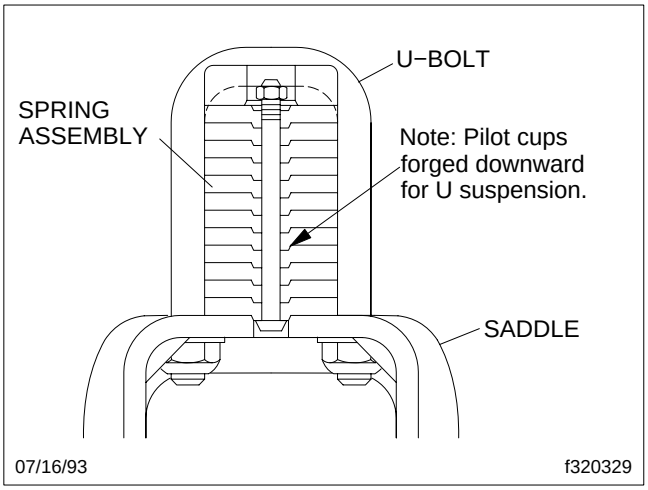


Fig. 3, Pilot Cups (cross-section view of springs)

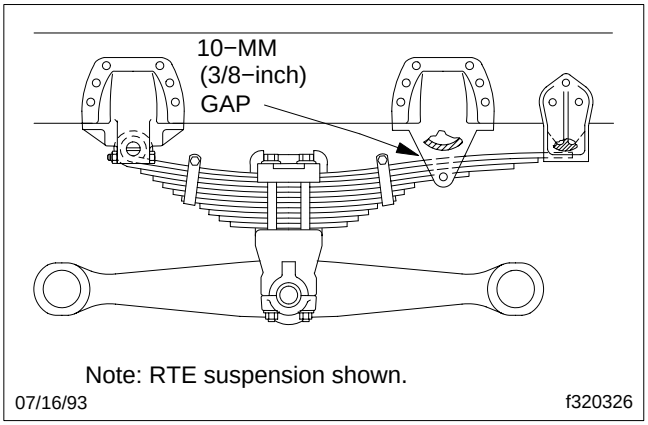


Fig. 4, Unloaded Suspension

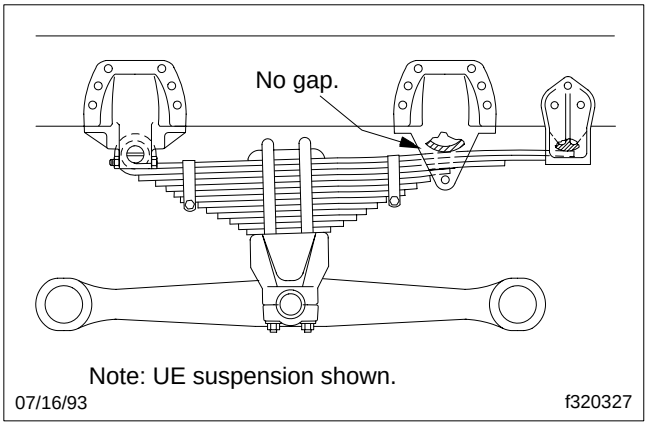


Fig. 5, Loaded Suspension

Removal (Refer to Fig.1or Fig.2)

1. Chock the front tires.
2. Drain the vehicle air system.
3. Disconnect all air lines leading to the rear axles, marking the lines for later assembly reference. Plug or cap all lines and fittings to prevent dirt from entering the system.
4. Disconnect the driveline rear universal joint from the forward-rear axle.
5. Manually release the spring brake chambers. For instructions, **refer to the brakes group.**

⚠ WARNING

WARNING: When the torque rods are disconnected from the axle brackets, the axles become free to pivot on the equalizer beam end bushings. Keep clear of the beam hangers and beam ends to avoid possible injury.

6. Remove the torque rods. For instructions, **refer to Subject 170.**

   To prevent the axles from pivoting, secure chains between the crosstube and each fore and aft torque rod axle mounting bracket.
7. Raise the rear of the vehicle so that all weight is removed from the suspension. Then, block the axles and the frame with safety stands. Make sure the stands will securely support the weight of the axles and the frame.

NOTE: Do not raise the vehicle to the point where the weight of the suspension and axles hangs from the vehicle.

8. Remove the saddle cap nuts and washers from each side of the vehicle, and remove the saddle caps.

NOTE: If the saddle cap studs are damaged, replace them.

9. Raise the rear of the vehicle frame until there is enough clearance to roll the axles out from under the vehicle. Install safety stands under the frame, then roll the axles— with the equalizer beams attached— out from under the vehicle.

Installation (Refer to Fig.1or Fig.2)

1. Roll the axles under the vehicle frame. Align the center bushing of each equalizer beam with the center of the saddle legs.
2. Raise the vehicle frame off the safety stands, then remove the safety stands.
3. Lower the frame, centering the saddles on the beam center bushings.
4. Lubricate the saddle cap studs with SAE 20 oil. Install the saddle caps, washers and new self-locking nuts. Do not tighten.
5. Install the torque rods. For instructions, **refer to Subject 170.**

   Remove the chains between the crosstube and each fore and aft torque rod axle mounting bracket.
6. Tighten the saddle cap locknuts to the applicable torque in the torque table in **"Specifications, 400."**

NOTE: Maintain an even gap between the saddle cap and the saddle when tightening the self-locking nuts **(see Fig.3).**

7. Remove the safety stands from under the frame and axle, and lower the vehicle.
8. Manually reset the spring brake chambers. For instructions, **refer to the brakes section.**
9. Connect the driveline rear universal joint to the forward-rear axle. For instructions, **refer to the driveline components section.**
10. Uncap all air lines and fittings, then connect the lines leading to the rear axles.

Suspension Removal and Installation

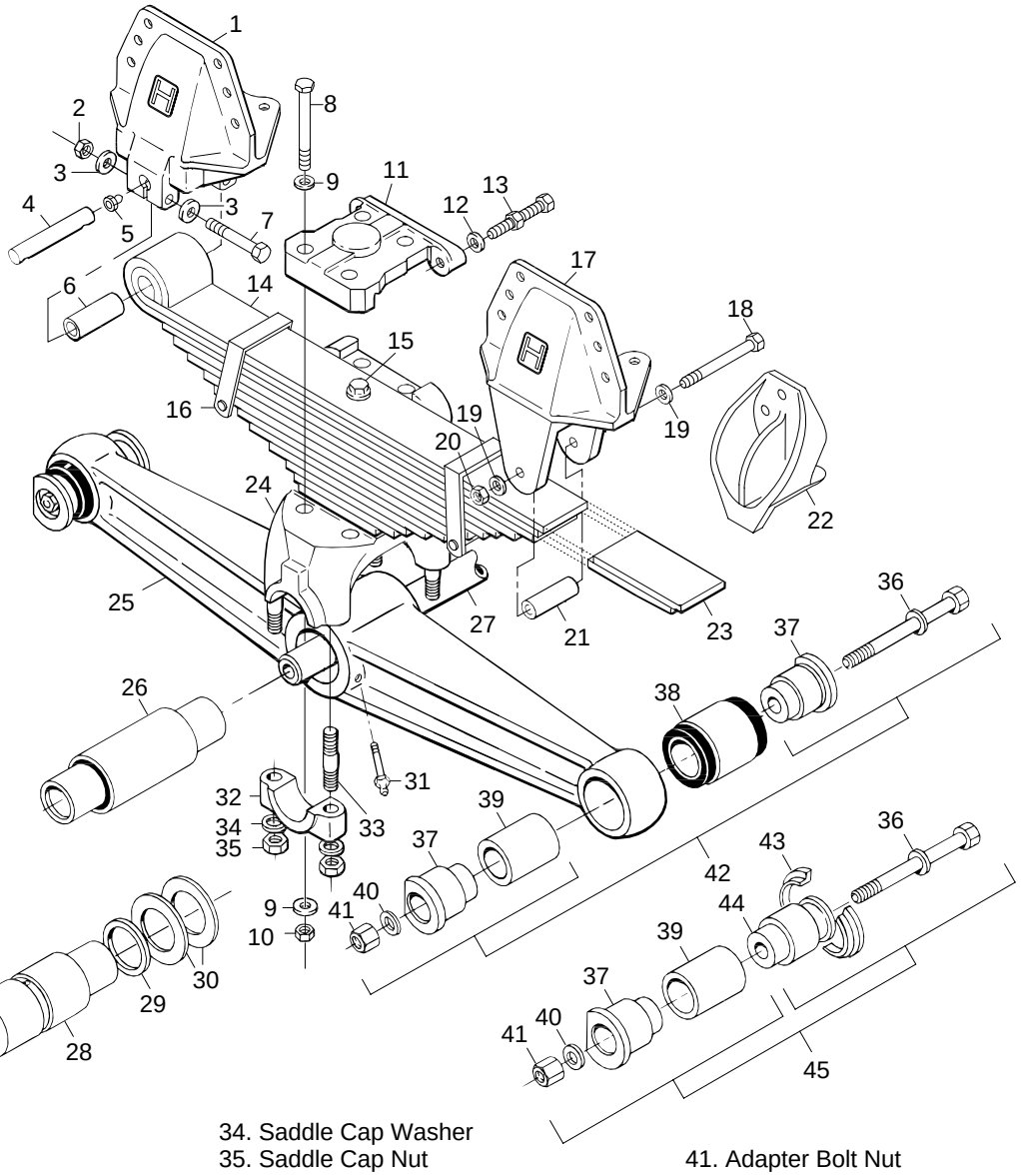


Fig. 1, RT and RTE Series (exploded view)

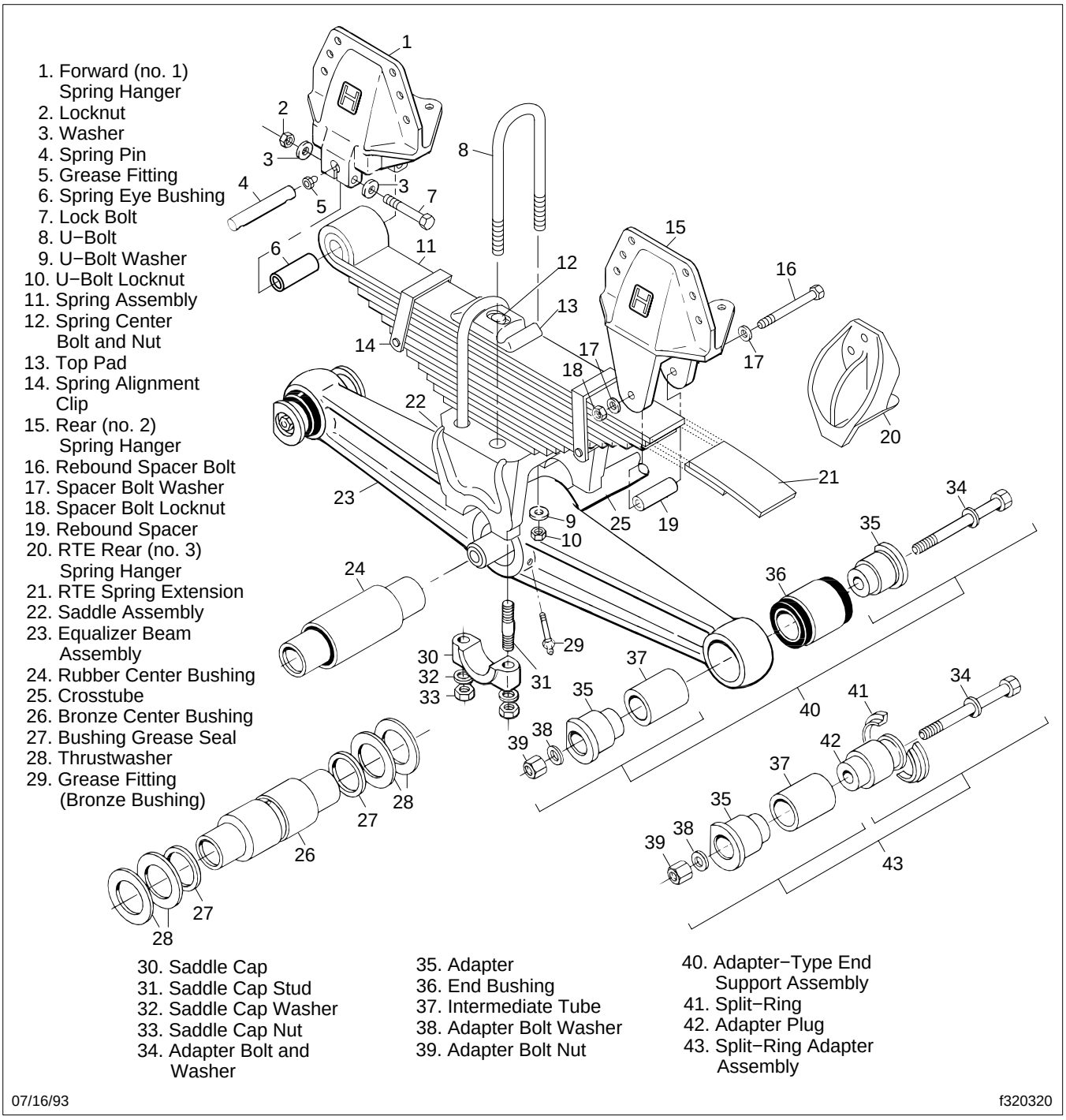


Fig. 2, U and UE Series (exploded view)

Suspension Removal and Installation

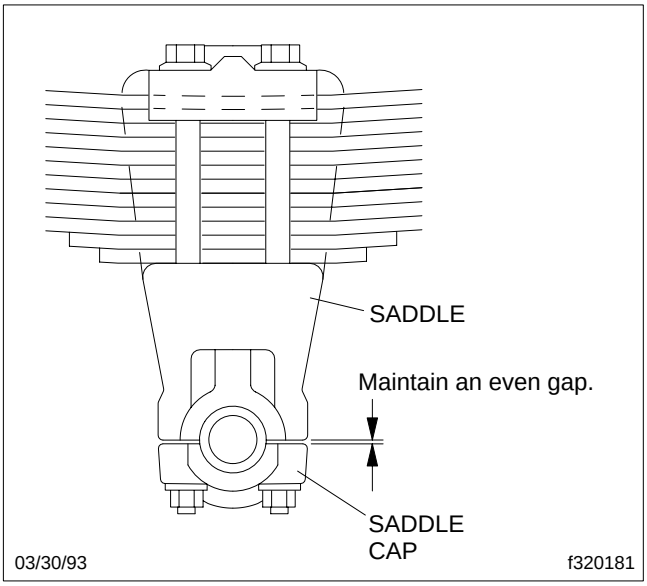


Fig. 3

Spring and Saddle Removal and Installation

Removal

1. Remove the suspension. For instructions, **refer to Subject 100.**
2. Support the spring and saddle assembly with a floor jack.
3. Remove the locknuts from the spring pin lockbolts; then remove the lockbolts and washers from the number one spring hanger.
4. Using a suitable drift, drive the spring pin through the no. 1 spring hanger and out the inboard side of the spring hanger **(see Fig. 1).**
5. Remove the locknut and lockwasher from the rebound spacer bolt in the no. 2 spring hanger. Remove the rebound spacer bolt and the spacer.

⚠ WARNING

WARNING: The leaf spring assembly is heavy. Use care when handling it to prevent injury.

6. Lower the spring and saddle assembly from the spring hangers.
7. Remove the spring assembly from the saddle.

   7.1 *On RT series suspensions ,* loosen the spring alignment setscrews on the top pad, and remove the top pad locknuts, washers, bolts, and top pad.

   On U series suspensions , remove the U-bolt locknuts, washers, U-bolts, and U-bolt top pad.

   7.2 Lift the spring assembly from the saddle.

Installation

1. Seat the leaf spring assembly on the saddle.
2. Install the spring assembly on the saddle.

   2.1 Position the top pad on the spring assembly, and check that the pad is seated on the spring center-bolt.

   IMPORTANT: The pilot cups on U springs are forged downward around the spring center-bolt and fit in a pilot hole in the saddle; therefore, springs for RT and U suspensions are not interchangeable.

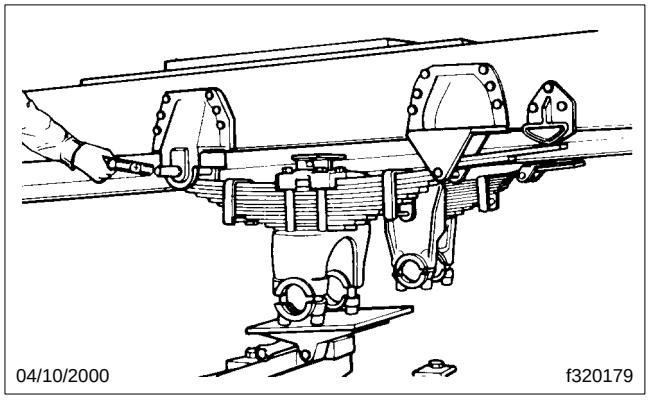


Fig. 1

NOTE: On RT series suspensions, the main leaf has a pilot cup forged upward around the center-bolt. This cup serves as a pilot when installing the top pad, and ensures correct alignment of the spring assembly.

2.2 Lubricate the threads of the top pad bolts or U-bolts with SAE 20 oil.

On RT series suspensions , install washers on the top pad bolts, and install the bolts through the top pad and saddle. Secure the bolts with new washers and nuts, and tighten the nuts finger-tight.

On U series suspensions , install the U-bolts over the top pad and spring assembly, and through the saddle. Secure the bolts with new washers and nuts, and tighten the nuts finger-tight.

2.3 *On RT series suspensions ,* lubricate the threads on the spring setscrews with SAE 20 oil. Hand-tighten the spring setscrews against the leaf springs, then tighten them 135 to 203 N·m (100 to 150 lbf·ft). Tighten the setscrew locknuts until the lockwashers are locked.

Tighten the top pad locknuts 373 to 542 N·m (275 to 400 lbf·ft). Use the tightening sequence shown in **Fig. 2**.

On U series suspensions , tighten the locknuts evenly 320 to 410 N·m (237 to 302 lbf·ft) Using a hammer, tap the tops of the U-bolts to settle the assembly, then tighten the locknuts 320 to 410 N·m (237 to 302 lbf·ft).

Spring and Saddle Removal and Installation

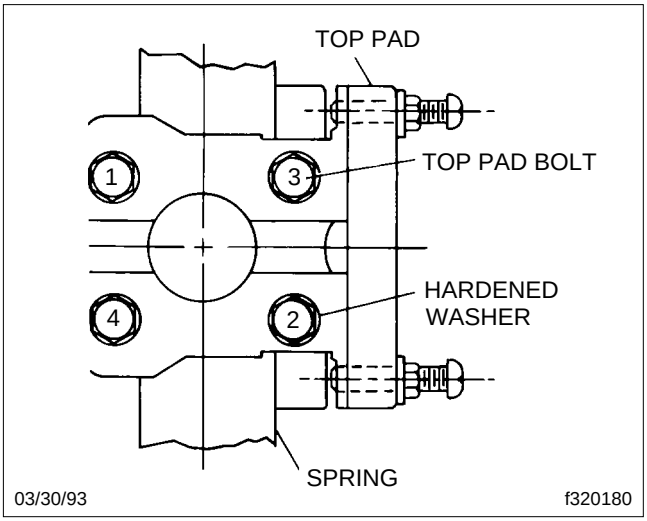


Fig. 2, Top Pad Bolt Tightening Sequence

CAUTION

CAUTION: Failure to tap the U-bolts and tighten the locknuts a second time could allow the assembly to loosen, damaging the pilot hole in the saddle seat.

3. Position the spring and saddle assembly into the no. 1 and no. 2 spring hangers.
4. Coat the spring pin and the inside diameter of the spring eye bushing with multipurpose chassis grease.
5. Align the spring pin with the spring eye bushing in the forward spring hanger.
6. From the outboard side of the spring hanger, tap the spring pin into the bushing with a soft hammer. If necessary, adjust the spring to assist spring pin entry.
7. Place washers on the spring pin lockbolts, and insert the lockbolts through the spring hanger. If necessary, use a screwdriver to turn the spring pin until the lockbolts can slide past it.
8. Lubricate the lockbolt threads with SAE 20 oil. Install the lockwashers and locknuts. Tighten the locknuts 61 to 85 N·m (45 to 63 lbf·ft).
9. Position the rebound spacer in the no. 2 spring hanger leg, then install the rebound spacer bolt, lockwasher, and locknut. Tighten the locknut 51 to 61 N·m (38 to 45 lbf·ft).
10. Install the grease fittings in both spring eye pins. Apply multipurpose chassis grease to the grease fittings until grease appears on both sides of the spring eye bushings.
11. Install the suspension. For instructions, **refer to Subject 100.**

Spring Leaf, Spring Pin, and Spring Eye Bushing Checking and Replacement

Checking

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Check for spring eye bushing or pin damage.
   - 2.1 Place a block of wood on the spring **(see Fig. 1),** and with a pry bar, try to lift the spring hanger and frame rail. Note how much movement occurs around the spring eye pin.
   - 2.2 With the vehicle unloaded, try to rock the chassis back and forth. Note how much movement occurs around the spring eye pin.
   - 2.3 In either case, if 3 mm (1/8 inch) or more movement occurs between the spring eye pin and the spring bushing, replace the bushing.

   NOTE: Movement around the spring eye pin can also indicate a broken spring eye. In this case, replace the main leaf or the spring assembly.
3. Remove the chocks from the tires.

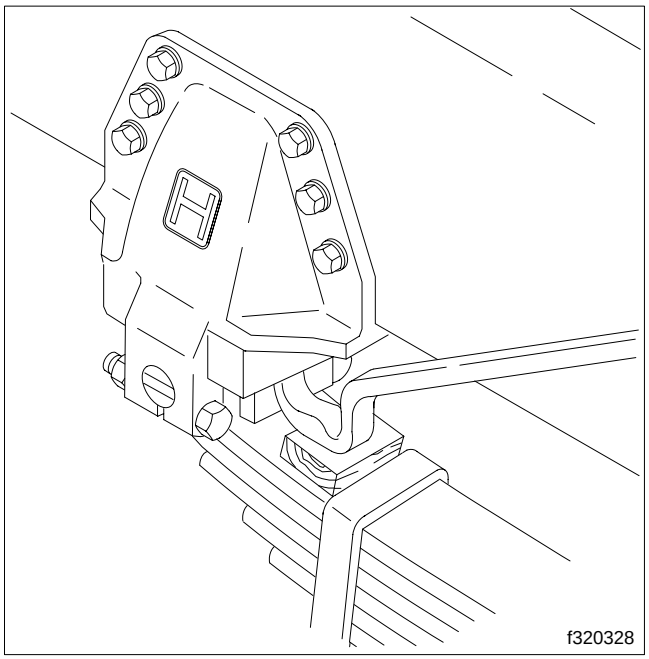


Fig. 1

Replacement

1. Remove the spring and saddle assembly. For instructions, **refer to Subject 110.**
2. Using a C-clamp to hold the spring leaves together, remove the center-bolt and nut, and the spring alignment clips. Remove the C-clamp and separate the leaves.

⚠ WARNING

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

3. Using a wire brush and solvent, clean all grease, dirt, and rust from the spring leaves. Inspect the spring leaves for cracks, gouges, wear, or abnormal bends. The no. 1 main and no. 2 wrapper spring leaves (the top two spring leaves) may each be replaced; if equipped with the RTE or UE series suspension, the nos. 1, 2, and 3 spring leaves (the top three spring leaves) may each be replaced. If a spring leaf is damaged below these numbers in a pack, replace the spring assembly. Replace both spring assemblies to ensure even spring deflection.
4. Inspect the spring pin and spring eye bushing for wear or damage. If the pin diameter is less than 1.367 inch, replace it. If the inside diameter of the spring eye bushing is more than 1.395 inch, replace it.

NOTE: If necessary, press out the bushing with a hydraulic press. Install the new bushing with the split of the bushing positioned at the top (30 degrees) of the spring eye **(see Fig. 2).**

5. Position the spring leaves in order, then insert a drift through the center-bolt hole to align the leaves.
6. Compress the leaves with a C-clamp, then install the spring alignment clips on the spring leaves. Install the spring alignment clip nuts and bolts. Tighten the nuts 20 N·m (15 lbf·ft).
7. Remove the drift punch. At the bottom of the spring, insert a new center-bolt. Install a new

Spring Leaf, Spring Pin, and Spring Eye Bushing Checking and Replacement

center-bolt nut and tighten to the value in the torque table in **"Specifications, 400."**

8. Install the spring and saddle assembly. For instructions, **refer to Subject 110.**

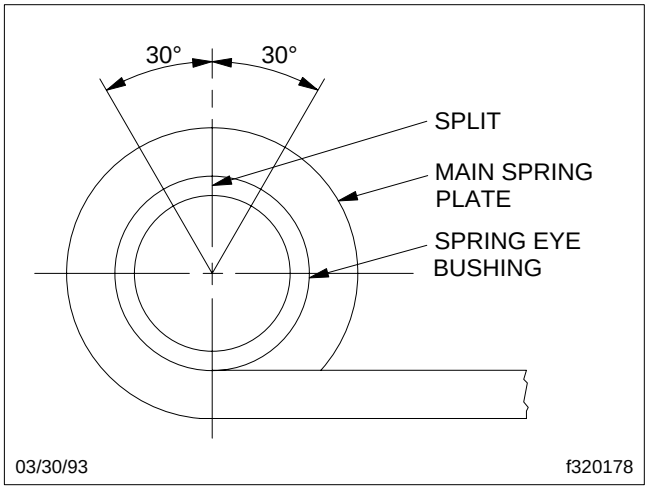


Fig. 2

Equalizer Beam Adapter- and Tube-Type End Support Removal and Installation

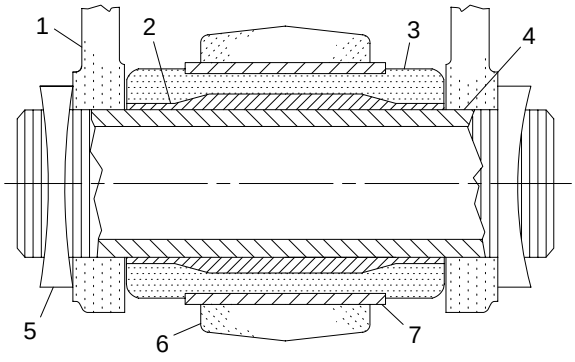
Removal

IMPORTANT: To ensure that the required tools are available, see the table of special tools **"Specifications, 400,"** before beginning these procedures. Special tools are available from the Owatonna Tool Company, Owatonna, Minnesota, or an affiliated dealer. Although these tools are recommended, shop-made adapters can be used if a vertical hydraulic press with a 50-ton capacity is available. Dimensions for the shop-made adapters are provided in the table in **"Specifications, 400."**

1. Chock the front tires.
2. Remove the saddle cap nuts and washers, then remove the saddle cap. Support the equalizer beam with safety stands.
3. Raise the rear of the vehicle until the saddle studs clear the equalizer beam. Block the axles and frame with safety stands.
4. Remove the wheels and tires. For instructions, **refer to the wheels and tires group.**
5. Remove the brake shoes, brake spider, and brake backing plate (dust shield). **Refer to the rear axle group** for instructions.
6. Apply a penetrating oil to all beam end connections.
7. On a tube-type end support **(see Fig. 1),** remove the tube nuts from both sides of the beam end tube.

   On an adapter-type end support **(see Fig. 2),** remove the nut, washers, and the adapter bolt.
8. If using Owatonna tools, remove the tube-type end supports by positioning the receiving tube over the outboard end of the beam end tube. Position the hydraulic ram, pulling screw, speed nut, and the removing adapter **(see Fig. 3).** Connect a hydraulic pumping unit to the ram, and apply pressure to remove the beam end tube.
9. Remove the adapter-type end supports (if using Owatonna tools).

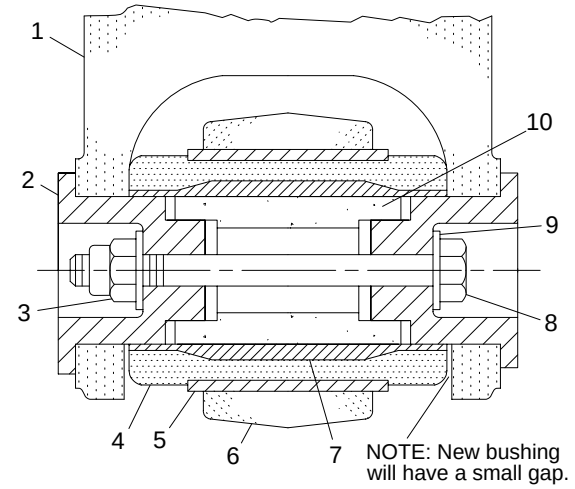
   9.1 Using either a 7/8-or 15/16-inch hand-tap **(see Fig. 4),** tap the adapter bolt hole (outboard side) to a depth of about 38 mm (1-1/2 inches).



1. Axle Beam Hanger
2. Bushing Inner Sleeve
3. Rubber End Bushing
4. Beam End Tube
5. End Tube Nut
6. Equalizer Beam
7. Bushing Outer Sleeve

03/26/92 f320337

Fig. 1, Equalizer Beam Tube-Type End Support



1. Axle Beam Hanger
2. Adapter
3. Adapter Bolt Nut
4. Rubber End Bushing
5. Bushing Outer Sleeve
6. Equalizer Beam
7. Bushing Inner Sleeve
8. Adapter Bolt
9. Washer (both ends)
10. Intermediate Tube

07/26/93 f320338

Fig. 2, Equalizer Beam Adapter-Type End Support

NOTE: Determine the correct size of hand-tap by using the plug gauge. If the gauge

Equalizer Beam Adapter- and Tube-Type End Support Removal and Installation

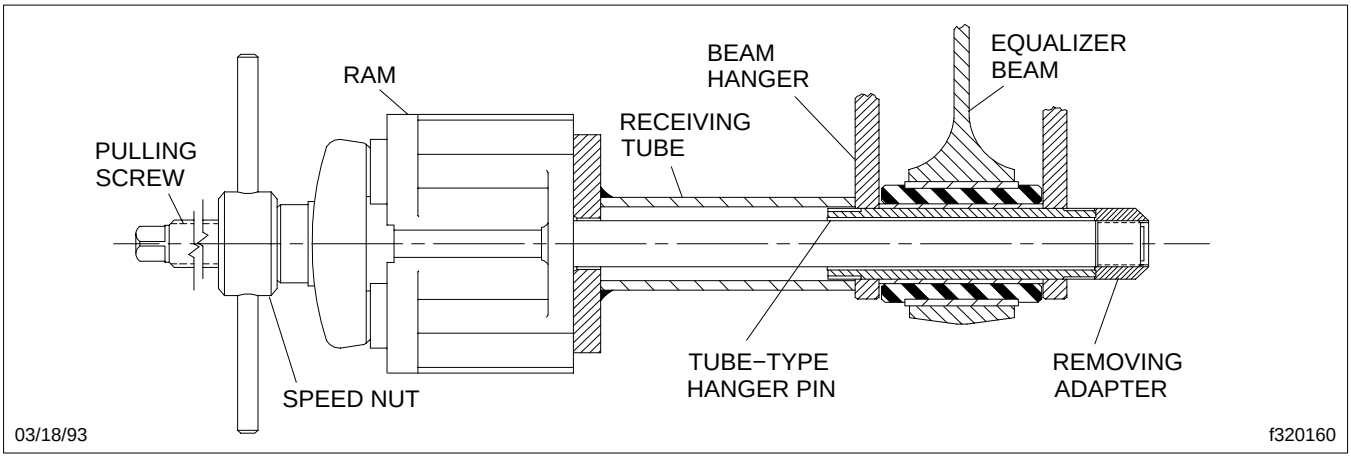


Fig. 3, Tube-Type Beam End Removal

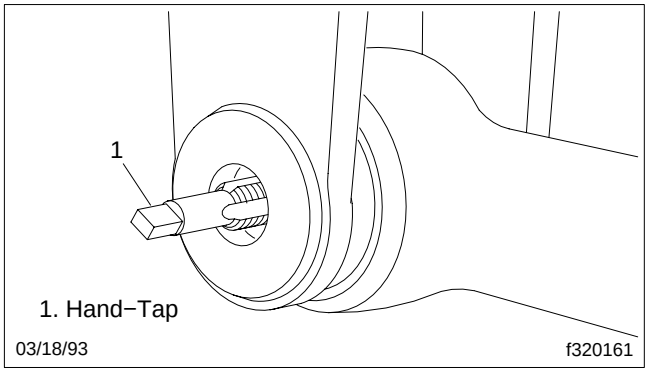


Fig. 4

passes through the adapter bolt hole, use a 15/16-inch tap; if it doesn't, use a 7/8-inch tap.

9.2 On the outboard side of the axle, thread the removing screw into the tapped hole. Position the receiving cup and hexnut on the removing screw **(see Fig. 5).** Turn the hexnut until the adapter plug breaks loose and bottoms on the inside of the receiving cup. If needed, add spacers to complete removal of the adapter plug. **See Fig. 6.**

9.3 On the inboard side of the axle, position the receiving cup over the adapter plug. On the outboard side of the axle, insert the removing screw through the receiving cup and secure it with the hexnut. **See Fig. 7.**

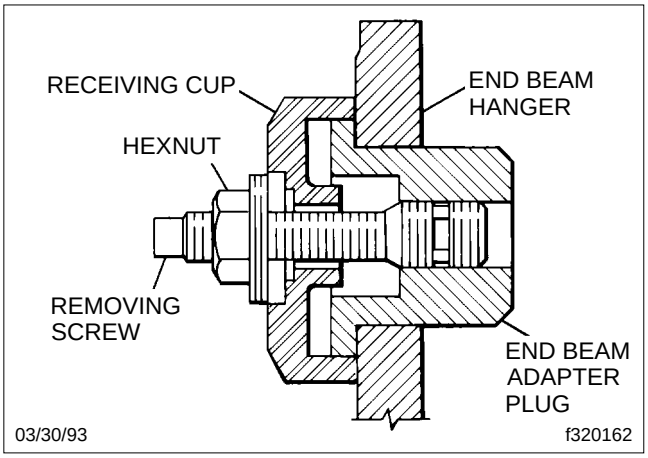


Fig. 5

9.4 Hold the removing screw and turn the nut with a 1-1/2 inch open-or box-end wrench. Turn the nut until the adapter plug bottoms on the inside of the receiving cup.

10. Remove the end supports (if not using Owatonna tools).

10.1 For tube-type end supports, install a spacer bushing between one end-tube nut and the beam hanger. Tighten the nut to pull the end tube out of the beam end bushing. If the tube doesn't come loose, use a hacksaw and saw the tube along the inside surface of both axle beam hanger legs.

Equalizer Beam Adapter- and Tube-Type End Support Removal and Installation

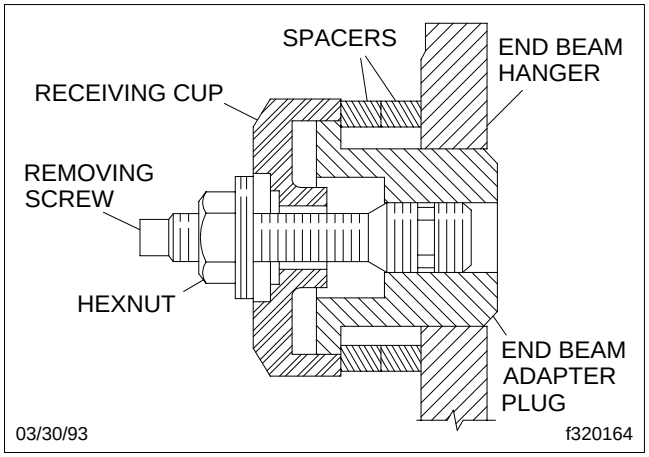


Fig. 6

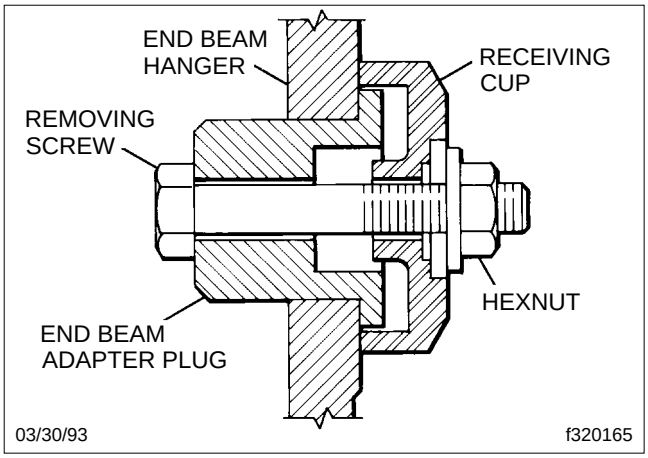


Fig. 7

⚠ WARNING

WARNING: Don't use a cutting torch to remove the equalizer beams from the beam hangers. The equalizer beams are heat treated, and using a cutting torch could weaken them. This could result in a loss of vehicle control and possible personal injury.

10.2 For adapter-type end supports, a relief is located on each side of the adapter **(see Fig. 8).** Turn the adapter with an air chisel, then insert a chisel into the relief on the inboard adapter. Drive the chisel in and wedge the adapter out of the beam hanger. Do the same on the outboard adapter.

If a split-ring adapter is used, drive a chisel between the two halves to remove the end support plug. Drive the plug into the equalizer beam end bushing until it is clear of the beam hanger. After the equalizer beam is removed, drive the adapter plug out of the bushing.

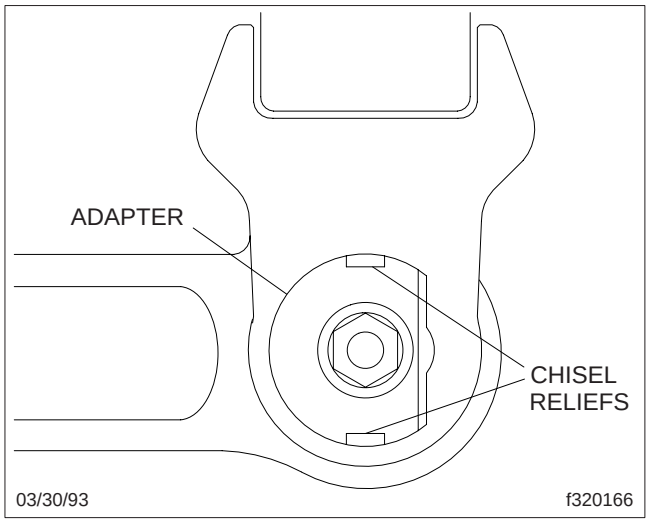


Fig. 8

11. Remove the ends of the equalizer beams from the axle beam hangers.
12. Lower the equalizer beams and the crosstube to the ground. Remove the thrustwashers and pull the beams from the crosstube.

Installation

1. On adapter-type end supports, apply Texaco Compound L, or an equivalent rust preventive lubricant, to the axle beam hanger eyes,

   beam end bushing inner sleeve, end support adapters, outside surface of the bushing intermediate tubes, and the ends of the crosstube.

   Install the crosstube and thrustwashers in both equalizer beam center bushings.

   On tube-type end supports, apply Texaco Compound L, or an equivalent rust preventive lubri-

Equalizer Beam Adapter- and Tube-Type End Support Removal and Installation

cant, to the axle beam hanger eyes, beam end bushing inner sleeve, outer surface of the beam end tubes, beam center bushing inner sleeves, and the ends of the crosstube.

Using SAE 20 oil, lubricate the threads of the beam end tube, then install the crosstube and thrustwashers in both equalizer beam center bushings.

2. Position the equalizer beam assembly under the axles, then raise the assembly and place the forward ends of each beam in the forward-rear axle beam hangers. Align the beam end bushings with the beam hangers.

   On adapter-type end supports, install the intermediate tubes, the adapters, the adapter bolt, washers, and nut in each beam end to hold the beam in the axle beam hangers. Do not tighten.

   On tube-type end supports, install the beam end tubes through the beam hangers and the beam end bushings. Hand-tighten both nuts on the beam end tubes.

3. Place the rear ends of each beam in the rearmost axle beam hangers. Align the beam end bushings with the beam hangers.

   On adapter-type end supports, install the intermediate tubes, the adapters, the adapter bolt, washers, and nut in each beam end to hold the beam in the axle beam hangers. Do not tighten.

   On tube-type end supports, install the beam end tubes through the beam hangers and the beam end bushings. Hand-tighten both nuts on the beam end tubes.

4. Position the saddle caps on the saddle cap studs, then install the washers and new self-locking nuts. Tighten the nuts to the applicable torque in the torque table in **"Specifications, 400."**

5. Tighten the adapter bolt nuts 285 to 325 N·m (210 to 240 lbf·ft). Make sure the flat section of the adapter flange is in the vertical position. **See Fig. 9.**

6. Tighten the end tube nuts 508 to 576 N·m (375 to 425 lbf·ft).

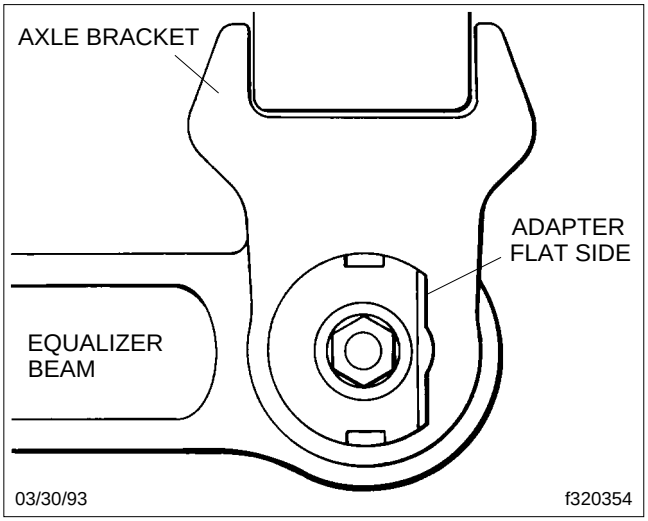


Fig. 9

WARNING

WARNING: The adapter bolt nuts and end tube nuts must be tightened to the specified values. If not, the metal surfaces of the end support assembly will rub, and excessive wear to the beam hanger legs and end bushing inner sleeves will occur. This could result in separation of suspension components, loss of vehicle control, and possible injury or property damage.

7. Install the brake backing plate (dust shield), brake spider, and brake shoes. **Refer to the rear axle group** for instructions.

8. Install the wheels and tires. For instructions, **refer to the wheels and tires group.**

Equalizer Beam End Bushing Removal and Installation

Removal

⚠ WARNING

WARNING: Don't use a cutting torch to remove the beam end bushing. Equalizer beams are heat treated by the manufacturer. Using a cutting torch could weaken the beams, and may result in a loss of vehicle control. This could cause personal injury or property damage.

1. Remove the equalizer beam ends from the axle beam hangers. For instructions, **refer to Subject 130.**
2. Cut off the protruding rubber from one side of each beam end bushing **(see Fig. 1).**
3. Remove the beam end bushings (if using Owatonna tools, refer to **Fig. 2**).
   - 3.1 Install the receiving adapter on the receiving tube.
   - 3.2 Position the hydraulic ram and slide the pulling screw through the end bushing.
   - 3.3 Install the end bushing removing adapter on the inboard side of the beam end bushing. Check that the cone-shaped surface of the adapter is facing the equalizer beam.

   IMPORTANT: Align the receiving tube so that the bushing will clear the edges of the tube when force is exerted against the beam. Align the removing adapter so that force is exerted only on the bushing to ensure a clean pull through the beam.

   - 3.4 Install the hexnut on the pulling screw. Full thread engagement is needed.
   - 3.5 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.
   - 3.6 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely remove the end bushing.

NOTE: If the pressure gauge on the hydraulic pumping unit reads 68 950 kPa (10,000 psi) and the bushing has not broken loose, stop and check the alignment of the receiving tool and removal adapter. If both tools are aligned correctly, attach a sledging adapter on the speed nut end of the pulling screw. Maintaining hydraulic pressure, strike the sledging adapter with a heavy hammer. A loud noise followed by a sudden drop of the pressure gauge reading indicates the bushing has broken loose.

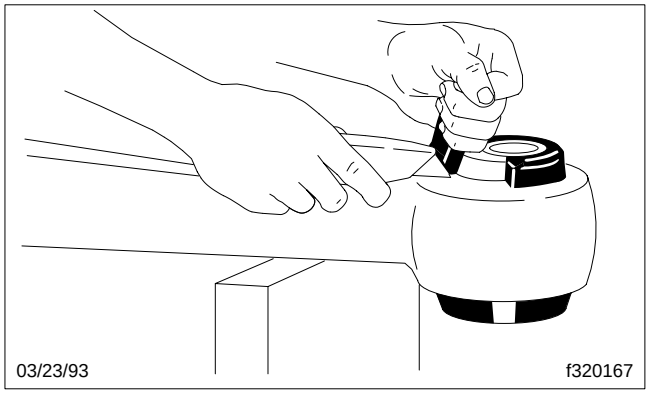


Fig. 1

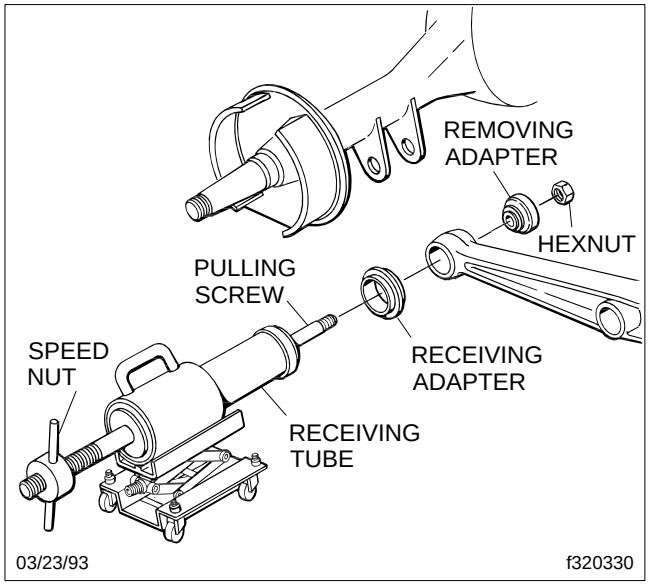


Fig. 2

4. Remove the beam end bushings (if using shop-made adapters).
   - 4.1 Remove the equalizer beams. For instructions, **refer to Subject 130.**

Equalizer Beam End Bushing Removal and Installation

4.2 Position the equalizer beam on a 50-ton vertical hydraulic press.

4.3 Center the shop-made adapter (refer to the table of special tools in **"Specifications, 400"**) on the trimmed end of the equalizer beam bushing. Press the end bushing from the beam eye.

Installation

1. Using emery cloth, remove all scale, rust, or corrosion from the beam eyes. Inspect the equalizer beam eyes for cracks, gouges, or damage. Replace the equalizer beam if any of these conditions exist.
2. Using emery cloth, clean the outer sleeves of the new equalizer beam end bushings. Apply a thin coating of Texaco Compound L, or an equivalent rust preventive lubricant, to the surface of the outer sleeves on the new bushing.
3. Install the beam end bushings, (if using Owatonna tools, refer to **Fig. 3**):

   3.1 Fit the adapter clamp over the exposed rubber on the new bushing. Tighten the clamp nuts until the clamp is flush against the bushing outer sleeve.

   3.2 Install the receiving adapter on the receiving tube.

   3.3 Position the hydraulic ram and slide the pulling screw through the end bushing.

   3.4 Center the adapter clamp and bushing on the inboard side of the beam end.

   3.5 Install the adapter plate and secure it with the hexnut.

   IMPORTANT: Check that the new bushing and the installation tools are centered so that the bushing will clear the receiving tube when force is exerted against the beam.

   3.6 Tighten the speed nut and remove any slack in the assembly.

   3.7 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

   3.8 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely install the end bushing.

   NOTE: The pressure gauge on the pumping unit should read 27 580 to 37 920 kPa (4000 to 5500 psi) during installation. If the reading reaches the operating limit of 68 950 kPa (10,000 psi) and the bushing is not going into the beam end, check the alignment of the bushing, tooling, and hydraulic equipment. Installation is complete when the adapter clamp is flush against the beam.

   3.9 Install the equalizer beam ends on the axle beam hangers. For instructions, **refer to Subject 130.**

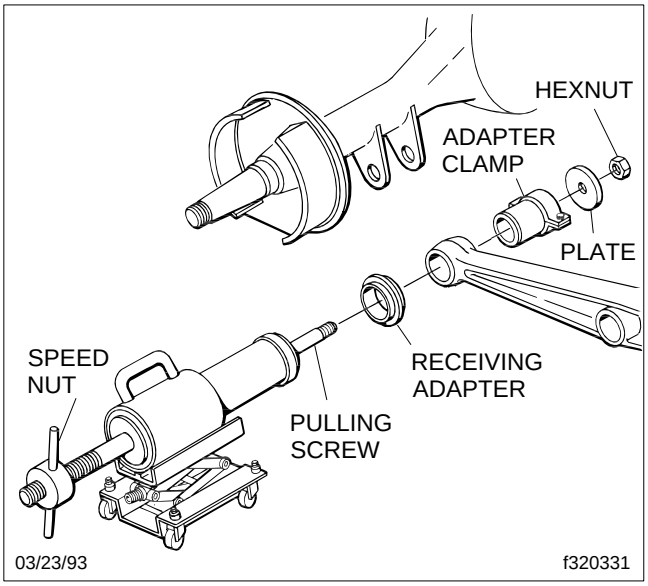


Fig. 3

4. Install the beam end bushings (if using shop-made adapters, see **Fig. 4**).

   4.1 Position the equalizer beam on a 50-ton hydraulic press.

   4.2 Using a sheave puller, compress the exposed rubber of the bushing until the puller jaws are flush against the end of the bushing outer sleeve.

   4.3 Position the shop-made adapter (refer to the table in **"Specifications, 400"**)

against the jaws of the sheave puller. Press the new bushing into the beam eye.

4.4 Install the equalizer beam. For instructions, **refer to Subject 130.**

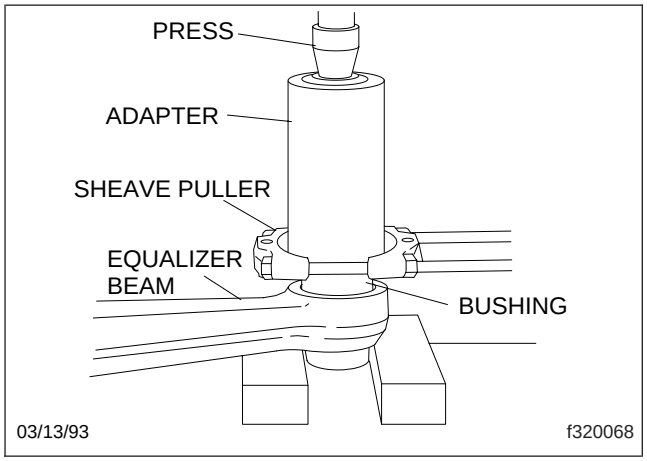


Fig. 4

Equalizer Beam Bar Pin/Bushing Assembly Removal, Installation, and Alignment

Removal

NOTE: From July 1995, most Hendrickson suspensions are manufactured with a bar pin-type bushing assembly that connects the equalizer beam to the axle. The bar pin/bushing assembly can be serviced without removing the brake assembly.

⚠ WARNING

Do not use a cutting torch to remove the equalizer beams from the beam hangers. The equalizer beams are heat-treated, and using a cutting torch could weaken them. This could result in a loss of vehicle control, possible personal injury, or property damage.

1. Shut down the engine and set the parking brake.
2. Chock the front tires.
3. Support the equalizer beams with jack stands.
4. Remove the four bolts attaching the equalizer beam to the saddle.
5. Apply a penetrating oil to the threads of the two 1-inch (25 mm) bolts and locknuts attaching each bar pin/bushing assembly to the axle brackets.
6. Remove the bolts. If the fasteners are rusted in place, an air hammer chisel may be used to loosen the bolts attaching the bar pin/bushing assembly to the axle brackets.

NOTE: The upper torque rods may have to be disconnected at the top of the axle, and the axle rotated to a more vertical position to assist in the removal of the equalizer beam from the axle bracket.

7. Remove the equalizer beam from the axle beam hangers.
8. The bar pin/bushing assemblies can be removed from the equalizer beams with Owatonna tools. To do so, follow Owatonna recommendations.
9. If shop-made tools are used, remove the bar pin/bushing assemblies from the beam ends as follows:
   - 9.1 Position the equalizer beam on a 50-ton vertical hydraulic press.
   - 9.2 Center the shop-made tool, and press the bar pin/bushing assembly from the beam end eye.

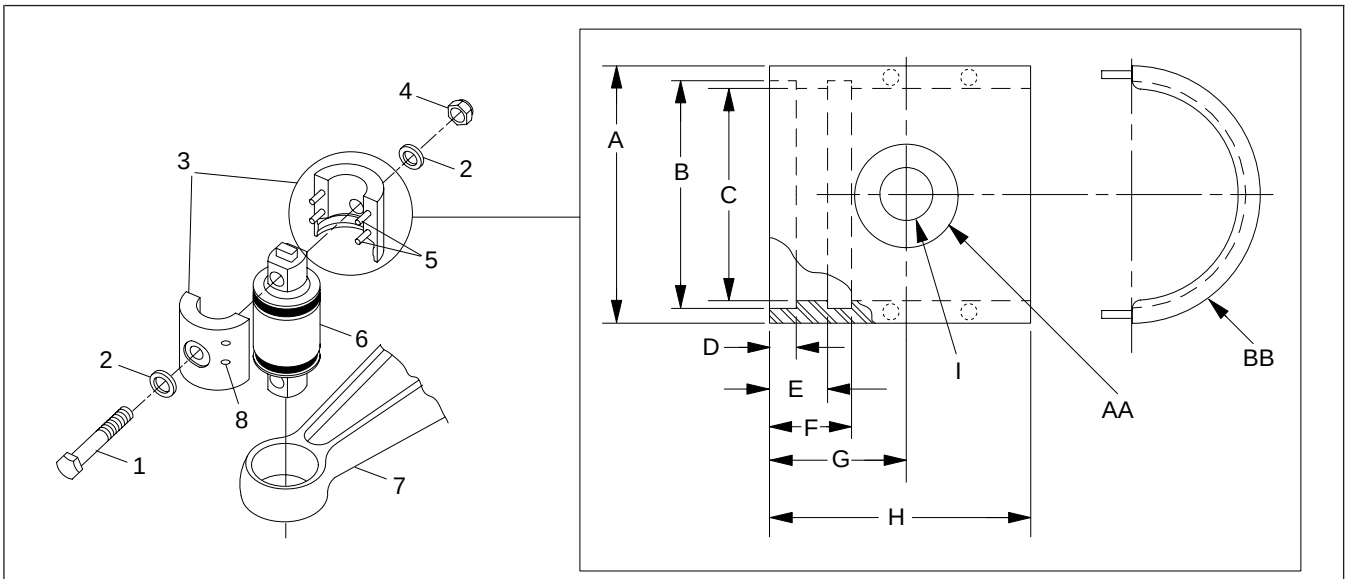
Installation

IMPORTANT: Do not reuse the old fasteners. Replace them during installation.

1. Using emery cloth, remove all scale, rust, or corrosion from the beam eyes. Inspect the equalizer beam eyes for cracks, gouges, or damage. Replace the equalizer beam if any of these conditions exist.
2. The outer metals of some Hendrickson rubber bushings are covered with a phosphate coating that acts as a rust preventive. This coating must be removed with emery cloth before installation. Also apply a coating of grease to the cleaned outer metals of the bar pin/bushing assembly, and to the beam end eyes to help when pressing the bar pin/bushing assembly into the beam end eye.
3. If using Owatonna tools, install the bar pin/bushing assemblies using Owatonna recommendations.
4. If using shop-made tools, create the needed assembly tool from a 5-inch (127 mm) length of 5-inch (127 mm) O.D. steel tubing with 1/2-inch (13 mm) wall thickness. See **Fig. 1**. The assembly tool must be split in half, then clamped or bolted together to compress the rubber to allow contact with the bushing outer metal.
   - 4.1 Position the equalizer beam on a 50-ton hydraulic press with the beam end bore squarely supported on the bed for safety and to avoid bending the equalizer beam.
   - 4.2 Before pressing the bar pin/bushing assembly, align the holes in the end of the bar pin/bushing assembly with the center line of the equalizer beam. This will help assembly into the axle brackets. Care should be taken during the assembly process to ensure the orientation of the bar pin/bushing assembly in the beam eye.

   NOTE: After installation, verify that the bar pin/bushing assembly is centered in the end of the beam.

Equalizer Beam Bar Pin/Bushing Assembly Removal, Installation, and Alignment



04/23/96 f320522

1. Bolt, 1" (25 mm)
2. Washer, 1" (25 mm) o.d.
3. Assembly Tool
4. Locknut
5. Alignment Pins
6. Bar Pin/Bushing Assembly
7. Equalizer Beam
8. Alignment Pin Hole

A. 5.0" (127 mm)
B. 4.43" (113 mm)
C. 4.12" (105 mm)
D. 0.50" (13 mm)
E. 1.07" (27 mm)
F. 1.54" (39 mm)
G. 2.62" (67 mm)
H. 5.0" (127 mm)
I. 1.0" (25 mm)

AA. Recess flat counter bore, 2.0" (51 mm) x 0.25" (6 mm) deep.
BB. Tool wall, 0.50" (13 mm), top view.
NOTE: Tool assembly to make use of 0.50" (13 mm) wall x 5.0" (127 mm) o.d. x 5.0" (127 mm) long steel tubing.

Fig. 1, Assembly Tool (exploded view, with manufacturing information)

5. Install the equalizer beam on the axle hangers.
6. Attach the bar pin/bushing assembly to the axle brackets. Tighten the 1-inch (25 mm) bolts 450 to 600 lbf·ft (610 to 813 N·m).

NOTE: Bar pin/bushing assembly kits are available with or without alignment shims.

7. Install the four bolts attaching the equalizer beam to the saddle. Tighten 225 to 275 lbf·ft (305 to 375 N·m).
8. Remove the jack stands.
9. Remove the chocks from the tires.

Alignment

For a detailed adjustment procedure, refer to Hendrickson's service literature, **Bar Pin Alignment Instructions, Technical Publication No. 17730-213**.

The instruction publication may be obtained from:

Hendrickson Truck Suspension Systems
1-630-910-2800
1-800-973-0360
(fax) 1-630-378-4849
800 South Frontage Road
Woodridge, IL 60517-4904

Equalizer Beam Rubber Center Bushing Removal and Installation

Removal

NOTE: If using Owatonna tools, removal of the equalizer beam is not required for removal or installation of the rubber center bushing.

1. Chock the front tires.
2. Raise the rear of the vehicle so that all weight is removed from the suspension. Block the axles and the frame with safety stands. Make sure the stands will securely support the weight of the axles and the frame.

NOTE: Do not raise the vehicle to the point where the weight of the suspension and axles hangs from the vehicle.

3. Remove the saddle cap nuts and washers from each side of the vehicle, and remove the saddle caps.
4. Raise the rear of the truck frame until the saddle studs clear the equalizer beam. Install safety stands under the frame.
5. Using a 2-1/2 inch diameter hole saw **(see Fig. 1),** cut out the end plug from the center bushing on each side of the suspension, and remove the crosstube.

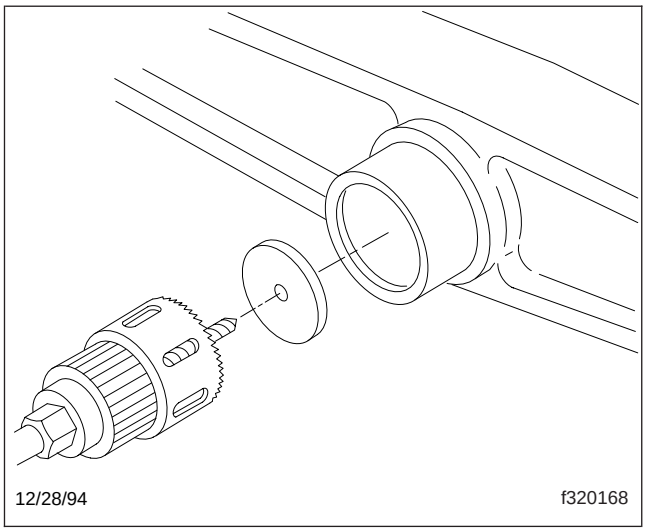


Fig. 1

⚠ CAUTION

CAUTION: Do not use a cutting torch to burn out the end plugs. The equalizer beams are heat treated, and the use of a cutting torch could weaken the beam.

6. On the inboard side of the equalizer beam, inspect the exposed edge of the bushing's outer sleeve.
7. Chisel or grind off any portion of the outer sleeve that has flared over the surface of the equalizer beam.
8. Remove the rubber center bushings (if using Owatonna tools, refer to **Fig. 2**).

   8.1 Position the hydraulic ram and slide the pulling screw through the center bushing.

   8.2 Install the center bushing removing adapter on the inboard side of the beam eye.

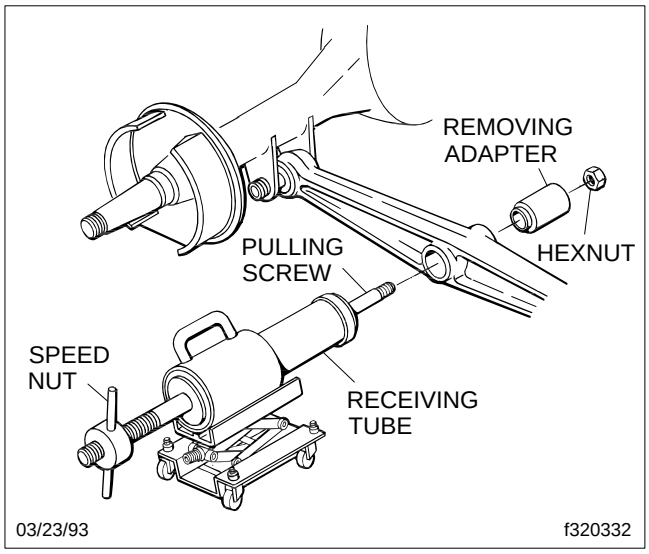


Fig. 2

IMPORTANT: Align the receiving tube so that the bushing will clear the edges of the tube when force is exerted against the beam. Align the removing adapter so that force is exerted only on the bushing to ensure a clean pull through the beam.

8.3 Install the hexnut on the pulling screw. Full thread engagement is needed.

Equalizer Beam Rubber Center Bushing Removal and Installation

8.4 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

8.5 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

8.6 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely remove the bushing.

NOTE: If the pressure gauge on the hydraulic pumping unit reads 68 950 kPa (10,000 psi) and the bushing has not broken loose, stop and check the alignment of the receiving tool and removal adapter. If both tools are aligned correctly, attach a sledging adapter on the speed nut end of the pulling screw. Maintaining hydraulic pressure, strike the sledging adapter with a heavy hammer. A loud noise followed by a sudden drop of the pressure gauge reading indicate that the bushing has broken loose.

9. If using shop-made adapters, remove the equalizer beams. For instructions, **refer to Subject 130.**

9.1 Position the equalizer beam on a 50-ton vertical hydraulic press.

9.2 Center the shop-made adapter (refer to the table in **"Specifications, 400"**) on the trimmed end of the equalizer beam bushing. Press the center bushing from the beam eye.

Installation

1. Using emery cloth, remove all scale, rust, or corrosion from the beam eyes. Inspect the equalizer beam eyes for cracks, gouges, or damage. Replace the equalizer beam if any of these conditions exist.

2. Using emery cloth, clean the outer sleeves of the new equalizer beam center bushings. Apply a thin coating of Texaco Compound L, or an equivalent rust preventive lubricant, to the surface of the outer sleeves on the new bushing.

3. Install the rubber center bushings (if using Owatonna tools, refer to **Fig. 3**).

3.1 Center the hydraulic ram and slide the pulling screw through the beam eye.

3.2 Position the bushing on the inboard side of the beam eye.

IMPORTANT: Center the new bushing to ensure a clean pull through the beam eye.

3.3 Fit the installing adapter over the inner sleeve and against the outer sleeve of the bushing.

3.4 Install the hexnut on the pulling screw. Full thread engagement is needed.

3.5 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

3.6 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

3.7 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely install the center bushing.

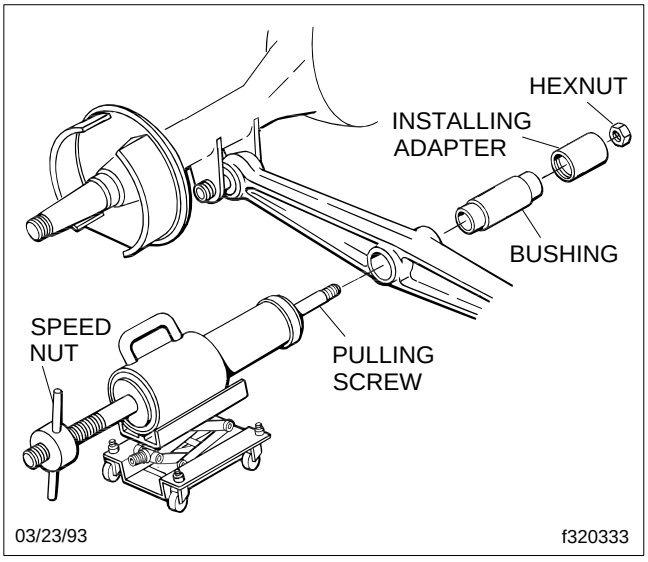


Fig. 3

NOTE: The pressure gauge on the pumping unit should read 27 580 to 37 920 kPa (4000 to 5500 psi) during installation. If the

reading reaches the operating limit of 68 950 kPa (10,000 psi) and the bushing is not going into the beam, check the alignment of the bushing, tooling, and hydraulic equipment. Installation is complete when the installing adapter is flush against the beam.

3.8 Position the crosstube in the center bushings.

⚠ WARNING

WARNING: Wear protective welding masks and gloves when welding. Failure to do so could result in personal injury due to the intensity of heat, sparks, and flying debris from the welding process.

3.9 Arc weld new end plugs to the tire side of each center bushing inner sleeve.

NOTE: Heat from welding the end plugs will not affect the beam or the new rubber bushings because of their distance from the point of welding.

4. Position the saddle caps on the saddle cap studs, then install the washers and new self-locking nuts. Tighten the nuts to the applicable torque in **"Specifications, 400."**

5. If using shop-made adapters, position the equalizer beam on a 50-ton hydraulic press.

5.1 Using standard center bushings with the end plugs welded in place, position the shop-made adapter (refer to the table in **"Specifications, 400"**) over the inner sleeve of the bushing. Check that the adapter bottoms against the bushing outer sleeve, then press the new bushing into the beam eye.

5.2 Install the equalizer beams. For instructions, **refer to Subject 130.**

Equalizer Beam Bronze Center Bushing Removal and Installation

Removal

NOTE: If using Owatonna tools, you can remove or install the bronze center bushing without removing the equalizer beam.

1. Chock the front tires.
2. Raise the rear of the vehicle so that all weight is removed from the suspension. Block the axles and the frame with safety stands. Make sure the stands will securely support the weight of the axles and the frame.

NOTE: Do not raise the vehicle to the point where the weight of the suspension and axles hangs from the vehicle.

3. Remove the saddle cap nut and washers from each side of the suspension, and remove the saddle caps.
4. Raise the rear of the truck frame until the saddle studs clear the equalizer beam. Install safety stands under the frame.
5. Using a 2-1/2 inch diameter hole saw, cut out the retaining disk from the center bushing on each side of the suspension, and remove the cross-tube.

⚠ CAUTION

CAUTION: Do not use a cutting torch to burn out the retaining disk. The equalizer beams are heat treated, and the use of a cutting torch could weaken the beam.

6. Remove the bronze center bushing (if using Owatonna tools, refer to **Fig. 1**).

   6.1 Position the hydraulic ram and slide the pulling screw through the center bushing.

   6.2 Install the center bushing removing adapter on the inboard side of the beam eye.

   IMPORTANT: Align the receiving tube so that the bushing will clear the edges of the tube when force is exerted against the beam. Align the removing adapter so that force is exerted only on the bushing to ensure a clean pull through the beam.

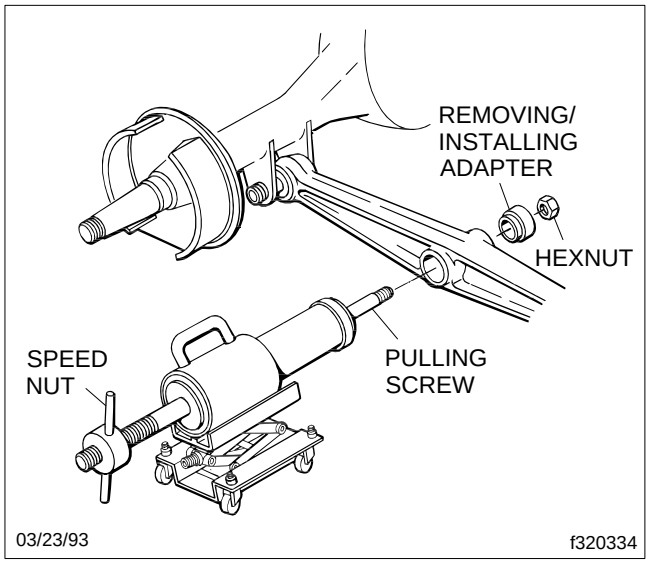


Fig. 1

   6.3 Install the hexnut on the pulling screw. Full thread engagement is needed.

   6.4 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

   6.5 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

   6.6 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely remove the center bushing.

   NOTE: If the pressure gauge on the hydraulic pumping unit reads 68 950 kPa (10,000 psi) and the bushing has not broken loose, stop and check the alignment of the receiving tool and removal adapter. If both tools are aligned correctly, attach a sledging adapter on the speed nut end of the pulling screw. Maintaining hydraulic pressure, strike the sledging adapter with a heavy hammer. A loud noise followed by a sudden drop of the pressure gauge reading indicates that the bushing has broken loose.

7. If using shop-made adapters, remove the equalizer beams. For instructions, **refer to Subject 130.**

Equalizer Beam Bronze Center Bushing Removal and Installation

7.1 Position the equalizer beam on a 50-ton vertical hydraulic press.

7.2 Center the shop-made adapter (refer to the table in **"Specifications, 400"**) on the center bushing. Press the bushing from the beam eye.

Installation

1. Using emery cloth, remove all scale, rust, or corrosion from the beam eyes. Inspect the equalizer beam eyes for cracks, gouges, or damage. Replace the equalizer beam if any of these conditions exist.
2. Using emery cloth, clean the outer sleeves of the new equalizer beam center bushings. Apply a thin coating of Texaco Compound L, or an equivalent rust preventive lubricant, to the surface of the outer sleeves on the new bushing, and to the inside surface of the beam eye.
3. Position the bushing on the equalizer beam eye.
4. Install the bronze center bushings (if using Owatonna tools, refer to **Fig. 2**):

4.1 Center the hydraulic ram and slide the pulling screw through the beam eye.

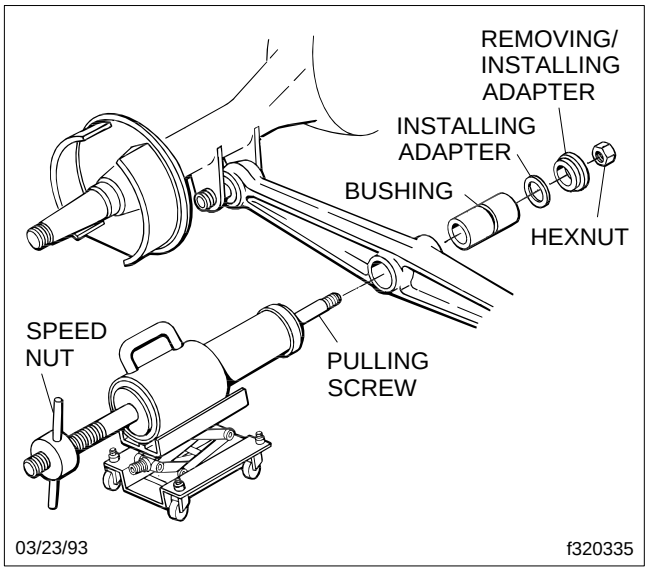


Fig. 2

4.2 Position the bushing on the inboard side of the beam eye. Check that the grooves of the bushing are aligned with the vertical centerline of the equalizer beam **(see Fig. 3).**

4.3 Fit the installing adapter and the removing/installing adapter against the outer sleeve of the bushing. Make sure the deep ridge on the installing adapter is positioned against the bronze bushing **(see Fig. 4).**

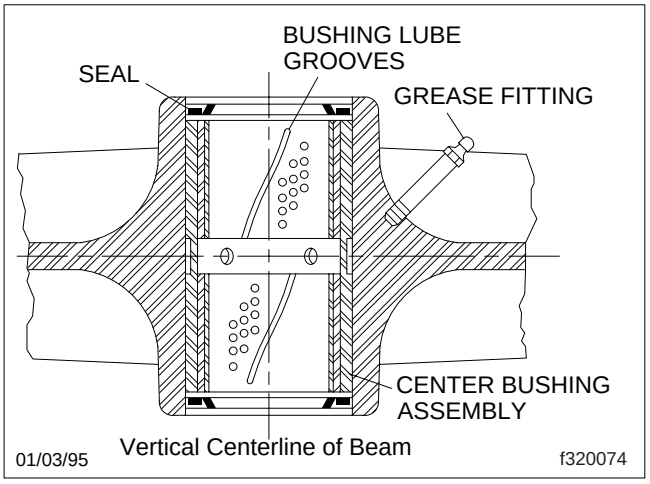


Fig. 3

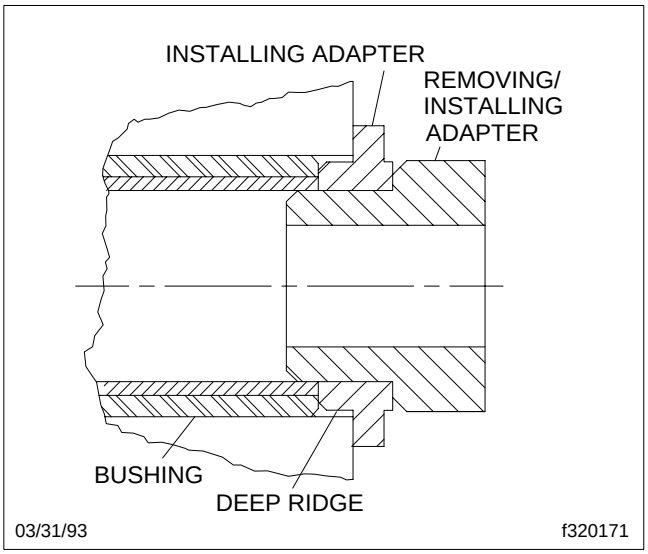


Fig. 4

4.4 Install the hexnut on the pulling screw. Full thread engagement is needed.

Equalizer Beam Bronze Center Bushing Removal and Installation

4.5 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

4.6 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

4.7 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely install the center bushing.

NOTE: The pressure gauge on the pumping unit should read 27 580 to 37 920 kPa (4000 to 5500 psi) during installation. If the reading reaches the operating limit of 68 950 kPa (10,000 psi) and the bushing is not going into the beam, check the alignment of the bushing, tooling, and hydraulic equipment. Installation is complete when the installing adapter is flush against the beam.

4.8 On the inboard side of the beam, position a grease seal and installing adapter against the center bushing. Make sure the shallow end of the adapter is against the grease seal **(see Fig. 5).** Using a hammer, tap the installing adapter until it is flat against the beam. Using the same procedure, install a grease seal on the outboard side of the beam.

5. If using shop-made adapters, position the equalizer beam on a 50-ton hydraulic press.

5.1 Center the new bushing in the beam eye. Using a standard bushing driver, press the bushing in until there is equal spacing between both bushing ends and the sides of the beam eye.

5.2 Install the new grease seals (with the seal lips facing out).

NOTE: Check that the new seals are 1/6 inch (4 mm) inside the beam hub surface to ensure clearance and protection of the seals when the saddle cap is installed.

6. Apply a thin coating of multipurpose chassis grease to the inside surface of the center bushing. Slide the bushing center sleeve into the bushing.

7. Install the grease fitting into the beam hub. Rotate the center sleeve and apply multipurpose chassis grease in the grease fitting. Lubricate until clean grease appears at both ends of the grease seals.

8. Install the crosstube.

9. Install the saddle caps or the equalizer beam (if removed) on the axle beam hangers. For instructions, **refer to Subject 130.**

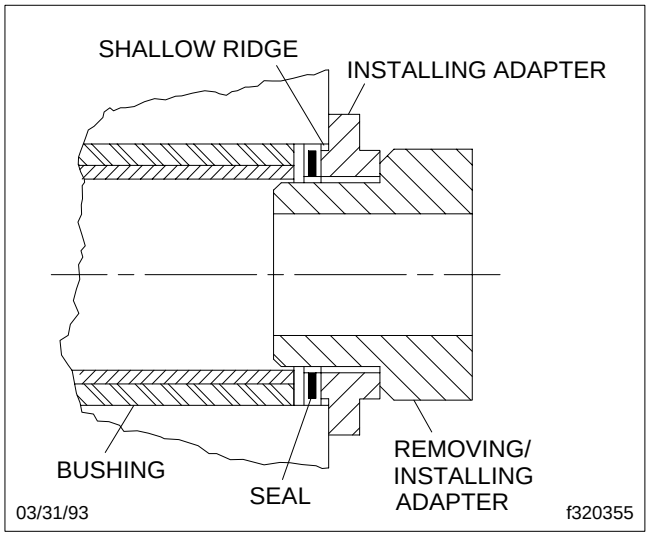


Fig. 5

Torque Rod Removal, Bushing Replacement, and Installation

Removal

IMPORTANT: To ensure that the required tools are available, see the table of special tools in **"Specifications, 400,"** before beginning these procedures. Special tools are available from the Owatonna Tool Company, Owatonna, Minnesota, or an affiliated dealer.

⚠ WARNING

WARNING: When the torque rods are disconnected from the axle brackets, the axles become free to pivot on the equalizer beam end bushings. Keep clear of the beam hangers and beam ends to avoid possible injury.

1. On fore-and-aft torque rods, remove the bolts and nuts from the torque rod axle brackets, and the crossmember mounting brackets **(see Fig.1).** Remove the torque rods.

   On transverse torque rods, remove the nuts and washers from the axle brackets, and remove the bolts and nuts from the frame rail mounting brackets **(see Fig.1).** Remove the torque rods.

NOTE: If necessary, use an impact hammer and tap the top of the axle bracket to disengage the rod stud from the axle bracket.

2. Inspect the torque rods. If bent or cracked, replace. Check the torque rod bushings. If one of the bushings is loose or damaged, replace both of the bushings.
3. Position the press plate on the hydraulic press. Check that the small counterbore of the plate hole is facing up.

NOTE: Some tapered stud torque rod bushings have a large non-removable washer on the stud that will not fit though the press plate hole. Loosen the press plate capscrews and separate the halves **(see Fig.2)** until the washer clears the counterbore, and the torque rod sets on the press plate. Tighten the capscrews until the press plate halves are closed.

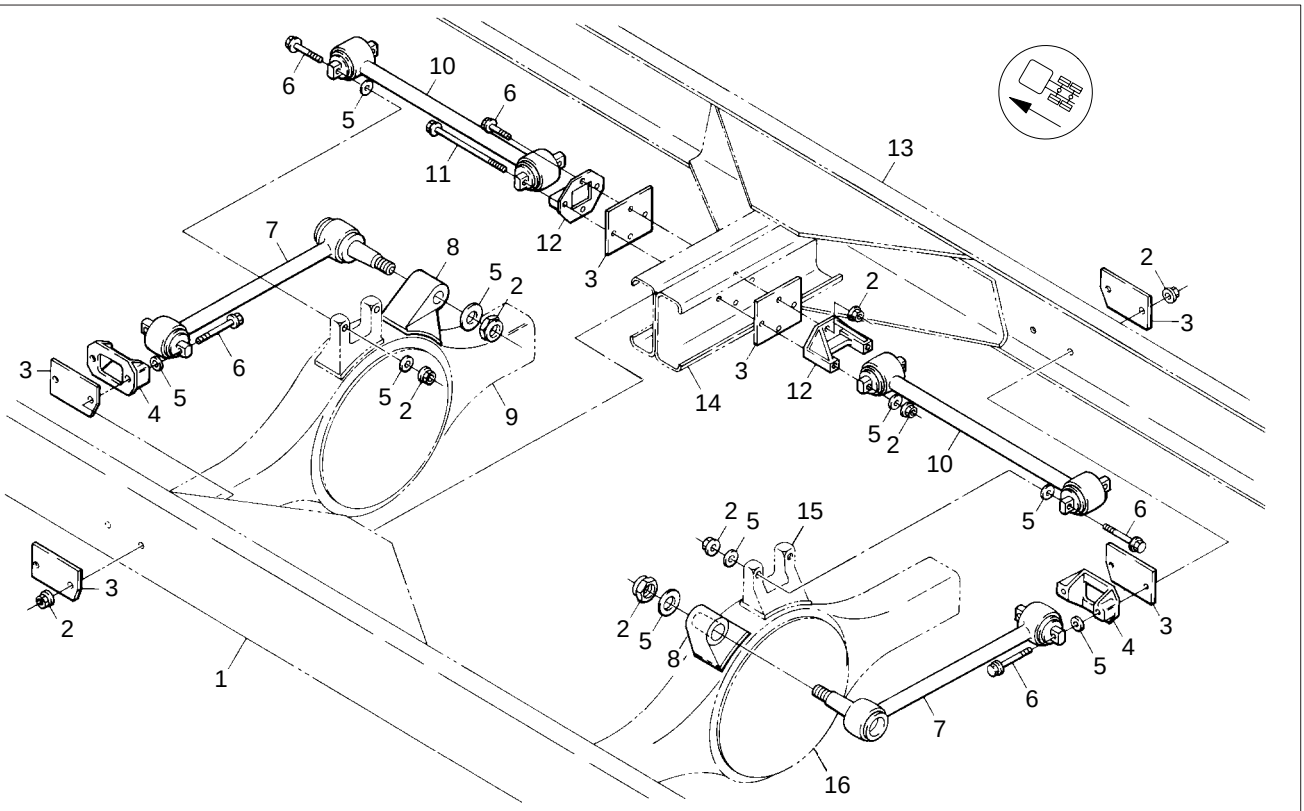
4. Position the tapered stud removal tool (using the end with the larger inside diameter) on the torque rod stud. Apply lubricating oil **(see Fig.3),** then press the stud out of the bushing.
5. Position the bushing remover/replacer tool (using the end with the larger outside diameter) on the bushing. Install the cap, then apply lubricating oil to the torque rod bushing.
6. Press the rubber bushing out of the torque rod eye.
7. Position the straddle mount end of the torque rod into the hole of the press plate. Tighten the press plate capscrews.
8. Position the straddle mount pin remover on the straddle mount pin **(see Fig.4).**
9. Apply lubricating oil to the straddle mount pin. Press the straddle mount pin out of the bushing.
10. Position the end of the rubber bushing remover/replacer tool (using the end that has the larger outside diameter) on the bushing. Install the cap, then apply lubricating oil to the torque rod bushing.
11. Press the rubber bushing out of the torque rod eye.

Installation

1. Remove all dirt and grease from the torque rod ends. Apply lubricant on the new bushings and in the torque rod eyes.
2. Position the press plate on the hydraulic press. Check that the small counterbore of the plate hole is facing up.
3. Position the new bushing on the tapered stud of transverse torque rods. Position the clamp and tighten it to compress the rubber **(see Fig.5).**
4. Place the torque rod end, the bushing, and the clamp on the press plate.
5. Place the remover/replacer tool **(see Fig.6)** and cap on top of the clamping tool and press the bushing in the torque rod end. Check that the bushing sleeve protrudes equally on each side of the torque rod end.
6. On straddle mount end assemblies, align the clamping tool on the bushing **as shown in Fig.7.** Tighten the clamp to compress the rubber of the new straddle mount bushing.

NOTE: When tightening the clamp, make sure that the position of the bushing pin is at a right

Torque Rod Removal, Bushing Replacement, and Installation



1. Left−Hand Frame Rail
2. Flanged Hexnut
3. Spacer
4. Transverse Torque Rod Mounting Bracket
5. Hardened Washer
6. Flanged Hexbolt
7. Transverse Torque Rod
8. Transverse Torque Rod, Axle Mounting Bracket
9. Forward Rear−Axle
10. Fore and Aft Torque Rod
11. Capscrew
12. Fore and Aft Torque Rod Mounting Bracket
13. Right−Hand Frame Rail
14. Crossmember
15. Fore and Aft Torque Rod, Axle Mounting Bracket
16. Rearmost Axle

03/23/93 f320172

Fig. 1, Torque Rod Mounting Assembly

angle to the center line of the torque rod shank **(see Fig.8).**

7. Place the torque rod end, the bushing, and the clamp on the press plate.
8. Using the larger end of the remover/ replacer tool, position the tool and cap on top of the clamp assembly.
9. Press the bushing in the torque rod end. Check that the bushing's outer sleeve protrudes equally on each side of the torque rod end.
10. Install the fore-and-aft torque rods **(refer to Fig.1).**
    - 10.1 Position a torque rod straddle mount pin in the forward-rear axle bracket. Install the bolts through the axle bracket and the straddle mount pin. Install a spacer and

Torque Rod Removal, Bushing Replacement, and Installation

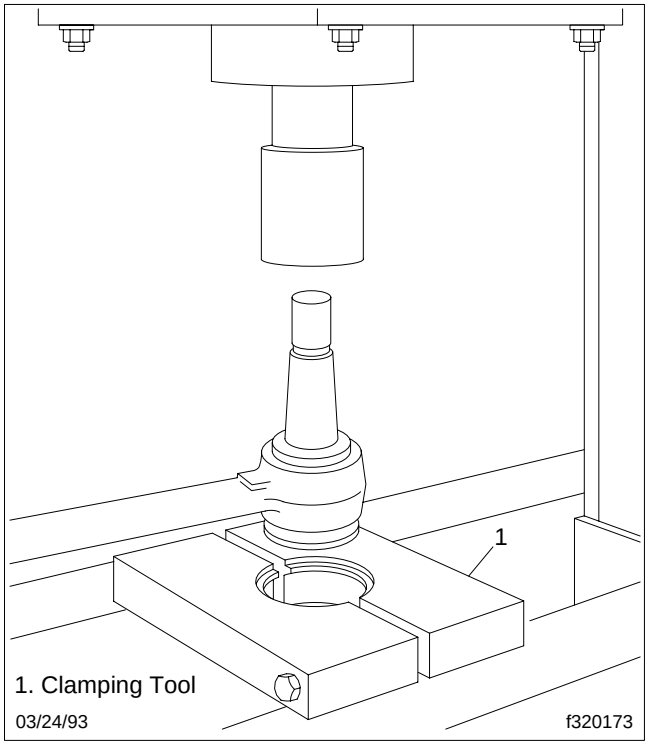


Fig. 2

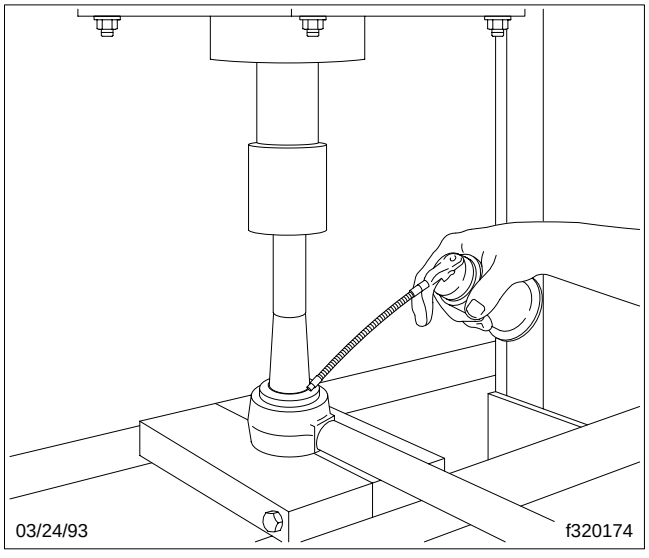


Fig. 3

nut on each bolt, and tighten the nut 260 N·m (190 lbf·ft).

10.2 Position a torque rod straddle mount pin in the rearmost axle bracket. Install the

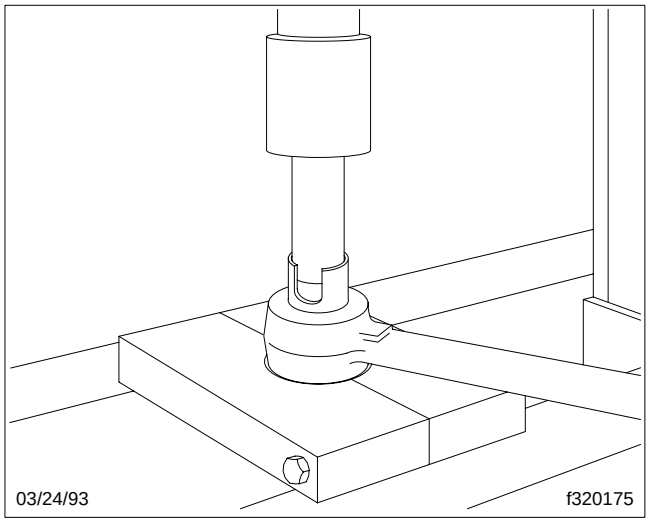


Fig. 4

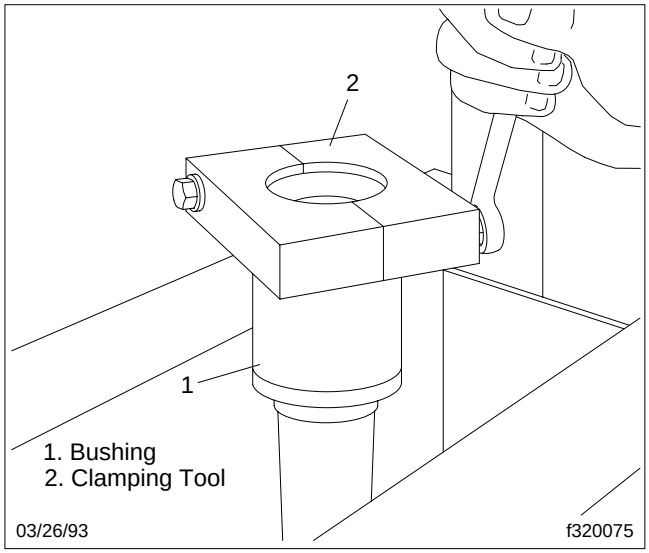


Fig. 5

flanged bolts through the axle bracket and the straddle mount pin. Install a spacer and nut on each bolt, and tighten the nut 260 N·m (190 lbf·ft).

10.3 Position a torque rod spacer and straddle mount bracket on each side of the cross-member. Insert bolts through the upper and lower holes of the forward mounting bracket. Install the nuts and tighten them 130 N·m (95 lbf·ft).

Torque Rod Removal, Bushing Replacement, and Installation

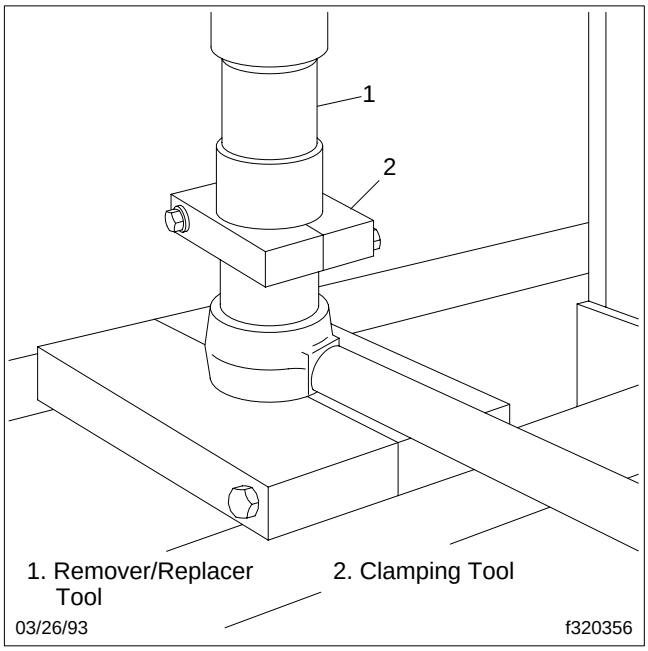


Fig. 6

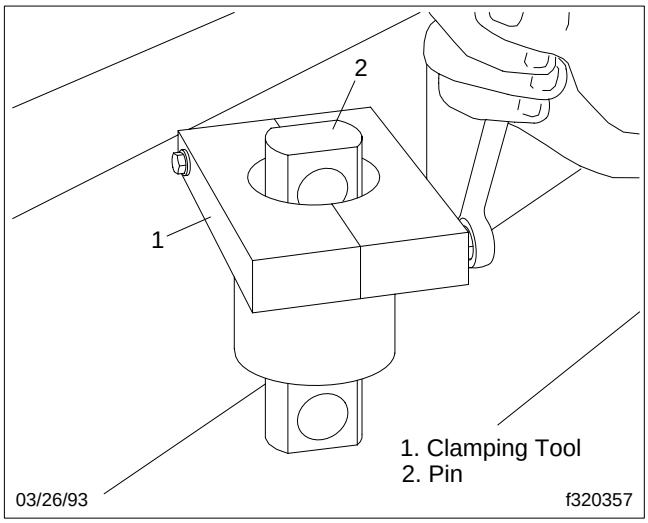


Fig. 7

10.4 Position the straddle mount pin of the forward torque rod in the mounting bracket. Insert bolts through the forward pin, both bracket assemblies, and the straddle mount pin of the rear torque rod. Install the nuts and bearing washers. Tighten the nuts 260 N·m (190 lbf·ft).

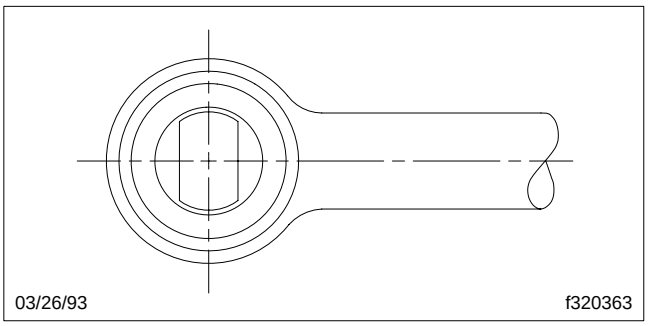


Fig. 8

11. Install the transverse torque rods **(refer to Fig.1).**

    11.1 Check that the tapered stud end and the tapered stud bracket hole are clean. Lubricate the tapered stud ends with SAE 20 oil.

    11.2 Install the tapered stud in the axle bracket. Install a washer and nut. Tighten the nut 235 to 305 N·m (175 to 225 lbf·ft).

    11.3 Align the straddle mount end, the mounting bracket, and the spacer against the inside frame rail.

    11.4 On the inboard side of the frame rail, install the bolts through the mounting assembly and the frame rail.

    11.5 On the outboard side of the frame rail, install a spacer over the mounting bolt studs. Install the nuts and tighten them 260 N·m (190 lbf·ft).

12. Check the axle pinion angle. For instructions, **refer to the driveline components group.**

Specifications

Torque Values		
Description	**Size**	**Torque lbf·ft (N·m)**
Top Pad to Spring Aligning Setscrew (RT/RTE)	—	135–200 (100–150)
Top Pad Nut (RT/RTE)	—	275–400 (375–542)
U-Bolt High Nuts (U/UE)	7/8–14	Stage 1: Hand tighten
		Stage 2: 60 (81) *
		Stage 3: 200 (271) *
		Stage 4: 420 to 500 (571 to 680) *
Spring Pin Locknut	1/2–13	45–63 (61–85)
Torque Rod Straddle Mount Nut	5/8–11	190 (260)
Torque Rod Stud Locknut	1-1/4–12	175–225 (235–305)
Saddle Cap Stud	7/8–14	55–65 (75–90)
	3/4–16	
Saddle Cap Locknut: RT/RTE	7/8–14	225–275 (305–373)
Saddle Cap Locknut: U/UE	3/4–16	125–145 (169–197)
Adapter-Type Beam End Locknut	3/4–16	210–240 (285–325)
Spring Center Bolt	7/16–20	50–60 (70–80)
	1/2–20	90–100 (65–75)
	1/2–13	
Rebound Spacer Locknut	1/2–13	38–45 (51–61)
Spring Alignment Clip	—	15 (20)
Fore and Aft Torque Rod Mount Nut	—	95 (130)

* Tighten in a diagonal pattern as shown in **Fig. 1**.

Table 1, Torque Values

Shop-Made Adapters		
Tool Number	**Dimensions**	**Usage**
1	4-1/4 inch o.d. by 4 inch	Beam End Bushing Removal
2	4-1/2 inch o.d. by 4 inch	Beam End Bushing Installation
3	4-5/8 inch o.d. by 7 inch	Beam Center Bushing Removal and Installation

Table 2, Shop-Made Adapters

Special Tools (Owatonna Tool Company)		
Part Number	**Tool**	**Usage**
1745	Adapter Puller Set	Adapter-Type End Support Removal
1761	Torque Rod Set	Torque Rod Bushing Removal and Installation
28536	Installing Adapter (5-3/4" o.d.)	Bronze Center Bushing and Seal Removal and Installation
44119	Receiving Tube	Center and End Bushing Removal and Installation

Specifications

Special Tools (Owatonna Tool Company)		
Part Number	**Tool**	**Usage**
45052	Adapter Clamp	End Bushing Installation
51678	80-Ton Hydraulic Ram	All Operations
51695	Jack	All Operations
206459	Plate	End Bushing Installation
302018	Spacer (3 qty.)	Center and End Bushing Removal and Installation
302019	Receiving Adapter	End Bushing Removal and Installation
302023	Pulling Screw	All Operations
302024	Removing and Installing Adapter	Bronze Center Bushing Removal and Installation
302026	Installing Adapter	Rubber Center Bushing Removal and Installation
302027	Removing Adapter	Rubber Center Bushing Removal and Installation
302028	Hexnut	All Operations
302029	Speed Nut	All Operations
302030	Removing Adapter	End Bushing Removal and Installation

Table 3, Special Tools (Owatonna Tool Company)

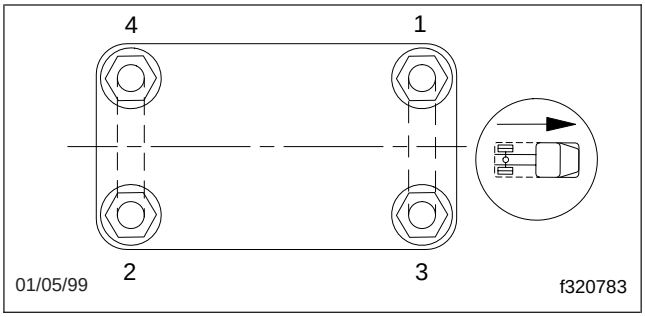


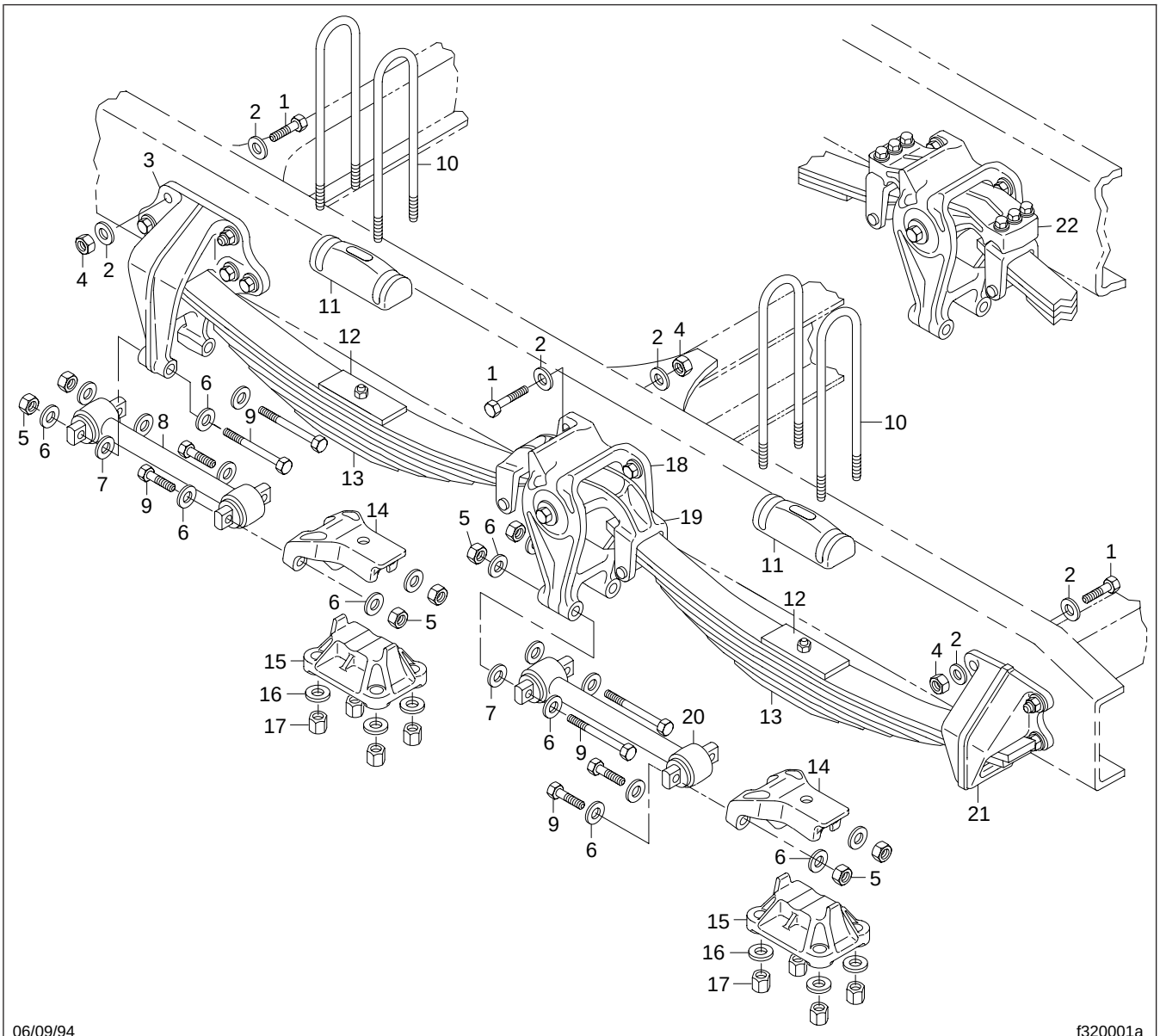
Fig. 1, Tightening Pattern for U-Bolt High Nuts

General Description

The tandem-axle rear spring suspension **(Fig. 1)** uses a six-point equalizing leaf spring design, which compensates for axle articulation, from side to side, and front to rear. Four semi-elliptical spring assemblies are attached to the axles with U-bolts. On both sides of the vehicle, the forward end of the forward spring and the rear end of the rear spring ride in aluminum brackets that are mounted on the frame rails. Steel wear shoes are cast into each bracket.

At the center, between the forward and rear springs, the springs ride on an equalizer, which pivots on a sleeve in the equalizer bracket. Equalizer travel is stopped when the top of the equalizer and the equalizer bracket make contact. Each axle is held in alignment by a pair of radius rods that extend forward from the axle seats to the forward spring brackets for the forward-rear axle, and to the equalizer brackets for the rearmost axle.

General Description

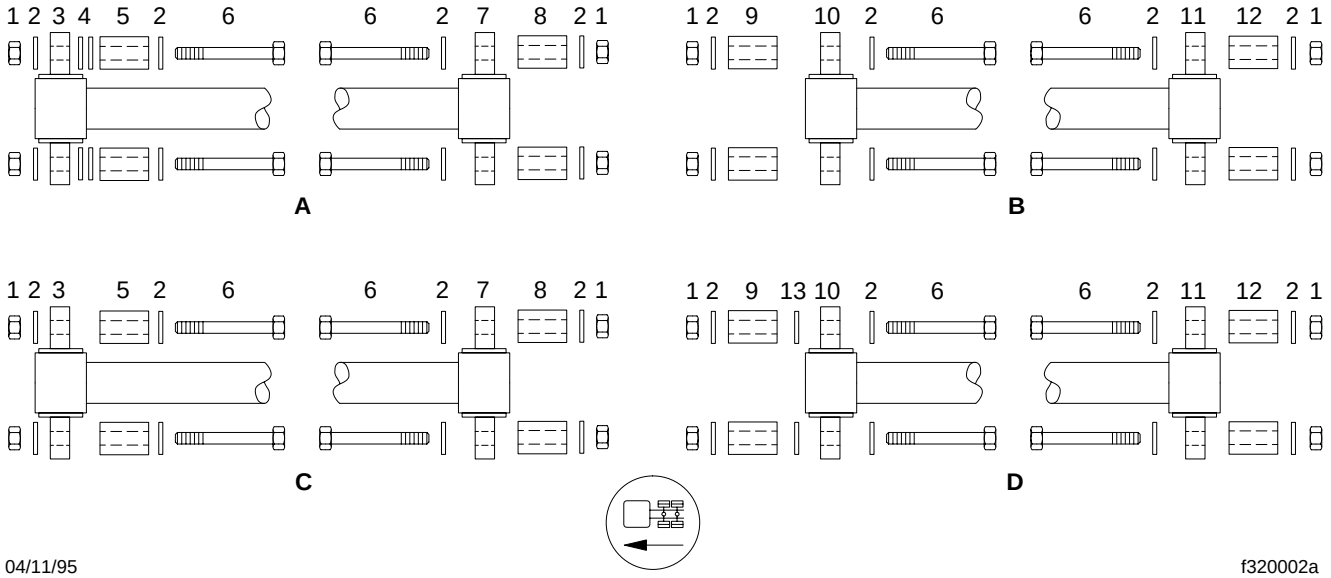


1. Suspension Bracket Hexbolt
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Radius Rod Hex Locknut
6. Hardened Washer
7. Axle Alignment Washer
8. Forward Radius Rod
9. Radius Rod Hexbolt
10. U-Bolt
11. U-Bolt Pad
12. Spring Liner
13. Leaf Spring Assembly
14. Spring Seat
15. U-Bolt Retainer
16. Hardened Washer
17. U-Bolt High Nut
18. Equalizer Bracket
19. Equalizer, One-Piece (tandem drive axles)
20. Rear Radius Rod
21. Rear Spring Bracket
22. Equalizer, Three-Piece (tag or pusher axle)

Fig. 1, Tandem-Axle Spring Suspension

Radius Rod Removal and Installation

Removal (See Fig. 1)



A. Forward Right-Side Radius Rod
B. Rear Right-Side Radius Rod
C. Forward Left-Side Radius Rod
D. Rear Left-Side Radius Rod

1. Hex Locknut
2. Hardened Washer
3. Forward Radius Rod Front Pin
4. Alignment Washers (install only on one side of front axle; right-side installation shown)
5. Forward Spring Bracket
6. Hexhead Bolt
7. Forward Radius Rod Rear Pin
8. Forward Axle Seat
9. Equalizer Bracket
10. Rear Radius Rod Front Pin
11. Rear Radius Rod Rear Pin
12. Rear Axle Seat
13. Alignment Washer (install only on one side of rear axle; left-side installation shown)

Fig. 1, Radius Rod Attachment (top view)

1. Apply the parking brakes, and chock the tires.
2. Note the number of axle alignment washers (Ref. 4) at the forward end of each radius rod that is being removed.
3. Remove the fasteners that attach the radius rod to the forward spring bracket or equalizer bracket, and to the axle seat.
4. Remove the radius rod and any axle alignment washers.

Installation (See Fig. 1)

IMPORTANT: At all points where steel parts (including bolts, washers, and nuts) contact aluminum brackets, apply Alumilastic compound, or an equivalent, on the mating surfaces.

⚠ CAUTION

CAUTION: Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the suspension.

If installing forward and rear radius rods, install the forward radius rod before installing the rear radius rod.

1. If installing a forward radius rod, place the radius rod front pin on the front side of the forward spring bracket, and place the radius rod rear pin in front of the axle seat.

   If installing a rear radius rod, place the radius rod pins between the rear side of the equalizer bracket and the front side of the axle seat.

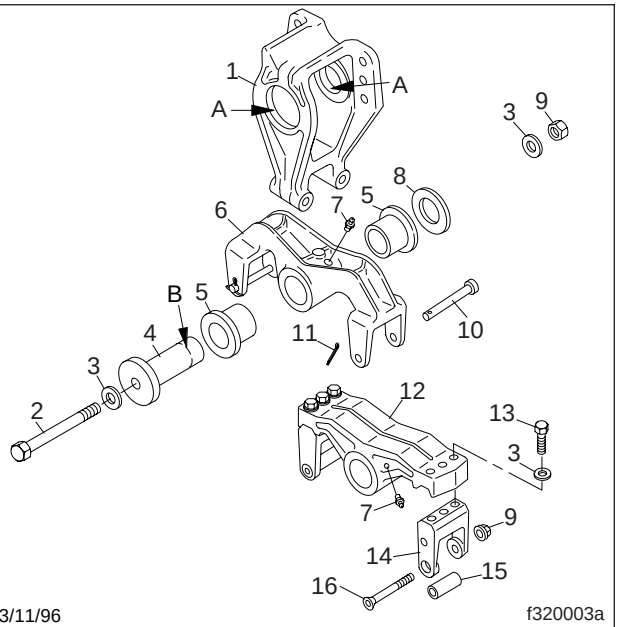
Radius Rod Removal and Installation

2. Install a hexhead bolt with a hardened washer through each end of the radius rod rear pin and the axle seat ears. Install the hardened washers and locknuts.
3. If installing a forward radius rod, install any previously removed axle alignment washers between the radius rod front pin and the forward spring bracket. Install the hexhead bolts, hardened washers, and locknuts.

   If installing a rear radius rod, install any previously removed axle alignment washers between the radius rod front pin and the equalizer bracket. Install the hexhead bolts, hardened washers, and locknuts.
4. Tighten the radius rod locknuts to the torque value in **Specifications, 400**.
5. After all of the radius rods are installed, check the rear axle alignment. For instructions, refer to **Group 35**. If necessary, adjust the axle alignment, using the instructions in **Subject 140**.

Equalizer Removal, Inspection, and Installation

Removal (See Fig. 1)



A. Apply Loctite here.
B. No grease here.
1. Equalizer Bracket
2. Hexbolt
3. Bearing Washer
4. Cap and Tube Assembly
5. Equalizer Assembly Bushing
6. Equalizer, One-Piece (tandem drive axles)
7. Grease Fitting
8. Wear Washer(s)
9. Locknut
10. Spring Retainer Pin
11. Cotter Pin
12. Equalizer, Three-Piece (tag or pusher axle)
13. Capscrew
14. Wear-Shoe Side-Restraint
15. Side-Restraint Sleeve
16. Flathead Bolt

Fig. 1, Equalizer Assembly

1. Chock the front tires.
2. Raise the rear of the vehicle, and block the axles with safety stands. Raise the vehicle frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Make sure the stands will securely support the weight of the axles and frame. To allow access to the equalizer, remove the wheel assemblies on that side, using the instructions found in **Group 40**.
3. If removing an equalizer from a vehicle with two drive axles, remove the cotter pin from the outboard end of each spring retainer pin, then remove the retainer pins.

   If removing an equalizer from a vehicle with a pusher or tag axle, remove the nuts from the flathead bolts in the wear-shoe side-restraints, on each end of the equalizer. Remove the flathead bolts and side-restraint sleeves. Remove the six capscrews and washers, and remove both wear-shoe side-restraints from the equalizer.
4. Remove the cap and tube assembly locknut, inboard bearing washer, bolt, and outboard bearing washer.
5. Insert a bar between the bottom of the equalizer and the equalizer bracket. Gently lever the weight of the equalizer off the cap and tube assembly. Insert a piece of barstock through the inboard cap and tube assembly bolt hole, and lightly tap the cap and tube assembly out of the equalizer.
6. Remove the equalizer from the equalizer bracket. Remove the wear washer(s) and equalizer bushings from the equalizer.

Inspection

1. Thoroughly clean the equalizer with steam or a hot soap solution. Inspect it for wear, cracks, or other damage. Replace the equalizer if any of these conditions are present.

⚠ WARNING

WARNING: Replace a worn or damaged equalizer. A broken equalizer could cause a loss of vehicle control, resulting in personal injury or property damage.

2. Inspect the equalizer bushings, cap and tube assembly, and the equalizer bracket. If wear, cracks, or other damage are present, replace the bushings, cap and tube assembly, or bracket.

Installation (See Fig. 1)

1. Apply a thin film of multipurpose chassis grease to the outside of the equalizer bushings, then install the bushings in the equalizer.

NOTE: The equalizer is *not* symmetrical. To ensure that the equalizer is installed in the proper direction, an arrow is cast into its top surface.

Equalizer Removal, Inspection, and Installation

2. Install the equalizer in the equalizer bracket. Make sure that the arrow cast into the top of the equalizer is pointing toward the frame rail. **See Fig. 2.**

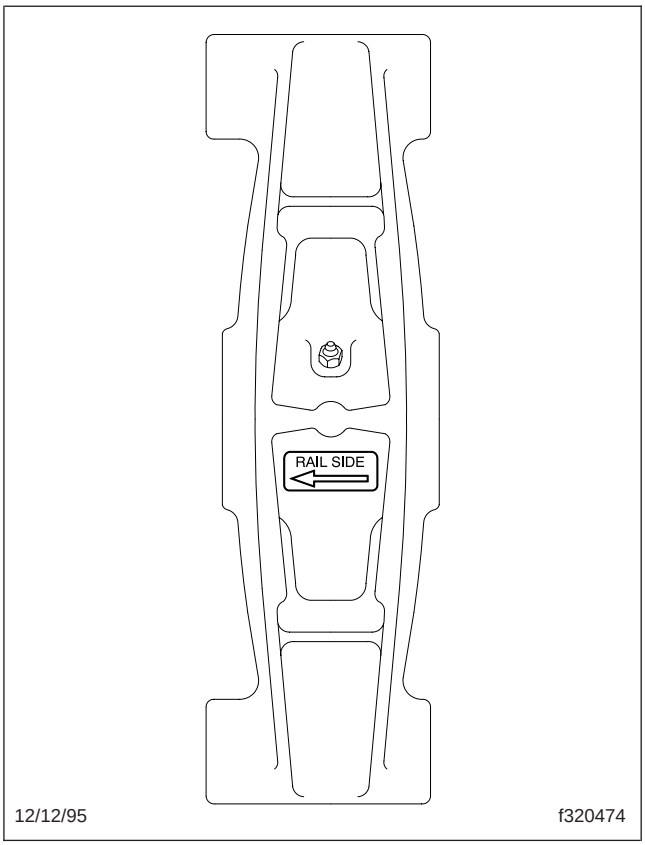


Fig. 2, Equalizer Marking

NOTE: The next four steps must be completed before the Loctite begins to cure (approximately 5 to 10 minutes).

IMPORTANT: Be careful to prevent grease from contacting the inboard surface of the cap and tube assembly, where the Loctite is applied.

3. Apply Loctite 680 to both interior surfaces of the equalizer bracket, where the cap and tube assembly is inserted. Apply multipurpose chassis grease to the cap and tube assembly, except the last inch which connects to the equalizer bracket. **See Fig. 1 ,** Ref. B. Start the cap and tube assembly into the equalizer, through the equalizer bracket.
4. Push the cap and tube assembly part way through the equalizer, then place the wear washer(s) between the inboard equalizer bushing and the equalizer bracket. Push the cap and tube assembly the rest of the way into the equalizer bracket.
5. Place the outboard bearing washer on the equalizer cap and tube assembly bolt, and install the bolt in the cap and tube assembly.
6. Install the inboard bearing washer and locknut on the cap and tube assembly bolt. Tighten the locknut to the torque value in **Specifications, 400**.
7. Lubricate the equalizer assembly by applying multipurpose chassis grease at the grease fitting. Lubricate with a hand gun or pressure gun until grease is forced past the bushing seals, or if equipped with a pressure-relief grease fitting, until grease is forced out from the base of the pressure relief fitting.
8. If installing an equalizer on a vehicle with two drive axles, apply Alumilastic compound, or an equivalent, to the spring retainer pins; then install them from the inboard side. Be sure the hooked ends of the spring leaves are above the retainer pins. Install a cotter pin in the outboard end of each retainer pin, and lock it in place.

   If installing an equalizer on a vehicle with a pusher or tag axle, apply Alumilastic compound, or an equivalent, to the surfaces where the wear-shoe side-restraints contact the equalizer. Attach the side-restraints to the equalizer, offsetting them toward the inboard side of the equalizer. Tighten the equalizer wear-shoe capscrews to the torque value in **Specifications, 400**. Install the side-restraint sleeves and flathead bolts in the wear-shoe side-restraints. Be sure the hooked ends of the spring leaves are above the side-restraint sleeves. Install the nuts, and tighten them to the applicable torque value in **Specifications, 400**.

⚠ CAUTION

CAUTION: Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel contact each other, could lead to corrosion of the metals, resulting in suspension damage.

9. Install the wheel assemblies, using the instructions found in **Group 40**. Remove the safety stands from under the frame and axle, and lower the vehicle.
10. If the radius rods have been loosened, or the equalizer bracket has been removed, check the rear axle alignment. For instructions, refer to **Group 35**. If necessary, adjust the axle alignment using the instructions in **Subject 140**.

Replacement (See Fig. 1)

⚠ WARNING

Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

1. Chock the front tires.
2. Raise the frame so that all weight is removed from the leaf springs; then block the frame with safety stands. Raise the rear axle until the spring no longer contacts the spring bracket wear shoes and the spring retainer pin (or side-restraint sleeve); then block the axle. Make sure the stands will securely support the weight of the axles and frame. To access the spring assembly, remove the wheel assembly. See **Group 40** for instructions.
3. If equipped with two drive axles, remove the cotter pin from the spring retainer pin on the end of the equalizer where the spring is being replaced. Drive the spring retainer pin out of the equalizer.

   If equipped with a pusher or tag axle, remove the nut from the flathead bolt on the end of the equalizer where the spring is being replaced. Remove the bolt and the side-restraint sleeve from the wear-shoe side-restraint.
4. Remove the U-bolt high nuts, hardened washers, U-bolt retainer, U-bolts, and upper U-bolt pad.
5. Remove the spring assembly by lifting it off the axle seat, then moving it toward the equalizer, out of the forward or rear spring bracket.
6. Using chassis grease, lubricate the new spring assembly where the ends will contact the stationary wear shoes in the spring bracket and equalizer.
7. Place the new spring assembly in the spring bracket and on the axle seat. Make sure the spring center-bolt head seats in the axle seat hole.
8. If the upper U-bolt pad is aluminum, apply Alumilastic compound, or an equivalent, to those areas of the pad that will come in contact with the U-bolts and with the upper spring leaf.

⚠ CAUTION

Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel contact each other, could lead to corrosion of the metals, resulting in suspension damage.

9. Place the upper U-bolt pad on the spring assembly. Place the U-bolts over the upper U-bolt pad and the spring assembly.
10. Install the U-bolt retainer, hardened washers, and U-bolt high nuts. Tighten the high nuts until snug.
11. If installing a spring assembly on a vehicle with two drive axles, apply Alumilastic compound, or an equivalent, to the spring retainer pins, then install them from the inboard side. Be sure the hooked ends of the spring leaves are above the retainer pins. Install a cotter pin in the outboard end of each retainer pin, and lock it in place.

    If installing a spring assembly on a vehicle with a pusher or tag axle, install the side-restraint sleeves and flathead bolts in the wear-shoe side-restraints. Be sure the hooked ends of the spring leaves are above the side-restraint sleeves. Install the nuts, and tighten them to the applicable torque value in **Specifications 400**.
12. Tighten the axle U-bolt high nuts as described in **Specifications 400**.

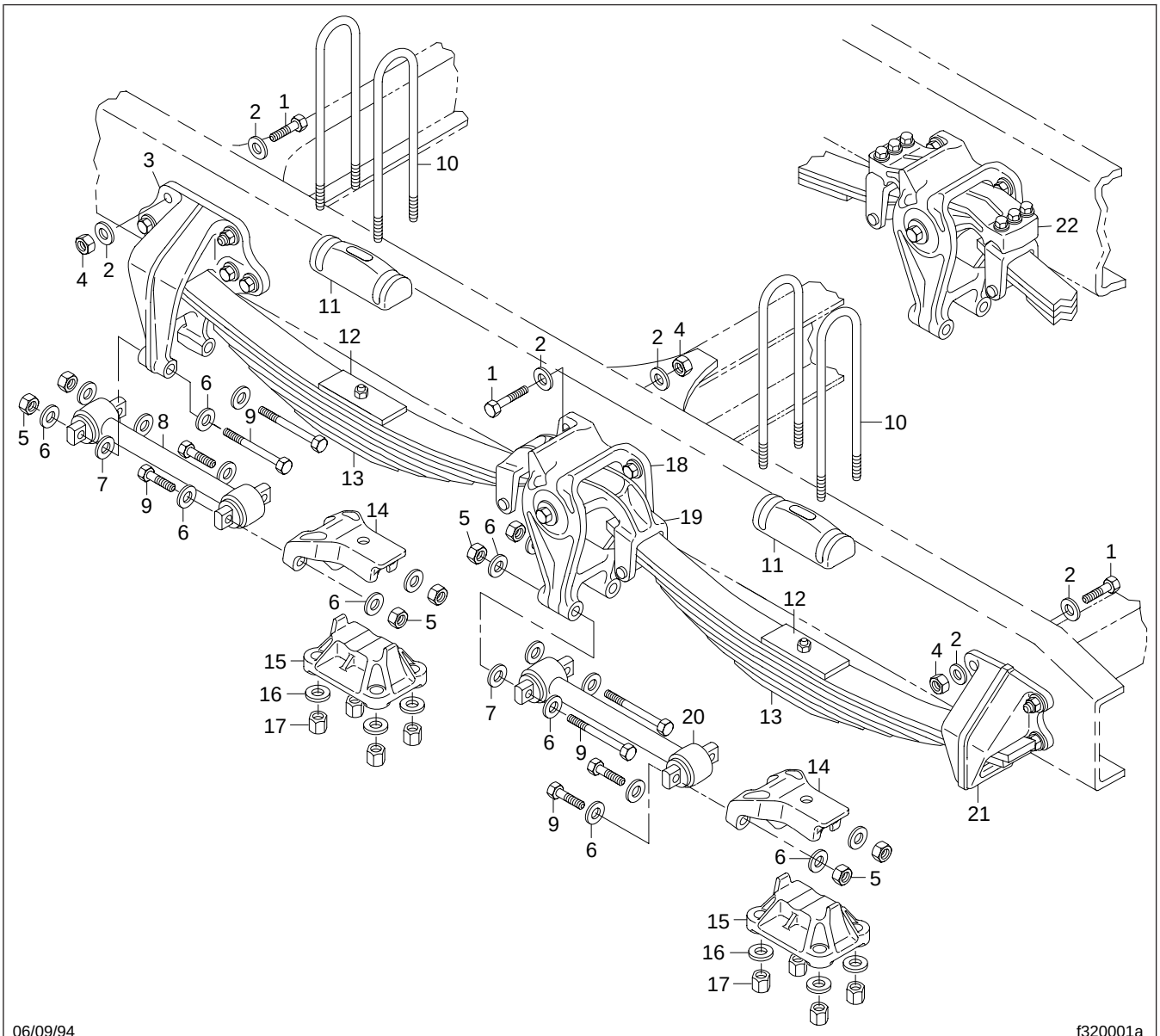
⚠ CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets,and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, refer to Group 32 of the *Business Class Trucks Maintenance Manual*.

13. Install the wheel assembly, using the instructions found in **Group 40**. Remove the safety stands from under the frame and axle, and lower the vehicle.

Spring Assembly Replacement



1. Suspension Bracket Hexbolt
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Torque Arm Hex Locknut
6. Hardened Washer
7. Axle Alignment Washer
8. Forward Torque Arm
9. Torque Arm Hexbolt
10. U-Bolt
11. U-Bolt Pad
12. Spring Liner
13. Leaf Spring Assembly
14. Spring Seat
15. U-Bolt Retainer
16. Hardened Washer
17. U-Bolt High Nut
18. Equalizer Bracket
19. Equalizer, One-Piece (tandem drive axles)
20. Rear Torque Arm
21. Rear Spring Bracket
22. Equalizer, Three-Piece (tag or pusher axle)

Fig. 1, Tandem-Axle Spring Suspension

14. Check the rear axle alignment. For instructions, see **Group 35.** If necessary, adjust the axle alignment, using the instructions in **Subject 140**.

Spring Bracket and Equalizer Bracket Replacement

Replacement (See Fig. 1)

WARNING

Failure to replace worn, cracked, or damaged spring brackets or equalizer brackets could result in breakage of the bracket, which could cause a loss of vehicle control, resulting in personal injury or property damage.

IMPORTANT: At all points where steel parts (including bolts, washers, and nuts) contact the aluminum spring brackets, apply Alumilastic compound, or an equivalent, on the mating surfaces.

CAUTION

Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the suspension.

1. Chock the front tires.
2. Raise the rear of the vehicle, and block the axles with safety stands. Raise the vehicle frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Make sure the stands will securely support the weight of the axles and frame.
3. If removing the forward spring bracket or the equalizer bracket, note the number of any axle alignment washers, then remove the fasteners that attach the radius rod to the forward spring bracket or equalizer bracket. Remove any axle alignment washers.
4. If removing an equalizer bracket, remove the equalizer. For instructions, refer to **Subject 110**.
5. Remove the fasteners that attach the forward or rear spring bracket, or equalizer bracket, to the frame rail. Remove the bracket.
6. Place the new spring bracket or equalizer bracket on the frame rail. Align the mounting holes, and install the bracket bolts, hardened washers, and locknuts.

NOTE: If installing the forward spring bracket, install the nuts for the top two bolts on the outboard side of the frame rail, and install the nuts for the bottom four bolts on the inboard side of the frame rail. See **Fig. 2**.

If installing the equalizer bracket, for clearance, install all of the nuts on the inboard side of the frame rail. See **Fig. 2**.

If installing the rear spring bracket, install the nuts for the top two bolts on the outboard side of the frame rail, and install the nuts for the bottom two bolts on the inboard side of the frame rail. See **Fig. 2.**

7. Tighten the bracket mounting locknuts to the applicable torque value in **Specifications, 400**.

CAUTION

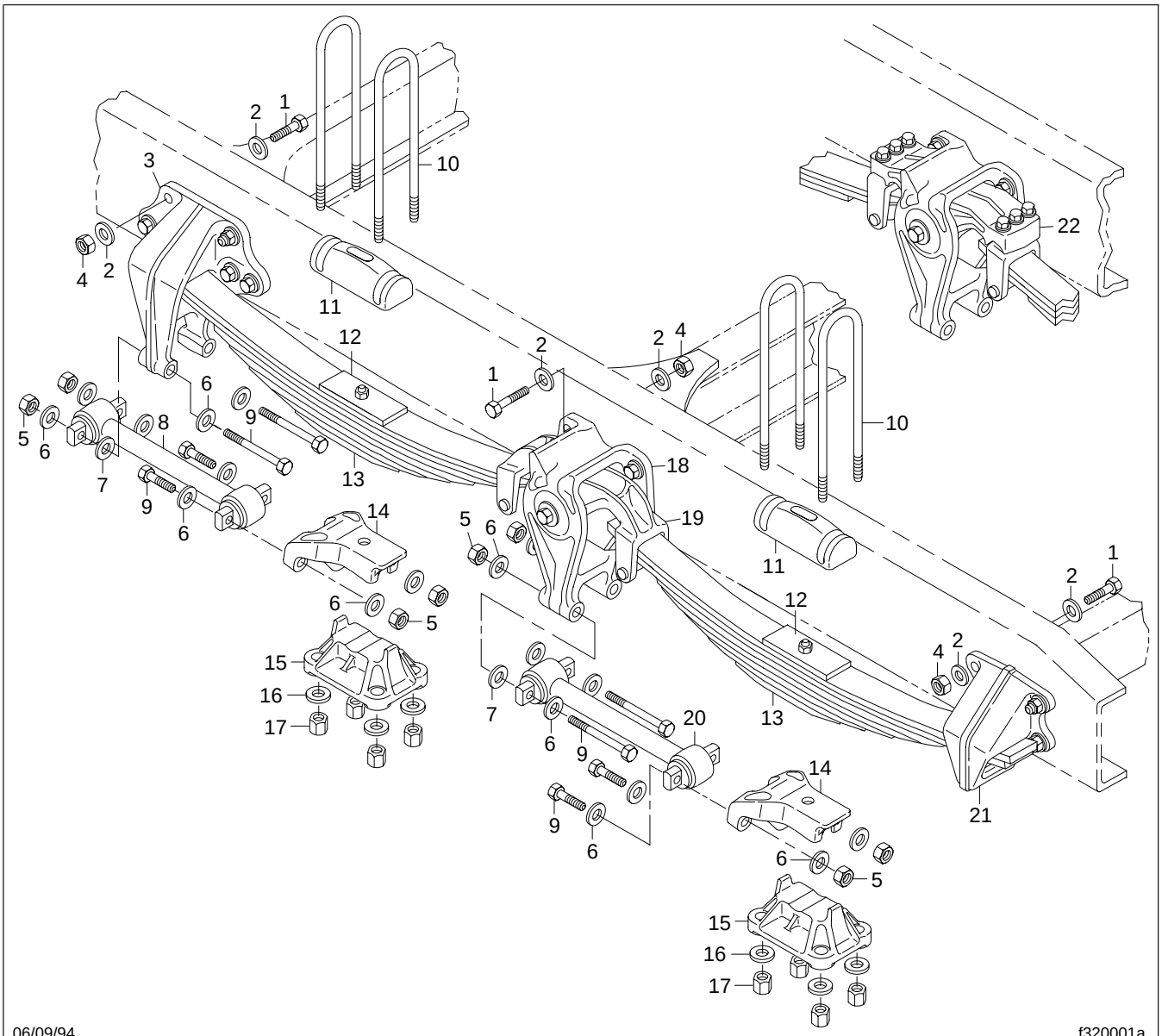
Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 of the *Business Class Trucks Maintenance Manual*.

8. When replacing the forward spring bracket or equalizer bracket, install any previously removed axle alignment washers between the forward radius rod front pin and the forward spring bracket, or between the rear radius rod front pin and the equalizer bracket, as applicable. See **Fig. 3**.

   Install bolts with hardened washers in the radius rod front pin, and the forward spring bracket or equalizer bracket. Install the hardened washers and locknuts, and tighten the locknuts to the torque value in **Specifications, 400**.
9. If replacing an equalizer bracket, install the equalizer. For instructions, see **Subject 110**.
10. Remove the safety stands from under the frame and axle, and lower the vehicle.
11. Check the rear axle alignment. For instructions, see **Group 35**. If necessary, adjust the axle alignment, using the instructions in **Subject 140**.

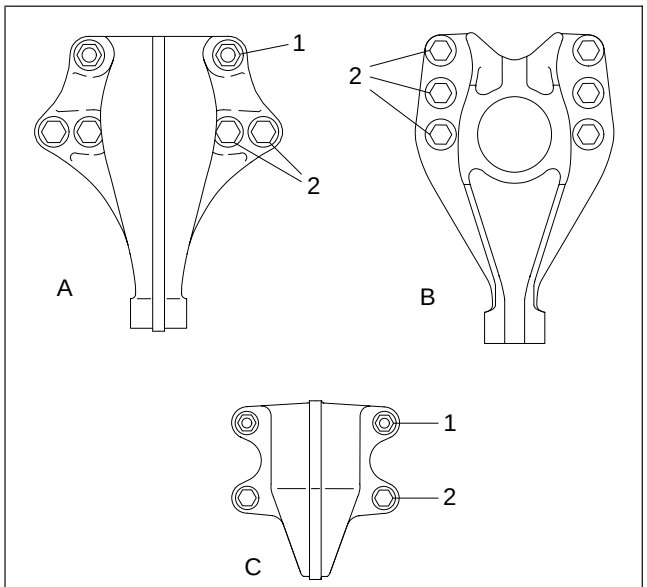
Spring Bracket and Equalizer Bracket Replacement



1. Suspension Bracket Hexbolt
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Radius Rod Hex Locknut
6. Hardened Washer
7. Axle Alignment Washer
8. Forward Radius Rod
9. Radius Rod Hexbolt
10. U-Bolt
11. U-Bolt Pad
12. Spring Liner
13. Leaf Spring Assembly
14. Spring Seat
15. U-Bolt Retainer
16. Hardened Washer
17. U-Bolt High Nut
18. Equalizer Bracket
19. Equalizer, One-Piece (tandem drive axles)
20. Rear Radius Rod
21. Rear Spring Bracket
22. Equalizer, Three-Piece (tag or pusher axle)

Fig. 1, Tandem-Axle Spring Suspension

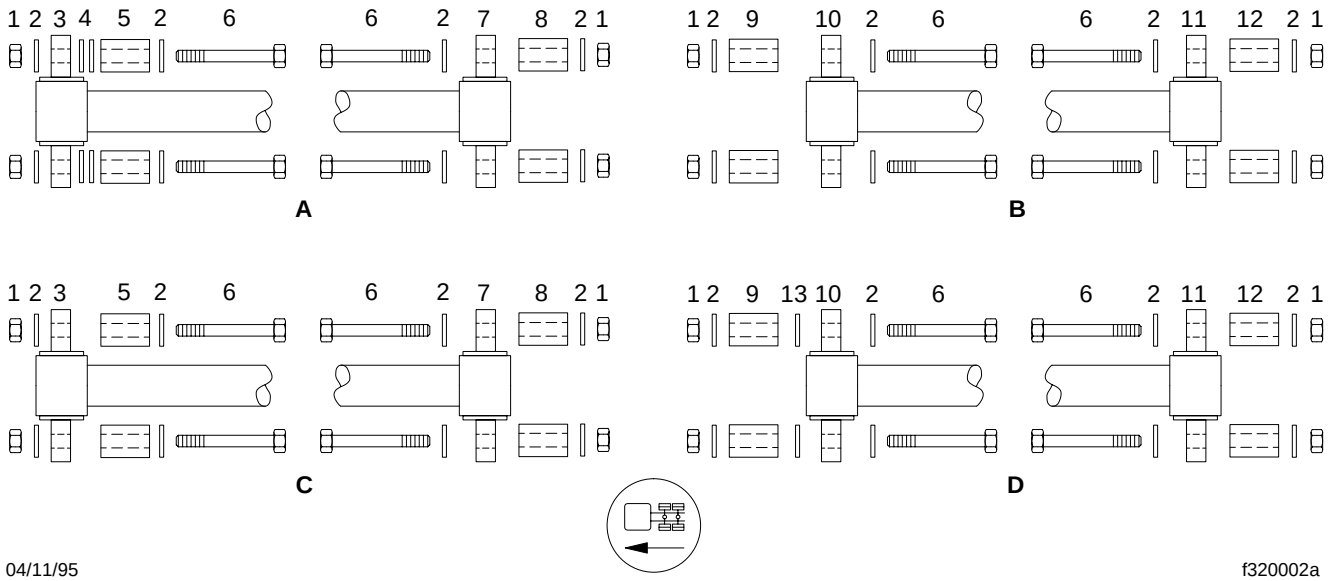
Spring Bracket and Equalizer Bracket Replacement



A. Forward Spring Bracket
B. Equalizer Bracket
C. Rear Spring Bracket
1. Nut (outboard)
2. Bolt Heads (outboard)

Fig. 2, Frame Brackets

Spring Bracket and Equalizer Bracket Replacement



A. Forward Right-Side Radius Rod
B. Rear Right-Side Radius Rod
C. Forward Left-Side Radius Rod
D. Rear Left-Side Radius Rod

1. Hex Locknut
2. Hardened Washer
3. Forward Radius Rod Front Pin
4. Alignment Washers (install only on one side of front axle; right-side installation shown)
5. Forward Spring Bracket
6. Hexhead Bolt
7. Forward Radius Rod Rear Pin
8. Forward Axle Seat
9. Equalizer Bracket
10. Rear Radius Rod Front Pin
11. Rear Radius Rod Rear Pin
12. Rear Axle Seat
13. Alignment Washer (install only on one side of rear axle; left-side installation shown)

Fig. 3, Radius Rod Attachment (top view)

Rear Axle Alignment Adjustment

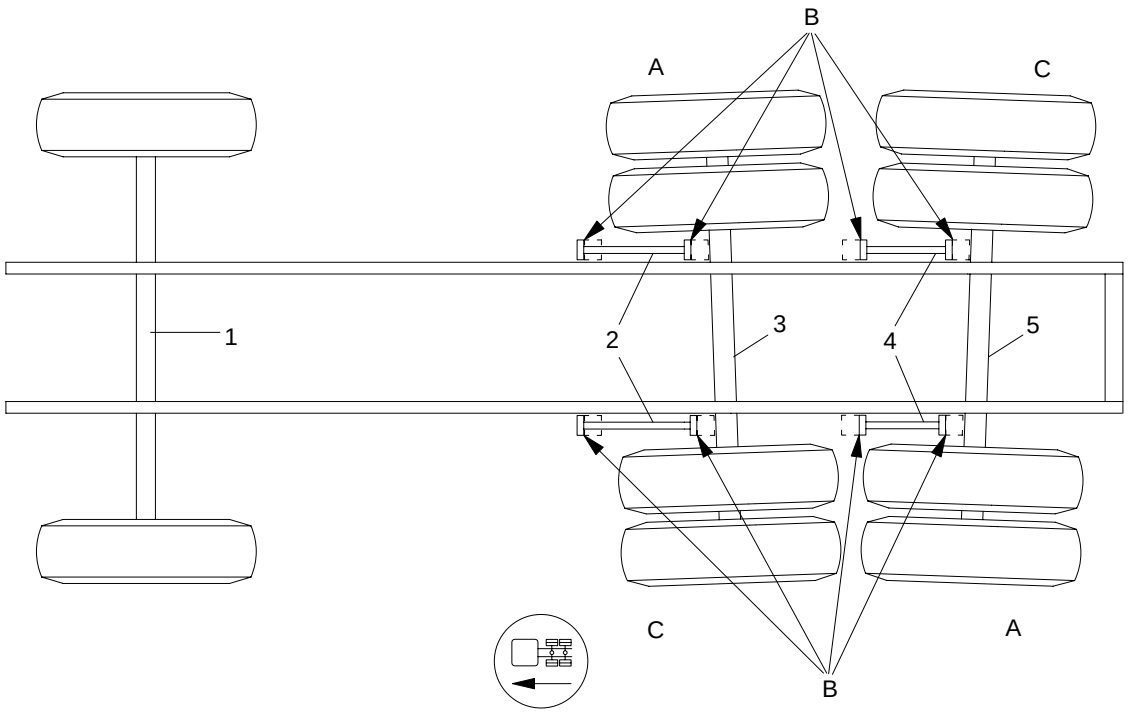
Adjustment

1. Using a straightedge and a tape measure, determine the amount of adjustment needed to align the forward-rear axle at a right angle to the frame. For instructions, see **Group 35**. The difference in measurements between the sides of the vehicle is the approximate amount that the trailing end of the forward-rear axle will have to be brought forward, or the leading end will have to be moved back to align it at a right angle to the frame. See **Fig. 1**.

   If the forward-rear axle alignment is within specifications, go to the step that begins "Using a center-point bar, determine...".

2. Chock the front tires. On both sides of the forward-rear axle, loosen the axle U-bolts enough to allow the springs to shift on the axle seats.
3. On the side of the vehicle that is to be adjusted, remove the fasteners that attach the forward radius rod to the forward spring bracket. Remove any axle alignment washers.

NOTE: To move the leading end of the forward-rear axle rearward, *remove* alignment washers from between the radius rod and the leading end of the forward spring bracket or *add* alignment washers between the radius rod and the forward-rear axle seat.



1. Front Axle
2. Forward-Rear Axle Radius Rod
3. Forward-Rear Axle
4. Rearmost Axle Radius Rod
5. Rearmost Axle

A. Leading End
B. Possible Adjustment Points
C. Trailing End

Fig. 1, Tandem Axle, Shown Out of Alignment

To move the trailing end of the forward-rear axle forward, *remove* alignment washers from be-

Rear Axle Alignment Adjustment

tween the radius rod and the forward-rear axle seat on the trailing end.

Whenever possible, alignment washers should be *removed* instead of added.

4. Raise the frame just enough to relieve the weight from the springs. Place safety stands under the frame. Make sure the stands will securely support the weight of the frame.
5. Move the loosened end of the axle forward or backward as needed, by rolling the wheels.
6. Insert or remove axle alignment washers at the appropriate location (front or rear of the left-hand or right-hand radius rod) to bring the forward-rear axle into alignment. Install the hexhead bolt, hardened washers, and locknut in the radius rod pin and forward spring bracket or axle seat.
7. Place an equal thickness of washers on the other end of the radius rod pin, and install the fasteners.
8. Tighten the radius rod locknuts to the torque value in **Specifications 400**.
9. Remove the safety stands, and lower the vehicle.
10. Check the forward-rear axle alignment with the straightedge and the tape measure. If alignment is within specifications, center the spring in the forward spring bracket, if needed, then tighten the axle U-bolt nuts to the torque value in **Specifications 400**.

    If not in alignment, repeat all of the steps above.

⚠ CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 in the vehicle maintenance manual.

11. Using a center-point bar, determine the difference between the forward-rear and the rearmost axles' center-to-center measurements on each side of the vehicle. For instructions, see **Group 35**. This difference is the approximate distance that the leading end of the rearmost axle will have to be adjusted rearward, or that the trailing end will have to be adjusted forward, to align it at a right angle to the frame, and to align it parallel to the forward-rear axle. See **Fig. 1**.
12. On both sides of the rearmost axle, loosen the axle U-bolts enough to allow the springs to shift on the axle seats.
13. On the side of the vehicle that is to be adjusted, remove the fasteners that attach the rear radius rod to the equalizer bracket. Remove any axle alignment washers.
14. Raise the frame just enough to relieve the weight from the springs. Place safety stands under the frame. Make sure the stands will securely support the weight of the frame.
15. Move the loosened end of the axle forward or backward, by rolling the wheels. Move the axle just enough to provide space to allow installation of alignment washers between the equalizer bracket and the radius rod pin.
16. Between one end of the radius rod pin and the equalizer bracket, insert the additional thickness of alignment washers needed to make up for the difference in center-point bar measurements.

    For example, if one end of the axle was equipped with a 4.5 mm (3/16-inch) thickness of washers, and the difference in the center-point bar measurements is 6 mm (1/4 inch) less on that side, add an additional 6 mm (1/4 inch) of washers — for a total of 10.5 mm (7/16 inch) — to correct the alignment.

    Or, if one end of the axle was equipped with a 6 mm (1/4-inch) thickness of washers, and the difference in center-point bar measurements is 4.5 mm (3/16 inch) more on that side, install a 1.6 mm (1/16-inch) thickness of washers in place of the 6 mm (1/4-inch) thickness.
17. Install the bolt, hardened washers, and locknut in the equalizer bracket and the radius rod pin. Place an equal thickness of alignment washers on the other end of the radius rod pin, and install the fasteners at that end.
18. Tighten the radius rod locknuts to the torque value in **Specifications 400**.

19. Remove the safety stands, and lower the vehicle. Remove the chocks from the front tires.
20. Using the center-point bar, check the rearmost axle alignment. If alignment is within specifications, center the spring in the rear spring bracket, if needed, then tighten the axle U-bolt nuts to the applicable torque value in **Specifications 400**.

    If not in alignment, repeat the applicable steps above.

CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 in the vehicle maintenance manual.

Specifications

Torque Values			
Description	**Size**	**IFI Grade**	**Torque lbf·ft (N·m)**
Equalizer Bracket-to-Frame Rail Locknut *	3/4–10	C	240 (325)
Forward Spring Bracket-to-Frame Rail Locknut *	3/4–10	C	240 (325)
Rear Spring Bracket-to-Frame Rail Locknut *	5/8–11	C	135 (180)
Axle U-Bolt High Nuts	7/8–14	C	Stage 1: Hand tighten Stage 2: 60 (81) † Stage 3: 200 (271) † Stage 4: 420 to 500 (571 to 680) †
Radius Rod Locknut *	5/8–18	C	135 (184)
Equalizer Cap and Tube Assembly Locknut *	3/4–16	C	270 (365)
Equalizer Wear Shoe Capscrew	5/8–11	8	135 (184)
Side-Restraint Sleeve Locknut	1/2–13	C	68 (93)

* Cadmium-plated, wax-coated nuts, and grade 8 hexbolts with phosphate- and oil-coated threads; both used with hardened washers.
† Tighten in a diagonal pattern as shown in **Fig. 1**.

Table 1, Torque Values

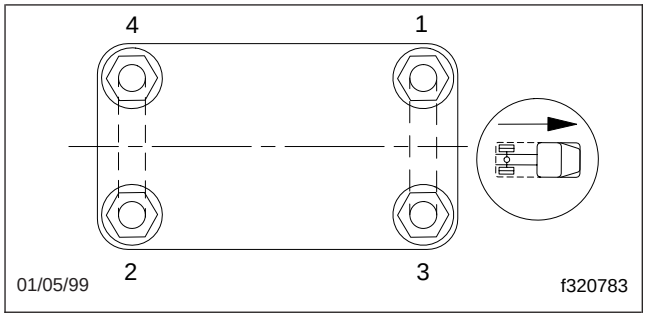


Fig. 1, Tightening Pattern for U-bolt High Nuts

General Description

The Chalmers 800 Series Rear Suspension is a walking beam-type tandem axle suspension that uses hollow rubber springs instead of leaf springs or air bags. Each hollow rubber spring is mounted between a frame-rail plate and the center (front-to-rear) of the steel walking beam. A sawhorse bracket assembly is attached to the frame and provides mounting points for the lower torque rods that tie the axles to the frame. The upper torque rods are fastened to brackets that bolt to the frame side rails and to tower assemblies that are welded to the top of the differential housings. **See Fig. 1.**

The 800 Series Rear Suspension allows a high degree of both parallel and diagonal articulation, while maintaining wheel load equalization to within 3%.

The Chalmers suspension design separates the rear suspension's responsibility for supporting/cushioning the load from that of locating/guiding the axles. The suspension is very light, relative to its load carrying capacity, but requires very little maintenance. In fact, there are no lubrication fittings since grease and oil are never needed.

The 800 Series Rear Suspension is available in two different maximum load capacities: 18,000 kg (40,000 lb) and 21,000 kg (46,000 lb). The 18,000 kg version is easily distinguished from the 21,000 kg version since the upper torque rods do not cross over one another on the 18,000 kg version.

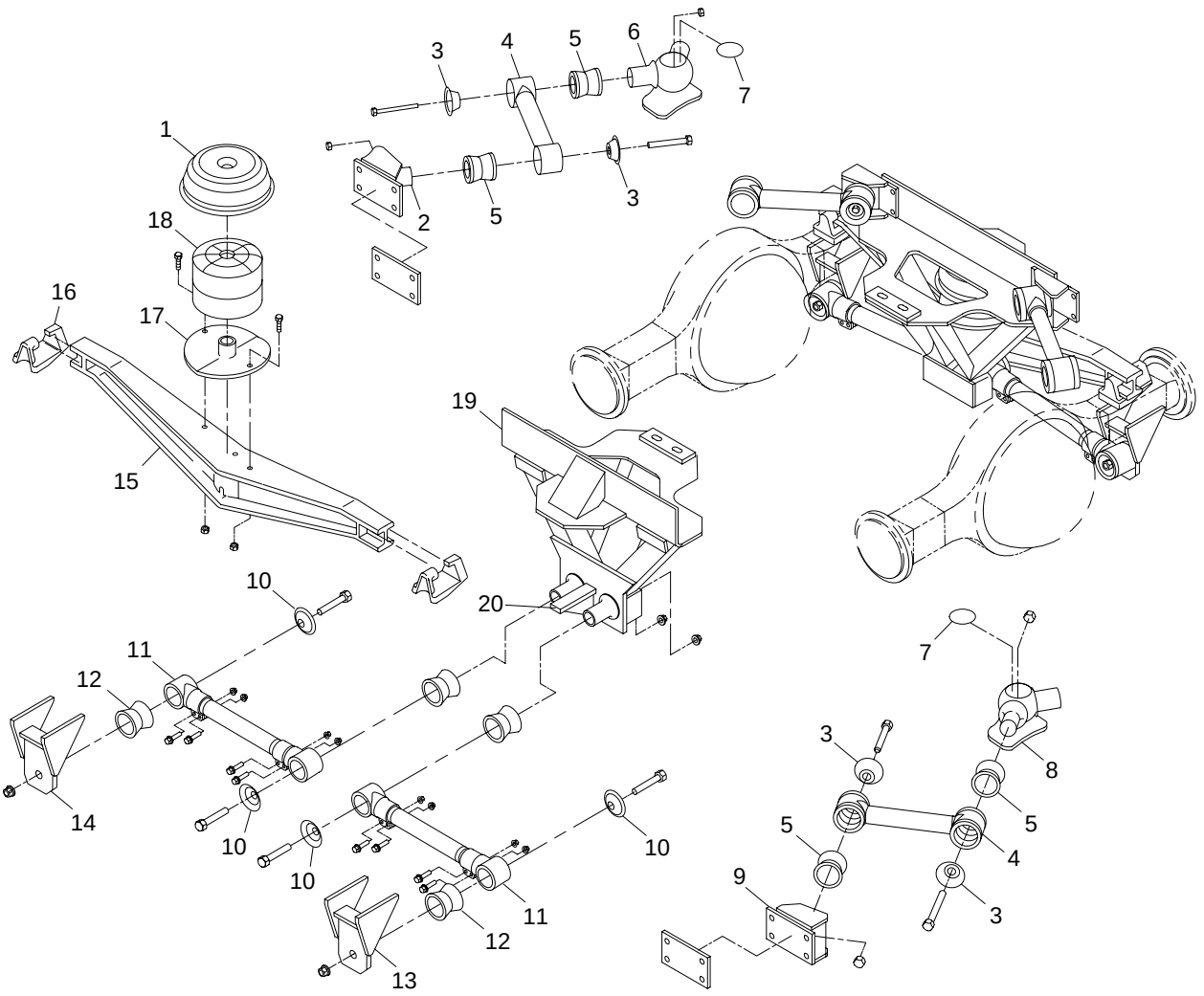
The 800 Series is also available in three different axle spacings: 54-inch, 60-inch, and 72-inch axle-to-axle. The axle-to-axle spacing dimension is often included as part of the suspension name, e.g. "Chalmers 854 Rear Suspension" or "Chalmers 860 Suspension."

Shock absorbers are optional on all versions of the suspension, and available in two styles—beam mounted and axle housing mounted.

Other variations depend on whether the suspension is installed on a truck (high-mount) or a tractor (low-mount) and whether high center-of-gravity or low center-of-gravity is desired.

The rear suspension may be precision-aligned by adjusting the length of the lower torque rods. These rods have both left and right hand threads cut on the same tube so rotating the tube changes the effective length of the tube.

General Description



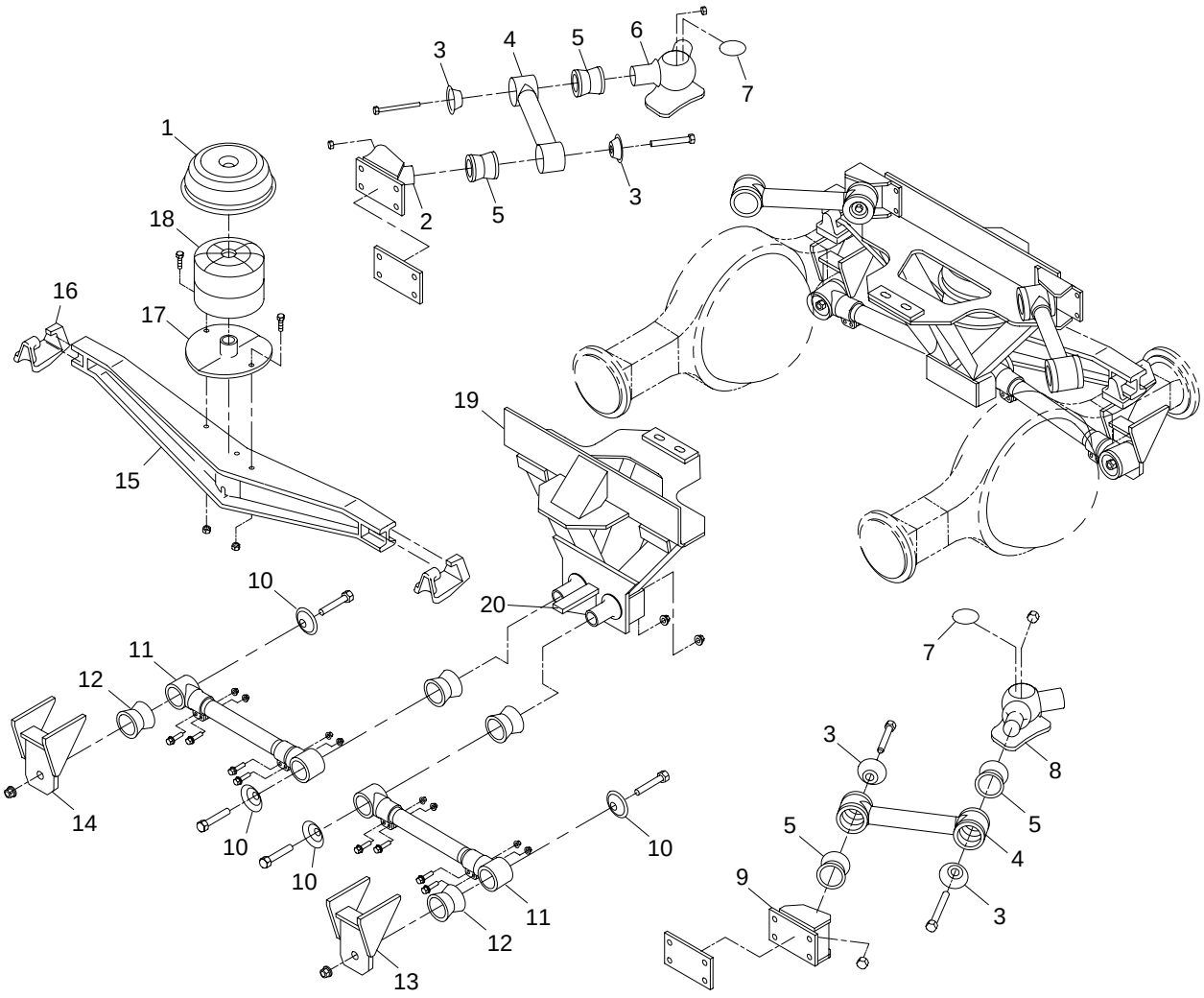
01/11/96 f320444

1. Restrictor Can
2. Upper Torque Rod Frame Bracket (LH forward)
3. Spigot Cap (upper)
4. Upper Torque Rod
5. Torque Rod Bushing (upper)
6. Forward Rear Axle Tower
7. Rear Axle Tower Plug
8. Rearmost Rear Axle Tower
9. Upper Torque Rod Frame Bracket (LH rear)
10. Spigot Cap (lower)
11. Lower Torque Rod (adjustable)
12. Torque Rod Bushing (lower)
13. Lower Torque Rod Axle Housing Bracket (LH rear)
14. Lower Torque Rod Axle Housing Bracket (LH forward)
15. Beam
16. Axle Housing Beam Saddle Bracket
17. Beam Spring Plate
18. Hollow Rubber Spring
19. Sawhorse Bracket Assembly
20. Beam Stop

Fig. 1, Chalmers 800 Series Tandem Axle Suspension (40k capacity shown without shock absorbers)

Restrictor Can Removal, Inspection, and Installation

Removal (See Fig. 1)



01/11/96 f320444

1. Restrictor Can
2. Upper Torque Rod Frame Bracket (LH forward)
3. Spigot Cap (upper)
4. Upper Torque Rod
5. Torque Rod Bushing (upper)
6. Forward Rear Axle Tower
7. Rear Axle Tower Plug
8. Rearmost Rear Axle Tower
9. Upper Torque Rod Frame Bracket (LH rear)
10. Spigot Cap (lower)
11. Lower Torque Rod (adjustable)
12. Torque Rod Bushing (lower)
13. Lower Torque Rod Axle Housing Bracket (LH rear)
14. Lower Torque Rod Axle Housing Bracket (LH forward)
15. Beam
16. Axle Housing Beam Saddle Bracket
17. Beam Spring Plate
18. Hollow Rubber Spring
19. Sawhorse Bracket Assembly
20. Beam Stop

Fig. 1, Chalmers 800 Series Tandem Axle Suspension (40k capacity shown without shock absorbers)

Restrictor Can Removal, Inspection, and Installation

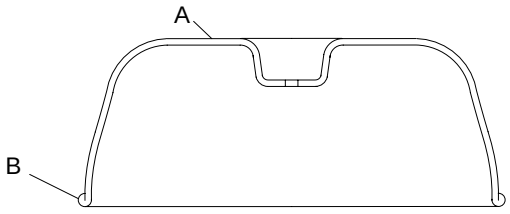
1. If necessary, power wash the spring restrictor can area to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Raise the rear of the vehicle just enough to remove all weight from the rear axles, and place safety stands under the frame to support the vehicle in its raised position.
4. Remove the two bolts and nuts that secure the walking beam spring plate (**see Fig. 1**, Ref. 17) to the walking beam assembly. Discard the fasteners.

NOTE: On 54-inch spread suspensions, it may be necessary to remove either the front or rear tires to allow spring assembly removal.

5. Pull the lower spring plate, rubber spring, and restrictor can as one assembly outward, off the beam assembly. **See Fig. 1**, Refs. 1, 17, 18.
6. Separate the restrictor can, spring, and spring plate.

Inspection

1. Carefully inspect the restrictor can for cracks or severe corrosion. Pay special attention to the top surface of the can and the can rim. **See Fig. 2 .**



A. Inspect top surface for cracks or severe corrosion.
B. Carefully inspect can rim for cracks.

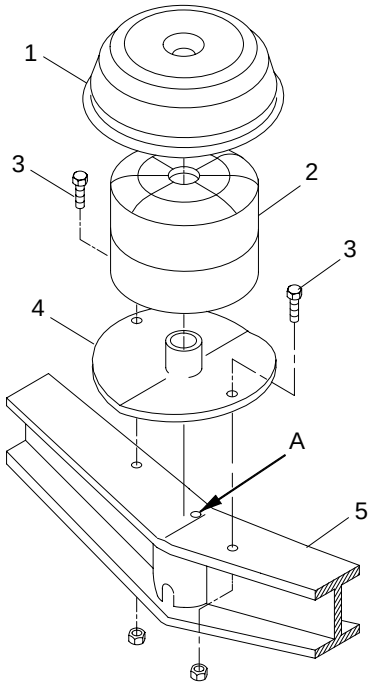
Fig. 2, Restrictor Can Inspection Areas

NOTE: It is recommended that both restrictor cans be replaced at the same time to insure evenness of ride and handling characteristics.

2. Replace a cracked or severely corroded restrictor can.

Installation

1. Using a stiff wire brush or gasket scraper, clean rust and road dirt from the spring plate. Also, make sure that the center vent holes in the plate and in the walking beam are free of rust and debris. **See Fig. 3.**



A. Make sure that the vent hole in the walking beam is free of rust and debris.

1. Spring Restrictor Can
2. Hollow Rubber Spring
3. Spring Plate Bolt
4. Spring Plate
5. Walking Beam

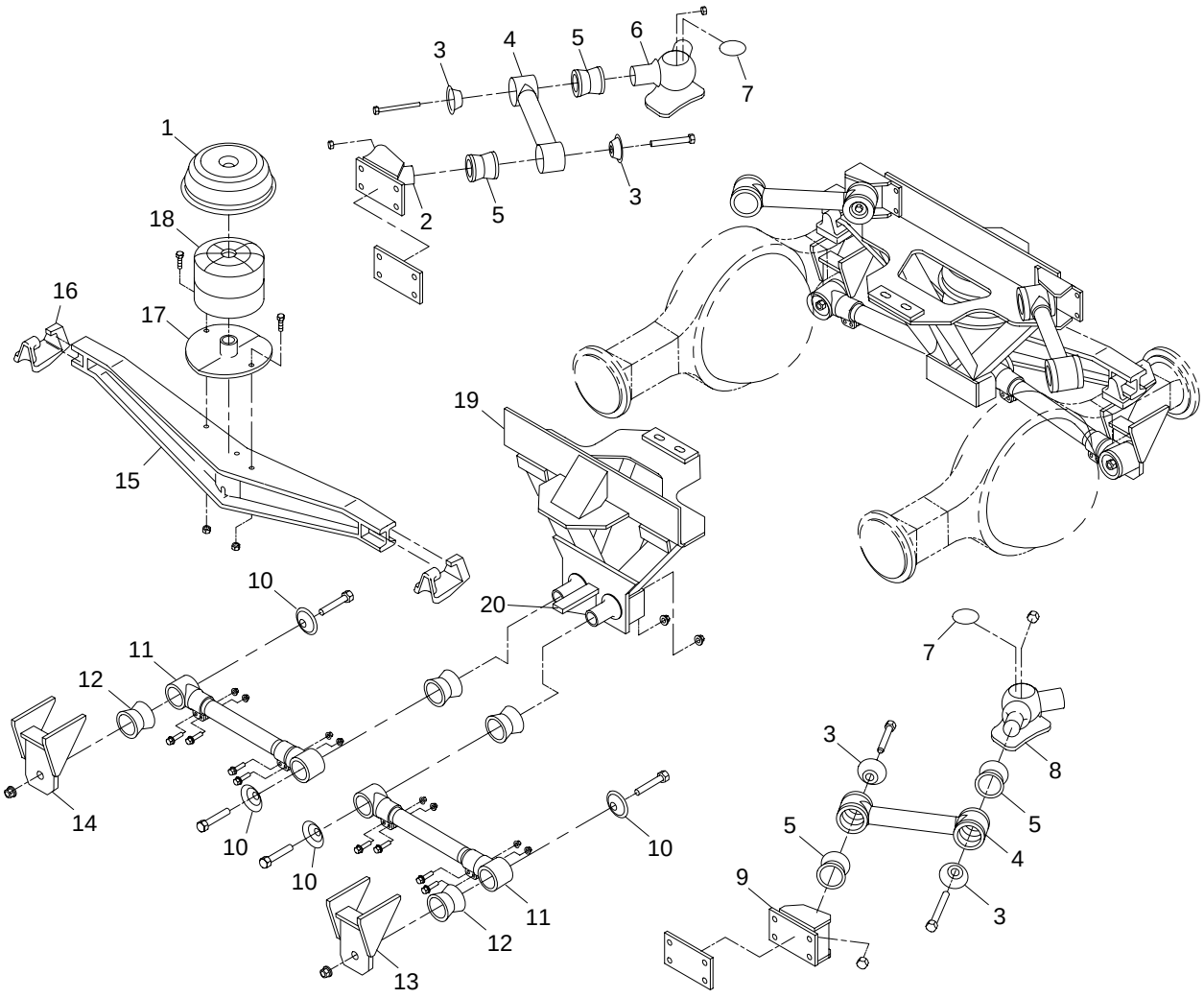
Fig. 3, Spring Assembly Components

2. Inspect the spring plate for cracks; replace it if any are present.

IMPORTANT: Never use any mineral based oils, greases, jellies, or solvent soaps to aid in the assembly of rubber suspension parts. Use only lubricants specifically designed for use with rubber compounds.

3. Position the rubber spring on the spring plate so it is upside down, relative to its original orientation. Make sure that the spring vent hole is centered on the spring plate tube. Place the new restrictor can over the spring; make sure the can is centered on the spring.
4. Slide, as one assembly, the spring plate, spring, and restrictor cap, into position on the walking beam.
5. Install and tighten the spring plate fasteners 47 N·m (35 lbf·ft).
6. Check the gap between the spring and the restrictor can to make sure it is even, all the way around the can. Rotate the spring and/or can as necessary to make the gap even.
7. Remove the safety stands from under the vehicle, then lower the vehicle.
8. Remove the chocks from the tires.

Replacement (See Fig. 1)



01/11/96 f320444

1. Restrictor Can
2. Upper Torque Rod Frame Bracket (LH forward)
3. Spigot Cap (upper)
4. Upper Torque Rod
5. Torque Rod Bushing (upper)
6. Forward Rear Axle Tower
7. Rear Axle Tower Plug
8. Rearmost Rear Axle Tower
9. Upper Torque Rod Frame Bracket (LH rear)
10. Spigot Cap (lower)
11. Lower Torque Rod (adjustable)
12. Torque Rod Bushing (lower)
13. Lower Torque Rod Axle Housing Bracket (LH rear)
14. Lower Torque Rod Axle Housing Bracket (LH forward)
15. Beam
16. Axle Housing Beam Saddle Bracket
17. Beam Spring Plate
18. Hollow Rubber Spring
19. Sawhorse Bracket Assembly
20. Beam Stop

Fig. 1, Chalmers 800 Series Tandem Axle Suspension (40k capacity shown without shock absorbers)

Rubber Spring Replacement

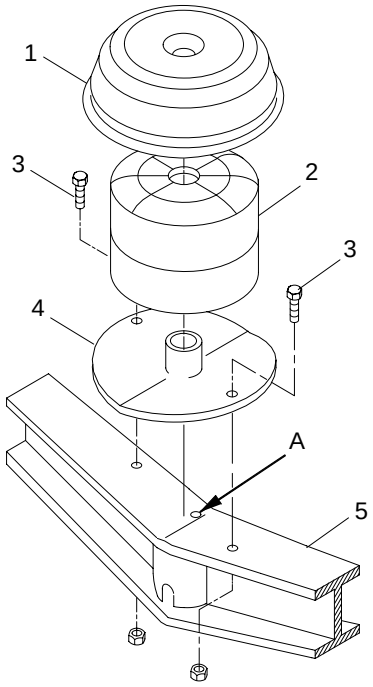
1. If necessary, power wash the spring restrictor can area to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Raise the rear of the vehicle just enough to remove all weight from the rear axles, and place safety stands under the frame to support the vehicle in its raised position.
4. Remove the two bolts and nuts that secure the walking beam spring plate (**see Fig. 1**, Ref. 17) to the walking beam assembly. Discard the fasteners.

NOTE: On 54-inch spread suspensions, it may be necessary to remove either the front or rear tires to allow spring assembly removal.

5. Pull the lower spring plate, rubber spring, and restrictor can as one assembly outward, off the beam assembly. **See Fig. 1**, Refs. 1, 17, 18.
6. Separate the restrictor can, spring, and spring plate; discard the spring.
7. Using a stiff wire brush or gasket scraper, clean rust and road dirt from the spring plate. Also, make sure that the center vent holes in the plate and in the walking beam are free of rust and debris. **See Fig. 2.**
8. Inspect the spring plate for cracks; replace it if any are present.

IMPORTANT: Never use any mineral based oils, greases, jellies, or solvent soaps to aid in the assembly of rubber suspension parts. Use only lubricants specifically designed for use with rubber compounds.

9. Position the new rubber spring on the spring plate, making sure that the vent hole is centered on the spring plate tube. Place the restrictor can over the spring; make sure the can is centered on the spring.
10. Slide, as one assembly, the spring plate, spring, and restrictor cap, into position on the walking beam.
11. Install and tighten the spring plate fasteners 47 N·m (35 lbf·ft).



10/12/95 f320437

A. Make sure that the vent hole in the walking beam is free of rust and debris.

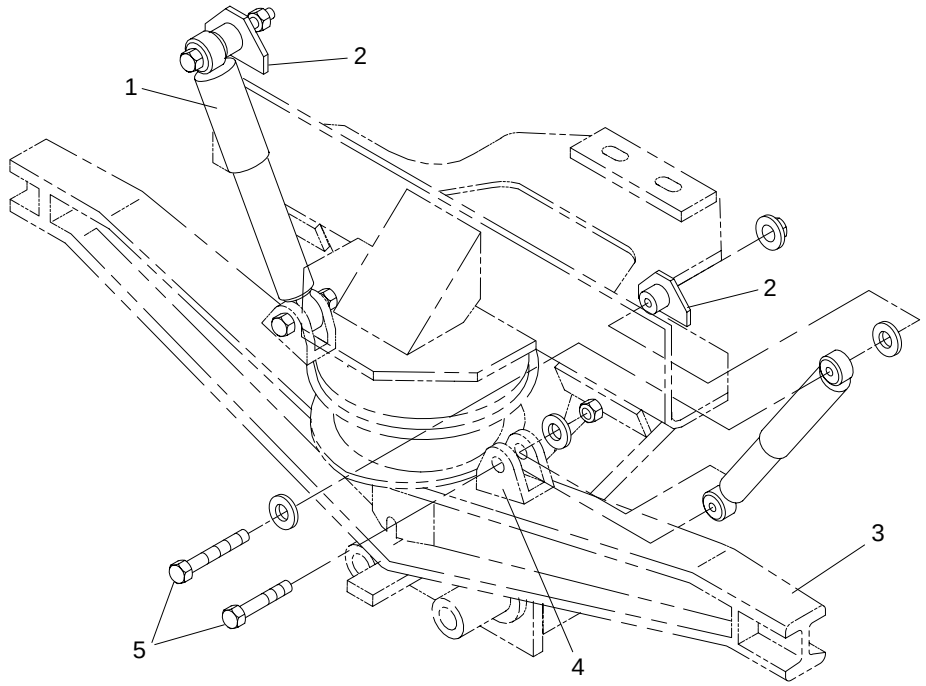
1. Spring Restrictor Can
2. Hollow Rubber Spring
3. Spring Plate Bolt
4. Spring Plate
5. Walking Beam

Fig. 2, Spring Assembly Components

12. Remove the safety stands from under the vehicle, then lower the vehicle.
13. Remove the chocks from the tires.

Replacement

The Chalmers 800 Series Suspension may be fitted with either beam-mounted or axle-mounted shock absorbers. **See Fig. 1** and **Fig. 2.** The replacement procedure is essentially the same for both types of shock absorber.



10/13/95 f320438

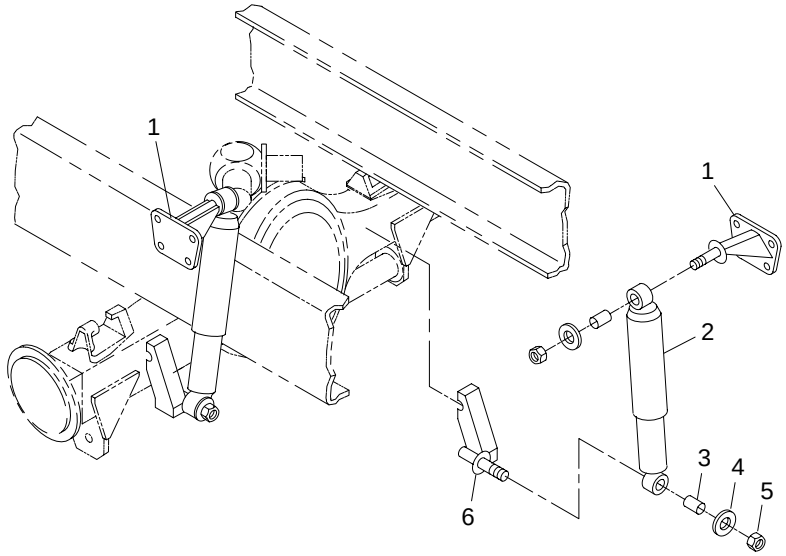
1. Shock Absorber
2. Frame-Mounted Bracket
3. Walking Beam
4. Beam-Mounted Bracket
5. 3/4" Mounting Bolts

Fig. 1, Shock Absorbers, Beam-Mounted

1. If necessary, power wash the rear suspension to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Remove the shock absorber mounting fasteners.
   - 3.1 On beam-mounted shocks, remove the upper and lower bolts. **See Fig. 1**, Ref. 5. Discard the fasteners.
   - 3.2 On axle-mounted shocks, remove the upper and lower locknuts and hardened washers. **See Fig. 2**, Refs. 4 and 5. Discard the fasteners.
4. Remove and discard the shock absorber.
5. On axle-mounted shock absorber installations, the compression sleeve (**see Fig. 2**, Ref. 3) may be rusted to the shock mounting pin and remain on the pin when the shock is removed. If this occurs, drive the sleeve off of the pin using a small, sharp chisel.
6. On axle-mounted shock absorber installations, clean the shock mounting pin threads using a stiff wire brush or, if necessary, a thread-chaser die.

   Lubricate the threads with a small amount of engine oil.
7. Install the new shock absorbers.
   - 7.1 On beam-mounted shock absorber installations, extend or compress the shock absorber as necessary to install the

Shock Absorber Replacement



1. Frame-Mounted Bracket
2. Shock Absorber
3. Compression Sleeve
4. Hardened Washer
5. 7/8" Mounting Locknut
6. Axle-Mounted Bracket

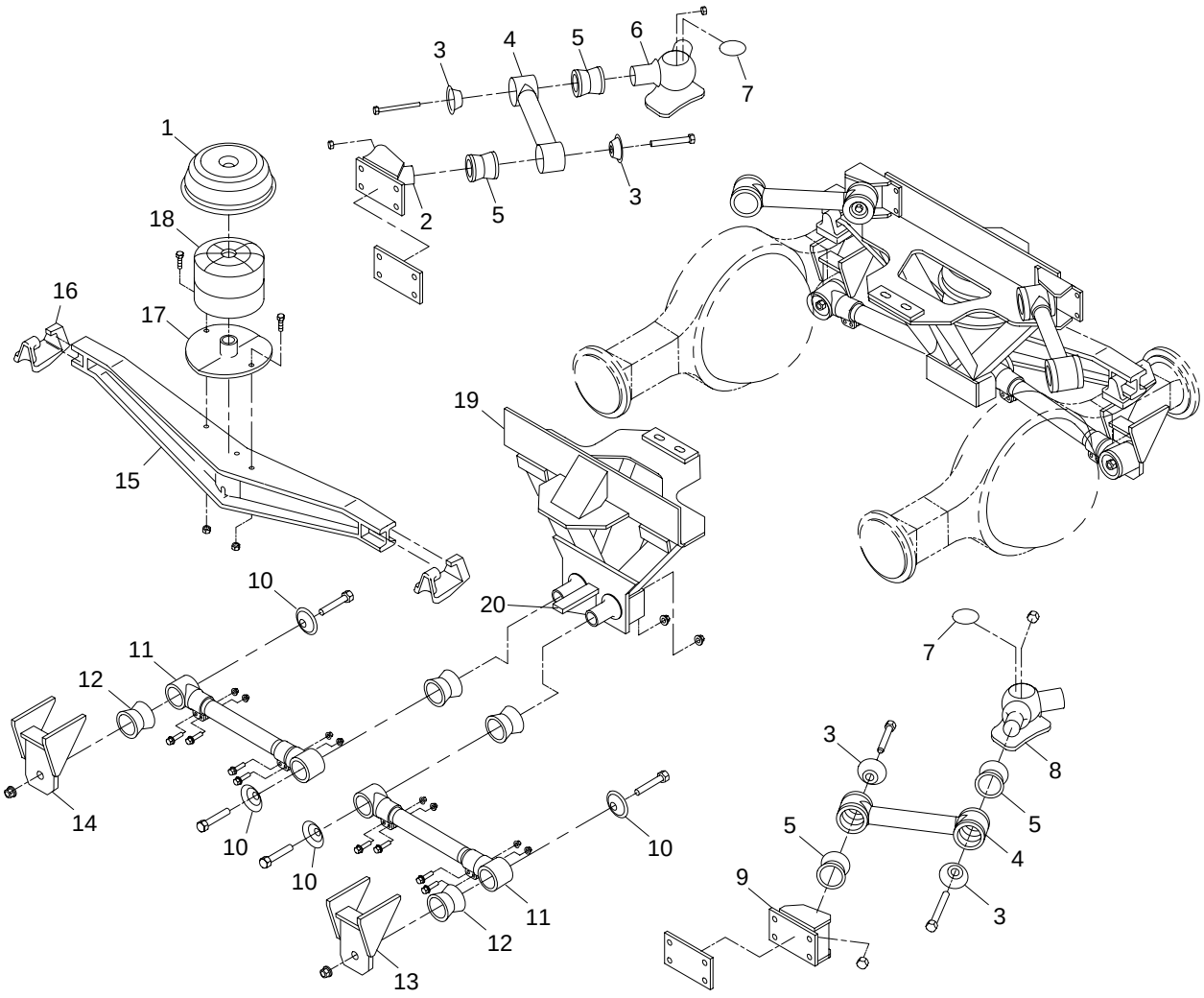
Fig. 2, Shock Absorbers, Axle-Mounted

mounting bolts. Install the locknuts and tighten the fasteners 230 N·m (170 lbf·ft).

7.2 On axle-mounted shock absorber installations, extend or compress the shock absorber as necessary to fit it on the mounting pins. Install the locknuts and tighten them 366 N·m (270 lbf·ft).

8. Remove the chocks from the tires.

Removal (See Fig. 1)



01/11/96 f320444

1. Restrictor Can
2. Upper Torque Rod Frame Bracket (LH forward)
3. Spigot Cap (upper)
4. Upper Torque Rod
5. Torque Rod Bushing (upper)
6. Forward Rear Axle Tower
7. Rear Axle Tower Plug
8. Rearmost Rear Axle Tower
9. Upper Torque Rod Frame Bracket (LH rear)
10. Spigot Cap (lower)
11. Lower Torque Rod (adjustable)
12. Torque Rod Bushing (lower)
13. Lower Torque Rod Axle Housing Bracket (LH rear)
14. Lower Torque Rod Axle Housing Bracket (LH forward)
15. Beam
16. Axle Housing Beam Saddle Bracket
17. Beam Spring Plate
18. Hollow Rubber Spring
19. Sawhorse Bracket Assembly
20. Beam Stop

Fig. 1, Chalmers 800 Series Tandem Axle Suspension (40k capacity shown without shock absorbers)

Walking Beam Removal, Inspection, and Installation

1. If necessary, power wash the walking beams and axle housing ends to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Relieve all drive axle brake or wind-up loads by placing the transmission in neutral and releasing the spring or driveline brakes.
4. Raise the rear of the vehicle to remove all weight from the rear axles, and place safety stands under the frame to secure the vehicle in its raised position.
5. If equipped, disconnect beam-mounted shock absorbers from the walking beam being replaced. Refer to **Subject 120**, if necessary.
6. Remove the two bolts and nuts that secure the walking beam spring plate (**see Fig. 1**, Ref. 17) to the walking beam assembly. Discard the fasteners.

NOTE: On 54-inch spread suspensions, it may be necessary to remove the front or rear tires to allow spring assembly removal.

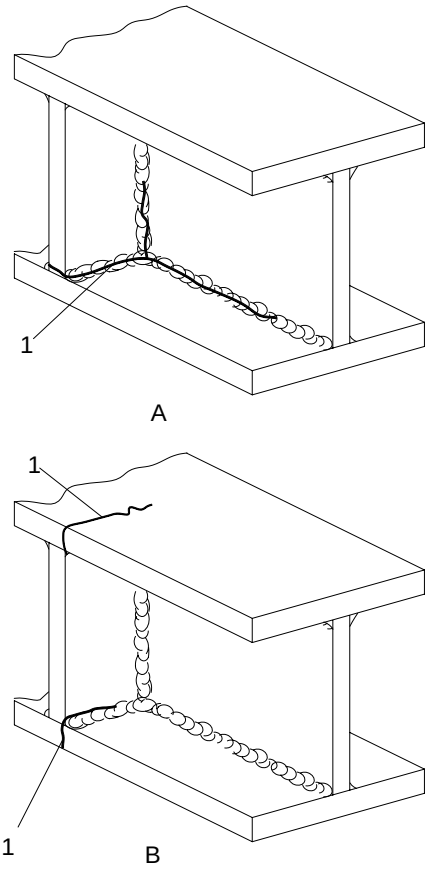
7. Pull the lower spring plate, rubber spring, and restrictor can as one assembly outward, off the beam assembly. **See Fig. 1**, Refs. 1, 17, 18.

NOTE: Tag or otherwise mark each torque rod to ensure that it can be re-installed in the same position and orientation.

8. Disconnect the rearmost axle's upper torque rods from the rear axle tower and the lower torque rods from the rear axle housing brackets. **See Fig. 1**, Refs. 4, 8, 11, 13.
9. Roll the rear axle rearward just enough to disengage the axle saddles (Ref. 16) from the walking beam ends.
10. Lift up the free end of the walking beam and slide the beam rearward to disengage it from the front axle saddle; remove the walking beam.

Inspection

1. Inspect the beam ends carefully, looking for cracks. Cracks along weld lines may be repairable, while cracks in or across the beam flanges require walking beam replacement. **See Fig. 2.**



10/17/95 f320441

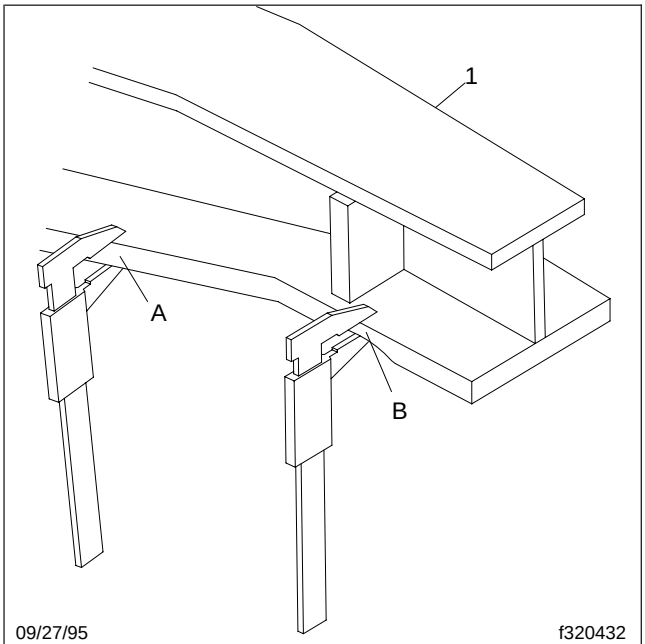
A. Repairable Walking Beam
B. Non-repairable Walking Beam
1. Cracks

Fig. 2, Repairable/Non-repairable Beam Cracks

NOTE: Take flange thickness measurements at least 12 mm (1/2 inch) from the flange edges. Measurements taken at the flange edges are not an accurate indication of beam wear and may lead to unnecessary beam repair/replacement.

2. Check for excessive wear on the beam flanges, where they contact the axle housing saddle brackets.

If flange wear is significant, use a micrometer or vernier calipers to take measurements at both unworn and worn areas. The maximum allowable difference between unworn and worn areas is 1.5 mm (0.062 inch). **See Fig. 3.**



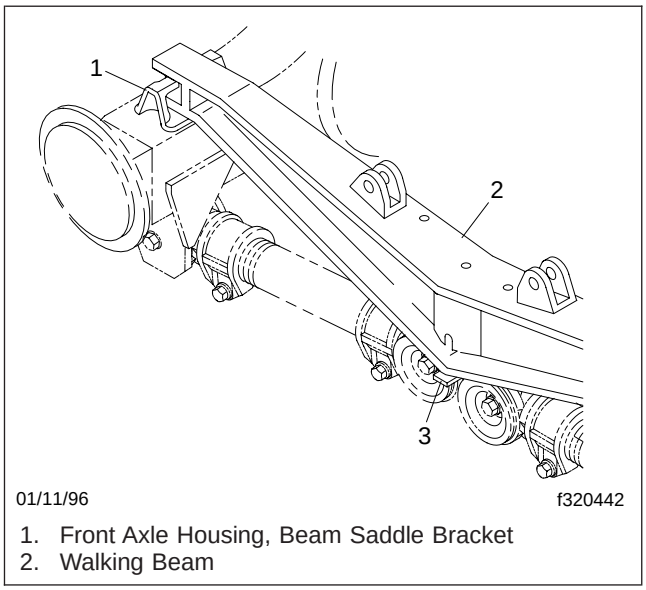
A. Flange thickness measurement taken at unworn area for reference.
B. Flange thickness measurement taken at wear area to assess beam condition.
1. Walking Beam

Fig. 3, Beam Wear Measurement

3. Beams showing excessive wear must be repaired or replaced. Refer to **Subject 140** for beam repair information.

Installation

1. Position the new or repaired walking beam over the rearmost rear axle, with the front end of the beam tilted downward.
2. Slide the beam forward and downward so the front end of the beam enters the axle housing saddle bracket. **See Fig. 4.** Let the middle of the beam rest on the sawhorse bracket beam stop.



1. Front Axle Housing, Beam Saddle Bracket
2. Walking Beam

Fig. 4, Beam/Saddle Bracket Alignment

NOTE: On 54-inch spread suspensions, it may be necessary to install the spring assembly before the rearmost axle is rolled into place.

3. Carefully roll the rearmost rear axle forward, while lifting the rear end of the walking beam enough so the beam end enters the axle housing saddle bracket.
4. Connect the rearmost axle's upper and lower torque rods to the axle housing brackets. Install and tighten the torque rod bushing through-bolts 183 N·m (135 lbf·ft).
5. Slide, as one assembly, the spring plate, rubber spring, and restrictor cap, into position on the walking beam.
6. Install and tighten the spring plate fasteners 47 N·m (35 lbf·ft).
7. If so equipped, connect the beam-mounted shock absorbers to the beam brackets and tighten the fasteners 230 N·m (170 lbf·ft).
8. Remove the safety stands from under the vehicle, then lower the vehicle.
9. Remove the chocks from the tires.

Repair

NOTE: This subject addresses only instances where excessive beam flange wear occurs, but cracks in the web or flange are not present.

Cracked webs and/or flanges require walking beam replacement.

Walking beams with excessive flange wear, however, can be repaired by welding a Chalmers Wear Plate over the worn areas as described below.

1. Remove the walking beam assembly. Refer to **Subject 130** for information.

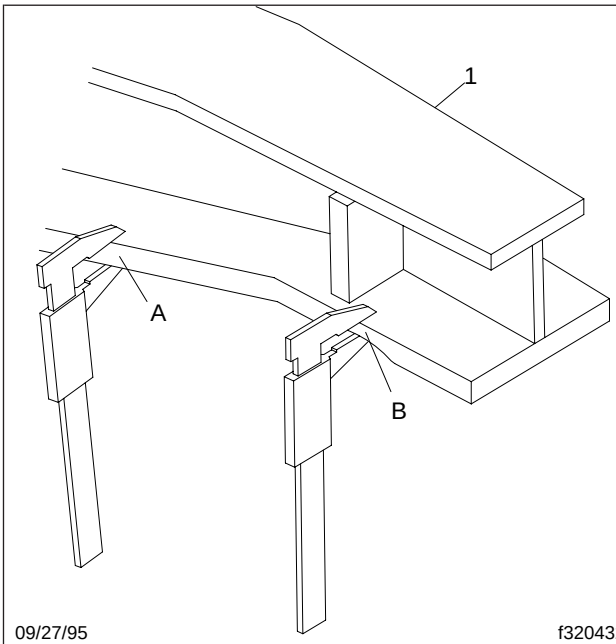
NOTE: Take flange thickness measurements at least 12 mm (1/2 inch) from the flange edges. Measurements taken at the flange edges are not an accurate indication of beam wear and may lead to unnecessary beam repair/ replacement.

2. Confirm that flange wear is severe enough to warrant repairs. Use a micrometer or vernier calipers to take flange thickness measurements at both unworn and worn areas. The maximum allowable difference between unworn and worn areas is 1.5 mm (0.062 inch). **See Fig. 1.**
3. If repair is required, clean the worn area of the beam thoroughly. Make sure that any oil or grease is removed, as well as rust or road dirt accumulation. If necessary, slight grinding of the beam is allowed to smooth raised areas.
4. Clamp Chalmers Wear Plate #700313 to the bottom flange of the beam. Make sure the plate is centered and has good surface-to-surface contact with the beam. Slight grinding is allowable to obtain good plate-to-beam contact.
5. Tack weld the plate to the beam, welding on the sides of the plate only.

CAUTION

CAUTION: Weld at sides of wear plate and beam only. Never weld at the ends of the wear plate.

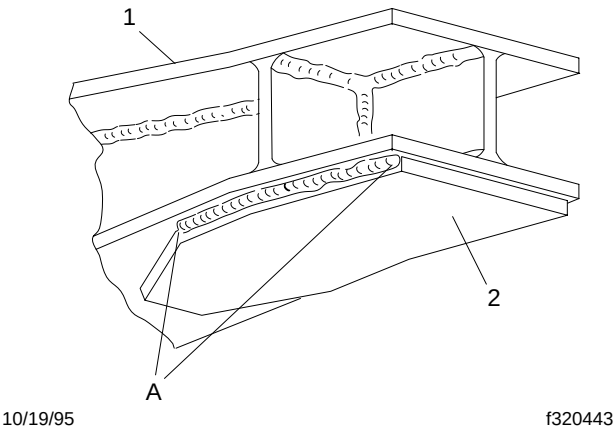
6. Remove the clamps and weld the plate to the beam, welding on the sides of the plate only. **See Fig. 2.**



09/27/95 f320432

A. Flange thickness measurement taken at unworn area for reference.
B. Flange thickness measurement taken at wear area to assess beam condition.
1. Walking Beam

Fig. 1, Beam Wear Measurement



10/19/95 f320443

A. Limit weld to this area only.
1. Walking Beam 2. Wear Plate

Fig. 2, Chalmers Wear Plate Welding

7. Prime and paint the repaired area.

Walking Beam Repair

8. Install the repaired walking beam assembly. Refer to **Subject 130** for information.

Torque Rod Removal and Installation

The torque rods hold the rear axles in place, maintaining both axle alignment and pinion nose angle. When servicing the torque rods, it is good practice to remove and install them one at a time to avoid the possibility of mixing them up and affecting the alignment or pinion nose angle.

Several different styles of torque rods and bushing spigots exist. On the 18,000 kg (40,000 lb) version of the 800 Series suspension, the torque rods have tubular steel bodies and the upper rods do not cross over one another. On the 21,000 kg (46,000 lb) version, the lower torque rods have tubular steel bodies, but the upper torque rods are made of "I-beam" shaped ductile iron. These upper torque rods do cross over one another. See **Fig. 1** and **Fig. 2.**

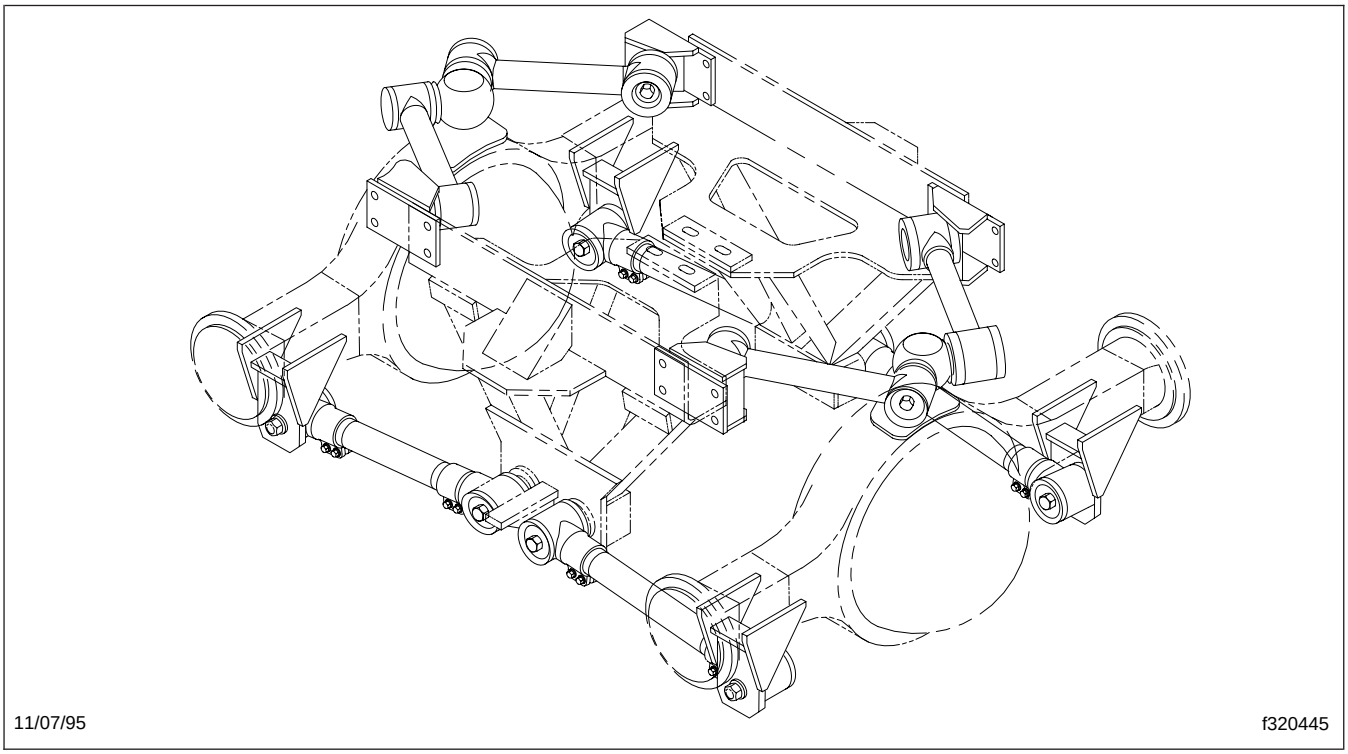


Fig. 1, Torque Rod Arrangement, 40,000 lb Capacity Suspension

Removal

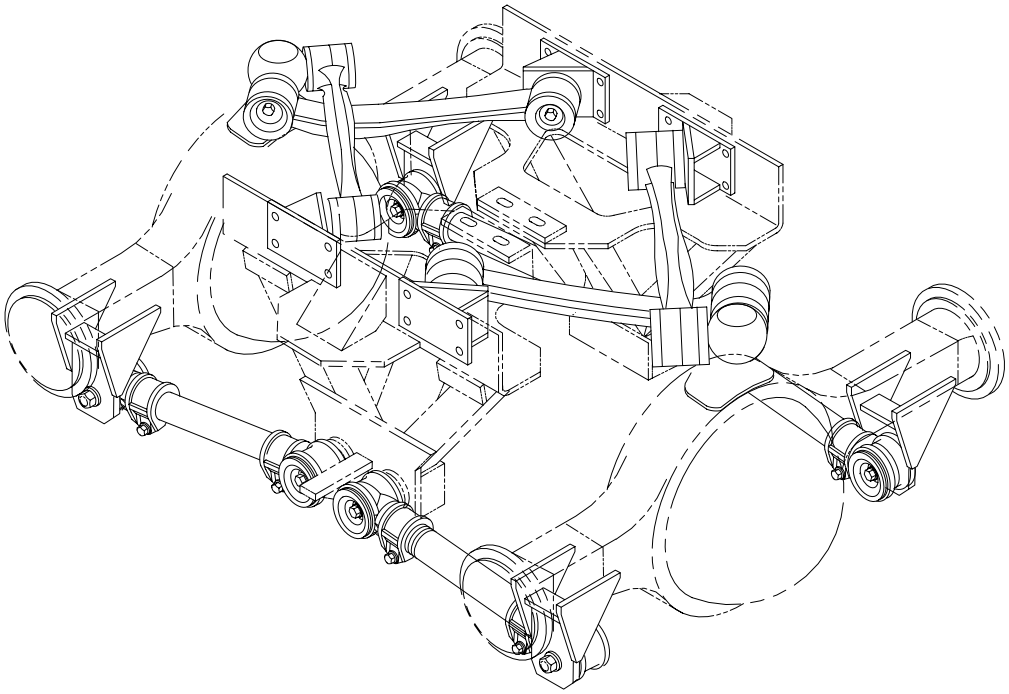
NOTE: Inspect torque rod bushings for free play before removing the torque rods. See **Subject 160** for torque rod bushing inspection information.

1. If necessary, power wash the rear suspension to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Relieve all drive axle brake or wind-up loads by placing the transmission in neutral and releasing the spring or driveline brakes.
4. Raise the rear of the vehicle to remove all weight from the rear axles, and place safety stands under the frame to secure the vehicle in its raised position.
5. Working on one torque rod at a time remove the torque rod bolts and spigot caps. Discard the bolts. Set the spigot caps aside for cleaning and inspection.

   Remove the torque rods by prying between the torque rod eye and the spigot base or frame bracket.

NOTE: At the axle housing towers, pry off the tower cap to access the torque rod fasteners.

Torque Rod Removal and Installation

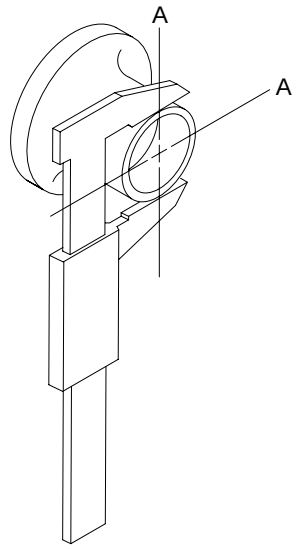


01/11/96 f320447

Fig. 2, Torque Rod Arrangement, 46,000 lb Capacity Suspension

6. Replace worn or damaged bushings following the instructions in **Subject 160**.
7. Inspect the spigots for damage, severe corrosion, or extensive wear. Replace damaged or severely corroded spigots. To determine whether or not a spigot is worn enough to warrant replacement, see **Fig. 3** and **Table 1**.

   The smaller of the two measurements should be used as the spigot diameter.
8. On vehicles equipped with Size #0 spigots, carefully inspect the spigot cap bolt head contact area for wear. A worn cap must be replaced to avoid fastener loosening. See **Fig. 4**.



10/24/95 f320446

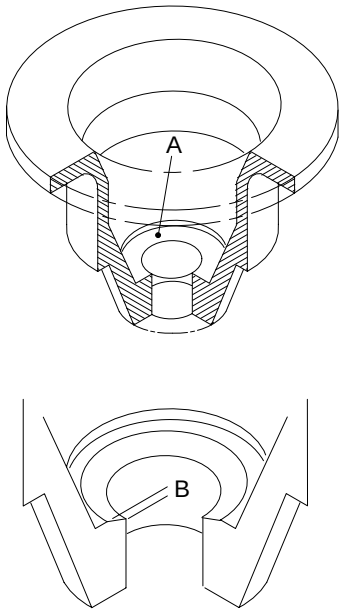
A. Measure outside diameter at two locations, 90 degrees apart.

Fig. 3, Spigot Measurement Points

Spigot Size	Spigot Part No.	Useage	Minimum Spigot Diameter With Standard Bushing	Minimum Spigot Diameter With Oversize Bushing
#0	700096	40,000 lb capacity—vehicles built before 1/93	59.69 mm (2.350 in)	58.93 mm (2.320 in)
#1	800200	40,000 lb capacity—vehicles built from 1/93	59.69 mm (2.350 in)	58.93 mm (2.320 in)
#2	800021	46,000 & 50,000 lb capacity—all	64.26 mm (2.530 in)	63.50 mm (2.500 in)

Table 1, Spigot Wear Limits

Installation

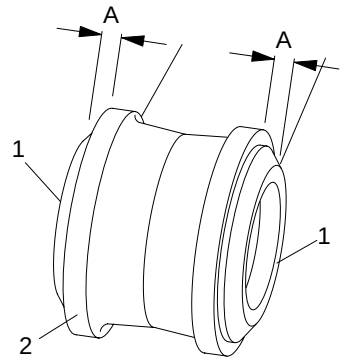


10/25/95 f320448

A. The bolt head contact area is the critical wear area.
B. Wear from the bolt head must not exceed 0.127 mm (0.005") in depth

Fig. 4, Size #0 Spigot Cap Inspection Areas

1. Check the torque rod bushings to make sure they are properly installed. They must be centered within the torque rod eye. See **Fig. 5**.



10/26/95 f320449

A. The amount of rubber protruding from each side of the torque rod eye must be equal.
1. Torque Rod Bushing 2. Torque Rod Eye

Fig. 5, Torque Rod Bushing Protrusion

IMPORTANT: Never use any mineral based oils, greases, jellies, or solvent soaps to aid in the assembly of rubber suspension parts. Use only lubricants specifically designed for use with rubber compounds.

2. Lubricate the outside of the spigots and the inside of the rubber bushings with a generous amount of rubber lubricant such as Rimslip® or equivalent.
3. Push the torque rod into position on its spigots. After the torque rod is partially installed, use a heavy soft-faced mallet to drive the torque rod into position until the bushing contacts the spigot bottom face.

Torque Rod Removal and Installation

NOTE: For easier installation, alternate mallet blows between ends of the torque rod to drive it onto the spigots evenly.

4. Install the spigot caps.
5. Install and tighten the torque rod bushing through-bolts 183 N·m (135 lbf·ft).
6. Remove the safety stands from under the vehicle, then lower the vehicle.
7. Remove the chocks from the tires.

Torque Rod Bushing Inspection and Replacement

Inspection

1. If necessary, power wash the upper and lower torque rods to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Relieve all drive axle brake or wind-up loads by placing the transmission in neutral and releasing the spring or driveline brakes.
4. Using your hands only, attempt to move the torque rod ends, checking for free play. Some movement as the bushings "give" is normal, but only free play is cause for bushing replacement.

NOTE: Never use a lever or pry bar to check for torque rod bushing free play. To do so may result in unnecessary bushing replacement.

5. If free play is detected, replace the bushing as described below.

Replacement

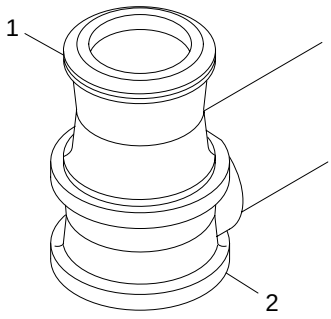
1. Remove the torque rod containing the worn out bushing. Refer to **Subject 150**, if necessary.

NOTE: Remove only one torque rod at a time to avoid mixing-up torque rod positions.

2. Place the torque rod on the floor or a workbench with a bushing open end facing upward. Push the tip of a large screwdriver down between the torque rod eye and the bushing and pry out the bushing. Discard removed bushings.
3. Use a wire brush and/or scraper to clean the torque rod eyes, removing all rust, scale, and rubber accumulations.
4. Inspect the torque rod eyes looking for cracks, distortion, or severe corrosion. Replace torque rods with damaged bushing eyes.

IMPORTANT: Never use any mineral based oils, greases, jellies, or solvent soaps to aid in the assembly of rubber suspension parts. Use only lubricants specifically designed for use with rubber compounds.

5. Lubricate both the inside of the torque rod eye and the outside of the new bushing with a generous amount of rubber lubricant, such as Rimslip® or equivalent.
6. Place the torque rod on a solid level floor with an open end of the eye facing upward. Position a lubricated bushing on the eye, making sure that the tapered shoulder of the bushing is centered on the eye. **See Fig. 1.**



1. Torque Rod Bushing 2. Torque Rod Eye

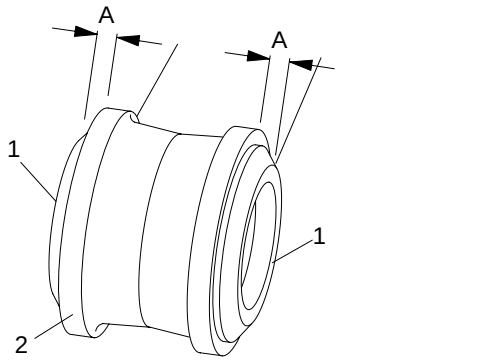
Fig. 1, Torque Rod Bushing Installation

7. Using a heavy, soft-faced mallet, strike the bushing squarely to drive it into the torque rod eye. Then, flip the torque rod over 180 degrees and tap on the torque rod shaft with the mallet while the bushing rests on the floor.

NOTE: If available, a small press may be used instead of a mallet for bushing installation.

8. The bushing is completely installed when it is centered within the torque rod eye. **See Fig. 2.**
9. Install the re-bushed torque rod. Refer to **Subject 150**, if necessary.

Torque Rod Bushing Inspection and Replacement



10/26/95 f320449

A. The amount of rubber protruding from each side of the torque rod eye must be equal .

1. Torque Rod Bushing 2. Torque Rod Eye

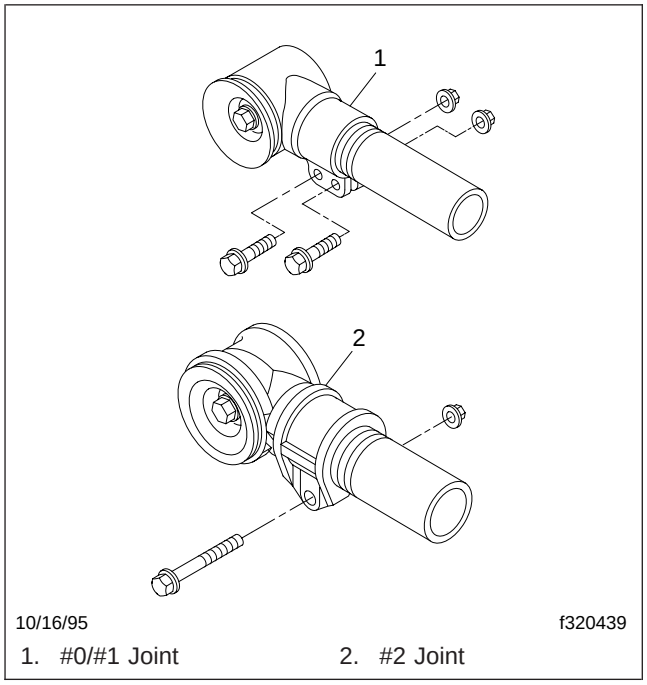
Fig. 2, Torque Rod Bushing Protrusion

Rear Axle Alignment Adjustment

On the Chalmers 800 Series Rear Suspension, the lower torque rods provide the only means for adjusting rear axle alignment. The upper torque rods play no part in the axle alignment process.

The lower torque rod bodies consist of steel tubes, with fine threads cut into the ends of the tube. Left-hand threads are cut into one end of the tube, right-hand threads into the other end. Therefore, by simply twisting the tube body while restraining the ends, the effective length of the tube is changed.

Two different types of torque rod ends are used. On #0 and #1 sizes, two 1/2-inch clamp bolts secure the rod ends to the tube. On the #2 size, a single 5/8-inch bolt is used. See **Fig. 1.**



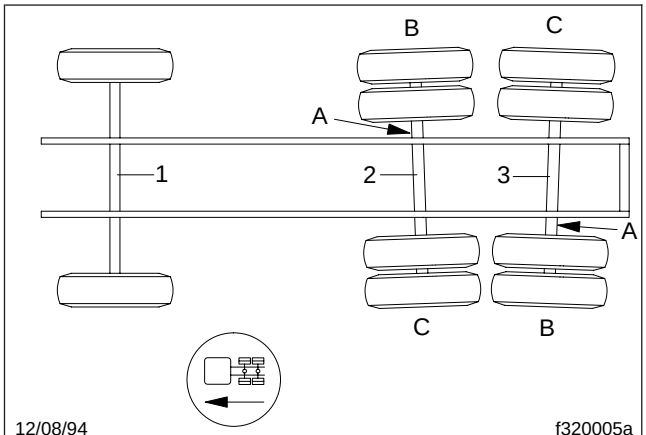
1. #0/#1 Joint
2. #2 Joint

Fig. 1, Adjustable Torque Rod Ends

Adjustment

1. Ensure that the torque rod bushings are in a fully relaxed, neutral state by slowly moving the vehicle back and forth a few times. Apply the service brakes, *not the parking brakes*.
2. Chock the front tires to prevent vehicle movement.
3. Relieve drive axle brake or wind-up loads by placing the transmission in neutral and releasing the brakes.
4. Using a straightedge and a tape measure, determine the amount of adjustment needed to align the forward-rear axle at right angles to the frame. For instructions, refer to **Group 35**. The difference in measurements between the sides of the vehicle is the approximate amount that the trailing end of the forward-rear axle will have to be brought forward, or the leading end will have to be moved back to align it at a right angle to the frame. See **Fig. 2**.

   If the forward-rear axle alignment is within specifications, go to the step that begins "Using a center-point bar, determine...".



A. Adjust here.
B. Leading End
C. Trailing End
1. Front Axle
2. Forward Rear Axle
3. Rearmost Axle

Fig. 2, Tandem Axle, Shown Out of Alignment

5. On the side of the vehicle that is to be adjusted forward or rearward, loosen the torque rod end pinch bolts at both ends of the torque rod.

NOTE: If the pinch bolts are badly corroded or otherwise damaged, remove and discard them. Install new Chalmers fasteners.

6. Attach a pipe wrench to the tube body (chain type preferred) and rotate the tube to shorten or

Rear Axle Alignment Adjustment

lengthen the torque rod. Continue to rotate the tube until the forward-rear axle is square to the frame.

NOTE: If the torque rod tube is difficult to rotate, apply penetrating oil to the tube threads. If this does not help, remove the pinch bolts and drive wedges between the eye lugs to relieve the clamping effect.

7. When the forward-rear axle is square with the frame, tighten the pinch bolts.
   - 7.1 Tighten 1/2-inch UNC bolts on #0 and #1 joints 88 N·m (65 lbf·ft).
   - 7.2 Tighten 5/8-inch UNC bolts on #2 joints 183 N·m (135 lbf·ft).
8. Using a center-point bar, determine the difference between the forward-rear and the rearmost axles' center-to-center measurements on each side of the vehicle. For instructions, refer to **Group 35**. This difference is the approximate distance that the leading end of the rearmost axle will have to be adjusted rearward, or that the trailing end will have to be adjusted forward, to align it at a right angle to the frame, and to align it parallel to the forward-rear axle. See **Fig. 2**.
9. On the side of the vehicle that is to be adjusted forward or rearward, loosen the torque rod end pinch bolts at both ends of the torque rod.

NOTE: If the pinch bolts are badly corroded or otherwise damaged, remove and discard them. Install new Chalmers fasteners.

10. Attach a pipe wrench to the tube body (chain type preferred) and rotate the tube to shorten or lengthen the torque rod. Continue to rotate the tube until the rearmost axle is square to the frame.

NOTE: If the torque rod tube is difficult to rotate, apply penetrating oil to the tube threads. If this does not help, remove the pinch bolts and drive wedges between the eye lugs to relieve the clamping effect.

11. When the rearmost axle is square with the frame, tighten the pinch bolts.
    - 11.1 Tighten 1/2-inch UNC bolts on #0 and #1 joints 88 N·m (65 lbf·ft).
    - 11.2 Tighten 5/8-inch UNC bolts on #2 joints 183 N·m (135 lbf·ft).
12. Remove the safety stands, and lower the vehicle. Remove the chocks from the front tires.
13. Using the center-point bar, check the rearmost axle alignment. If alignment is not within specifications, repeat the applicable steps above.

⚠ CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the suspension.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 of the *Business Class Trucks Maintenance Manual*.

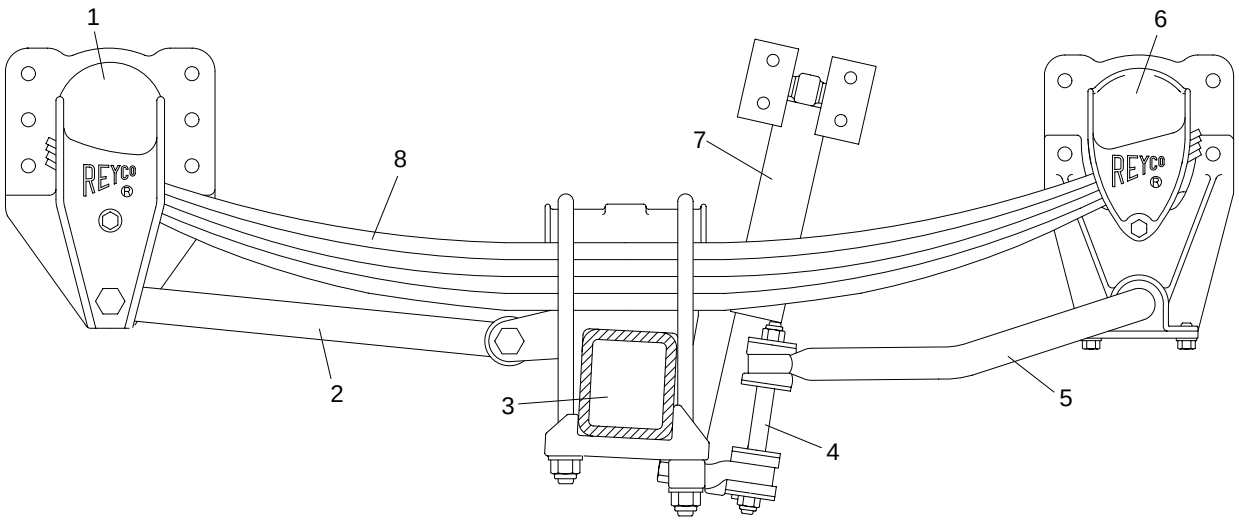
Specifications

Description	Bolt Size	IFI Grade	Torque N·m (lbf·ft)
Beam Spring Plate Bolt	3/8 UNC	8	47 (35)
Torque Rod End Through Bolts	5/8 UNC	8	183 (135)
Shock Absorber (Beam-Mounted) Bolt	3/4	8	230 (170)
Shock Absorber (Axle-Mounted) Nut	7/8	G	366 (270)
#0/#1 Torque Rod End Pinch Bolts	1/2 UNC	8	88 (65)
#2 Torque Rod End Pinch Bolts	5/8 UNC	8	183 (135)

Table 1, Fastener Torques, 800 Series Suspension

General Description (See Fig. 1)

The Reyco 79KB suspension uses a full–floating spring design. Semi-elliptical spring assemblies, or optional parabolic springs, are attached to the axles with U–bolt assemblies. The spring ends ride in hangers that are mounted on the frame rails. Adjustable torque rods are attached to the forward spring hanger and axle seat to hold the axle in alignment.



03/11/96 f320489

1. Forward Spring Hanger
2. Torque Rod
3. Axle
4. Anti-Sway Bar End-Link (optional)
5. Anti-Sway Bar (optional)
6. Rear Spring Hanger
7. Shock Absorber
8. Leaf Spring

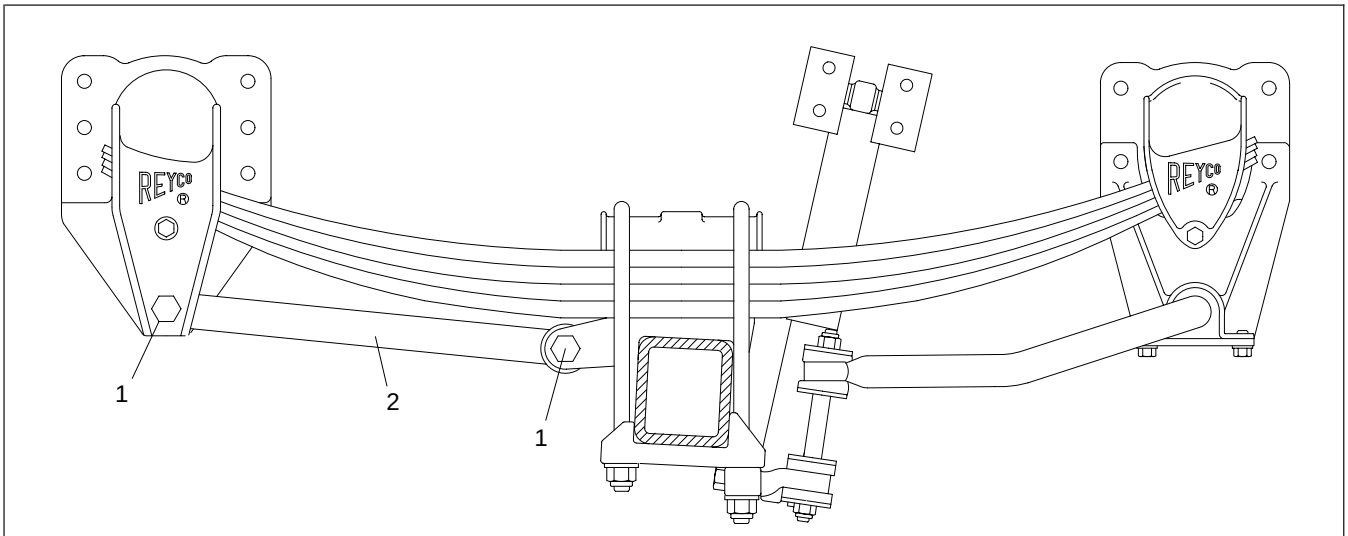
Fig. 1, Reyco 79KB Suspension

Torque Rod Removal and Installation

Removal (See Fig. 1)

There are two torque rods installed on the Reyco 79KB suspension. The curb (right) side torque rod is not adjustable (rigid). The left (driver's) side torque rod is adjustable to allow proper axle alignment.

1. Apply the spring, or driveline brakes and chock the front tires.
2. Use a lifting device and raise the rear of the tractor until the rear tires are elevated above the ground. Place jack stands under the frame rails to unload the suspension, and lower the lifting device until only the jack stands are supporting the vehicle weight.
3. Place the lifting device under the axle and raise the axle to unload the torque rod. Place jack stands under the axle.
4. Remove the two torque rod bolts and nuts, and remove the torque rod. See **Fig. 1**.
2. Raise the opposite end of the torque rod on the lower axle mounting plate.
3. Install a bolt on the torque rod
4. Tighten the torque rod locknuts 540 to 610 N·m (400 to 450 lbf·ft).
5. Raise the axle and remove the jack stands. Lower the axle to the ground.
6. Raise the rear of the vehicle and remove the jack stands. Lower the vehicle to the ground.
7. Check the axle alignment. For instructions, see **Group 35**. If necessary, adjust the rear axle alignment, using the instructions in **Subject 130**.



01/03/96 f320490

1. Torque Rod Bolt
2. Torque Rod

Fig. 1, Reyco 79KB Torque Rod

Installation (See Fig. 1)

1. Place the torque rod on the forward frame hangar and install a torque rod bolt to hold it in place.

Spring Assembly Replacement

Removal (See Fig. 1)

⚠ WARNING

Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.

Leaf spring assemblies weigh approximately 100 to 190 lbs (45 to 86 kg). Do not attempt to remove a leaf spring assembly without assistance. Personal injury and property damage may result.

1. Park the vehicle on a level surface. Apply the spring, or driveline brakes and chock the front tires.
2. Raise the frame so that all weight is removed from the leaf springs, then support the frame with safety stands. Raise the rear axle until the spring no longer contacts the spring retainer rollers, then support the axle with safety stands. Make sure the stands will securely support the weight of the axles and frame. To gain easy access to the suspension system, remove the wheel assembly; see **Group 40** for instructions.
3. Remove the U-bolt locknuts and washers. Remove the U-bolt mounting plate. Remove the U-bolts, and the upper axle mounting plate.
4. Remove the spring retaining bolts, spring rollers, and nuts.
5. Use a pry tool to lift the leaf spring assembly off of the lower mounting plate.

NOTE: There is a projection at the center of the leaf spring assembly to locate the spring.

6. With assistance, carefully move the leaf spring assembly forward to clear the rear hanger. Raise the rear of the leaf spring assembly and move it rearward to clear the front hanger. Remove the leaf spring from the vehicle.

Installation

⚠ WARNING

Leaf spring assemblies weigh approximately 100 to 190 lbs (45 to 86 kg). Do not attempt to install a leaf spring assembly without assistance. Personal injury and property damage may result.

1. With assistance, position the leaf spring assembly on the axle.
2. Place the front of the leaf spring assembly through the hanger, then place the rear of the leaf spring assembly through the rear hanger.
3. Install the projection on the center of the leaf spring assembly on the spring seat.
4. Install the U-bolt pad on the leaf spring assembly.
5. Install the U-bolts over the U-bolt pad and axle tube. Insert the U-bolts through the axle clamp, then install the U-bolt washers and high nuts. Tighten the U-bolt high nuts as described in **Section 32.07, Specifications 400**.
6. Install the spring retainer bolts, rollers, and locknuts. Tighten the spring retaining bolt locknuts 60 to 80 lbf·ft (85 to 110 N·m).
7. Move the torque rod into position with the lower axle mounting plate.
8. Install the torque rod mounting bolt and locknut. Tighten the locknut 350 to 400 lbf·ft (475 to 545 N·m).
9. Install the wheel assembly. See **Group 40** for instructions.
10. Raise the axle assembly, remove the safety stands and lower the axle to the ground.
11. Raise the vehicle frame, remove the safety stands from under the frame and lower the vehicle.

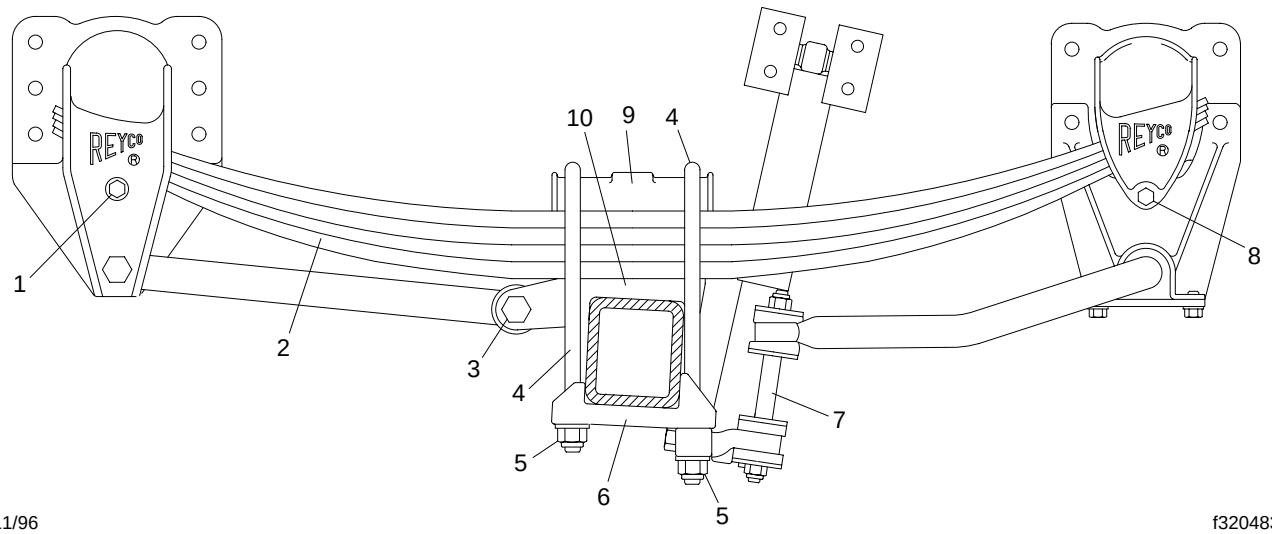
⚠ CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

Spring Assembly Replacement

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, Group 32 of the *Business Class Trucks Maintenance Manual*.

12. Check the axle alignment. For instructions, see **Group 35** in this manual. If necessary, adjust the rear axle alignment, using the instructions in **Subject 130**.



1. Forward Hanger Spring Retainer Bolt
2. Leaf Spring
3. Torque Rod Bolt
4. U-Bolt
5. U-Bolt High Nut
6. Axle Clamp
7. Anti-Sway Bar End Link (optional)
8. Rear Hanger Spring Retainer Bolt
9. U-Bolt Pad
10. Spring Seat

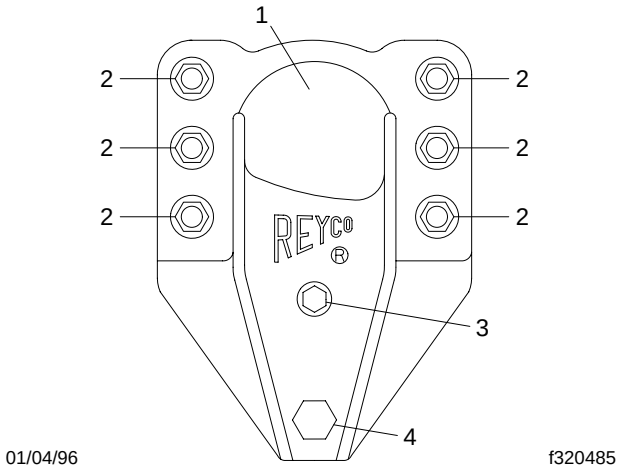
Fig. 1, Reyco 79KB Leaf Spring Replacement

Removal

⚠ WARNING

Replace worn, cracked, or damaged spring hangers. Failure to do so could result in bracket breakage, possibly leading to loss of vehicle control and resulting in personal injury or property damage.

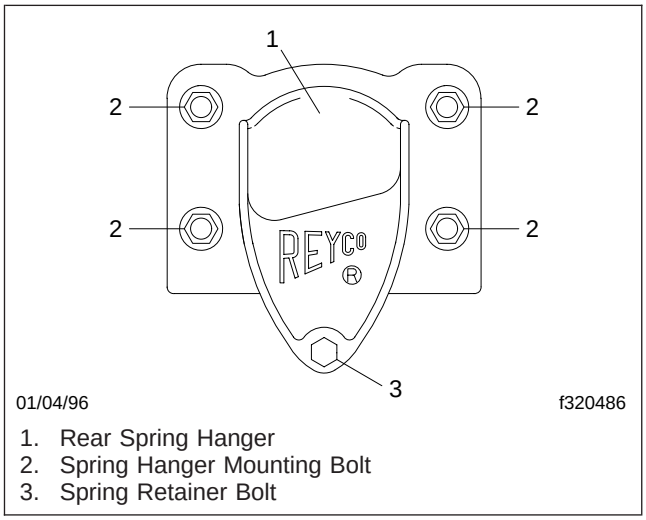
1. Park the vehicle on a level surface. Apply the spring or driveline brakes, and chock the front tires.
2. Place a lifting device under the vehicle frame. Lift the frame until the leaf spring assemblies are no longer in contact with the hangers, and support the frame with safety stands.
3. Remove the torque rod mounting bolt located on the forward hanger. See **Fig. 1**, Ref. 4.



1. Forward Spring Hanger
2. Forward Spring Hanger Mounting Bolt
3. Spring Retainer Bolt
4. Torque Rod Bolt

Fig. 1, Reyco 79KB Forward Spring Hanger

4. Remove the spring retainer bolt from the forward hanger. See **Fig. 1**, Ref. 3.
5. Remove the six hanger mounting bolts and nuts. See **Fig. 1**, Ref. 2.
6. Remove the forward hanger from the frame rail.
7. Remove the spring retainer bolt from the rear hanger. See **Fig. 2**, Ref. 3.



1. Rear Spring Hanger
2. Spring Hanger Mounting Bolt
3. Spring Retainer Bolt

Fig. 2, Reyco 79KB Rear Spring Hanger

8. Remove the anti-sway bar end links, if equipped. See **Fig. 3**, Ref. 4.
9. Remove the lower spring hanger mounting bolts (see **Fig. 2**, Ref. 2) and remove the anti-sway bar mounting bracket, if equipped. See **Fig. 3**, Ref. 5.
10. Remove the upper spring hanger mounting bolts (see **Fig. 2**, Ref. 2) and remove the rear hanger.

⚠ CAUTION

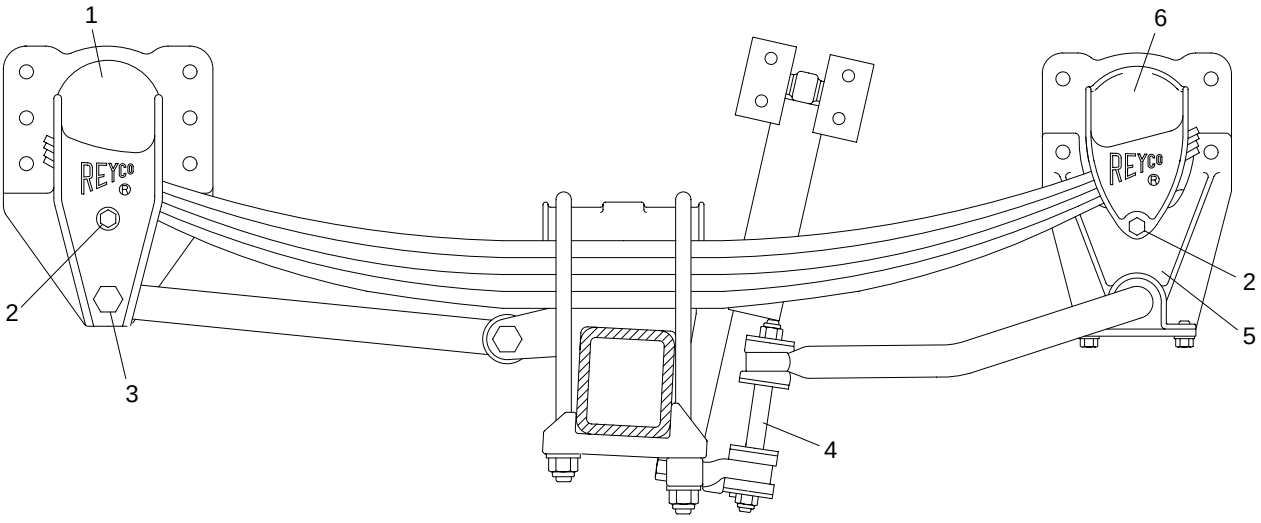
Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 of the *Business Class Trucks Maintenance Manual*.

Installation

1. Install the rear spring hanger on the frame rail, then install the two upper mounting bolts.

Spring Hanger Replacement



1. Forward Spring Hanger
2. Spring Retainer Bolt
3. Torque Rod Bolt
4. Anti-Sway Bar End Link (optional)
5. Anti-Sway Bar Mounting Bracket (optional)
6. Rear Spring Hanger

Fig. 3, Reyco 79KB Frame Hangar Components for Removal

2. If equipped, position the anti-sway bar mounting bracket over the lower bolt holes on the rear hanger, and install the two lower mounting bolts.
3. Tighten the rear spring hanger mounting bolts 190 lbf·ft (258 N·m).
4. Install the anti-sway bar end link and bushings, if equipped. Tighten the end link capscrew. See **Group 00** for torque specifications.
5. Install the spring retainer bolt, roller, and nut. Tighten the spring retainer bolt 60 to 80 lbf·ft (85 to 110 N·m).
6. Install the forward spring hanger on the frame rail, then install the mounting bolts. Tighten the mounting bolts 190 lbf·ft (258 N·m).
7. Install the torque rod mounting bolt. Tighten the torque rod mounting bolt 350 to 400 lbf·ft (475 to 545 N·m).
8. Install the spring retainer bolt, roller, and nut. Tighten the spring retainer bolt 60 to 80 lbf·ft (85 to 110 N·m).
9. Raise the vehicle frame with a lifting device, and remove the safety stands. Lower the vehicle to the ground.
10. Remove the wheel chocks.

Adjustment

CAUTION

Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 of the *Business Class Trucks Maintenance Manual*.

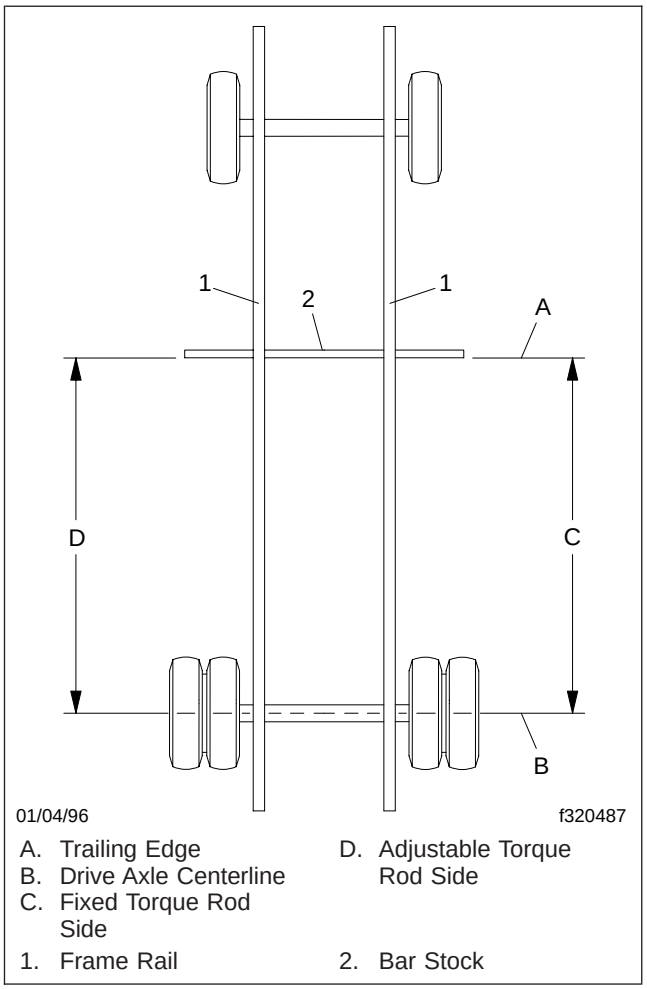
1. Park the vehicle on a level surface. Move the vehicle slowly back and forth several times without using the brakes to free all of the suspension joints. Shut down the engine. Do not apply the spring, or driveline brakes.
2. Chock the front tires.

NOTE: Check that the leaf springs are not binding in the frame hangars. Make sure that the U-bolts and torque rod bolts are torqued to specification, and all of the bushings are in good condition.

3. Position an 2-1/2 meter (8 ft) length of bar stock, or angle iron across the frame. Square the bar across the frame using a carpenter's square, and clamp it in place on the frame rail. See **Fig. 1**, Ref. 2.

NOTE: Position the bar as far forward of the drive axle as possible.

4. Start on the fixed (right) torque rod side. Measure the distance from the bar stock to the centerline of the drive axle. Repeat the same procedure on the adjustable (left) torque rod side. See **Fig. 1**, Ref. C and D.
5. If the distance varies more than 1/8-inch, alignment is necessary.
6. Loosen the torque rod clamp bolts. See **Fig. 2**, Ref. 1.
7. Use a pipe wrench or other suitable tool and slowly turn the torque rod.

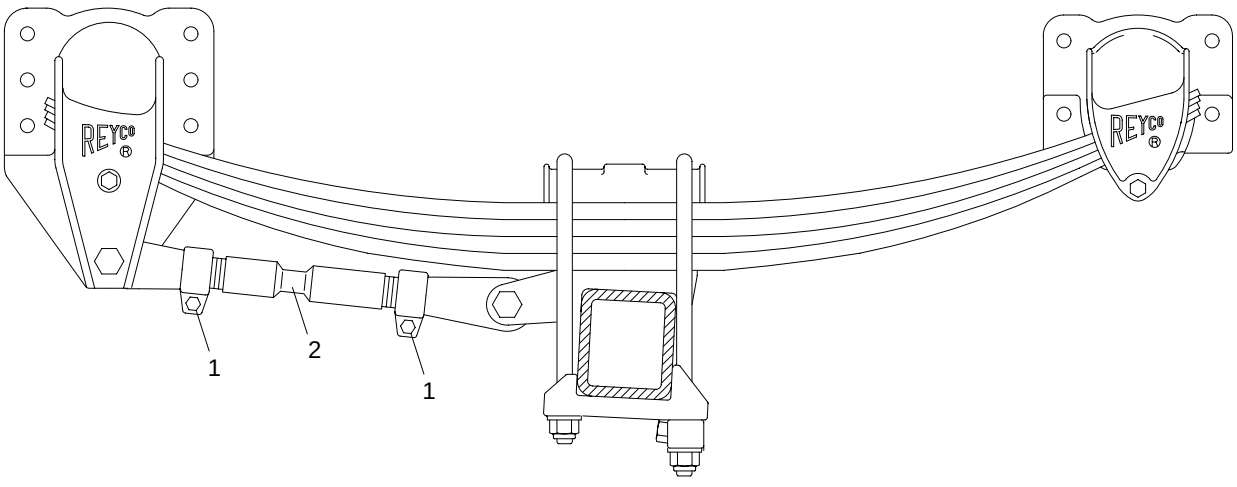


A. Trailing Edge
B. Drive Axle Centerline
C. Fixed Torque Rod Side
D. Adjustable Torque Rod Side
1. Frame Rail
2. Bar Stock

Fig. 1, Measuring Axle Alignment

8. Turn until the measurement on both sides of the axle are within 1/8-inch, then tighten the torque rod clamp bolts 170 to 203 N·m (125 to 150 lbf·ft).
9. Remove the wheel chocks and drive the vehicle through a short series of turns.
10. Recheck the alignment.

Rear Axle Alignment Adjustment



01/04/96 f320488

1. Torque Rod Clamp Bolt
2. Torque Rod Adjustment Location

Fig. 2, Adjustable Torque Rod

Specifications

Reyco 79KB Torque Values		
Description	**Size in.**	**Torque lbf·ft (N·m)**
Forward Spring Hanger	5/8	190 (258)
Rear Spring Hanger	5/8	190 (258)
U-bolt High Nuts	3/4–16	Stage 1: Hand tighten Stage 2: 60 (81) * Stage 3: 200 (271) * Stage 4: 270 to 330 (367 to 449) *
	7/8–14	Stage 1: Hand tighten Stage 2: 60 (81) * Stage 3: 200 (271) * Stage 4: 420 to 500 (571 to 680) *
Torque Rod Bolts	7/8	400 to 450 (545 to 615)
Torque Rod Clamp Nuts	5/8	125 to 150 (170 to 203)
Spring Retainer Bolts	1/2	60 to 80 (85 to 110)

* Tighten in a diagonal pattern as shown in **Fig. 1**.

Table 1, Reyco 79KB Torque Values

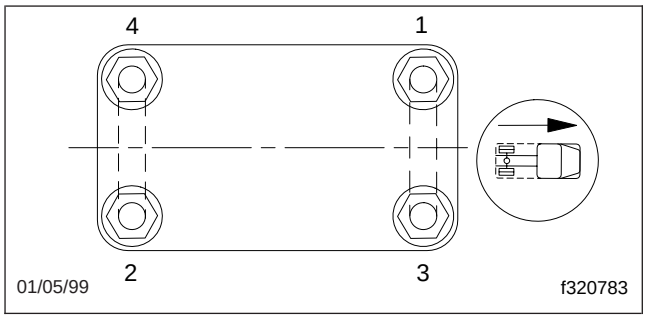
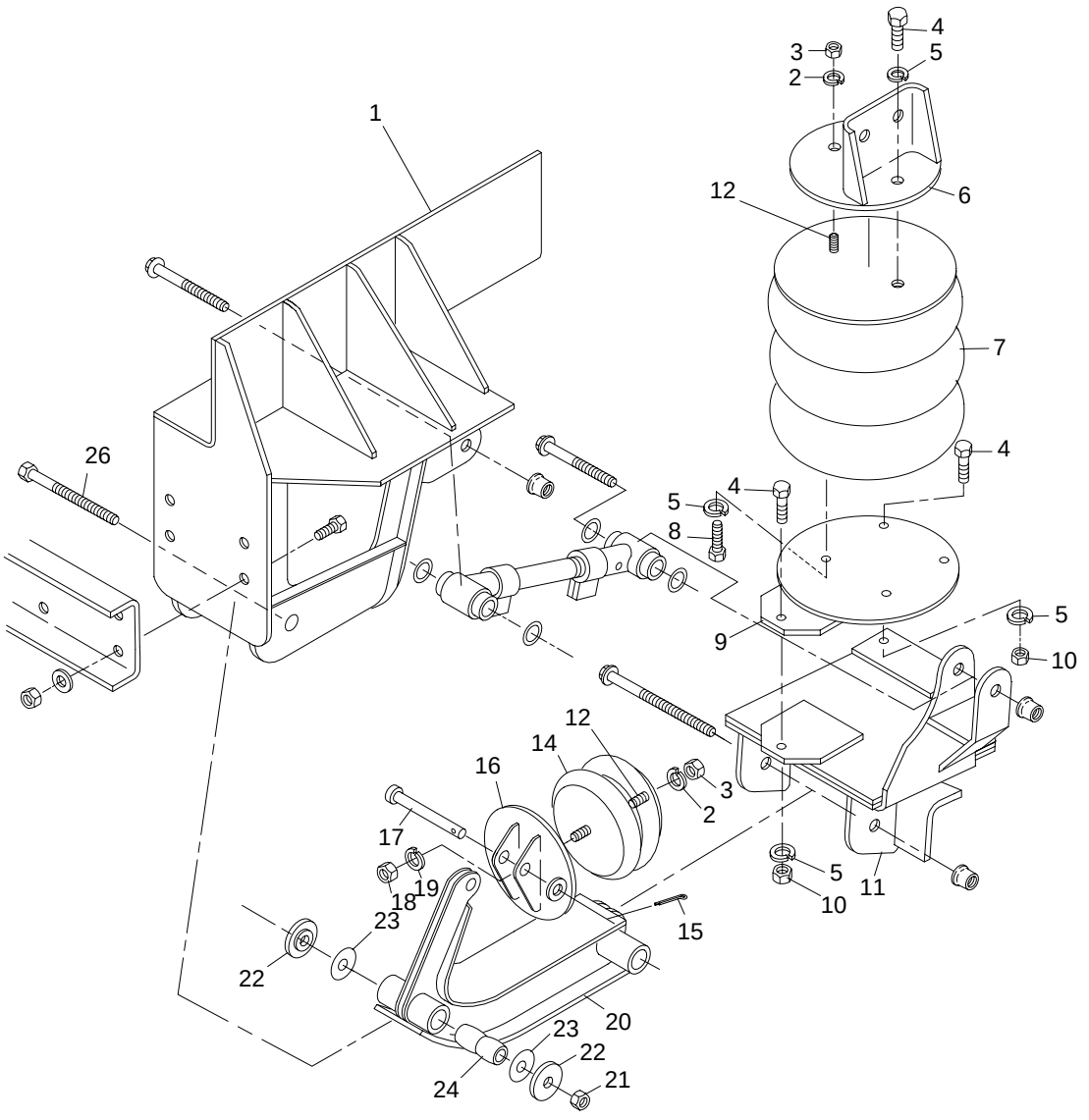


Fig. 1, Tightening Pattern for U-bolt High Nuts

General Description

The Watson and Chalin SL series steerable axle lift suspension (**Fig. 1**) uses a full-floating air spring design. Two air springs are attached to a trailing arm assembly. One air spring controls the suspension riding height, depending on load requirements, and the other air spring is used to lift the axle assembly when not in use. The trailing arm and air springs are attached to the frame rail with an upper torque rod, and a fastener that rides on a rubber bushing. Weld collars locate the suspension on the frame and hold the axle in alignment.

General Description



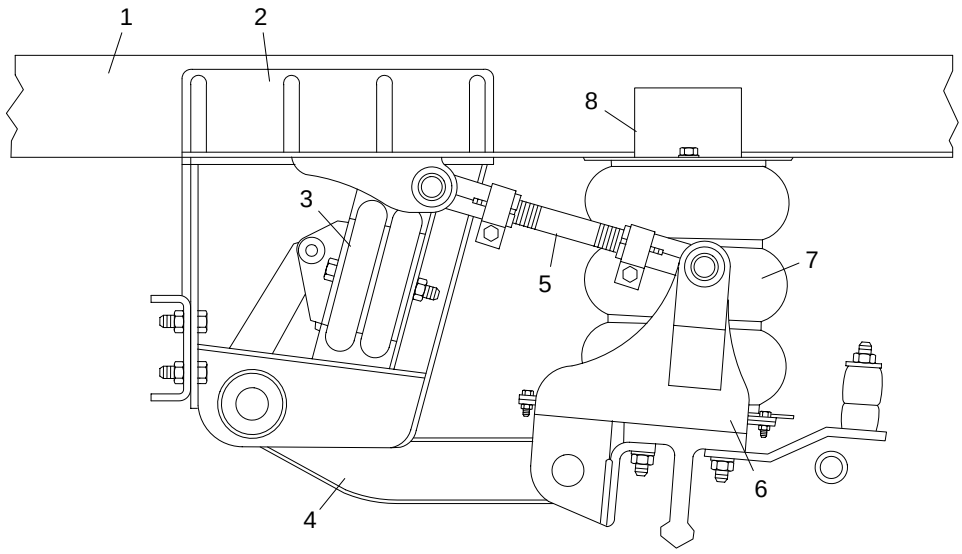
1. Side Rail Assembly
2. 3/4-Inch Lockwasher
3. 3/4-Inch UNF Hexnut
4. 3/8 x 1-1/8 Inch Capscrew
5. 3/8-Inch Lockwasher
6. Upper Air-Spring Plate
7. Load-Bearing Air Spring
8. 3/8-Inch UNC x 1 Inch Capscrew
9. Lower Air-Spring Plate
10. 3/8-Inch UNF Hexnut
11. Axle Pad Assembly
12. Air Fitting
13. Flatwasher
14. Axle Lift-Air Spring
15. Cotter Pin
16. Lift Plate
17. 3/4-Inch Clevis Pin
18. 1/2-Inch UNC Hexnut
19. 1/2-Inch Lockwasher
20. Trailing Arm
21. 1-1/8-Inch Locknut
22. Weld Collar
23. Washer
24. Bushing

Fig. 1, Air Spring Replacement, Exploded View

Upper Torque Rod Removal and Installation

Removal (See Fig. 1)

Installation (See Fig. 1)



10/16/96 f320527

1. Frame Rail
2. Side Rail Assembly
3. Axle-Lift Air Spring
4. Trailing Arm
5. Torque Rod
6. Axle Pad Assembly
7. Load-Bearing Air Spring
8. Upper Air-Spring Mounting Plate

Fig. 1, Watson and Chalin SL Series Steerable Axle Lift Suspension

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Completely drain all of the air from the air system. The air pressure gauge should read 0 psi (0 kPa).

⚠ WARNING

WARNING: Failure to drain the air system could result in personal injury, or property damage.

NOTE: If the upper torque rod has been previously serviced, remove the two mounting capscrews, two nuts, and four washers that attach the upper torque rod to the frame rail and axle assembly.

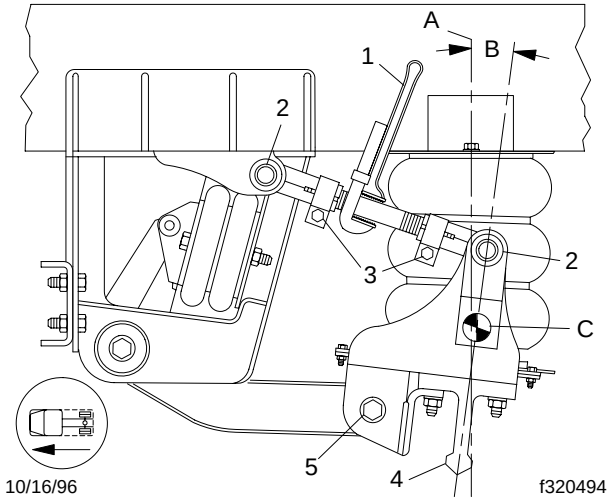
3. Remove the two huck bolts, two huck collars, and four washers that attach the upper torque rod to the frame rail and axle assembly.
4. Remove the upper torque rod from the vehicle.

1. If you are replacing the upper torque rod, measure the length of the old upper torque rod.
2. Duplicate the measurement, as closely as possible, on the new upper torque rod.
3. Install the upper torque rod onto the frame rail and axle assembly using the two capscrews, four washers, and two locknuts. Do not tighten the upper torque rod clamps.

   Use a pipe wrench to align the upper torque rod to the frame hanger and the axle pad assembly.
4. Tighten the capscrew at the frame rail 600 lbf·ft (814 N·m).
5. Tighten the capscrew at the axle assembly 1000 lbf·ft (1356 N·m).
6. Connect a magnetic protractor to the steerable axle.
7. Position the protractor on the axle pad assembly, so it is even with the centerline of the axle and the axle spindle center. See **Fig. 2**, Ref. 2.

Upper Torque Rod Removal and Installation

8. Move the protractor to position the centerline of the axle with the centerline of the upper torque rod capscrew. See **Fig. 2**, Ref. 6.
9. Record the caster setting. See **Fig. 2**, Ref. A.



A. Centerline of Axle
B. Caster Setting
C. Axle Spindle Center
1. Pipe Wrench
2. Huck Collar
3. Upper Torque Rod Clamp
4. Steerable Axle
5. Axle Seat Capscrew

Fig. 2, Watson & Chalin SL Series Suspension, Adjusting Caster

NOTE: Check both wheels for proper caster settings.

Caster should be set at 5° to 6° positive. Caster cannot be less than 5° positive.

10. If the caster setting is incorrect, adjust by turning the upper torque rod clockwise, or counterclockwise to achieve the proper caster setting. See **Fig. 2**, Ref. 1.
11. Tighten the upper torque rod clamps 600 lbf·ft (814 N·m).
12. Check the toe-in of the axle, using instructions found in **Group 33**.

Air Spring Inspection and Replacement

Inspection (See Fig. 1)

Check the air springs periodically to ensure that there is no dry-rot, cracking, deformities, or other damage that could impede the performance of the vehicle. Refer to the driver's manual for additional information regarding daily, pre-trip inspections of the air springs.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Check the air bags for cracks, deformities, dry-rotting, or other damage. Replace the air bags as needed.
3. Check for obstructions that could cause a breach of the air bag integrity. Reposition any component that is making contact with the air spring.
4. Check that the air system is fully charged, then check the operation of the axle lift air spring. If the axle lift air springs do not operate properly, refer to **Subject 300** for troubleshooting information.
5. Check the air lines for cracks, deformities, or leaking. Replace the air lines as needed.

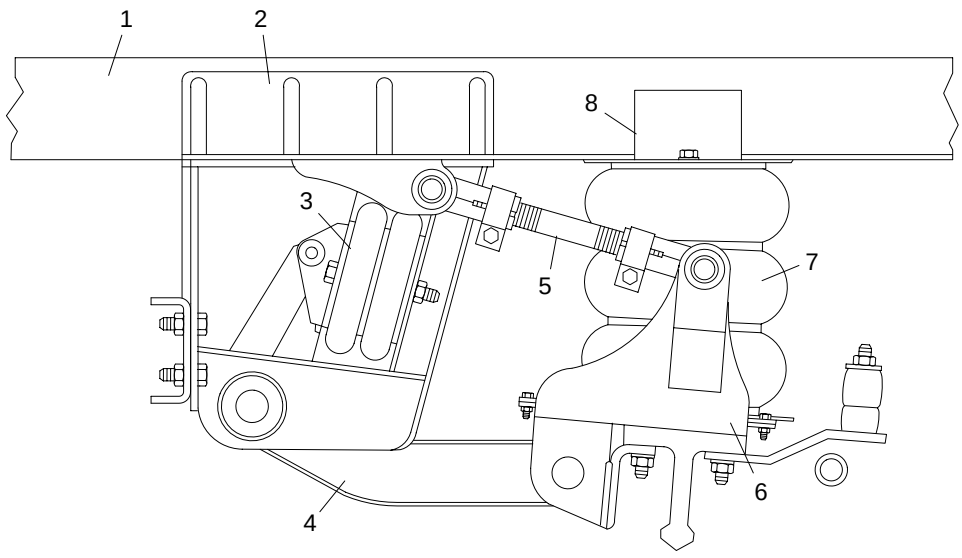
Replacement (See Fig. 2)

⚠ WARNING

WARNING: Before attempting to remove the air springs, be sure that all of the air has been drained from the air system. The air spring will expand, suddenly, when removed from its mount if the air system is not fully drained and could result in personal injury, or property damage.

Axle Lift Air Spring

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the wheels.
2. Completely drain all of the air from the air system. The air pressure gauges should read 0 psi (0 kPa).
3. Use a lifting device and elevate the steerable axle.
4. Place jack stands under the axle beam.
5. Remove the cotter pin, washer, and clevis pin from the lift plate.

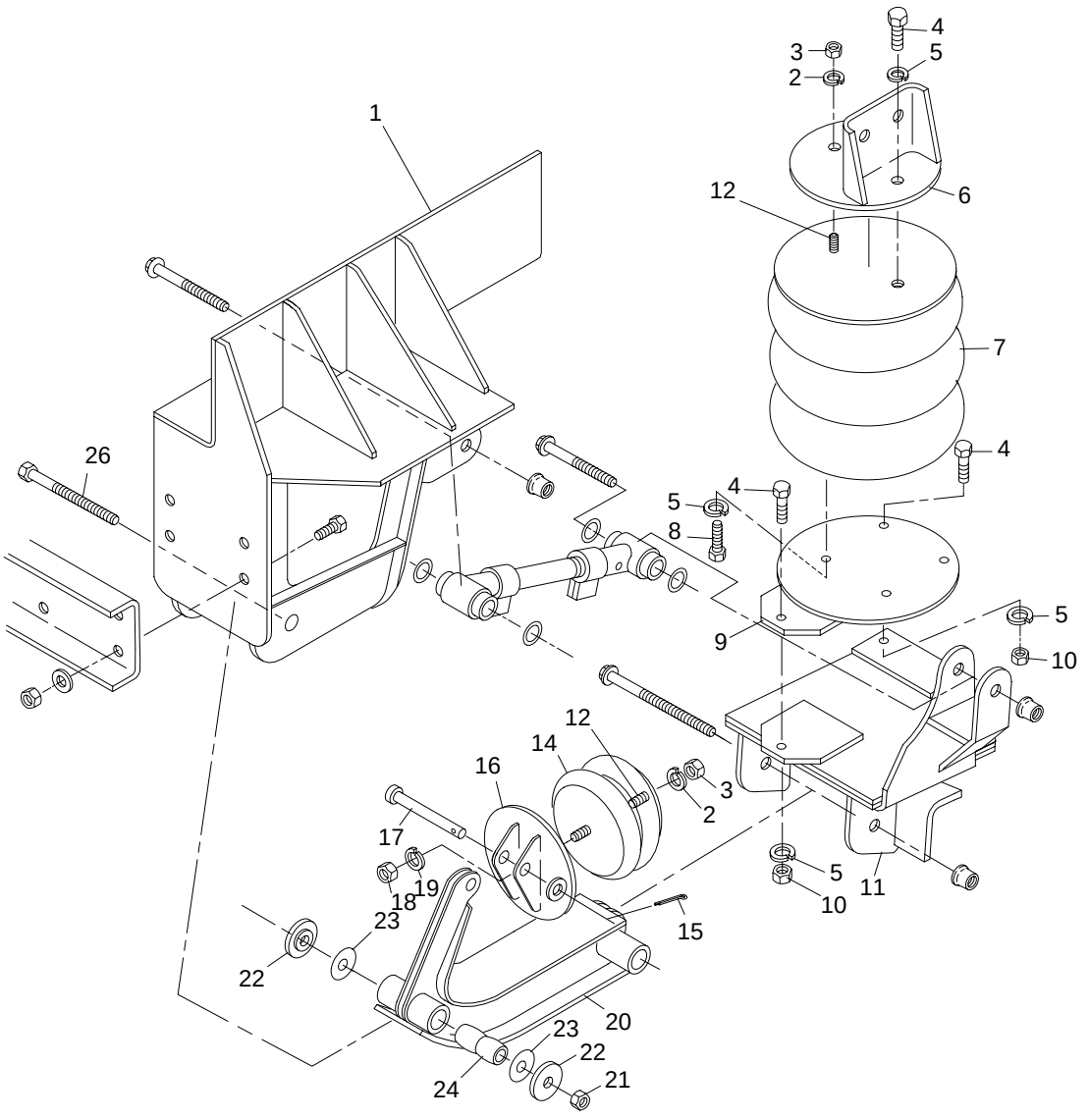


10/16/96 f320527

1. Frame Rail
2. Side Rail Assembly
3. Axle-Lift Air Spring
4. Trailing Arm
5. Torque Rod
6. Axle Pad Assembly
7. Load-Bearing Air Spring
8. Upper Air-Spring Mounting Plate

Fig. 1, Watson & Chalin SL Series Steerable Axle Lift Suspension

Air Spring Inspection and Replacement



1. Side Rail Assembly
2. 3/4-Inch Lockwasher
3. 3/4-Inch UNF Hexnut
4. 3/8 x 1-1/8 Inch Capscrew
5. 3/8-Inch Lockwasher
6. Upper Air-Spring Plate
7. Load-Bearing Air Spring
8. 3/8-Inch UNC x 1 Inch Capscrew
9. Lower Air-Spring Plate
10. 3/8-Inch UNF Hexnut
11. Axle Pad Assembly
12. Air Fitting
13. Flatwasher
14. Axle Lift-Air Spring
15. Cotter Pin
16. Lift Plate
17. 3/4-Inch Clevis Pin
18. 1/2-Inch UNC Hexnut
19. 1/2-Inch Lockwasher
20. Trailing Arm
21. 1-1/8-Inch Locknut
22. Weld Collar
23. Washer
24. Bushing

Fig. 2, Air Spring Replacement, Exploded View

6. Remove the air line and fitting from the axle lift air spring.
7. Remove the capscrew, two washers, two washers, and one locknut then lower the trailing arm.

8. Remove the 3/4-inch hexnut and washer; then remove the axle lift air spring.
9. Remove the 1/2-inch hexnut and lockwasher from the lift plate; then separate the axle-lift air spring (Ref. 14).
10. Install the axle-lift air spring on the lift plate. Install the 1/2-inch hexnut and lockwasher on the lift plate. Tighten the hexnut 25 lbf·ft (34 N·m).
11. Install the new axle-lift air spring, lockwasher, and 3/4-inch hexnut on the frame hanger. Tighten the hexnut 200 lbf·ft (271 N·m).
12. Raise the trailing arm and insert the clevis pin through the lift plate; then insert and lock a new cotter pin into the clevis pin.
13. Start the capscrew (Ref. 26) through the frame hanger (Ref 1). Position the washers between the frame hanger and the lower trailing arm and the trailing arm. Install the capscrew through the frame hanger and the trailing arm. Install the locknut and tighten it 1000 lbf·ft (1356 N·m).
14. Install the air fittings and the air lines.
15. Remove the jack stands.
16. Start the engine and build up air pressure.
17. Check for air leaks, and check axle lift operation.
18. Remove the chocks from the tires.

Load Bearing Air Spring

⚠ WARNING

WARNING: Before attempting to remove the air springs, be sure that all of the air has been drained from the air system. The air spring will expand suddenly when removed from its mount if the air system is not fully drained. This could result in personal injury or property damage.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Completely drain all of the air from the air system. The air pressure gauges should read 0 psi (0 kPa).
3. Remove the air line and fitting.
4. Remove the 3/4-Inch hexnut and lockwasher (Refs. 2 and 3) from the upper air-spring plate.
5. Remove the 3/8-inch capscrew and lockwasher (Refs. 4 and 5) from the upper air-spring plate.
6. Remove three 3/8-inch capscrews, hexnuts, and three lockwashers (Refs. 4, 5 and 10) from the rear of the axle pad assembly.
7. Place a pry tool between the upper air-spring plate and the load bearing air spring.
8. Pull down on the pry tool to separate the air spring from the mounting plate, and remove the air spring from the vehicle.
9. Remove two 3/8-inch capscrews and two lockwashers that secure the lower air-spring plate to the air spring. Separate the lower air-spring plate from the air spring.
10. Check the upper and lower air-spring plates for signs of corrosion, cracks, or other damage. Replace any air-spring plate that appears damaged, or excessively corroded.
11. Install the lower air-spring plate on the air spring.
12. Apply a light coating of Loctite® 242 to the threads of the capscrews. Install the capscrews on the air spring and tighten 15 lbf·ft (20 N·m).
13. Install the air spring on the upper air-spring plate and center the lower air-spring plate capscrew holes on the axle pad assembly.
14. Install the three 3/8-inch capscrews, three lockwashers, and three hexnuts on the lower air spring plate. Tighten the capscrews 15 lbf·ft (20 N·m).
15. Install the 3/8-inch x 1-1/8 inch capscrew and lockwasher on the upper air-spring plate. Tighten the capscrew 15 lbf·ft (20 N·m).
16. Install the 3/4-inch hexnut and lockwasher on the upper air-spring plate. Tighten the hexnut 200 lbf·ft (271 N·m).
17. Install the air fitting, then connect the air line to the air springs.
18. Start the engine and build up air pressure. Check for air leaks and repair as needed. See **Subject 300** for troubleshooting information.
19. Shut down the engine and remove the chocks from the tires.

Ride Height Measurement and Load Capacity Adjustment

IMPORTANT: It is the responsibility of the vehicle operator to weigh the vehicle to get accurate axle load capacity for the vehicle for legal operation. The amount of air pressure supplied to the lift axle load air spring will vary depending on vehicle load.

Ride Height Measurement

Suspension ride height is defined as the distance between the suspension mounting surface and the spindle center of the auxiliary liftable axle.Suspension ride height must be calculated with the vehicle in its loaded condition.

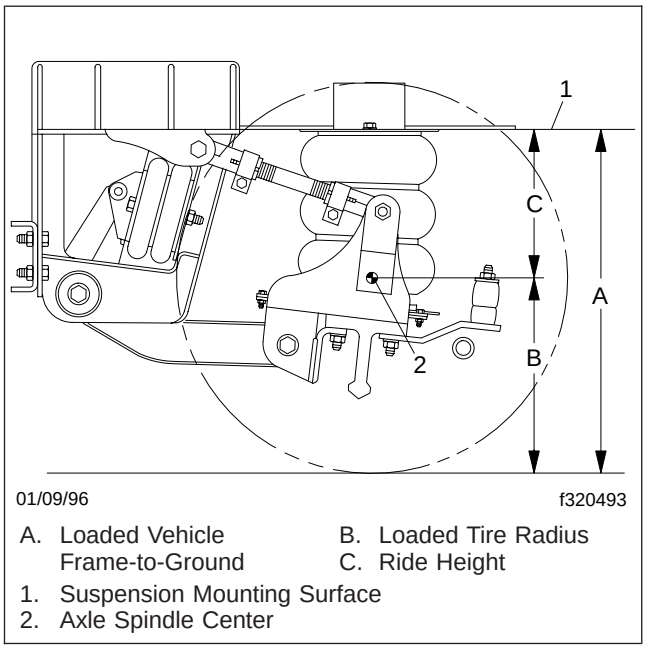
To check the ride height of the Watson & Chalin SL series suspension, use the following formula: A (loaded vehicle frame-to-ground) – B (loaded tire radius) = C (Ride Height). See **Fig. 1**.

1. Park the vehicle on a level surface. Apply the parking brakes and chock the front tires.
2. Run the engine until pressure in the air brake system exceeds 115 psi (792 kPa). Shut down the engine.
3. Measure the loaded frame-to-ground measurement; the distance from the bottom of the frame rail to the ground, with the vehicle in a loaded condition.
4. Measure the loaded tire radius; the distance from the axle spindle center to the ground, with the vehicle in a loaded condition.
5. Subtract the loaded tire radius from the loaded frame-to-ground measurement to determine ride height.

Load Capacity Adjustment

Load capacity can be adjusted by increasing or decreasing the air pressure to the lift air springs. The amount of air pressure varies depending on vehicle load. See **Specifications 400**, for load-to-pressure specifications.

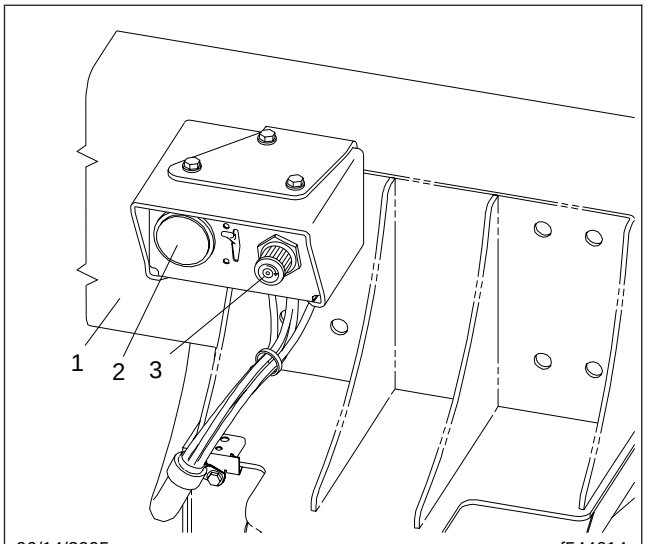
The air pressure to the lift air springs, which is indicated on the gauge located on the frame rail or in the cab, is set by the pressure regulator. See **Fig. 2**. Pressure is increased by turning the knob clockwise, and it is reduced by turning the knob counterclockwise.



01/09/96 f320493

A. Loaded Vehicle Frame-to-Ground
B. Loaded Tire Radius
C. Ride Height
1. Suspension Mounting Surface
2. Axle Spindle Center

Fig. 1, Watson & Chalin SL Series Suspension, Calculating Ride Height



06/14/2005 f544614

1. Frame Rail
2. Gauge
3. Regulator

Fig. 2, Pressure Regulator and Gauge

Inspection

The Watson & Chalin SL series steerable-axle lift suspension is operated from a control panel consisting of an air pressure gauge, pressure regulator, and a double-pull, double-throw air valve. See **Fig. 1**.

The control panel is designed so the driver can regulate the load pressure in the air springs for the proper, or desired load on the auxiliary axle. It is also designed to lift the auxiliary axle to the UP position when the vehicle load is empty, or the auxiliary axle is not required.

Optionally, an automatic reverse lift can be installed to automatically lift the suspension when the vehicle is shifted into reverse. An automatic reverse lockout will automatically lock the steerable axle to prevent it from turning when the vehicle is shifted to reverse. See **Fig. 2**.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the front tires.
2. Start the engine and build up air pressure in excess of 80 psi (552 kPa).

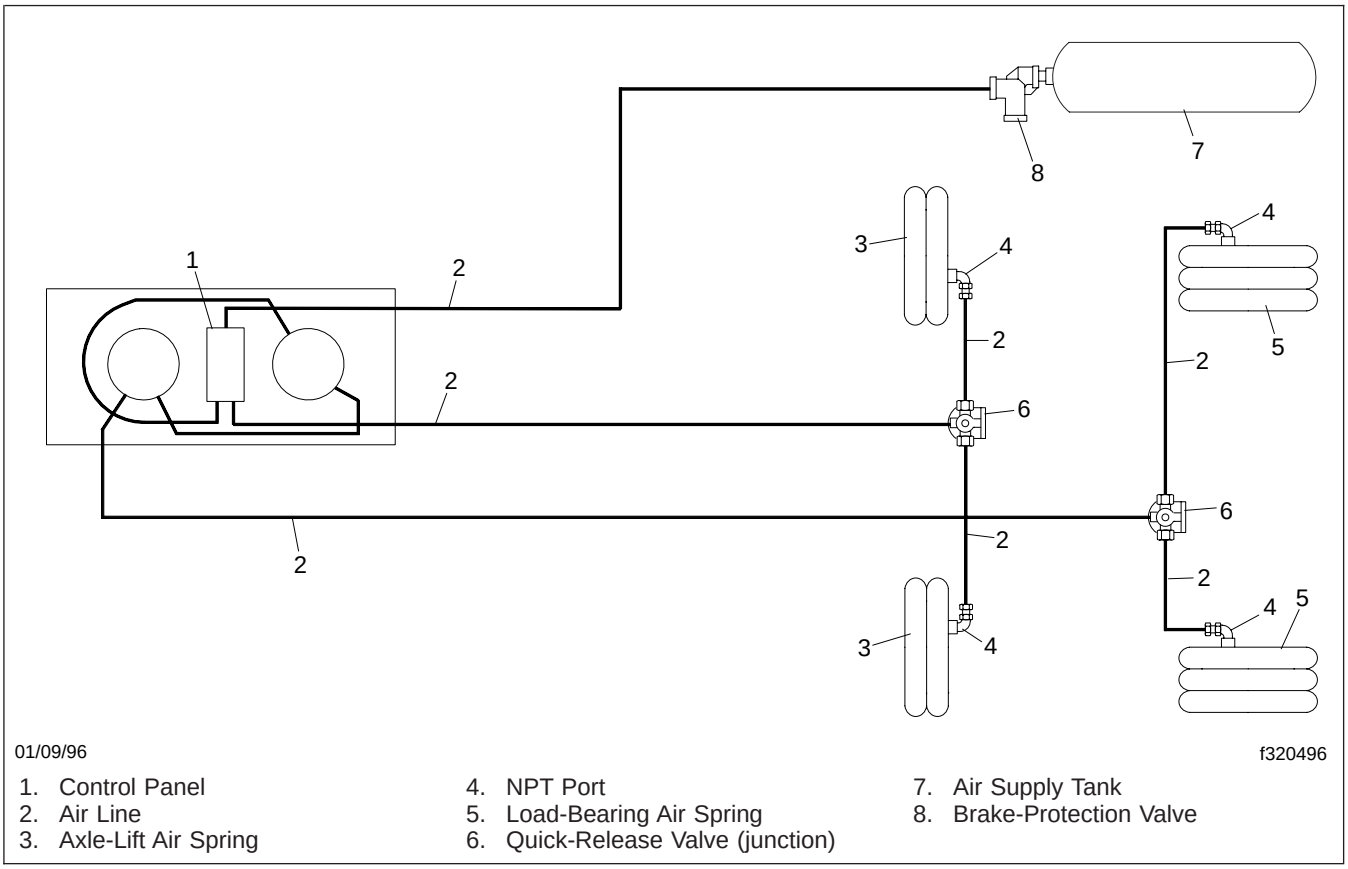
⚠ WARNING

Maintain air pressure of 80 psi (552 kPa). Failure to do so could result in brake failure if the suspension system suffered an air loss. This could result in personal injury or property damage.

3. Shut down the engine.
4. With a mixture of soap and water, coat the air fitting on the load bearing air springs, axle lift air springs, and at each air line junction.
5. If an air leak exists, air bubbles will form around the area where the leak originated. Repair or replace any leaking air line, fitting, or junction as needed.
6. Inspect the air supply tank for excessive corrosion, dents, or other damage that could weaken the tank. Replace any air supply tank that's damaged.
7. On vehicles equipped with an automatic reverse lift, check the solenoids for proper operation.
   - 7.1 Start the engine and lower the auxiliary axle suspension.
   - 7.2 Shift the transmission to reverse and check the position of the auxiliary axle.

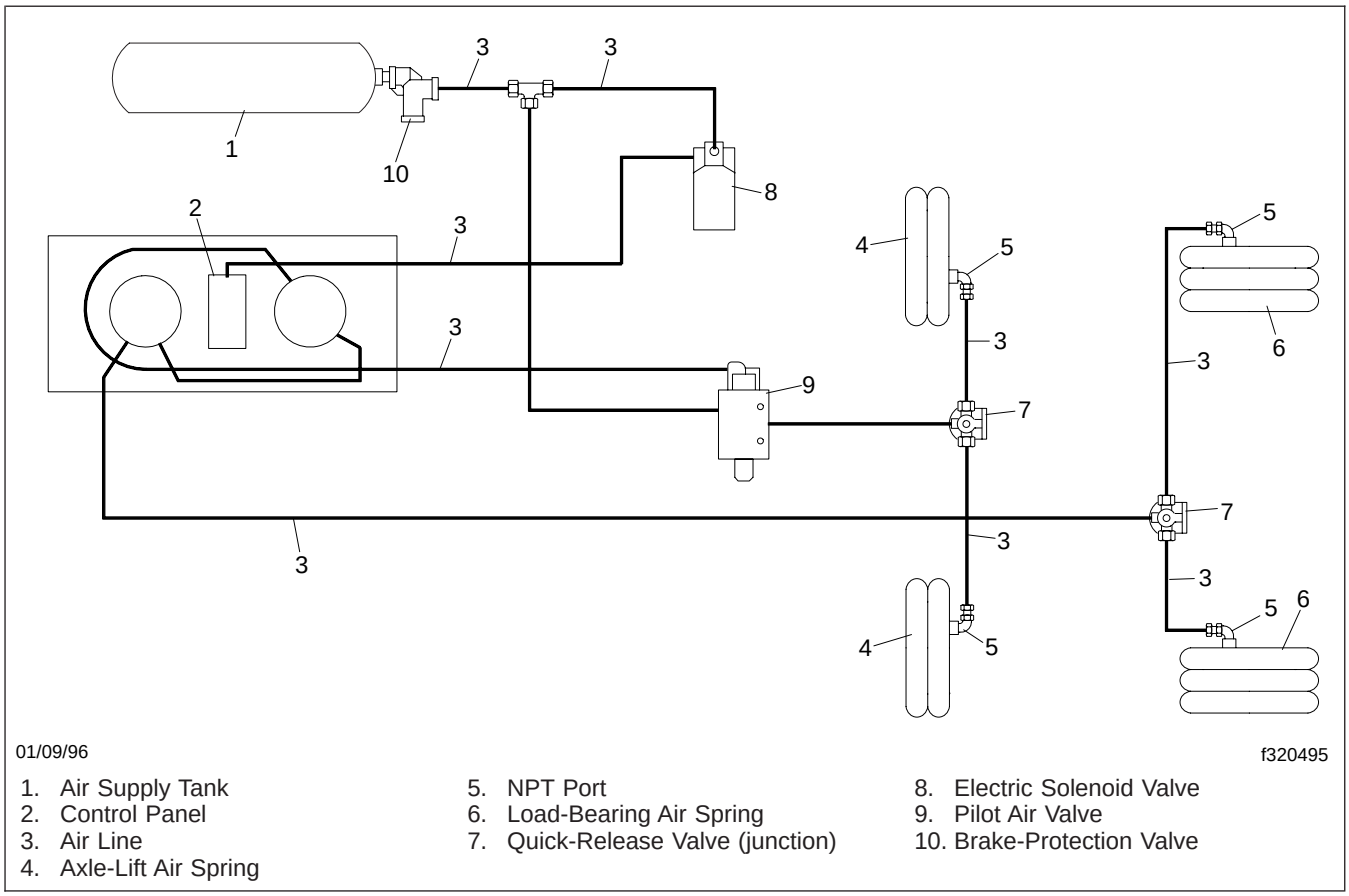
   NOTE: When the shifter is placed in reverse, the steering will lock in a straight-ahead position, and the axle will lift off the ground.
8. If the axle does not lift, shut down the engine and use the following instructions.
   - 8.1 Turn the ignition key ON, but do not start the engine.
   - 8.2 Disconnect the harness connector from the reverse lock-out solenoids.
   - 8.3 With a voltmeter, probe the harness side of the connector. There should be no voltage with the shifter in neutral or any forward gear.
   - 8.4 Do not start the engine. Move the shifter into reverse, and recheck for voltage. When the shifter is in reverse gear there should be 11 to 13 volts at the solenoid. If no voltage is found, trace and correct a short to ground in circuit 120B.
9. Check the air springs for cuts, dry-rotting, deformities, or other damage. Replace the air springs as needed. Refer to **Subject 110**, for replacement instructions.

Air System Inspection



1. Control Panel
2. Air Line
3. Axle-Lift Air Spring
4. NPT Port
5. Load-Bearing Air Spring
6. Quick-Release Valve (junction)
7. Air Supply Tank
8. Brake-Protection Valve

Fig. 1, Watson and Chalin Suspension with Standard Air Control



1. Air Supply Tank
2. Control Panel
3. Air Line
4. Axle-Lift Air Spring
5. NPT Port
6. Load-Bearing Air Spring
7. Quick-Release Valve (junction)
8. Electric Solenoid Valve
9. Pilot Air Valve
10. Brake-Protection Valve

Fig. 2, Watson and Chalin Suspension with Automatic Reverse Lockout

Problem–Not Getting the Desired Load on Steerable Axle

Problem–Not Getting the Desired Load on Steerable Axle	
Possible Cause	**Remedy**
Incorrect air pressure to load the air springs.	Increase or decrease air pressure at regulator valve.
Air control system not properly installed.	Check piping of air system.
Mounted too high.	Shim axle area. May require lower trailing arm replacement.

Problem–Insufficient Air Pressure to Steerable Axle System

Problem–Insufficient Air Pressure to Steerable Axle System	
Possible Cause	**Remedy**
Damaged brake protection valve or air compressor.	Replace brake protection valve and check air compressor.

Problem–Steerable Axle Not Getting the Correct Lift

Problem–Steerable Axle Not Getting the Correct Lift	
Possible Cause	**Remedy**
Axle lift air springs not getting proper air pressure.	Check system pressure, and check air system piping.
Interference with chassis, driveline, or other chassis components.	Check for interference, and correct as needed.
Unit not properly installed.	Check installation.
Lower trailing arm being restricted from full retraction.	Contact Watson & Chalin.

Problem–Steerable Axle is Steering in Opposite Direction from Truck

Problem–Steerable Axle is Steering in Opposite Direction from Truck	
Possible Cause	**Remedy**
Improper caster setting.	Adjust caster.

Problem–Steerable Axle has Vertical Hop

Problem–Steerable Axle has Vertical Hop	
Possible Cause	**Remedy**
Insufficient air pressure.	Increase air pressure.
Excessive road vibration.	Install vertical shock kit.

Specifications

Load-to-Pressure Ratings for SL–1100–SR Suspension			
Load at Ground lb (kg)	**Run Height 10 Inches psi (kPa)**	**Run Height 11 Inches psi (kPa)**	**Run Height 12 Inches psi (kPa)**
5000 (2268)	29 (200)	31 (214)	34 (234)
6000 (2722)	37 (255)	39 (269)	43 (297)
7000 (3175)	44 (303)	47 (324)	52 (360)
8000 (3629)	52 (360)	56 (386)	60 (414)
9000 (4082)	60 (414)	64 (441)	69 (476)
10,000 (4536)	67 (462)	72 (496)	78 (538)
11,000 (4990)	75 (517)	80 (552)	87 (600)
12,000 (5443)	82 (565)	88 (607)	96 (662)
13,000 (5897)	90 (621)	97 (669)	105 (724)
14,000 (6350)	98 (676)	105 (724)	114 (786)

Table 1, Load-to-Pressure Ratings for Watson & Chalin SL-1100-SR Suspension

Torque Specifications for Watson & Chalin SL–1100–SR Suspension	
Size in.	**Torque Rating lbf·ft (N·m)**
1/4	5 (7)
3/8	15 (20)
1/2	25 (35)
5/8	150 (205)
3/4	200 (270)
7/8	550 (745)
1	600 (815)
1-1/8	1000 (1355)

Table 2, Bolt Torque Specifications for Watson & Chalin SL-1100-SR suspension

Wheel Caster and Toe-In Specifications		
Item	**Minimum Setting**	**Variable**
Caster	+5°	+1°

Wheel Caster and Toe-In Specifications		
Item	**Minimum Setting**	**Variable**
Toe-In	+1/32-Inch (+0.8 mm)	±1/32-Inch (±0.8 mm)

Table 3, Wheel Caster and Toe-In Specifications

General Information

The AirLiner Plus suspension is used on vehicles with pusher or tag axles to improve traction performance.

The system maintains an accurate leveling of frame height through the use of the Rockwell WABCO ECAS (Electronically Controlled Air Suspension) system with sensors and an electronic control unit. A height sensor mounted between the frame and the drive axle housing provides the ECAS control unit with frame height information. Other sensors provide additional information, which the control unit uses to quickly lower or raise the frame height as necessary. The operation occurs while the vehicle is in motion or while parked.

The vehicle must be equipped with a rear axle air suspenion, and requires ABS with Automatic Traction Control to trigger the optional load transfer function automatically.

AirLiner Plus components include:

- A cab-mounted electronic control unit that uses information about the vehicle's rear frame height to adjust the air pressure of the air spring bags;
- A frame rail-mounted solenoid valve that adjusts the air pressure;
- An axle- and frame-mounted height sensor that provides the control unit with frame-height information;
- A brake light switch that informs the control unit when the brakes are applied;
- A dash-mounted warning light that indicates a system fault;
- A load transfer light that displays automatic load transfer status;
- A three-position dash switch that allows automatic load transfer, driver-activated load transfer, or no load transfer.
- An optional hand-held remote control unit that is used to alter the chassis height for loading and unloading.

System Operation

Indicator Lights

ECAS FAIL: Lights for approximately two seconds when the ignition key is turned on, then the light goes out and remains out during vehicle operation. If the ECAS FAIL light does not go out after two seconds, or if it comes on during vehicle operation, there is a failure in the ECAS system.

LOAD X-FER: Lights for approximately two seconds when the igition key is turned on, then the light goes out. Lights whenever there is a manual or an automatic load transfer.

Frame Height Control

ECAS will maintain the vehicle frame to a pre-set height within a 3/16-inch (5 mm) range. The optional remote control unit allows frame height adjustment within operating limits if the vehicle is parked or moving less than 7 mph.

Load Transfer Activation

If the load weight is transferred from the tag axle to the drive axle, it will remain shifted for 20 seconds and is then slowly transferred back to a normal condition. The complete load cycle takes approximately 45 seconds.

Slippage of the driving wheels (usually when starting out on a slick surface) will activate the automatic load transfer. The load transfer will activate after the Automatic Traction Control activates.

Pressing the MOM ON (momentary on) side of the LOAD X-FER dash switch will activate the load transfer system. Manual activation works, however, only at vehicle speeds less than 30 mph.

Load Transfer Termination

The load transfer cycle will immediately terminate if the service brakes are applied when the vehicle speed is more than 30 mph, when the STOP button on the remote control (if equipped) is pressed, or when the vehicle speed exceeds 75 mph.

The STOP button on the remote control will terminate the load transfer at any speed.

ECU Removal and Installation

Removal

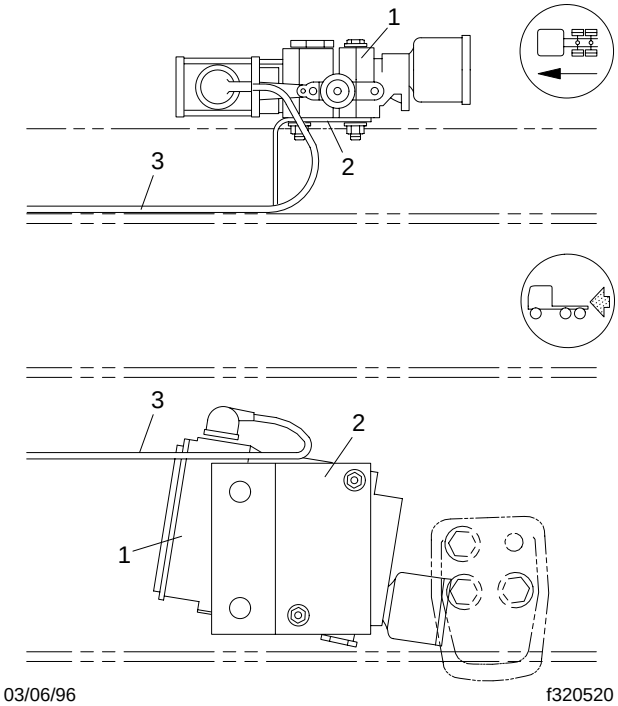
1. Shut down the engine and set the parking brake.
2. Chock the front tires.
3. Remove the lower cover at the base of the left B-pillar.
4. Disconnect the electrical connections at the base of the B-pillar.
5. Remove the grab handle.
6. Remove the shoulder harness adjustable D-loop mechanism mounted to the B-pillar.
7. Detach the plastic channel that attaches the upholstery to the door frame. This will provide slack in the upholstery to allow access to the ECU mounted inside the B-pillar.
8. Remove the fasteners that attach the B-pillar upholstery to the cab wall.
9. Reach inside the B-pillar and remove the fasteners that attach the ECU.
10. Disconnect the electrical connections on the unit, and remove the ECU from the B-pillar.

Installation

1. Install the ECU inside the B-pillar. Connect the electrical connections.
2. Install the B-pillar upholstery.
3. Attach the plastic channel around the door frame and upholstery.
4. Install the shoulder harness adjustable D-loop mechanism.
5. Install the grab handle.
6. Connect the electrical connections at the base of the B-pillar.
7. Install the lower panel at the base of the B-pillar.
8. Remove the chocks from the tires.

Replacement

1. Shut down the engine and set the parking brake.
2. Chock the front tires.
3. Drain air from the suspension system.
4. At the ECAS solenoid valve (see **Fig. 1**), which is mounted to the frame rail, disconnect the electrical connector.



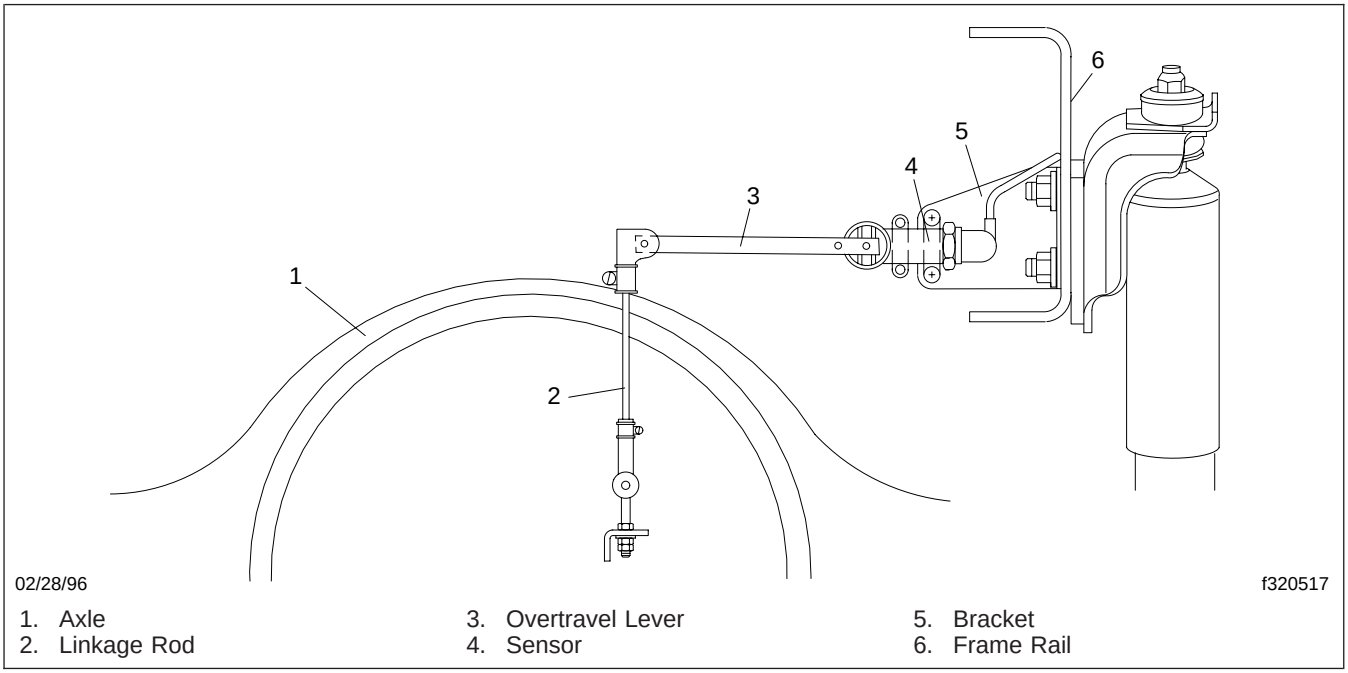
1. Solenoid Valve
2. Bracket
3. Wire

Fig. 1, Solenoid Valve Assembly

5. Mark the air lines for later reference.
6. Disconnect the air lines from the solenoid valve.
7. Remove the two bolts attaching the solenoid valve to the valve bracket.
8. Remove the valve from the bracket.
9. Attach the new valve to the bracket. Install the bolts.
10. Connect the air lines to the valve as marked earlier.
11. Connect the electrical connector to the valve.
12. Remove chocks from tires.

Replacement

1. Shut down the engine and set the parking brake.
2. Chock the front tires.
3. At the ECAS height sensor (see **Fig. 1**), which is mounted between the frame rail and the drive axle housing, disconnect the electrical plug on the back of the sensor.



1. Axle
2. Linkage Rod
3. Overtravel Lever
4. Sensor
5. Bracket
6. Frame Rail

Fig. 1, Height Sensor Assembly

4. Remove the bolts attaching the sensor to the frame rail bracket.
5. Disconnect the linkage rod from the axle housing.
6. Remove the overtravel lever from the height sensor.
7. Remove the sensor.
8. To install the sensor, attach the overtravel lever to the height sensor.
9. Attach the linkage rod to the axle housing.
10. Fasten the sensor to the frame rail bracket.
11. Connect the electrical plug to the back of the height sensor.
12. Remove the chocks from the tires.

Troubleshooting Information

1. Indicator Lights:
    - ECAS FAIL lights up if there is a failure in the ECAS system.
    - Load XFER lights up whenever there is a manual or automatic load transfer.
2. Frame Height Control: ECAS will maintain the vehicle frame height to a preset value within 3/16-inch (4.7 mm) by adjusting the pressure in the rear suspension air bags. With the remote-control unit, the operator can adjust the frame height within the operating limits if the vehicle is parked or traveling less than 7 mph (15 km/h).
3. Load Transfer Activation: The weight is transferred from the tag axle to the drive axle by adjusting the pressure in the air bags. The load is shifted for 20 seconds, then is slowly equalized back to the normal condition. The complete load transfer cycle takes approximately 45 seconds. The load transfer occurs under the following conditions.
    - Automatic activation: The drive wheels slipping (usually when staring out on a slick surface) will activate the load transfer. If the vehicle is equipped with Automatic Traction Control, the load transfer will activate just after the ATC.
    - Manual activation: Pressing the MOM ON (Momentary On) side of the ECAS XFER dash switch will activate the load transfer. Manual activation works only at vehicle speeds less than 30 mph (50 km/h).
4. Load Transfer Termination: The load transfer cycle will terminate under the following conditions.
    - Applying the service brakes with a vehicle speed of more than 30 mph (50 km/h).
    - Vehicle speed exceeds 75 mph (120 km/h).
    - Pressing the STOP button on the remote control or disconnecting the remote control. This will terminate the load transfer at any speed.

Troubleshooting Tables

Before performing any diagnostics, make sure there are no ABS faults. Because of the interaction of the ABS and the ECAS systems, a fault in one system may cause a malfunction in the other system.

The following types of failures cause the "ECAS FAIL" indicator light to remain on:

- Grounded "ECAS FAIL" light wire;
- No power at ECAS electronic control unit (ECU) pin 1;
- Electrical fault in ECAS height sensor;
- Electrical fault in ECAS valve;
- Failure of J1587 data bus;
- Internal ECU fault;
- Faulty calibration of ECAS height control;
- Frame height cannot be adjusted within five minutes after ignition or within 30 seconds during normal service.

See **Table 1** for troubleshooting problems when the "ECAS FAIL" light remains on. This would include problems where the wrong action occurs, such as the air bags inflating rather than deflating, or the drive axle air bags deflating rather than the tag axle air bags. The causes may be crossed electrical wiring or air supply plumbing.

See **Table 2** for frame height problems.

See **Table 3** for incorrect ECAS functionality.

See **Table 4** for indicator lamp problems.

See **Table 5** for manual load transfer problems.

NOTE: All lamps are activated by the ECU for approximately two seconds after the ignition is switched on. The ignition must be switched off for at least 6.4 seconds before restarting to determine lamp condition.

Troubleshooting

Electrical Systems Testing

Electrical Systems Testing				
System Tested	**Ignition**	**Test these pins on ECAS ECU harness 35-pin connector (disconnected unless otherwise noted)**	**Acceptable Value**	**Remedy (if not within specification)**
ECAS FAIL light	On	—	Light is out	Find short to ground in wire between ECAS FAIL light and ECU.
Ground	Off	27 and Battery Ground	0 ohms	Trace wire between pin 27 and ground to find cause of high resistance.
Ground	Off	1 and 27	System voltage	Find open circuit or cause of high resistance in wiring.
Ignition and constant power	On	1 and 27 9 and 27	System voltage	Find open circuit or cause of high resistance in wiring.
Height sensor	Off	25 and 27	100 to 140 ohms	If resistance is infinite (open circuit), find open circuit in wires to height sensor and repair. If there is continuity but resistance is out of specification, check resistance at height sensor. If sensor is not within specification, replace sensor.
ECAS valve electrical checks	Off	13 and 27 15 and 27 30 and 27	15 to 25 ohms	If resistance is infinite (open circuit), find open circuit in wires to ECAS valve and repair. If there is continuity but resistance is out of specification, check resistance at ECAS valve. If valve is not within specification, replace valve.
Data bus connectivity (ECAS reads vehicle speed and other data from J1587 data bus)	On	Connect harness to ECU, and run Service Link to see if ECU is connected to data bus.	—	If other ECUs are identified with Service Link, check data bus wires to ECU for open, grounded, or crossed wires (pins 4 and 2). If no other ECUs are identified with Service Link, there is a main data bus problem, not a specific ECAS problem.
Internal ECU fault	—	There is no test for ECU. If all other tests are within specifications, ECU is probably bad.	—	Replace ECU.

Table 1, Electrical Systems Testing

Frame Height Systems Testing

Frame Height Systems Testing		
System Tested	**Test Procedure**	**Remedy (if not within specification)**
ECAS height calibration	Using the remote control unit, raise or lower the vehicle frame. Press the Normal key, and the frame should return to normal height.	Install the height sensor arm in the correct position relative to the height sensor rotating spool.

Frame Height Systems Testing		
System Tested	**Test Procedure**	**Remedy (if not within specification)**
Frame height adjust time	Check air suspension system for leaks or restrictions in lines or valve ports. Check air supply system for proper charge time.	Repair as required.

Table 2, Frame Height Systems Testing

ECAS Functionality Testing

ECAS Functionality Testing				
System Tested	**Ignition**	**Test these pins on ECAS ECU harness 35-pin connector (disconnected)**	**Acceptable Value**	**Remedy (if not within specification)**
Inflate function	On	Connect 9 to 15. Alternately connect 13 to 9 and to 15.	All rear suspension air bags inflate when (and only when) 13 is connected	Make sure there is adequate air in the supply tanks to inflate the air bags. Check for crossed wiring to the ECAS valve. Check for correct air plumbing between the ECAS valve and the air bags. **⚠ CAUTION** **Do not over-inflate air bags. This may extend the shock absorbers to their limits and cause damage.**
Deflate function	On	Connect 9 to 13	All rear suspension air bags deflate	Make sure there is adequate air in the supply tanks to inflate the air bags. Check for crossed wiring to the ECAS valve. Check for correct air plumbing between the ECAS valve and the air bags.
Load transfer function	On	Connect 9 to 30	Tag axle air bags deflate	Make sure there is adequate air in the supply tanks to inflate the air bags. Check for crossed wiring to the ECAS valve. Check for correct air plumbing between the ECAS valve and the air bags.
		Disconnect 9 from 30 Connect 9 to 15	Pressure will equalize between drive and tag axle air bags.	Check for crossed wiring to the ECAS valve. Check for correct air plumbing between the ECAS valve and the air bags.

Table 3, ECAS Functionality Testing

Indicator Light Testing

Indicator Light Testing				
System Tested	**Ignition**	**Test these pins on ECU harness 35-pin connector (disconnected)**	**Acceptable Value**	**Remedy (if not within specification)**
ECAS FAIL light	On	Connect 33 and 27	Light on	Replace bulb. If bulb still does not light, check the wiring between the bulb and the 35-pin connector.

Troubleshooting

Indicator Light Testing				
System Tested	**Ignition**	**Test these pins on ECU harness 35-pin connector (disconnected)**	**Acceptable Value**	**Remedy (if not within specification)**
ECAS XFER light	On	Connect 18 and 27	Light on	Replace bulb. If bulb still does not light, check the wiring between the bulb and the 35-pin connector.

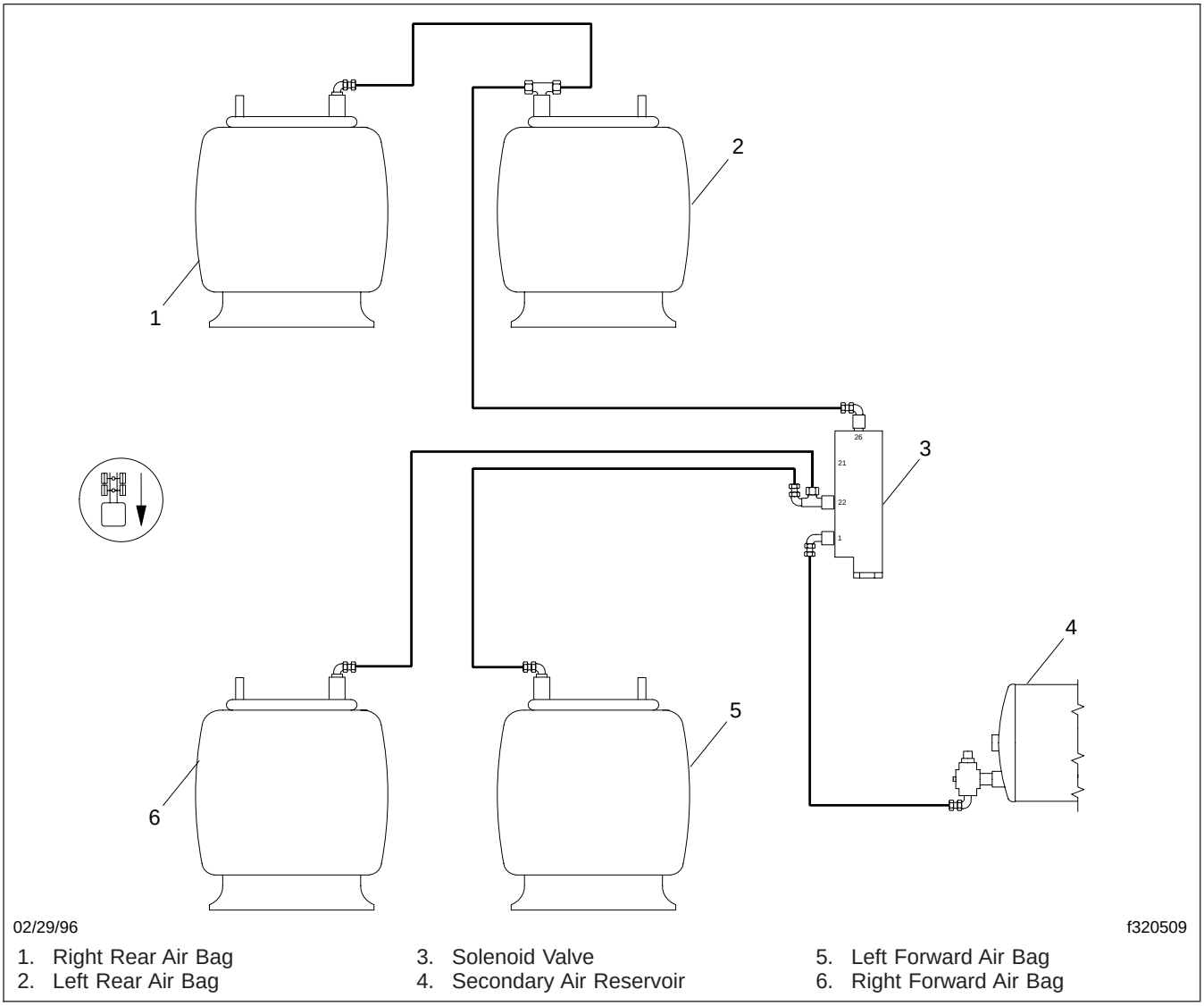
Table 4, Indicator Light Testing

Manual Load Transfer Testing

Manual Load Transfer Testing				
System Tested	**Ignition**	**Test These Pins On ECAS ECU harness 35-pin connector**	**Acceptable Value**	**Remedy (if not within specification)**
Manual load transfer switch	Off	17 and 27, MOM ON switch released (with harness disconnected)	>30k ohms	Locate and repair ground (wire pin to pin 17).
		17 and 27, MOM ON switch pressed (with harness disconnected)	0 to 2 ohms	Locate and repair high resistance in switch circuit.
	On	ECAS ECU harness; Jump pin 17 to ground (with harness connected to ECU	Load transfer cycle will occur	Perform air bag functionality tests. If air bags function correctly as described, manual load transfer function of ECU is malfunctioning. Replacement of ECU is probably necessary.

Table 5, Manual Load Transfer Testing

See **Fig. 1** for the AirLiner Plus air system plumbing diagram, and see **Fig. 2**, **Fig. 3** and **Fig. 4** for diagrams of the AirLiner Plus electrical system.



1. Right Rear Air Bag
2. Left Rear Air Bag
3. Solenoid Valve
4. Secondary Air Reservoir
5. Left Forward Air Bag
6. Right Forward Air Bag

Fig. 1, AirLiner Plus ECAS Air System Plumbing Diagram

Specifications

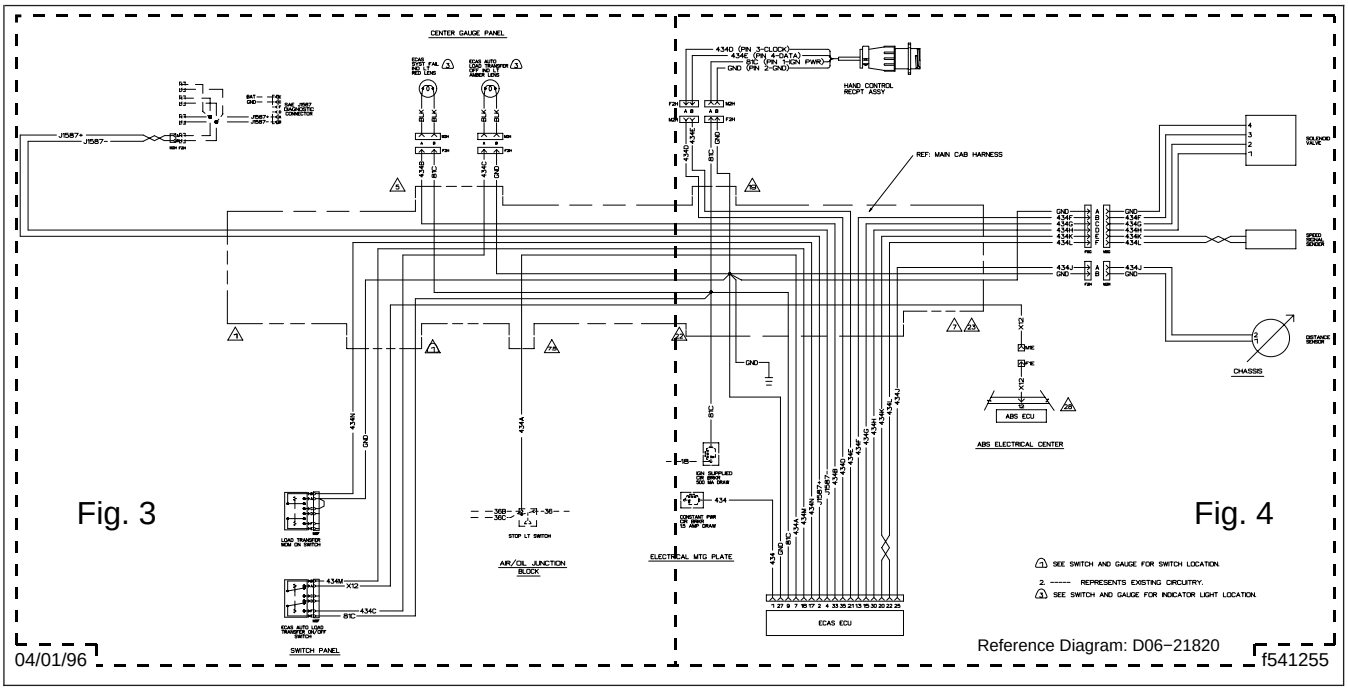


Fig. 2, AirLiner Plus ECAS Electrical Diagram (complete view)

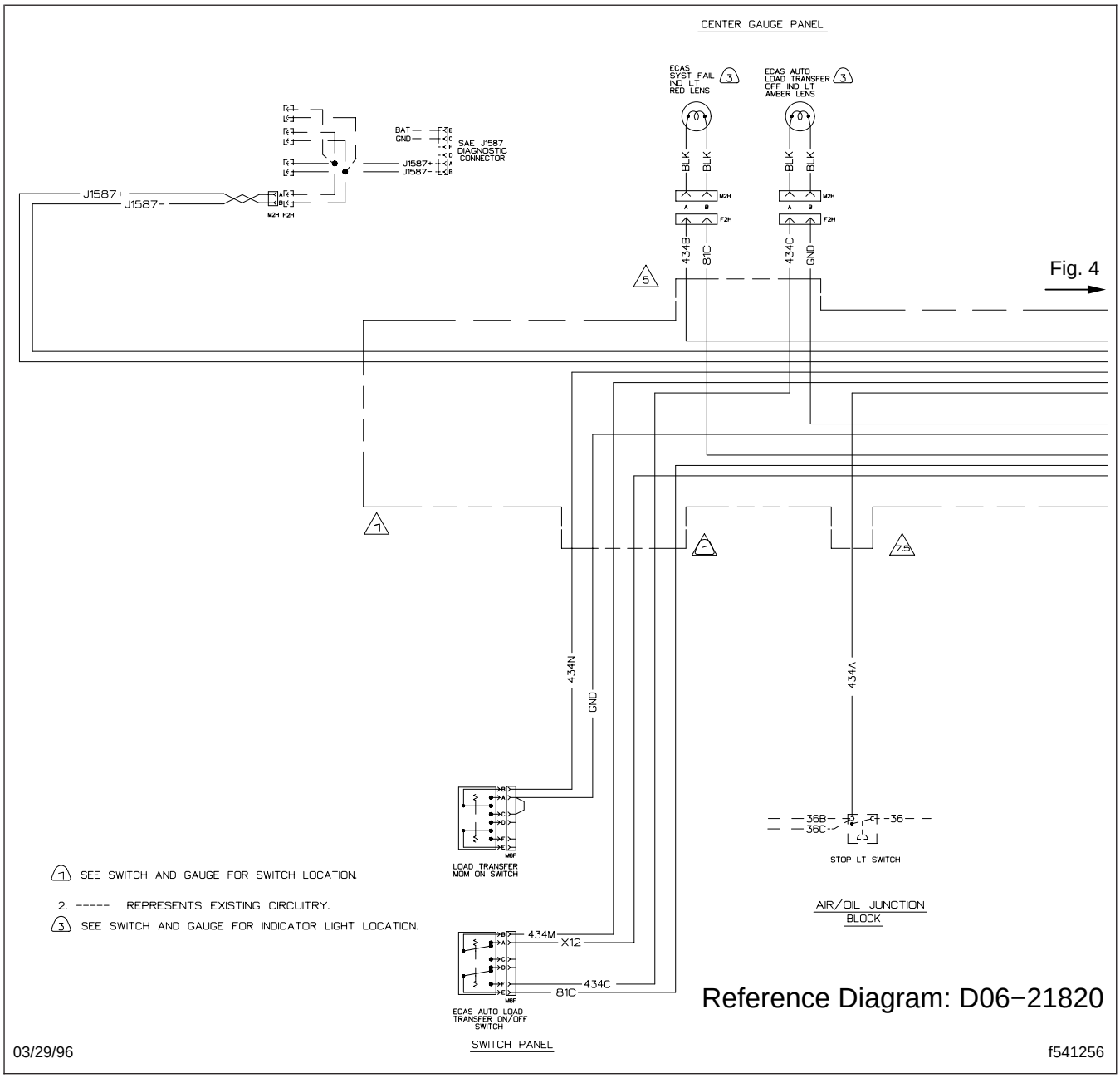


Fig. 3, AirLiner Plus ECAS Electrical Diagram (partial view)

Specifications

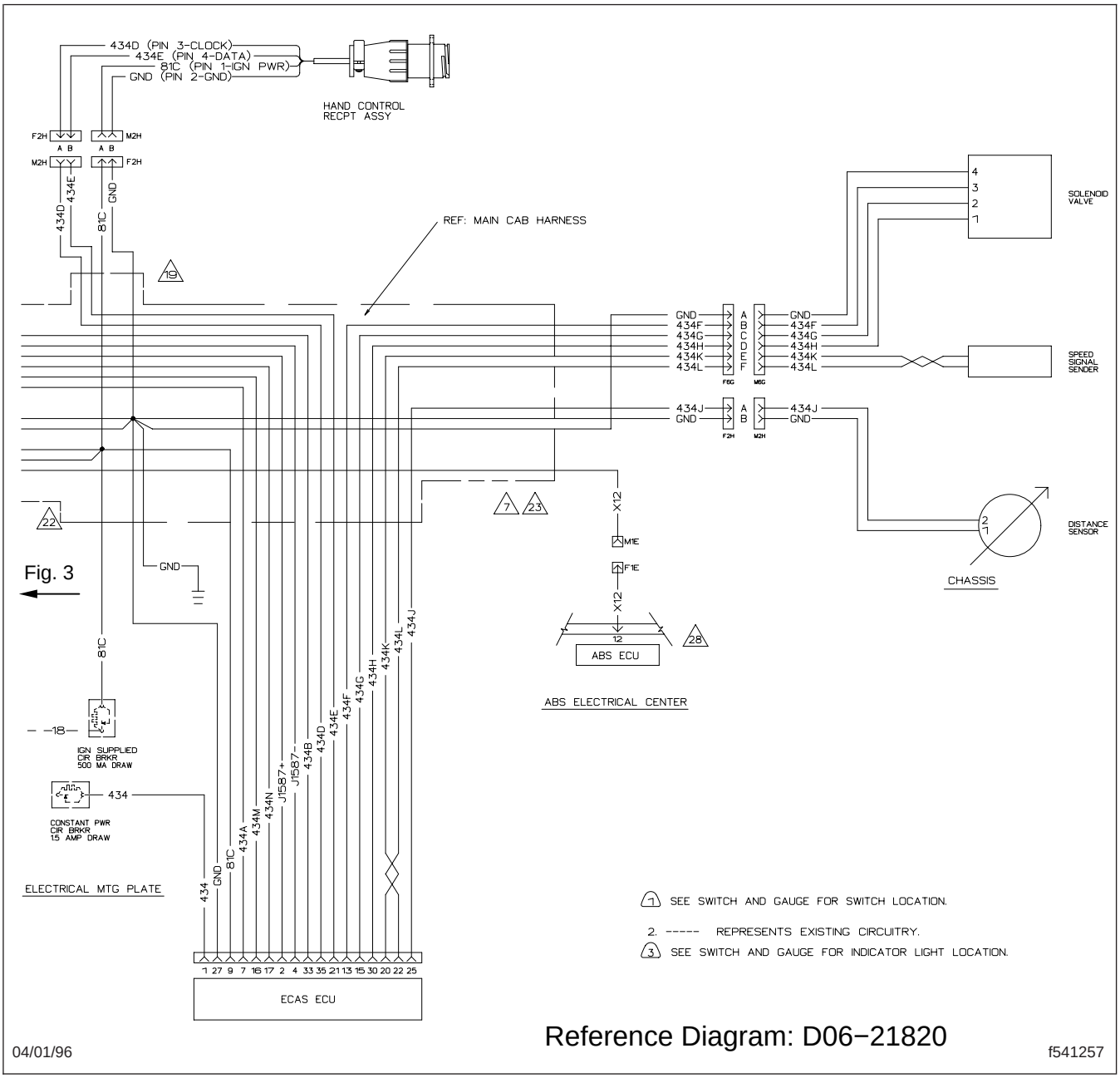


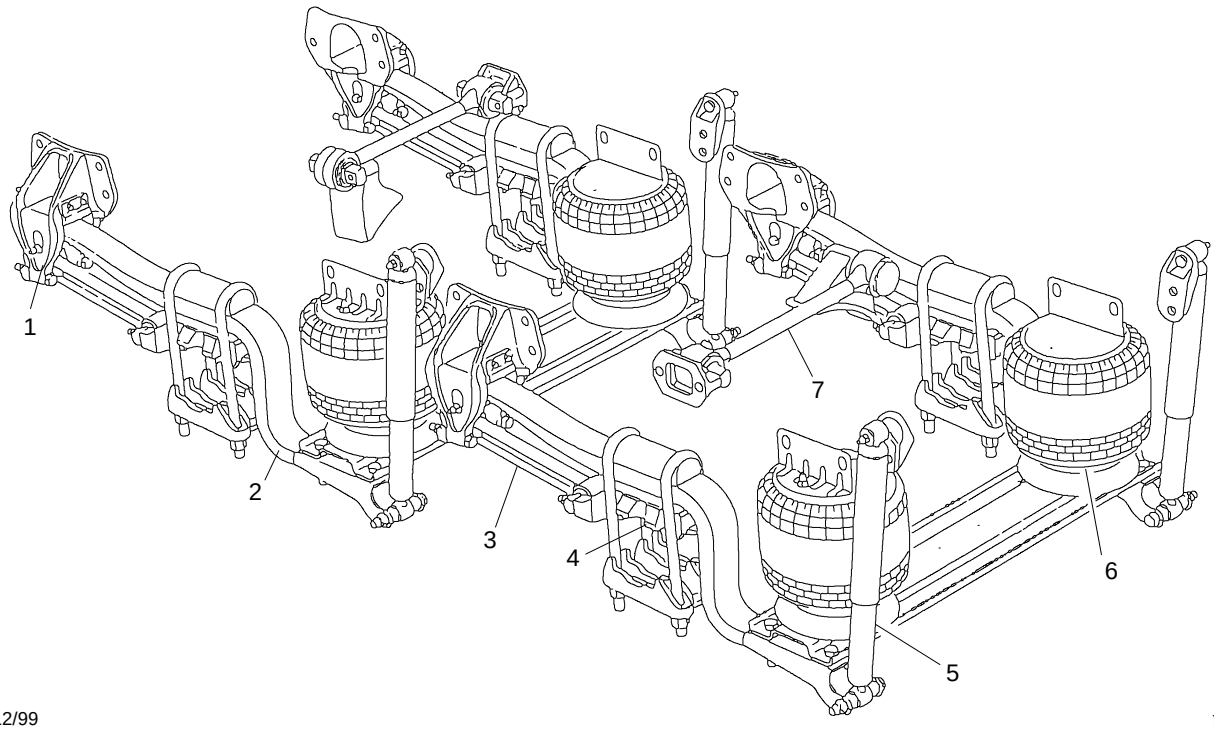
Fig. 4, AirLiner Plus ECAS Electrical Diagram (partial view)

General Description

The Hendrickson HAS suspension (see **Fig. 1**) uses air bags to support the sprung weight on vehicles with both single and tandem axles. The air bags (air springs) mount on a crossmember between the two main support beams that are fastened to the axle housing and pivot on forward-mounted hanger brackets on the frame. Torque rods, running from the hanger brackets to the axle seats, transfer vehicle motion to the frame. Lateral stability is provided by transverse torque rods from the inside of the frame rails to brackets on the axle housings. The shock absorbers help to dampen the oscillations of the air springs and control the torque reaction of the axle housings on acceleration.

height, even with varying loads. Although most vehicles with the HAS system use only one height control valve for the rear suspension, some vehicles with uneven loading may have a height control valve for each side of the vehicle. An optional suspension dump system permits the driver to temporarily lower the frame for trailer coupling or uncoupling without having to leave the cab. See **Subject 400** for a schematic of the air control system.

The suspension air control system uses air supplied from the secondary air brake system. The air supply line is connected to a secondary air manifold located behind the instrument panel. If a loss of air pressure occurs forward (upstream) of the protection valve, the air spring system will be isolated and maintain



04/12/99 f320749

1. Hanger Bracket
2. Main Support Beam
3. Torque Rod
4. Axle Seat
5. Shock Absorber
6. Air Spring
7. Transverse Rod

Fig. 1, Rear Suspension, Hendrickson HAS-Series

AIR CONTROL SYSTEM

The Hendrickson HAS air suspension system allows for a smooth ride while maintaining a constant ride

the air pressure within the suspension system until repairs can be made. However, if a loss of air occurs rearward (downstream) of the protection valve, the

General Information

air in the brake system will be protected, but the air pressure in the air springs will be lost.

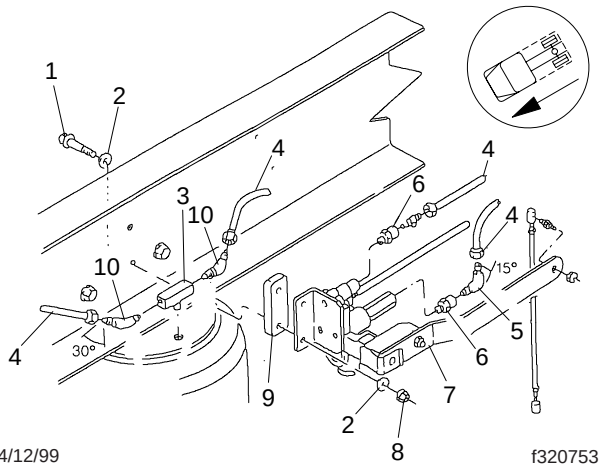
The vehicle ride height is maintained by a height control valve mounted on the frame and linkage that connects the valve to the suspension crossmember. (See **Fig. 2**). As the frame-to-axle housing clearance changes due to a change in the vehicle load, the linkage moves the lever on the height control valve, causing air to move in or out of the air bags. A slight delay in the operation of the height control valve prevents the system from trying to adjust the ride height for each suspension movement.

The optional air suspension dump system is used to deflate the rear suspension air springs during trailer coupling and uncoupling operations. The dump control valve is located on the dash in the cab. When the dump control valve is toggled, supply air flows through the dump control valve delivery port and pressurizes the signal line to the relay valve. The pressurization of the signal line closes the relay valve supply port while opening the ports from the air bags to the atmosphere. Air from the air bags exhausts through the relay valve until the dump control valve is released or until the frame rests on the stops inside the air bags. A pressure switch in the signal line to the relay valve senses the signal pressure and switches on an optional red status light on the dash. To allow the air springs to inflate after being dumped, the dump control valve must be first toggled downward to exhaust the pressure in the signal line.

The pilot-operated relay valve is used for rapid deflation of the air bags for trailer coupling and uncoupling. When pilot pressure from the dump control valve is applied to the relay valve, the supply air from the height control valve is stopped from flowing through the relay valve and, simultaneously, the air spring pressure is exhausted directly to the atmosphere through passages in the relay valve.

REAR SUSPENSION COMPONENTS

The axle housing, the lower shock mounts and the lower air bag mounts are all solidly attached to the HAS main support arms. See **Fig. 3 and Fig. 4**. The main support arm hanger brackets, the upper shock mounts and the upper air bag mounts are all solidly mounted to the frame rails. The torque rods, with flexible bushings in each end, connect the hangers to the axle seats. When the vehicle travels over a bump, the axle housing suddenly rises and compresses the air bags. The pressure in the air bags increases immediately, which absorbs most of the energy of the upward-moving axle housing without transferring that movement to the frame. The shock absorbers then help absorb the release of that higher pressure by slowing the downward movement of the axle housing after the bump.

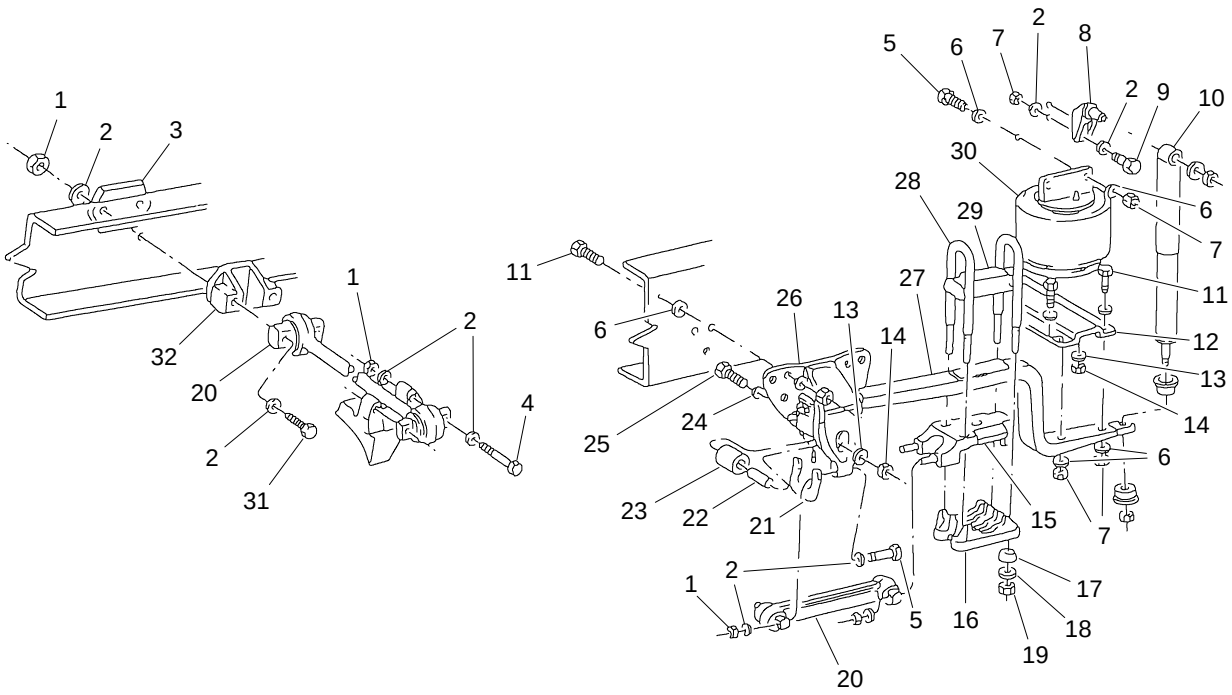


1. Bolt
2. Washer
3. Tee
4. Tube Assembly
5. Elbow
6. Adapter
7. Height Control Valve
8. Nut
9. Bracket
10. Elbow

Fig. 2, Height Control Valve Assembly (typical)

The front of each main support arm is allowed to pivot and slide on replaceable slipper pads in the hanger brackets. A torque rod is attached to each hanger bracket and to each axle seat bracket by rubber bushings with internal pins, installed in the torque rods at specified angles. Shims are used for adjustment at the front of each torque rod to make sure that the wheels run parallel to the frame rails.

The torque rods control the forward and aft movement of the unsprung pieces during suspension travel. The flexible rubber bushings in the torque rods allow vertical movement of the axle housing while limiting its forward and aft movement. The driveline angles are kept within the specified limits by the torque rods' control of the rotational forces on the axle housings during acceleration and deceleration. The torque rods transfer the forward motion of the axle housing to the frame rails on acceleration and pull back on the frame during braking.



04/13/99 f320755

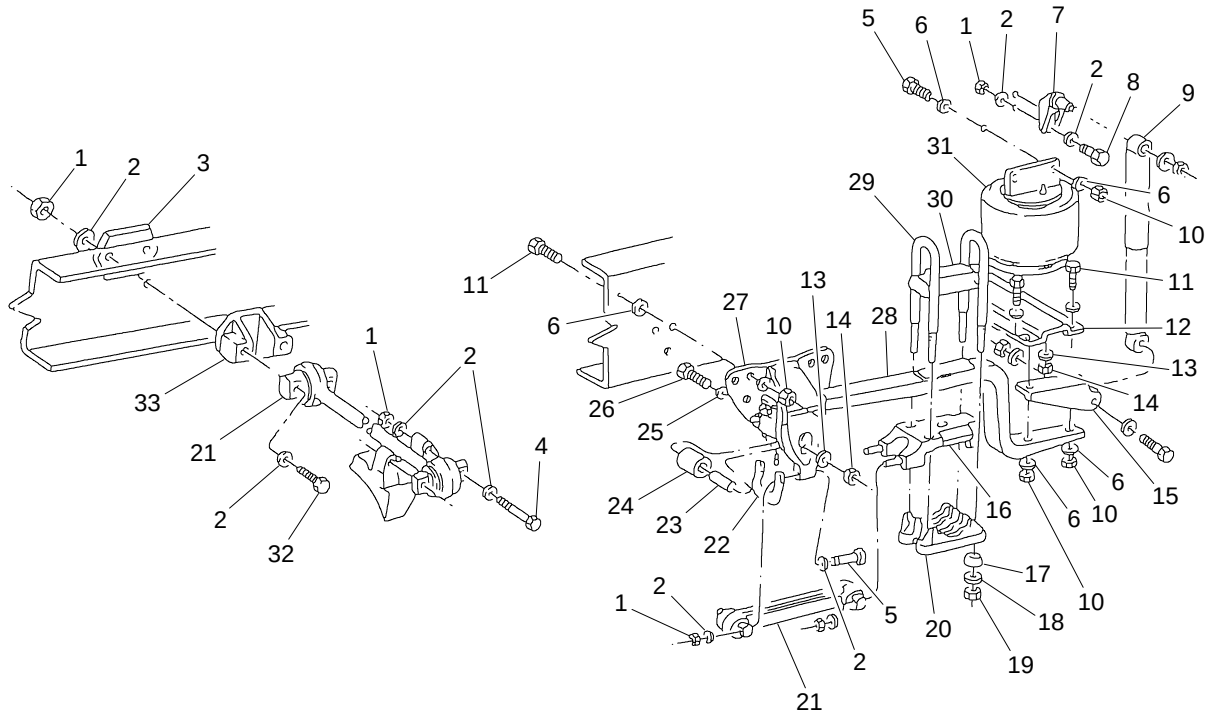
1. Nut
2. Washer
3. Reinforcement
4. Bolt
5. Bolt
6. Washer
7. Nut
8. Shock Absorber Mounting Bracket
9. Bolt
10. Shock Absorber
11. Bolt
12. Suspension Support
13. Washer
14. Nut
15. Axle Seat
16. Bottom Cap Assembly
17. Spherical Washer
18. Washer
19. Nut
20. Transverse Rod Assembly
21. Alignment Shims
22. Spacer
23. Rebound Roller
24. Washer
25. Bolt
26. Hanger
27. Main Support Beam
28. U-Bolt
29. Top Pad
30. Air Spring Assembly
31. Bolt
32. Bracket

Fig. 3, Rear Suspension Components, Hendrickson HAS-40LH Series

The transverse rods, also with rubber bushings in each end, connect the brackets on the axle housings to the brackets on the frame rails. The transverse rods keep a constant lateral relationship of the frame to the axle housing, while still allowing vertical movement of the axle housings.

The Hendrickson HAS suspension is available in varying capacities and for limited off-highway use. The heavy-duty or off-highway suspensions have thicker main support arms, heavier crossmembers and torque rods, and heavy-duty air bags and shock absorbers. There are two HAS ride height specifications (measured from the bottom of the frame rail to the bottom of the main support arm at the axle seat) depending on which suspension is used. The HAS suspensions are available for single or tandem axle vehicles and can be ordered with or without the suspension dump feature.

General Information



1. Nut
2. Washer
3. Reinforcement
4. Bolt
5. Bolt
6. Washer
7. Shock Absorber Mounting Bracket
8. Bolt
9. Shock Absorber
10. Nut
11. Bolt
12. Suspension Support
13. Washer
14. Nut
15. Shock Absorber Mounting Bracket
16. Axle Seat
17. Spherical Washer
18. Washer
19. Nut
20. Bottom Cap Assembly
21. Transverse Rod Assembly
22. Alignment Shims
23. Spacer
24. Rebound Roller
25. Washer
26. Bolt
27. Hanger
28. Main Support Beam
29. U-Bolt
30. Top Pad
31. Air Spring Assembly
32. Bolt
33. Bracket

Fig. 4, Rear Suspension Components, Hendrickson HAS-400, HAS-402, and HAS-460 Series

REAR SUSPENSION SERVICE NOTES

⚠ WARNING

A main support member that has been subjected to heat, nicks or gouges can fail, causing loss of vehicle control and possible personal injury or property damage.

⚠ CAUTION

Do not use an arc welder on the suspension parts or use a cutting torch to remove any fasteners. The use of heat on suspension components will adversely affect the strength of these parts. Never reinstall used suspension fasteners. Always use the same part number or an exact equivalent part number when replacing any suspension fastener. All fasteners must be tightened

to their specified torque and the U-bolts must be tightened in stages as described in Specifications 400.

Check the axle alignment after replacing components that affect alignment, such as a main support beam, a torque rod or a hanger.

NOTE: During installation, apply Pipe Sealant with Teflon D8AZ–19554–A or equivalent meeting specification WSK–M2G350–A2 or ESR–M18P7–A to the air fitting threads.

NOTE: When replacing the torque rod bushings, lubricate the new bushings with a vegetable-based oil only. Make sure the new bushings are centered in the torque rod bores.

NOTE: A shim pack of three 0.11 inch (2.8 mm) thick spacers are used to adjust axle lateral tracking offset. Install the spacers as required to adjust tracking.

Main Support Member Removal and Installation

Removal

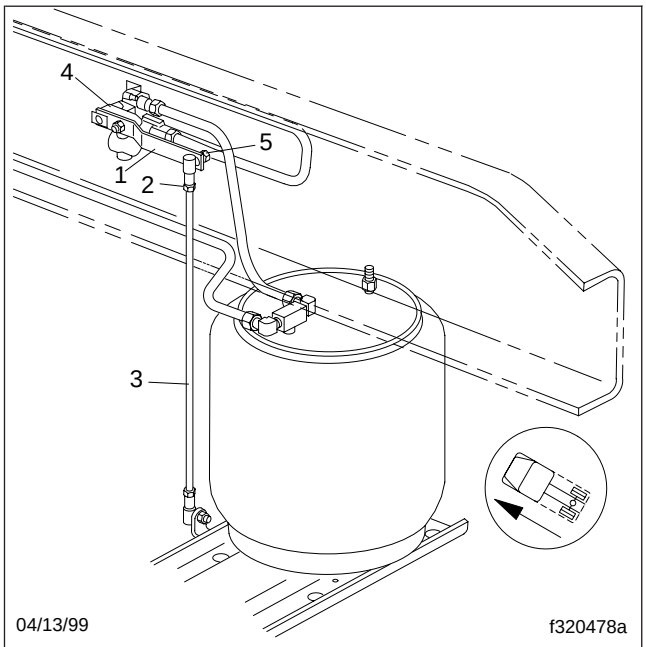
NOTE: Operation of the HAS suspension will result in wear between the main support member and the spring hanger slipper pad. In normal use, these components will function satisfactorily even though they show some wear. Premature wear may occur, however, and requires the replacement of one or both parts. A main support member should be replaced if it has 3/8 inch (9.5 mm) or more wear at the hanger cam contact area.

1. Stop the vehicle on a level surface, shut down the engine and apply the park brakes. Chock the front and rear tires.
2. Support the axle housing with a jack stand under the pinion nose to prevent the axle housing from rotating when the U-bolts are removed.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

3. Disconnect the vertical linkage for the height control valve at the end of the horizontal lever. See **Fig. 1**. Lift the lever on the height control valve so that the air bags raise the frame about 3 inches (75 mm). Support the frame at that position with jack stands.
4. Remove the locknuts, washers and bolts that connect the cross channel and shock absorber brackets to both main support members. See **Fig. 2**. Remove the lower shock mount fasteners on the HAS–40LH models.
5. Use a floor jack to raise the cross channel about 3 inches (75 mm). Support the cross channel assembly with jack stands.
6. Remove the locknut, washers and bolt from the rebound roller assembly at the front hanger. See **Fig. 3**. Remove the rebound roller and spacer.
7. Remove the U-bolt high nuts and washers, then remove the bottom cap, U-bolts and the top pad and Delrin liner.

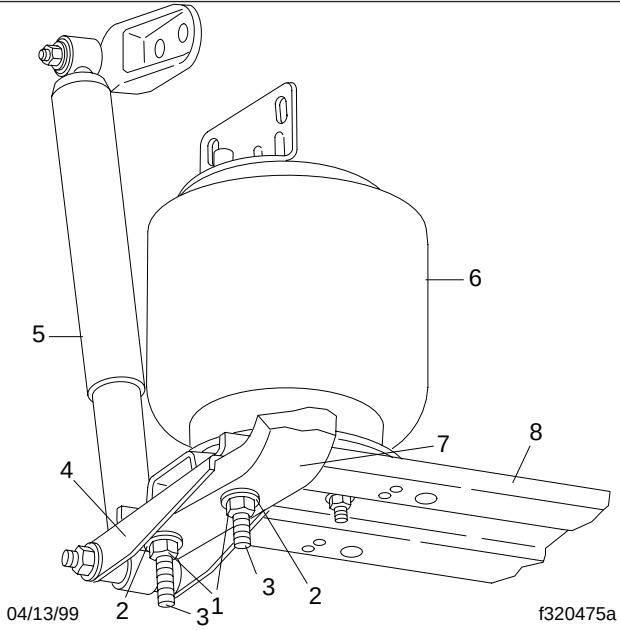


1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

Fig. 1, Ride Height Control Linkage

8. Slide the main support member out of the hanger and remove the main support assembly from the vehicle.
9. Inspect the main support member for wear. Replace the main support member if worn more than 3/8 inch (9.5 mm) at the hanger end where it contacts the slipper pad or if it has cracks, nicks or signs of the application of heat from a torch or welder.
10. Inspect the slipper pad for wear. Replace the slipper pad if worn. Remove the four bolts and washers that hold the slipper pad to the hanger. If rivets were installed instead of bolts to hold the slipper pad, use a grinder to remove the rivet heads.

Main Support Member Removal and Installation



1. Locknut
2. Washer
3. Bolt
4. Lower Shock Bracket
5. Shock Absorber
6. Air Spring
7. Main Support Member
8. Cross Channel

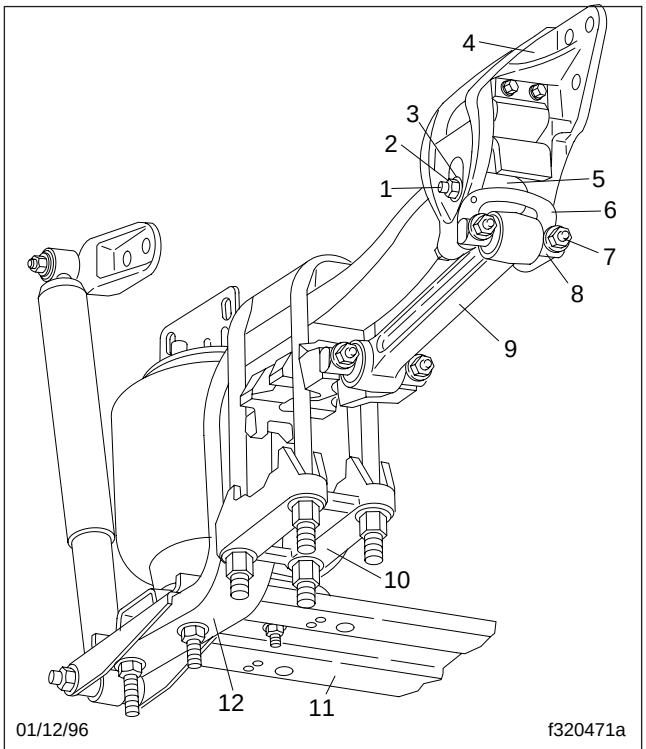
Fig. 2, Main Support Member

Installation

⚠ WARNING

Always use new fasteners when installing suspension components. Reuse of fasteners can lead to component damage and loss of vehicle control, possibly resulting in personal injury or property damage.

1. Install the slipper pad, bolts and washers into the hanger. Tighten the bolts 25 lbf·ft (34 N·m). Install new rivets if so equipped.
2. Slide the main support member into the hanger assembly.
3. Position the main support member on the axle seat, or on the spacer plate if the vehicle is so equipped, with the main support member center dowel sliding into the hole in the axle seat or spacer plate.



1. Rebound Bolt
2. Locknut
3. Washer
4. Hanger
5. Rebound Roller
6. Alignment Shim(s)
7. Bolt
8. Bar Pin
9. Torque Rod
10. Bottom Cap
11. Cross Channel
12. Main Support Member

Fig. 3, Removing the Rebound Roller

4. The Delrin liner must be positioned on the top of the main support member. Install the U-bolt top pad on the Delrin liner. Install the U-bolts over the top pad and liner and around the main support member, the spacer (if so equipped), the axle seat assembly, the axle housing, and the bottom cap. Install the washers and high nuts and tighten with your fingers, but do not fully tighten the U-bolt high nuts at this time.
5. Lower the floor jack under the cross channel until the cross channel is against the main support members. Install the shock absorber bracket (if so equipped) and bolts into the cross channel and main support members. See **Fig. 2**. Install the washers and tighten the locknuts 280 lbf·ft (380 N·m). On the HAS–40LH models, install the

lower shock absorber mount bolts, washers and nuts. Tighten the shock absorber nut 60 lbf·ft (82 N·m).

6. Install the rebound roller into the hanger. Install the bolt, washer and locknut. Tighten the locknut 60 lbf·ft (82 N·m).
7. Center the main support member between the hanger legs. Move the lever for the height control valve up to lift the frame from its jack stands. Remove the jack stands from the frame.
8. Tighten the U-bolt locknuts in stages as described in **Specifications 400**. Rap the top of the U-bolts with a hammer and then retighten the high nuts 500 lbf·ft (680 N·m).

IMPORTANT: Do not exceed the specified torque on the U-bolt high nuts. Retighten the U-bolt high nuts after 1000 miles (1600 km).

9. Move the lever for the height control valve down to lower the frame until the upper ball joint stud in the vertical linkage exactly aligns with the hole in the lever when the lever is in the horizontal position. Install the height control valve ball joint stud, washer and locknut. Tighten the locknut 10 lbf·ft (14 N·m).
10. Remove the jack stand from under the nose of the axle housing.
11. Check and adjust the ride height as described in **Subject 180**.
12. Check the alignment after new main support members are installed.

Axle Seat Removal and Installation

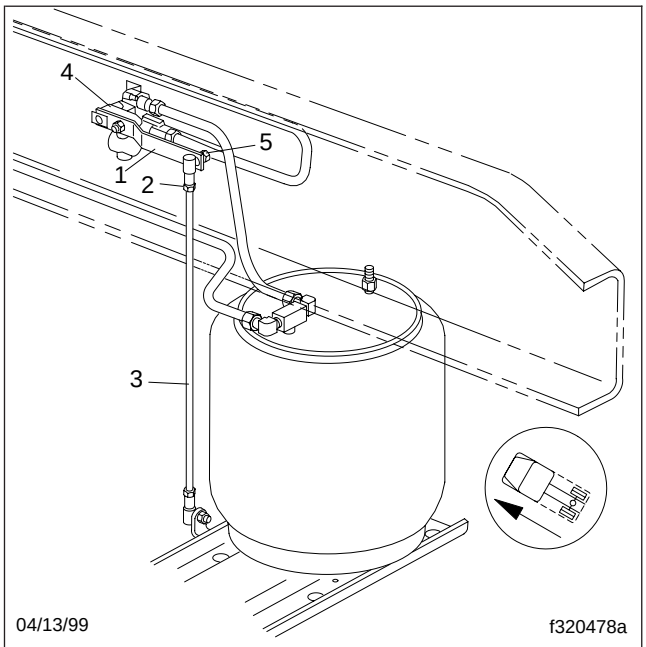
Removal

1. Stop the vehicle on a level surface, shut down the engine and apply the park brakes. Chock the front and rear tires.
2. Support the axle housing with a jack stand under the pinion nose to prevent the axle housing from rotating when the U-bolts are removed.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

3. Disconnect the vertical linkage for the height control valve at the end of the horizontal lever. See **Fig. 1**. Lift the lever on the height control valve so that the air bags raise the rear of the frame about 3 inches (75 mm). Support the frame at that position with jack stands.
4. Remove the nuts, washers and bolts that hold the torque rod to the hanger legs.
5. Remove the nuts and washers that hold the torque rod to the axle seat. Remove the torque rod.
6. Remove the high nuts from the U-bolts and remove the bottom cap and top pad and Delrin liner.
7. Use a floor jack to raise the cross channel and main support member just enough to remove the axle seat.
8. Remove the axle seat. See **Fig. 2**.
9. If the axle seat studs need replacement, remove them with a hammer and brass drift.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

Fig. 1, Ride Height Control Linkage

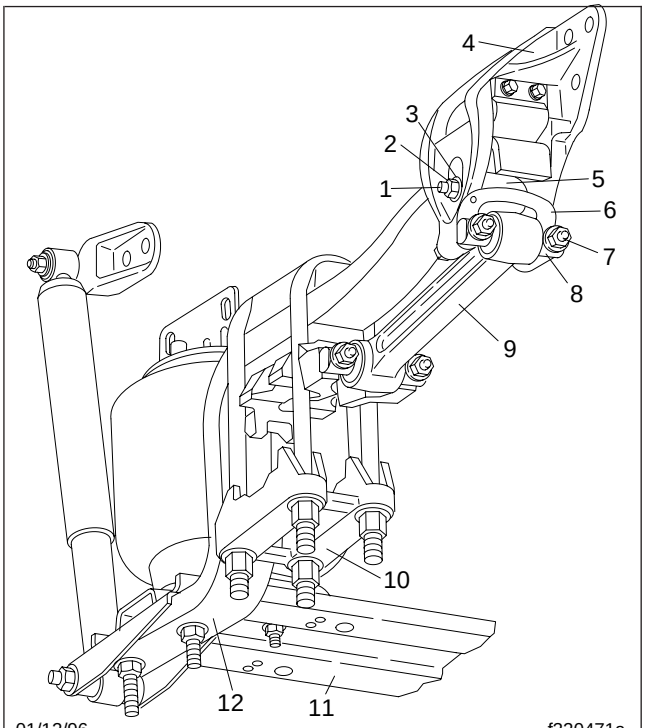
Installation

⚠ WARNING

Always use new fasteners when installing suspension components. Reuse of fasteners can lead to component damage and loss of vehicle control, possibly resulting in personal injury or property damage.

1. Install the new studs with a stud driver. Insert the stud in the hole of the axle seat and tap into position with a hammer and brass drift.
2. Lift the main support member with a floor jack and install the axle seat on the top of the axle housing. Install the spacer (if so equipped) above the axle seat.
3. Position the main support member on the axle seat, or on the spacer plate if the vehicle is so equipped, with the main support member center dowel sliding into the hole in the axle seat or spacer plate.
4. The Delrin liner must be positioned on the top of the main support member. Install the U-bolt top pad on the Delrin liner. Install the U-bolts over the top pad and liner and around the main support member, the spacer (if so equipped), the axle seat assembly, the axle housing, and the bottom cap. Install the washers and high nuts

Axle Seat Removal and Installation



1. Rebound Bolt
2. Locknut
3. Washer
4. Hanger
5. Rebound Roller
6. Alignment Shim(s)
7. Bolt
8. Bar Pin
9. Torque Rod
10. Bottom Cap
11. Cross Channel
12. Main Support Member

Fig. 2, Removing the Axle Seat

and tighten with your fingers, but do not fully tighten the U-bolt high nuts at this time.

5. Install the torque rod on the axle seat so that the holes in the bushing pin align with the axle seat studs. Install the washers and nuts, but do not tighten at this time.
6. Install the front end of the torque rod onto the hanger legs and install any shims that were removed. Install the bolts through the hanger legs, shims, and the front bushing pin.
7. Tighten the nuts on the front of the torque rod 175 lbf·ft (237 N·m).
8. Tighten the nuts for the torque rod pin at the axle seat 175 lbf·ft (237 N·m).
9. Move the lever for the height control valve up to lift the frame from its jack stands, Remove the jack stands from the frame.
10. Tighten the U-bolt locknuts in stages as described in **Specifications 400**. Rap the top of the U-bolts with a hammer and then retighten the high nuts 500 lbf·ft (680 N·m).

IMPORTANT: Do not exceed the specified torque on the U-bolt high nuts. Retighten the U-bolt high nuts after 1000 miles (1600 km).

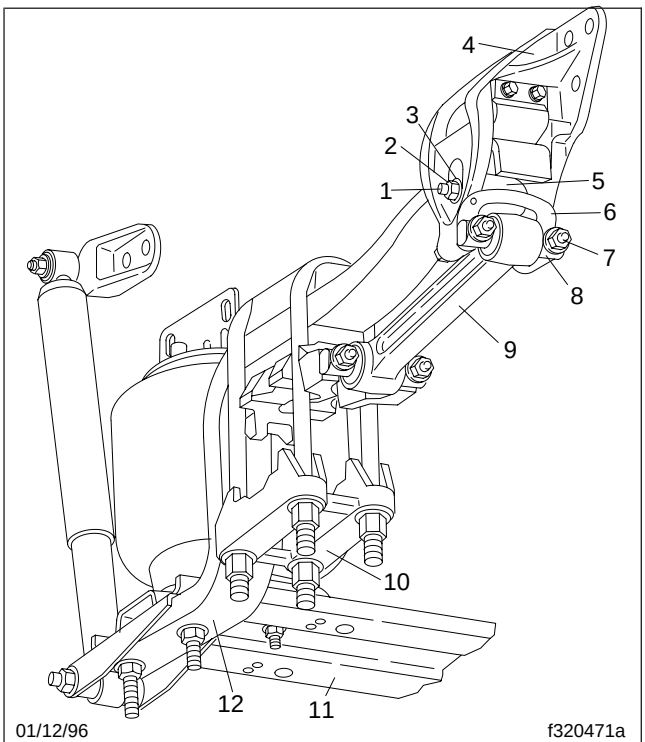
11. Move the lever for the height control valve down to lower the frame until the upper ball joint stud in the vertical linkage exactly aligns with the hole in the lever when the lever is in the horizontal position. Install the height control valve ball joint stud, washer and locknut. Tighten the locknut 10 lbf·ft (14 N·m).
12. Remove the jack stand from under the nose of the axle housing.
13. Check and adjust the ride height as described in **Subject 180**.
14. Check the alignment after new axle seats are installed.

Torque Rod Bushing Replacement

Replacement (See Fig. 1)

Use the following procedure to replace the torque rod bushing.

1. Chock the front tires, and the tires of the drive axles.
2. Remove the bushing pin locknuts and washers at the axle end of the torque rod. See **Fig. 1**.



1. Rebound Bolt
2. Locknut
3. Washer
4. Hanger
5. Rebound Roller
6. Alignment Shim(s)
7. Bolt
8. Bar Pin
9. Torque Rod
10. Bottom Cap
11. Cross Channel
12. Main Support Member

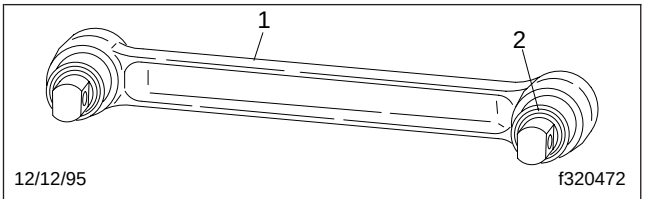
Fig. 1, Torque Rod Installation

3. Loosen the rebound bolt locknut in the hanger.
4. Remove the bushing pin locknuts, bolts and washers, and any alignment shims at the hanger end of the torque rod. Note the number of shims, as the same thickness shim pack must be reinstalled to avoid affecting the vehicle's alignment.
5. Push out the old bushings. Use a vertical shop press with a capacity of at least 10 tons. A 5-inch (127 mm) piece of 2-inch by 1/4-inch (50-mm by 6-mm) wall, steel-tubing receiving tool is required. The bushings are not cartridge-type bushings and do not have a metal outer sleeve.
6. Support the torque rod end on the receiving tool with the end tube of the torque rod centered on the tool.

⚠ WARNING

Do not use heat or a cutting torch to remove the bushings from the torque rod. The use of heat will weaken the torque rod, which could cause the rod to break. This could result in a loss of vehicle control, personal injury, or property damage.

7. Push directly on the bushing pin until the bushing is pushed out of the torque rod end tube.
8. Clean and inspect the torque rod ends. Remove any nicks with emery cloth.
9. Lubricate the torque rod ends and the new rubber bushings with a vegetable-based oil. Do not use a petroleum-based or soap-based lubricant.
10. Press in the new bushings while supporting the torque rod end on the receiving tool with the end tube of the torque rod centered on the receiving tool. The bushings must be installed with the mounting flats on the bar pin positioned 90 degrees to the shank of the torque rod. See **Fig. 2**.



1. Torque Rod
2. Bushing Bar Pin

Fig. 2, Positioning the Bar Pin Mounting Flats

11. Press directly on the bar pin of the bushings, which must be centered within the torque rod end tubes. When pressing in the new bushings, overshoot the final position by approximately 3/16 inch (5 mm).
12. Press the bushing again from the opposite side to center the bushing within the torque rod end.

Torque Rod Bushing Replacement

13. Position the torque rod into the axle seat and attach it with the washers and locknuts. Handtighten the locknuts.
14. Position the torque rod onto the forward face of the hanger legs. Assemble the bolts, washers and locknuts, and any alignment shims. Tighten locknut 175 lbf·ft (237 N·m). See **Fig. 1**.
15. Tighten locknuts at the axle end of the torque rods 175 lbf·ft (237 N·m).
16. Tighten rebound bolt locknut 60 lbf·ft (81 N·m).

Height Control Valve Removal and Installation

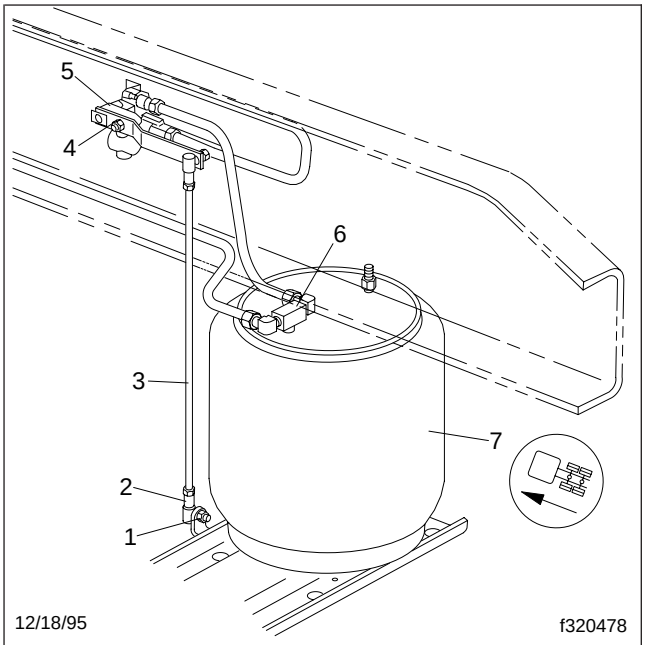
Removal

1. Chock the front tires.
2. Drain the vehicle's air system.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

3. Remove the height control valve vertical rod from the valve lever by removing the nut and lock washer. Push down on the lever of the height control valve to exhaust the air from the rear suspension air bags.
4. Remove the air lines attached to the height control valve. See **Fig. 1**.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

Fig. 1, Height Control Valve System

5. Remove the locknuts, washers, and bolts that attach the height control valve to the frame.
6. Remove the brass air fittings from the height control valve.

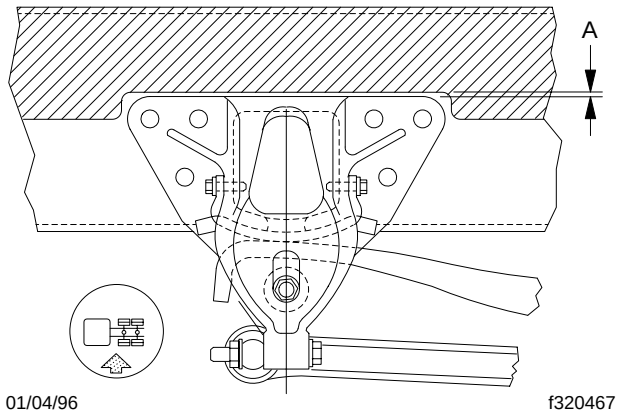
Installation

1. Install the brass air fittings into the height control valve ports.
2. Install the bolts, washers, and locknuts that attach the valve to the frame rail.
3. Attach the air lines to the height control valve.
4. Attach the height control valve vertical linkage rod to the height control valve lever, and install the lock washer and nut. See **Fig. 1**.
5. Return air to the system.
6. Adjust the height control valve for proper ride height as described in **Subject 180**.

Fifth Wheel/Hanger Clearance

Information

The HAS front hangers must have at least 1/4-inch (6 mm) clearance between the top of the hanger and the bottom of the fifth wheel mounting bracket on the sides of the frame rails. In some cases, the fifth wheel mounting bracket may have to be cut out to provide the correct clearance. See **Fig. 1** for an example of a fifth wheel mounting bracket that has been modified.

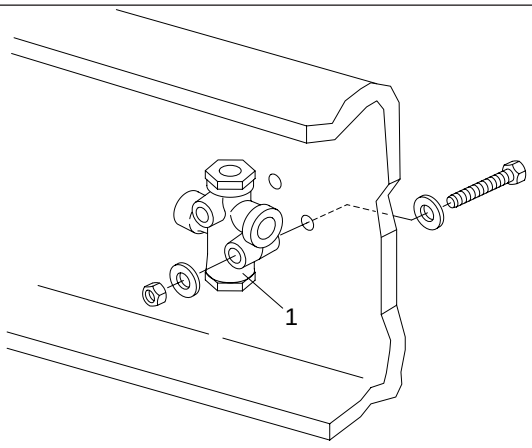


A. Clearance: 1/4 inch (6 mm)

Fig. 1, Fifth Wheel Mounting Angle Clearance

Replacement (See Fig. 1)

1. Chock the front tires.
2. Drain the vehicle's air system.
3. Disconnect the air lines from the quick release valve. Identify the air line at the top of the valve.
4. Remove the quick release valve from the frame or cross member.
5. Remove the brass air fittings from the valve.
6. Attach the brass air fittings to the replacement quick release valve.
7. Attach the valve to the frame or cross member.



12/18/95 f320479

1. Quick Release Valve

Fig. 1, Quick Release Valve Installation

8. Connect the air lines to the valve, making sure to attach the identified line to the top of the valve.
9. Build up pressure in the air system.
10. Remove the chocks from the front tires.

Slipper Pad Removal and Installation

Removal

NOTE: Operation of the HAS suspension will result in wear between the main support member and the hanger slipper pad. In normal use, these components will function satisfactorily even though the components indicate some wear.

1. Chock the front tires.

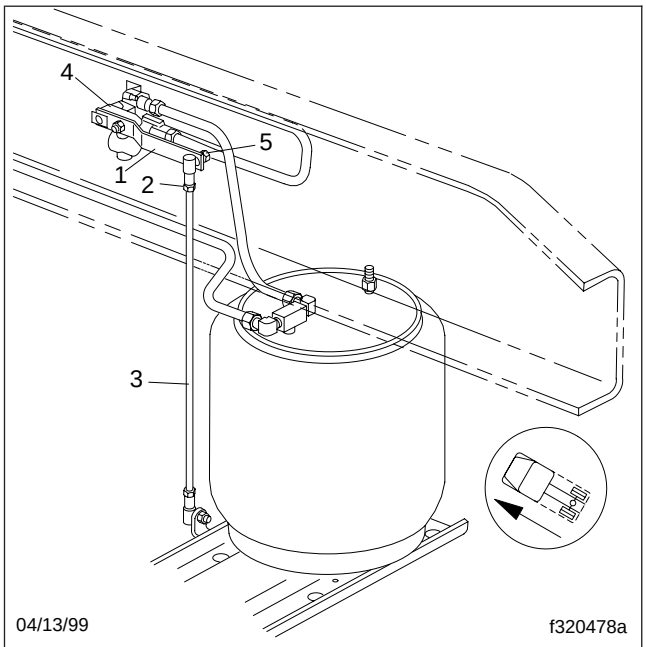
⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

2. Disconnect the vertical linkage from the lever of the height control valve and lift the lever to raise the rear of the frame about 3 inches (75 mm). See **Fig. 1**.
3. Support the frame with jack stands.
4. Apply an upward force on the cross channel with a jack or, on single axles, by pushing down on the height control lever to lift the cross channel. This will cause the tips of the main support members to drop away from the slipper pad. See **Fig. 2**.

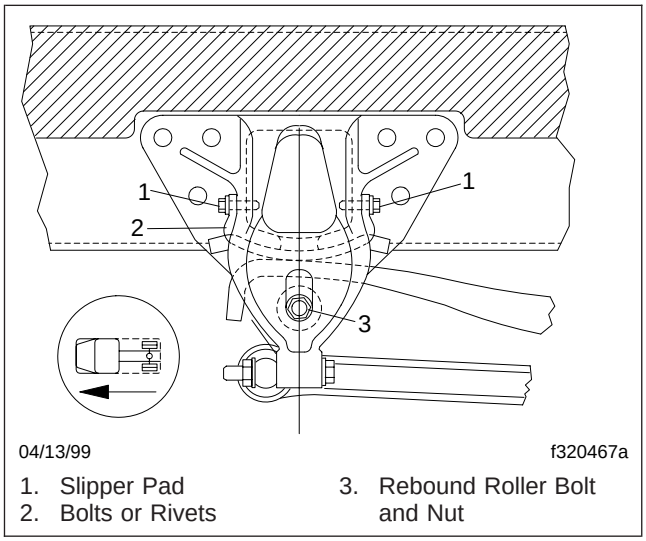
IMPORTANT: Do not nick or gouge the cross channel.

5. Remove the fasteners and the slipper pad. In some instances, the screws may have to be drilled out. See **Fig. 3**.
6. In some instances, remove the rebound roller to gain enough clearance to remove the slipper pad. Loosen the rebound bolt locknut, remove the washer, the bolt, and the rebound roller assembly.
7. For rivets, remove the four 1/4-inch (6-mm) rivets by grinding away the rivet heads. With a drift pin, punch the rivets through the holes and remove the slipper pad.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

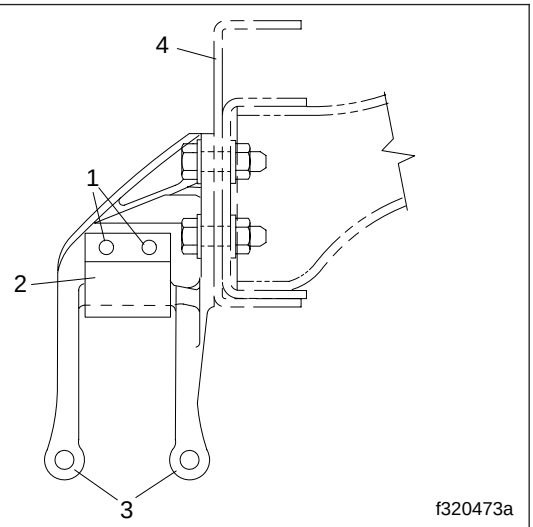
Fig. 1, Ride Height Control Linkage



1. Slipper Pad
2. Bolts or Rivets
3. Rebound Roller Bolt and Nut

Fig. 2, Slipper Pad Installation

Slipper Pad Removal and Installation



1. Bolts or Rivets
2. Slipper Pad
3. Hanger Legs
4. Frame Rail

Fig. 3, Hanger Assembly

Installation

1. Position the slipper pad and retainer plate on the frame hanger.
2. Tighten the hexhead self-tapping screws 25 lbf·ft (34 N·m).
3. Or, install the rivets using a rivet gun.
4. Raise the frame off the jack stands by pulling up on the height control valve lever. Remove the jack stands.
5. Push down on the height control valve lever to lower the frame until the upper ball stud on the vertical linkage rod exactly aligns with the hole in the lever when the lever is horizontal.
6. Install the ball stud into the hole in the lever and install the washer and nut. Tighten the nut 10 lbf·ft (14 N·m).
7. Remove the chocks from the tires.

Cross Channel Removal and Installation

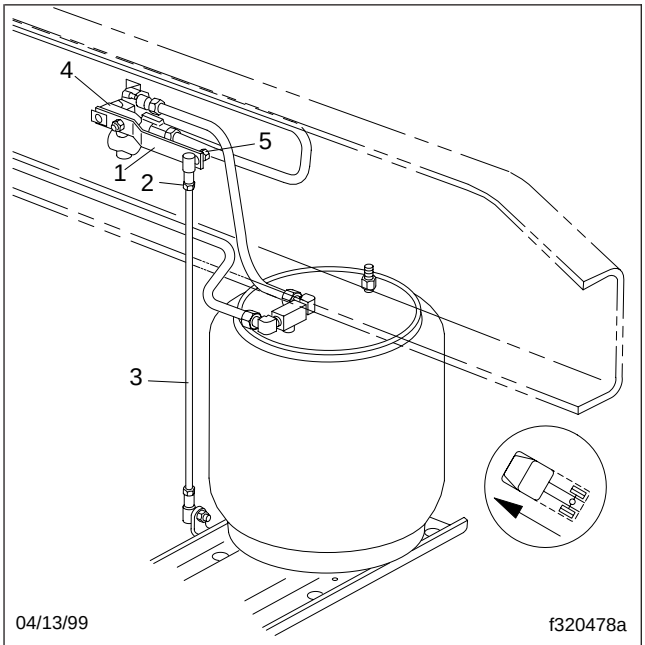
Removal

1. Stop the vehicle on a level surface and shutdown the engine. Chock the front and rear tires.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

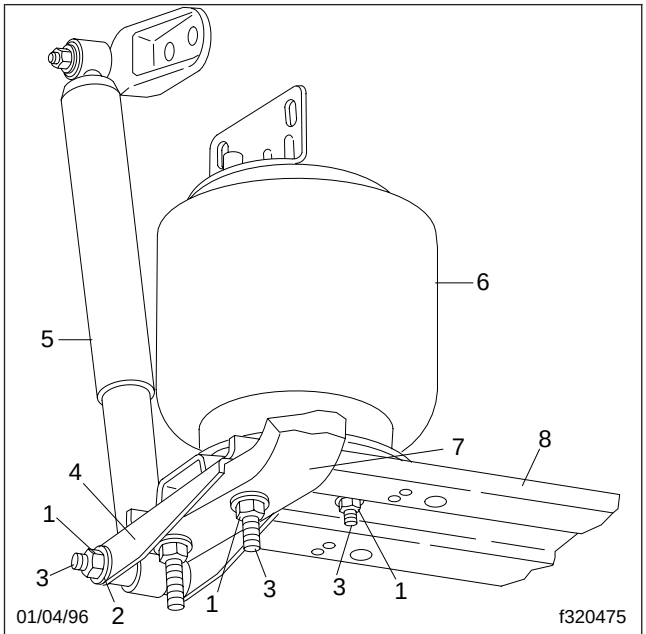
2. Disconnect the vertical linkage for the height control valve at the end of the horizontal lever. See **Fig. 1**. Lift the lever on the height control valve so that the air bags raise the rear of the frame about 3 inches (75 mm). Support the frame at that position with jack stands.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

Fig. 1, Height Control Linkage

3. Remove the locknuts and washers that attach both the air springs to the cross channel. See **Fig. 2**.



1. Locknut
2. Washer
3. Bolt
4. Lower Shock Bracket
5. Shock Absorber
6. Air Spring
7. Main Support Member
8. Cross Channel

Fig. 2, Main Support Member

4. Remove the locknuts, washers, and bolts that attach the cross channel to the main support members and to the shock absorber lower mounting brackets.
5. Raise the cross channel by pushing down on the height control lever to compress the air springs just enough to clear the studs on the bottom of the air springs. Remove the cross channel.

Installation

1. Position the cross channel so that the holes in the cross channel are aligned under the studs of the air springs. Install the washers and nuts. Tighten the nuts on the air spring studs 25 lbf·ft (34 N·m).

Cross Channel Removal and Installation

2. Lower the cross channel assembly onto the main support members by pushing down on the height control valve lever.
3. Install the bolts, washers and locknuts that connect the cross channel to the main support member and lower shock absorber mounts. Tighten the locknuts 290 lbf·ft (393 N·m).
4. Raise the frame by lifting the height control valve lever and remove the jack stands.
5. Attach the ball joint stud of the vertical linkage rod to the height control valve link, and tighten the locknut on the ball joint stud 10 lbf·ft (14 N·m).
6. Remove the chocks from the tires.

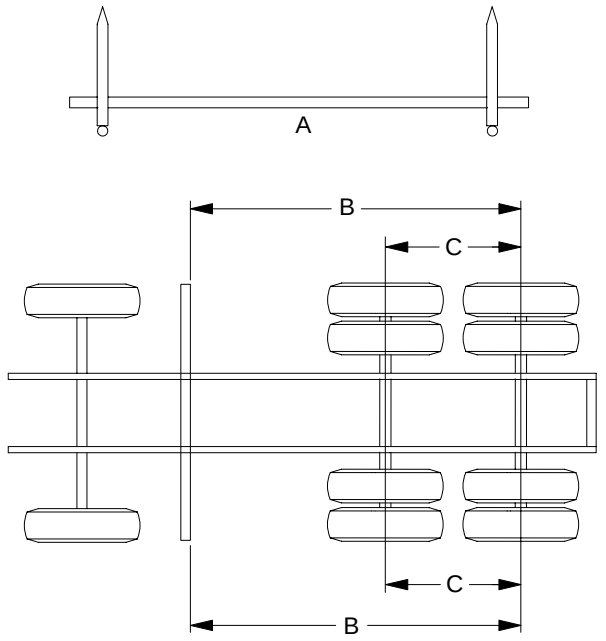
Checking and Adjustment

Use the following procedure after all repairs to the suspension:

1. Park vehicle on a level surface. Free and center all suspension joints by slowly moving the vehicle back and forth several times without applying the brakes.
2. Chock the front tires and the tires of drive axles.
3. C-clamp a nine-foot (2.74-m) piece of straight bar stock or angle iron across the frame. Select a location as far forward of the forward drive axle as possible where components will not interfere. The lower frame flange may be preferred on some vehicles, otherwise use the upper frame flange.
4. Align the straight bar stock or angle iron on the frame using a carpenter's square.
5. Check the rear drive axle first. See **Fig. 1** . Use a trammel bar or its equivalent to measure from the straight edge to the center line of the rear axle on both sides of the vehicle. If both sides measure within 3/16 inch (5 mm) of being the same, the alignment of the rear drive axle is acceptable. If the sides differ by more than 3/16-inch (5 mm), first loosen the rebound locknut, and then adjust the rear drive axle by loosening up the torque rod bar pin locknuts on the hangers. Add or remove drop-in shims as needed.

NOTE: The torque rod bar pin must be mounted to the forward face of the hanger legs. No more than four shims may be used (for a maximum thickness of 1/4 inch (6 mm).

6. Snug the torque rod bar pin locknuts but do not torque to specification.
7. With the rear drive axle properly aligned, the front drive axle alignment can be checked by measuring forward from the center of the axle shafts on the rear drive axle using a trammel bar. If the forward drive axle spacing measurements differ by more than 1/8 inch (3 mm), add or subtract shims at the forward hangers.
8. Following the adjustment of both axles, move the vehicle back and forth several times prior to removing the straight edge from the frame. Recheck the alignment.



A. Trammel Bar
B. Each side must be within 3/16 inch (5 mm) of each other.
C. Distances between axles must be within 1/8 inch (3 mm) of each other.

Fig. 1, Drive Axle Tracking Alignment

9. Tighten the torque rod bar pin locknuts 180 lbf·ft (244 N·m).
10. Remove the chocks from the tires.

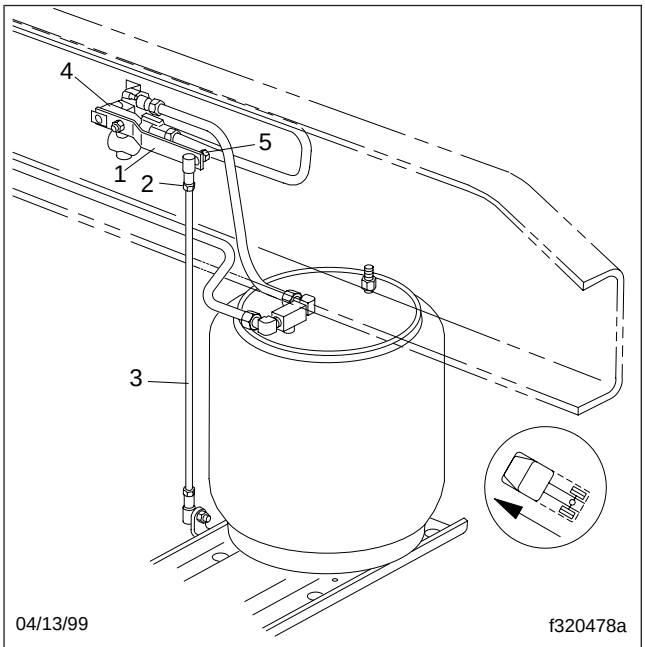
Replacement

1. Chock the front tires.
2. Support the frame with jack stands.
3. Drain the vehicle's air system.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

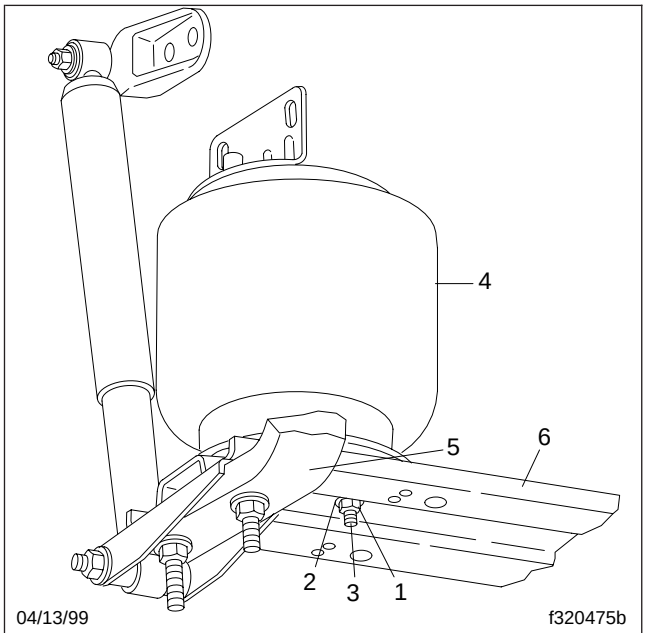
4. Remove the upper ball joint nut and stud from the lever on the height control valve. See **Fig. 1**. Move the height control valve lever down to exhaust all the air from the air bags.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

Fig. 1, Ride Height Control Linkage

5. Remove the locknuts and washers that attach the air spring to the cross channel. See **Fig. 2**.
6. Disconnect the air lines to the air spring.
7. Remove the brass air fittings from the air spring.
8. Remove the locknuts and washers that attach the air spring to the upper air spring frame hanger.
9. Remove the air spring.
10. Attach the new air spring to the air spring frame hanger by inserting the studs into the appropriate holes.
11. Attach the air spring to the cross channel. Tighten the nuts 25 lbf·ft (34 N·m).
12. Tighten the outboard locknut that attaches the air spring to the air spring frame hanger 25 lbf·ft (34 N·m).



1. Locknut
2. Washer
3. Bolt
4. Air Spring
5. Main Support Member
6. Cross Channel

Fig. 2, Air Spring Mounting

13. Attach the brass fittings to the air spring using a Teflon thread seal.
14. Connect the air lines to the air spring.

Air Spring Replacement

15. Connect the ball stud on the vertical linkage rod to the lever for the height control valve. Install the washer and tighten the nut 10 lbf·ft (14 N·m).
16. Remove the jack stands.
17. Build up pressure in the air system and check the ride height as described in **Subject 180**.
18. Remove the chocks from the tires.

Air Spring Frame Hanger Removal and Installation

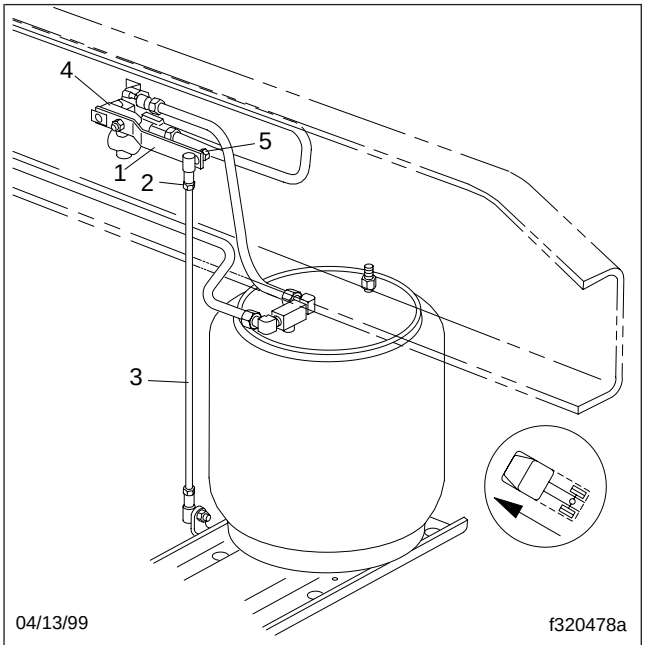
Removal

1. Chock the front tires.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

2. Disconnect the vertical linkage for the height control valve at the end of the horizontal lever. See **Fig. 1**. Lift the lever on the height control valve so that the air bags raise the rear of the frame about 3 inches (75 mm). Support the frame at that position with jack stands.



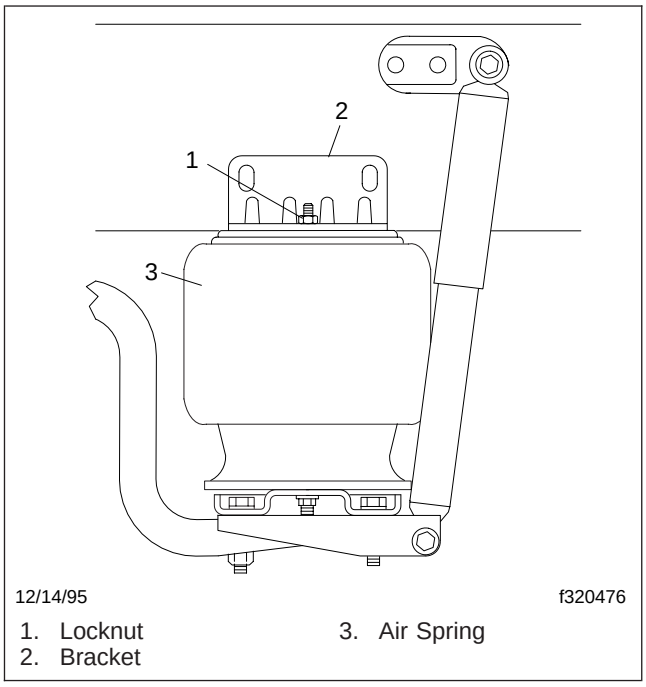
1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

Fig. 1, Height Control Valve Linkage

3. Drain the air from the vehicle's air system then lower the lever on the height control valve to exhaust the air from the air springs.
4. Disconnect the air lines from the air spring fittings.
5. Remove the brass air fittings from the air spring.
6. Remove the locknuts and washers that attach the air springs studs to the upper bracket on the frame rail. See **Fig. 2**.
7. Remove the nuts, washers and bolts that hold the upper air spring bracket to the frame rail. Remove the air spring bracket.

Installation

1. Position the air spring upper bracket on the frame rails. Install the bolts through the frame rail and upper bracket and install the washers, and locknuts. Tighten the locknuts 340 lbf·ft (461 N·m).
2. Attach the air spring to the air spring frame bracket. Tighten the outboard locknut 25 lbf·ft (34 N·m).



1. Locknut
2. Bracket
3. Air Spring

Fig. 2, Air Spring Installation

3. Attach the brass air fittings to the air spring port using Teflon thread sealant.
4. Connect the air lines to the air spring fittings.

Air Spring Frame Hanger Removal and Installation

5. Build up pressure in the air system and raise the height control lever to lift the frame off the jack stands. Remove the jack stands and lower the vehicle.
6. Align the ball joint stud in the vertical linkage rod with the hole in the height control lever. Install the ball joint stud, the washer and locknut. Tighten the locknut 10 lbf·ft (14 N·m).
7. Remove the chocks from the tires.

Shock Absorber Bracket Removal and Installation

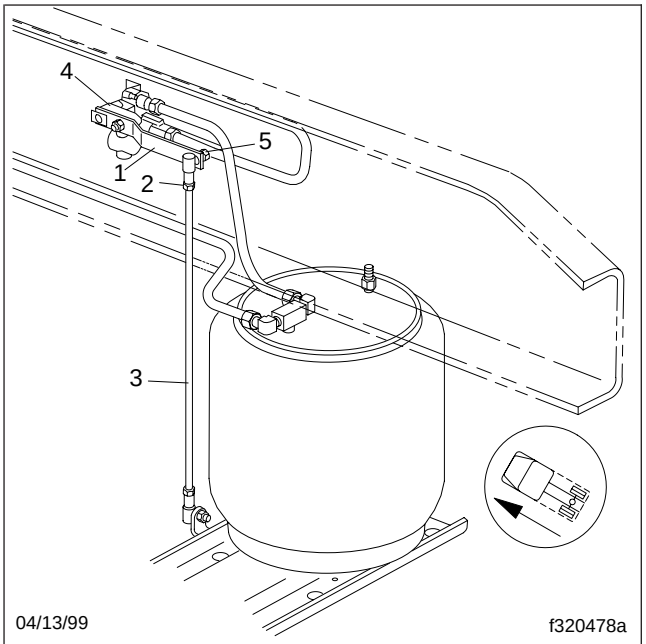
Removal

1. Chock the front tires.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

2. Remove the locknut and washer and disconnect the ball joint stud on the top of the vertical linkage rod from the height control valve lever. See **Fig. 1**.



1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

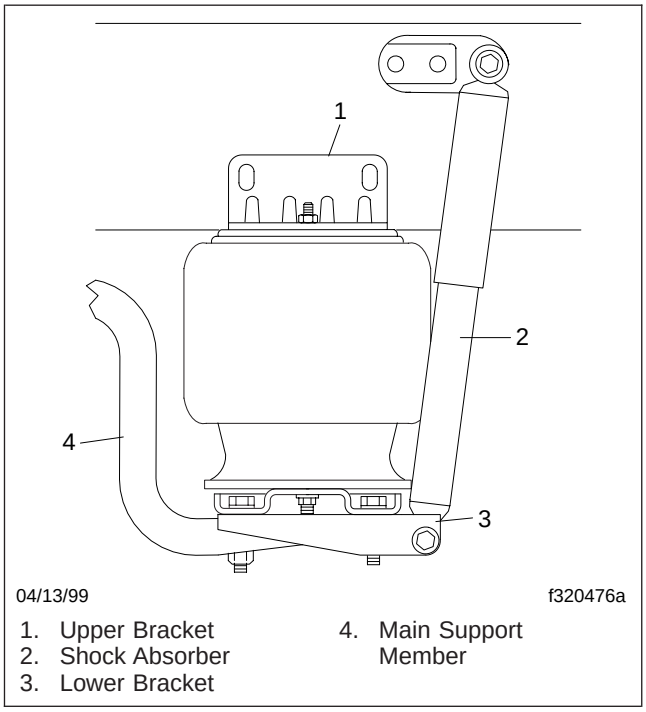
Fig. 1, Height Control Valve Linkage

3. Lift the height control lever to raise the rear of the frame enough to remove the load from the suspension.

   NOTE: The front of the main support member will move downward as the load is removed. Support the frame in this position with jack stands.

4. Remove the shock absorber. Refer to **Subject 170**.

5. Remove nuts, washers and bolts from the shock absorber frame hanger bracket. See **Fig. 2**. Remove the top shock absorber bracket from the frame.



1. Upper Bracket
2. Shock Absorber
3. Lower Bracket
4. Main Support Member

Fig. 2, Shock Absorber Mounts (typical)

6. Remove the nuts, washers and bolts that attach the cross channel and lower shock absorber bracket to the rear of the main support member.

7. Remove the lower bracket by sliding the bracket to the rear.

Installation

1. Install the bolts and washers that attach the frame hanger bracket from the inboard side of the frame. Install the brackets, washers and locknuts. Tighten the nuts 340 lbf·ft (461 N·m).

2. Position the lower bracket between the cross channel and the main support member.

Shock Absorber Bracket Removal and Installation

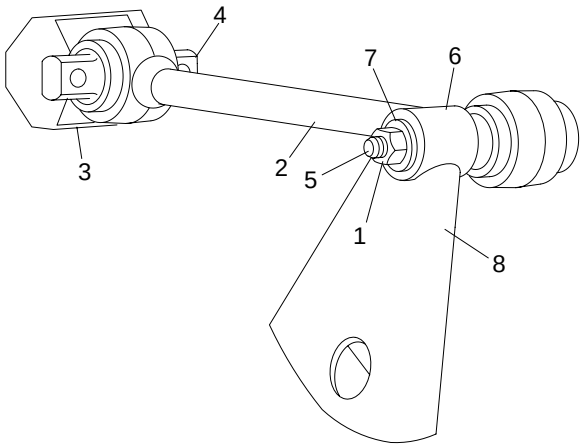
3. Install the bolts and washers from the top of the cross channel, through the shock bracket and main support member. Install the washers and locknuts and tighten the locknuts attaching the cross channel to the main support member 290 lbf·ft (393 N·m).
4. Install the shock absorber. Install the washers at both sides of each shock bushing for a total of four washers per shock absorber.
5. Tighten shock absorber locknuts 60 lbf·ft (81 N·m).
6. Lift the lever of the height control valve to raise the rear of the frame off the jack stands. Remove the jack stands and lower the frame by pushing down on the height control valve lever.
7. Align the ball joint stud in the vertical linkage rod with the hole in the height control valve lever. Install the washer and locknut. Tighten the locknut 10 lbf·ft (14 N·m).
8. Remove the chocks from the tires.

Transverse Rod Removal and Installation

Removal (See Fig. 1)

NOTE: This procedure is for replacement of a transverse rod with a tapered stud at the axle connection and a straddle mount pin at the frame bracket end. Some installations have straddle mounts at both ends of the transverse rod.

1. Chock the front and rear tires.
2. Remove the nuts and washers from the bolts that fasten the pin in the transverse rod bushing to the frame bracket. Disconnect the transverse rod where it is attached to the frame bracket bracket.
3. Remove the nut from the tapered stud in the tube bracket on the axle housing. Hit the top of the axle bracket tube hard with a large hammer to momentarily distort the tube and loosen the tapered stud. Remove the stud and transverse rod from the bracket on the axle housing.



04/13/99 f320477

1. Locknut
2. Transverse Rod
3. Frame Bracket
4. Straddle Mount Pin
5. Tapered Stud End
6. Axle Bracket Tube
7. Washer
8. Axle Bracket

Fig. 1, Transverse Rod Assembly

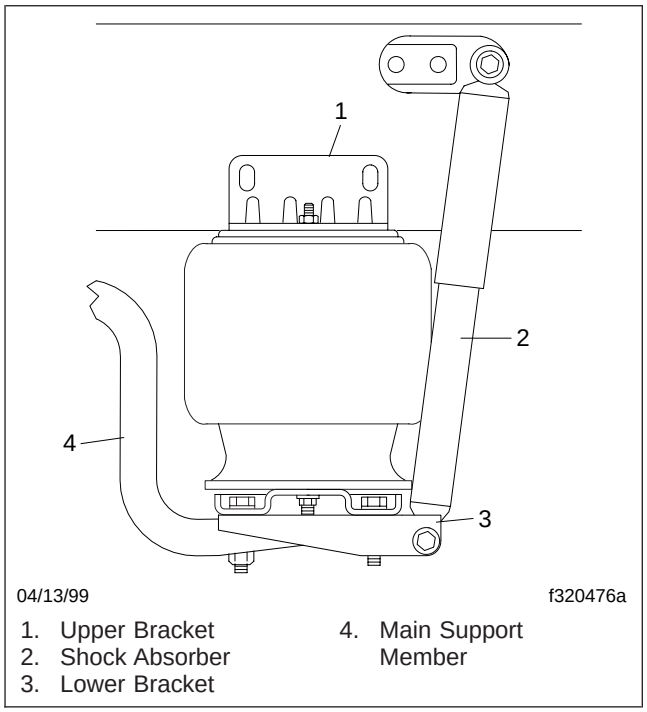
Installation

1. Clear the tapered hole in the axle bracket of all foreign matter.
2. Insert the tapered stud and torque rod bushing into the bracket.
3. Attach the washer and locknut to the stud. Tighten 200 lbf·ft (271 N·m).
4. After tightening, hit the top of the axle bracket tube with a hammer to seat the tapered stud. Retighten.
5. Position the straddle mount end of the transverse rod at the frame bracket, and tighten 200 lbf·ft (271 N·m).
6. Remove the chocks from the tires.

Replacement

NOTE: Shock absorbers are 1 3/8 inches (35 mm) in diameter with a compressed length of 18 1/3 inches (466 mm) and an extended length of 30 inches (762 mm).

1. Chock the front tires.
2. Remove the nut, washer and bolts that attach the shock absorber to the frame hanger bracket. See **Fig. 1**.



1. Upper Bracket
2. Shock Absorber
3. Lower Bracket
4. Main Support Member

Fig. 1, Shock Absorber Mounts (typical)

3. Remove the fasteners that attach the shock absorber to the lower bracket.
4. Remove the shock absorber.
5. Install the new shock absorber with the rod and shield tube at the top. Install the bolts, washers and nuts in the lower bracket and the frame hanger bracket. Install washers at both sides of each shock bushing, that is four washers per shock absorber.
6. Tighten the fasteners 60 lbf·ft (81 N·m).

General Information

NOTE: This subject applies only to Hendrickson series HAS 190/210/230/40LH/400/402/460 suspensions.

Adjust the vehicle ride height with the unloaded vehicle on a level surface. The frame slope, driveline angles, and axle mounting alignment should be checked after the ride height has been changed.

⚠ CAUTION

Failure to adjust the vehicle ride height could adversely affect driveline angles. Also, if the air springs are set too high, the driver may have difficulty (or be prevented from) backing the vehicle under a trailer. If the air springs are set too low, rapid wear of driveline parts will result.

Ride Height Adjustment

The vehicle ride height for Hendrickson HAS air suspension systems is changed by adjusting the length of the vertical linkage at the ride height control valve. Use the following procedure to adjust the ride height of the frame rails.

IMPORTANT: Before checking the ride height, make sure there is no load on the chassis. For tractors, unhitch the trailer. Trucks must be empty when checking the ride height.

1. Stop the vehicle on a level surface, using a light application of the brakes. Slowly move the vehicle forward and back several times without using the brakes to center the suspension joints. Do not apply the parking brakes.
2. Put the transmission in neutral. Build the secondary air pressure to at least 100 psi (690 kPa). Shut down the engine.

   NOTE: Allow several minutes for the air pressure to equalize in the system before checking the ride height.
3. Mark the location of the front and rear tires on the floor so that the vehicle can be checked in the same location after a test drive. Chock the front tires.

IMPORTANT: Any difference in height between the two sides of the vehicle must be corrected using spacers between the main support arm and the rear axle housing before setting the vehicle ride height. See the appropriate section in Group 32 in the vehicle's service manual for the alignment procedure.

4. Measure the distance from the bottom of the frame rail to the bottom of the main support arm at the rear axle U-bolts. See **Fig. 1**. The correct measurement for Hendrickson HAS suspension systems is 4-1/4±1/8 inches (108±3 mm) for vehicles with a specified ride height of 8-1/2 inches (215 mm) or greater. For vehicles with less than an 8-1/2-inch (215 mm) ride height, the distance between the bottom of the frame rail and the bottom of the main support arm must be 2-3/8 inches (60 mm).

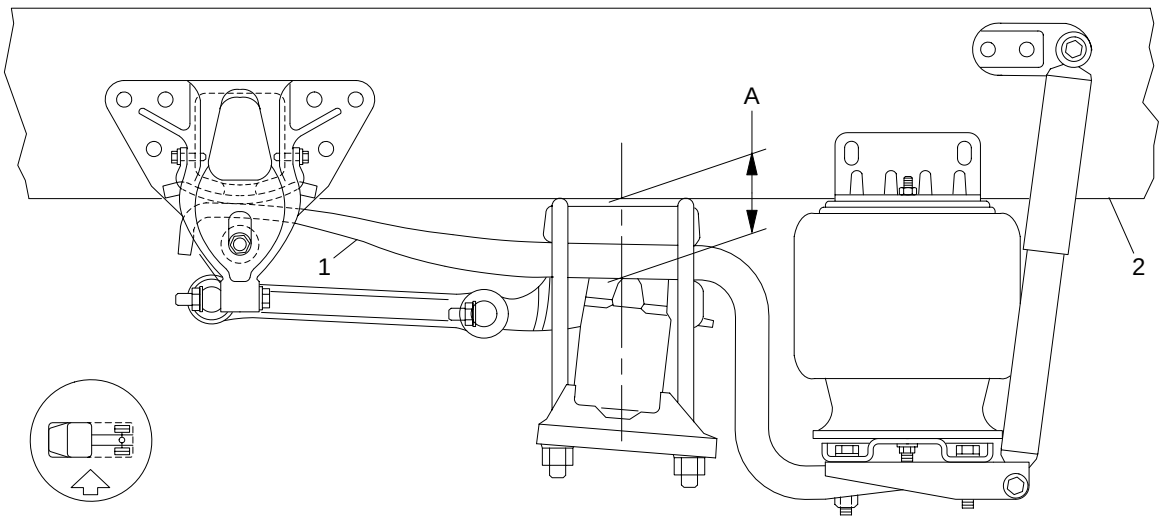
   If the measurement is the same as the specification at each support arm, the ride height is correctly adjusted. If the distance measured is not the same at each rear axle mount on the vehicle, correct this alignment problem before attempting to adjust the ride height.

⚠ WARNING

The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.

5. Remove the nut and lockwasher from the ball joint stud at the end of the lever on the ride height control valve. See **Fig. 2**. Separate the vertical rod assembly from the lever, being careful to avoid moving the lever while disconnecting the ball joint.
6. Push the lever down to lower the frame by removing the air in the suspension air bags.
7. Slowly pull the lever up to raise the frame until the ride height measurement is exactly correct for the specified ride height.
8. Make sure that the centering hole in the lever near its pivot aligns with the centering hole in the height control valve body. Check the height control valve to make sure that no air flows through

Ride Height Adjustment

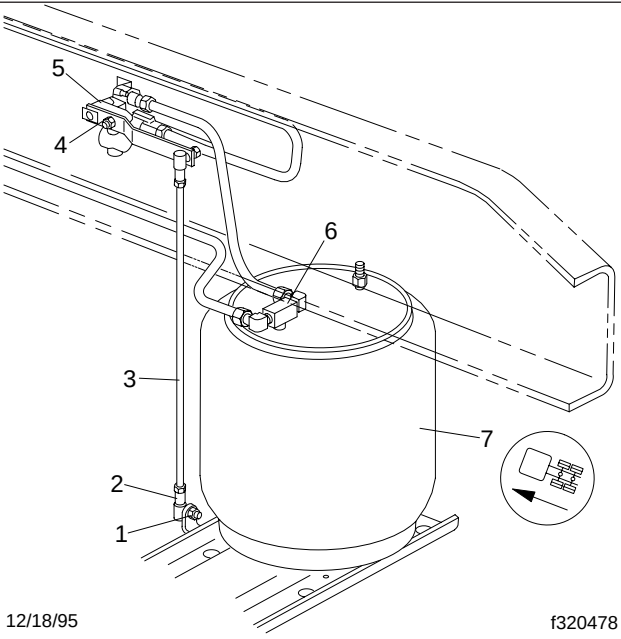


A. Measure ride height here.
1. Bottom of Main Support Arm
2. Bottom of Frame Rail

Fig. 1, Measuring the Ride Height

the ride height control valve when the lever is in the centered position.

9. Loosen the jam nuts a few turns at the top and bottom ball joints on the vertical rod that attaches to the height control lever. Note that one of the ball joints and jam nuts has left-hand threads. Hold the top ball joint with your hand and turn the vertical rod with a wrench until the top ball joint stud exactly aligns with the hole in the end of the lever when the lever is centered horizontally on the control valve.
10. Install the ball joint stud in the lever and install the lockwasher and nut on the stud. Tighten the nut on the stud to 125 lbf·inch (11 N·cm).
11. Tighten the jam nut on each ball joint without changing the length of the vertical rod.
12. Apply the parking brakes; then remove the chocks from the tires. Drive the vehicle unloaded for about 1/4 mile (1/2 km); then stop the vehicle in the exact location (as previously marked) of the original measurement.
13. Park the vehicle using only a light brake application. Chock the tires on one axle only and put the transmission in neutral. Do not apply the parking brakes.
14. Check the adjusted distance between the bottom of the frame and the bottom of the main support arm at the U-bolts. See **Fig. 1**.
15. If the distance is still not correct, loosen the ball joint jam nuts on the vertical rod and turn the rod to adjust the ride height. Lengthen the vertical rod to raise the frame or shorten the rod to lower the frame to the correct ride height. Drive the vehicle and again check the ride height.
16. Apply the parking brakes; then remove the chocks from the tires.



1. Lockwasher and Nut
2. Ball Joint and Jam Nut
3. Vertical Rod
4. Leveling Arm Locknut
5. Ride Height Control Valve
6. Brass Air Fitting
7. Air Spring

Fig. 2, Ride Height Control System

Problem—All Air Bags Are Deflated

Problem—All Air Bags Are Deflated	
Possible Cause	**Remedy**
The vehicle air system pressure is too low.	Run the engine until the air gauge indicates 100 psi (690 kPa).
Air is leaking from the vehicle air system.	Listen for air leakage at the air fittings, tanks, and brake componenets. Repair or replace fittings as needed.
The linkage for the height control valve is disconnected or maladjusted.	Connect the linkage and adjust as described in **Subject 180**.
The suspension dump valve is activated.	Toggle the dump control valve to the normal position.
The relay valve is stuck open.	Check and repair the relay valve.
The air bags have a leak.	Listen for leaks at the air bags, tubes, and fittings.
The height control valve is not operating correctly.	Disconnect the linkage and raise and lower the lever to check the operation of the height control valve. Make sure that no air flows through the valve when the lever is in the center position. Replace the valve if it is bad.
There is a obstruction in the lines to the height control valve.	Check the air pressure at the height control valve supply port. Remove any obstruction or restriction to air flow to the valve.
The pressure protection valve is not allowing air to flow to the height control valve.	Check the operation of the pressure protection valve between the secondary air tank and the height control valve. Replace the valve if it is not operating correctly.

Problem—One Side of the Vehicle Is Higher Than the Other

Problem—One Side of the Vehicle Is Higher Than the Other	
Possible Cause	**Remedy**
The axle seat spacer thickness is not the same on each side.	Adjust the spacers so that the frame is level before adjusting the ride height.
The load on the vehicle is not distributed evenly.	Change the position of the load to ensure equal weight on each side.
There is an obstruction to air flow to the air bags on one side of the vehicle.	Disconnect the fittings and test the flow to the air bags on the lower side of the vehicle.
The height control valve or relay valve has an internal restriction.	Check for the same pressure at the ports on each side of the valve. Replace the valve if the pressure is not the same.
The air bags or fittings have a leak.	Listen for leaks at the air bags, tubes, and fittings. Tighten the fittings, if loose, or replace any bad parts.

Problem—The Ride Height Is Not Constant

Problem—The Ride Height Is Not Constant	
Possible Cause	**Remedy**
Air is leaking from the air bags or lines.	Listen or use soap bubbles to find air leaks. Tighten or replace leaking fittings or air bags.
The height control valve is not working correctly.	Make sure that no air is exhausted from the height control valve when the lever is in the horizontal position and that the air bags inflate when the lever is raised. The bags must deflate when the lever is pushed down. There must be a slight delay between the lever movement and the valve operation. Check for fluid leaks from the height control valve. Replace the valve if damaged.

Troubleshooting

Problem—The Ride Height Is Not Constant	
Possible Cause	**Remedy**
There is an obstruction to air flow to the air bags.	Disconnect the fittings and test the flow to the air bags.
The height control valve has a restriction at the exhaust port.	Check for air exhausting from the valve when the height control lever is pushed down.
The height control linkage is loose.	Make sure that all the jam nuts are tight and that the ball sockets are not worn.

Problem—The Ride Height Measurement Is Not Correct

Problem—The Ride Height Measurement Is Not Correct	
Possible Cause	**Remedy**
The vehicle is loaded.	The ride height of a loaded vehicle will be slightly lower than that of an unloaded vehicle. Adjust the ride only when the vehicle is unloaded.
The ride height adjustment is not correct.	Adjust the ride height as described in **Subject 180**.
Air is leaking from the air bags or lines.	Listen or use soap bubbles to find air leaks. Tighten or replace leaking fittings or air bags.
The height control valve is not working correctly.	Make sure that no air is exhausted from the height control valve when the lever is in the horizontal position and that the air bags inflate when the lever is raised. The bags must deflate when the lever is pushed down. There must be a slight delay between the lever movement and the valve operation. Check for fluid leaks from the height control valve. Replace the valve if damaged.
There is an obstruction to air flow to the air bags.	Disconnect the fittings and test the flow to the air bags.
The height control valve has a restriction at the exhaust port.	Check for air exhausting from the valve when the height control lever is pushed down.
The height control linkage is loose.	Make sure that all the jam nuts are tight and that the ball sockets are not worn.

Problem—The Air Springs Have Cuts

Problem—The Air Springs Have Cuts	
Possible Cause	**Remedy**
The ride height is adjusted too high.	Adjust the ride height so that the air bags are not continually overinflated.
The tires are too wide and are rubbing the air bags.	Install the correct tires.
A shock absorber or mount is broken.	Replace any broken components.

Problem—The Vehicle Does Not Track Straight

Problem—The Vehicle Does Not Track Straight	
Possible Cause	**Remedy**
The axle alignment is not correct.	Adjust the alignment with shims at the front of the torque rods.
The bushings in the torque rods are worn.	Replace the worn bushings.

Problem—The Vehicle Does Not Track Straight	
Possible Cause	**Remedy**
The bushings in the transverse rods are worn.	Replace the worn bushings.
A shock absorber or mount is broken.	Replace any broken components.
The U-bolt high nuts are loose.	Periodically tighten the nuts as described in **Specifications 400**.
The suspension fasteners are loose or damaged.	Tighten or replace the fasteners.

Problem—The Vehicle Vibrates When Driven

Problem—The Vehicle Vibrates When Driven	
Possible Cause	**Remedy**
The ride height is not correct.	Adjust the ride height as described in **Subject 180**.
The axle housing rotational alignment is not correct.	Adjust the rotational alignment of the axle housing with wedge-shaped shims at the axle seats. The driveline U-joint angles must be with 1% of each other.
The shock absorbers are worn or disconnected.	Replace the shock absorbers, if worn, or tighten the mounting fasteners.
The bushings in the torque rods are worn.	Replace the worn bushings.
The U-bolt high nuts are loose.	Periodically tighten the nuts as described in **Specifications 400**.
The suspension fasteners are loose or damaged.	Tighten or replace the fasteners.
The frame is not level from front to rear.	Check and adjust the ride height at the front suspension and each rear axle. The frame should not slope more than 1/2 inch (13 mm). Correct the ride height if not at specifications.

Specifications

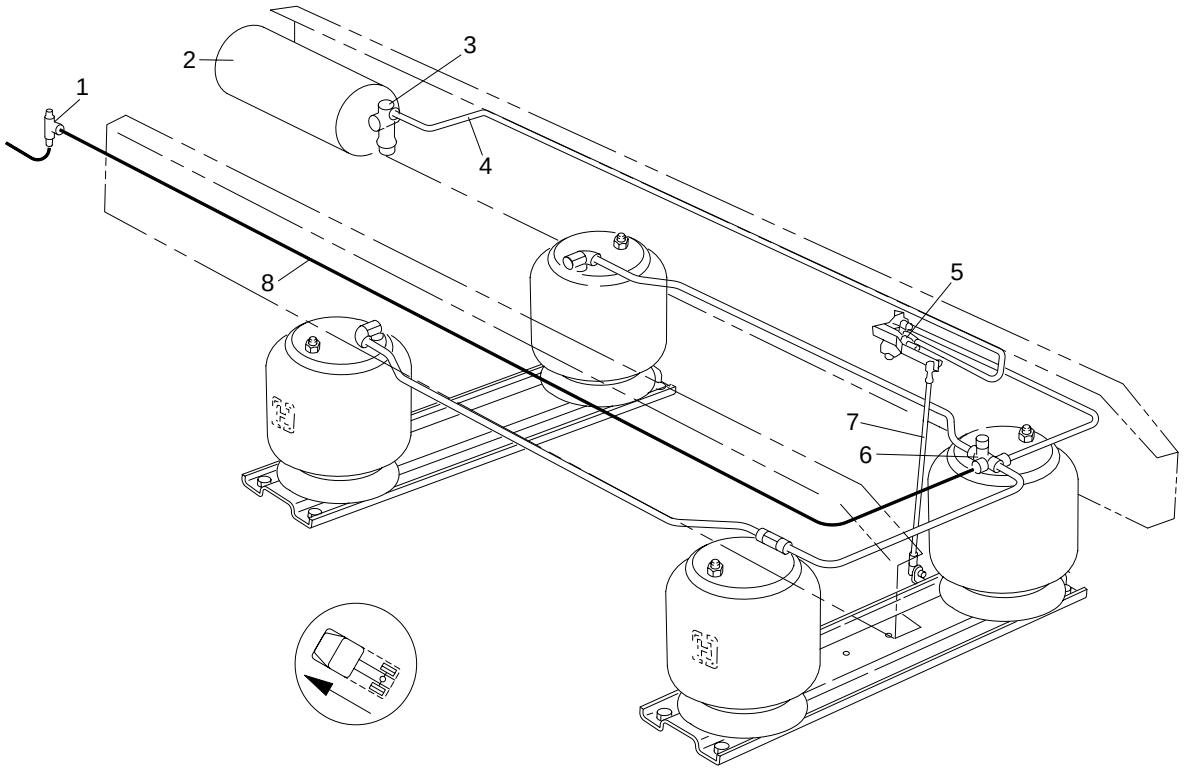
For an overview of the Hendrickson HAS air system plumbing, see **Fig. 1** and **Fig. 2**.

Torque Values		
Description	**Size**	**Torque: lbf·ft (N·m)**
U-bolt High Nuts	7/8–14	Stage 1: Hand tighten Stage 2: 60 (81) * Stage 3: 200 (271) * Stage 4: 420 to 500 (571 to 680) *
	1–14	Stage 1: Hand tighten Stage 2: 60 (81) * Stage 3: 200 (271) * Stage 4: 520 to 600 (707 to 816) *
Torque Rod Bar Pin Locknut	5/8–11	180 (244)
Axle Seat Stud	5/8–11	65 (88)
Rebound Bolt Locknut	1/2–13	60 (81)
Shock Absorber Locknut, Upper	1/2–13	60 (81)
Shock Absorber Locknut, Lower	3/4–10	60 (81)
Cross Channel to Main Support Member Locknut	3/4–10	290 (393)
Air Spring to Frame Hanger Locknut	1/2–13	25 (34)
Air Spring to Cross Channel Locknut	1/2–13	25 (34)
Transverse Rod Locknut	1-1/4–12	200 (271)
Extension Arm Jam Nut	5/16–24	125 (169)
Extension Arm Locknut	5/16–24	125 (169)

* Tighten in a diagonal pattern as shown in **Fig. 3**.

Table 1, Torque Values

Specifications

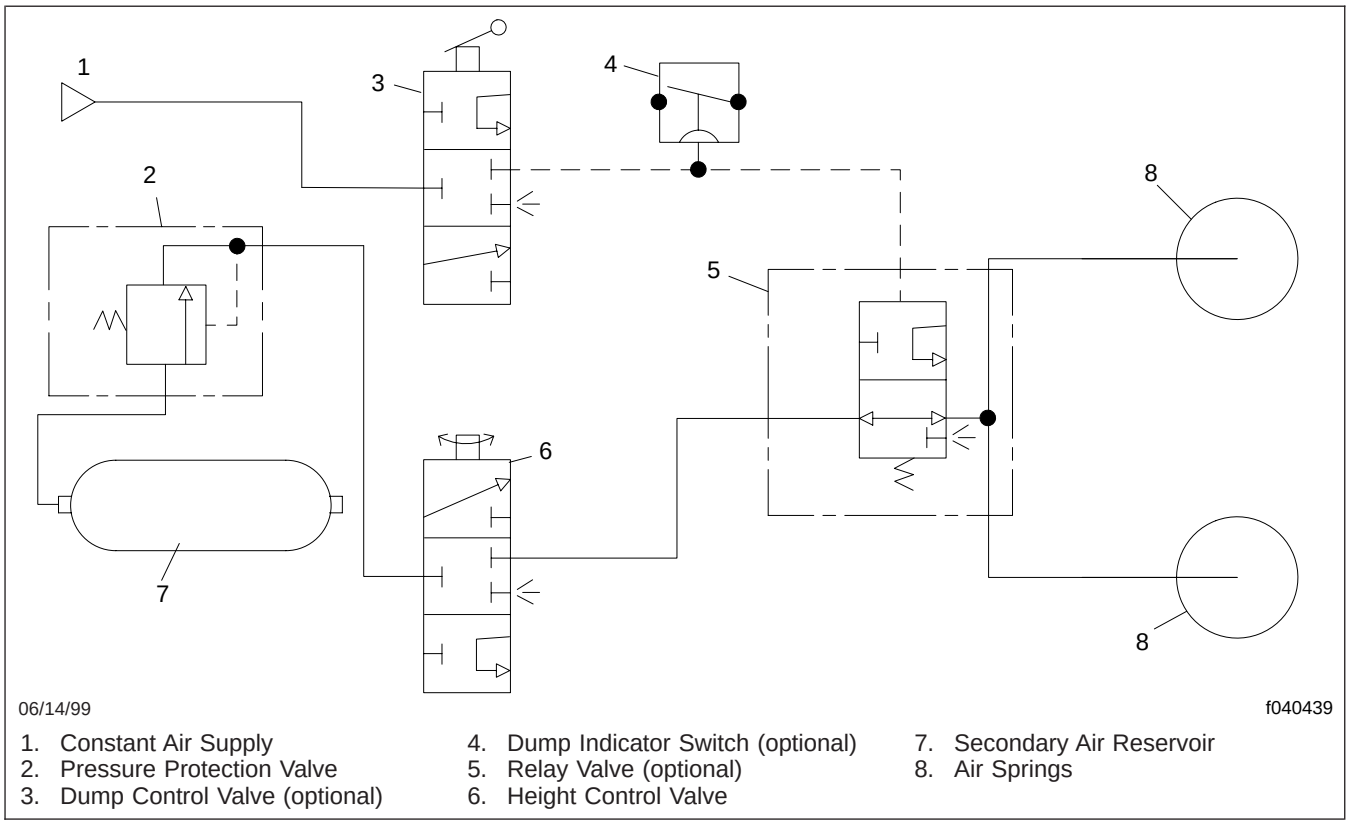


06/16/99 f320803

NOTE: The height control valve was moved to the forward axle on later HAS systems.

1. Switch Control Valve
2. Air Tank
3. Pressure Protection Valve
4. Air Supply Line
5. Height Control Valve
6. Quick Release Valve
7. Leveling Valve Extension Arm
8. Air Signal Line

Fig. 1, Suspension Air Plumbing



1. Constant Air Supply
2. Pressure Protection Valve
3. Dump Control Valve (optional)
4. Dump Indicator Switch (optional)
5. Relay Valve (optional)
6. Height Control Valve
7. Secondary Air Reservoir
8. Air Springs

Fig. 2, Air Suspension Dump System Schematic (typical)

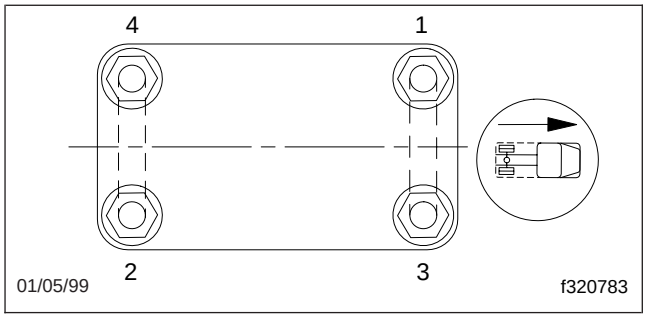


Fig. 3, Tightening Pattern for U-bolt High Nuts

General Description

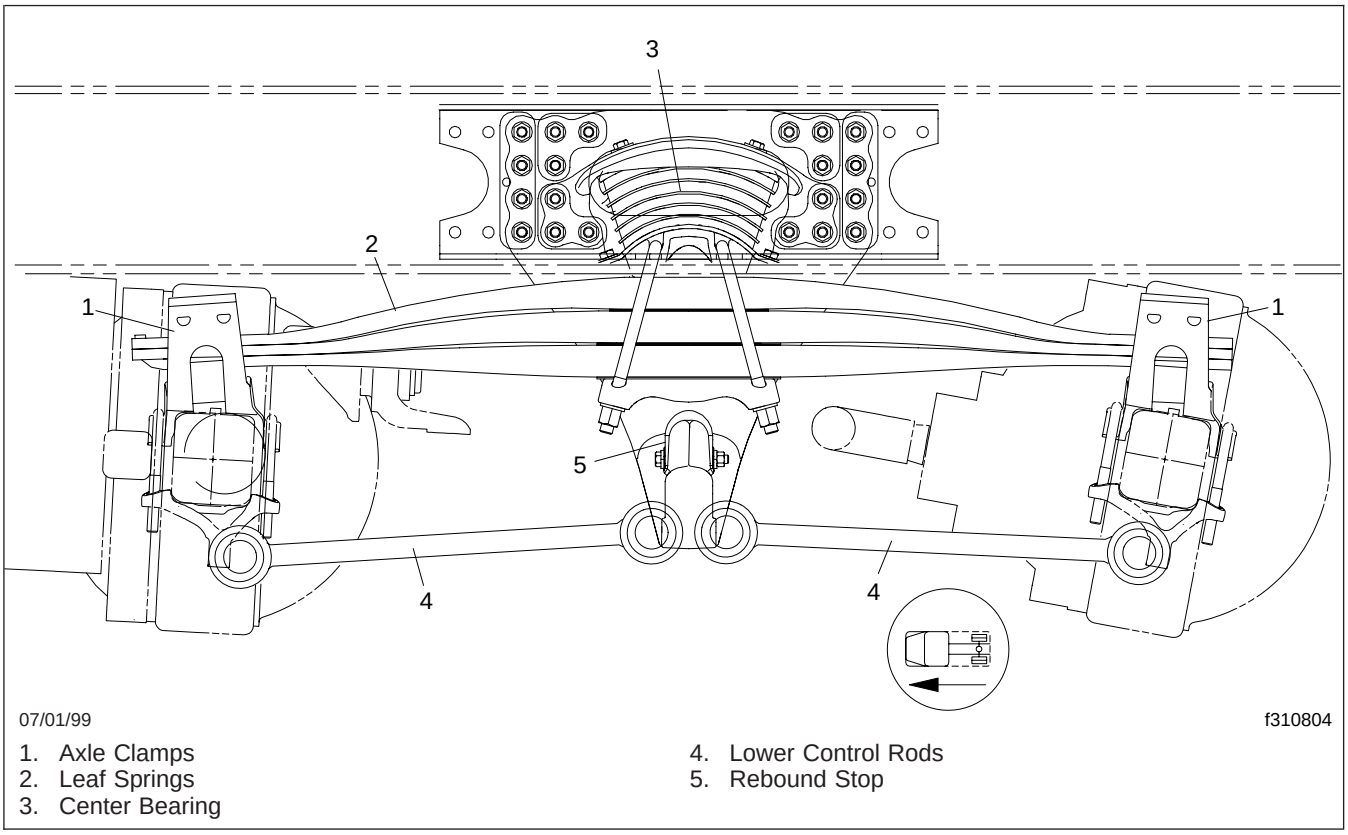
The TufTrac Suspension (**Fig. 1**) is heavy-duty "six rod" tandem-axle suspension option for trucks built for severe on/off highway work. The TufTrac design allows a truck to maneuver over bumps, ridges and washboard roads that typically generate high rates of axle articulation, without bottoming out the suspension or losing traction.

The TufTrac suspension is available in three weight ratings – 40,000-, 46,000- and 52,000-pound (18 144-, 20 865-, 23 586-kilogram) capacities. The 40,000-pound (18 144-kilogram) capacity suspension uses two taper leaf springs and has an axle spacing of 54 inches. The 46,000-pound (20 865-kilogram) capacity suspension has three leaf springs (shown in this section), while the 52,000-pound (23 586-kilogram) suspension features four leaf springs. Both the 46,000-pound (20 865-kilogram) and the 52,000-pound (23 586-kilogram) suspensions have a standard axle spacing of 56 inches.

Principles of Operation

Six functional links in the TufTrac suspension maintain the positions of the axles. Side-to-side axle movement is controlled by two v-rods from the frame to the axles at the top of the suspension. Four bar links from the frame to the axles at the bottom control the forces of driving and braking as well as fore-and-aft road shocks. Vertical loads are carried by the rubber-isolated parabolic taper leaf spring packs.

General Information

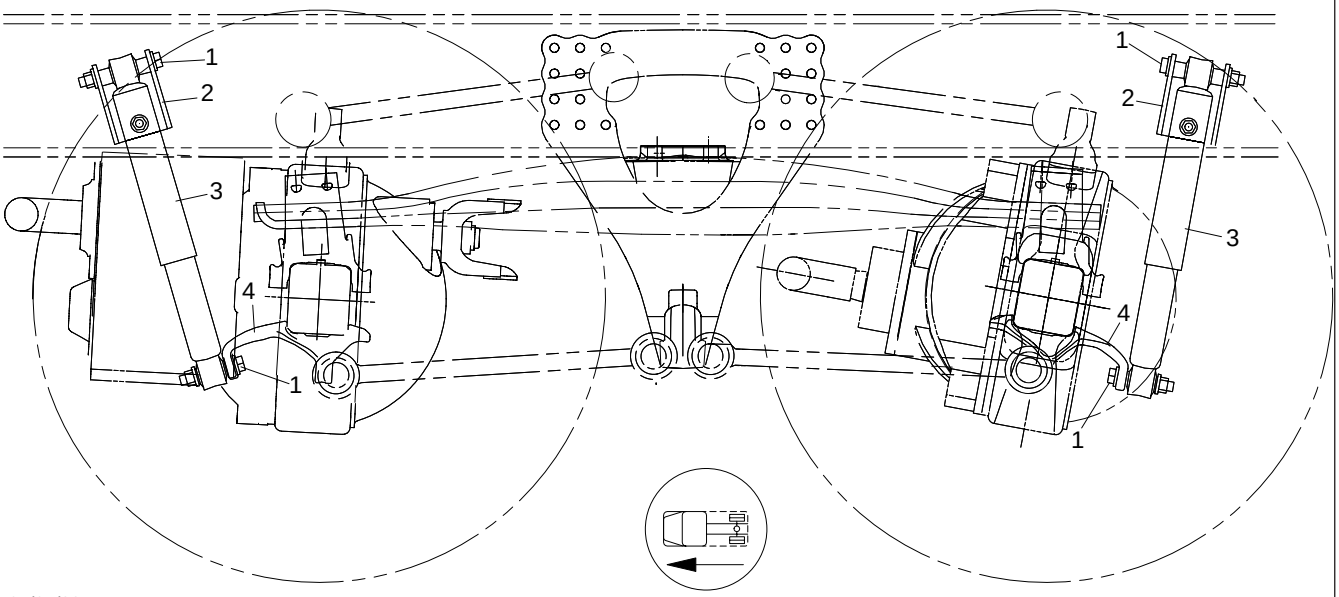


1. Axle Clamps
2. Leaf Springs
3. Center Bearing
4. Lower Control Rods
5. Rebound Stop

Fig. 1, TufTrac Suspension (46,000-pound [20 865-kilogram] version shown)

Replacement

1. Park the vehicle on a level surface, shut down the engine and apply the parking brakes. Chock the tires.
2. Remove the lower shock mounting nut and washer. See **Fig. 1**.
3. Remove the upper shock mounting nut and washer.
4. Remove the upper and lower mounting bolts and remove the shock absorber.
5. Position the new shock absorber in place and install the mounting bolts.
6. Loosely fasten the bolts with the nuts and washers removed from the old shock absorber.
7. Torque each mounting nut 241 lbf·ft (327 N·m).
8. Remove the chocks from the tires.

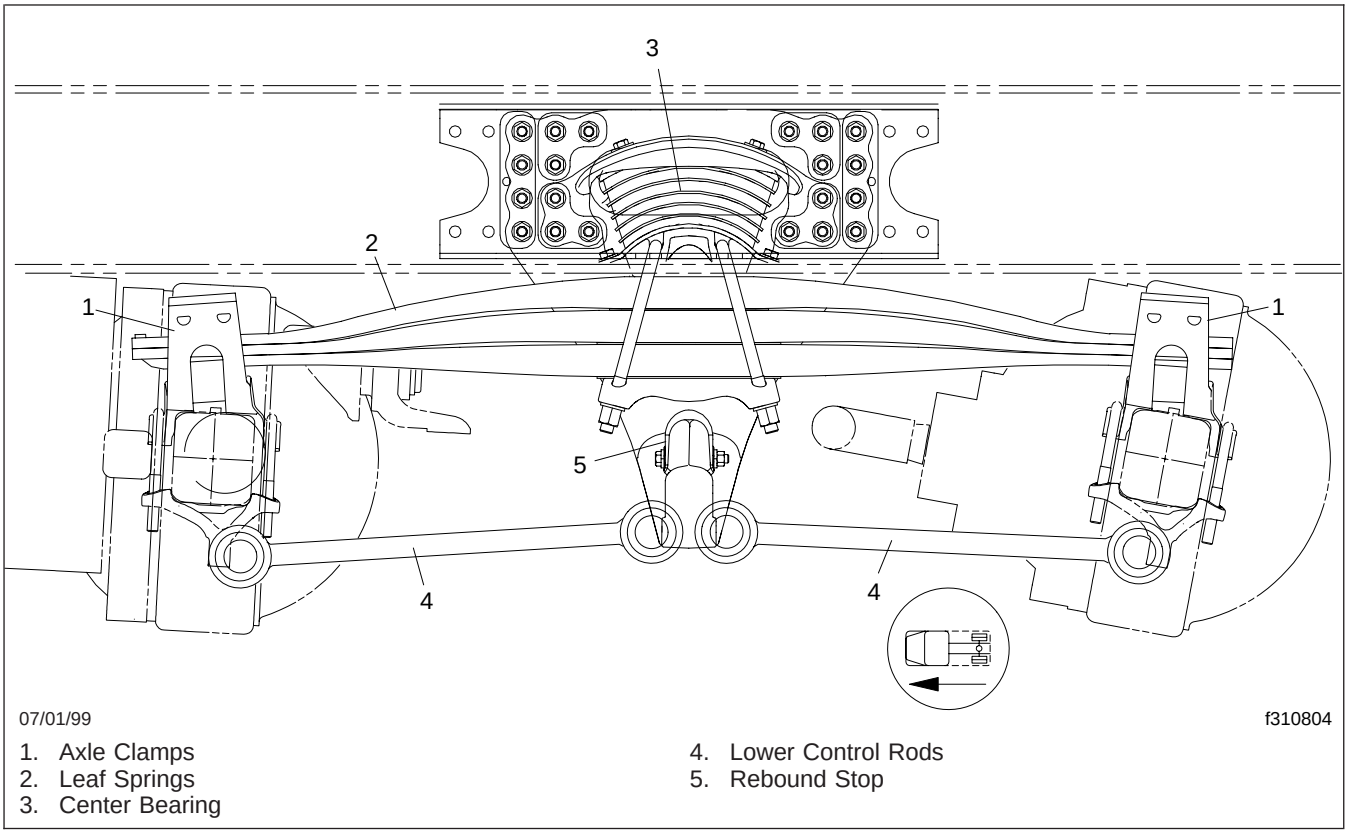


1. Mounting Bolt
2. Upper Mounting Bracket
3. Shock Absorber
4. Lower Mounting Bracket

Fig. 1, Shock Absorber Replacement

Replacement

1. Park the vehicle on a level surface, shut down the engine and apply the parking brakes. Chock the tires.
2. Remove the rebound stop from the suspension. See **Fig. 1**.



1. Axle Clamps
2. Leaf Springs
3. Center Bearing
4. Lower Control Rods
5. Rebound Stop

Fig. 1, TufTrac Suspension (46,000-pound [20 865-kilogram] version shown)

   2.1 Remove the nut and bolt securing the rebound stop to the mounting bracket.

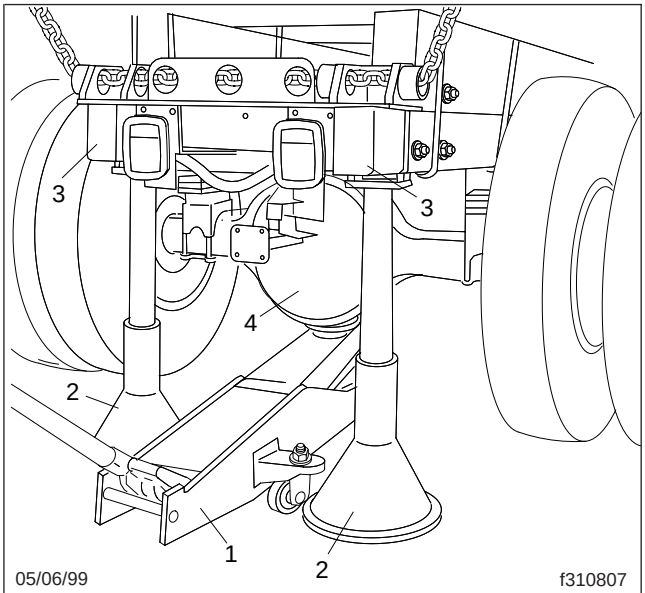
   2.2 Slide the rebound stop from the mounting bracket.

3. Remove the upper two fasteners on the center bearing.
4. Jack up the vehicle under the rear axle.
5. Support the rear frame rails with jack stands, then lower the jack. This will clear the center bearing from the top of the mounting bracket. See **Fig. 2**.
6. Remove the lower center bearing bolts attached to the spring assembly casting. Discard the bolts.
7. Remove the center bearing. See **Fig. 3**.
8. Position the new center bearing in the mounting bracket.
9. Install the upper mounting bolts and tighten 68 lbf·ft (92 N·m).
10. With the jack, raise the rear axle until bottom of the center bearing meets the mounting bracket on the leaf springs.

IMPORTANT: Be sure to use new bolts with loctite (p/n 23–12576–125) when attaching the center bearing to the leaf spring casting.

11. Install new lower mounting bracket bolts (p/n 23–12576–125). Tighten the bolts 155 lbf·ft (210 N·m).

Center Bearing Replacement



1. Jack
2. Jack Stand
3. Frame Rail
4. Rear Axle

Fig. 2, Jack and Jack Stand Placement

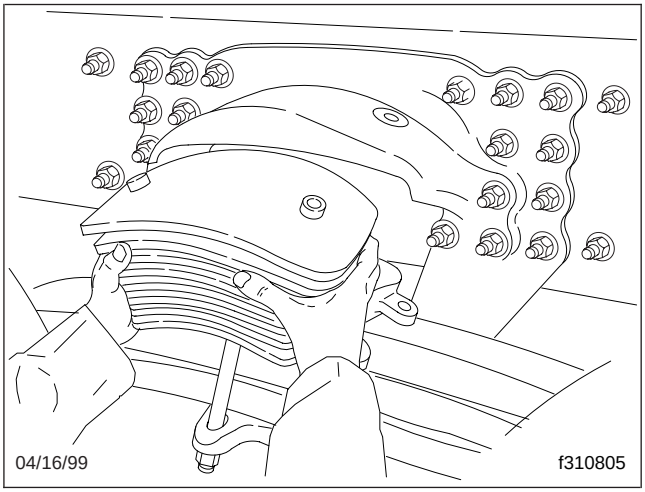
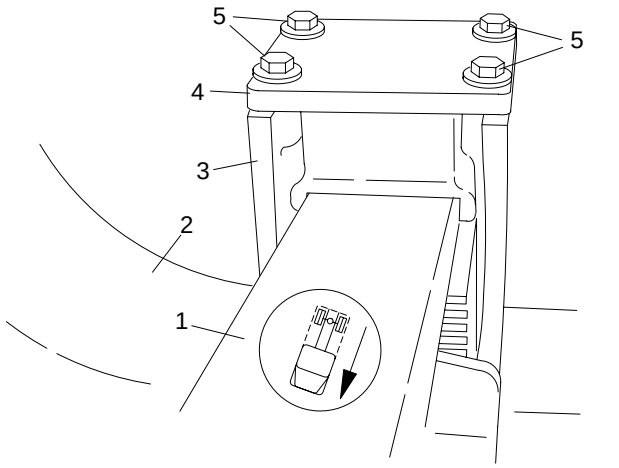


Fig. 3, Center Bearing Removal

12. Return the vehicle to its normal operating position.
13. Install the rebound stop.
14. Remove the chocks from the tires.

Replacement

1. Park the vehicle on a level surface, shut down the engine and apply the parking brakes. Chock the tires.
2. Remove the tip pad bolts above each axle on the axle clamp. There are four bolts on each pad. See **Fig. 1**.



1. Leaf Springs
2. Axle
3. Axle Pad
4. Tip Pad
5. Tip Pad Bolts

Fig. 1, Tip Pad Installation

3. Remove the center bearing. See **Subject 110**.
4. With the vehicle still raised, remove the wheels on both rear axles on the side the spring assembly will be replaced. For instructions, see **Group 40**.

⚠ WARNING

Do not attempt to remove the spring assembly by hand. The assembly is very heavy and attempting to remove it could result in bodily injury.

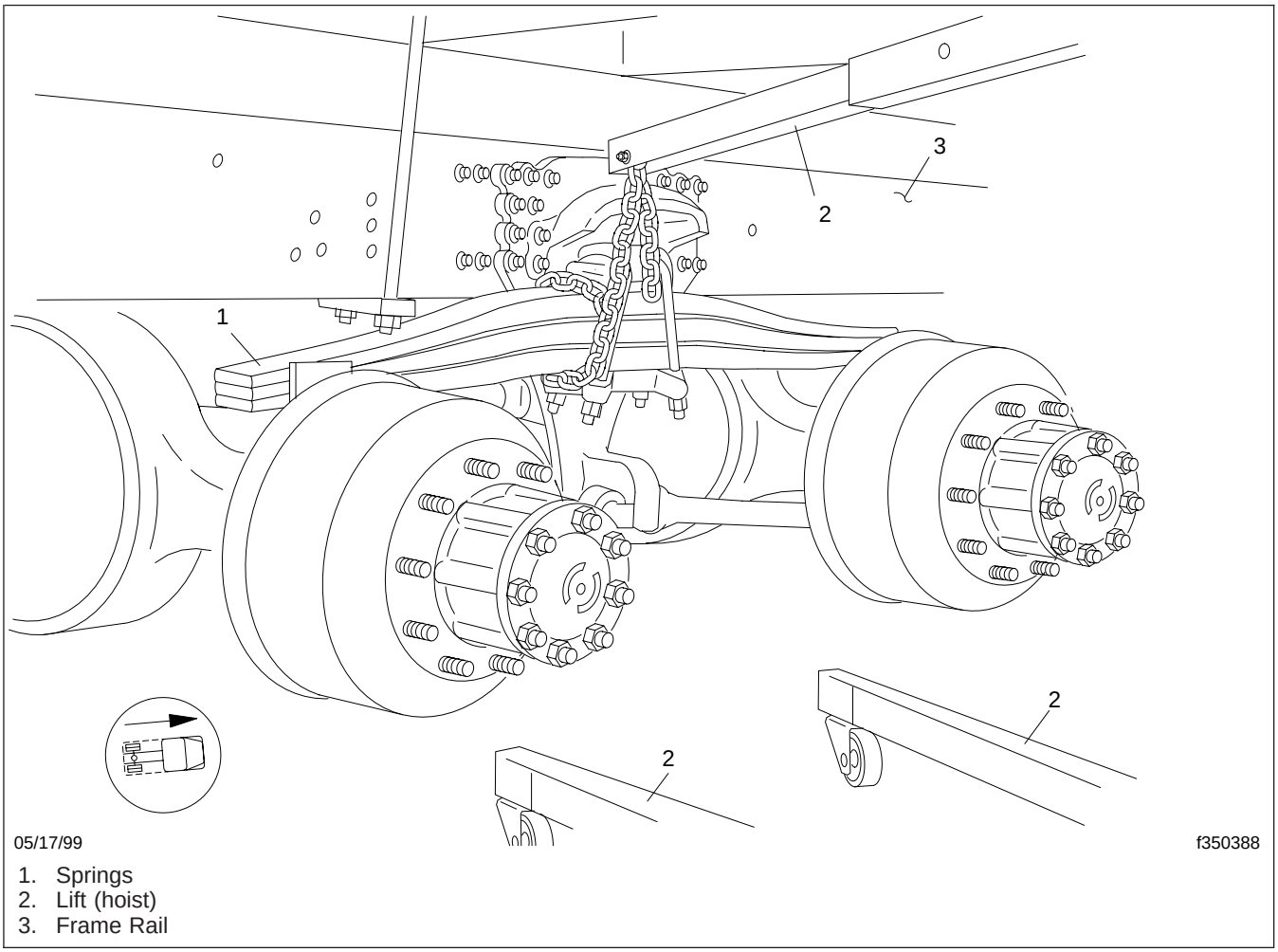
5. Using a lift (i.e. engine hoist), remove the leaf spring assembly from the vehicle. See **Fig. 2**.

⚠ WARNING

Do not attempt to install the spring assembly by hand. The assembly is very heavy and attempting to remove it could result in bodily injury.

6. Place the new spring assembly on the vehicle.
   - 6.1 Attach the new assembly to the lift.
   - 6.2 Using the lift (hoist), lift the assembly into place on the axle clamps.
7. Install the center bearing. For instructions, see **Subject 110**.
8. Install the tip pad and bolts on each axle clamp. Tighten the bolts 37 lbf·ft (50 N·m). See **Fig. 1**.
9. If not already installed, install the rebound stop and mounting bolt. Tighten the nut 68 lbf·ft (92 N·m).
10. Install the wheels. For instructions, see **Group 40**.
11. Return the vehicle to its normal operating position.
12. Remove the chocks from the tires.

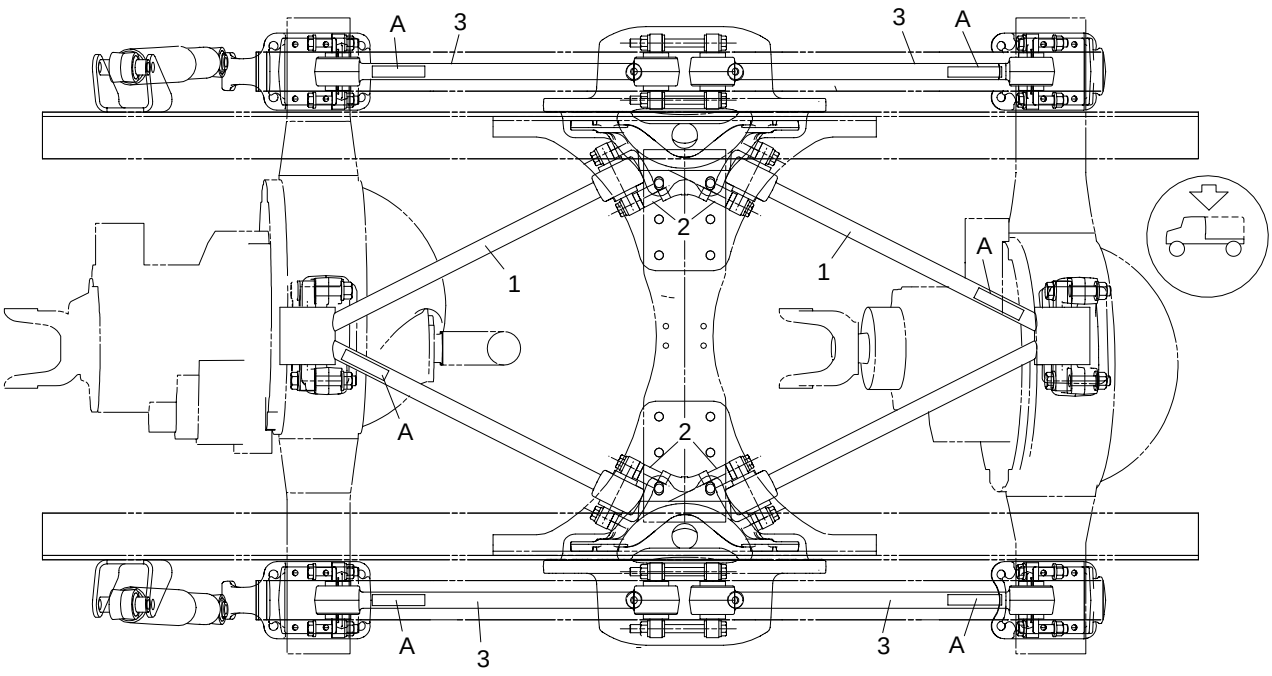
Spring Assembly Replacement



1. Springs
2. Lift (hoist)
3. Frame Rail

Fig. 2, Leaf Spring Replacement

Lower Control Rod Replacement (See Fig. 1)



A. Label
1. V-Rod
2. Spacer
3. Lower Control Rod

Fig. 1, Control and V-Rod Replacement

1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the front tires.
2. Raise the rear axle and support the frame rails with jack stands.
3. Lower the jack under the axle. See **Fig. 2**.
4. Remove the bolts holding both rods between the rear axles, below the rebound stop. See **Fig. 3**.
5. Remove the nut and bolt from the axle clamp.
6. Remove the control rod from the vehicle.

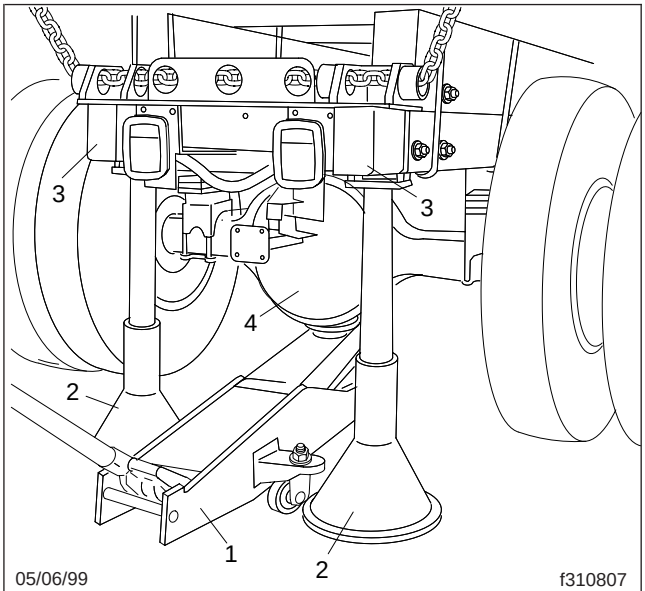
IMPORTANT: When installing the rods make sure the labels on the rods are facing upward. Forward axle rods are marked "FDA" and rear axle rods "RDA."

7. Fasten the new control rod to the axle clamp. Tighten the nut 136 lbf·ft (184 N·m).
8. Fasten the other end of the rod to the bracket below the rebound stop. Tighten the nut 136 lbf·ft (184 N·m).
9. Return the vehicle to the normal operating position.

V-Rod Replacement

1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the tires.
2. Raise the rear axle and support the frame rails with jack stands.
3. Lower the jack under the axle. See **Fig. 2**.

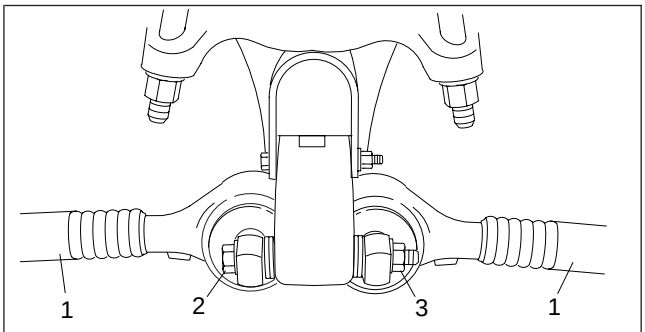
Lower Control Rod and V-Rod Replacement



05/06/99 f310807

1. Jack
2. Jack Stand
3. Frame Rail
4. Rear Axle

Fig. 2, Jack and Jack Stand Placement



06/10/99 f320800

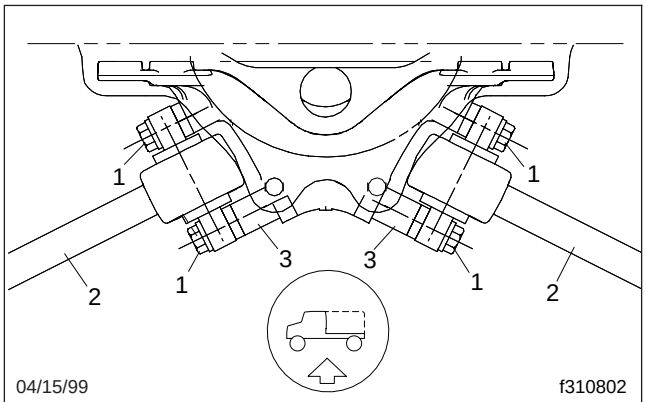
1. Lower Control Rod
2. Mounting Bolt
3. Mounting Nut

Fig. 3, Lower Control Rods

4. Remove all six mounting bolts securing the v-rod to the chassis and axle.
5. Remove the v-rod from the chassis.

IMPORTANT: When installing the rods make sure the labels on the rods are facing upward. Forward axle rods are marked "FDA" and rear axle "RDA."

6. Install the v-rod. See **Fig. 4**.



04/15/99 f310802

1. Mounting Bolt
2. V-Rod
3. Spacer

Fig. 4, V-Rod Replacement

6.1 Place the new rod in position between the frame rails.

6.2 Install the bolts and spacers and loosely tighten all connections.

6.3 After all fasteners and spacers are installed, torque as follows:

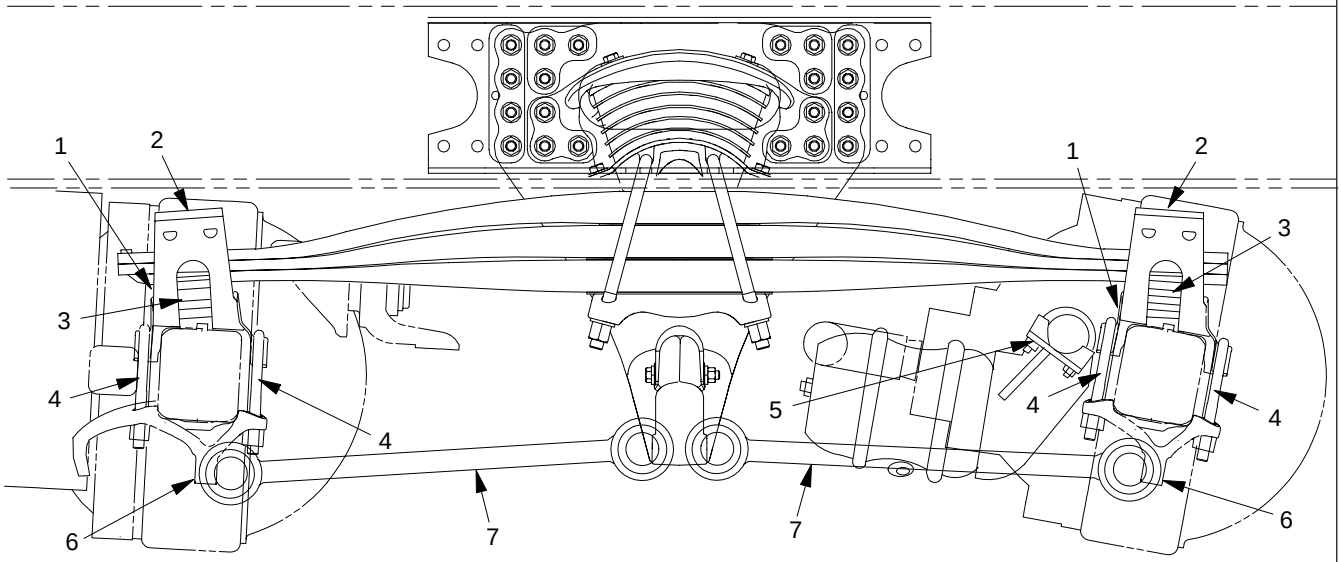
- Tighten the bolts at the frame bracket 136 lbf·ft (184 N·m).
- Tighten the bolts at the axle bracket 427 lbf·ft (579 N·m).

7. Return the vehicle to normal operating position.
8. Remove the chocks from the tires.

Axle Clamp and Retainer Replacement

Replacement

For a side view of the TufTrac suspension, see **Fig. 1**.



1. Upper Axle Clamp
2. Upper Spring Tip Pad
3. Lower Spring Tip Pad
4. U-Bolt
5. Brake Cam Tube Support Bracket
6. Lower Axle Retainer
7. Lower Control Rods

Fig. 1, TufTrac Suspension (left-side view)

1. Park the vehicle on a level surface, shut down the engine and apply the parking brakes. Chock the front tires.
2. Remove the two upper spring tip pads and bolts from the left suspension spring.
3. Disconnect the shock absorbers from the lower axle retainer on the left suspension spring.
   - 3.1 Remove the lower shock mounting nuts and washers.
   - 3.2 Remove the lower shock absorber mounting bolts.
4. Disconnect the two lower torque control rods from the lower axle retainers on the left side of the vehicle.
5. Loosen and remove the U-bolt nuts and washers, and discard.
6. Remove the brake cam tube support bracket from the left rear axle.
7. Remove the lower axle retainers from the left forward and left rear drive axles, and discard.
8. Remove the axle U-bolts from the left forward drive axle and the left rear drive axle, and discard.
9. Jack up the center of the left suspension spring (at the center bearing, between the tandem) and support with the jack stands at the frame. See **Fig. 2**. Make sure that all of the weight has been relieved from the axle clamp group and that there is sufficient clearance to remove the upper axle clamp.
10. Remove the lower spring tip pads from the left forward and left rear drive axles.
11. Remove the upper axle clamps from the left forward and left rear drive axles. Discard the clamps.

Axle Clamp and Retainer Replacement

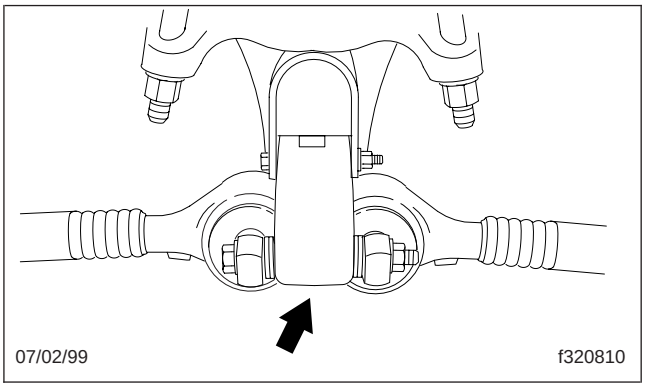


Fig. 2, Jack the Vehicle Here

12. Install the new upper axle clamps from the applicable warranty kit to the left forward and left rear drive axles. Locate the dowel pin through the hole in the bottom of each axle clamp to confirm proper alignment

NOTE: Confirm that you are installing the correct upper axle clamps before continuing. You are able to visually identify the new upper axle clamp because the step has been removed from the area directly above the U-bolt saddles. See **Fig. 3**.

13. Install the lower spring tip pads into the left front and rear axle clamps.
14. Jack up the left suspension spring, remove the jack stands, and lower the suspension spring. Ensure while the spring is being lowered that it is seated correctly onto the lower spring tip pads.
15. Install the new lower axle retainers onto the left forward and rear drive axles.
16. Install the brake cam tube support bracket onto the left rear axle.
17. Install the U-bolts on the left forward and rear drive axles.

    IMPORTANT: Install two washers for each U-bolt nut.

    17.1 Install each U-bolt over the U-bolt saddle in the upper axle clamp and through the holes in the lower axle retainer.

    17.2 Install the washers and finger-tighten the nuts in the order shown in **Fig. 4**.

    Make sure all brackets are snug against the axle housing before proceeding to the next step.

    IMPORTANT: U-bolt nuts must be tightened in the order shown in **Fig. 4**.

    17.3 Tighten the nuts 60 lbf·ft (81 N·m) and then to 200 lbf·ft (271 N·m) in two separate rotations following the order shown in **Fig. 4**.

18. Install the lower torque control rods to the lower axle retainers on the left side of the vehicle and tighten 136 lbf·ft (184 N·m).
19. Install the shock absorbers to the lower axle retainers.

    19.1 Install the lower shock mounting bolts.

    19.2 Install the lower shock absorber mounting washers and nuts and tighten by hand.

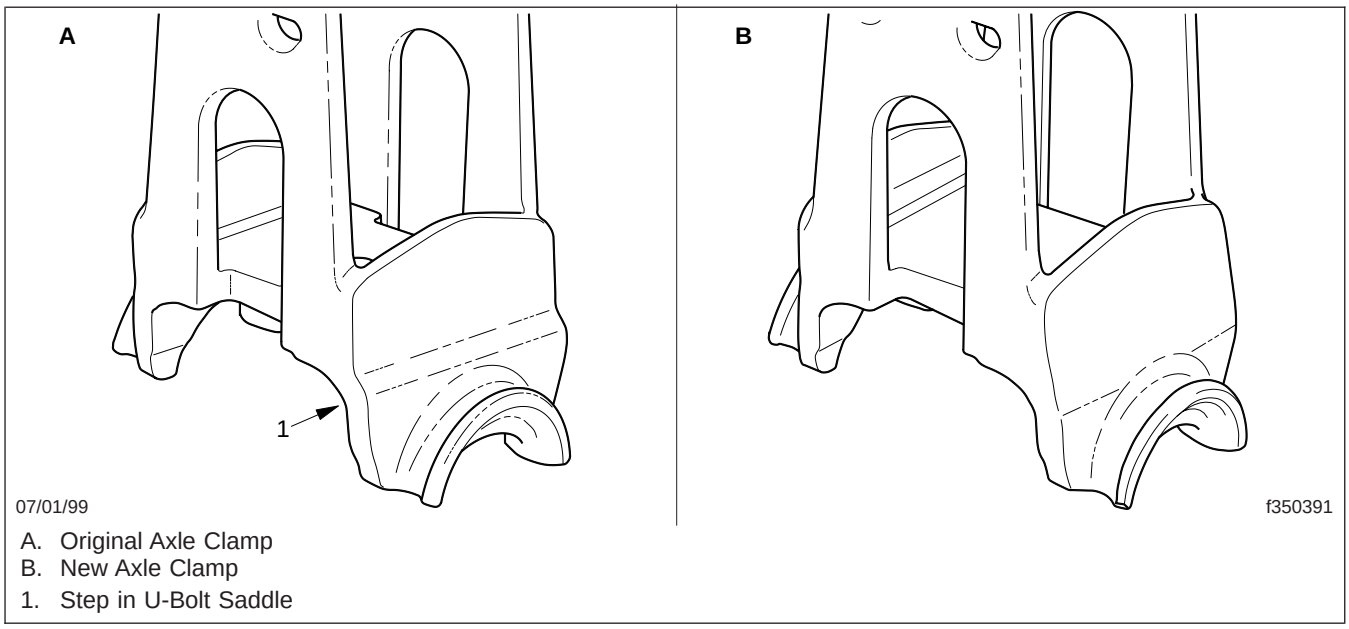
    19.3 Tighten the lower shock absorber mounting nuts to 241 lbf·ft (327 N·m).

20. Install the spring tip pads to the left suspension spring.

    20.1 Install the spring tip pads to the upper axle clamps.

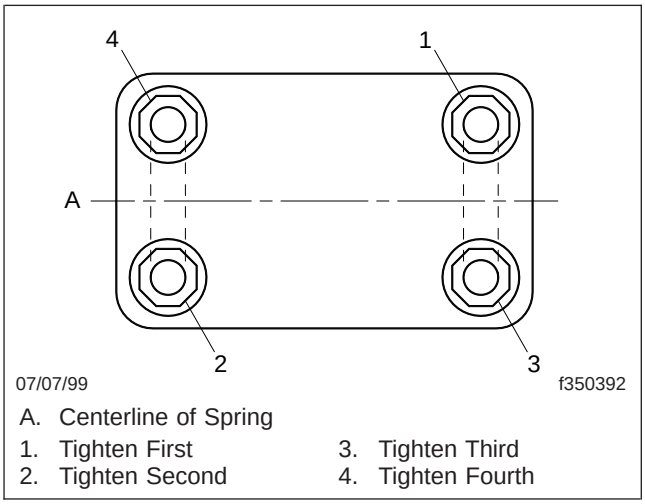
    20.2 Install the bolts to secure each upper spring tip pad and tighten 37 lbf·ft (50 N·m).

21. Repeat the above steps for the right suspension spring.
22. Remove the chocks from the tires.



A. Original Axle Clamp
B. New Axle Clamp
1. Step in U-Bolt Saddle

Fig. 3, Upper Axle Clamps



A. Centerline of Spring
1. Tighten First
2. Tighten Second
3. Tighten Third
4. Tighten Fourth

Fig. 4, U-Bolt Nut Tightening Sequence

Adjustments

Rear axle positioning and alignment on a vehicle equipped with the TufTrac suspension is determined by the length of the lower control rods and the V-rods. See **Fig. 1**. The length of the control rods and V-rods can be controlled by the addition or removal of shims at the mounting points of the control rods and/or V-rods. The addition of shim(s) between the control rod or V-rod and its mounting will effectively lengthen the rod moving the axle relative to the frame. Conversely, the removal of shim(s) will shorten the length of the rod, moving the axle in the opposite direction.

The lower control rods use a horse-shoe style of shim (**Fig. 2**) while the V-rods use hardened washers for shims.

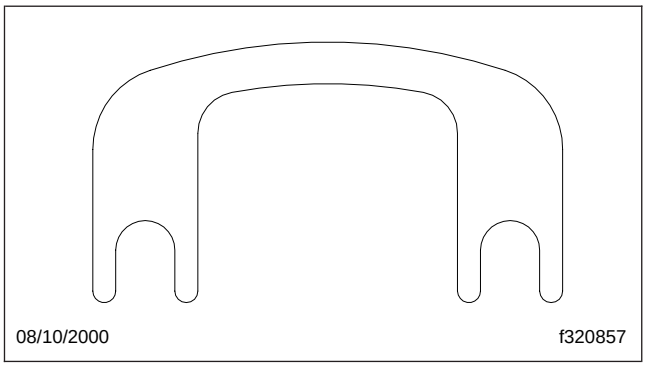
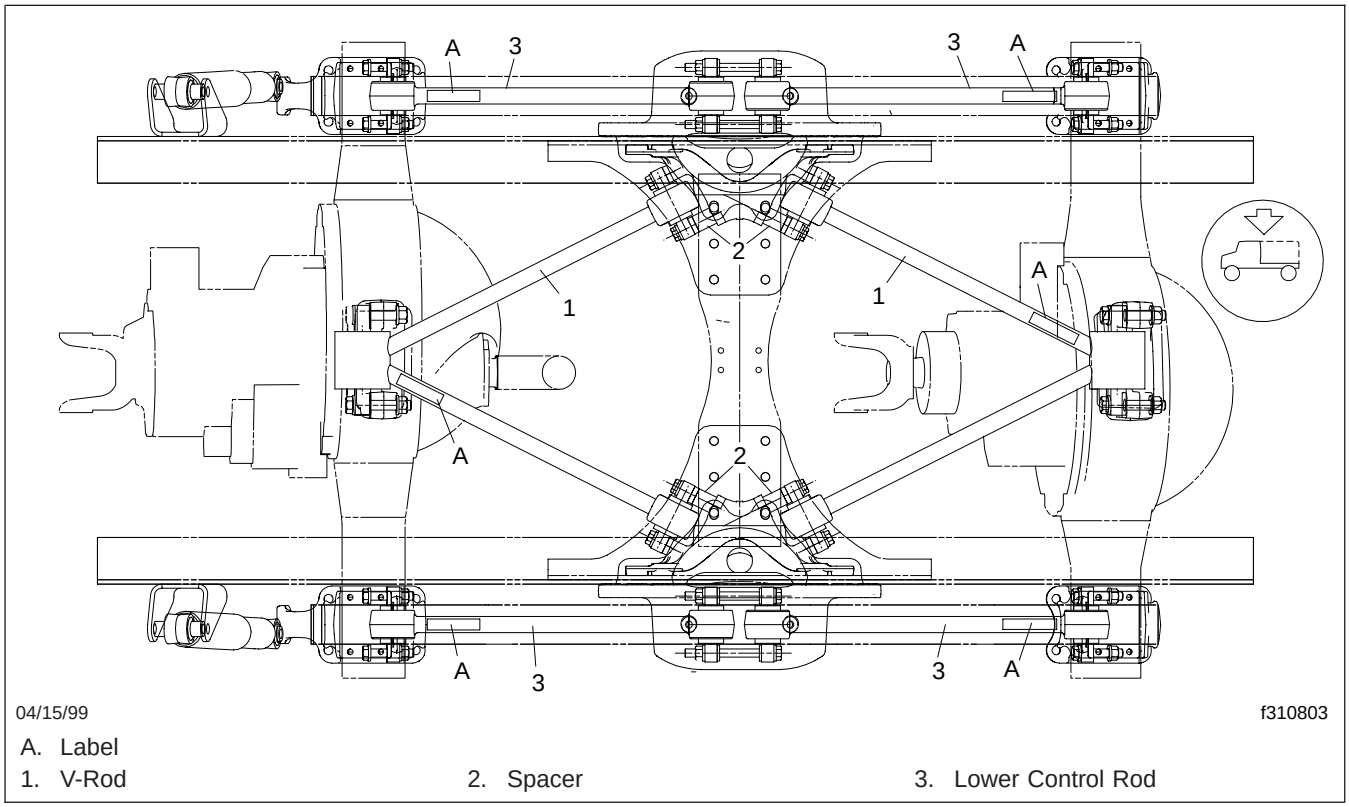


Fig. 2, Lower Control Rod Shim

Control rod shimming is performed at the center bracket. See **Fig. 3**. The purpose of this shim adjustment is to provide axle alignment and planing adjustment (angle of the axle from vertical in the side view).

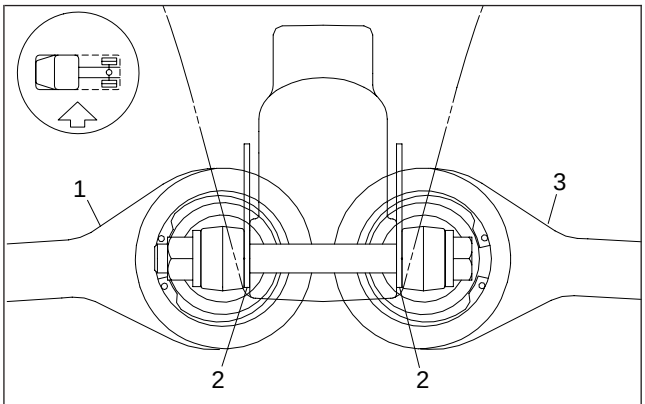


A. Label
1. V-Rod
2. Spacer
3. Lower Control Rod

Fig. 1, Control Rod and V-Rod Installation

Axle tracking (lateral axle positioning) is performed by inserting or removing hardened washers at the V-rod mounting at the frame end. See **Fig. 4**.

Rear Axle Alignment Adjustments



08/10/2000 f320856

1. Forward Lower Control Rod
2. Shims
3. Rear Lower Control Rod

Fig. 3, Lower Control Rod Shim Installation

Lower Control Rods

Alignment Adjustments

NOTE: Alignment refers to the squareness of the axles to each other and the frame rails viewed from the top of the vehicle.

Add or remove shims at the center bracket to achieve proper alignment. See **Fig. 3**. To minimize the effect on planing angles, if possible, add or remove shims from both sides of the vehicle.

When one 3mm thick shim is added and one removed (from the opposite side) the axle position is affected as follows:

- Angle of the axle in the plan view: 0.33 degrees
- Fore-aft movement of the wheel at the outside (assuming 97.6 in. (2480 mm) wheel to wheel distance): 0.283 in. (7.2 mm)

Planing Adjustments

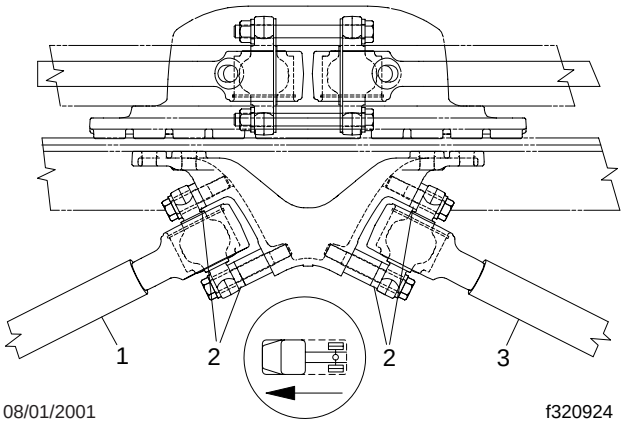
NOTE: planing refers to the angle of the axle from vertical in the side view.

Add or remove shims at the center bracket to change the planing angle. See **Fig. 3**. Unless alignment is required, an equal number of shims should be used left and right for a given axle; example, when adding one shim to the left forward rod add one shim to right forward rod. A shim 0.12 inch thick changes the planing angle 0.3 degrees.

V-Rods

Axle Tracking Adjustments

The tracking adjustment of the forward and rear axles is done by adding and/or removing hardened washers between the V-rod bar pin and the frame-mounted bracket. See **Fig. 4**.



08/01/2001 f320924

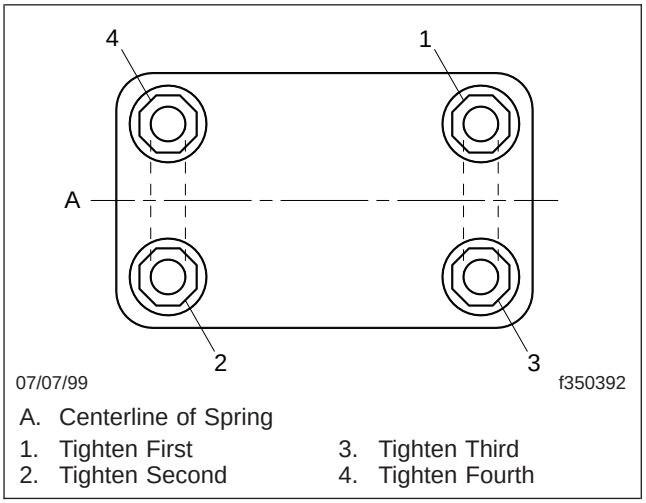
1. Forward Rear Axle V-Rod
2. Hardened Washers
3. Rear Rear Axle V-Rod

Fig. 4, V-Rod Hardened Washer Installation

Specifications

Torque Specifications	
Description	**Torque: lbf·ft (N·m)**
Shock Absorber Mounting Bolt	241 (327)
Center Bearing Upper Mounting Bolts	68 (92)
Center Bearing Lower Mounting Bolts	155 (210)
Tip Pad Bolts	37 (50)
Rebound Stop Mounting Bolt	68 (92)
Lower Control Rod Mounting Bolts	136 (184)
V-Rod Frame Bracket Mounting Bolts	136 (184)
V-Rod Axle Bracket Mounting Bolts	427 (579)
5/8—18 Axle Clamp U-bolt Nuts (tighten as shown in **Fig. 1**)	Stage 1: Hand-Tighten Stage 2: 60 (81) Stage 3: 200 (271)
3/4-Inch Spring Pack U-bolt Nuts	Stage 1: 60 (81) Stage 2: 200 (271) Stage 3: 300 (406)

Table 1, Torque Specifications



A. Centerline of Spring
1. Tighten First
2. Tighten Second
3. Tighten Third
4. Tighten Fourth

Fig. 1, Tightening Pattern for U-bolt Nuts

Preliminary Checks

Precision instruments and equipment are needed for accurately measuring and adjusting wheel alignment. Refer to the operating instructions provided by the wheel alignment equipment manufacturer.

Before checking or correcting wheel alignment, make sure the vehicle is at curb weight. Curb weight is the weight of the unloaded vehicle complete with accessories and full fuel tanks.

If a road test is necessary, the route should be one that allows full left and right turns and full stops. It should also include a length of straight, level road to check the steering wheel position during straight-ahead driving.

During the road test, note any steering effort and possible roughness. Check for looseness, too much wheel play, any tendency for the vehicle to lead in one direction, and for pull during stopping.

Note the position of the steering wheel while driving on a straight, level road. When the steering gear is centered, the steering wheel spokes should be within 10 degrees of the 4 and 8 o'clock positions. **See Fig. 1.**

NOTE: These steering wheel location specifications are for reference and apply only for the conditions of this road test. Variations outside of these specifications may occur later when the vehicle is placed in service.

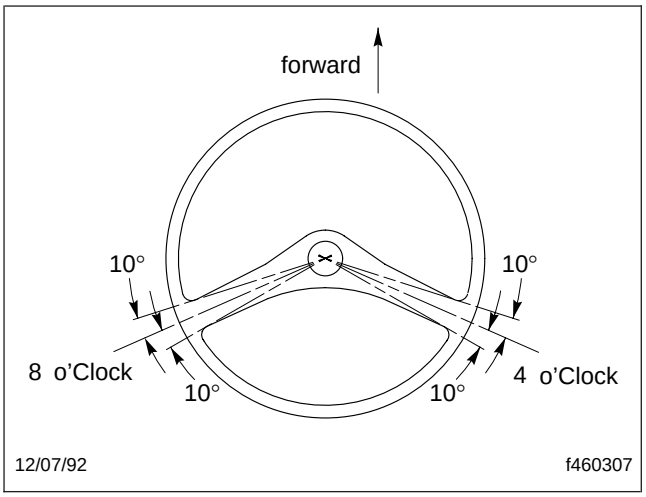


Fig. 1, Steering Wheel Position

If there are any problems, **refer to "Troubleshooting, 300."**

1. Steering axle wheel assemblies should be balanced, especially for vehicles that travel at sustained speeds of more than 80 km/h (50 mph). Off-balance wheel assemblies cause vibrations that result in severely shortened life for tires, and steering suspension parts.
2. Do not mix tires of different size, type, or weight. Tire wear should be even and not worn to limits exceeding government specifications. **Refer to the wheels and tires group** in this manual and the vehicle maintenance manual, for more information. Replace any tire that is excessively worn.
3. Check the inflation pressure of the tires. **Refer to the wheels and tires group** in this manual for recommended pressures. An underinflated tire causes tread wear completely around both tire shoulders. An overinflated tire causes tread wear in the center of the tire. **Refer to Fig. 2.**
4. Check for out-of-round wheels, rims, or wheel stud holes. Replace the wheel if any of these conditions exist.
5. On each side of the vehicle, check the height of the chassis above the ground. Sagging, fatigued, or broken suspension springs create a lopsided vehicle appearance. This causes an unbalanced weight distribution. Anything that changes the ratio of weight on the springs affects the alignment angles and also the tire tread contact area. Replace damaged springs as instructed **in the suspension group.**
6. Inspect the front axle beam (also called the axle center) for bends or twists. If the axle beam is bent or twisted over 1/2 degree, replace it before aligning the front axle wheels.
7. Check for damaged, worn, or bent steering gear or linkage parts. Make sure the steering gear is centered. Replace damaged components, and adjust the steering gear, using the instructions **in the steering group.**
8. Check the steering angle, and adjust the axle steering stops, as needed. **Refer to "Steering Angle Checking and Adjusting, 110."**

Preliminary Checks

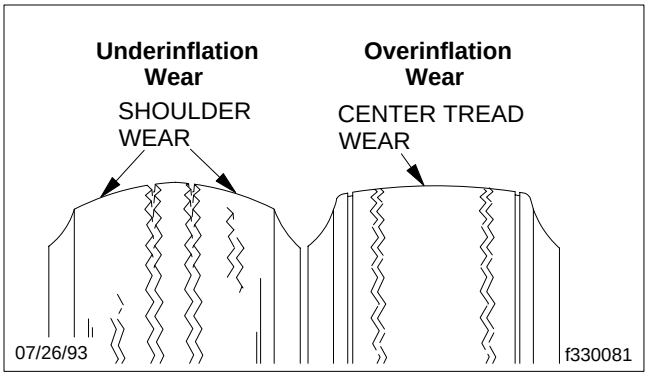


Fig. 2, Tire Damage Due to Underinflated or Overinflated Tires

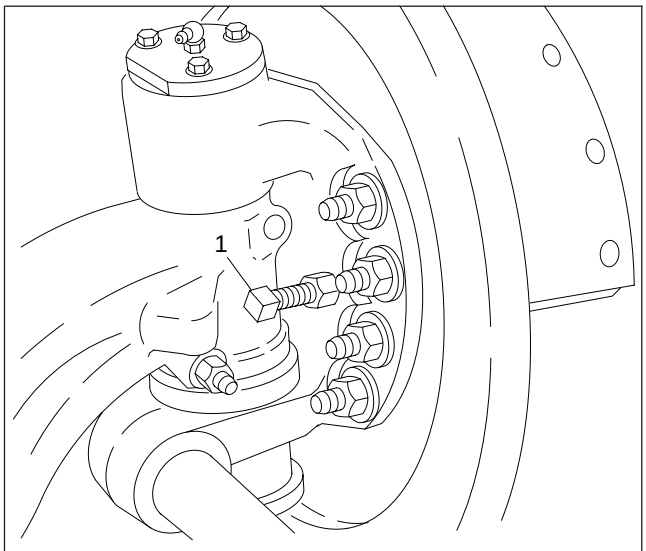
Checking and Adjusting

Steering (or turning) angle is the degree of front wheel movement from a straight-ahead position to either an extreme right or left position. Although front wheel movement can be limited by the amount of internal travel in the steering gear, it generally depends on how much clearance there is between chassis components and the tire and wheel assemblies. All axles have adjustable stopscrew-and locknut-type axle stops (**Fig. 1**), which are located on the rear side of each front axle spindle.

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

1. Make sure the steering gear is in the center of travel when the wheels are in a straight-ahead position. Center the gear, using the instructions in the steering gear section in the **steering group**. Bottoming of the steering gear must not occur when making an extreme right or left turn.
2. If using stationary turn-plates or turntables (**Fig. 2**), drive the vehicle on the plates; the tires must be exactly straight ahead. Apply the parking brakes.

   If using portable gauges, apply the parking brakes, chock the rear tires, and raise the front of the vehicle. Place a turn-plate or turntable under each tire. With the tires exactly straight ahead, lower the vehicle so that the tires rest on the center of the gauges.
3. Remove the lockpins from the gauges, and adjust the dials so that the pointers on both gauges read zero.
4. With the brakes fully applied, turn the steering wheel clockwise to the end of travel. Have someone check both sides of the vehicle for interference at the tires and wheels. There must be at least 0.50 inch (13 mm) clearance from any fixed object, and 0.75 inch (19 mm) from any moving object.



1. Stopscrew and Locknut

Fig. 1

   If necessary, loosen the stopscrew locknut; adjust the stopscrew to contact the axle when the maximum turning angle of the wheels is determined.

   Tighten the locknut to the value in the torque table in **Specifications, 400**.

   Repeat the step with the steering wheel turned counterclockwise. Adjust the axle stop, as needed.

NOTE: The turning angle may not be the same on both sides.

5. Adjust the steering gear so that pressure is released ahead of the axle stop. This will prevent possible damage to the steering or axle components. For poppet valve adjustment instructions, refer to the steering gear section in the **steering group**.
6. Drive the vehicle off the turn-plates or turntables, or remove them from under the tires and lower the vehicle.

Steering Angle Checking and Adjusting

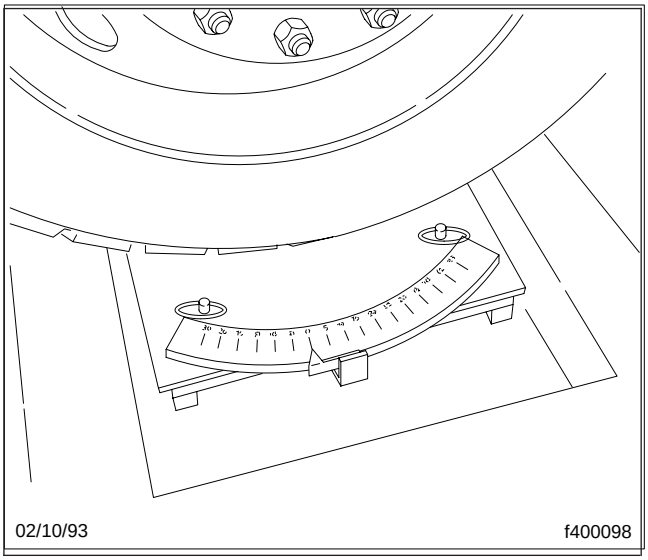
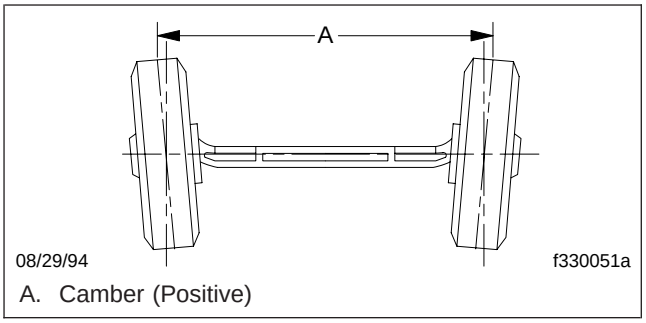


Fig. 2, Turn-Plate (Turntable), Stationary Type

Checking (See Fig. 1)

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

1. Apply the parking brakes and chock the rear tires.
2. Raise the front of the vehicle until the tires clear the ground. Place safety stands under the axle; make sure the stands will support the weight of the cab, frame, and front axle.
3. Before measuring camber, check the front wheel bearings for wear and incorrect adjustment. Try moving the wheel on the axle spindle (steering knuckle) either by grasping the front tire on the top and bottom, or by using a bar for leverage. If movement between the brake drum and the backing plate or other axle-mounted reference point is 0.05 inch (1 mm) or more, the bearings may be worn or incorrectly adjusted. Inspect the wheel bearings for damage using the instructions in the front axle group of the vehicle maintenance manual. If needed, replace or adjust the bearings using the instructions in **Section 33.01** of this manual.
4. Remove the safety stands, and lower the vehicle to the ground.
5. Using the alignment equipment manufacturer's instructions, measure the front wheel camber.



A. Camber (Positive)

Fig. 1, Camber Angle

6. Compare the camber angles with those shown in the applicable table in **Specifications, 400**. Differences between the measurements taken in this subject and the angles in the applicable table in **Specifications, 400** are caused by damaged (bent) axle components.

   Incorrect camber angles could be caused by damage in one or more of the following front axle components: the knuckle pin, the knuckle pin bushings, the axle spindle, or the axle beam. Replace twisted or otherwise damaged components. Don't try to straighten twisted or bent components; replace them with new components. If a bent or twisted front axle knuckle pin, axle spindle, or axle beam has been straightened, the axle warranty will be voided.

WARNING

WARNING: Trying to straighten a twisted or bent front axle component can crack or weaken it. A cracked or weakened axle component could result in a collapsed front axle or the loss of a wheel, which could cause serious personal injury.

7. Remove the chocks from the tires.

Checking and Adjusting

(See Fig. 1)

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

Using the alignment equipment manufacturer's operating instructions, measure the front wheel caster.

Compare the caster angles with those shown in the applicable table in **Specifications, 400**. If needed, adjust the caster angle by placing wedge-shaped shims between the axle spacer and the axle beam, as follows (**see Fig. 2**):

IMPORTANT: Extreme angle shims cannot be used to correct caster angles that vary by more than 2 degrees from the values in the table in **Specifications, 400**. Weak or broken leaf springs, or worn shackle bushings, can cause extreme deviations to caster angles. Replace damaged parts before doing caster adjustments.

1. Apply the parking brakes and chock the front and rear tires.
2. Back off the U-bolt high nuts from the U-bolts on one side of the front axle. **See Fig. 2.**
3. Raise the spring away from the axle enough to allow removal of the front caster shim.
4. Remove the shim, and install one that will provide the correct caster angle, as specified in the table in **Specifications, 400**. Install the dowel pin and check penetration.

IMPORTANT: Place front caster shims between the axle beam and the axle spacer. **See Fig. 2.**

5. Lower the vehicle onto the axle.
6. Coat the threaded ends of the U-bolts with chassis lube or an antiseize compound, such as Loctite® 242. Tighten the U-bolt nuts to the value in the torque table in **Specifications, 400**.

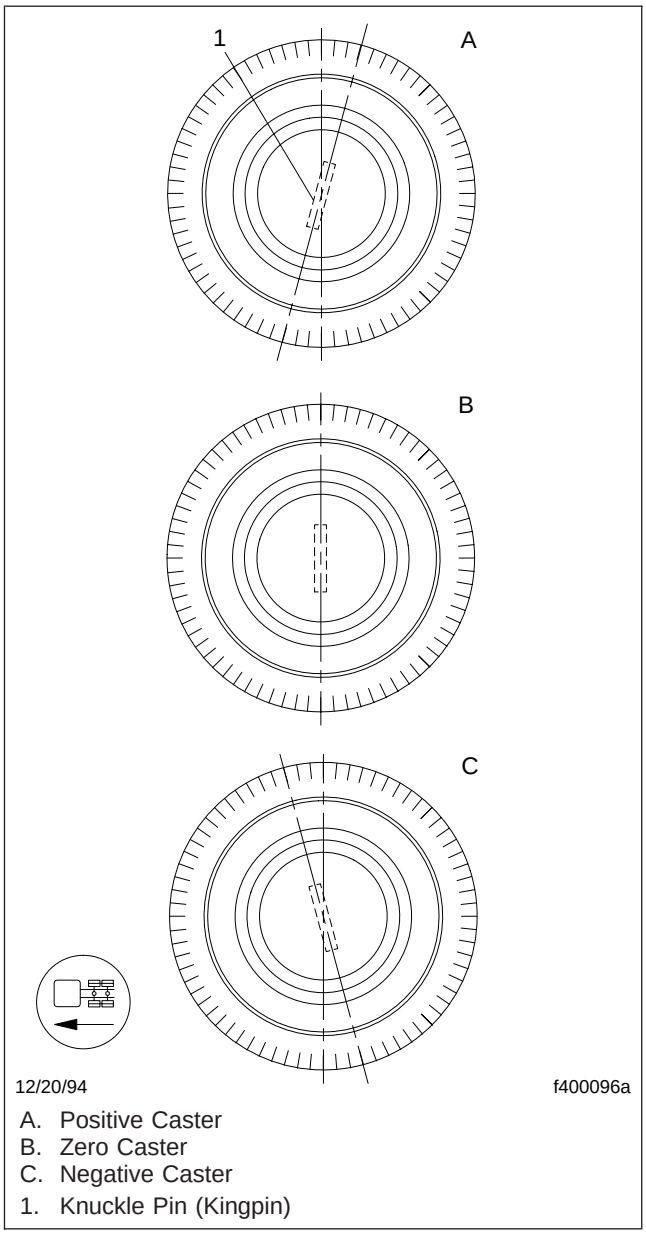
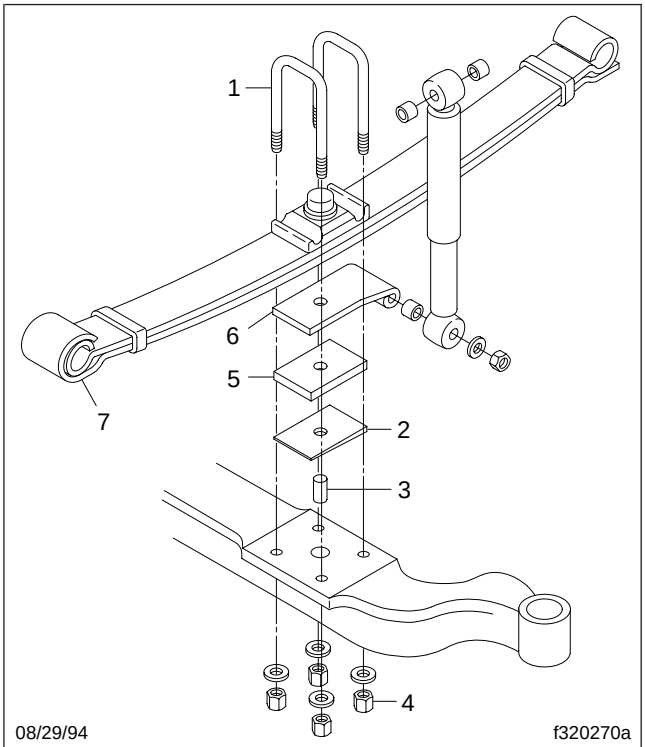


Fig. 1, Caster Angle

U-bolt high nuts need periodic retightening. Refer to the suspension group in the vehicle maintenance manual for recommended intervals.

Caster Angle Checking and Adjusting



1. Axle Spring U-Bolt
2. Front Caster Shim
3. Dowel Pin
4. U-Bolt High Nut
5. Spacer
6. Shock Absorber Lower Mounting Bracket
7. Leaf Spring Assembly

Fig. 2

⚠ CAUTION

CAUTION: Failure to periodically retighten the U-bolt high nuts could result in spring breakage and abnormal tire wear.

7. Using the steps above, replace the shim on the other side of the axle.
8. Remove the chocks from the tires. Do a final caster angle check.

Checking and Adjusting

(See Fig. 1)

NOTE: If using electronic alignment equipment, measure the wheel toe-in following the manufacturer's operating instructions. Compare the measurement with that shown in the table in **Specifications, 400**. If corrections are needed, go to the step in this subject which describes loosening the tie rod clamp nuts, and proceed.

If electronic alignment equipment is not available, do all the steps.

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

1. Apply the parking brakes and chock the rear tires.
2. Raise the front of the vehicle until the tires clear the ground. Place safety stands under the axle. Make sure the stands will support the weight of the cab, axle, and frame.
3. Using spray paint or a piece of chalk, mark the entire center rib of each front tire.
4. Place a scribe or pointed instrument against the marked center rib of each tire, and turn the tires. The scribes must be held firmly in place so that a single straight line is scribed all the way around each tire.
5. Place a turn-plate or turntable under each tire. Remove the safety stands from under the axle, then lower the vehicle. Remove the lockpins from the gauges; make sure the tires are exactly straight ahead.
6. Place the trammel bar at the rear of the front tires; locate the trammel pointers at spindle height, and adjust the pointers to line up with the scribe lines. Lock in place. Make sure that the scale is set on zero.

NOTE: If turn-plates or turntables are not available, lower the vehicle. Remove the chocks from the rear tires and release the parking brakes. Move the vehicle backward and then forward about two meters (six feet).

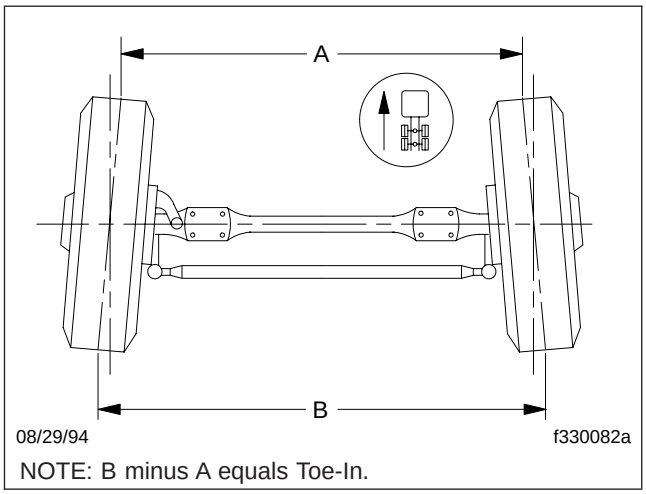


Fig. 1, Wheel Toe-In (Overhead View)

7. Place the trammel bar at the front of the tires as shown in **Fig. 2**. Adjust the scale end so that the pointers line up with the scribe lines. **See Fig. 3.**
8. Read the toe-in from the scale. Compare the toe-in with the value in the table in **Specifications, 400**. Make corrections if necessary.
9. Loosen the tie rod (cross tube) clamp nuts, and turn the tie rod as needed.

   If the vehicle is not on turn-plates or turntables, move the vehicle backward and then forward about two meters (six feet). This is important when setting the toe-in on vehicles equipped with radial tires.

   Do a final wheel toe-in check to make sure that it is correct.

   Tighten the clamp nuts to the values in the table in **Specifications, 400**.
10. If not already done, remove the chocks from the rear tires. Road test the vehicle.

Wheel Toe-In Checking and Adjusting

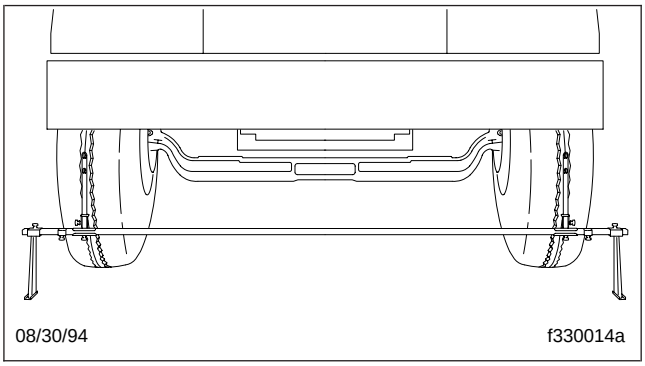


Fig. 2, Trammel Bar Positioning

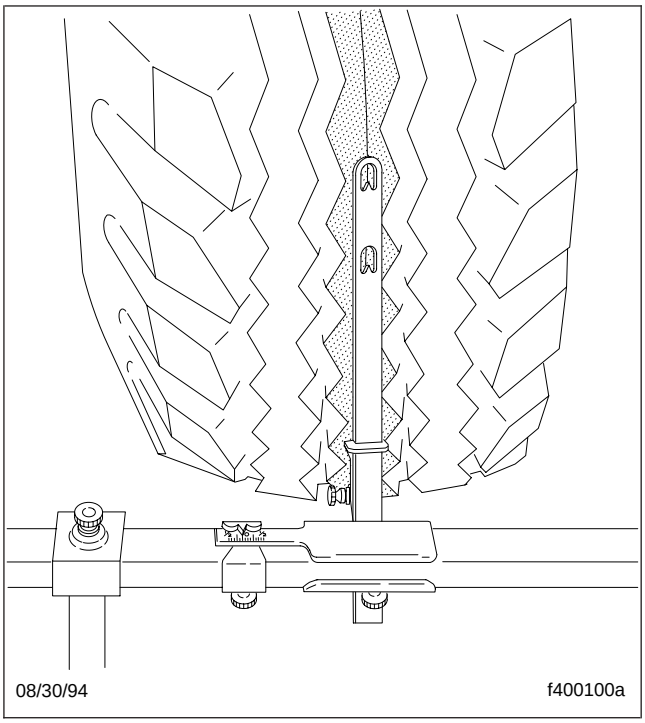


Fig. 3, Calculating Wheel Toe-In

General Information

Correct front axle wheel alignment is needed to ensure long tire life, ease of handling, and steering stability.

Three factors are involved in wheel alignment: camber angle, caster angle, and wheel toe-in.

Camber angle **(Fig. 1)** is the vertical tilt of the wheel as viewed from the front of the vehicle. Camber angle is measured in degrees, and is not adjustable. Positive camber is the outward tilt of the wheel at the top. Excessive positive camber in one wheel causes the vehicle to pull in the opposite direction, rapidly wearing the outboard side of the tire tread. Negative camber is the inward tilt of the wheel at the top. Excessive negative camber in one wheel causes the vehicle to pull in the same direction that the negative-camber wheel is on, wearing the inboard side of the tire tread. If camber angles are not correct, the tires will wear smooth around the edge on one side. **See Fig. 2.**

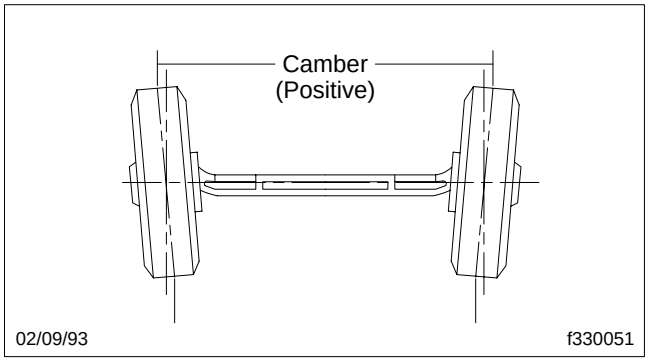


Fig. 1, Camber Angle

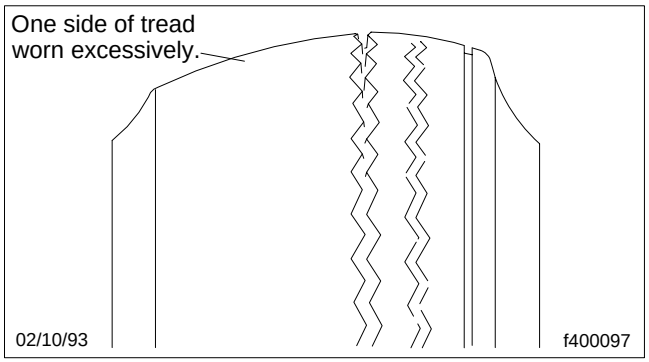


Fig. 2, Tire Damage Due to Excessive Camber

Caster angle **(Fig. 3)** is the tilt of the knuckle pin (or kingpin) as viewed from the side. Caster angle is measured in degrees and it is adjustable. A positive caster angle is the tilt of the top of the knuckle pin toward the rear of the vehicle. A negative caster angle is the tilt of the top of the knuckle pin toward the front of the vehicle. Caster angles are based on the design load of the vehicle. An incorrect caster angle does not cause tire wear. However, a positive caster angle that exceeds specifications could cause vehicle shimmy, road shock, and an increased steering effort. A negative caster angle that does not meet specifications could cause unstable steering. The vehicle may wander and weave, and extra steering effort may be necessary. After leaving a turn, the tendency to return to and maintain a straight-ahead position is reduced. Too much or too little caster in one wheel can cause erratic steering when the service brakes are applied to stop the vehicle.

Wheel toe-in **(Fig. 4)** is the distance in inches that the front of the wheels are closer together than the rear of the wheels, as viewed from the top. Wheel toe-in is adjustable. If it is not adjusted correctly, the vehicle could pull to one side while driving. Wheel shimmy and cupped tire treads (indentations on the road contact surface of the treads) could occur. Also, rapid or severe tire wear on the steering axle could occur, usually in a feather-edged pattern. **See Fig. 5.**

Advanced wear patterns can be seen, but less severe wear patterns are detected only by rubbing the palm of your hand flat across the tire tread.

Feather-edging more often affects the front tire on the passenger's side of the vehicle, and is usually more apparent on the outside grooves of the tire.

If any of the conditions listed above occur, the vehicle could need a front end wheel alignment, and possibly, drive axle alignment. However, in some cases these conditions are not wheel alignment related: **refer to "Troubleshooting, 300"** for other possible causes.

If excessive tire tread wear has resulted from incorrect wheel alignment, replace the damaged tires. For minimum tread wear specifications, refer to the wheels and tires group of the vehicle maintenance manual.

General Information

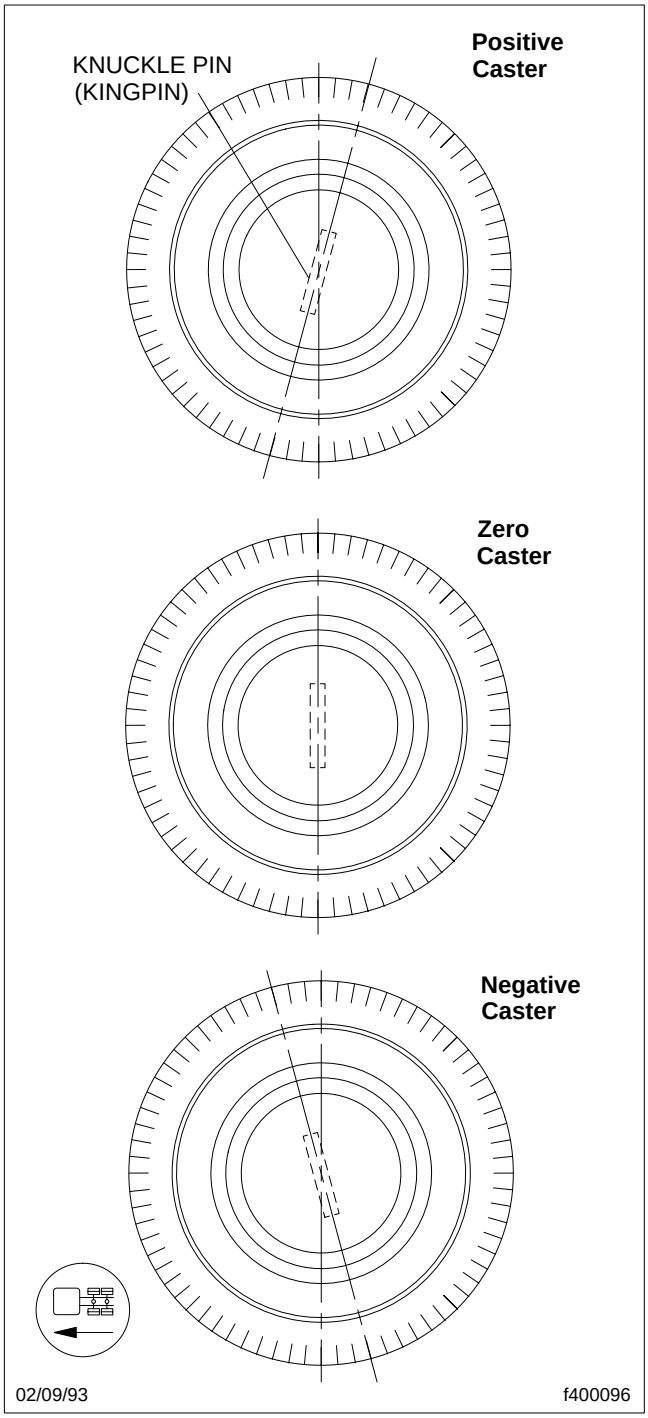


Fig. 3, Caster Angle

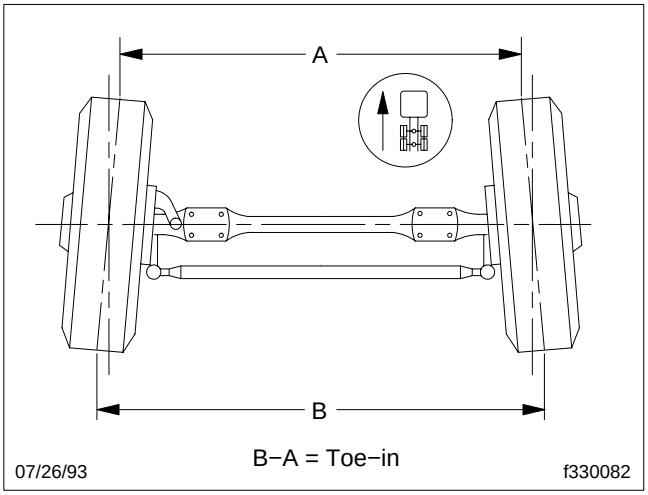


Fig. 4, Wheel Toe-In (Overhead View)

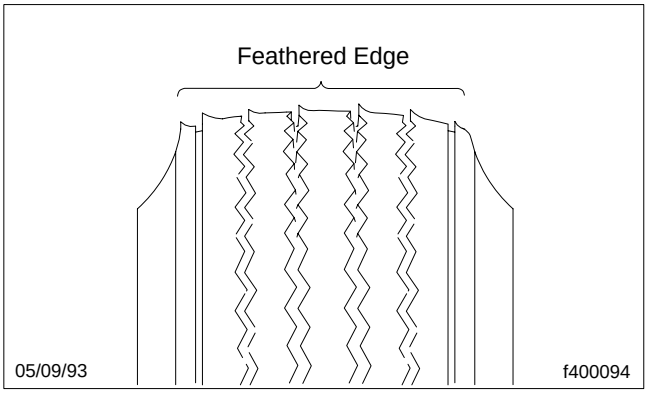


Fig. 5, Tire Damage Due to Excessive Toe-In or Incorrect Drive Axle Alignment

Troubleshooting

Service instructions for most of the remedies below are found by referring to the index in the back of this manual. For axles, refer to the service literature provided by either Rockwell or Eaton Corporation. For tire inflation pressures, refer to the wheels and tires section in this manual. For more steering system troubleshooting information, refer to the steering section in this manual.

Problem - Hard Steering

Problem - Hard Steering	
Possible Cause	**Remedy**
Tire pressure is low in one or both front tires.	Inflate tires to the correct pressure.
Binding in the steering gear due to a lack of lubrication.	Lubricate the steering gear. For instructions, refer to the vehicle maintenance manual.
Too much caster angle in the front wheels.	Check the caster angle and adjust as needed
The front suspension is sagging due to a damaged spring.	Repair or replace the spring as needed. For instructions, refer to the suspension section in this manual.
The axle spindle is bent.	Replace the spindle.
The frame is misaligned.	Check the frame alignment; correct, as needed.
Low pressure in the power steering system.	Repair the power steering system.
Steering gear is not assembled correctly.	Assemble the steering gear correctly.
King pins are binding.	Replace the king pins.
Steering arm geometry is incorrect.	Service the steering system as necessary.
Tie rod ends are hard to move.	Replace the tie rod ends.
Thrust bearing is worn.	Replace the thrust bearing.

Problem - Erratic Steering When the Brakes are Applied

Problem - Erratic Steering When the Brakes are Applied	
Possible Cause	**Remedy**
Tire pressure is low in one or both front tires.	Inflate the tires to the correct pressure.
One or more front axle spring U-bolt nuts are loose.	Check the U-bolt nuts for looseness. If loose, check the U-bolt for damage. Replace damaged parts; tighten loose nuts.
The brakes are not adjusted evenly.	Adjust the brakes on all axles. Also, check the operation of the slack adjusters.
Grease or oil contamination of the brake linings is reducing brake effectiveness.	Replace the brake linings and clean the drums. Find and correct the cause of grease or oil contamination.
The caster angle is wrong.	Check, and adjust as needed.
An axle spindle is bent.	Replace the axle spindle.
The front axle wheel bearings are worn or were incorrectly adjusted.	Check the bearings for wear or damage; replace as needed.

Troubleshooting

Problem - Vehicle Pulls to One Side During Operation

Problem - Vehicle Pulls to One Side During Operation	
Possible Cause	**Remedy**
Tire pressure is low in one or both front tires.	Inflate the tires to the correct pressure.
One or more of the alignment measurements are incorrect.	Check all the alignment measurements. Correct as needed.
The wheels or tires are out-of-round.	Inspect the wheels and tires. Replace out-of-round parts.
The front axle wheel bearings are too tightly adjusted.	Check the bearings for wear or other damage. Replace the bearings if needed.
The front suspension is sagging due to a damaged spring.	Repair or replace the spring as needed. For instructions, refer to the suspension section in this manual.
The axle spindle is bent.	Replace the spindle.
The frame is misaligned.	Check the frame alignment; correct as needed.
The rear axle(s) is out of alignment.	Check, and if needed, adjust the rear axle alignment.

Problem - Front Wheel Wander

Problem - Front Wheel Wander	
Possible Cause	**Remedy**
One or more wheels or brake drums are out-of-balance.	Balance the wheels. Check for out-of-round brake drums; correct as needed.
One of the front springs is weak or broken.	Repair or replace the spring as needed. For instructions, refer to the suspension section in this manual.

Problem - Front Wheel Shimmy

Problem - Front Wheel Shimmy	
Possible Cause	**Remedy**
Tire pressure is low in one or both front tires.	Inflate the tires to the correct pressure.
One or more wheels or brake drums are out-of-balance.	Balance the wheels. Check for out-of-round brake drums, correct or replace as needed.
One or more tires are out-of-round or bulged.	Replace the tire.
The front axle wheel bearings are worn or were incorrectly adjusted.	Check the bearings for wear or other damage. Replace the bearings if needed.
Parts of the steering gear or linkage are worn.	Test for play in the steering gear and linkage with the front tires off the ground. Replace parts as needed.
The axle spindle is bent.	Replace the spindle.
One or more of the alignment measurements are incorrect.	Check all alignment measurements and correct as needed.
The knuckle pin is loose due to worn bushings.	Inspect the knuckle pin and bushings for damage. Replace worn or damaged parts as needed.

Problem - Front Wheel Shimmy	
Possible Cause	**Remedy**
Shock absorbers are worn or damaged.	Check the shock absorbers and replace if needed.
Caster is out of adjustment.	Adjust the caster.

Problem - Vehicle Wanders

Problem - Vehicle Wanders	
Possible Cause	**Remedy**
Tire pressure is low in one or both front tires.	Inflate the tires to the correct pressure.
One or more of the alignment measurements are incorrect.	Check all of the alignment measurements; correct as needed.
The rear axle(s) is out of alignment.	Check the rear axle alignment and adjust as needed.
Parts of the steering gear or linkage are worn.	Test for play in the steering gear and linkage with the front tires off the ground. Replace parts as needed.
A knuckle pin is loose due to worn bushings.	Inspect the knuckle pin and bushings for damage. Replace worn or damaged parts.
The axle spindle is bent.	Replace the spindle.

Problem - Cupped Tires

Problem - Cupped Tires	
Possible Cause	**Remedy**
Tire pressure is too low or too high in one or both front tires.	Inflate or deflate the tires to the correct pressure.
One or more wheels or brake drums are out-of-balance.	Balance the wheels. Check for eccentric brake drums; correct or replace as needed.
The wheel toe-in is not correct.	Adjust the wheel toe-in.
The brakes are not adjusted evenly.	Adjust the brakes on all axles. Also, check the operation of the slack adjusters.
The front axle wheel bearings are worn or were not adjusted correctly.	Check the bearings for wear or other damage; replace them if needed.
The camber angle is not within specifications.	Check the front wheel camber angle. If not correct, find and replace the damaged axle component.

Problem - Steering Wheel Spokes Do Not Point at the 4 and 8 O'clock Positions

Problem - Steering Wheel Spokes Do Not Point at the 4 and 8 O'clock Positions	
Possible Cause	**Remedy**
The steering gear is not centered.	Center the steering gear.
If adjustable, the drag link is out of adjustment.	Adjust the drag link.

Troubleshooting

Problem - Steering Wheel Spokes Do Not Point at the 4 and 8 O'clock Positions	
Possible Cause	**Remedy**
The steering wheel was not installed (positioned) correctly on the steering column.	Reposition the steering wheel on the steering column.
The pitman arm is not correctly aligned with the timing mark on the steering gear output shaft.	Reposition the pitman arm on the steering gear output shaft. For instructions, refer to the steering section in this manual.

Problem - Tires Wear Out Quickly or Have Uneven Tire Tread Wear

Problem - Tires Wear Out Quickly or Have Uneven Tire Tread Wear	
Possible Cause	**Remedy**
Tires have incorrect air pressure.	Inflate or deflate the tires to the correct pressure.
Tires are out of balance.	Balance or replace the tires.
Tandem axle alignment is incorrect.	Align the tandem axles.
Toe-in setting is incorrect.	Adjust toe-in to the specified setting.
Steering arm geometry is incorrect.	Service the steering arm as necessary.

Problem - Ends of the Cross Tube are Worn

Problem - Ends of the Cross Tube are Worn	
Possible Cause	**Remedy**
Ends of the cross tube need lubrication.	Lubricate the ends of the cross tube. Make sure lubrication schedule is followed.
Vehicle is operated in severe conditions.	Operate the vehicle correctly.
Boot on end of cross tube is damaged.	Replace the boot.
Add-on type of power steering cylinders are not installed correctly.	Install the power steering cylinders correctly.

Problem - Bent or Broken Cross Tube, Ball Stud, Steering Arm or Cross Tube Arm

Problem - Bent or Broken Cross Tube, Ball Stud, Steering Arm or Cross Tube Arm	
Possible Cause	**Remedy**
Too much pressure in the power steering system.	Adjust the power steering system to the specified pressure.
Cut-off pressure in the power steering system is out of adjustment.	Adjust the power steering system to the specified pressure.
Vehicle is not operated correctly.	Make sure vehicle is operated correctly.
Add-on type power steering system is not installed correctly.	Install the add-on power steering system correctly.

Problem - Worn or Broken Steering Ball Stud

Problem - Worn or Broken Steering Ball Stud	
Possible Cause	**Remedy**
Drag link fasteners are tightened past specified torque.	Tighten the drag link fasteners to the specified torque.
Lack of lubrication, or lubricant is incorrect.	Lubricate the linkage with specified lubricant.
Power steering stops are out of adjustment.	Adjust the stops to specified dimension.

Problem - Worn King Pins and Knuckle Bushings

Problem - Worn King Pins and Knuckle Bushings	
Possible Cause	**Remedy**
Seals and gaskets are worn or missing.	Replace the seals and gaskets.
Lubricant is incorrect.	Lubricate the axle with specified lubricant.
Axle is not lubricated at scheduled frequency.	Lubricate the axle at scheduled frequency.
Lubrication procedures are incorrect.	Use the correct lubrication procedures.
Lubrication schedule does not match the operating conditions.	Change the lubrication schedule to match the operating conditions.

Specifications

IMPORTANT: When aligning the front axle, it is essential that the rear axle(s) be checked for correct alignment at the same time. Alignment of the rear axle(s) has a direct impact on how the vehicle tracks. See **Section 35.01**, Specifications.

Camber and Toe-In					
Axle Manufacturer	**Axle Model**	**Left Camber (deg)**	**Right Camber (deg)**	**Toe-In Limits in (mm)**	**Toe-In Target in (mm)**
Meritor	FF–943 FF–961 FG–941 FL–941	Axles built before September 1992: * +1/2 ± 7/16 Axles built from September 1, 1992: * 0 ± 7/16	0 ± 7/16	0 to +1/8 † (0 to +3.2)	+1/16 (+1.6)
Freightliner	FK–120	+1/2 ± 1/4	+1/2 ± 1/4	0 to +1/8 (0 to +3.2)	+1/16 (+1.6)
Dana Spicer	EFA–12F4	+7/16 ± 7/16	+7/16 ± 7/16	0 to +1/8 (0 to +3.2)	+1/16 (+1.6)

* A manufacturer's code tag is riveted to the front of the axle beam for identification. Tags with no date code, or with a date code followed by the letter "P" (for example "24592P"), were manufactured before September 1, 1992.
† If adjustment is required, set the toe-in as close as possible to +1/16 inch.

Table 1, Camber and Toe-In

Caster					
Axle Model	**Beissbarth (deg)**	**Bee Line**		**Hunter (deg)**	**Target, All Models (deg)**
		Except LC 4000 (deg)	**LC 4000 (deg)**		
Meritor, Freightliner, and Dana Spicer	+3 to +6-1/2	+3 to +6-1/2	+2-1/4 to +4-3/4	+1-1/2 to +5	Left +3-1/2; Right +4
IMPORTANT: Caster settings for the left and right sides *must* be within 1/2 degree of each other. It is necessary for only one side to be within the specifications given in this table.					

Table 2, Caster

Tie Rod Clamp Nut Torque Values				
Axle Manufacturer	**Axle Model**	**Tie Rod Clamp Nut Size**	**Plain Nut Torque * lbf·ft (N·m)**	**Locknut Torque * lbf·ft (N·m)**
Meritor	FF–943, FF–961, FG–941, FL–941	5/8–11	40–60 (54–81)	40–60 (54–81)
Meritor	FF–943, FF–961, FG–941, FL–941	5/8–18	40–60 (54–81)	40–55 (54–75)
Freightliner	FK–120	7/16–14	—	46–50 (62–68)
Dana Spicer	EFA–12F4	1/2–13	—	45–60 (61–81)

* All torque values in this table apply to parts lightly coated with rust-preventive type oil.

Table 3, Tie Rod Clamp Nut Torque Values

Specifications

Miscellaneous Torque Values	
Description	**Torque lbf·ft (N·m)**
U-Bolt Nuts 7/8–14	400 (542)
Meritor Stopscrew Locknut	50–65 (68–88)
Freightliner Stopscrew Locknut	80–85 (108–115)
Dana Spicer Stopscrew Locknut	90–120 (122–163)

Table 4, Miscellaneous Torque Values

General Information

The front axle full-floating wheel hub assembly is made up of four major components: tapered wheel bearings, the wheel hub, wheel studs, and the brake drum or rotor. **See Fig. 1.**

TAPERED WHEEL BEARINGS

A typical tapered wheel bearing assembly consists of a cone, tapered rollers, a roller cage, and a separate cup that is press-fit in the hub. **See Fig. 2.** All components carry the load, with the exception of the cage, which spaces the rollers around the cone.

Each hub has a set of inner and outer tapered wheel bearing assemblies. The bearing setting is locked in place on the axle spindle (steering knuckle) by an adjusting nut and jam nut. **See Fig. 3.**

WHEEL HUB

The wheel and the brake drum or rotor are mounted on a steel or iron wheel hub **(Fig. 4).**

Both the inner and outer wheel bearing cups and the wheel studs are press-fit in the hub.

Spoke wheels combine the wheel and hub into a single unit.

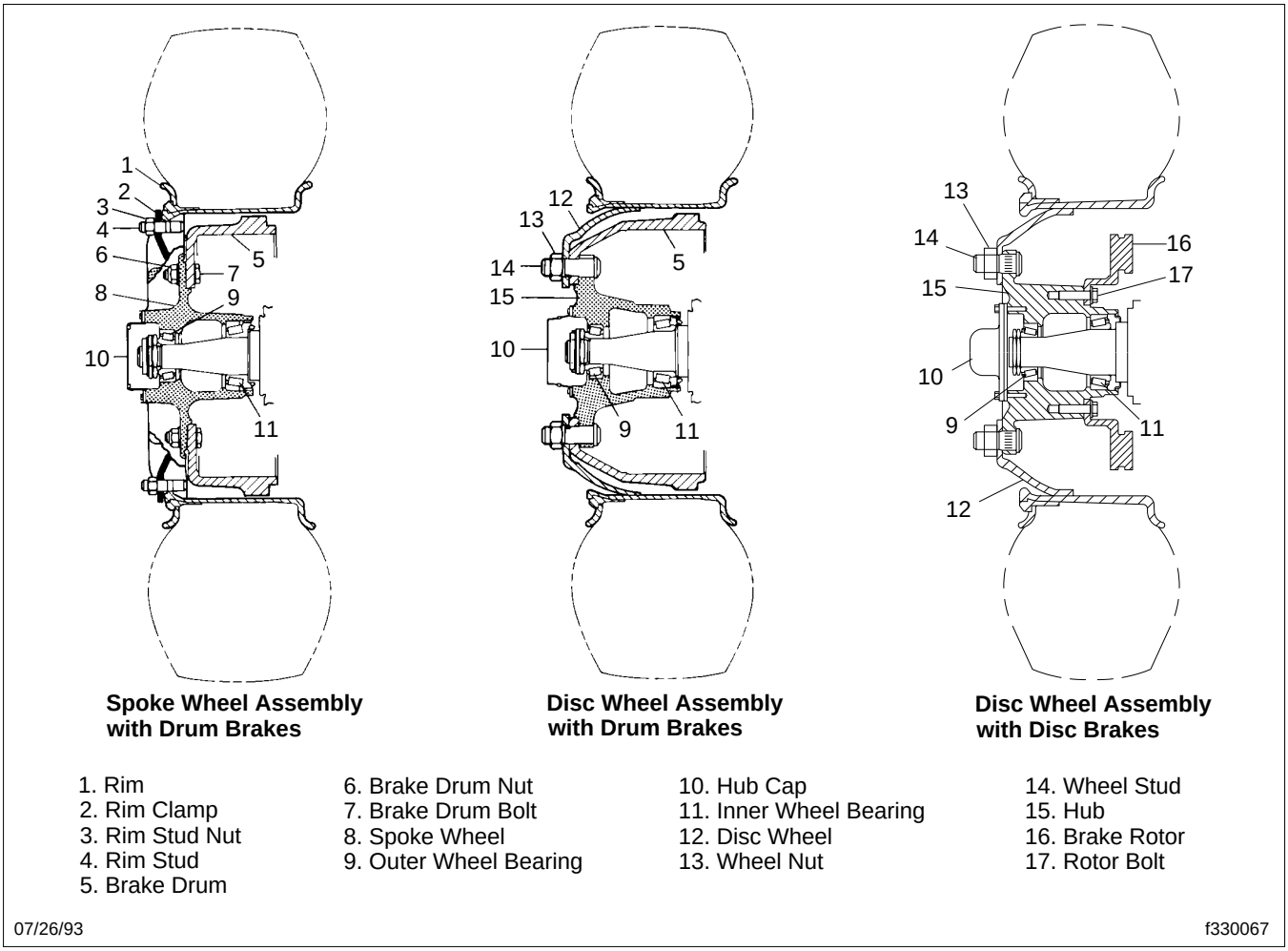
WHEEL STUDS

A headed wheel stud **(Fig. 5)** is used on front axle disc wheel hub assemblies and has serrations on the stud body to prevent the stud from turning in the wheel hub.

The end of the stud that faces away from the vehicle is stamped with an "L" or "R," depending on which side of the vehicle the stud is installed. Studs stamped with an "L" are left-hand threaded and are installed on the driver's side of the vehicle. Studs stamped with an "R" are right-hand threaded and are installed on the passenger's side of the vehicle.

Spoke wheels have rim studs. Rim studs are threaded on both ends, with a nonthreaded section midway along the shaft of the stud. The studs are coated with an anaerobic locking compound.

General Information



Spoke Wheel Assembly with Drum Brakes

Disc Wheel Assembly with Drum Brakes

Disc Wheel Assembly with Disc Brakes

1. Rim
2. Rim Clamp
3. Rim Stud Nut
4. Rim Stud
5. Brake Drum
6. Brake Drum Nut
7. Brake Drum Bolt
8. Spoke Wheel
9. Outer Wheel Bearing
10. Hub Cap
11. Inner Wheel Bearing
12. Disc Wheel
13. Wheel Nut
14. Wheel Stud
15. Hub
16. Brake Rotor
17. Rotor Bolt

07/26/93 f330067

Fig. 1

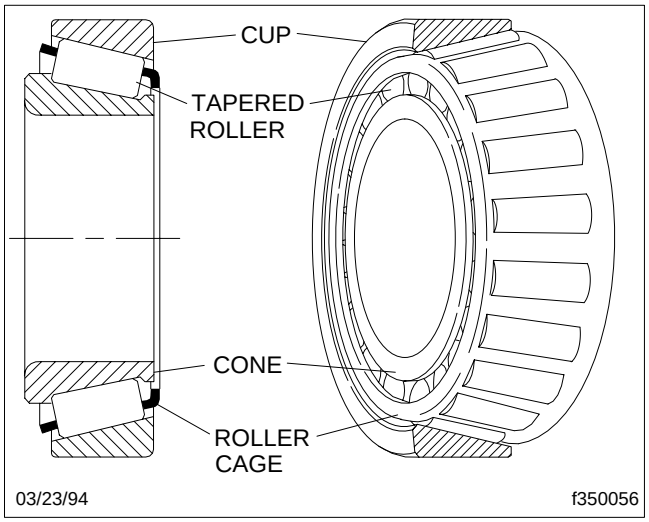


Fig. 2

General Information

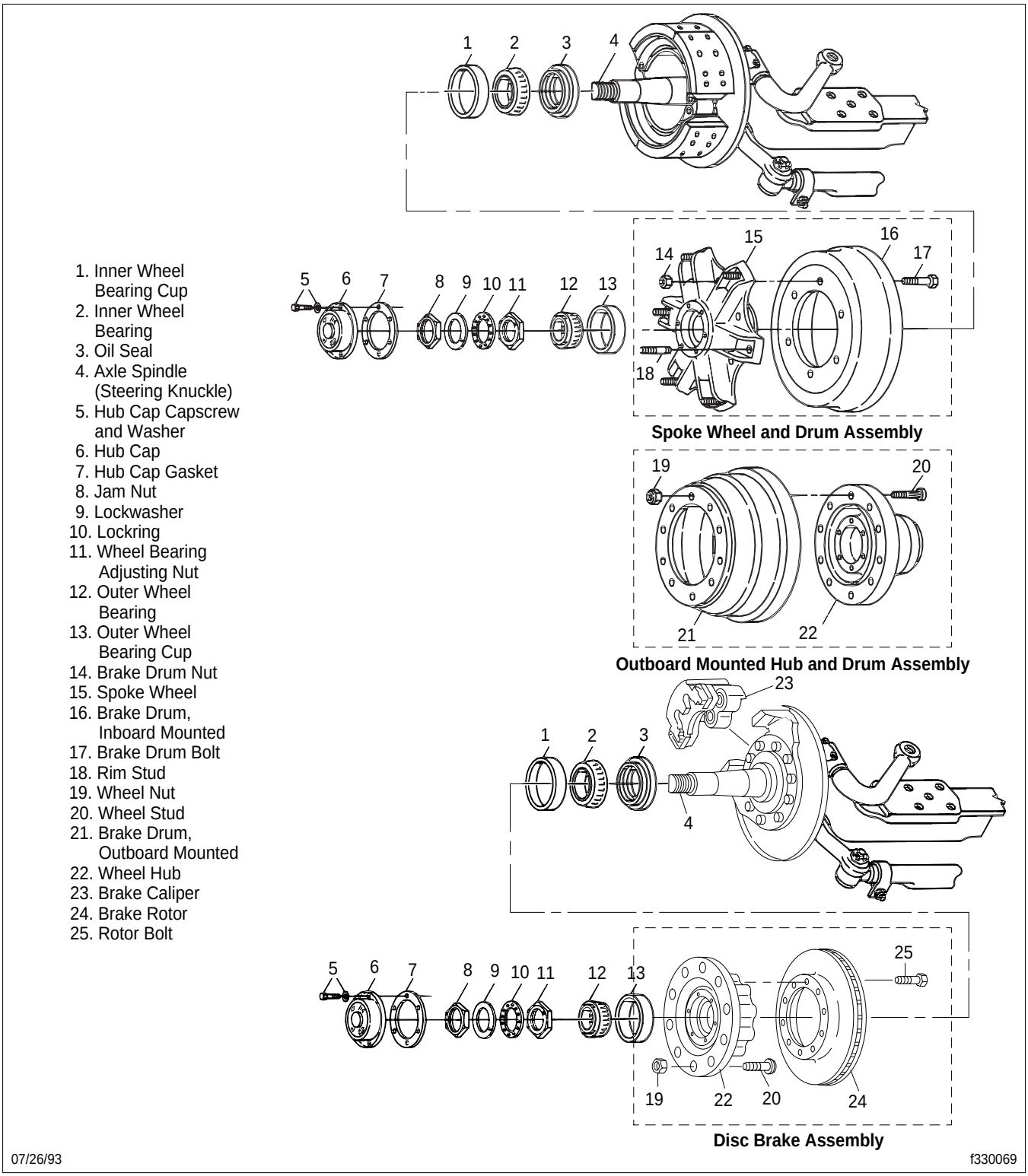


Fig. 3

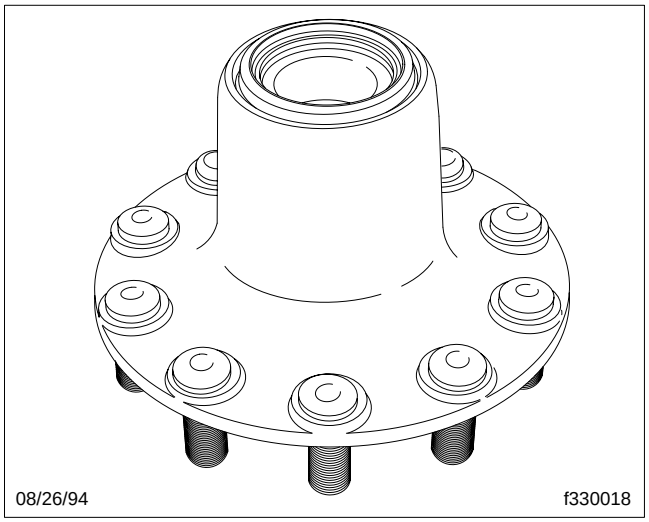


Fig. 4, Front Axle Wheel Hub

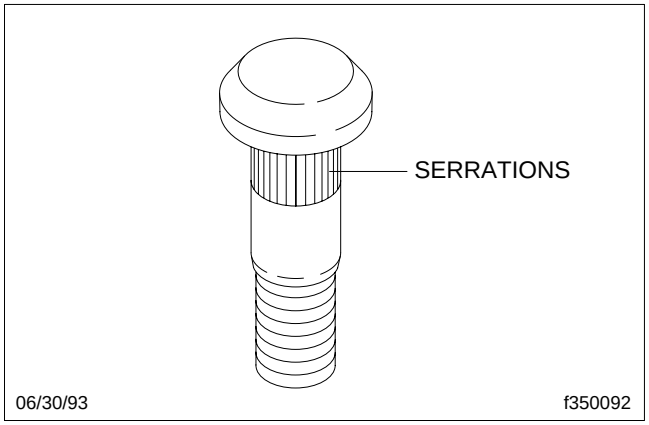


Fig. 5

Hub Assembly Removal and Installation, Disc Wheels

Removal

WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer, or lung disease. OSHA has set maximum safe levels of exposure, and requires workers to wear an air-purifying respirator approved by MSHA or NIOSH. Always wear a respirator when servicing the brakes, from removal of the wheels through assembly.

Never use compressed air or dry brushing to remove brake dust. Both methods can spread hazardous particles beyond the work area.

1. Apply the parking brakes, and chock the rear tires.
2. Raise the front of the vehicle until the tires clear the ground. Place safety stands under the axle.
3. Remove the wheel and tire assembly. See **Group 40** for instructions.
4. Remove the brake drum or brake caliper. For instructions, see **Group 42**.

NOTE: On vehicles equipped with oil-lubricated bearings, oil will spill as the hub cap and wheel hub are removed. Place a suitable container under the axle spindle to catch any spilled oil. Dispose of the oil properly.

5. Remove the capscrews, washers, and hub cap. Remove and discard the hub cap gasket. See **Fig. 1**.
6. Remove the axle spindle jam nut, lockwasher, and cotter pin or lockring. See **Fig. 2** for the cotter pin, or **Fig. 3** for the lockring.
7. Back off the wheel bearing adjusting nut about two turns, enough to allow the weight of the hub to be lifted from the wheel bearings.
8. Lift the hub until all weight is removed from the wheel bearings. Remove the adjusting nut.

IMPORTANT: When moving the hub, be careful not to let the outer wheel bearing fall from the axle spindle. Dropping the bearing can warp the cage or damage the rollers, ruining the bearing.

9. Move the hub about 1/2 inch (13 mm) to jar loose the outer wheel bearing. Allow the hub-only assembly to rest on the axle spindle; be careful not to damage the axle spindle threads.
10. Carefully remove the outer wheel bearing. Handle the bearing assembly with clean, dry hands or gloves; wrap all bearing assembly parts in clean oil-proof paper or lint-free rags.

IMPORTANT: Do not spin the bearing rollers. Be careful to keep them clean. Dirt or grit can scratch their surfaces, and cause rapid wear of the bearing assembly. Treat good used bearings as carefully as new ones.

11. Remove the hub from the axle spindle. Be careful not to damage the axle spindle threads as the assembly is removed.
12. Remove the oil or grease seal from the hub with a seal removal tool.
13. Remove the inner wheel bearing from the hub. Handle the bearing assembly with clean, dry hands.

    If the bearing is difficult to remove, place a protective cushion to catch it. Then, use a hardwood drift and a light hammer to gently tap the bearing (and seal, if needed) out of the cup. Wrap all bearing assembly parts in clean, oil-proof paper or lint-free rags.

IMPORTANT: When cleaning the wheel hub cavity and axle spindle, be careful not to allow dirt or filings to get inside. They can scratch the bearing roller surfaces, and cause premature wear of the bearing assembly.

14. Use an emery cloth or file to remove all burrs from the hub shoulder. See **Fig. 4** or **Fig. 5**.

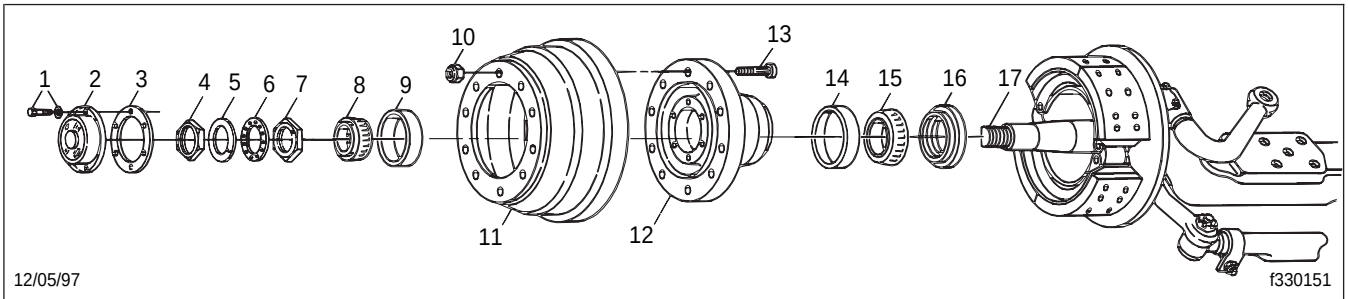
    Clean any metal filings from the parts. For instructions, see **Subject 110**.

Installation

1. Use clean solvent to remove the old oil or grease from the axle spindle and the disassembled parts. Allow the parts to dry, or dry them with a clean, absorbent, and lint-free cloth or paper.
2. Wrap a protective layer of tape onto the axle spindle threads.

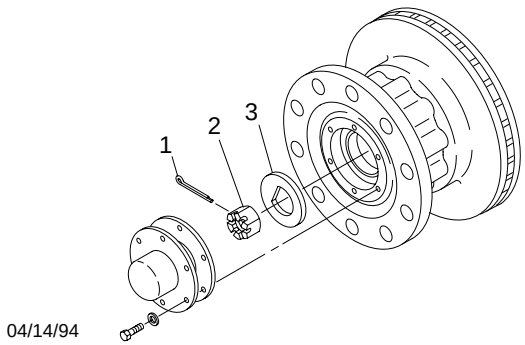
IMPORTANT: When coating the bearing assemblies with oil or grease, do not use old lubricant,

Hub Assembly Removal and Installation, Disc Wheels



1. Hub Cap Capscrew and Washer
2. Hub Cap
3. Hub Cap Gasket
4. Jam Nut
5. Lockwasher
6. Lockring
7. Wheel Bearing Adjusting Nut
8. Outer Wheel Bearing
9. Outer Wheel Bearing Cup
10. Wheel Nut
11. Brake Drum, Outboard-Mounted
12. Wheel Hub
13. Wheel Stud
14. Inner Wheel Bearing Cup
15. Inner Wheel Bearing
16. Oil Seal
17. Axle Spindle

Fig. 1, Typical Front Hub Assembly

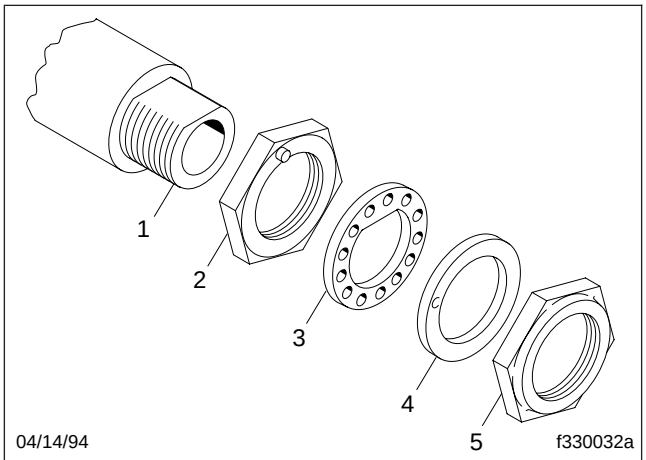


1. Cotter Pin
2. Adjusting Nut
3. Thrustwasher ("D" Washer)

Fig. 2, Single-Nut Adjustment Hub Assembly, Shown With Disc Brake

which could be contaminated with dirt or water. Both are corrosive, and can damage the wheel bearings and hub.

3. If the axle is equipped with oil-lubricated bearings, coat them with fresh oil. If it is equipped with greased bearings, pack them using a pressure packer, if one is available; otherwise, pack the bearings by hand. Starting from the large end of the cone, force lithium-based wheel bearing grease into the cavities between the rollers and the cage. For lubricant specifications, see **Specifications, 400**.



1. Axle Spindle
2. Adjusting Nut
3. Lockring
4. Lockwasher
5. Jam Nut

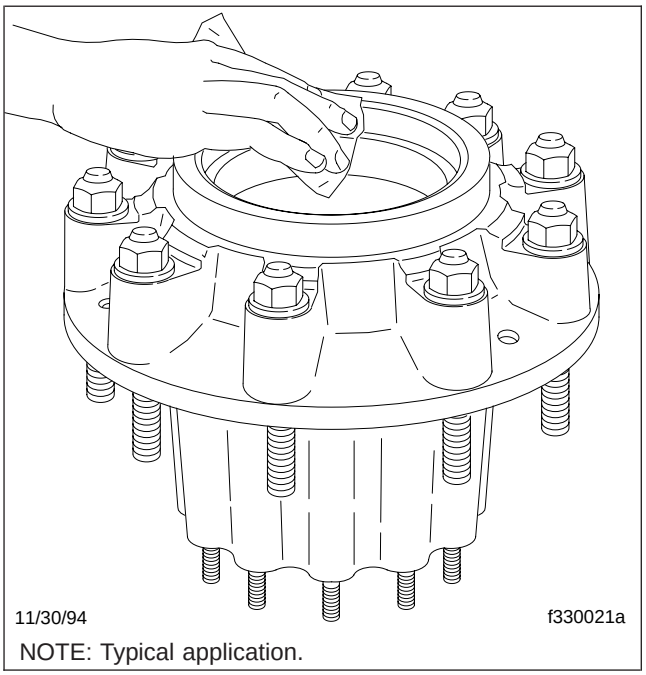
Fig. 3, Axle With Jam Nut and Plain Lockring

Install the inner wheel bearing and oil or grease seal. Handle the bearing assembly with clean, dry hands.

4. Depending on the type of bearing lubricant used on the axle, wipe a film of axle oil or grease on the axle spindle, to prevent rust from forming behind the inner wheel bearing.
5. Install new National® oil seals. See **Fig. 6**.

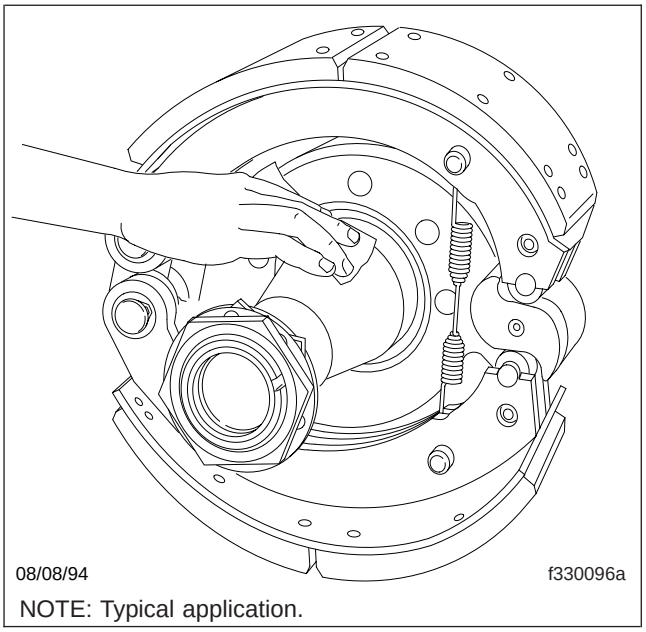
   NOTE: Special installation tools for the oil seals are available from the PDCs.

Hub Assembly Removal and Installation, Disc Wheels



NOTE: Typical application.

Fig. 4, Cleaning the Hub Shoulder



NOTE: Typical application.

Fig. 5, Cleaning the Spindle

5.1 Put a light coating of gear oil on the inner and outer surfaces of the new oil seal.

5.2 If using a press, put the hub onto a centering fixture, inboard side up.

If you are manually installing the oil seal, make sure the hub is on a firm, level surface (inboard side up).

5.3 Install the adapter plate and bearing pilot onto the steel handle using the hexnut and washers provided.

5.4 Put the oil seal onto the adapter plate, making sure the words "Air Side" on the oil seal are facing the adapter plate surface.

5.5 Making sure the oil seal is aligned straight with the hub bore, install it into the hub. See **Fig. 7**.

5.6 If using a press, press the oil seal into the hub with 3000 to 5000 psi (20 684 to 34 500 kPa) of pressure.

If manually installing the seal, strike the end of the installation tool with a heavy mallet. Continue striking until the sound changes, indicating the tool flange is against the hub, and the seal is flush with the face of the hub.

5.7 Wipe any excess oil from the face of the oil seal.

NOTE: When the oil seal is correctly installed in the hub bore, the face of the seal (the side with the words "Air Side") should be flush with the face of the hub.

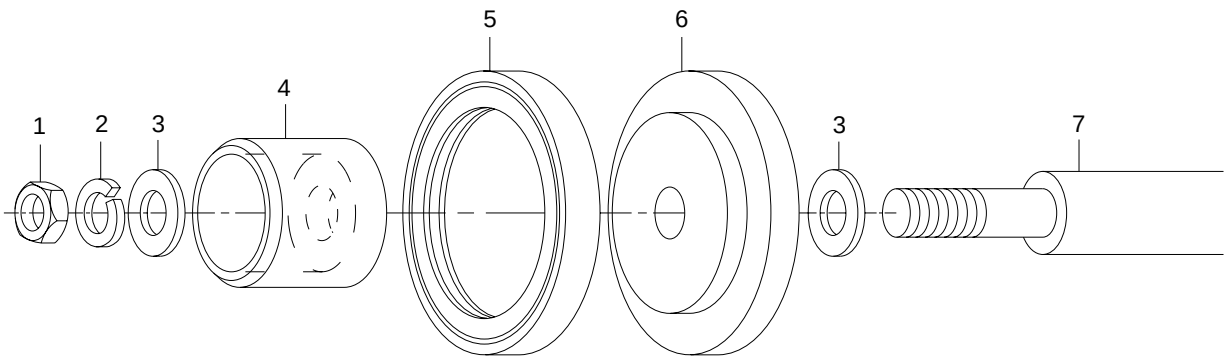
6. Carefully mount the hub and inner wheel bearing assembly on the axle spindle. Be careful not to unseat the inner wheel bearing or seal.

7. If the axle is equipped with oil-lubricated bearings, fill the hub cavity with oil; if equipped with greased bearings, pack the hub between the bearing cups with lubricant to the level of the smallest diameter of the cups. See **Fig. 8**.

   Install the outer wheel bearing. Handle the bearing assembly with clean, dry hands. Use care not to damage the bearing while seating it in the cup. Remove the tape from the axle spindle threads.

8. Install the wheel bearing adjusting nut (see **Fig. 2** for single-nut assemblies, **Fig. 3** for dual-

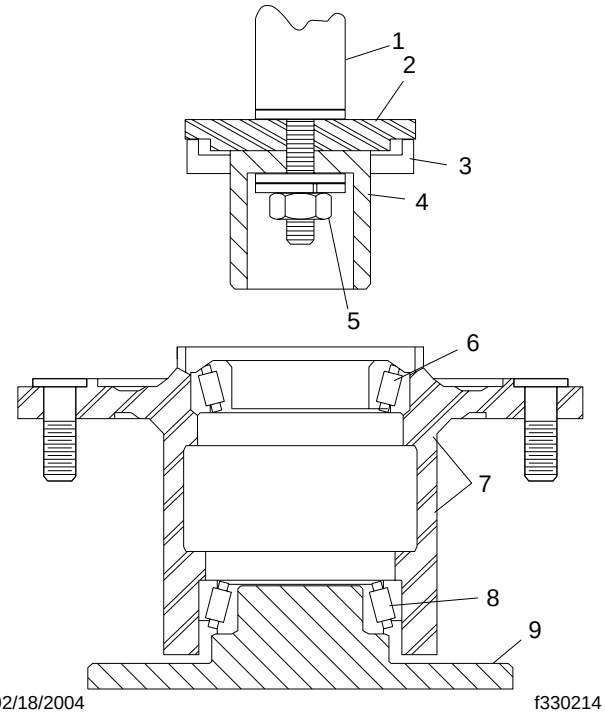
Hub Assembly Removal and Installation, Disc Wheels



02/18/2004 f330215

1. Hexnut, 3/4–10
2. Lockwasher
3. Flatwasher
4. Bearing Pilot
5. Oil Seal
6. Adapter Plate
7. Installation Handle

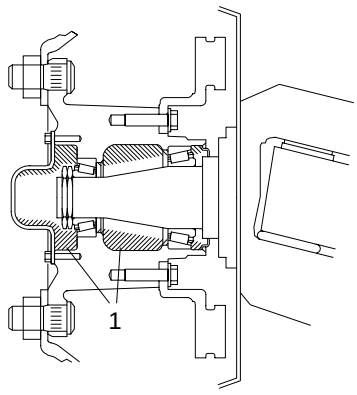
Fig. 6, National Oil Seal and Installation Tools



02/18/2004 f330214

1. Installation Handle
2. Adapter Plate
3. Oil Seal
4. Bearing Pilot
5. Hexnut, 3/4–10
6. Inner Bearing
7. Hub
8. Outer Bearing
9. Centering Fixture

Fig. 7, Installing the National Oil Seal Into the Hub (cross-sectional view)



04/14/94 f330071a

1. Lubricate here.

Fig. 8, Bearing Lubrication Areas

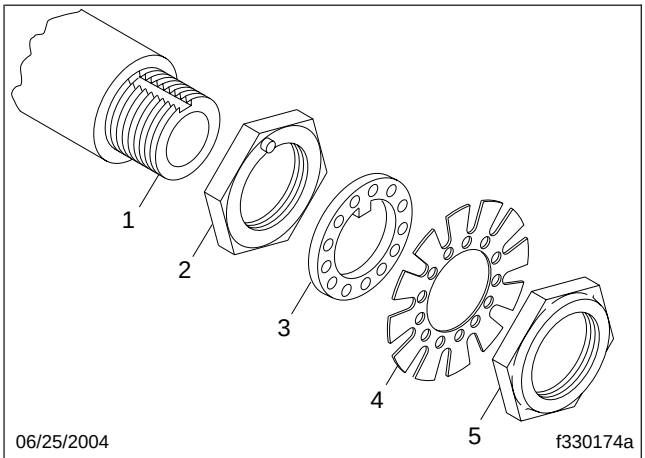
nut assemblies with a plain lockring, or **Fig. 9** for dual-nut assemblies with a tanged nut-lock).

8.1 After the wheel hub and bearings are assembled on the spindle, tighten the inner adjusting nut finger-tight.

IMPORTANT: Be sure there is sufficient clearance between the brake shoe and the brake drum, so brake shoe drag will not interfere with bearing adjustment.

8.2 Rotate the wheel hub assembly, as you tighten the inner adjusting nut 100 lbf·ft (136 N·m).

Hub Assembly Removal and Installation, Disc Wheels



1. Axle Spindle
2. Adjusting Nut
3. Tanged Nut-Lock
4. Bend-Type Locking Washer
5. Jam Nut

Fig. 9, Axle With Jam Nut and Tanged Nut-Lock

8.3 Back off the adjusting nut completely.

8.4 Rotate the wheel hub assembly, as you tighten the adjusting nut 20 lbf·ft (27 N·m).

8.5 Back off the adjusting nut one-third turn.

9. Install the locking device and jam nut.

On single-nut assemblies, install a new cotter pin (see **Fig. 2**).

On dual-nut assemblies, install the jam nut and locking device as follows (see substeps):

NOTE: If you are securing the wheel bearings with a pierced lockring, and no hole in the lockring aligns with the dowel on the adjusting nut, remove the lockring, turn it over and install it again. If still no hole aligns with the dowel, loosen the adjusting nut, but only enough to align the dowel with a hole in the lockring.

9.1 Install the locking device.

NOTE: The locking device can be any one of the following types:

- Tanged nut-lock
- Lockring
- Lockwasher *and* lockring
- Nut-lock *and* lockring

9.2 Install the jam nut, and tighten it to the applicable torque value in **Table 1**.

10. With the jam nut installed and tightened, adjust the wheel bearings.

IMPORTANT: Do not adjust the bearings with the wheel mounted on the hub. You cannot accurately adjust or measure the bearing end play with the wheel mounted on the hub.

10.1 Attach a dial indicator to the hub, and set the point of the indicator in line with the end of the axle spindle.

If the hub is aluminum, you may have to install the brake drum to provide a steel base for the magnet of the dial indicator. Mount the drum on the hub's drum pilot, then adjust the brake, or have someone apply the brakes to hold the drum securely. Secure the drum using the stud at the 12 o'clock position, then the studs at about the 4 o'clock and 8 o'clock positions.

NOTE: If using a stud-piloted hub and a steel drum, install 1-1/4 inch washers between the nuts and the drum.

10.2 Grip the sides of the hub at the three o'clock and nine o'clock positions. Push in on the hub (and drum, if applicable), to seat the inboard bearing set. Zero the dial indicator.

10.3 Grip the sides of the hub at the three o'clock and nine o'clock positions. Pull out on the hub (and drum, if applicable). Read the dial indicator, and note the end play.

10.4 Push the hub back in, and confirm that the needle of the dial indicator returns to zero.

11. The end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm). If the end play is not within this range, adjust the end play.

11.1 Remove the jam nut and locking device, and back off or tighten the inner adjusting nut.

IMPORTANT: *If the axle has a nut-lock,* turning the adjusting nut 1/4 turn will change the end play about 0.014 inch (0.36 mm).

Hub Assembly Removal and Installation, Disc Wheels

If the axle has a lockring, turning the inner nut one lockring hole will change the end play about 0.005 inch (0.13 mm). If you take the lockring off, reverse it, and then turn the adjusting nut to the next hole, this will change the end play about 0.0025 inch (0.064 mm).

11.2 Install the locking device and jam nut as described earlier, and measure the end play. If the end play is not between 0.001 and 0.005 inch (0.03 and 0.13 mm), turn the inner adjusting nut again.

11.3 Once the end play is correct, bend the nut-lock or lockwasher, as applicable. This will lock the jam nut and/or adjusting nut in place.

11.4 Rotate the hub in both directions. It should turn freely with no dragging or binding.

12. If the axle is equipped with grease-packed bearings, pack the hub between the bearing cups with lithium-based wheel bearing grease to the level of the smallest diameter of the cups (see **Fig. 8**).

13. Place the hub cap and a new gasket in position, then install the washers and capscrews. Tighten the capscrews to the value in the torque table in **Specifications, 400**.

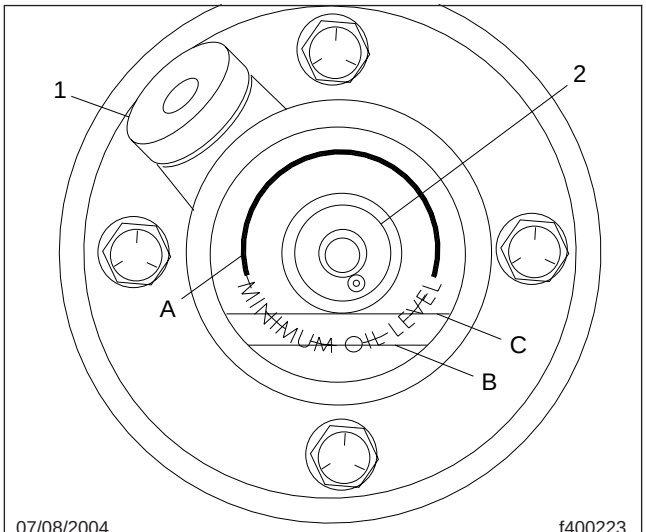
14. If the axle is equipped with oil-lubricated bearings, add fresh oil to the wheel hub, to the level mark on the hub cap. See **Fig. 10**, and see **Specifications, 400**, for recommended axle lubricants.

14.1 Turn the hub until the drain/fill plug on the hub cap is at the top of the hub.

14.2 Remove the drain/fill plug and put a funnel into the hole.

⚠ WARNING

You must add oil to the wheel hub after the hub has been serviced, or the wheel bearings will overheat and seize during vehicle operation. See Fig. 11. Seized bearing rollers can cause sudden, severe damage to the tire or axle, possibly causing lost vehicle control and resulting in personal injury.



A. Minimum Oil Level Line
B. Minimum Oil Level
C. Normal Oil Level

1. Drain/Fill Plug
2. Vent Plug

Fig. 10, Hub Oil Levels

14.3 Add enough oil (about 2 oz or 60 ml) to the hub, to bring the level up to the bottom of the vent cap.

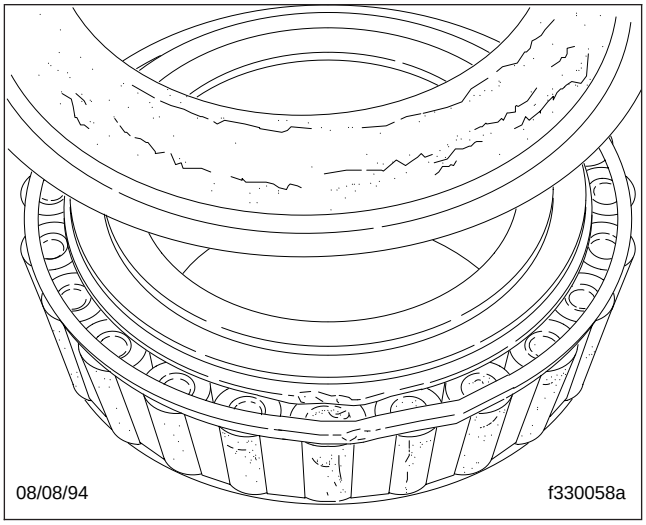


Fig. 11, Bearing Damage Resulting from Inadequate Lubrication

14.4 Install the drain/fill plug, and rotate the hub several times to distribute the oil.

14.5 Once the oil level has stabilized in the hub cap, check the level in the window and if needed, add enough oil to bring the level up to the bottom of the vent plug. See **Fig. 10**.

14.6 Let the hub sit for about 30 minutes, then check the oil level again. Add oil as needed.

15. Install the brake drum or caliper on the wheel hub. See **Group 42** for instructions.
16. Install the wheel and tire assembly. See **Group 40** for instructions.

⚠ WARNING

If the wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking action, and the wheel hub flange is probably damaged. In that case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when these conditions exist could result in the loss of a wheel or loss of vehicle control, and possible personal injury.

17. Remove the safety stands from under the axle, and lower the vehicle.
18. Remove the chocks from the rear tires.

Dual-Nut Wheel Bearing Lock Torque Values		
Application	**Size**	**Torque: lbf·ft (N·m)**
Adjusting Nut	—	Stage 1: Tighten to 100 (135)
		Stage 2: Back Off Completely
		Stage 3: Tighten to 20 (25) While Rotating Hub
		Stage 4: Back Off 1/3 Turn
Jam Nut (with Wheel Bearing Nut, Pierced Lockwasher, and Bendable Lockwasher)	1-1/8	Target: 175 (235) Permissible Range: 150–225 (205–305)
	1-1/2 to 2-1/2	Target: 250 (340) Permissible Range: 200–300 (270–405)
	2-5/8 or Larger	Target: 325 (440) Permissible Range: 250–400 (340–540)

Table 1, Dual-Nut Wheel Bearing Lock Torque Values

Hub Assembly Removal and Installation, Spoke Wheels

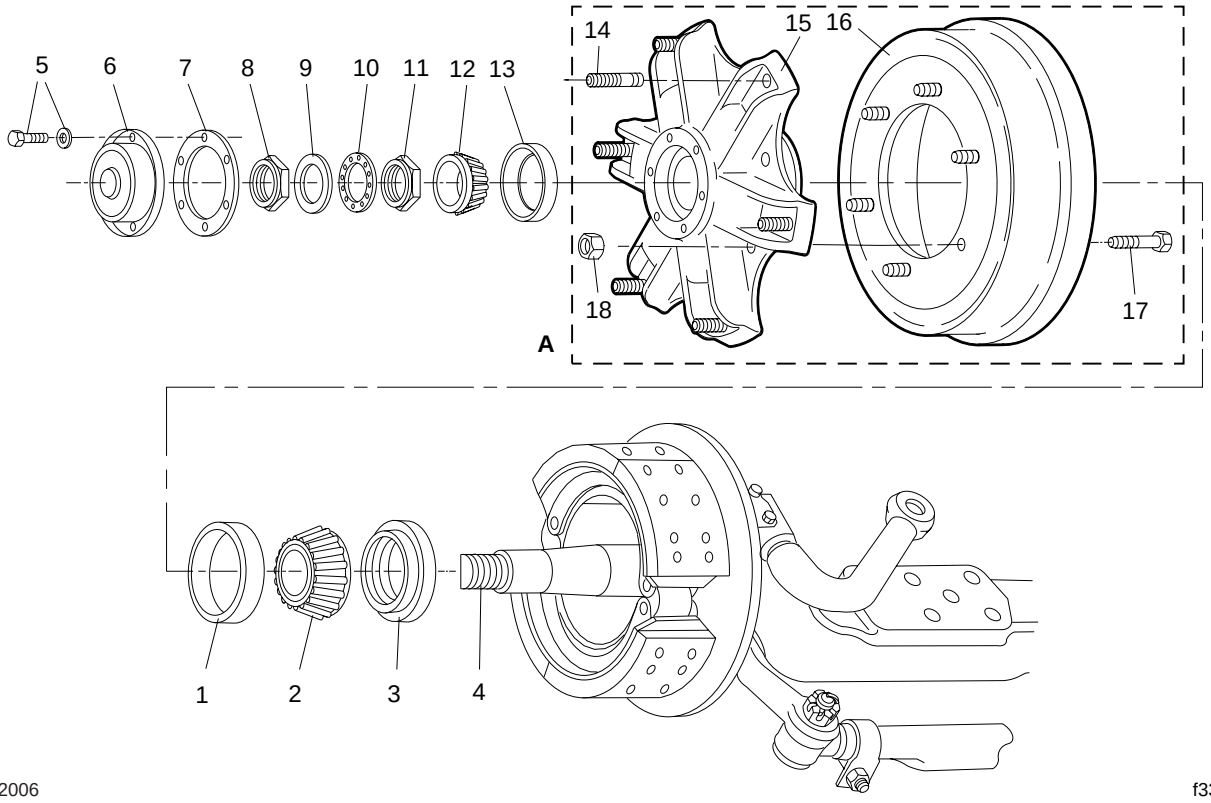
Removal

See **Fig. 1** for this procedure.

1. Apply the parking brake, and chock the rear tires.
2. Raise the front of the vehicle until the tires clear the ground, and place safety stands under the axle. Position a jack, or wheel-and-tire dolly under the tire.
3. Remove the rim and tire assembly. See **Group 40** for instructions.

NOTE: On axles equipped with oil-lubricated bearings, oil will spill as the hub cap is removed. Place a suitable container under the wheel to catch any spilled oil. Dispose of the oil properly.

4. Remove the capscrews, washers, and hub cap. Remove and discard the hub cap gasket and oil.
5. Remove the axle spindle jam nut, lockwasher, and lockring or cotter pin. See **Fig. 2** or **Fig. 3**.
6. Back off the wheel bearing adjusting nut about two turns, enough to allow the weight of the

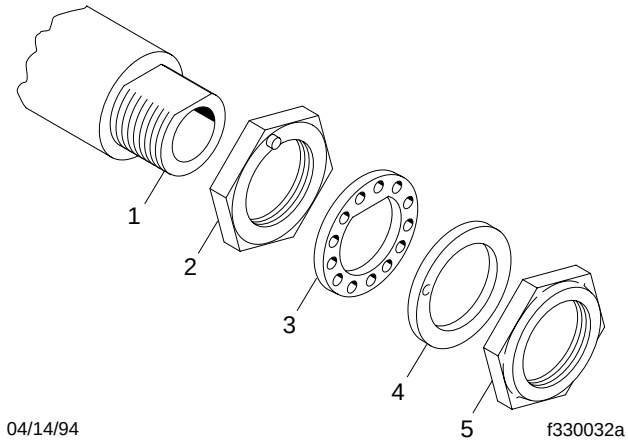


A. Dual-nut bearing lock system shown; Axi-Lok® locking nuts are used with ConMet PreSet® hubs.

1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle
5. Hub Cap Capscrew
6. Hub Cap
7. Gasket
8. Jam Nut
9. Nut-Lock
10. Lockring
11. Adjusting Nut
12. Outer Wheel Bearing
13. Outer Bearing Cup
14. Bearing Spacer (used only with ConMet PreSet hubs)
15. Wheel Nut
16. Wheel Stud
17. Brake Drum
18. Hub

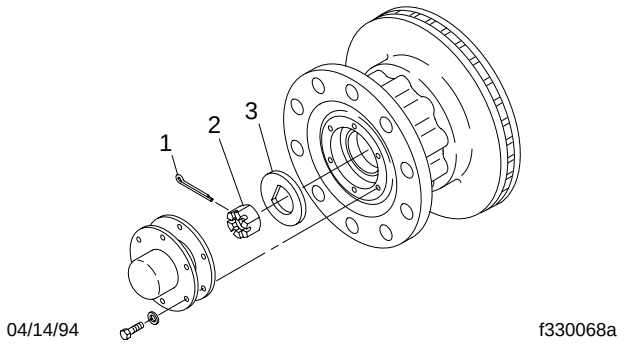
Fig. 1, Typical Spoke Wheel Front Hub Assembly

Hub Assembly Removal and Installation, Spoke Wheels



1. Axle Spindle
2. Adjusting Nut
3. Lockring
4. Lockwasher
5. Jam Nut

Fig. 2, Axle With Jam Nut and Lockring



1. Cotter Pin
2. Adjusting Nut
3. Thrustwasher ("D" Washer)

Fig. 3, Single Nut Adjustment Hub Assembly, With Disc Brakes Shown

wheel and drum assembly to be lifted from the wheel bearings.

7. Use an adjustable wheeled support to raise the wheel and drum assembly until all weight is removed from the bearings. Remove the adjusting nut.

8. Carefully remove the outer wheel bearing. Handle the bearing assembly with clean, dry hands. If the bearing hasn't loosened from the cup, move the wheel assembly about 1/2 inch (13 mm), to jar loose the outer wheel bearing. Be careful to not drop the bearing. Wrap all bearing assembly parts in clean oil-proof paper or lint-free rags.

CAUTION

Do not spin the bearing rollers, and be careful to keep them clean. Dirt or grit can scratch their surfaces and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

9. Use the wheeled support to pull the wheel assembly away from the vehicle. Be careful not to damage the axle spindle threads as the assembly is removed.

WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air-purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, from removal of the wheels through assembly.

Never use compressed air or dry brushing to clean brake dust away. Both methods can spread dangerous particles beyond the work area.

10. To minimize exposure to brake lining dust, clean the brake drum, brake backing plate and brake assembly, using OSHA-approved materials and methods. Do not use compressed air or dry brushing to clean the brake assembly.

11. Remove the brake drum nuts (see **Fig. 1**) and detach the brake drum from the wheel.

12. Remove the oil or grease seal using a seal removal tool.

13. Remove the inner wheel bearing from the hub. Handle the bearing assembly with clean, dry hands.

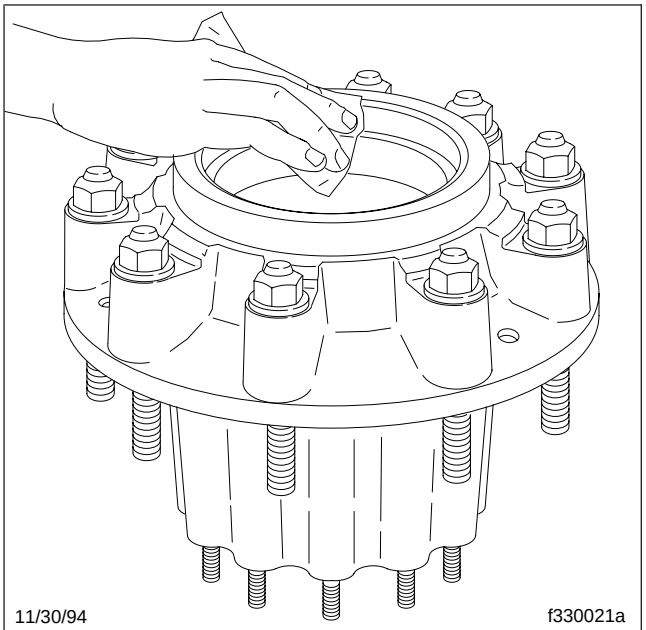
    If the bearing is difficult to remove, place a protective cushion to catch it. Then use a hardwood drift and a light hammer to tap the bearing (and seal if needed) gently out of the cup. Wrap all bearing assembly parts in clean oil-proof paper or lint-free rags.

IMPORTANT: Dirt, metal filings, or other debris can scratch the bearing roller surfaces, and

cause premature wear of the bearing assembly. Be very careful when cleaning the wheel hub cavity and axle spindle.

14. Use an emery cloth or file to remove all burrs from the hub shoulder. See **Fig. 4** or **Fig. 5**.

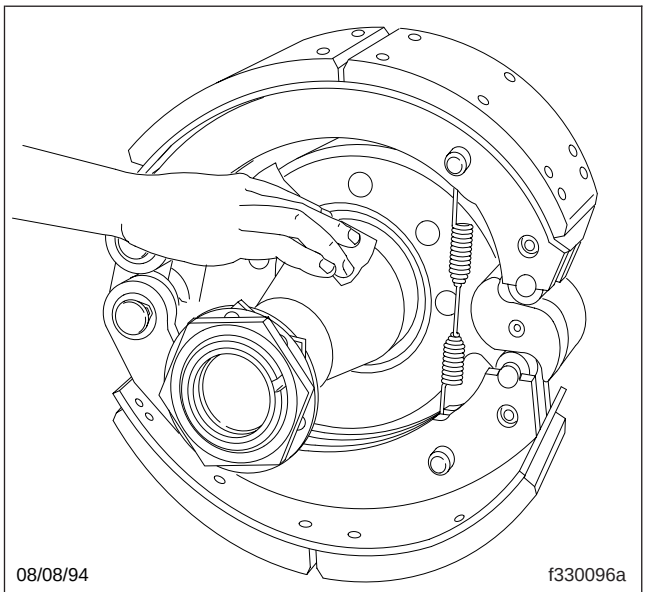
    Clean any metal filings from the parts. For instructions, see **Subject 110**.



11/30/94 f330021a

NOTE: Typical application.

Fig. 4, Cleaning the Hub Shoulder



08/08/94 f330096a

NOTE: Typical application.

Fig. 5, Cleaning the Spindle

Installation

⚠ WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air-purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, from removal of the wheels through assembly.

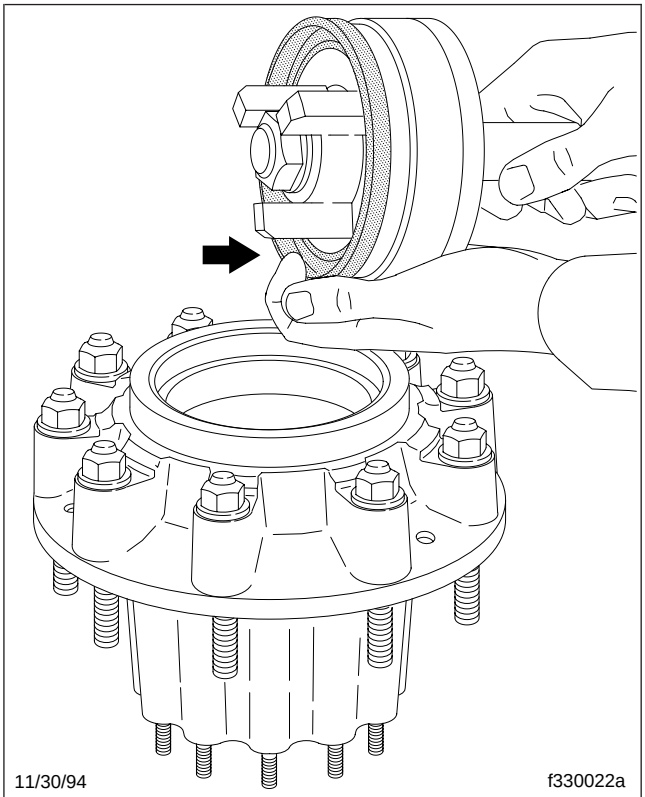
Never use compressed air or dry brushing to clean brake dust away. Either method can spread dangerous particles beyond the work area.

1. Use clean solvent to remove the old oil or grease from the axle spindle (steering knuckle) and the disassembled parts. Inspect and clean the wheel hub cavity and the wheel bearings as detailed under **Subject 110**. Allow the parts to dry, or dry them with a clean, absorbent, and lint-free cloth or paper.
2. Wrap a protective layer of tape on the axle spindle threads.
3. If it was removed, attach the brake drum to the hub. Install the bolts and nuts, then tighten the nuts 240 lbf·ft (325 N·m).
4. If the axle is equipped with oil-lubricated bearings, coat them with fresh oil; If equipped with greased bearings, pack them using a pressure packer, if possible. If a packer is not available, pack the bearing by hand. Starting from the large end of the cone, force lithium-based wheel bearing grease into the cavities between the rollers and the cage. For lubricant specifications, see **Specifications, 400**.

   Install the inner wheel bearing. Handle the bearing assembly with clean, dry hands.
5. Install the new oil or grease seals.

   5.1 Seat the small outer diameter of the seal in the recess of the tool adaptor. See **Fig. 6**. The correct adaptor is identified on the box.

Hub Assembly Removal and Installation, Spoke Wheels



NOTE: Typical application.

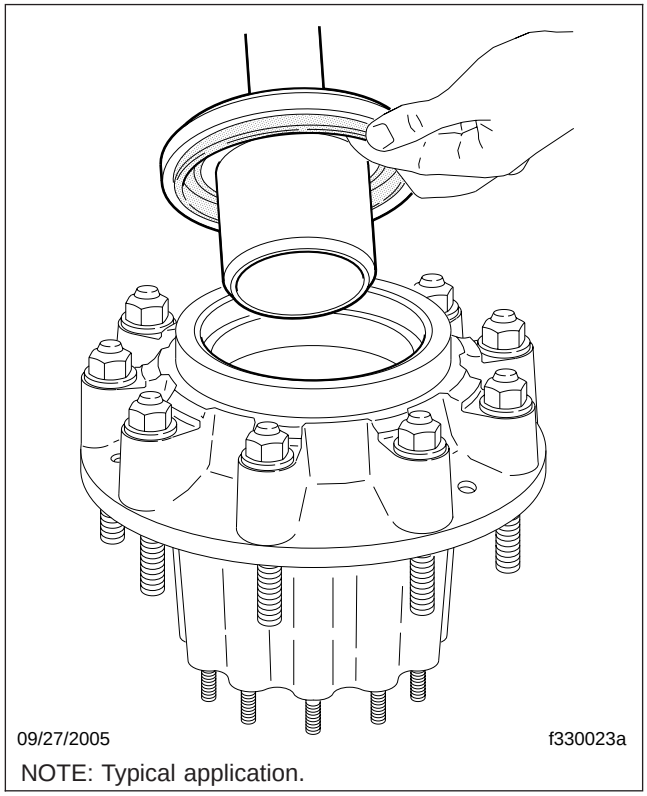
Fig. 6, Seating the Seal on the Tool

5.2 Insert the centering plug of the tool in the bore of the inner bearing cone. See **Fig. 7**. The plug prevents the seal from getting cocked and jamming in the bore.

5.3 Hold the tool handle firmly, and strike it until the sound of the impact changes as the tool flange bottoms out against the hub face. See **Fig. 8**. Hold the tool firmly to prevent bouncing, and unseating of the seal from the adaptor.

5.4 When the seal is flush with the hub face, check for freedom of movement by manually moving the interior rubber part of the seal back and forth. If it is not damaged, the seal should move slightly.

6. Depending on the type of bearing lubricant used on the axle, wipe a film of axle oil or grease on the axle spindle, to prevent rust from forming behind the inner wheel bearing.



NOTE: Typical application.

Fig. 7, Inserting the Tool into the Hub

7. Use a wheeled support to mount the wheel and drum assembly on the axle spindle; be careful not to unseat the bearing or seal.

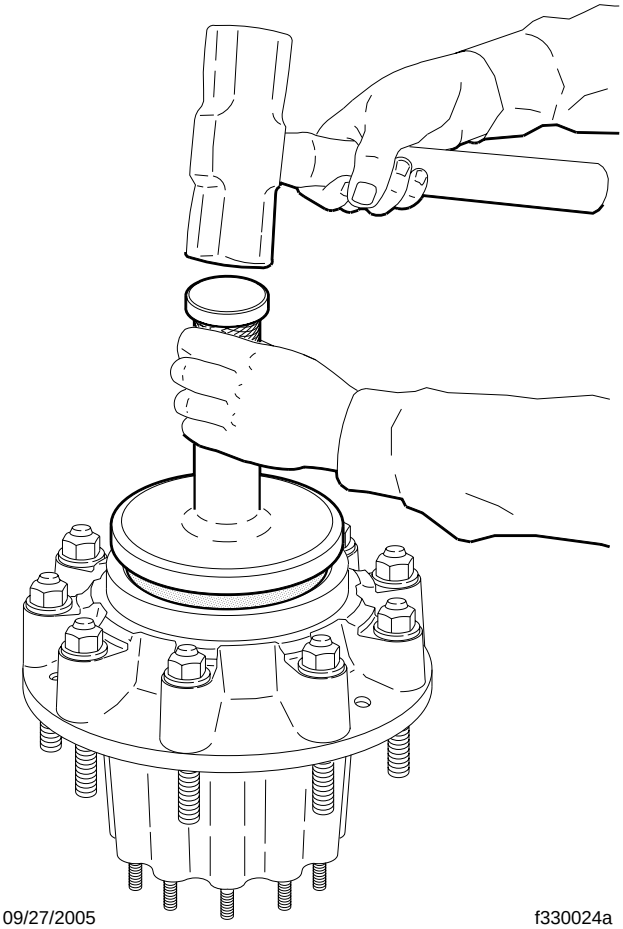
⚠ WARNING

You must add oil to the wheel hub after the hub has been serviced, or the wheel bearings will overheat and seize during vehicle operation. See Fig. 10. Seized bearing rollers can cause sudden, severe damage to the tire or axle, possibly causing loss of vehicle control, and personal injury.

8. If the axle is equipped with oil-lubricated bearings, fill the hub cavity with oil; if equipped with greased bearings, pack the hub between the bearing cups with lubricant to the level of the smallest diameter of the cups. See **Fig. 9**.

   Install the outer wheel bearing. Handle the bearing assembly with clean, dry hands or gloves. Be careful not to damage the bearing as you seat it in the cup. Remove the friction tape from the axle spindle threads.

Hub Assembly Removal and Installation, Spoke Wheels



NOTE: Typical application.

Fig. 8, Striking the Tool

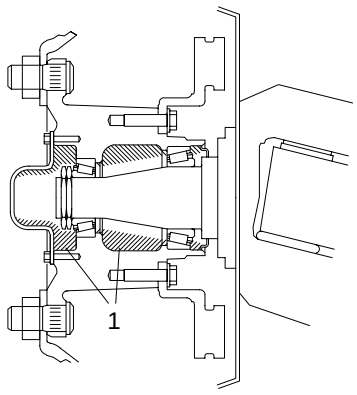
9. Install the wheel bearing adjusting nut. Tighten the nut finger-tight. Adjust the bearings (see **Fig. 2** or **Fig. 3**).

   IMPORTANT: Be sure there is sufficient clearance between the brake shoe and the brake drum, so brake shoe drag won't interfere with bearing adjustment.

   9.1 After the wheel hub and bearings are assembled on the spindle, tighten the inner (adjusting) nut 200 lbf·ft (271 N·m) while rotating the wheel hub assembly.

   9.2 Back off the inner nut one full turn.

   9.3 Tighten the inner nut 50 lbf·ft (68 N·m) while rotating the wheel hub assembly.



1. Lubricate here.

Fig. 9, Bearing Lubrication

   9.4 Back off the inner nut one quarter turn.

   9.5 Where one is used, install a new cotter pin (see **Fig. 3**), or install the jam nut and locking device as follows:

   NOTE: If you are securing the wheel bearings with a pierced lockring, but no hole in the lockring aligns with the dowel on the adjusting nut, remove the lockring, turn it over and install it again. If still no hole aligns with the dowel, loosen the adjusting nut just enough to align the dowel with a hole in the lockring.

   9.6 Install the locking device:

   - Tanged nut-lock
   - Lockring
   - Lockwasher *and* a lockring
   - Nut-lock *and* a lockring

   Install the jam nut, and tighten it to the proper torque from **Table 1**.

   IMPORTANT: Do not adjust the wheel bearings with the wheel mounted. You cannot accurately adjust or measure bearing end play with the wheel mounted.

   9.7 With the jam nut installed and tightened, attach a dial indicator to the hub and set the point of the indicator in line with the end of the axle spindle.

Hub Assembly Removal and Installation, Spoke Wheels

Dual-Nut Wheel Bearing Lock Torque Values		
Application	**Size**	**Torque: lbf·ft (N·m)**
Adjusting Nut	—	Stage 1: Tighten to 100 (135)
		Stage 2: Back Off Completely
		Stage 3: Tighten to 20 (25) While Rotating Hub
		Stage 4: Back Off 1/3 Turn
Jam Nut (with Wheel Bearing Nut, Pierced Lockwasher, and Bendable Lockwasher)	1-1/8	Target: 175 (235) Permissible Range: 150–225 (205–305)
	1-1/2 to 2-1/2	Target: 250 (340) Permissible Range: 200–300 (270–405)
	2-5/8 or Larger	Target: 325 (440) Permissible Range: 250–400 (340–540)

Table 1, Dual-Nut Wheel Bearing Lock Assembly Torque Values

9.8 Release the brakes, if you used them to hold the drum while installing it.

Grip the sides of the hub at the three o'clock and nine o'clock positions then push the hub to seat the inboard bearing set. Zero the dial indicator.

Grip the sides of the hub at the three o'clock and nine o'clock positions, and pull outward. Read the dial indicator, and note the end play.

Push the hub back in to confirm that the needle of the dial indicator returns to zero.

The end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm).

10. If the end play is not within this range, remove the jam nut and locking device, and back off or tighten the inner (adjusting) nut to adjust the end play. Keep the following in mind:

    If you are using a nut-lock: turning the inner nut 1/4 turn will change the end play about 0.014 inch (0.36 mm).

    If you are using a lockring: turning the inner nut one lockring hole will change the end play about 0.005 inch (0.13 mm). If you take the lockring off and reverse it, then turn the inner nut to the next hole, this will change the end play about 0.0025 inch (0.06 mm).

    Install the locking device and jam nut as described earlier, and measure the end play. If the end play is not between 0.001 and 0.005 inch (0.03 and 0.13 mm), adjust the inner (adjusting) nut again.

11. Once the end play is correct, bend the nut-lock or lockwasher as needed to lock the jam nut and/or adjusting nut in place.
12. Rotate the wheel in both directions. It should turn freely with no dragging or binding.
13. If the axle is equipped with grease-packed bearings, pack the hub between the bearing cups with lithium-based wheel bearing grease to the level of the smallest diameter of the cups (see **Fig. 9**).
14. Place the hub cap and a new gasket in position, then install the washers and capscrews. Tighten the capscrews to the value from the torque table in **Specifications, 400**.
15. Install the rim and tire assembly. See **Group 40** for instructions.

⚠ WARNING

If the rim nuts cannot be tightened to minimum torque values, the rim studs have lost their locking ability, and the wheel hub flange is probably damaged. In this case, install a new wheel. Failure to replace the wheel when these conditions exist could result in loss of a wheel, loss of vehicle control, physical damage, and possible personal injury.

16. Lower and remove the jack or wheel-and-tire dolly from under the tires.
17. If the axle is equipped with oil-lubricated bearings, add fresh oil to the wheel hub to the level shown on the hub cap. See **Specifications, 400** for recommended axle lubricants.

⚠ WARNING

You must add oil to the wheel hub after the hub has been serviced, or the wheel bearings will overheat and seize during vehicle operation. See Fig. 10. Seized bearing rollers can cause sudden, severe damage to the tire or axle, possibly causing loss of vehicle control, and personal injury.

18. Adjust the front axle brakes. For instructions, see **Group 42**.

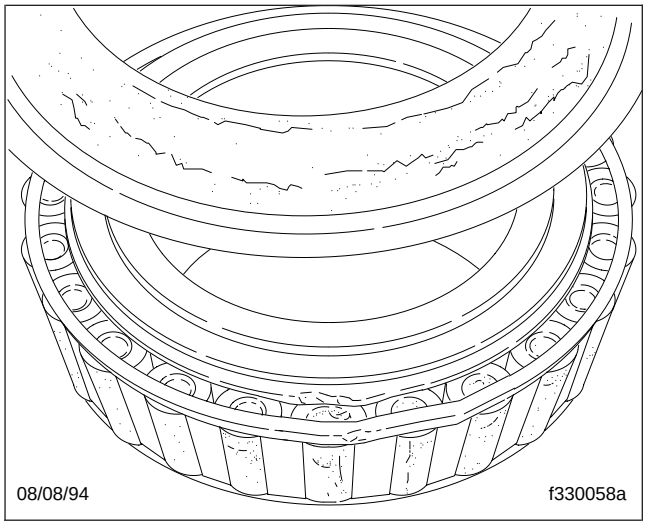


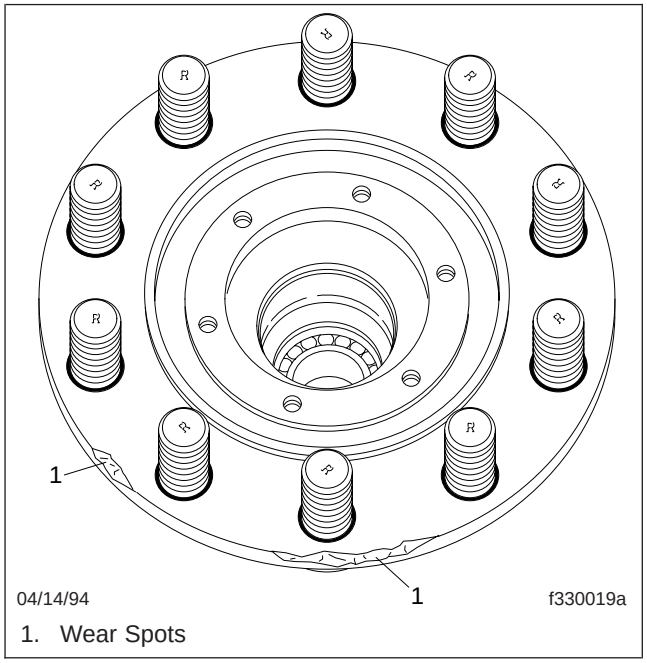
Fig. 10, Bearing Damage Resulting from Inadequate Lubrication

19. Remove the safety stands from under the axle; lower the vehicle.
20. Remove the chocks from the rear tires.

Wheel Hub Assembly Inspection

1. Inspect the wheel hub mounting flange. A loose wheel assembly will cause the flange to be worn, jagged, or warped. **See Fig. 1.** Replace the wheel hub if any of these conditions exist.

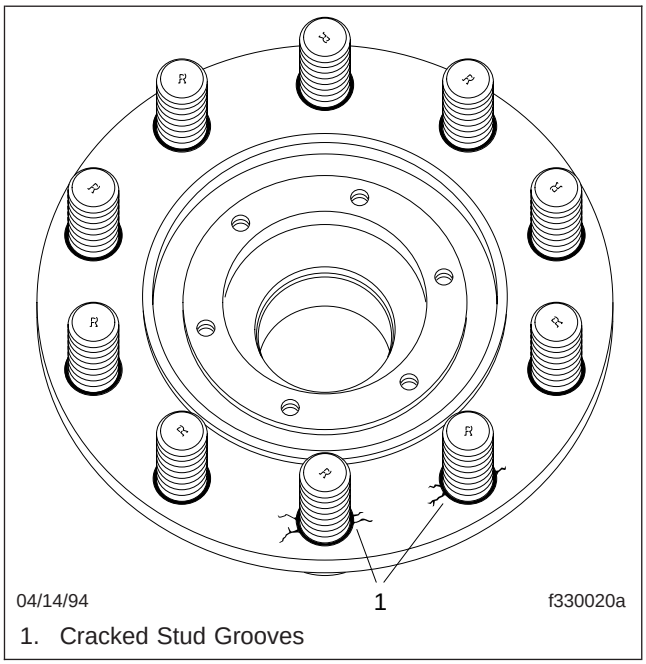
   Inspect the flange surface around the wheel studs. Improperly torqued wheel nuts will cause worn or cracked stud grooves on the hub. **See Fig. 2.** If wear spots or cracks appear anywhere on the hub, or if the hub is otherwise damaged, replace it with a new one.



1. Wear Spots

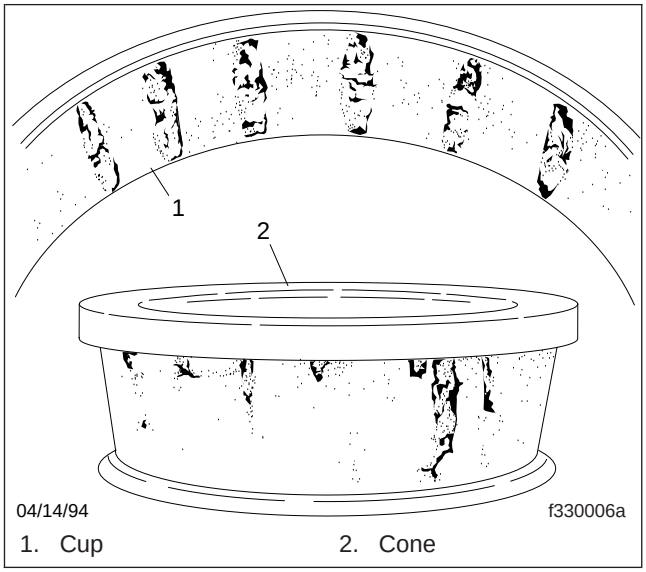
Fig. 1, Damaged Front Axle Wheel Hub

2. Remove all the old oil or grease from the spoke wheel or hub cavity. Inspect the inner surface of the wheel or hub for cracks, dents, wear, or other damage. Replace the wheel or hub if damaged.
3. Remove all the old grease or oil from the surfaces of the wheel bearing cups. Inspect the cups for cracks, wear, spalling, or flaking. **See Fig. 3.** Replace the cups if damaged in any way. Refer to **Subject 120**.
4. Inspect the wheel nuts on disc wheel installations, or the rim nuts on spoke-wheel installations. Damaged nuts (**Fig. 4**), usually caused by inadequate tightening, must be replaced with new ones.



1. Cracked Stud Grooves

Fig. 2, Damaged Front Axle Wheel Hub



1. Cup 2. Cone

Fig. 3, Spalling (Flaking) of Wheel Bearing Assembly

Axle Components Cleaning and Inspection

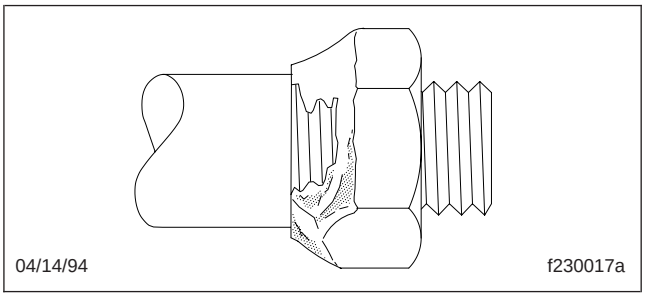


Fig. 4, Damaged Wheel Stud Nut

5. Inspect the wheel studs or rim studs. Replace studs that are stripped, broken, bent, or otherwise damaged. Refer to **Subject 130** or **Subject 140**.

Wheel Bearing Cleaning and Inspection

CLEANING

⚠ WARNING

WARNING: To prevent skin irritation, wear chemical resistant gloves when working with diesel fuel or kerosene. Also, don't expose these fluids to flames or heat exceeding 38°C (100°F); both are combustible, and could cause personal injury if ignited.

⚠ CAUTION

CAUTION: Don't spin the bearing rollers at any time. Dirt or grit can scratch the roller surface and cause premature wear of the bearing assembly. Treat a used bearing as carefully as a new one.

Wheel bearings should be very closely inspected at the time of disassembly. The best inspection conditions are possible only after the bearings have been thoroughly cleaned using kerosene or diesel fuel oil, and a stiff brush (**see Fig. 5**). Before inspecting, clean the bearings, as described below.

1. Clean all old oil or grease from the bearings and hub cavities, with kerosene or diesel fuel and a stiff brush. **See Fig. 5.** Don't use gasoline or heated solvent.

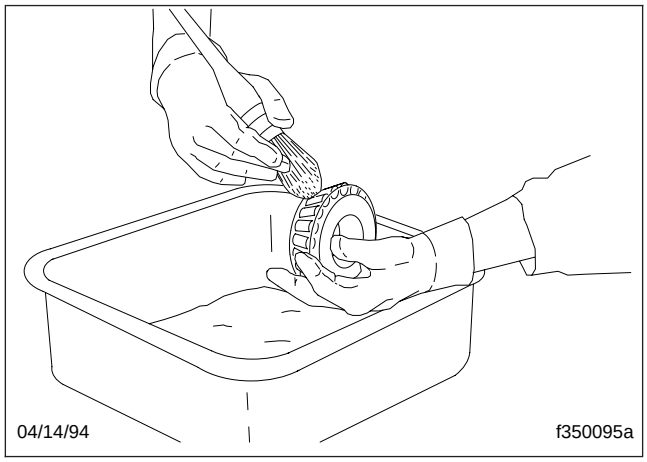


Fig. 5, Wheel Bearing Cleaning

2. Allow the cleaned parts to dry, or dry them with a clean absorbent cloth or paper.

   Clean and dry your hands and all tools used in the maintenance operation. Oil will not stick to a surface that is wet with kerosene or diesel fuel, and the kerosene or diesel fuel may dilute the lubricant.

INSPECTION

After the bearings are cleaned, inspect the assemblies, which include the rollers, cones, cups, and cages. If any of the conditions below exist, replace the bearing assemblies.

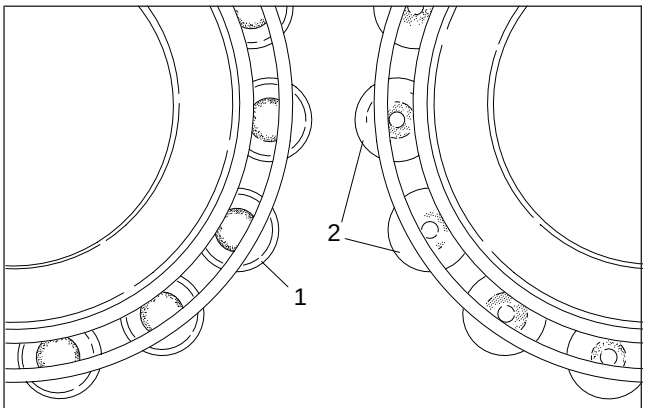
A. The large ends of the rollers are worn flush to the recess; the radii at the large ends of the rollers are worn sharp. These are signs of advanced wear. **See Fig. 6.**

B. Visible step wear, especially at the small end of the roller track, or deep indentations, cracks, or breaks in the cone surfaces. **See Fig. 7.**

C. Bright rubbing marks on the dark phosphate surfaces of the bearing cage. **See Fig. 8.**

D. Water etch on any bearing surface. Water etch appears as gray or black stains on the steel surface, and it greatly weakens the affected area. If water etch is present, check the bearing seal sealing surfaces.

E. Etching or pitting on functioning surfaces. **See Fig. 9.**



1. New Bearing
2. Worn Bearing Rollers

Fig. 6, Wheel Bearing Roller Wear

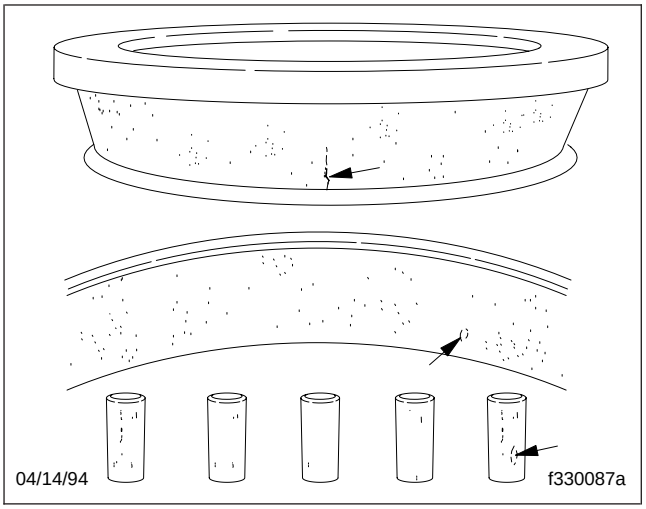


Fig. 7, Indentations, Cracks, or Breaks in Bearing Surfaces

F. Spalling (flaking) of the bearing cup, roller, or cone surfaces. **See Fig. 3.**

After inspection, pack the bearings with fresh axle lubricant. If a packer is not available, pack the bearing by hand. Starting from the large end of the cone, force lithium-based wheel bearing grease into the cavities between the rollers and the cage. For installation, refer to **Subject 100** or **Subject 102**.

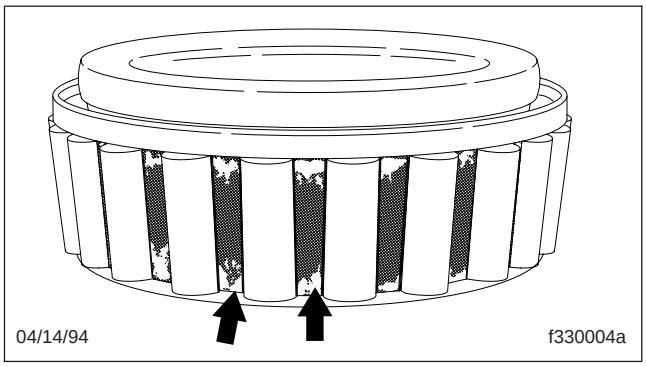


Fig. 8, Rubbing Marks on Bearing Cage

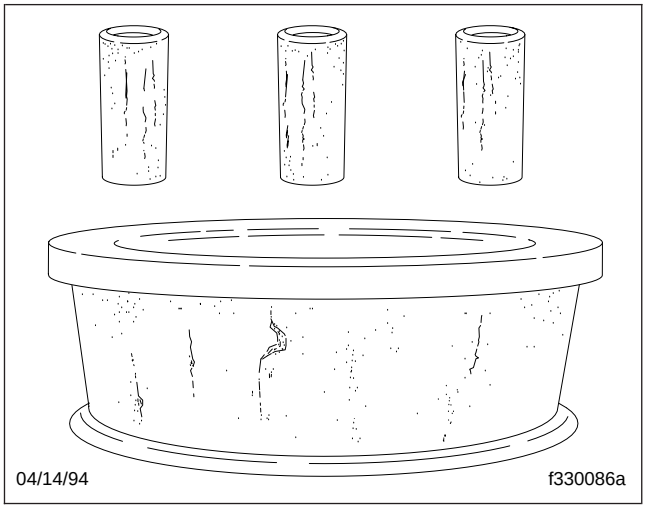


Fig. 9, Etching (Pitting) on Bearing Surfaces

Wheel Bearing Cup Removal and Installation, Ferrous Hubs

Removal

Wheel bearing cups in ferrous hubs are removed by driving them out; there is no need to first heat the hubs.

⚠ WARNING

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

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly.
2. Using a mild-steel rod through the opposite end of the hub, drive against the inner edge of the bearing cup. Alternately drive on opposite sides of the cup to avoid cocking the cup and damaging the inside of the hub.

Installation

Wheel bearing cups are installed in ferrous hubs by pressing them in; there is no need to first heat the hubs.

⚠ WARNING

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

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly, including the bearing cup bores.
2. Inspect the bearing cup bores of the hub for warpage or uneven surfaces. If a bearing cup bore is damaged, replace the wheel hub assembly.
3. Coat the hub-contact surface of the replacement bearing cup with a film of grease.
4. Position the cup in the hub and press it into place, using a suitable driving tool. Cups must seat against the shoulder in the hub.

⚠ WARNING

WARNING: To prevent skin irritation, wear chemical resistant gloves when working with diesel fuel or kerosene. Also, don't expose these fluids to flames or heat exceeding 38°C (100°F); both are combustible, and could cause personal injury if ignited.

5. Wipe off the accumulation of grease left after the bearing cup has been seated. Then, using a clean lint-free cloth dampened with kerosene or diesel fuel oil, clean the inner surface of the bearing cup. Wipe the surface dry using a clean, absorbent, and lint-free cloth or paper.

Replacement

WARNING

WARNING: If a wheel stud breaks, the remaining studs are subjected to undue strain and could fail due to fatigue. When a broken stud is replaced, replace the stud on each side of it. See Fig. 1. If more than one stud is broken, replace all of the studs. Failure to replace the studs could result in the loss of a wheel or loss of vehicle control, possibly resulting in personal injury.

1. Remove the wheel hub from the axle. For instructions, **refer to "Hub Assembly Removal and Installation, Disc Wheels, 100."**
2. If a bent portion of a wheel stud will have to pass through the wheel stud bore, cut off the bent portion before removing the wheel stud.
3. Place the wheel hub on a suitable press; make sure the hub flange is evenly supported around and next to the stud being removed. With steady movement, press the damaged stud out of the hub.

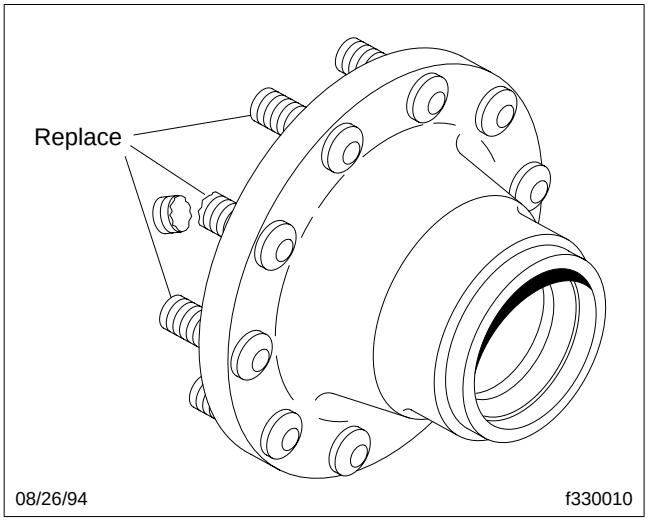


Fig. 1

CAUTION

CAUTION: Don't use a drift and hammer or concentrated heat for removing and installing the wheel studs. Constant, smooth movement of the wheel stud is needed to ensure the least amount of metal removal from the wheel stud bore. Concentrated heat will damage the hub. If the hub is damaged during wheel stud removal or installation, replace it.

4. Apply a coat of clean axle grease to the entire shaft on headed studs.
5. With the hub on a suitable press, make sure the hub flange is evenly supported around and next to the stud being installed.
6. Position the stud in its hole.

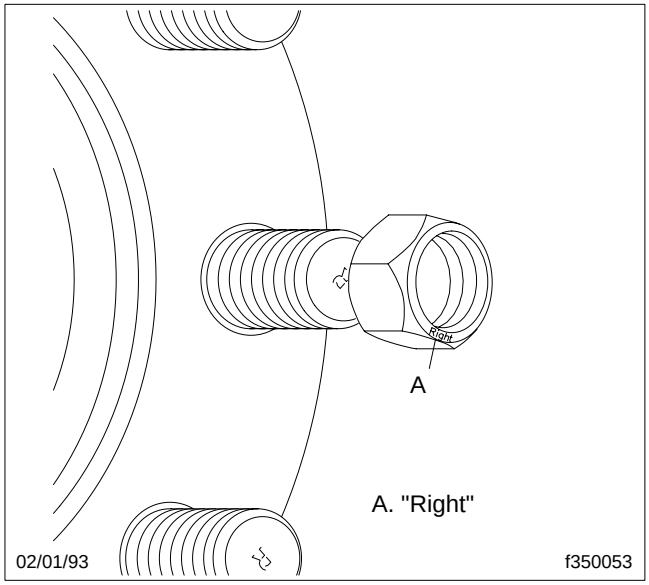


Fig. 2

CAUTION

CAUTION: Position the teeth of the serrated portion in the notches carved by the original wheel studs during factory installation. If additional metal is scraped from the wheel stud bores, the locking action provided by the serrations will be greatly weakened. Loss of locking action will prevent achieving final torque of the wheel nuts during wheel installation. If final wheel nut torques cannot be achieved, replace the wheel hub assembly.

IMPORTANT: If the driver's side of the vehicle is being serviced, the replacement wheel stud must be stamped with an "L" (left-hand

Wheel Stud Replacement, Disc Wheels

threaded), and the nut's face must be stamped "Left." If the passenger's side of the vehicle is being serviced, the replacement stud must be stamped with an "R" (right-hand threaded), and the nut's face must be stamped "Right" **(Fig. 2).**

7. With steady movement, press the new stud all the way into the hub.
8. Make sure the stud is fully seated and that its head (flange) is not embedded in the hub. If the head of the stud is embedded in the hub, replace the hub.
9. Wipe off any grease on the wheel studs and hub. Install wheel nuts on dry wheel studs only.
10. Install the wheel hub on the axle. For instructions, **refer to "Hub Assembly Removal and Installation, Disc Wheels, 100."**

Replacement

1. Remove the rim and tire assembly from the spoked wheel. For instructions, **refer to the wheels and tires group.**
2. If enough threads remain on the damaged stud, remove it by double-nutting the stud. Turn the inner nut with a wrench in order to remove the stud. Then, go to the step for tapping out the rim stud hole.

   If the rim stud is broken near the surface of the wheel, the stud should be center-drilled using a high-speed drill, and then removed with an easy-out tool. If needed, grind off a flat surface on the damaged stud, then centerpunch the surface as starting point for drilling. Remove the stud.

   2.1 Determine the correct drill diameter by referring to the easy-out tool manufacturer's guidelines. At no time should it be large enough to penetrate the threads of the stud; if the stud threads in the wheel are damaged, replace the wheel.

   2.2 Don't drill more than 32 mm (1-1/4 inches) into the broken stud, as measured at the stud's entrance into the wheel. Drilling through the bottom of the rim stud could damage the wheel. If the wheel is drilled into, replace it.

   2.3 While drilling, keep the cutting surfaces of the drill well lubricated with oil, which acts as a coolant. Allow the drill and drill bit to cool frequently.
3. After the damaged stud is removed, tap out the rim stud hole in the wheel to rid the threads of old stud-locking compound. Use an appropriate tap size, depending on the original rim stud installation size.
4. Be sure the threads of the new stud are clean and dry. Then, coat the insertion end of the rim stud with an anaerobic thread-lock compound.
5. Using double nuts on the fine thread portion of the stud, install the new stud. Seat the rim stud using the torques values in the torque table in **"Specifications, 400."**
6. Allow enough time for the thread-lock compound to set, as suggested by the manufacturer.
7. Install the rim and tire assembly. For instructions, **refer to the wheels and tires group.**

Troubleshooting

- Noisy Bearings or Excessive Bearing Replacement Intervals
- Broken Wheel or Rim Studs
- Damaged Hub
- Loss of Lubricant from the Wheel Hubs
- Vehicle Doesn't Slow Down Quickly Enough When the Brakes Are Applied

Problem—Noisy Bearings or Excessive Bearing Replacement Intervals

Possible Cause	Remedy
Not enough oil or grease was used on the bearings, or the wrong type of oil or grease was used.	Clean then inspect the bearings for wear. Replace worn seals. Coat the bearing assemblies with fresh oil or grease. For lubricant specification, **refer to "Specifications, 400."**
Foreign matter or corrosive agents entered the bearing assembly. Dirt or metallic debris from the bearings was not removed.	Clean then inspect the bearings for wear. Replace worn seals. Also clean the wheel hub, the axle spindle, and any other part in contact with the bearing lubricant.
An incorrect adjustment of the wheel bearings is causing noise and wear.	Adjust the wheel bearings following the instructions in **Subject 100** and **Subject 102** in this section.
Flat spots or dents on the roller surface were caused by skidding of the roller or improper handling of the wheel bearing during installation.	Clean then inspect the bearing rollers. Replace the bearing if damaged. Coat the replacement bearings with fresh oil. For lubricant specifications, **refer to "Specifications, 400."**

Problem—Broken Wheel or Rim Studs

Possible Cause	Remedy
The wheel or rim nuts were overtightened.	Replace the wheel or rim studs. **Refer to the wheels and tires group** for the wheel or rim nut tightening sequence.
An incorrect nut tightening sequence was used.	
The vehicle is being overloaded.	Don't exceed the maximum load-carrying capacity of the vehicle.

Problem—Damaged Hub

Possible Cause	Remedy
(Bent flange) Incorrect installation of the wheel studs, such as using a hammer and drift, or the hub flange was not fully supported on the press during wheel stud replacement.	Replace the hub assembly. Replace the wheel studs as instructed under **"Wheel Stud Replacement, Disc Wheels, 130."**
Insufficient tightening of the wheel nuts to the wheel hub.	Replace the hub assembly and tighten the wheel nuts to the values in the torque table in **"Specifications, 400."**

Problem—Loss of Lubricant from the Wheel Hubs

Possible Cause	Remedy
The seals or gaskets are worn or damaged.	Replace worn or damaged parts.

Troubleshooting

Problem—Vehicle Doesn't Slow Down Quickly Enough When the Brakes Are Applied

Possible Cause	Remedy
The brake drums are worn, heat-checked, or cracked.	Install new brake drums.

Specifications

Dual-Nut Wheel Bearing Lock Torque Values		
Application	**Size**	**Torque: lbf·ft (N·m)**
Adjusting Nut	—	Stage 1: Tighten to 100 (135)
		Stage 2: Back Off Completely
		Stage 3: Tighten to 20 (25) While Rotating Hub
		Stage 4: Back Off 1/3 Turn
Jam Nut (with Wheel Bearing Nut, Pierced Lockwasher, and Bendable Lockwasher)	1-1/8	Target: 175 (235) Permissible Range: 150–225 (205–305)
	1-1/2 to 2-1/2	Target: 250 (340) Permissible Range: 200–300 (270–405)
	2-5/8 or Larger	Target: 325 (440) Permissible Range: 250–400 (340–540)

Table 1, Dual-Nut Wheel Bearing Lock Torque Values

Lubricants for Rockwell Axles With Oil-Lubricated Bearings		
Lubricant	**Viscosity Grade By Ambient Temperature**	
Hypoid Gear Oil API Service Classification GL-5	SAE 85-140/0-76-A:	+10°F (–12°C) and up
	SAE 80W-140/0-76-B	–15°F (–26°C) and up
	SAE 80W-90/0-76-D	–15°F (–26°C) and up
	SAE 75W-90/0-76-E	–40°F (–40°C) and up
	SAE 75W/0-76-J	–40°F to +35°F (–40°C to +2°C)
	SAE 75W-140/0-76-L	–40°F (–40°C) and up

Table 2, Lubricants for Rockwell Axles With Oil-Lubricated Bearings

Lubricants for Rockwell Axles With Grease-Lubricated Bearings	
Lubricant	**Specification**
Lithium-Based Wheel Bearing Grease	Standard: 0-617A or equivalent
	Optional: 0-617B or equivalent

Table 3, Lubricants for Rockwell Axles With Grease-Lubricated Bearings

General Information

Rear axle alignment should be checked whenever rear axle or suspension components are replaced. It should also be checked when there is excessive front or rear tire wear, or hard or erratic steering.

Manufacturers of axle alignment equipment offer a variety of systems to precisely measure and correct rear axle alignment. Alignment specifications for Hunter and Bee Line alignment equipment, and for manual measurement, are in **"Specifications, 400."**

If alignment equipment is not available, the basic tools needed for checking rear axle alignment on tandem axles are a straightedge (which is nonflexible and at least as long as the axle), a steel tape rule, and a center point bar. On single axle vehicles, a straightedge, trammel bar, and steel tape rule are needed.

The straightedge is used to see if a single axle, or a forward rear axle of a tandem axle installation, is in alignment with the frame. The distance from the straightedge to the center of the wheel hub is measured on each side of the vehicle; any difference in the measurements means that the axle is out of alignment.

The center point bar **(Fig. 1)** is used to see if the forward rear axle and rearmost axle of a tandem installation are aligned with each other (parallel). The center point bar has adjustable pointers at each end, which are inserted into the axle cap holes of each axle. By comparing the distance between the two axles on one side to the distance on the other side, it can be determined if the axles are parallel.

Instructions and a list of materials for making the center point bar are in **"Specifications, 400."**

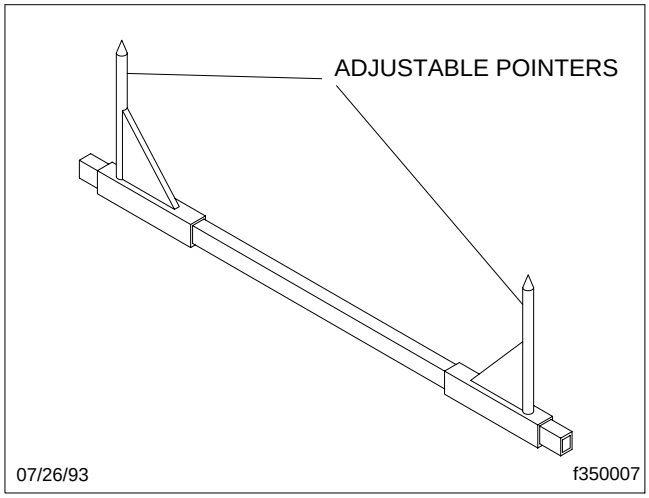


Fig. 1, Center Point Bar

Checking Thrust Angle (Perpendicularity)

NOTE: Before checking the axle alignment, make sure the wheel bearings are adjusted. For instructions, refer to the appropriate subject in this group. Make sure that no wheel rims are bent and that all rims are correctly seated. Check the frame rail alignment following the instructions in the frame group in this manual. Correct the frame rail alignment if necessary.

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

1. Park the vehicle on a level surface. Relieve internal stresses in the suspension by driving the vehicle back and forth in a straight line, or by jacking the axle up and letting it down.
2. Chock the front tires and place the transmission in neutral. Release the parking brakes.

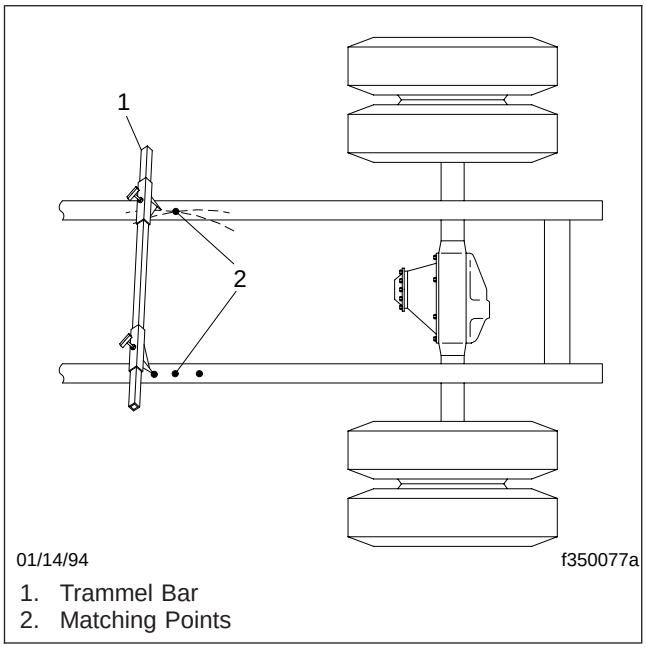
CAUTION

CAUTION: Do not use scribe lines for marking on frame rails. Scribe lines which cut or scratch the metal can develop into starting points for structural damage to the frame.

3. Select a point on the frame rail forward of the rear axle. Using a pencil or soapstone, mark two other points, about 102 mm (4 inches) forward and to the rear of the original point.

IMPORTANT: The distance from the original point to the forward and to the rear point does not have to be exactly 102 mm (4 inches), but the distance from the original point to the forward point *must* exactly equal the distance from the original point to the rear point.

4. Make sure that all three marks are aligned and of equal distance from the outside edge of the frame rail. Using a trammel bar, place one trammel pointer on the forwardmost point, and make an arc with a pencil or soapstone on the opposite frame rail. Then place the trammel pointer on the rearmost point and make an arc on the opposite frame rail intersecting the first arc. **See Fig. 1.** The point where the two arcs intersect and the original (or middle) point on the opposite frame rail have matching locations.



1. Trammel Bar
2. Matching Points

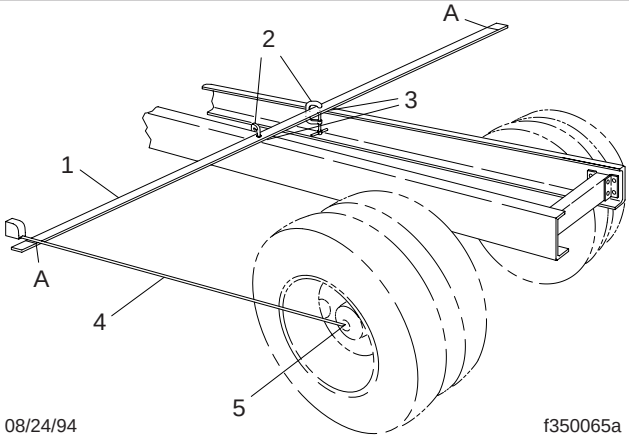
Fig. 1, Marking an Arc With the Trammel Bar

5. Line up the straightedge with the two matching points. Check that the straightedge extends out about the same distance on each side of the frame rail. Using C-clamps, clamp the straightedge to the frame. **See Fig. 2.** The straightedge must line up exactly with the points.
6. Measuring from the outside edge of each frame rail, mark the straightedge on both sides of the frame. The marks (**Fig. 2**, Ref. A) must be of equal distance from the frame and as far from the frame rail as the tires are at their farthest point from the frame.

IMPORTANT: The distance between the mark on the straightedge and the frame rail must be equal on both sides of the vehicle.

7. On each side of the vehicle, measure the distance from the mark on the straightedge to the center of the wheel hub. **See Fig. 2.** The difference between these measurements should be 9

Alignment Checking, Single Axle



1. Straightedge
2. C-Clamps
3. Matching Points
4. Tape Measure
5. Wheel Hub

Fig. 2, Straightedge to Wheel Hub Measurement

mm (3/8 inch) or less. If the difference is more than 9 mm (3/8 inch), adjust the axle alignment. For instructions, refer to the suspension section in this manual, or to the suspension manufacturer's service literature.

Checking

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Freightliner dealers must have proof of this calibration history.

A straightedge and a center point bar are needed to align a tandem axle. First, a straightedge and trammel bar are used to check and, if needed, align the rearmost axle. Then, the center point bar is used to check and, if needed, align the forward-rear axle.

Use the instructions in **Subject 100** to check and align the rearmost axle. Then, check the alignment of the forward-rear axle as follows:

IMPORTANT: Align the rearmost axle before checking the forward-rear axle.

1. Using the center point bar, set the two points into the axle cap holes as shown in **Fig. 1**. Lock them in place by tightening the setscrews.

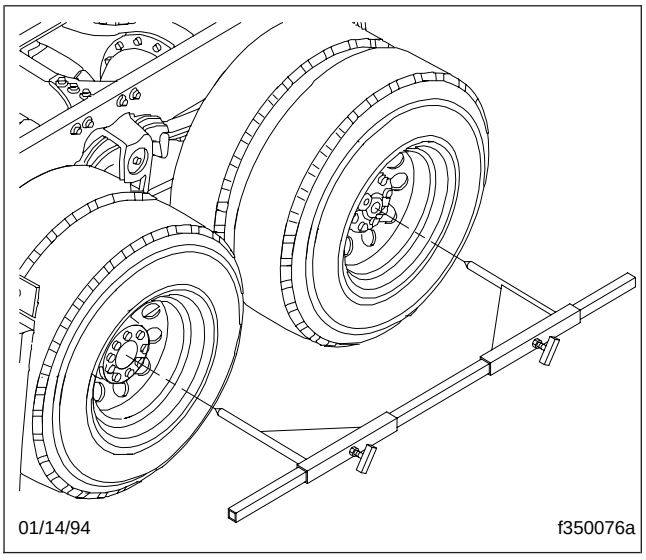
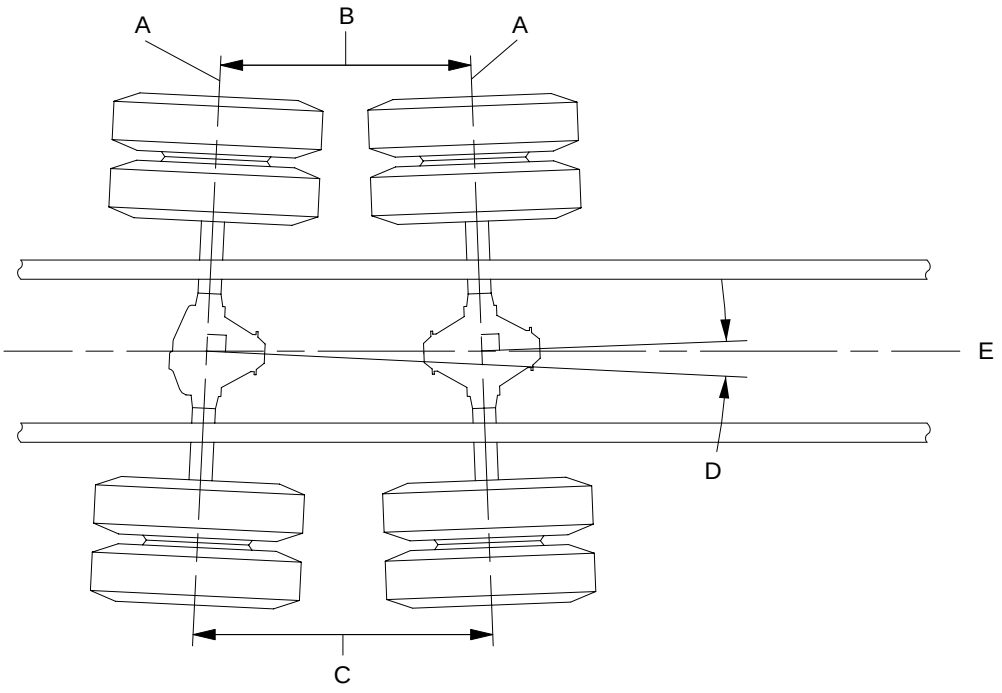


Fig. 1

2. With the points still locked in place, move the center point bar to the other side of the vehicle, set the two points into the axle cap holes, and compare the axle spacing. If there is a difference of 1/8 inch (3 mm) or less between the spacing on one side of the vehicle compared to the other, no further action is necessary.

   If the difference is more than 1/8 inch (3 mm), adjust the forward-rear axle alignment. **See Fig. 2.** For instructions, refer to the suspension section in this manual, or to the suspension manufacturer's service literature.

Manual Alignment Checking, Tandem Axle



A. Axle Centerline
B. Left-Hand Axle End Spacing, Measured Manually or with Bee Line Alignment Tools
C. Right-Hand Axle End Spacing, Measured Manually or with Bee Line Alignment Tools
D. Maximum Tolerance as Measured with Hunter Alignment Tools = ±0.08 degree
E. Vehicle Centerline

Fig. 2

Specifications

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Dealers must have proof of this calibration history.

Maximum Tolerance from Perpendicular, Manual Method	
Method	**Maximum Tolerance ± from Perpendicular**
Manual	1/4-inch (6 mm)

Table 1, Maximum Tolerance from Perpendicular, Manual Method

Maximum Tolerance from Perpendicular, Hunter Equipment	
Method	**Maximum Tolerance ± from Perpendicular**
Hunter *	0.18 degree

* To use Hunter alignment equipment, refer to the applicable Hunter service literature.

Table 2, Maximum Tolerance from Perpendicular, Hunter Equipment

Maximum Tolerance from Perpendicular at Target, Bee Line Equipment	
Distance from the Forward or Rear Drive Axle to Target inches (mm)	**Maximum Tolerance± from Perpendicular inches (mm)**
100 (2540)	5/16 (8)
120 (3048)	3/8 (10)
140 (3556)	7/16 (11)
160 (4064)	1/2 (13)
180 (4572)	9/16 (14)
200 (5080)	5/8 (16)
220 (5588)	11/16 (17)
240 (6096)	3/4 (19)
260 (6604)	13/16 (21)

Table 3, Maximum Tolerance from Perpendicular at Target, Bee Line Equipment

Rear Axle Parallelism Specifications	
Method	**Maximum Tolerance**
Hunter	±0.08 degree maximum axle-to-axle difference; reference "C" in **Fig. 1**.
Bee Line or Manual	±1/8-inch max. difference in axle end-spacing; reference "B" minus "A" in **Fig. 1**.

Table 4, Rear Axle Parallelism Specifications

Specifications

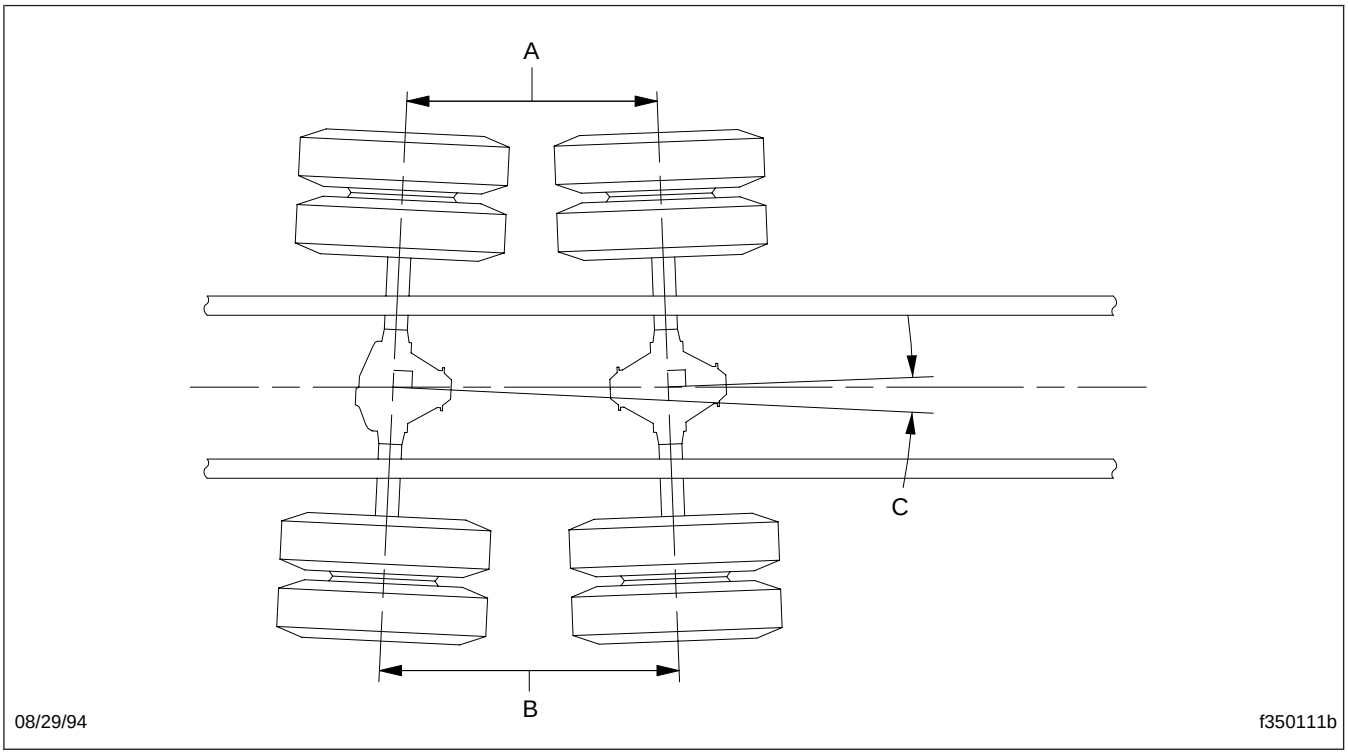


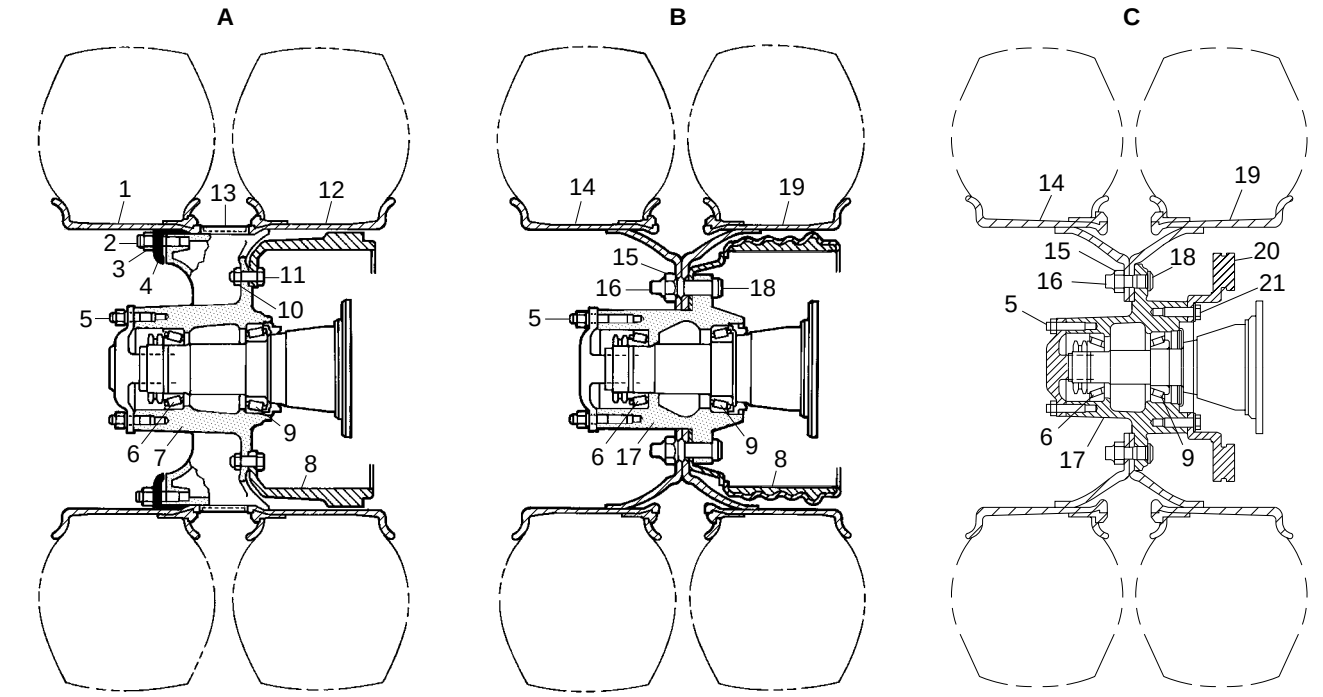
Fig. 1, Tandem Axle Measurements

General Information

The rear axle full-floating wheel hub assembly is made up of five major components: inner and outer tapered wheel bearings, the drive axle spindle assembly, the wheel hub, the brake drum, and the wheel studs. **See Fig. 1.**

Each hub has a set of inner and outer tapered wheel bearing assemblies. The bearing setting is locked in place on the axle spindle by an adjusting nut, lockring, and jam nut. **See Fig. 3.**

DRIVE AXLE SPINDLE ASSEMBLY



A. Spoke Wheel and Brake Drum Assembly
B. Disc Wheel, Wheel Hub, and Brake Drum Assembly
C. Disc Wheel, Wheel Hub, and Brake Rotor Assembly

1. Outer Rim
2. Rim Stud
3. Rim Stud Nut
4. Rim Clamp
5. Drive Axle Stud
6. Outer Wheel Bearing
7. Spoke Wheel
8. Brake Drum
9. Inner Wheel Bearing
10. Brake Drum Nut
11. Brake Drum Bolt
12. Inner Rim
13. Rim Spacer
14. Outer Wheel
15. Outer Wheel Nut
16. Inner Wheel Nut
17. Wheel Hub
18. Wheel Stud
19. Inner Wheel
20. Brake Rotor
21. Rotor Bolt

Fig. 1

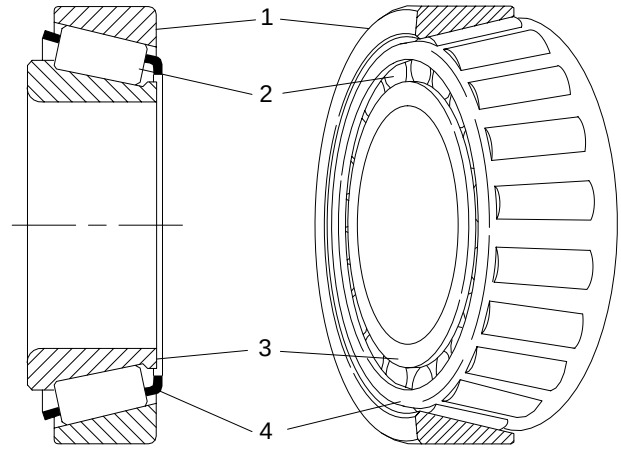
TAPERED WHEEL BEARINGS

A typical tapered wheel bearing assembly consists of a cone, tapered rollers, a roller cage, and a separate cup that is press-fit in the hub. **See Fig. 2.** All components carry the load, with the exception of the cage, which spaces the rollers around the cone.

The drive axle spindle assembly is made up of a drive axle flange and shaft, drive axle studs and stud nuts, a flange gasket, an axle spindle, an oil seal, and the nut/lockring assembly described above (**see Fig. 4**, Refs. 3 through 10, 13).

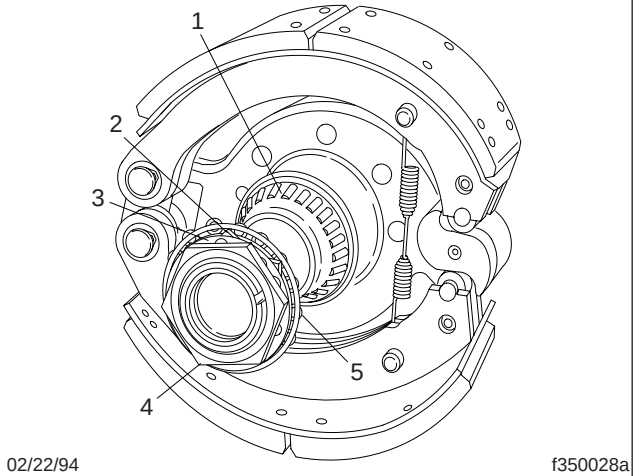
The surfaces of the spindle and the nut threads are machined. When these surfaces become damaged,

General Information



1. Cup
2. Tapered Roller
3. Cone
4. Roller Cage

Fig. 2, Tapered Wheel Bearing Assembly



1. Inner Wheel Bearing
2. Wheel Bearing Inner Adjusting Nut
3. Lockring
4. Axle Spindle Jam Nut
5. Outer Wheel Bearing

Fig. 3, Drive Axle Bearings and Spindle Assembly

repairs are necessary. There are standard methods for performing those repairs that preserve the proper alignment of the axle spindle assembly. Refer to the axle manufacturer for instructions.

CAUTION

CAUTION: The National Highway Traffic Safety Administration (NHTSA) has warned against repairs that involve cutting off a portion of a damaged spindle and welding on a replacement part. The heat of welding can reduce the strength of spindles made with heat-treated materials and lead to spindle failure. After the cutting and welding operations, the replacement part may not be correctly aligned on the spindle. This can cause damage to the spindle nut.

WHEEL HUB

The inner disc wheel and/or brake drum is mounted on an aluminum or iron wheel hub (**Fig. 4**, Ref. 20). Both the inner and outer bearing cups and certain types of wheel studs are press-fit in the hub. The hub is also the interconnecting point for the drive axle shaft and wheels.

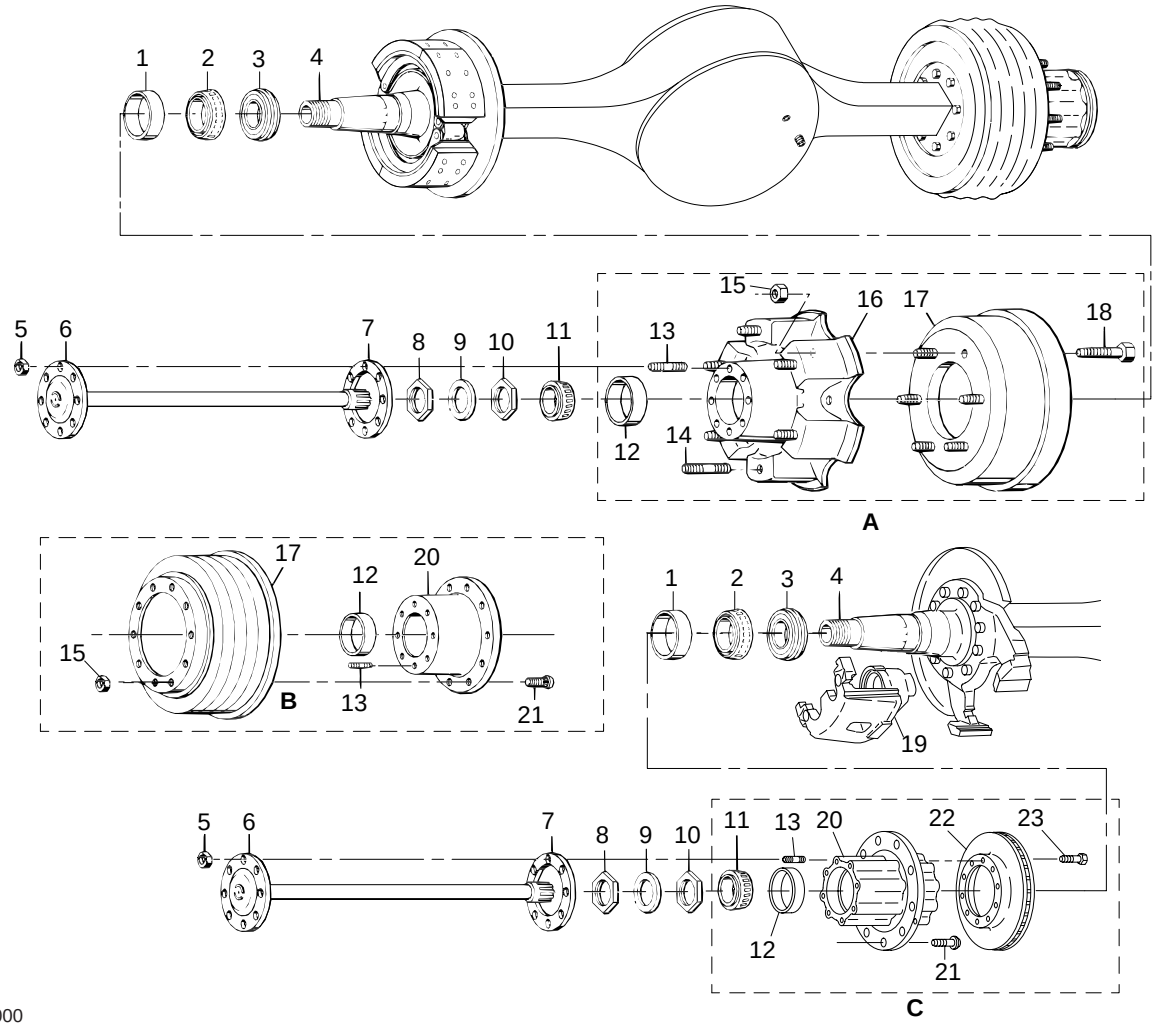
Each spoke wheel (**Fig. 4**, Ref. 16) combines both wheel and hub into a single unit.

WHEEL STUDS

A headed wheel stud (**Fig. 5**) is used on rear axle disc wheel hub assemblies and has either serrations on the stud body or a flat area on the stud's head to prevent the stud from turning in the wheel hub.

The end of the stud that faces away from the vehicle is stamped with an "L" or "R," depending on which side of the vehicle the stud is installed. Studs stamped with an "L" are left-hand threaded and are installed on the driver's side of the vehicle. Studs stamped with an "R" are right-hand threaded and are installed on the passenger's side of the vehicle.

Spoke wheels have rim studs. Rim studs are threaded on both ends, with a nonthreaded section midway along the shaft of the stud. The studs are coated with an anaerobic locking compound.



A. Spoke Wheel and Drum Assembly
B. Disc Wheel, Hub, and Drum Assembly
C. Disc Wheel, Hub, and Rotor Assembly

1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle
5. Drive Axle Stud Nut
6. Drive Axle Flange and Shaft
7. Gasket
8. Jam Nut
9. Lockring
10. Wheel Bearing Inner Adjusting Nut
11. Outer Wheel Bearing
12. Outer Wheel Bearing Cup
13. Drive Axle Stud
14. Rim Stud
15. Brake Drum Nut
16. Spoke Wheel
17. Brake Drum
18. Brake Drum Bolt
19. Brake Caliper
20. Wheel Hub
21. Wheel Stud
22. Brake Rotor
23. Rotor Bolt

Fig. 4, Typical Drive Axle (exploded view)

General Information

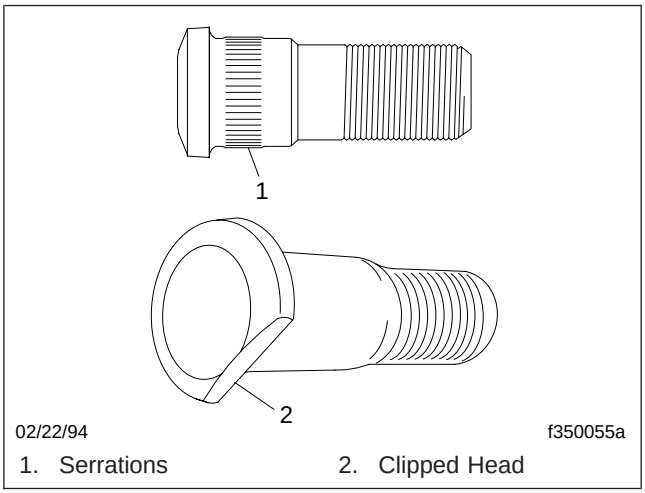


Fig. 5, Typical Headed Wheel Studs

Hub Assembly Removal and Installation, Disc Wheels

Removal

See **Fig. 1** for this procedure.

1. Chock the front tires to prevent vehicle movement. Release the parking brakes.
2. Raise the rear of the vehicle until the tires clear the ground. Place safety stands under the axle.
3. On vehicles equipped with air brakes, back off the slack adjuster to release the rear axle brake shoes. For instructions, see the applicable slack adjuster section in **Group 42**.
4. Remove both wheel and tire assemblies. For instructions, see **Group 40**.

WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air-purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, from removal of the wheels through assembly.

Never use compressed air or dry brushing to clean brake dust away. Either method can spread dangerous particles beyond the work area.

5. To minimize the possibility of creating airborne brake lining dust, clean the dust from the brake drum, brake backing plate, and brake assembly, using an industrial-type vacuum cleaner equipped with a high-efficiency filter system. Then, using a rag soaked in water and wrung until nearly dry, remove any remaining dust. Don't use compressed air or dry brushing to clean the brake assembly.
6. On vehicles with outboard drum brakes, remove the brake drum. On vehicles with disc brakes, remove the brake caliper; for instructions, see **Group 42**.

NOTE: Oil will spill as the drive axle shaft and the wheel hub are removed. Place a suitable container under the drive axle flange to catch any spilled oil. Dispose of the oil properly.

7. Remove the drive axle stud nuts and washers. See **Fig. 2**.
8. Using a hammer and a soft drift, such as one made of brass, sharply tap the center portion of the drive axle flange. See **Fig. 2**. The shaft will usually spring slightly outward after the seal has broken. Remove the drive axle shaft.

CAUTION

When tapping the drive axle flange, avoid striking the drive axle studs. If struck, the studs may bend or break, or the stud threads can be damaged. Replace damaged studs.

NOTE: Even if the drive axle shaft doesn't spring outward, the seal may have loosened enough to allow the shaft to be pulled from the axle spindle. If the seal has not broken, repeat this step.

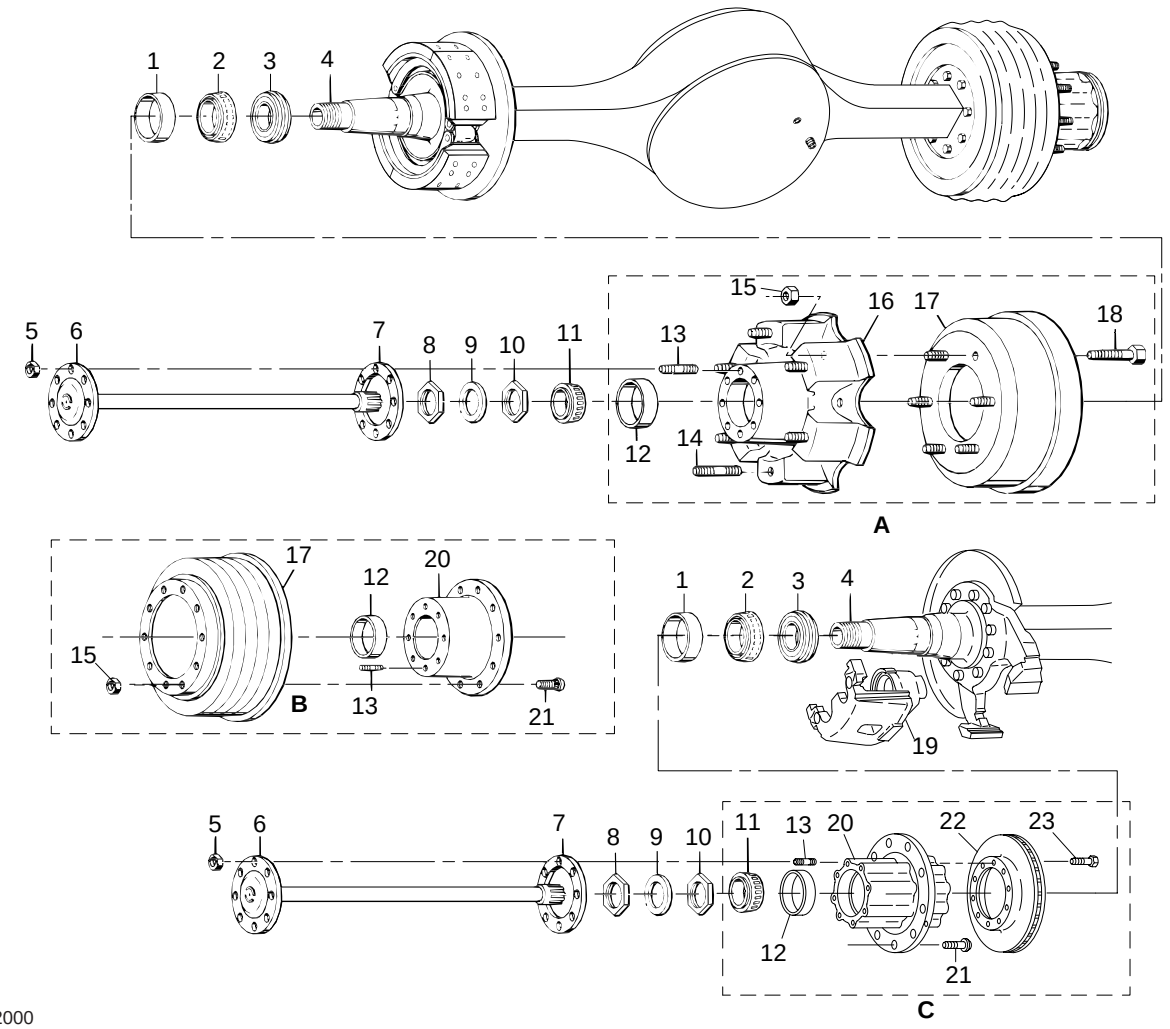
9. If equipped, remove the tapered dowels and washers from the drive axle flange.
10. Remove and discard the gasket.
11. Remove the axle spindle jam nut and the lock-ring or nut-lock, as equipped. See **Fig. 3**.
12. Back off the wheel bearing inner adjusting nut about two turns, or enough to allow the weight of the hub to be lifted from the wheel bearings.
13. Lift the hub until all weight is removed from the wheel bearings; remove the wheel bearing inner adjusting nut.

CAUTION

When moving the hub, be careful not to let the outer wheel bearing drop from the axle spindle. Dropping the bearing can warp the cage or damage the rollers, ruining the bearing.

14. Move the hub about 1/2 inch (13 mm) to jar loose the outer wheel bearing (allow the hub-only assembly to rest on the axle spindle; be careful not to damage the axle spindle threads).
15. Carefully remove the outer wheel bearing; handle the bearings with clean, dry hands. Wrap them in either clean oil-proof paper or lint-free rags.

Hub Assembly Removal and Installation, Disc Wheels



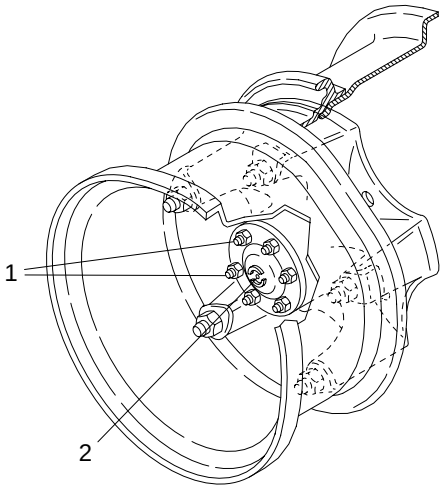
02/24/2000 f350058a

A. Spoke Wheel and Drum Assembly
B. Disc Wheel Hub and Drum Assembly
C. Disc Wheel Hub and Rotor Assembly

1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle
5. Drive Axle Stud Nut
6. Drive Axle Flange and Shaft
7. Gasket
8. Jam Nut
9. Lockring
10. Wheel Bearing Inner Adjusting Nut
11. Outer Wheel Bearing
12. Outer Wheel Bearing Cup
13. Drive Axle Stud
14. Rim Stud
15. Brake Drum Nut
16. Spoke Wheel
17. Brake Drum
18. Brake Drum Bolt
19. Brake Caliper
20 Wheel Hub
21. Wheel Stud
22. Brake Rotor
23. Rotor Bolt

Fig. 1, Typical Rear Axle Assembly

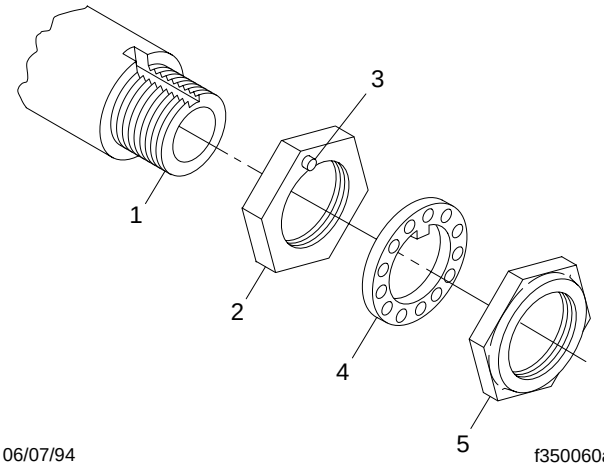
Hub Assembly Removal and Installation, Disc Wheels



06/09/94 f400090b

1. Drive Axle Studs and Nuts
2. Center Portion of Drive Axle Flange

Fig. 2, Wheel Assembly and Hub



06/07/94 f350060a

1. Axle Spindle
2. Adjusting Nut
3. Dowel
4. Pierced Lockring
5. Jam Nut

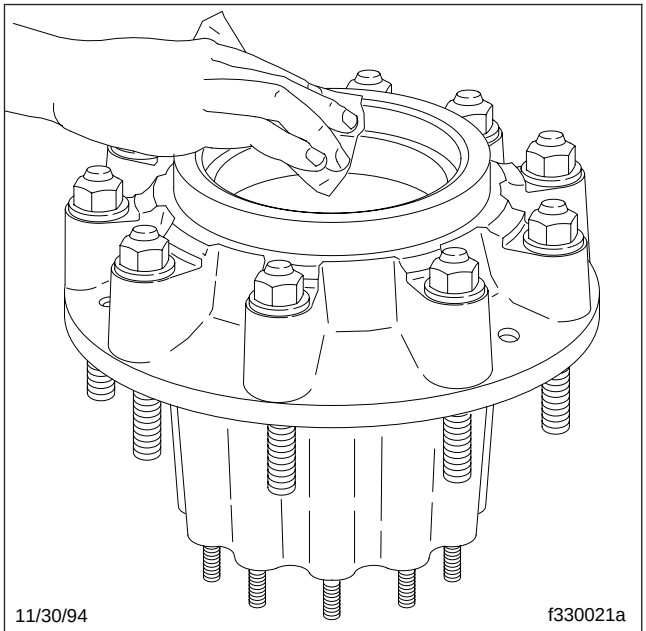
Fig. 3, Axle Secured With a Lockring

CAUTION

Do not spin bearing rollers at any time. Dirt or grit can scratch their surfaces and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

16. Remove the hub. Be careful not to damage the axle spindle threads as the assembly is removed.
17. Using a seal removal tool, remove the oil seal from the hub, if not already removed.
18. Remove the inner wheel bearing from the hub. Handle all bearing assembly parts with clean, dry hands.

    If the bearings aren't easily removed, place a protective cushion where it will catch them. Then, use a hardwood drift and a light hammer to gently tap the bearings (and seal, if needed) out of the cup. Wrap all bearing assembly parts in clean oil-proof paper or lint-free rags.
19. Using an emery cloth or a file, remove all burrs from the hub shoulder and the seal bore. See **Fig. 4** and **Fig. 5**. Clean any metal filings from the parts. For instructions, see **Subject 110**.



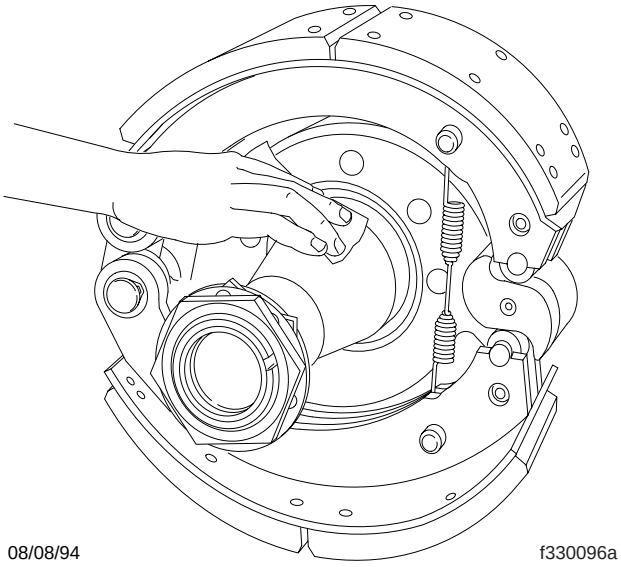
11/30/94 f330021a

NOTE: Typical application.

Fig. 4, Clean the Hub Shoulder

IMPORTANT: Use extreme care in cleaning the wheel hub cavity and axle. Dirt, metal filings, or other debris can scratch the bearing roller surfaces, and cause premature wear of the bearing assembly.

Hub Assembly Removal and Installation, Disc Wheels



NOTE: Typical application.

Fig. 5, Clean the Spindle

Installation

⚠ WARNING

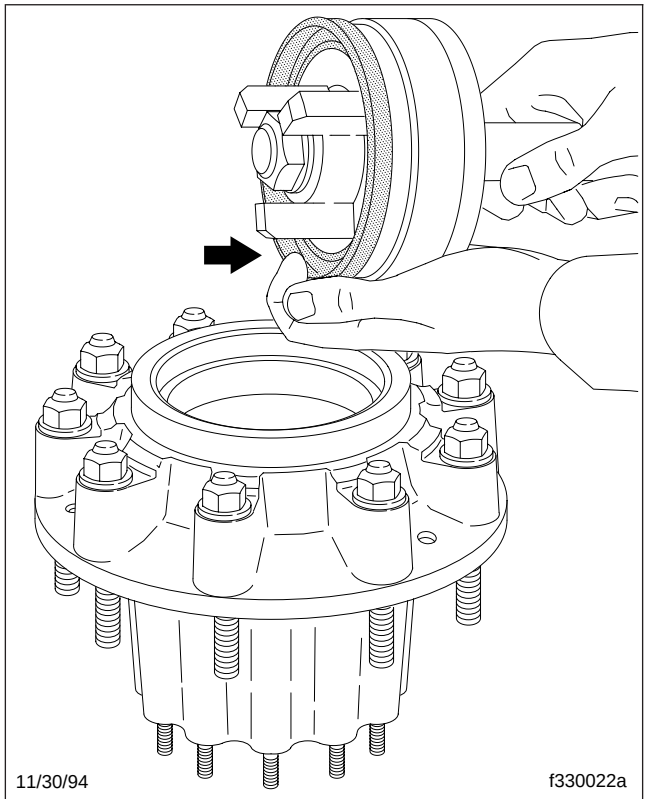
Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, continuing through installation of the wheels.

1. Using clean solvent, remove the old oil from the axle spindle and the disassembled parts. Allow the parts to dry, or dry them with a clean, absorbent, and lint-free cloth or paper. Wrap a protective layer of friction tape on the axle housing threads.
2. Coat both bearing assemblies with fresh oil. Install the inner wheel bearing and oil seal. Handle the bearings with clean, dry hands. For lubricant specifications, see **Specifications, 400**.

⚠ CAUTION

Use only fresh oil on the bearing assemblies; old oil could be contaminated with dirt or water (both are corrosives) and could cause damage to both wheel bearing assemblies and the wheel hub.

2.1 Seat the small outer diameter of the seal in the recess of the tool adaptor. See **Fig. 6**. The correct adaptor is identified on the box.



NOTE: Typical application.

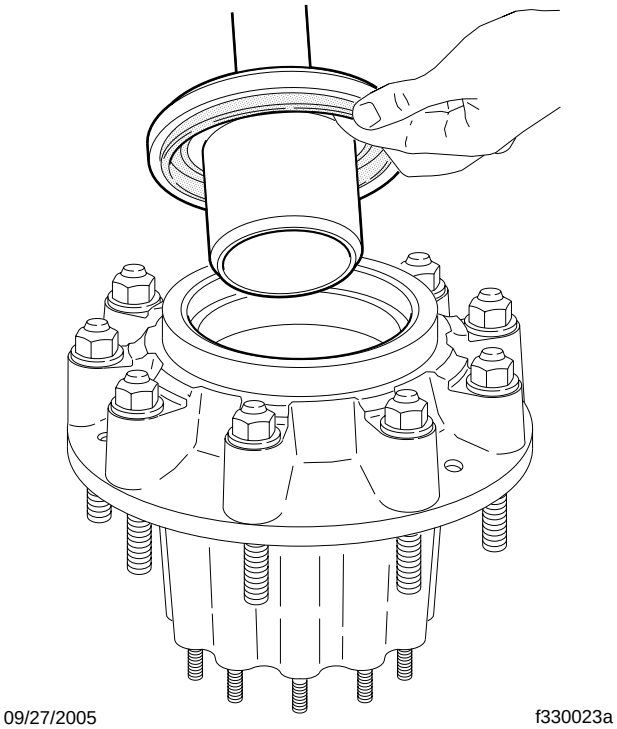
Fig. 6, Seat the Seal in the Tool

2.2 Insert the centering plug of the tool in the bore of the inner bearing cone. See **Fig. 7**. The plug prevents cocking of the seal in the bore.

2.3 Hold the tool handle firmly, and strike it until the sound of the impact changes as the seal bottoms out. See **Fig. 8**. Hold the tool firmly to avoid bounce or unseating of the seal from the adaptor.

2.4 After the seal is bottomed in the bore, check for freedom of movement by manually moving the interior rubber part of the

Hub Assembly Removal and Installation, Disc Wheels

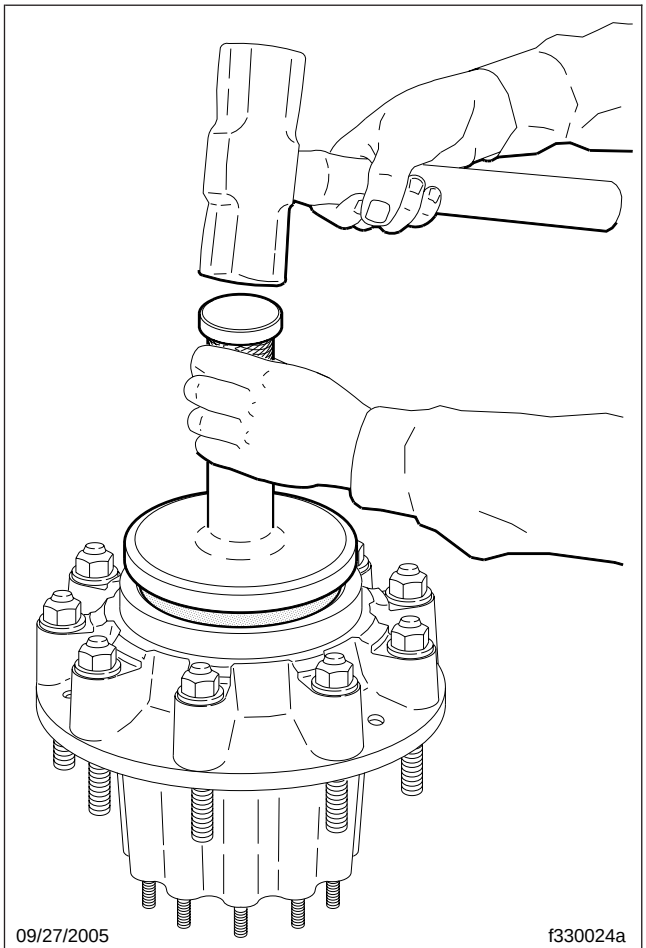


NOTE: Typical application.

Fig. 7, Insert the Tool

seal back and forth. A slight movement indicates a damage-free installation.

3. Wipe a film of axle oil on the axle spindle to prevent rust from forming behind the inner wheel bearing.
4. Carefully mount the hub and inner wheel bearing assembly on the axle spindle. Be careful not to unseat the inner wheel bearing or seal.
5. Fill the hub cavity with oil, and install the outer wheel bearing; handle the bearings with clean, dry hands. Use care not to damage the bearings as they are seated in the bearing cups. Then remove the friction tape from the axle spindle threads.
6. Install the wheel bearing adjustment nut (see **Fig. 3**):
   - 6.1 After the wheel hub and bearings are assembled on the spindle, tighten the inner adjusting nut finger-tight.



NOTE: Typical application.

Fig. 8, Strike the Tool

IMPORTANT: Be sure there is enough clearance between the brake shoes and the brake drum, so brake shoe drag won't interfere with bearing adjustment.

- 6.2 While rotating the wheel hub assembly, tighten the inner adjusting nut 100 lbf·ft (135 N·m).
- 6.3 Back off the adjusting nut completely.
- 6.4 Tighten the adjusting nut 20 lbf·ft (27 N·m) while rotating the wheel hub assembly.
- 6.5 Back off the adjusting nut one-third turn.

NOTE: If you're securing the wheel bearings with a pierced lockring, and no hole in the

Hub Assembly Removal and Installation, Disc Wheels

lockring aligns with the dowel on the adjusting nut, remove the lockring, turn it over and install it again. If a hole still doesn't align with the dowel, loosen the adjusting nut, but only enough to align the dowel with a hole in the lockring.

7. Install the locking device and jam nut.

   7.1 Install the locking device.

   NOTE: The locking device can be any one of the following types:

   - Tanged nut-lock
   - Lockring
   - Lockwasher *and* lockring
   - Nut-lock *and* lockring

   7.2 Install the jam nut, and tighten it to the applicable torque value in **Table 1**.

Dual-Nut Wheel Bearing Lock Torque Values		
Application	**Size**	**Torque: lbf·ft (N·m)**
Adjusting Nut	—	Stage 1: Tighten to 100 (135)
		Stage 2: Back Off Completely
		Stage 3: Tighten to 20 (25) While Rotating Hub
		Stage 4: Back Off 1/3 Turn
Jam Nut (with Wheel Bearing Nut, Pierced Lockwasher, and Bendable Lockwasher)	1-1/8	Target: 175 (235) Permissible Range: 150–225 (205–305)
	1-1/2 to 2-1/2	Target: 250 (340) Permissible Range: 200–300 (270–405)
	2-5/8 or Larger	Target: 325 (440) Permissible Range: 250–400 (340–540)

Table 1, Dual-Nut Wheel Bearing Lock Torque Values

8. With the jam nut installed and tightened, adjust the wheel bearings.

   8.1 Attach a dial indicator to the hub and set the point of the indicator in line with the end of the axle spindle.

   If using aluminum hubs, you may have to install the brake drum on the hub to provide a steel base for the magnet of the dial indicator. Mount the drum on the hub's drum pilot, then adjust the brake or have someone apply the brakes to hold the drum securely while you secure the drum using the stud at the 12 o'clock position, then the studs at about the 4 o'clock and 8 o'clock positions.

   NOTE: If using a stud-piloted hub and a steel drum, install 1–1/4 inch washers between the nuts and the drum.

   8.2 Release the brakes if you used them to hold the drum while installing it.

   8.3 Grip the sides of the hub at the three o'clock and nine o'clock positions, then push the hub (and drum, if applicable), to seat the inboard bearing set. Zero the dial indicator.

   8.4 Grip the sides of the hub at the three o'clock and nine o'clock positions, then pull the hub (and drum, if applicable). Read the dial indicator, and note the end play.

   8.5 Push the hub back in to confirm that the needle of the dial indicator returns to zero.

9. The end play must be between 0.001 and 0.005 inch (0.025 and 0.127 mm). If the end play is not within this range, adjust the end play.

Hub Assembly Removal and Installation, Disc Wheels

9.1 Remove the jam nut and locking device, and back off or tighten the inner adjusting nut to adjust the end play.

IMPORTANT: *If you're using a nut-lock,* turning the adjusting nut 1/4 turn will change the end play about 0.020 inch (0.51 mm).

If you're using a lockring, turning the adjusting nut one lockring hole will change the end play about 0.005 inch (0.13 mm). If you take the lockring off and reverse it, then turn the adjusting nut to the next hole, this will change the end play about 0.0025 inch (0.064 mm).

9.2 Install the locking device and jam nut as described earlier, and measure the end play. If the end play is not between 0.001 and 0.005 inch (0.03 and 0.13 mm), turn the inner adjusting nut again.

9.3 Once the end play is correct, bend the nut-lock or lockwasher as applicable to lock the jam nut and/or adjusting nut in place.

9.4 Rotate the wheel in both directions. It should rotate freely with no dragging or binding.

10. Install a new gasket on the drive axle studs.
11. Install the drive axle shaft. The splined end of the axle shaft must seat before the drive axle flange will fit over the studs.
12. If equipped, install the dowels and washers on the drive axle studs. Install the drive axle stud nuts. Using the sequence shown in **Fig. 9**, tighten the nuts to the torque values in the torque table in **Specifications, 400**.
13. Install the brake drum on the wheel hub.
14. Install the inner and outer wheel and tire assemblies. For instructions, see **Group 40**.

⚠ WARNING

If the inner wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking action, and the hub flange is probably damaged. In this case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when the conditions described above exist, could result in loss of a wheel or loss of vehicle control, and possible personal injury.

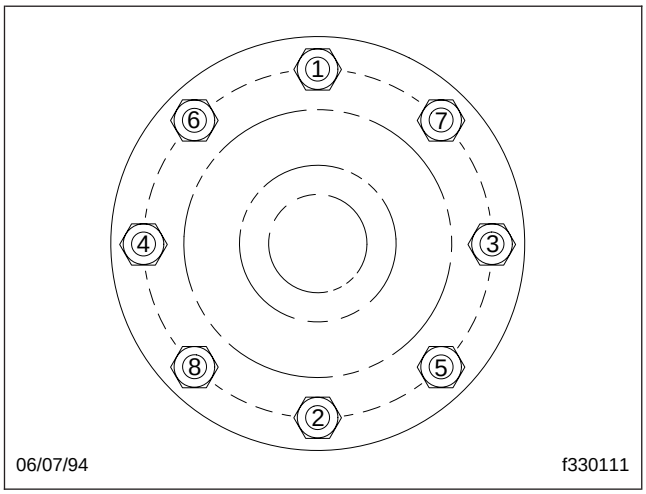


Fig. 9, Drive Axle Stud Nuts, Tightening Sequence

15. Fill the axle with lubricant. See **Specifications, 400** for the recommended axle lubricants.

⚠ WARNING

Failure to add oil to the axle housing bowl or the wheel hub after the drive axle shaft and wheel hub have been serviced will damage the wheel bearings and cause them to seize during vehicle operation. See Fig. 10. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury.

15.1 Add the recommended drive axle lubricant through the axle housing filler hole (see **Fig. 11**) or the carrier filler hole (see **Fig. 12**) until the lubricant is level with the bottom of the hole. See **Fig. 13**. Tighten the fill plug 35 lbf·ft (47 N·m).

15.2 Tilt the axle to the left and right, by jacking the opposite side. Hold the tilted position for one minute on each side, to allow oil to run into the wheel end.

15.3 Return the axle to a level position, and add oil through the axle housing fill hole. About one quart (0.9 liter) of lubricant will be needed to bring the oil level even with the base of the fill hole.

Hub Assembly Removal and Installation, Disc Wheels

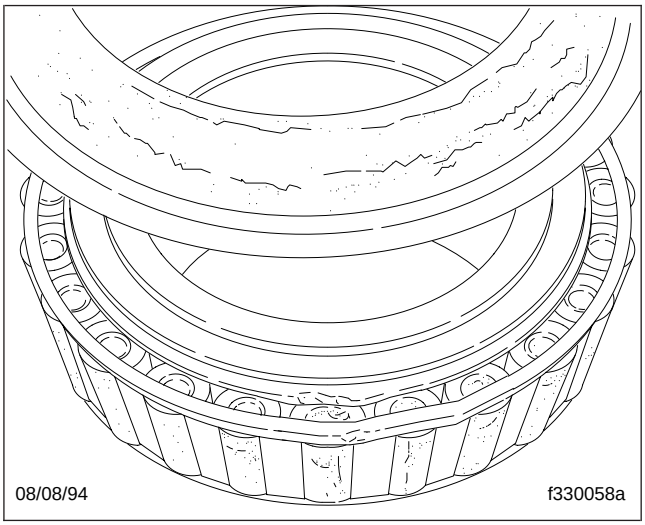
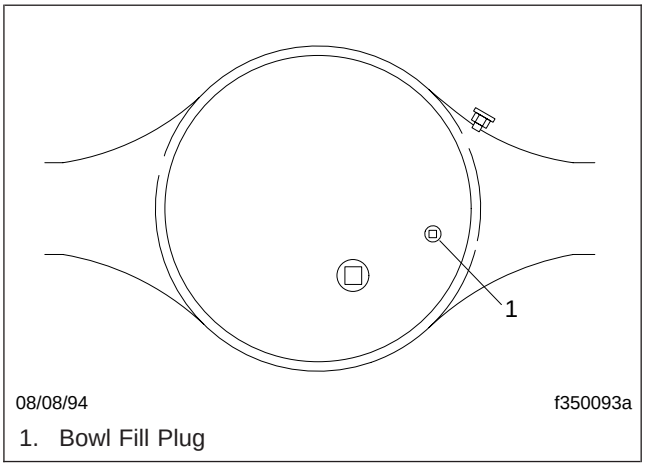


Fig. 10, Bearing Damage Resulting from Inadequate Lubrication

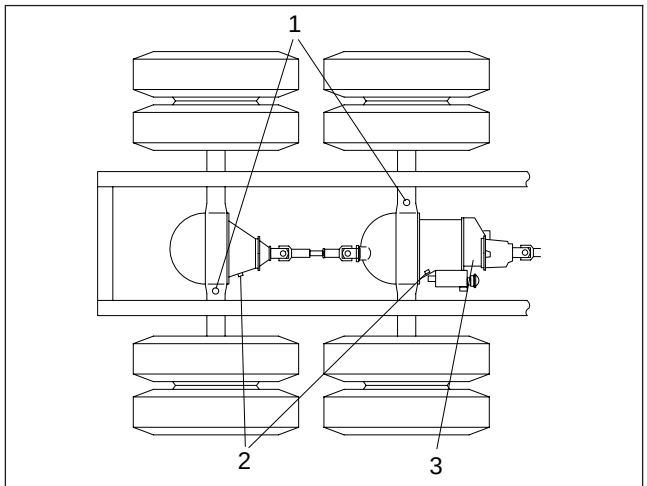


1. Bowl Fill Plug

Fig. 11, Axle Housing Filler Hole

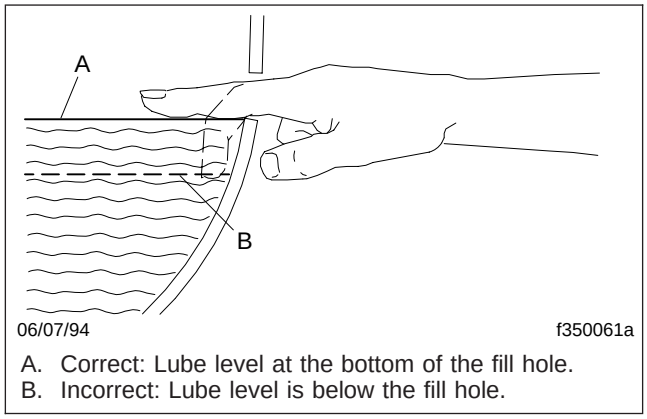
NOTE: Drive axle wheel bearings are lubricated by oil drawn from the axle housing bowl section. This method ensures good exchange of heat, prevents stagnation, and minimizes the maintenance required on bearings and hub assemblies.

16. Turn the wheels, and check the lubricant level.
17. Adjust the rear axle brakes at the slack adjuster. For instructions, see **Group 42** of the *Business Class Trucks Maintenance Manual*.
18. Remove the safety stands from under the axle and lower the vehicle.



1. Axle Housing Breathers
2. Carrier Fill Hole Plugs
3. Interaxle Differential

Fig. 12, Carrier Filler Holes



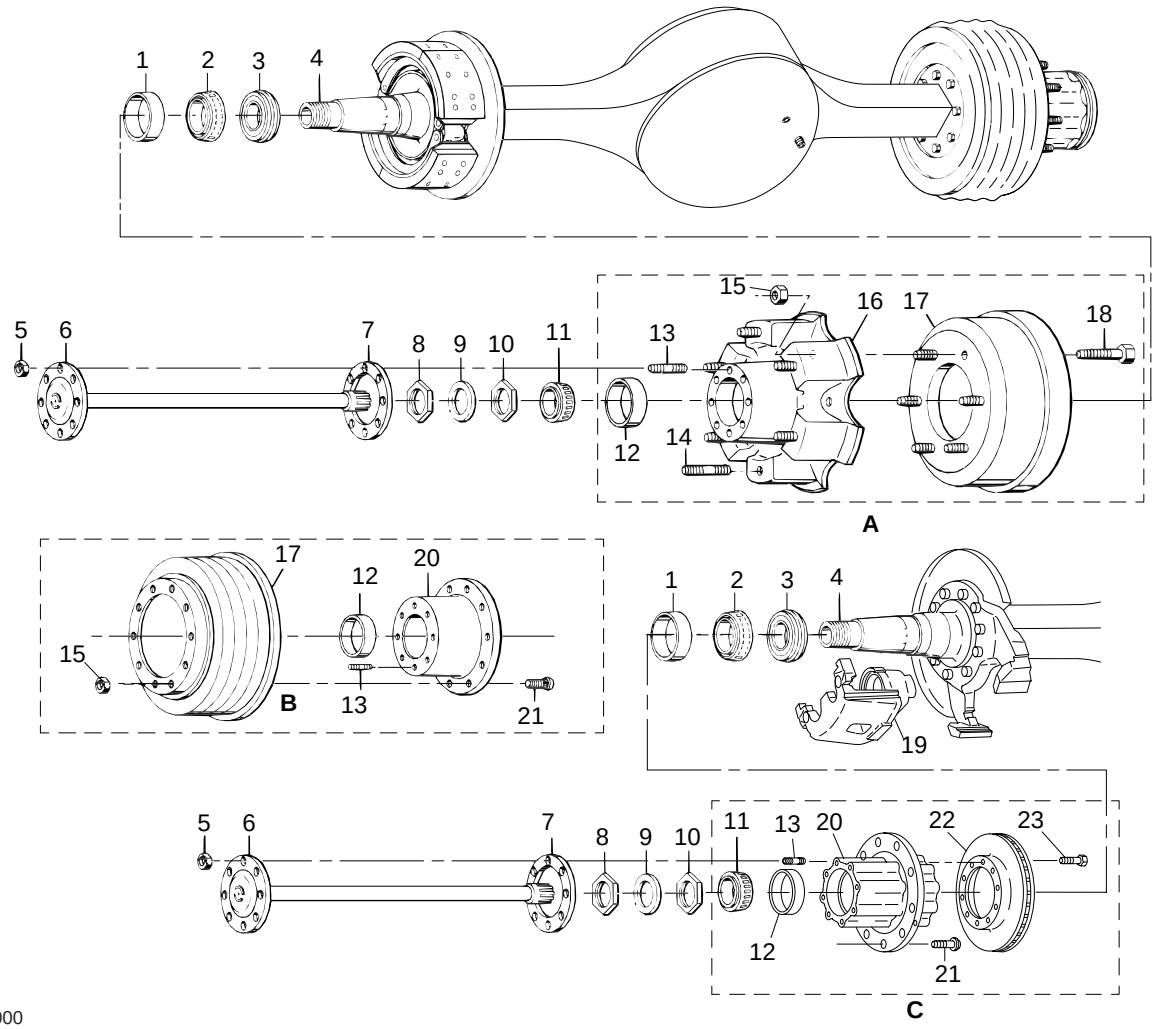
A. Correct: Lube level at the bottom of the fill hole.
B. Incorrect: Lube level is below the fill hole.

Fig. 13, Checking Lubricant Level

19. Apply the parking brakes and remove the chocks from the front tires.

Hub Assembly Removal and Installation, Spoke Wheels

Removal (See Fig. 1)



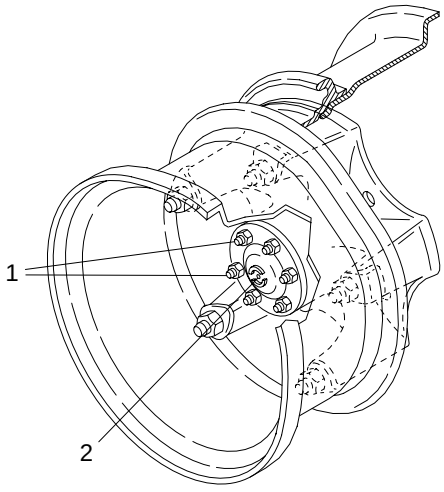
A. Spoke Wheel and Drum Assembly
B. Disc Wheel Hub and Drum Assembly
C. Disc Wheel Hub and Rotor Assembly
1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle
5. Drive Axle Stud Nut
6. Drive Axle Flange and Shaft
7. Gasket
8. Jam Nut
9. Lockring
10. Wheel Bearing Inner Adjust Nut
11. Outer Wheel Bearing
12. Outer Wheel Bearing Cup
13. Drive Axle Stud
14. Rim Stud
15. Brake Drum Nut
16. Spoke Wheel
17. Brake Drum
18. Brake Drum Bolt
19. Brake Caliper
20 Wheel Hub
21. Wheel Stud
22. Brake Rotor
23. Rotor Bolt

Fig. 1, Typical Rear Axle Assembly

Hub Assembly Removal and Installation, Spoke Wheels

Spoke wheel assemblies with inboard drums don't need to be completely disassembled for brake component maintenance. The tires and rims can remain attached to the wheel, and the wheel to the brake drum. The assembly is then removed from the axle as a single unit to expose brake components. See **Group 42** for brake assembly service information.

1. Chock the front tires to prevent vehicle movement. Release the parking brakes.
2. Raise the rear of the vehicle until the tires clear the ground. Then place safety stands under the axle to be serviced. Position a jack or wheel-and-tire dolly under the tires.
3. Remove both rim and tire assemblies. For instructions, see **Group 40**.
4. If the vehicle is equipped with air brakes, back off the slack adjuster to release the rear axle brake shoes. For instructions, see the applicable slack adjuster section in **Group 42**. If the vehicle is equipped with hydraulic brakes, remove the brake caliper. For instruction, see **Group 42**.
5. Remove the drive axle flange nuts (**Fig. 2**) and washers.



06/09/94 f400090b

1. Drive Axle Studs and Nuts
2. Center Portion of Drive Axle Flange

Fig. 2, Wheel Assembly and Hub

NOTE: Oil will spill as the drive axle shaft and wheel are removed. Place a suitable container under the wheel to catch any spilled oil. Safely discard the oil.

6. Using a hammer and a soft drift, such as one made of brass, sharply tap the center portion of the drive axle flange. See **Fig. 2**. The shaft will usually spring slightly outward after the seal has broken. Then remove the drive axle shaft.

CAUTION

When tapping the drive axle flange, avoid striking the drive axle studs. If struck, the studs may bend or break, or the stud threads can be damaged. Replace damaged studs.

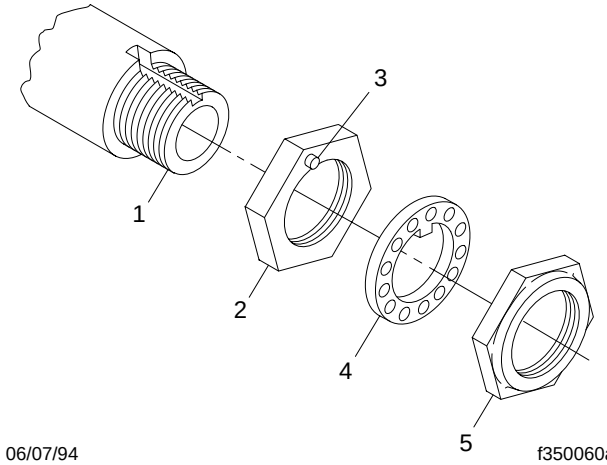
NOTE: Even if the drive axle shaft doesn't spring outward, the seal may have loosened enough to allow the shaft to be pulled from the axle housing. If the seal has not broken, repeat the above step.

7. If so equipped, remove the tapered dowels and washers from the drive axle flange.
8. Remove and discard the gasket.
9. Remove both the axle spindle jam nut and the lockring. See **Fig. 3**. Then, back off the wheel bearing inner adjusting nut about two turns, or enough to allow the weight of the wheel and drum assembly to be lifted from the wheel bearings.
10. Using the wheel dolly or jack, raise the wheel and drum assembly until all weight is removed from the bearings. Then remove the wheel bearing inner adjusting nut.
11. Carefully remove the outer wheel bearing; handle the bearings with clean, dry hands. If the wheel bearings have not loosened from the cup, move the wheel assembly about 1/2 inch (13 mm) to jar loose the outer wheel bearing. Be careful to not drop the bearings. Wrap them in clean oil-proof paper or lint-free rags.

WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air-purifying respirator approved by MSHA or NIOSH. Wear a res-

Hub Assembly Removal and Installation, Spoke Wheels



1. Axle Spindle
2. Adjusting Nut
3. Pin
4. Pierced Lockring
5. Jam Nut

Fig. 3, Axle Secured With a Lockring

pirator at all times when servicing the brakes, from removal of the wheels through assembly.

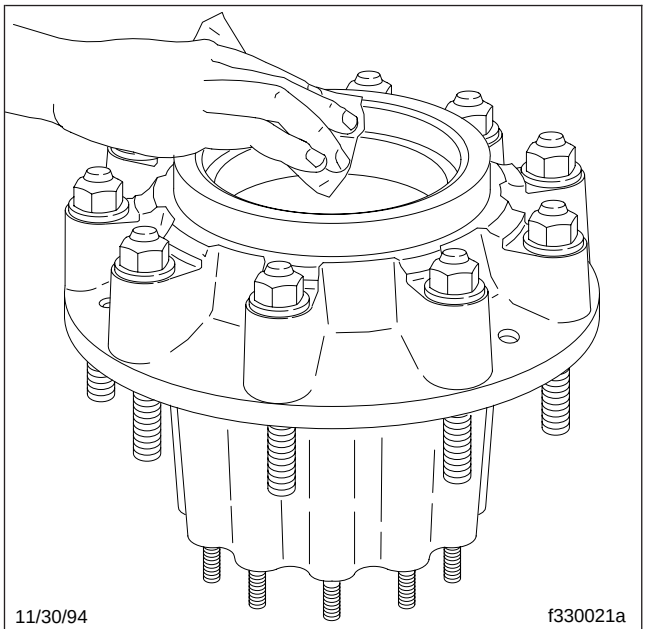
Never use compressed air or dry brushing to clean brake dust away. Either method can spread dangerous particles beyond the work area.

⚠ CAUTION

Don't spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

12. Using the wheeled support, pull the wheel assembly away from the vehicle. Be careful not to damage the axle spindle threads as the assembly is removed.
13. Remove the brake drum or rotor nuts (**Fig. 1**) and detach the brake drum or rotor from the wheel. For instructions, see **Group 42**.

    To minimize the possibility of creating airborne brake lining dust, clean the dust from the brake drum, brake backing plate, and brake assembly, using an industrial-type vacuum cleaner equipped with a high-efficiency filter system. Then, using a rag soaked in water and wrung until nearly dry, remove any remaining dust. Don't use compressed air or dry brushing to clean the brake assembly.
14. Remove the oil seal, using an oil seal removal tool.
15. Remove the inner wheel bearing from the hub. If the bearings aren't easily removed, place a protective cushion where it will catch the bearing. Then, use a hardwood drift and a light hammer to gently tap the bearing (and seal, if needed) out of the cup. Handle the bearings with clean, dry hands. Wrap them in clean oil-proof paper or lint-free rags.
16. Remove all burrs from the shoulder and the seal bore with an emery cloth or a file. See **Fig. 4** and **Fig. 5**. Clean any metal filings from the parts.

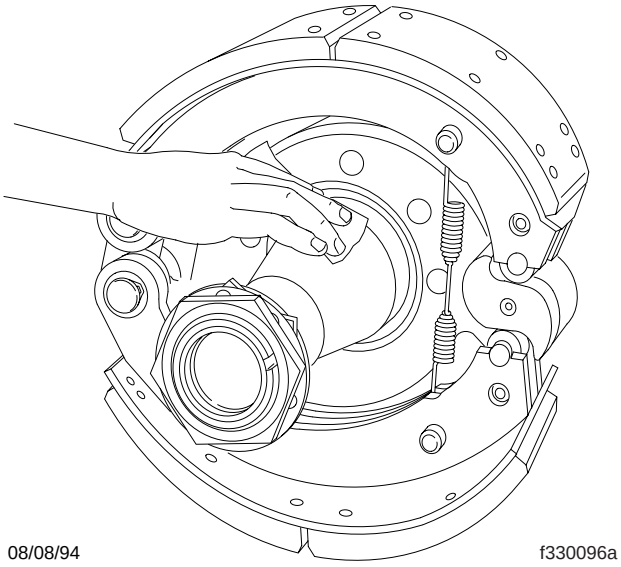


NOTE: Typical application.

Fig. 4, Clean the Hub Shoulder

IMPORTANT: Use extreme care in cleaning the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause premature wear of the bearing assembly.

Hub Assembly Removal and Installation, Spoke Wheels



NOTE: Typical application.

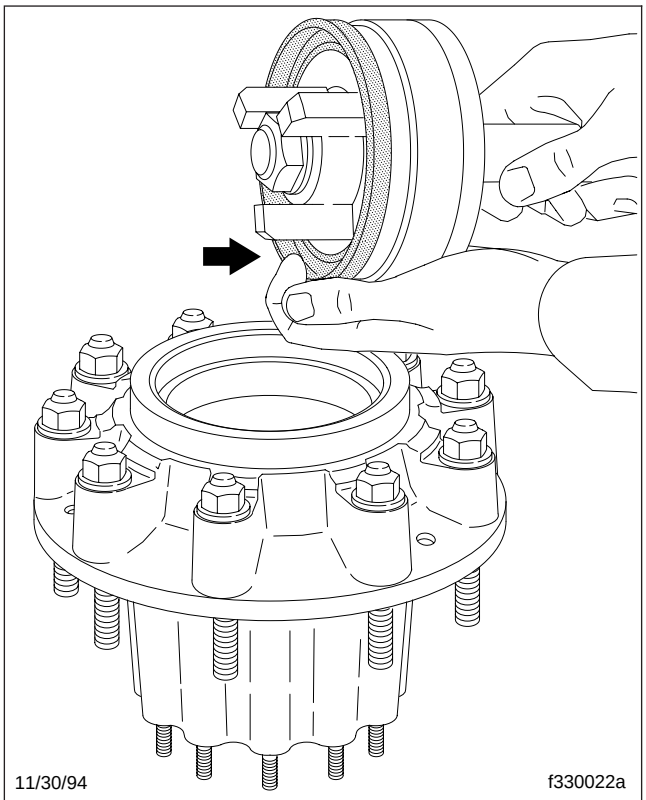
Fig. 5, Clean the Spindle

Installation (See Fig. 1)

⚠ WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, continuing through installation of the wheels.

1. Using clean solvent, remove the old oil from the axle spindle and also the disassembled parts. Inspect and clean the wheel hub cavity and the wheel bearings as instructed under **Subject 110**. Allow the parts to dry, or dry them with a clean, absorbent, and lint-free cloth or paper.
2. Wrap a protective layer of friction tape on the axle spindle threads.
3. If it was removed, attach the brake drum or rotor to the wheel. Install the brake drum or rotor bolts and nuts, then tighten the nuts to the torque values in the torque table in **Specifications, 400**. See **Group 42** for additional instructions.
4. Coat both bearing assemblies with fresh oil. Install the inner wheel bearing and oil seal. Handle the bearings with clean, dry hands.
   - 4.1 Seat the small outer diameter of the seal in the recess of the tool adaptor. See **Fig. 6**. The correct adaptor is identified on the box.
   - 4.2 Insert the centering plug of the tool in the bore of the inner bearing cone. See **Fig. 7**. The plug prevents cocking of the seal in the bore.

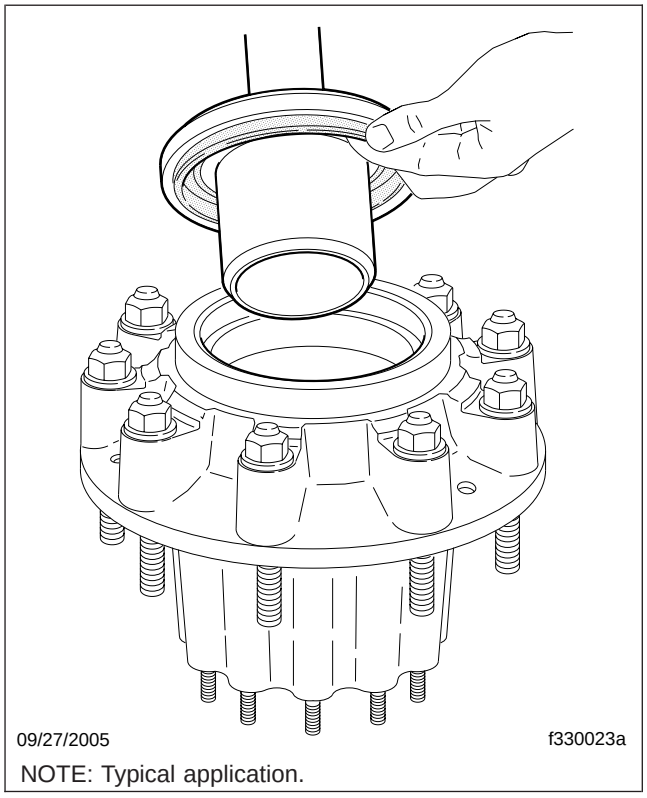


NOTE: Typical application.

Fig. 6, Seat the Seal in the Tool

   - 4.3 Hold the tool handle firmly, and strike it until the sound of the impact changes as the seal bottoms out. See **Fig. 8**. Hold the tool firmly to avoid bounce or unseating of the seal from the adaptor.
   - 4.4 After the seal is bottomed in the bore, check for freedom of movement by manually moving the interior rubber part of the

Hub Assembly Removal and Installation, Spoke Wheels



NOTE: Typical application.

Fig. 7, Insert the Tool

seal back and forth. A slight movement indicates a damage-free installation.

5. Wipe a film of axle oil on the axle spindle to prevent rust from forming behind the inner wheel bearing.
6. Using a wheeled support, mount the wheel and drum assembly on the axle spindle; be careful not to unseat the bearings or seal.
7. Fill the hub cavity with oil, and install the outer wheel bearing; handle the bearings with clean, dry hands. Then remove the friction tape from the axle spindle threads.
8. Adjust the wheel bearings as follows (see **Fig. 3**):

   IMPORTANT: Be sure there is enough clearance between the brake shoes and the brake drum, so brake shoe drag won't interfere with bearing adjustment.

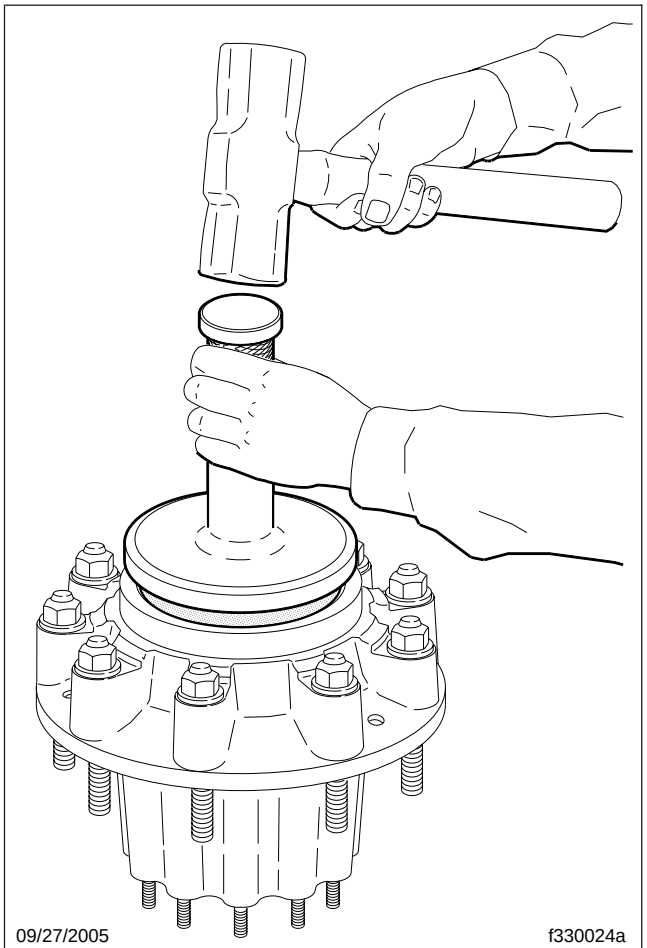
   8.1 After the wheel hub and bearings are assembled on the spindle, tighten the inner (adjusting) nut 200 lbf·ft (271 N·m) while rotating the wheel hub assembly.

   8.2 Back off the inner nut one full turn.

   8.3 Tighten the inner nut 50 lbf·ft (68 N·m) while rotating the wheel hub assembly.

   8.4 Back off the inner nut one quarter turn.

   NOTE: If you're securing the wheel bearings with a pierced lockring, and no hole in the lockring aligns with the dowel on the adjusting nut, remove the lockring, turn it over and install it, again. If a hole still doesn't align with the dowel, loosen the adjusting nut, but only enough to align the dowel with a hole in the lockring.



NOTE: Typical application.

Fig. 8, Strike the Tool

Hub Assembly Removal and Installation, Spoke Wheels

8.5 Install the locking device:

- Tanged nut-lock
- Lockring
- Lockwasher *and* a lockring
- Nut-lock *and* a lockring

Then install the jam nut, and tighten it to the applicable torque in **Table 1**.

Dual-Nut Wheel Bearing Lock Torque Values

Application	Size	Torque: lbf·ft (N·m)
Adjusting Nut	—	Stage 1: Tighten to 100 (135) Stage 2: Back Off Completely Stage 3: Tighten to 20 (25) While Rotating Hub Stage 4: Back Off 1/3 Turn
Jam Nut (with Wheel Bearing Nut, Pierced Lockwasher, and Bendable Lockwasher)	1-1/8	Target: 175 (235) Permissible Range: 150–225 (205–305)
	1-1/2 to 2-1/2	Target: 250 (340) Permissible Range: 200–300 (270–405)
	2-5/8 or Larger	Target: 325 (440) Permissible Range: 250–406 (340–540)

Table 1, Dual-Nut Wheel Bearing Lock Torque Values

8.6 With the jam nut installed and tightened, attach a dial indicator to the hub and set the point of the indicator in line with the end of the axle spindle.

If using aluminum hubs, you may have to install the brake drum on the hub to provide a steel base for the magnet of the dial indicator. Mount the drum on the hub's drum pilot, then adjust the brake or have someone apply the brakes to hold the drum securely while you secure the drum using the stud at the 12 o'clock position, then the studs at about the 4 o'clock and 8 o'clock positions.

NOTE: If using a stud-piloted hub and a steel drum, install 1–1/4 inch washers between the nuts and the drum.

8.7 Release the brakes if you used them to hold the drum while installing it.

Grip the sides of the hub at the three o'clock and nine o'clock positions, then push the hub (and drum, if applicable), to seat the inboard bearing set. Zero the dial indicator.

Grip the sides of the hub at the three o'clock and nine o'clock positions, then pull the hub (and drum, if applicable). Read the dial indicator, and note the end play.

Push the hub back in to confirm that the needle of the dial indicator returns to zero.

The end play must be between 0.001 and 0.005 inch (0.025 and 0.127 mm).

9. If the end play is not within this range, remove the jam nut and locking device, and back off or tighten the inner (adjusting) nut to adjust the end play. Keep the following in mind:

If you're using a nut-lock: turning the inner nut 1/4 turn will change the end play about 0.020 inch (0.508 mm).

If you're using a lockring: turning the inner nut one lockring hole will change the end play about 0.005 inch (0.127 mm). If you take the lockring off and reverse it, then turn the inner nut to the next hole, this will change the end play about 0.0025 inch (0.0635 mm).

Install the locking device and jam nut as described earlier, and measure the end play. If the end play is not between 0.001 and 0.005 inch (0.025 and 0.127 mm), adjust the inner (adjusting) nut, again.

10. Once the end play is correct, bend the nut-lock or lockwasher as applicable to lock the jam nut and/or adjusting nut in place.
11. Rotate the wheel in both directions. It should rotate freely with no dragging or binding.
12. Install a new gasket on the drive axle studs.
13. Install the drive axle shaft. The splined end of the axle shaft must seat before the drive axle flange will fit over the studs.
14. If equipped, install the dowels and washers on the drive axle studs. Install the drive axle nuts. Using the sequence shown in **Fig. 9**, tighten the nuts to the torque values in the torque table in **Specifications, 400**.

Hub Assembly Removal and Installation, Spoke Wheels

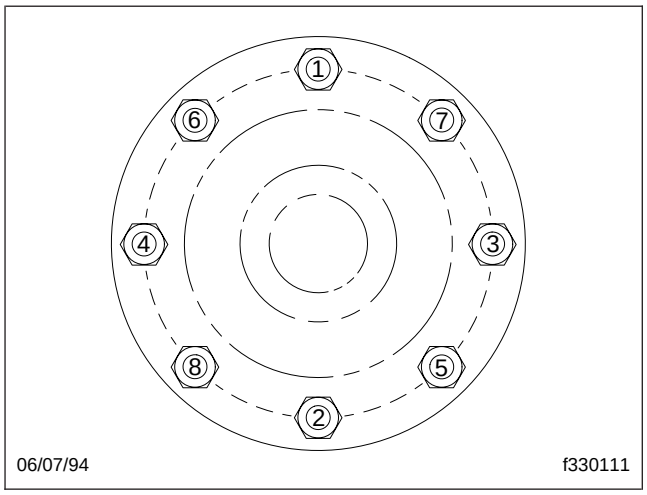


Fig. 9, Axle Shaft Flange Nut-Tightening Sequence

15. Install the brake caliper, if removed. See **Group 42** for instructions.
16. Install the rim and tire assemblies. For instructions, see **Group 40**.

⚠ WARNING

If the inner rim nuts cannot be tightened to minimum torque values, the rim studs have lost their locking action, and the wheel is probably damaged. In this case, replace it with a new wheel. Failure to replace the wheel when the conditions described above exist, could result in loss of a wheel or loss of vehicle control, and possible personal injury.

17. Fill the axle with lubricant.

⚠ WARNING

Failure to add oil to the axle housing bowl or the wheel hub after the drive axle shaft and wheel have been serviced will damage the wheel bearings and cause them to seize during vehicle operation. See Fig. 10. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury.

17.1 Pour the recommended drive axle lubricant through the axle housing filler hole (**Fig. 11** or **Fig. 12**) until the lubricant is level with the bottom of the hole. See **Fig. 13**. See **Specifications, 400** for the recommended axle lubricants. Tighten the plug 35 lbf·ft (47 N·m).

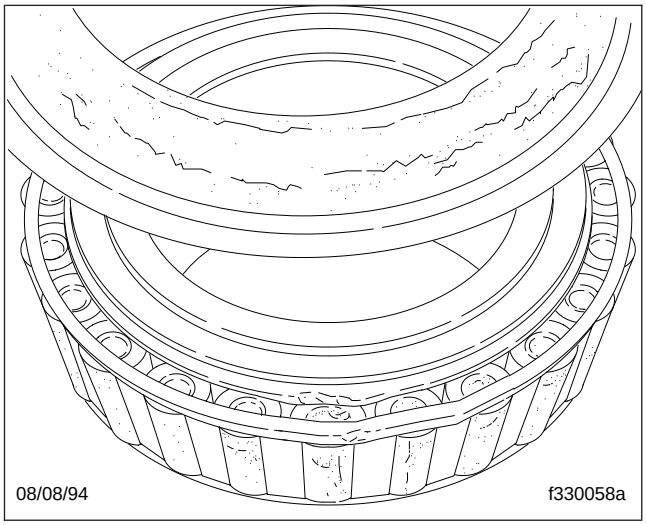


Fig. 10, Bearing Damage Resulting from Inadequate Lubrication

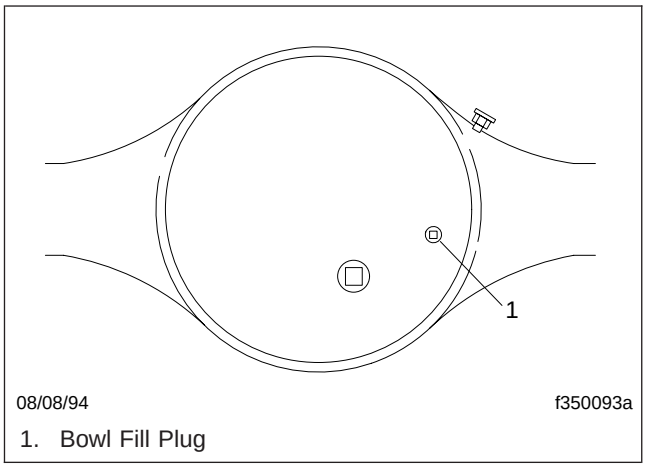
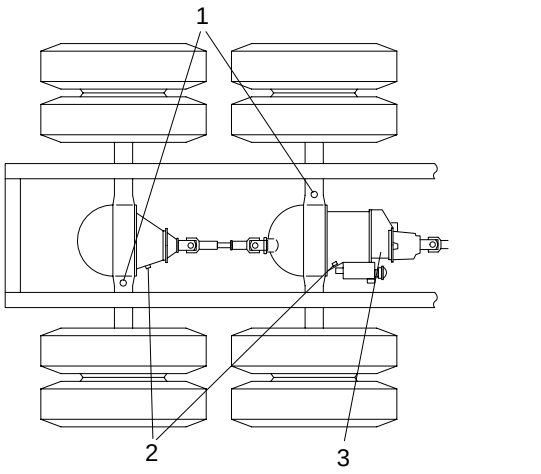


Fig. 11, Filler Hole

17.2 Tilt the axle to the left and right, by jacking the opposite side. Hold the tilted position for one minute on each side, to allow oil to run into the wheel end.

17.3 Return the axle to a level position, and add oil through the axle housing filler hole. About one extra liter (two pints) of lubricant will be needed, to bring the oil level even with the base of the filler hole.

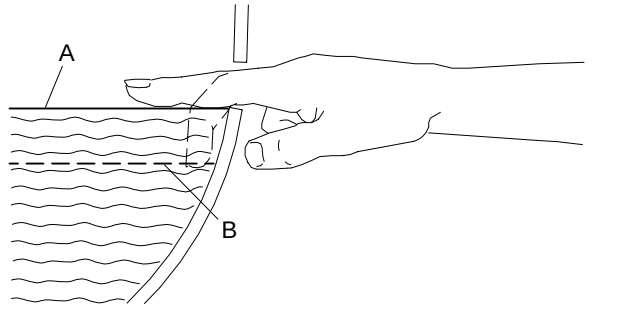
Hub Assembly Removal and Installation, Spoke Wheels



06/07/94 f350062a

1. Axle Housing Breathers
2. Carrier Fill Hole Plugs
3. Interaxle Differential

Fig. 12, Fill Hole Plug and Axle Housing Breather Locations



06/07/94 f350061a

A. Correct: Lube level at the bottom of the fill hole.
B. Incorrect: Lube level is below the fill hole.

Fig. 13, Checking the Lubricant Level

NOTE: Drive axle wheel bearings are lubricated by oil drawn from the axle housing bowl section. This method ensures good exchange of heat, prevents stagnation, and minimizes the maintenance required on bearings and hub assemblies.

18. Turn the wheels, and check the lubricant level.
19. If the vehicle is equipped with air brakes, adjust the rear axle brakes at the slack adjusters. For instructions, see Group 42 of the *Business Class Trucks Maintenance Manual*.
20. Remove the safety stands from under the axle, then lower the vehicle.
21. Apply the parking brakes, then remove the chocks from the front tires.

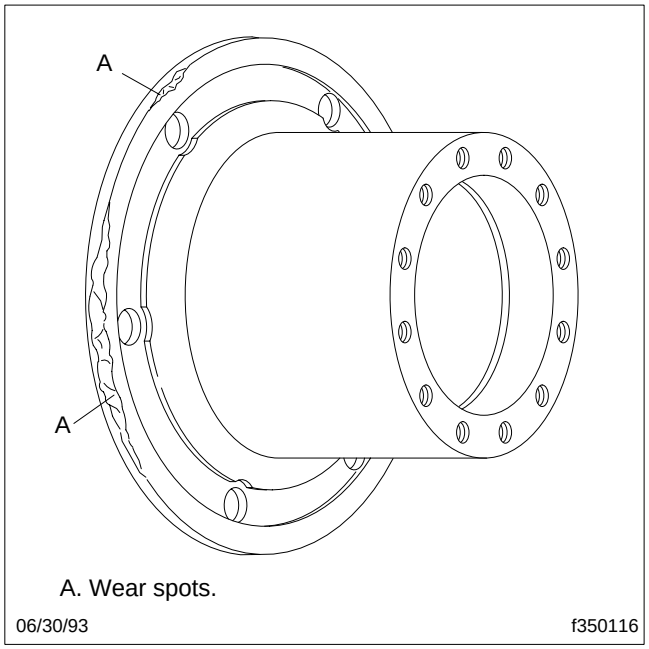
Wheel Hub Assembly and Drive Axle Inspection

1. Inspect the wheel hub flange. A loose wheel assembly will cause the flange to be worn, jagged, or warped. **See Fig. 1.** Replace the wheel hub if any of these conditions exist.

   Inspect the flange surface around the wheel studs. Improperly torqued wheel nuts will cause worn or cracked stud grooves on the hub. **See Fig. 2.** If wear spots or cracks appear anywhere on the hub, or if the hub is otherwise damaged, replace it with a new one.

2. Remove all the old oil from the spoke wheel or hub cavity. Inspect the inner surface of the wheel or hub for cracks, dents, wear, or other damage. Replace the wheel or hub if damaged.

3. Remove all the old grease or oil from the surfaces of the wheel bearing cups. Inspect the cups for cracks, wear, spalling, or flaking. **See Fig. 3.** Replace the cups if damaged in any way; for instructions, **refer to "Wheel Bearing Cup Removal and Installation, Ferrous Hubs, 120."**



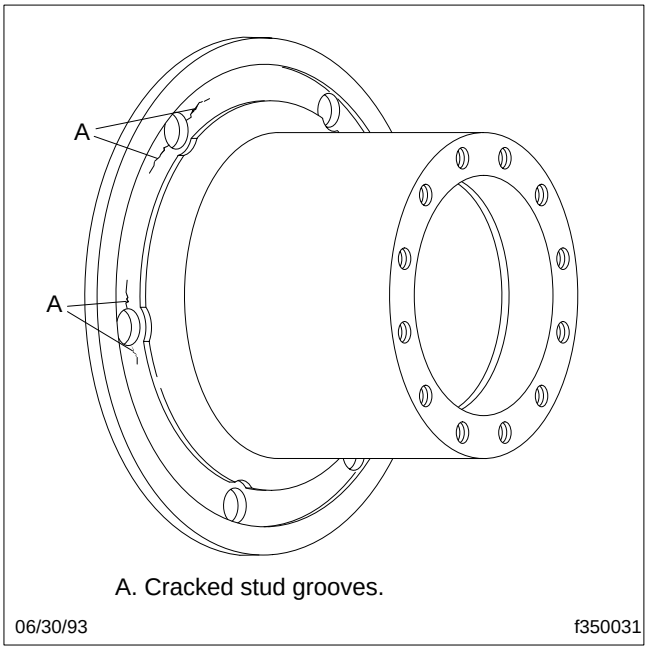
A. Wear spots.

06/30/93 f350116

Fig. 1, Typical Wheel Hub, Damaged

4. Inspect the wheel nuts on disc wheel installations, or the rim nuts on spoke-wheel installations. Damaged nuts **(Fig. 4),** usually caused by inadequate tightening, must be replaced with new ones.

   Inspect the wheel studs or rim studs. Replace studs that are stripped, broken, bent, or otherwise damaged **(Fig. 5);** for instructions, **refer to "Wheel Stud Replacement, Disc Wheels, 130"** or **"Spoke Rim Stud Replacement, Spoke Wheels, 140."**



A. Cracked stud grooves.

06/30/93 f350031

Fig. 2, Typical Wheel Hub, Damaged

5. Inspect the drive axle studs. Replace the studs that have stripped threads or are broken. Also, replace bent or otherwise damaged studs; for instructions, **refer to "Drive Axle Stud Replacement, 150."**

6. Inspect the drive axle shaft. If the vehicle has been overloaded, or used under severe or improper operations, the drive axle shaft may be twisted, bent, or otherwise damaged. **See Fig. 6.** Replace the drive axle shaft and flange assembly if damaged.

Axle Components Cleaning and Inspection

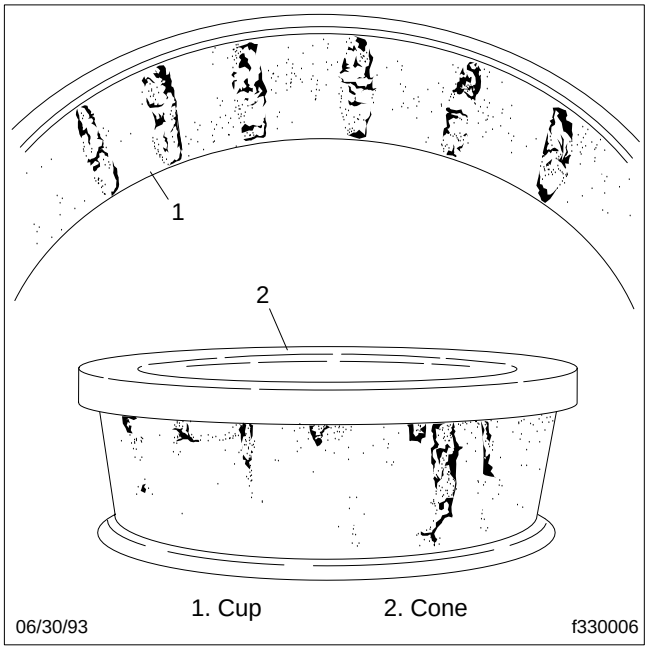


Fig. 3, Spalling (Flaking) of Wheel Bearing Assembly

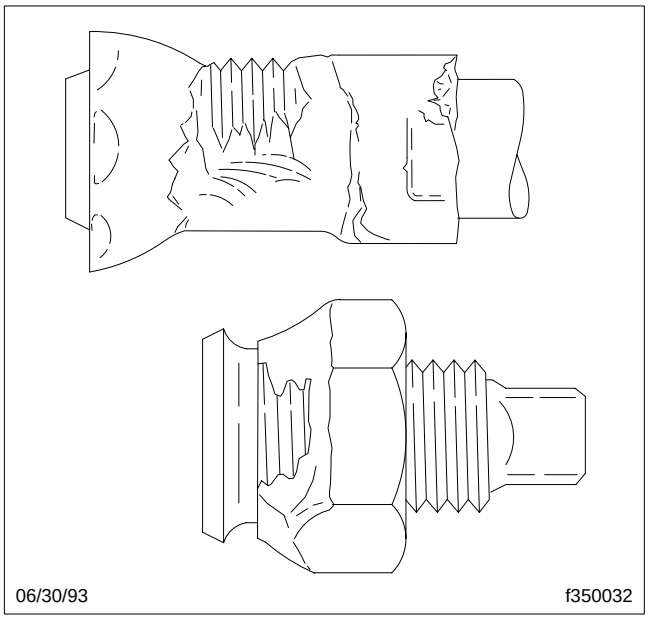


Fig. 4, Damaged Wheel Stud Nuts

⚠ CAUTION

CAUTION: If the drive axle shaft and flange assembly is not replaced once the shaft is twisted or otherwise damaged, it will continue to twist until fracture occurs. With complete fracture of the shaft, other axle parts may be damaged which will increase the cost of repairs. Whenever a drive axle assembly is damaged, the drive axle shaft and flange on the opposite side of the axle should also be carefully examined, and replaced if damaged.

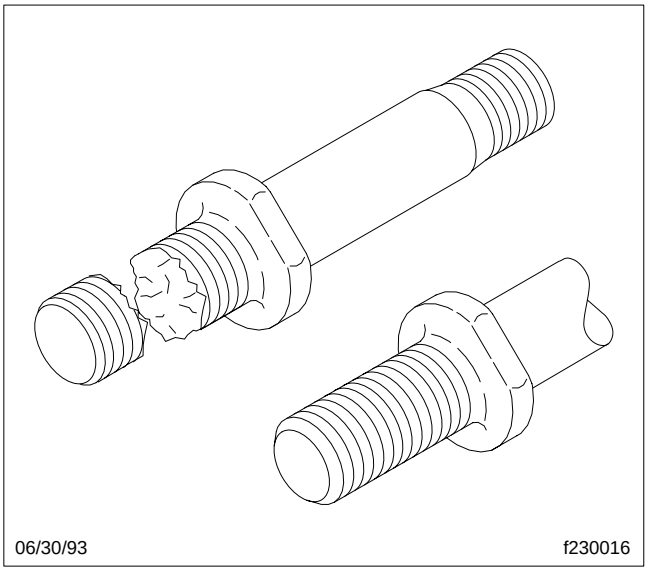


Fig. 5, Damaged Wheel Studs (shouldered type)

7. Inspect the drive axle shaft-to-flange surface. Loose wheel bearings can lead to progressive fatigue fractures where the shaft and flange meet. **See Fig. 7.** Replace the drive axle assembly if damaged.
8. Inspect the inboard portion of the drive axle flange. Minor burrs or rough spots can adversely affect the sealing action of the oil or grease seals. Remove the burrs or rough spots using fine-grit emery cloth. If they cannot be removed, replace the drive axle shaft.
9. Inspect the drive axle flange around the stud holes. Replace the drive axle shaft and flange assembly if any of the following conditions exist:
   - cracks on the flange surface;
   - metal build-up around the stud holes (a result of wear);
   - out-of-round stud holes.

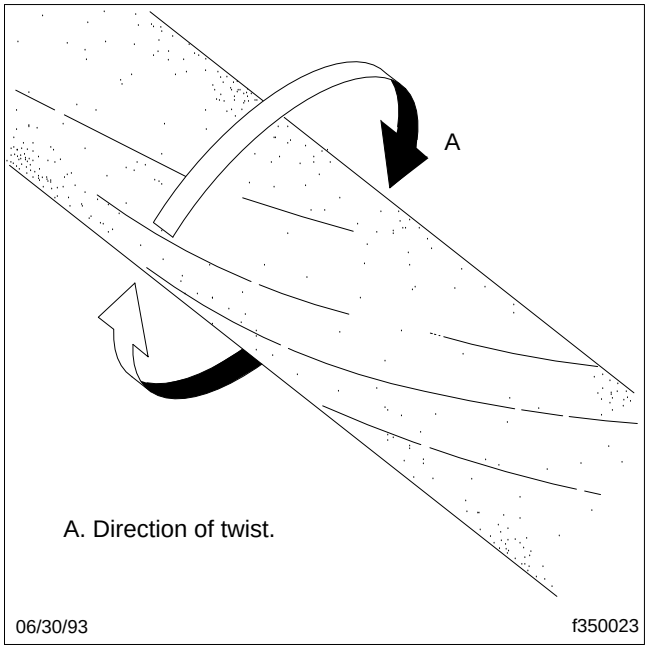


Fig. 6

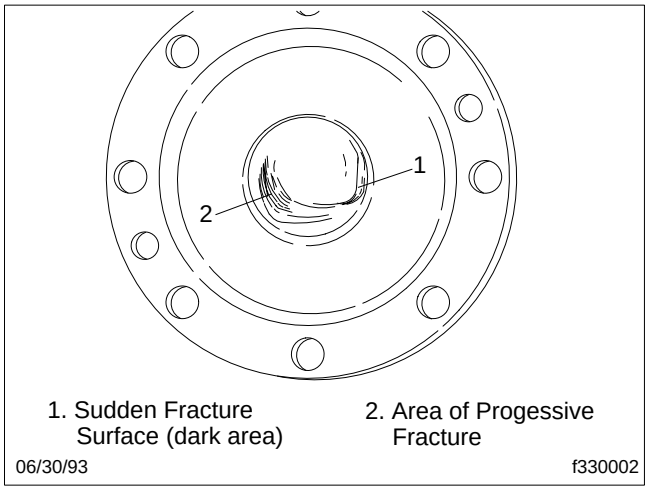


Fig. 7

Wheel Bearing Cleaning and Inspection

CLEANING

⚠ WARNING

WARNING: To prevent skin irritation, wear chemical resistant gloves when working with diesel fuel or kerosene. Also, don't expose these fluids to flames or heat exceeding 38°C (100°F); both are combustible, and could cause personal injury if ignited.

Don't spin the bearing rollers at any time. Dirt or grit can scratch the roller surface and cause premature wear of the bearing assembly. Treat a used bearing as carefully as a new one.

Wheel bearings should be very closely inspected at the time of disassembly. The best inspection conditions are possible only after the bearings have been thoroughly cleaned using kerosene or diesel fuel oil, and a stiff brush **(Fig. 8).** Before inspecting, clean the bearings as follows:

1. Clean all old oil from the bearings and hub cavities, with kerosene or diesel fuel and a stiff brush. **See Fig. 8.** Don't use gasoline or heated solvent.
2. Allow the cleaned parts to dry, or dry them with a clean absorbent cloth or paper. Clean and dry your hands and all tools used in the maintenance operation. Oil will not stick to a surface that is wet with kerosene or diesel fuel, and the kerosene or diesel fuel may dilute the lubricant.

INSPECTION

After the bearings are cleaned, inspect the assemblies, which include the rollers, cones, cups, and cages. If any of the following conditions exist, replace the bearing assemblies:

1. The large ends of the rollers are worn flush to the recess; the radii at the large ends of the rollers are worn sharp. These are signs of advanced wear. **See Fig. 9.**
2. Visible step wear, especially at the small end of the roller track, or deep indentations, cracks, or breaks in the cone surfaces. **See Fig. 10.**

Axle Components Cleaning and Inspection

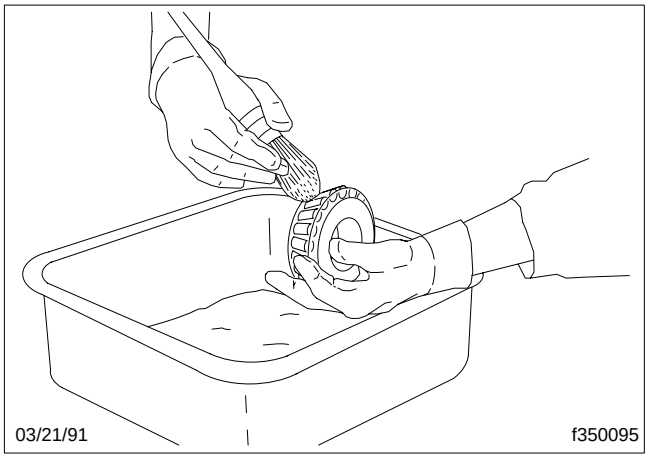


Fig. 8

3. Bright rubbing marks on the dark phosphate surfaces of the bearing cage. **See Fig. 11.**

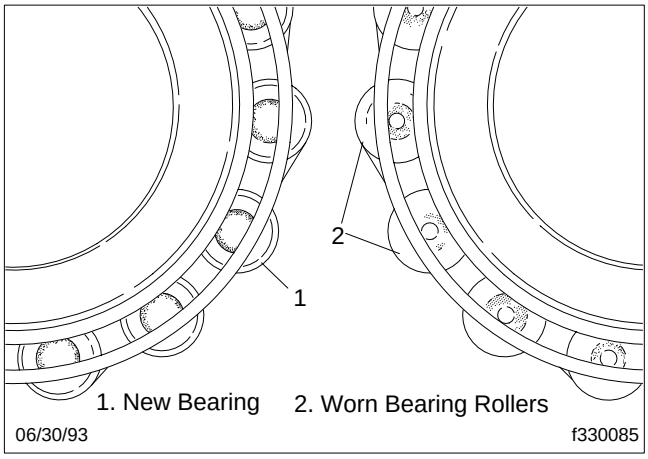


Fig. 9

4. Water etch on any bearing surface. Water etch appears as gray or black stains on the steel surface, and it greatly weakens the affected area. If water etch is present, check the oil seal sealing surfaces.

5. Etching or pitting on functioning surfaces. **See Fig. 12.**

6. Spalling (flaking) of the bearing cup, roller, or cone surfaces. **See Fig. 3.**

After inspection, brush the bearings with fresh axle lubricant.

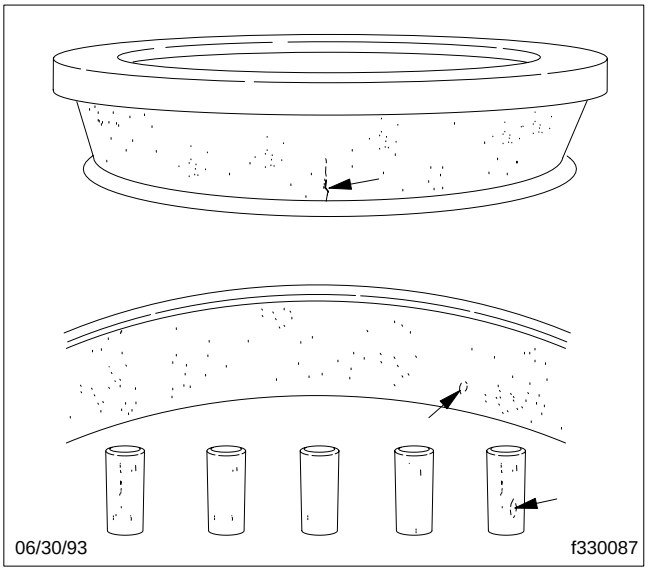


Fig. 10, Indentations, Cracks, or Breaks in Bearing Surfaces

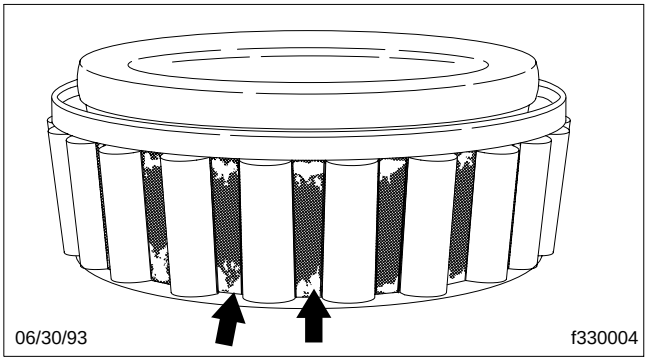


Fig. 11, Rubbing Marks on Bearing Cage

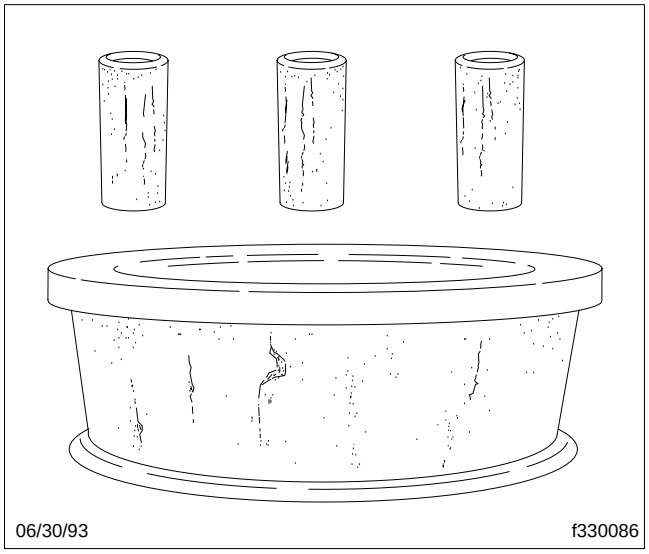


Fig. 12, Etching (Pitting) on Bearing Surfaces

Wheel Bearing Cup Removal and Installation, Ferrous Hubs

Removal

Wheel bearing cups are removed from ferrous hubs by driving them out; there is no need to first heat the hubs.

⚠ WARNING

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

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly.
2. Using a mild steel rod through the opposite end of the hub, drive against the inner edge of the bearing cup. Alternately drive on opposite sides of the cup to avoid cocking the cup and damaging the inside of the hub.

Installation

Wheel bearing cups are installed in ferrous hubs by pressing them in; there is no need to first heat the hubs.

⚠ WARNING

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

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly, including the bearing cup bores.
2. Inspect the bearing cup bores of the hub for warpage or uneven surfaces. If a bearing cup bore is damaged, replace the wheel hub assembly.
3. Coat the hub-contact surface of the replacement bearing cup with a film of grease.
4. Position the cup in the hub and press it into place, using a suitable tool against the outer edge of the cup. Cups must seat against the shoulder in the hub.

⚠ WARNING

WARNING: To prevent skin irritation, wear chemical resistant gloves when working with diesel fuel or kerosene. Also, don't expose these fluids to flames or heat exceeding 38°C (100°F); both are combustible, and could cause personal injury if ignited.

5. Wipe off the accumulation of grease left after the bearing cup has been seated. Then, using a clean lint-free cloth dampened with kerosene or diesel fuel oil, clean the inner surface of the bearing cup. Wipe the surface dry using a clean, absorbent, and lint-free cloth or paper.

Wheel Stud Replacement, Disc Wheels

Replacement

⚠ WARNING

WARNING: If a wheel stud breaks, the remaining studs are subjected to undue strain and could fail due to fatigue. When a broken stud is replaced, replace the stud on each side of it (Fig. 1). If more than one stud is broken, replace all of the studs. Failure to replace the studs could result in the loss of a wheel or loss of vehicle control, possibly resulting in personal injury.

1. Remove the wheel hub from the axle. For instructions, refer to **"Hub Assembly Removal and Installation, Disc Wheels, 100."**
2. If a bent portion of a wheel stud will have to pass through the wheel stud bore, cut off the bent portion before removing the wheel stud.
3. Place the wheel hub on a suitable press; make sure the hub flange is evenly supported around and next to the stud being removed. With steady movement, press the damaged stud out of the hub.

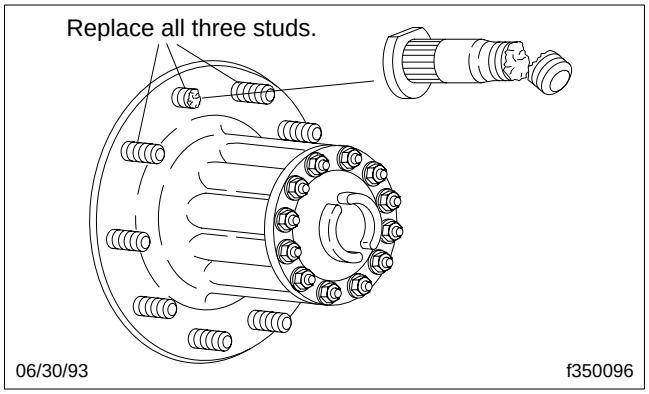


Fig. 1

⚠ CAUTION

CAUTION: Don't use a drift and hammer or concentrated heat to remove or install the wheel studs. Constant, smooth movement of the wheel stud is necessary to ensure the least amount of metal removal from the wheel stud bore. Concentrated heat will damage the hub. If the hub is damaged during wheel stud removal or installation, replace it.

4. Apply a coat of clean axle grease to the entire shaft on headed studs.
5. With the hub on a suitable press, make sure the hub flange is evenly supported around and next to the stud being installed.
6. Position the stud in its hole.

⚠ CAUTION

CAUTION: Position the teeth of the serrated portion in the notches carved by the original wheel studs during factory installation. If additional metal is scraped from the wheel stud bores, the locking action provided by the serrations will be greatly weakened. Loss of locking action will prevent achieving final torque of the wheel nuts during wheel installation. If final wheel nut torques during wheel installation cannot be achieved, replace the wheel hub assembly.

IMPORTANT: If the driver's side of the vehicle is being serviced, the replacement wheel stud and inner wheel nut must be stamped with an "L" (left-hand threaded), and the nut's face must be stamped "Left." **Refer to Fig. 2.** If the passenger's side of the vehicle is being serviced, the replacement stud and inner wheel nut must be stamped with an "R" (right-hand threaded), and the nut's face must be stamped "Right."

7. With steady movement, press the new stud all the way into the hub.
8. Make sure the stud is fully seated and that its head (flange) is not embedded in the hub. If the head of the stud is embedded in the hub, replace the hub.

⚠ WARNING

WARNING: Wheel studs with heads embedded in the wheel hub will weaken the wheel hub flange. Weakness in the wheel hub can result in the loss of a wheel or loss of steering control, possibly resulting in personal injury.

9. Wipe off any grease on the wheel studs and wheel hub. Install wheel nuts on dry wheel studs only.

Wheel Stud Replacement, Disc Wheels

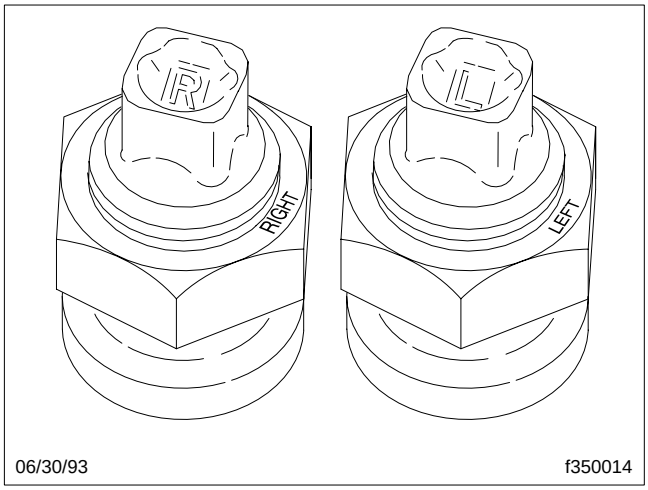


Fig. 2, Wheel Nuts

10. Install the wheel hub on the axle. For instructions, **refer to "Hub Assembly Removal and Installation, Disc Wheels, 100."**

Rim Stud Replacement, Spoke Wheels

Replacement

1. Remove the rim and tire assemblies from the spoke wheel. For instructions, **refer to the wheels and tires group.**
2. If enough threads remain on the damaged stud, remove it by double-nutting the stud. Turn the inner nut with a wrench in order to remove the stud. Then, go to the step for tapping out the rim stud hole.

   If the rim stud is broken near the surface of the wheel, the stud should be center-drilled using a high-speed drill, and then removed with an easy-out tool. If needed, grind off a flat surface on the damaged stud, then centerpunch the surface as a starting point for drilling. Remove the stud.

   2.1 Determine the correct drill diameter by referring to the easy-out tool manufacturer's guidelines. At no time should it be large enough to penetrate the threads of the stud; if the stud threads in the wheel are damaged, replace the wheel.

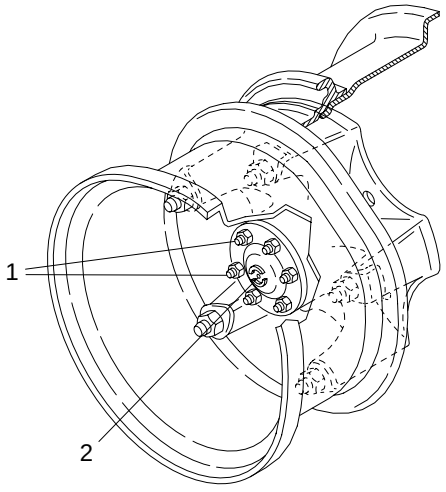
   2.2 Don't drill more than 32 mm (1-1/4 inches) into the broken stud, as measured at the stud's entrance into the wheel. Drilling through the bottom of the rim stud could damage the wheel. If the wheel is drilled into, replace it.

   2.3 While drilling, keep the cutting surfaces of the drill well lubricated with oil, which acts as a coolant. Allow the drill and drill bit to cool frequently.
3. After the damaged stud is removed, tap out the rim stud hole in the wheel to rid the threads of old stud-locking compound. Use an appropriate sized tap, depending on the original rim stud installation size.
4. Be sure the threads of the new stud are clean and dry. Then, coat the insertion end of the rim stud with an anaerobic thread-lock compound.
5. Using double nuts on the fine thread portion of the stud, install the new stud. Seat the rim stud using the torque values in the torque table in **"Specifications, 400."**
6. Allow enough time for the thread-lock compound to set, as suggested by the manufacturer.
7. Install the rim and tire assemblies. For instructions, **refer to the wheels and tires group.**

Replacement

NOTE: If the hub has been removed from the axle, go to the step for removing the stud.

1. Apply the parking brakes.
2. Oil will spill as the drive axle shaft is removed. Place a suitable container inside the wheel and under the drive axle flange. Safely discard the lubricant after removal.
3. Remove the drive axle shaft.
   - 3.1 Remove the drive axle stud nuts (**see Fig. 1**), and the washers.



06/09/94 f400090b

1. Drive Axle Studs and Nuts
2. Center Portion of Drive Axle Flange

Fig. 1

   - 3.2 Using a hammer and a soft drift, such as one made of brass, sharply tap the center portion of the drive axle flange (**see Fig. 1**). The shaft will usually spring slightly outward after the seal has broken.

CAUTION

CAUTION: When tapping the drive axle flange, avoid striking the drive axle studs. If struck, the studs may bend or break, or the stud threads can be damaged. Replace damaged studs.

   - 3.3 If the drive axle shaft does not spring outward, the seal may have loosened enough to allow the shaft to be manually pulled from the axle housing. Try to manually remove the drive axle shaft from the housing. If the seal has not broken, repeat steps as required.
4. If equipped, remove the tapered dowels and washers from the drive axle flange.
5. Remove and discard the gasket.
6. If enough threads remain on the damaged stud, remove it by double-nutting the stud. Turn the inner nut with a wrench in order to remove the stud. Then, go to the step for tapping out the drive axle stud hole.

   If the drive axle stud is broken near the surface of the hub, the stud should be center-drilled using a high-speed drill, and then removed with an easy-out tool. If needed, grind off a flat surface on the damaged stud, then centerpunch the surface as a starting point for drilling.

   - 6.1 Determine the correct drill diameter by referring to the easy-out tool manufacturer's guidelines. At no time should it be large enough to penetrate the threads of the stud; if the stud threads in the wheel hub are damaged, replace the hub.
   - 6.2 Do not drill more than 32 mm (1-1/4 inches) into the broken stud, as measured at the stud's entrance into the wheel hub. Drilling through the bottom of the drive axle stud could damage the hub. If the wheel hub is drilled into, replace it.
   - 6.3 While drilling, keep the cutting surfaces of the drill well lubricated with oil, which acts as a coolant. Allow the drill and drill bit to cool frequently.
7. After the damaged stud is removed, tap out the drive axle stud hole in the wheel to rid the threads of old stud-locking compound. Use an appropriate sized tap, depending on the original drive axle stud installation size.
8. Be sure the threads of the new stud are clean and dry. Then, coat the insertion end of the drive axle stud (the coarse threads) with an anaerobic thread-lock compound.

Drive Axle Stud Replacement

9. Using double nuts on the fine-thread portion of the stud, install the new stud. Seat the drive axle stud using the torque values in the torque table in **Specifications, 400.**
10. Allow sufficient time for the thread-lock compound to set, as suggested by the manufacturer.
11. If the hub was removed from the axle, proceed to **Subject 100** or **Subject 102** for installation instructions. If the hub was not removed from the axle, install the drive axle shaft.
    - 11.1 Install a new axle flange gasket over the drive axle studs.
    - 11.2 Install the drive axle shaft in the axle housing. The splined end of the shaft must seat before the drive axle flange will fit over the drive axle studs.
    - 11.3 If equipped, install the dowels and washers on the drive axle studs. Install the drive axle nuts. Using the sequence shown in **Fig. 2**, tighten the nuts to the torque values in the torque table in **Specifications, 400**.

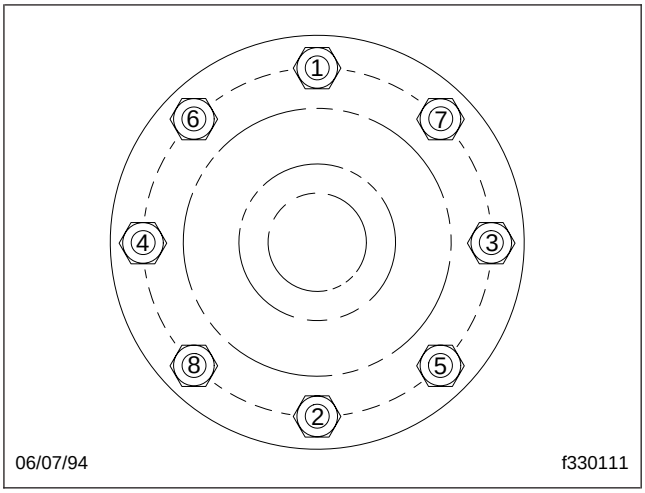


Fig. 2, Axle Shaft Flange Nut-Tightening Sequence

- 11.4 Add fresh oil to the wheel hub. For instructions, refer to **Subject 100** or **Subject 102**.

WARNING

WARNING: Failure to add oil to the wheel hub after the drive axle shaft has been serviced will damage the wheel bearings and cause them to seize during vehicle operation. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury.

Troubleshooting

This subject contains the following troubleshooting tables:

- Noisy Bearings or Excessive Bearing Replacement Intervals
- Broken Wheel or Rim Studs
- Damaged Hub
- Loss of Lubricant From the Wheel Hubs

Problem—Noisy Bearings or Excessive Bearing Replacement Intervals

Possible Cause	Remedy
Not enough oil was used on the bearings, or the wrong type of oil was used.	Clean then inspect the bearings for wear. Replace worn seals. Coat the bearing assemblies with fresh oil. For lubricant specifications, **refer to "Specifications, 400."**
Foreign matter or corrosive agents entered the bearing assembly. Dirt or metallic debris from the bearings was not removed.	Clean then inspect the bearings for wear. Replace worn seals. Also clean the wheel hub, the axle spindle, and any other part in contact with the bearing lubricant.
An incorrect adjustment of the wheel bearings is causing noise and wear.	Adjust the wheel bearings following the instructions in **Subject 100** and **Subject 102** in this section.
Flat spots or dents on the roller surface were caused by skidding of the roller or improper handling of the wheel bearing during the installation.	Clean then inspect the bearing rollers. Replace the bearing if damaged. Coat the replacement bearings with fresh oil. For lubricant specifications, **refer to "Specifications, 400."**

Problem—Broken Wheel or Rim Studs

Possible Cause	Remedy
The wheel or rim nuts were overtightened.	Replace the wheel or rim studs. **Refer to the wheels and tires group** for the wheel or rim tightening sequence.
The vehicle is being overloaded.	Don't exceed the maximum load-carrying capacity of the vehicle.

Problem—Damaged Hub

Possible Cause	Remedy
(Bent flange) Incorrect installation of the wheel studs, such as using a hammer and drift, or the hub flange wasn't fully supported on the press during wheel stud replacement.	Replace the hub assembly. Replace the wheel studs as instructed under **"Wheel Stud Replacement, Disc Wheels, 130."**
Insufficient tightening of the wheel nuts to the wheel hub.	Replace the hub assembly and tighten the wheel nuts to the values in the torque table in **"Specifications, 400."**

Problem—Loss of Lubricant From the Wheel Hubs

Possible Cause	Remedy
The drive axle studs are loose.	Tighten the nuts to the torque values in the torque table in **"Specifications, 400."** Add lubricant to the axle housing or to the wheel hub.
The seals or gaskets are worn or damaged.	Replace worn or damaged parts.
Minor burrs or rough spots are on the inboard portion of the drive axle flange.	Use fine-grit emery cloth to remove the burrs or rough spots. If they can't be removed, replace the drive axle shaft.

Specifications

Torque Values		
Description	**Size (grade 8)**	**Torque in lbf·ft (N·m)**
Drive Axle Stud Nuts	1/2–20	75–115 (102–156)
	5/8–18	150–170 (203–230)
Drive Axle Studs-to-Hub	1/2–13	70 (95)
	5/8–11	135 (185)
Fill Plug, Drive Axle Lubricant	—	35 (47)
Hub Cap Capscrews	5/16–18	15 (20)
Rotor Capscrews	9/16–12	130 (175)
Spoke Wheel Rim Studs	3/4–10	240 (325)
Spoke Wheel Brake Drum Nuts	3/4–10	240 (325)
Wheel-Bearing Adjusting Nut, 4-Piece System, Standard Hub	—	Stage 1: Tighten to 100 (135)
		Stage 2: Back Off Completely
		Stage 3: Tighten to 20 (27) While Rotating Hub
		Stage 4: Back Off 1/3 Turn

Table 1, Torque Values

Meritor Drive Axle Lubricant Capacities, Single Axles*			
Axle Model	**Capacity in pints (liters)†**	**Axle Model**	**Capacity in pints (liters)†**
RS-13-120	16 (7.6)	RS-19-220	31 (14.7)
RS-15-120	16 (7.6)	RS-21-145	32 (15.1)
RS-15-210	16 (7.6)	RS-21-160	39.5 (18.7)
RS-17-140	31 (14.7)	RS-21-230	39 (18.5)
RS-17-145	33.6 (15.9)	RS-23-160	42 (19.9)
RS-17-220	31 (14.7)	RS-23-240	45 (21.3)
RS-19-145	34.4 (16.3)		

* Single drive axles equipped with traction equalizers may require a "friction modifier" to correct a slip-stick condition, as described in the vehicle driver's manual. Meritor's experience shows that the following additives perform adequately: Add Elco No. 2 Friction Modifier (1 ounce [30 ml] of additive for each 1 pint [0.5 liter] of lube capacity) or Lubrizol No. 797 or 762 (1 ounce [30 ml] of additive for each 1 pint [0.5 liter] of lube capacity).

† Quantities listed are approximate and include 1 pint (0.5 liter) for each wheel end and with the drive pinion at 3 degrees.

Table 2, Meritor Drive Axle Lubricant Capacities, Single Axles

Dana® Spicer® Drive Axle Lubricant Capacities, Tandem Axles	
Axle Model	**Capacity in pints (liters)***
RT-34-135	Forward 29.8 (14.1)
	Rear 34.0 (16.1)

Specifications

Dana® Spicer® Drive Axle Lubricant Capacities, Tandem Axles	
Axle Model	**Capacity in pints (liters)***
RT-40-145	Forward 30.4 (14.4)
	Rear 34.4 (16.3)

* Quantities listed are approximate and include 1 pint (0.5 liter) for each wheel end and with the drive pinion at 3 degrees.

Table 3, Dana Spicer Drive Axle Lubricant Capacities, Tandem Axles

Meritor Drive Axle Recommended Lubricant			
Recommended Lubricant Type	**Ambient Temperature**	**Lubricant SAE Viscosity Grade**	**Meritor Specification**
Hypoid Gear Oil API Service Classification GL-5	–12.2°C (+10°F) and up*	85W–140	0-76-A
	–26.1°C (–15°F) and up*	80W–140	0-76-B
	–26.1°C (–15°F) and up*	80W–90	0-76-D
	–40°C (–40°F) and up*	75W–90	0-76-E
	–40°C (–40°F) to +2°C (+35°F)	75W	0-76-J
	–40°C (–40°F) and up*	75W–140	0-76-L
Synthetic Gear Oil	–40°C (–40°F) and up*	75W–90	0-76-N
	–40°C (–40°F) and up*	75W–140	0-76-M

* There is no upper limit on these ambient temperatures, but axle sump temperature must never exceed 121°C (250°F).

Table 4, Meritor Drive Axle Recommended Lubricant

Dual-Nut Wheel Bearing Lock Torque Values		
Application	**Size**	**Torque: lbf·ft (N·m)**
Adjusting Nut	—	Stage 1: Tighten to 100 (135)
		Stage 2: Back Off Completely
		Stage 3: Tighten to 20 (25) While Rotating Hub
		Stage 4: Back Off 1/3 Turn
Jam Nut (with Wheel Bearing Nut, Pierced Lockwasher, and Bendable Lockwasher)	1-1/8	Target: 175 (235)
		Permissible Range: 150–225 (205–305)
	1-1/2 to 2-1/2	Target: 250 (340)
		Permissible Range: 200–300 (270–405)
	2-5/8 or Larger	Target: 325 (440)
		Permissible Range: 250–400 (340–540)

Table 5, Dual-Nut Wheel Bearing Lock Torque Values

General Information

WHEELS AND TIRES

The tires support the weight of the vehicle, and are integral parts of the drivetrain and braking systems. The wheels serve as load carrying members between the tires and the axle.

There are two types of wheels: spoke and disc.

Spoke wheels consist of a wheel and brake drum assembly installed on the axle **(Fig. 1),** and a tire and rim assembly that mounts on the wheel. Rim clamps and rim nuts hold the tire and rim assembly in place.

Disc wheels consist of a rim and disc. The rim, the portion of the wheel on which the tire is mounted and supported, is welded to the disc **(Fig. 2).** After the tire is mounted on the wheel, the assembly is held in place on the hub with wheel studs and nuts.

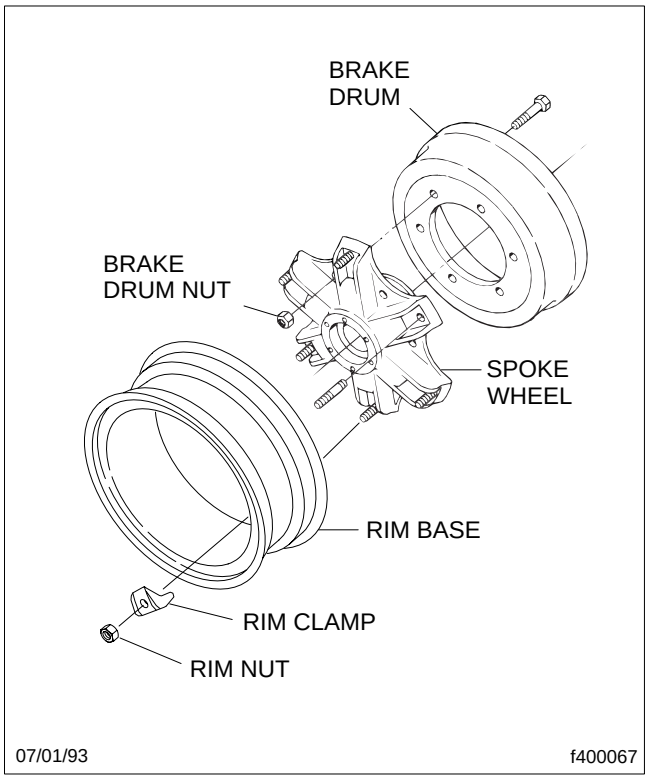


Fig. 1, Spoke Wheel and Brake Drum Assembly

Standard ten-hole dual disc wheels are held in place on the hub by self-centering inner and outer wheel nuts. Eight-hole and optional ten-hole (single and dual) disc wheels are centered by pilot pads and are held in place on the hub with cone locknuts.

Tires are constructed of either radial or bias plies:

Radial tires have ply cords that run from bead to bead, and at a right angle to the belt plies and tire tread **(Fig. 3).** The belt plies constrict the radial ply cords and give rigidity to the tread.

Bias ply tires have body ply cords that run diagonally from bead to bead **(Fig. 4).** The tires may also have narrow plies under the tread, called breakers, with cords that lie in about the same direction as the body ply cords.

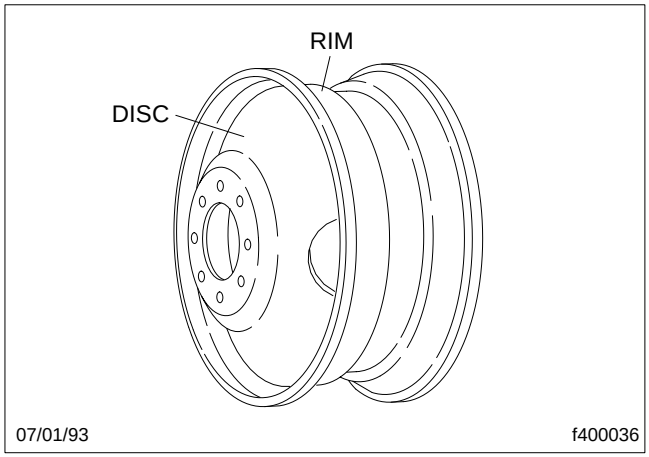


Fig. 2, Disc Wheel

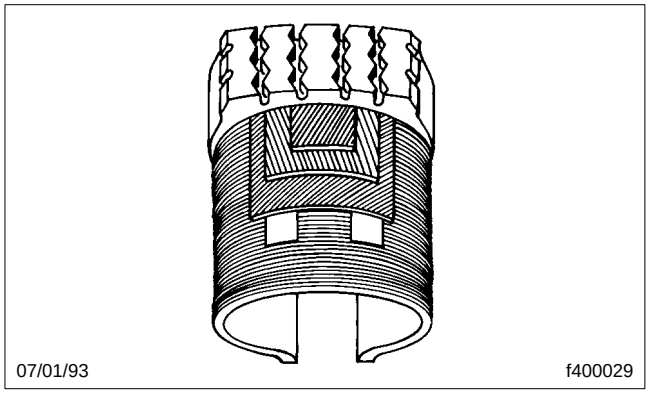


Fig. 3, Radial Ply Tire Construction

Tire body plies, breakers, and belts are made of polyester, rayon, nylon, fiberglass, steel, or aramids (fibrous reinforcements). In radial ply tires, these materials are used in various combinations, including

General Information

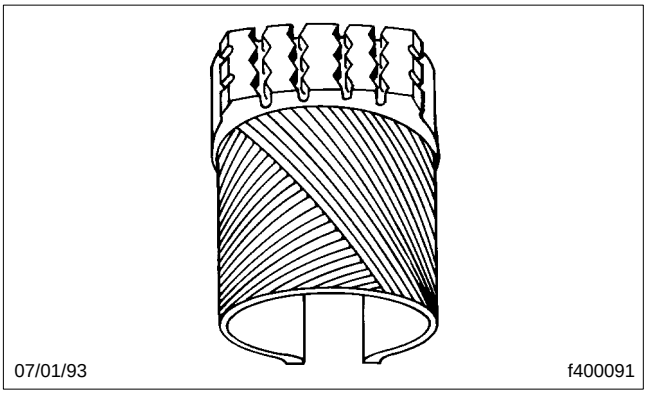


Fig. 4, Bias Ply Tire Construction

steel body/steel belt, polyester body/fiberglass belt, or nylon body/steel belt.

Wheels and tires operate either with or without tubes. Tube-type tires require a tube and flap for correct assembly on a two-or three-piece rim **(Fig. 1).** Tubeless tires require only the tire, and a one-piece drop-center wheel or rim. **See Fig. 2.**

TIRE MATCHING AND MIXING

IMPORTANT: Review and follow these requirements for matching and mixing tires, before installing any tire and wheel or rim assembly on a vehicle.

Before changing wheels and tires, consider the effect that the change may have on the Gross Vehicle Weight Rating (GVWR) of the vehicle. At the time of vehicle certification, the GVWR is calculated by adding the vehicle's Gross Axle Weight Ratings (GAWR). The GVWR and each of the GAWRs are shown on a certification label (U.S.-purchased vehicles) or "Statement of Compliance" label (Canadian-purchased vehicles) attached to the left rear door post. **See Fig. 5.**

Tire and rim labels **(Fig. 5 and Fig. 6)** certify the minimum tire and rim combinations that can be installed on the vehicle for the given GAWRs. Each GAWR is determined by considering each component of the axle system, including suspension, axle, wheels, and tires. The lowest component's capacity is the value used for the system. Therefore, the tires and rims installed on the vehicle at the time of vehicle manufacture may have a higher load capacity than that certified by the tire and rim label. Tires and rims of the minimum capacity can be installed without changing the load limitations. If tires and rims are installed that have a lower load capacity than that shown on the tire and rim label, then the tires and rims determine the load limitations (the GAWRs and GVWR will be lower).

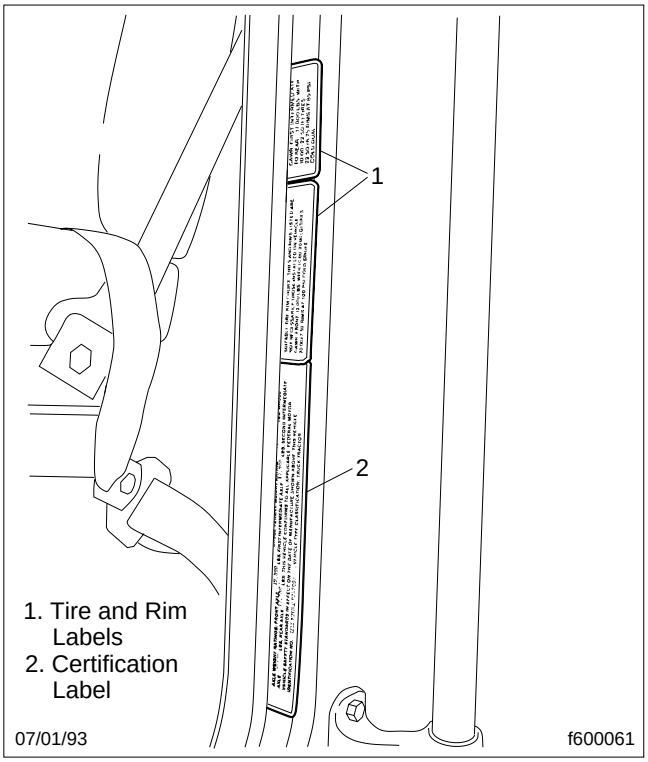


Fig. 5

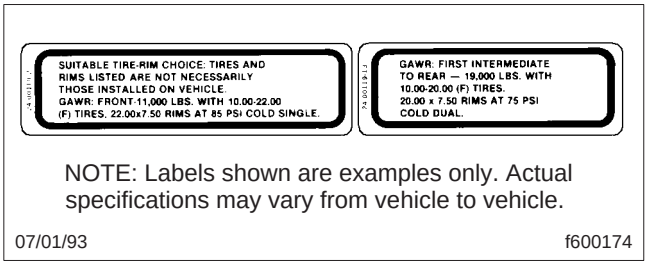


Fig. 6

When pairing tires in a dual assembly, the tire diameters must not differ by more than 1/4 inch (6.4 mm), or the tire circumference by more than 3/4 inch (19 mm).

CAUTION

CAUTION: Mismatching dual tires overloads the larger diameter tire, causing it to overdeflect and overheat. The smaller diameter tire, lacking proper road contact, wears faster and unevenly. Tread or ply separation, tire body breaks, and blowouts can occur from mismatched duals.

With an endless pi tape **(Fig. 7)** or square **(Fig. 8),** measure the diameter of the tires 24 hours after inflation. A matching stick **(Fig. 9),** string gauge **(Fig. 10),** or tire straight edge **(Fig. 11)** can also be used to determine the difference in tire radius, which is then doubled to calculate the diameter difference.

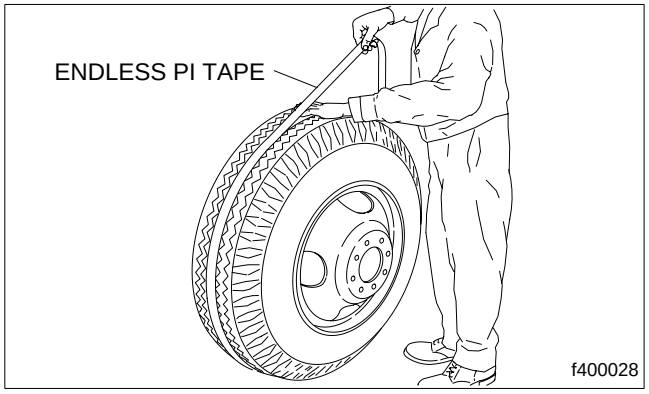


Fig. 7

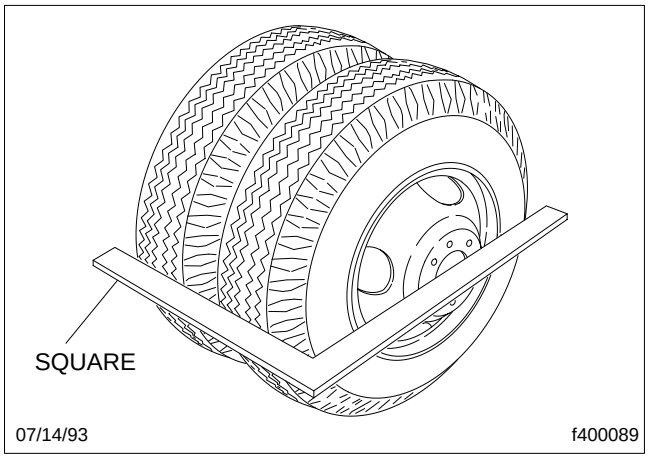


Fig. 8

When pairing tires of unequal diameters (but within the above limits), mount the larger tire on the outside.

CAUTION

CAUTION: Driving a vehicle on one tire of a dual assembly dangerously exceeds the carrying capacity of the single tire and wheel. Operating in this manner can cause damage to the wheel and tire.

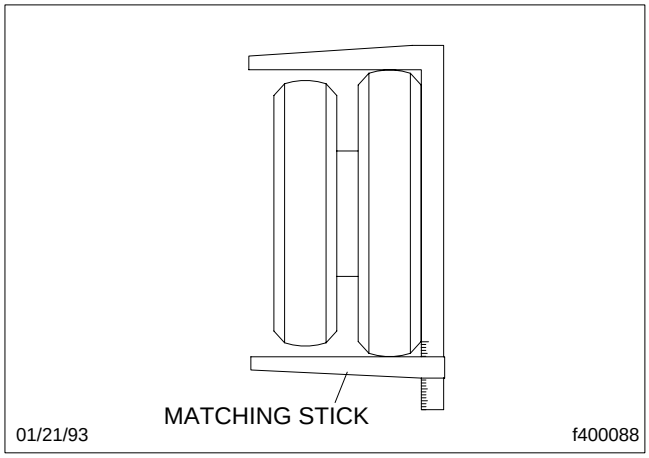


Fig. 9

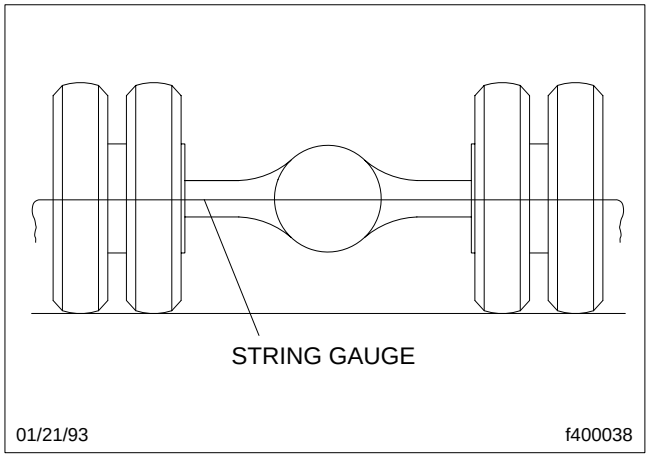


Fig. 10

Inflate all tires on an axle to within 35 kPa (5 psi) of one another. For tire inflation specifications, refer to the applicable tables in **"Specifications, 400."**

There must be sufficient space between dual tires for air to flow and cool the tires, and to prevent them from rubbing against one another. Rims and wheels of the same size, but of different makes and types, can have different offsets, which would affect dual

General Information

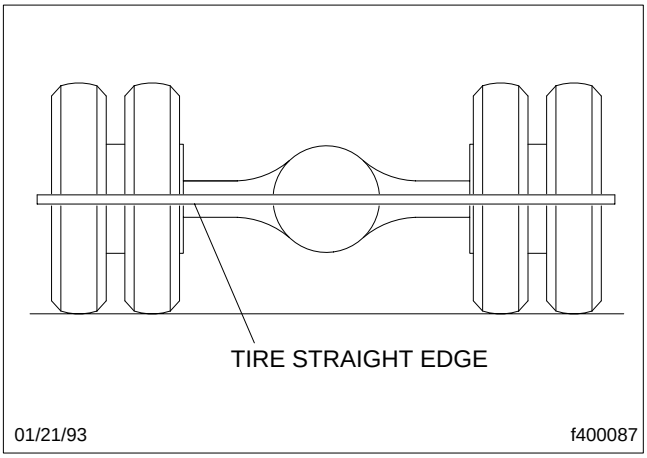


Fig. 11

spacing. If there is sidewall contact between tires, or between the inside tire and the chassis, refer to the tire manufacturer's catalog to determine the minimum dual spacing. Refer to the rim or wheel manufacturer's catalog to determine the correct offset.

Federal Motor Carrier Safety regulations require the removal of all tires with less than 3-mm (4/32-inch) remaining groove depth on a front axle, and tires with less than 1.5-mm (2/32-inch) remaining groove depth on a rear axle. However, tires with the word "Regroovable" on the sidewall, may be regrooved.

Better tire and vehicle performance is usually obtained by using tires of the same size and construction. Using tires of different construction is permitted if the following rules are observed:

- Do not mix radial and bias ply tires on the same axle.
- If both radial and bias ply tires are used, better handling is usually obtained by using the bias ply tires on the front axle.

⚠ CAUTION

CAUTION: Mixing radial and bias ply tires should be done as an emergency measure only. Some loss of steering control and premature tire wear could occur when driving under such conditions.

If installing radial tires on a vehicle formerly equipped with bias ply tires, refer to the applicable tables in **"Specifications, 400,"** concerning the inflation needs and load limits of the bias ply tires being removed, and of the radial ply tires being installed. Radial ply tires permit greater loads per tire, but also require higher inflation. They can also cause higher stresses on rims and wheels than bias ply tires. Contact the rim or wheel manufacturer about the compatibility of the rim or wheel with radial ply tires.

8-Hole Disc Wheel With Two-Piece Flange Nuts Removal and Installation

Removal

1. Chock all tires that will not be serviced, to prevent vehicle movement. If removing the wheels and tires from the front axle, apply the parking brake.
2. Raise the end of the vehicle being serviced until the tires clear the floor. Place safety stands under the axle being serviced.
3. If the tire or wheel is damaged (or if there is suspected damage), deflate the tire being serviced by removing the valve core. On rear axles deflate both tires of the dual assembly.
4. Place a jack or wheel-and-tire dolly under the wheel assembly being serviced. Turn the wheel until one hub-pilot pad is in the top-center position.
5. Leaving the top nut until last, remove all eight two-piece flange nuts.

CAUTION

The wheel center hole and hub pilot have close tolerances. If the wheel is not kept square to the hub, it could bind during removal and damage the stud threads or pilot pads. Keep the wheel square to the hub during removal.

IMPORTANT: On both sides of the vehicle, the two-piece flange nuts have right-hand threads.

6. Remove the wheel. Do not let it drop on or drag across the stud threads.

Installation

NOTE: Before installing a wheel and tire assembly, inspect it using the instructions in **Subject 160**. Also, follow the tire matching and mixing requirements in **Subject 050**.

1. Clean the hub and wheel mounting surfaces, and between the rims of dual wheels. Make sure the tire is correctly inflated. For instructions, see **Subject 180**.
2. Apply a few drops of light engine oil to the wheel studs and the area between the body and the flange of each two-piece flange nut. Wipe off any excess oil.

CAUTION

The wheel center hole and hub pilot have close tolerances. If the wheel is not kept square to the hub, it could bind during installation and damage the stud threads or pilot pads. Keep the wheel square to the hub during installation.

IMPORTANT: Before installing the wheels, make sure the drum is positioned on the raised step of the pilot pad. One of the hub's pilot pads must be at the top location. To help keep the drum in place, it may be necessary to adjust the brakes before installing the wheels.

3. Locate one hub-pilot pad in the top-center position. Using a jack or wheel-and-tire dolly, position the wheel assembly (inner wheel assembly of rear axles) on the hub. Make sure the wheel is square to the hub and that the threads or pilot pads are not damaged by contact with the wheel during installation. On rear axles, mount the outer wheel against the inner wheel using the same procedure.
4. Make sure the hub-pilot pad is still centered at the top.

IMPORTANT: Install the wheel assembly so that the balance weight(s) on the wheels are 180 degrees opposite the balance weight(s) on the brake drum. If this causes the valve stems on rear wheel assemblies to be in the same wheel hole, mount the outer wheel so that the outer wheel balance weight(s) are on the same side as the brake drum balance weight(s).

5. Install and hand-tighten a two-piece flange nut on the top and bottom studs.

CAUTION

The two-piece flange nuts have right-hand metric threads. Do not try to install a similar size SAE nut on a stud, or the stud and nut will be damaged.

6. Install and hand-tighten the remaining two-piece flange nuts. Tighten the two-piece flange nuts 50 to 100 lbf·ft (68 to 135 N·m) following the sequence in **Fig. 1**.

8-Hole Disc Wheel With Two-Piece Flange Nuts Removal and Installation

7. Check that the wheel is correctly seated against the hub and on the hub-pilot pads.
8. Following the sequence in **Fig. 1**, tighten the two-piece flange nuts 450 to 500 lbf·ft (610 to 678 N·m).

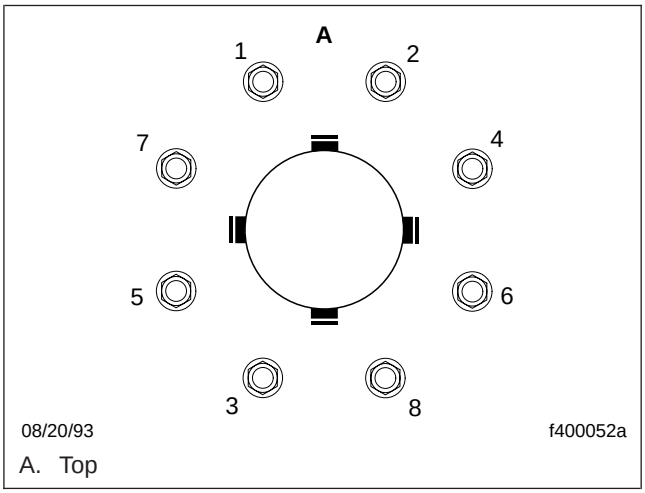


Fig. 1, 8-Stud Disc Wheel Tightening Sequence

WARNING

If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this case, the wheel hub assembly is damaged and must be replaced with a new assembly.

Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts. Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing property damage or personal injury.

NOTE: Replace damaged parts following the instructions in the front axle or rear axle group in this manual.

9. Remove the safety stands, lower the vehicle, and remove the chocks.
10. After operating the vehicle for 50 to 100 miles (80 to 160 km), retighten the wheel nuts 450 to 500 lbf·ft (610 to 678 N·m). Follow the sequence in **Fig. 1**.

CAUTION

Too little wheel nut torque can cause wheel shimmy, wheel damage, stud breakage, and extreme tire tread wear. Too much wheel nut torque can break studs, damage threads, and crack discs in the stud hole area. Use the specified torque values, and follow the tightening sequence in Fig. 1.

IMPORTANT: The two-piece flange nuts seat during vehicle operation. It is necessary to periodically tighten the wheel nuts to the specified torque. Tighten the two-piece flange nuts to the specified torque 50 to 100 miles (80 to 160 km) after service work, and check the torque every 50,000 miles (80 000 km) thereafter.

10-Hole Disc Wheel With Two-Piece Flange Nuts Removal and Installation

Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock all tires that will not be serviced to prevent vehicle movement.
2. Raise the end of the vehicle being serviced until the tires clear the floor. Place safety stands under the axle being serviced.
3. If the tire or wheel is damaged or if there is suspected damage, deflate the tire (or tires, on a dual assembly) being serviced by removing the valve core.
4. Turn the wheel until one hub-pilot pad is in the top-center position.
5. Leaving the top and bottom nuts until last, remove the other eight two-piece flange nuts.
6. Place a jack or wheel-and-tire dolly under the wheel assembly being serviced. Remove the top and bottom nuts.

CAUTION

The wheel center hole and hub pilot have close tolerances. If the wheel is not kept square to the hub, it could bind during removal and damage the stud threads or pilot pads. Keep the wheel square to the hub during removal.

IMPORTANT: On both sides of the vehicle, the two-piece flange nuts have right-hand metric threads.

7. Remove the wheel. Do not let it drop on or drag across the stud threads.

Installation

NOTE: Before installing a wheel and tire assembly, inspect it using the instructions in **Subject 160**. Also follow the tire matching and mixing requirements in **Subject 050**.

1. Clean the hub and wheel mounting surfaces, and all disc faces of dual wheels. Make sure the tire is correctly inflated. For instructions, see **Subject 180**.
2. Apply a few drops of light engine oil to the wheel studs and the area between the body and the flange of each two-piece flange nut. Wipe off any excess oil.

CAUTION

The wheel center hole and hub pilot have close tolerances. If the wheel is not kept square to the hub, it could bind during installation and damage the stud threads or pilot pads. Keep the wheel square to the hub during installation.

IMPORTANT: Before installing the wheels, make sure the drum is positioned on the raised step of the pilot pad. One of the hub's pilot pads must be at the top location. To help keep the drum in place, it may be necessary to adjust the brakes before installing the wheels.

3. Locate one hub-pilot pad in the top-center position. Using a jack or wheel-and-tire dolly, position the wheel assembly (inner wheel assembly of rear axles) on the hub. Make sure the wheel is square to the hub and that the threads are not damaged by contact with the wheel during installation. On rear axles, mount the outer wheel against the inner wheel using the same procedure.
4. Make sure the hub-pilot pad is still centered at the top.

IMPORTANT: Install the wheel assembly so that the balance weight(s) on the wheels are 180 degrees opposite the balance weight(s) on the brake drum. If this causes the valve stems to be in the same wheel hole on the rear wheel assemblies, mount the outer wheel so that the outer wheel balance weight(s) is on the same side as the brake drum balance weight(s).

5. Install and hand-tighten a two-piece flange nut on the top and bottom studs.

CAUTION

The two-piece flange nuts have right-hand metric threads. Do not try to install a similar size SAE nut on a stud, or the stud and nut will be damaged.

6. Install and hand-tighten the remaining two-piece flange nuts. Tighten the nuts 50 lbf·ft (68 N·m) following the sequence in **Fig. 1**.

10-Hole Disc Wheel With Two-Piece Flange Nuts Removal and Installation

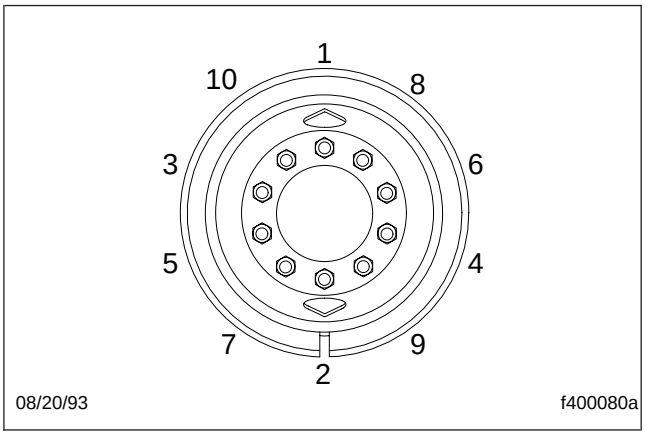


Fig. 1, 10-Stud Disc Wheel Tightening Sequence

7. Check that the wheel is correctly seated against the hub and on the hub-pilot pads.
8. Following the sequence in **Fig. 1**, tighten the two-piece flange nuts 450 to 500 lbf·ft (610 to 678 N·m).

⚠ WARNING

If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this case, the wheel hub assembly is damaged and must be replaced with a new assembly.

Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts. Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing property damage or personal injury.

IMPORTANT: Replace damaged parts following the instructions in the front axle or rear axle group in this manual.

9. Remove the safety stands, lower the vehicle, and remove the chocks.
10. After operating the vehicle for 50 to 100 miles (80 to 160 km), retighten the wheel nut 450 to 500 lbf·ft (610 to 678 N·m). Follow the sequence in **Fig. 1**.

⚠ CAUTION

Too little wheel nut torque can cause wheel shimmy, wheel damage, stud breakage, and extreme tire tread wear. Too much wheel nut torque can break studs, damage threads, and crack discs in the stud hole area. Use the specified torque values, and follow the tightening sequence in Fig. 1.

IMPORTANT: The two-piece flange nuts seat during vehicle operation. It is necessary to periodically tighten the wheel nuts to the specified torque. Tighten the two-piece flange nuts to the specified torque 50 to 100 miles (80 to 160 km) after service work, and check the torque every 10,000 miles (16 000 km) thereafter.

10-Hole Disc Wheel With Inner and Outer Nuts; Removal and Installation

Removal

1. Chock all tires that will not be serviced, to prevent vehicle movement. If removing the wheels and tires from the front axle, apply the parking brake.
2. Raise the end of the vehicle being serviced until the tires clear the floor. Place safety stands under the axle being serviced.
3. If the tire or wheel is damaged (or if there is suspected damage), deflate the tire being serviced by removing the valve core. On rear axles deflate both tires of the dual assembly.
4. Place a jack or wheel-and-tire dolly under the wheel assembly being serviced. Remove the wheel nuts, then raise and remove the wheel assembly. Be careful not to damage the threads of the wheel studs as the wheel is pulled away. On rear wheel assemblies, remove the outer wheel first, being careful not to damage the threads of the inner wheel nuts.

Installation

NOTE: Before installing a wheel and tire assembly, inspect it using the instructions under **Subject 160**. Also, follow the tire matching and mixing requirements under **Subject 050**.

1. Clean the hub and wheel mounting surfaces, and between the rims of dual wheels. Make sure the tire is inflated using the procedures under **Subject 180**.
2. Use a jack or wheel-and-tire dolly to mount the wheel assembly (inner dual wheel of rear wheel assemblies) on the wheel studs. Be careful not to damage the threads of the wheel studs when installing the wheel assembly.

IMPORTANT: Mount the wheel assembly so that the balance weight(s) on the wheels are 180 degrees opposite the balance weight(s) on the brake drum (**Fig. 1**).

If, on two-handhole wheels, this causes the valve stems of rear wheel assemblies to be in the same wheel hole, mount the outer wheel so that the outer wheel balance weight(s) are on the same side of the assembly as the brake drum balance weight(s). **See Fig. 2**.

If, on five-handhole or aluminum wheels, the valve stems of rear wheel assemblies are in the same handhole, separate the valve stems by one hole. Install the wheel weights evenly and as close to 180 degrees opposite the brake drum balance weight(s) as possible. **See Fig. 3**.

3. Install a wheel nut (inner wheel nut of rear wheel assemblies) on each wheel stud, and run them up until each nut is flush with the face or the chamfer of the wheel. Rotate the wheel a half turn to seat the parts.
4. Tighten the wheel nuts 68 N·m (50 lbf·ft), following the sequence in **Fig. 4**.
5. Following the same sequence, tighten the wheel nuts again. Refer to the applicable table in **Specifications, 400**.

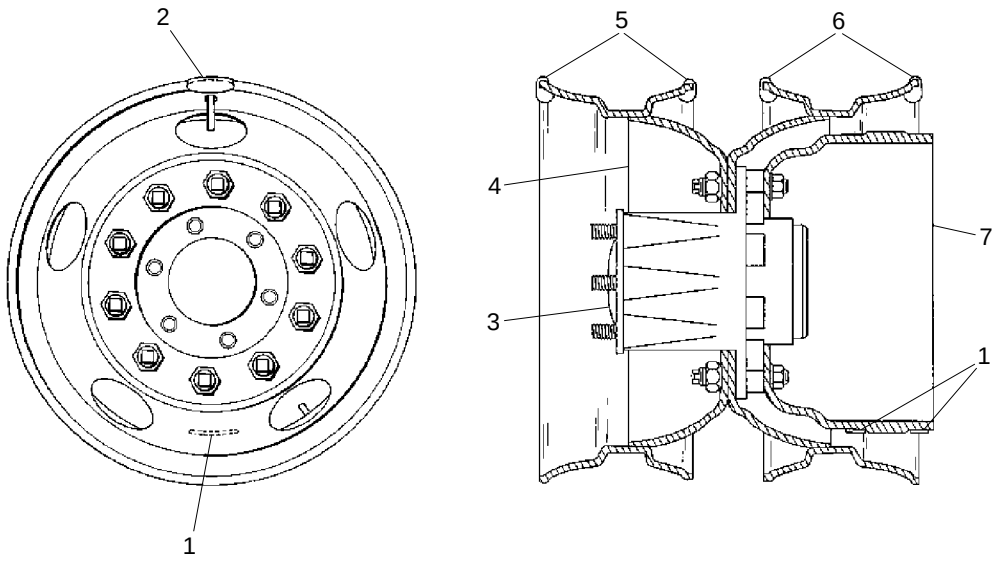
⚠ WARNING

WARNING: If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this case, the wheel hub assembly is damaged and must be replaced with a new assembly.

Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts, as described in the front axle or rear axle group of this manual. Failure to replace damaged parts could result in the loss of a wheel and loss of vehicle control, causing property damage or personal injury.

6. For front wheel assemblies, go to the next step. For rear wheel assemblies, use a jack or wheel-and-tire dolly to mount the outer dual wheel on the inner wheel nuts. Be careful not to damage the threads of the inner wheel nuts when installing the wheel assembly. Install the outer wheel nuts following the procedures above.
7. Remove the safety stands, lower the vehicle, and remove the chocks.
8. After operating the vehicle for 80 to 160 km (50 to 100 miles), retighten the wheel nuts to the

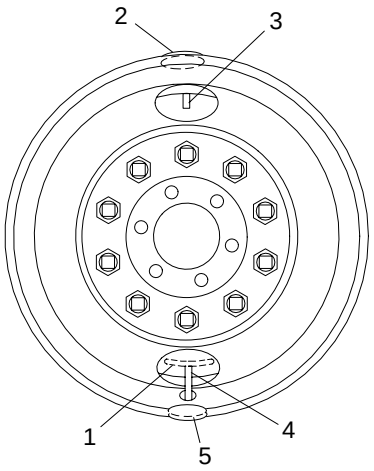
10-Hole Disc Wheel With Inner and Outer Nuts; Removal and Installation



07/14/93 f400035a

1. Brake Drum Balance Weight(s)
2. Inner and Outer Wheel Balance Weight(s)
3. Hub
4. Disc Wheel
5. Outer Wheel Balance Weight(s)
6. Inner Wheel Balance Weight(s)
7. Brake Drum

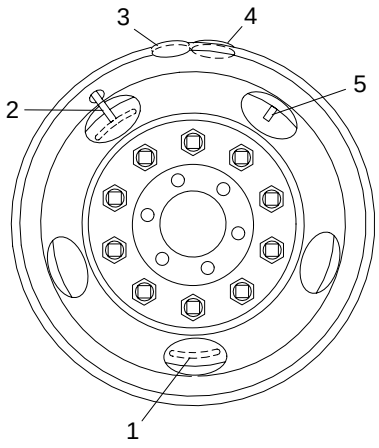
Fig. 1, Recommended Location of Wheel and Brake Drum Balance Weights



01/22/93 f400092a

1. Brake Drum Balance Weight(s)
2. Inner Wheel Balance Weight(s)
3. Inner Wheel Valve Stem
4. Outer Wheel Valve Stem
5. Outer Wheel Balance Weight(s)

Fig. 2, Alternate Location of Wheel and Brake Drum Balance Weights, Two-Handhole Wheels



08/24/93 f400093a

1. Brake Drum Balance Weight(s)
2. Outer Wheel Valve Stem
3. Outer Wheel Balance Weight(s)
4. Inner Wheel Balance Weight(s)
5. Inner Wheel Valve Stem

Fig. 3, Alternate Location of Wheel and Brake Drum Balance Weights, Five-Handhole or Aluminum Wheels

10-Hole Disc Wheel With Inner and Outer Nuts; Removal and Installation

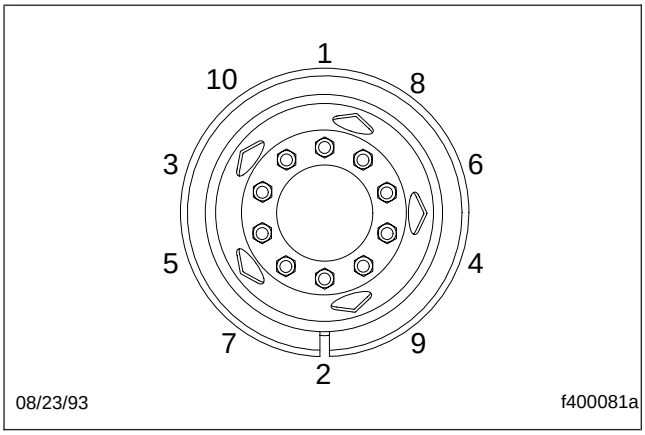


Fig. 4, 10-Stud Disc Wheel Tightening Sequence

torque in the applicable table in **Specifications, 400**. Follow the sequence in **Fig. 4**.

CAUTION

CAUTION: Locknuts seat during vehicle operation. It is necessary to periodically tighten the wheel nuts to the specified torque. Too little wheel nut torque can cause wheel shimmy, wheel damage, stud breakage, and extreme tire tread wear. Too much wheel nut torque can break studs, damage threads, and crack discs in the stud hole area. Use the specified torque values, and follow the tightening sequence in Fig. 4.

NOTE: When retightening the inner wheel nuts, loosen the outer wheel nuts several turns, retighten the inner wheel nuts, then the outer wheel nuts.

Spoke Wheel, Tire and Rim Assembly; Removal and Installation

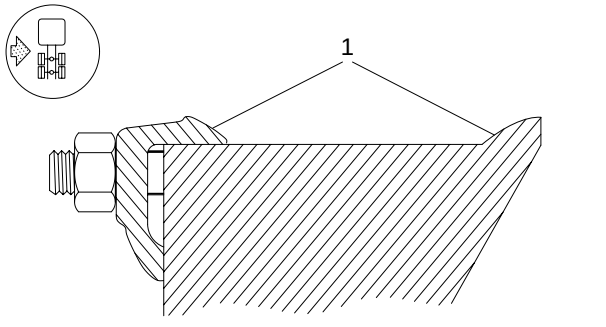
Removal

1. Chock all tires that will not be serviced, to prevent vehicle movement. If removing tire and rim assemblies from the front axle, apply the parking brake.
2. Raise the end of the vehicle being serviced until the tires clear the floor. Place safety stands under the axle being serviced.
3. Deflate the tire(s) being serviced by removing the valve core(s).
4. Place a jack or wheel-and-tire dolly under the tire and rim assembly being serviced (outer tire and rim assembly on rear axle). Remove the rim nuts and clamps; then, slide the tire and rim (outer tire and rim on rear axle) off the wheel.
5. On rear axles only, remove the rim spacer. Place a jack or wheel-and-tire dolly under the inner tire and rim assembly, and slide it off.

Installation

NOTE: Before installing a wheel and tire assembly, inspect it using the instructions under **Subject 160**. Also, follow the tire matching and mixing requirements under **Subject 050**.

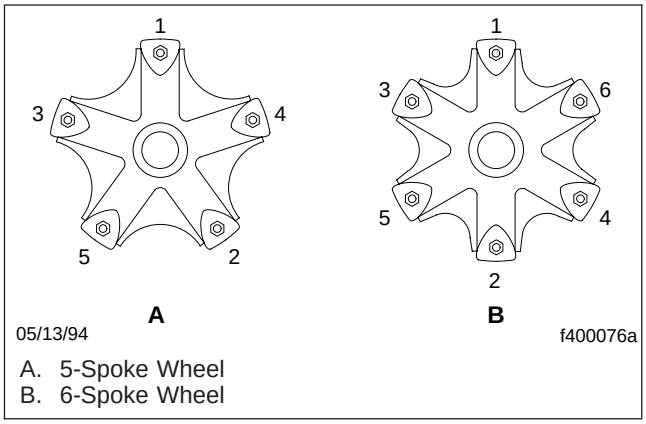
1. Clean the wheel, rim spacer, and rim mounting surfaces. The mounting surface of the wheel is the 28-degree taper on the inboard side of each spoke. **See Fig. 1**.



1. 28-Degree Tapered Rim Mounting Surfaces

Fig. 1, Spoke Wheel Tapered Mounting Surface

2. Make sure the tire and rim assembly is inflated using the procedures under **Subject 180**.
3. Slide the assembly over the wheel and push it into place against the tapered mounting surface. It should fit snugly against all the tapers. Be sure that the valve stem faces out and is centered between two spokes.
4. Install the rim clamps and nuts. Run the nuts up until the end of each wheel stud is flush with the face of its nut. Rotate the wheel a half turn to seat the parts.
5. Tighten the rim nuts a quarter turn at a time, following the star pattern **shown in Fig. 2**. Continue until all the rim nuts are tightened to the required torque value. Refer to the applicable torque table in **Specifications, 400**.



A. 5-Spoke Wheel
B. 6-Spoke Wheel

Fig. 2, Spoke Wheel Tightening Sequence

WARNING

WARNING: If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this case, the wheel hub assembly is damaged and must be replaced with a new assembly.

Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts, as described in the front axle or rear axle group in this manual. Failure to replace damaged parts could result in the loss of a wheel and loss of vehicle control, causing property damage or personal injury.

Spoke Wheel, Tire and Rim Assembly; Removal and Installation

CAUTION

CAUTION: Failure to tighten the nuts in the sequence shown, and to the correct torque, could cause misalignment of the tire and chording of the rim (Fig. 3). This would result in excessive vehicle vibration and permanent damage to the rim and wheel.

IMPORTANT: On rear tire and rim assemblies, the clamps must not bottom out until at least 80 percent of the recommended torque is reached. If the clamps do bottom out, make sure the correct clamps and rim spacers are being used. Make sure the rim edges contact the spacer edges.

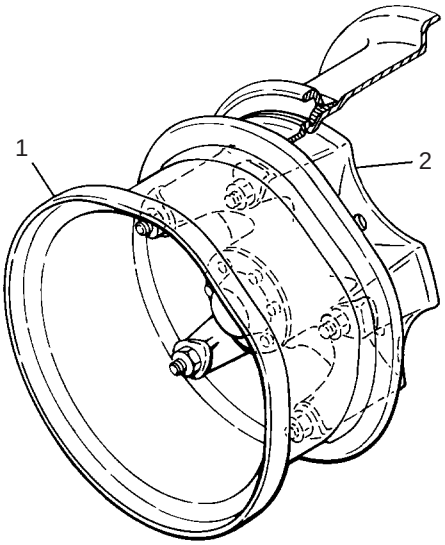
NOTE: When replacing a spoke wheel, contact the wheel manufacturer for the correct torque value for the brake drum nuts attaching the spoke wheel to the brake drum.

6. Check the wheel alignment by placing a block of wood or any other point of reference on the floor next to the tire. Rotate the tire and note any variations in the space between the tire and the block. If the variation exceeds 1.5 mm (1/16 inch) for front rims, or 3 mm (1/8 inch) for rear duals, the rim is not correctly mounted.

   To correct any misalignment, loosen the rim nuts where the largest gap occurs, and tighten the nuts on the opposite side. Recheck and correct until the variation is corrected. Make sure the rim nuts are tightened to the correct. Refer to the applicable torque table in **Specifications, 400**.

7. Remove the safety stands, lower the vehicle, and remove the chocks.

8. After operating the vehicle for 80 to 160 km (50 to 100 miles), retighten the rim nuts to the torque specified in the applicable table in **Specifications, 400**. Follow the sequence **shown in Fig. 2**.



1. Rim
2. Spoke Wheel

Fig. 3, Out-of-Round Rim (Rim Chording)

Tire Demounting and Mounting Service Precautions

Safety Precautions

IMPORTANT: Don't mount or demount tires without proper training as required in Occupational Safety and Health Administration (OSHA) Rules and Regulations 1910.177, *Servicing Multi-Piece and Single Piece Rim Wheels* . Service information containing mounting and demounting instructions are available through your rim supplier. Charts detailing service procedures are available through OSHA area offices. The address and telephone number of the nearest OSHA area office can be obtained by looking in the local telephone directory under U.S. Government, Labor Department of Occupational Safety and Health Administration.

Use the information from the above sources with the following precautions before and during the demounting and mounting of tires:

- Examine all wheel and tire parts as explained under the headings **Subject 160** and **Subject 170**. Replace damaged, rusted, or worn parts.
- Since wheels and rims are under stress, and are dangerous if improperly assembled, be sure all parts of an assembly match in size, manufacturer, and classification within a manufacturer's line. Before assembling the wheel or rim, check the catalog issued by the wheel or rim manufacturer for the correct part numbers and sizes of approved parts. Never use a part that does not bear clear, legible, and correct numbers and manufacturer's identification, even if that part appears to fit.
- Make sure that tires are stored indoors, or outdoors under cover, to prevent water collecting inside the tire.
- Use special tools, as recommended by tire suppliers, for mounting and demounting tires. These tools must be smooth, and used with care, to avoid gouging the rim.
- Loosening tire beads may be difficult, since considerable force may be needed. The use of a machine designed for loosening tire beads is recommended.
- Handle the wheels and rims on a wooden floor or rubber mat to prevent nicking or gouging the wheel or rim.
- Do not use a duck-bill hammer, or any steel hammer on wheel or rim parts. Use rubber, leather-faced, or plastic mallets to tap parts together, if necessary.
- Lubricate the tire with an approved tire-mounting lubricant. Never use antifreeze, silicones, petroleum-based lubricants, or any flammable material (ether/starting fluid).
- When lubricating a tire prior to mounting, make sure excess lubricant does not run into the tire.
- Michelin Tire Corporation recommends applying lubricant to the valley of the tire, formed by the tire and rim, before using tools to break the bead.
- Michelin also recommends applying a sufficient but sparing amount of lubricant to the entire rim face when mounting a tire on a rim, to ensure correct bead seating and ease of mounting.
- Balance the tire and wheel or rim assembly before installing the assembly on a vehicle.
- Don't reinflate a tire that has been run flat or has been run at 80 percent or less of its recommended operating pressure. Use your spare. Before removing the low tire from the vehicle, make sure it is completely deflated. Later, have the assembly taken apart and all the parts checked for damage, including the side or lockrings.
- The air pressure contained in a tire is dangerous. When servicing a tire, stay out of any potential path or route that a rim wheel component may travel during an explosive separation.

Demounting and Mounting Tubeless Tires on One-Piece Drop Center Wheels or Rims

Fifteen Degree Tapered Drop Center

⚠ WARNING

WARNING: Read the information under Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst causing equipment damage and personal injury.

DEMOUNTING

1. Deflate the tire being serviced by removing the valve core. Check the valve stem by running a piece of wire through the stem to make sure it is not plugged.
2. Loosen both beads from the rim by driving the flat end of the tire tool between the tire bead and the rim flange. Holding the tool upright, hammer on the neck to free the tire bead from the rim **(Fig. 1).** Repeat at 20-cm (8-inch) intervals around the flanges, until both beads are free from the rim.
3. Place the wide side of the rim down. Lubricate the tire bead and the rim. Insert the curved end of two tire tools between the bead and the rim, and just to one side of the tire valve. Step on the side of the tire, opposite from the valve, to force the first bead into the rim well **(Fig. 2).** Hold one of the tools in place with your foot and pry with the second tool, forcing the bead over the rim flange. Continue to work the first bead off of the rim.
4. When the first bead is off the rim, and the second bead is in the rim well, stand the assembly upright with the valve stem near the top. Lubricate the second bead and rim. Insert the straight end of the tool between the tire bead and the back rim flange, hooking the tool over the second flange. Lean the tire assembly toward the tool and use a rocking or bouncing action to pry the rim out of the tire. **See Fig. 3.**
5. Clean and inspect all parts. Refer to **Subject 160** and **Subject 170** for procedures.

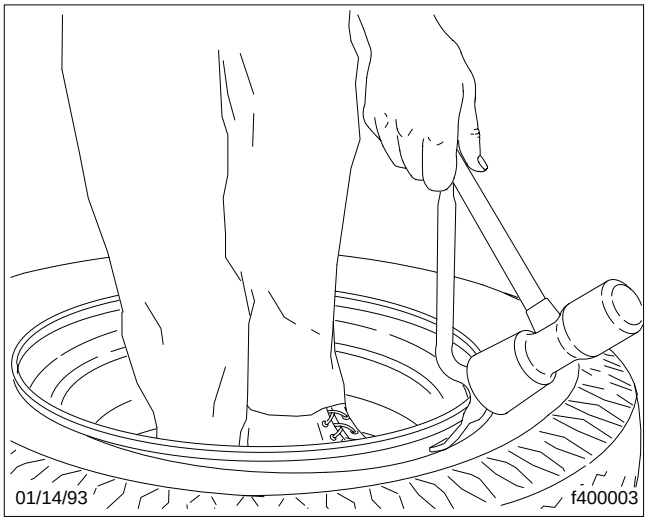


Fig. 1

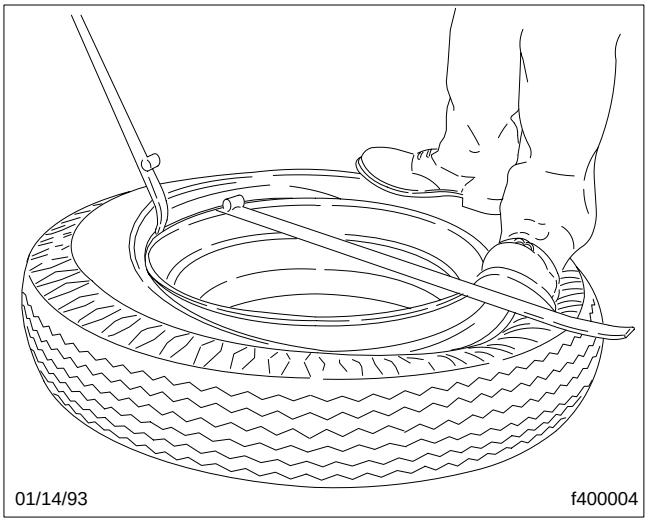


Fig. 2

MOUNTING

1. Place the valve stem, with a rubber washer, through the valve hole from the tire side of the rim. Screw on the valve nut from the opposite side. Make sure the rubber bushing and metal collar or nut are centered and fit snugly in the valve hole **(Fig. 4).** Tighten the nut securely.
2. Place the rim on the floor with the wide side down. Using a brush or swab, lubricate both bead seats (flanges) of the rim, and both tire beads, with an approved lubricant. Apply enough

Demounting and Mounting Tubeless Tires on One-Piece Drop Center Wheels or Rims

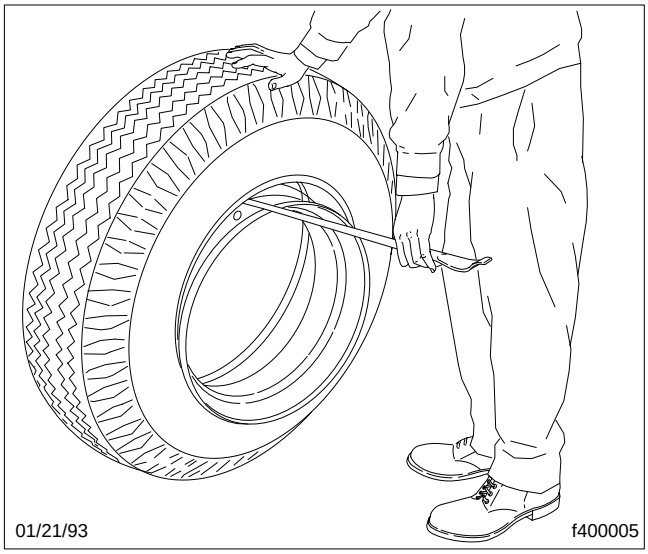


Fig. 3

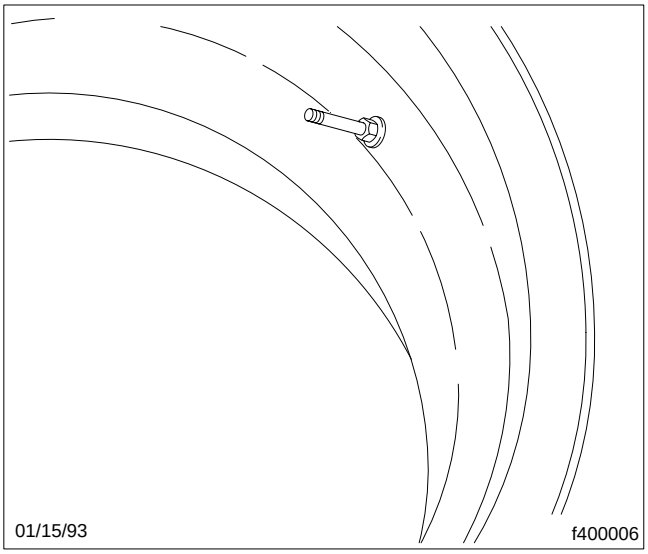


Fig. 4

lubricant to enable correct bead seating, and to make mounting easier. Don't let excess lubricant run inside the tire.

3. Lay the tire on the rim. If there is a balance mark on the tire, line up this mark with the valve stem. Push the lower bead over the flange and into the rim well. Using the straight end of the tire tool (with the stop resting on the rim flange), take small bites to work the remaining section of the bead into the rim. **See Fig. 5.**
4. Start the upper bead over the rim flange and into the rim well by standing on the tire. If necessary, push a section of the bead into the rim well, and anchor it by attaching Vise-Grip® pliers to the rim flange (snub side toward the tire). Using the spoon end of the tire iron, with the stop toward the rim, work around the bead **(Fig. 6).** Use small bites until the bead slips over the flange and into the rim well. If necessary, insert a second tire iron and relubricate the last 8 inches (20 cm) of bead.
5. Inflate the tire. Refer to **Subject 180** for procedures.

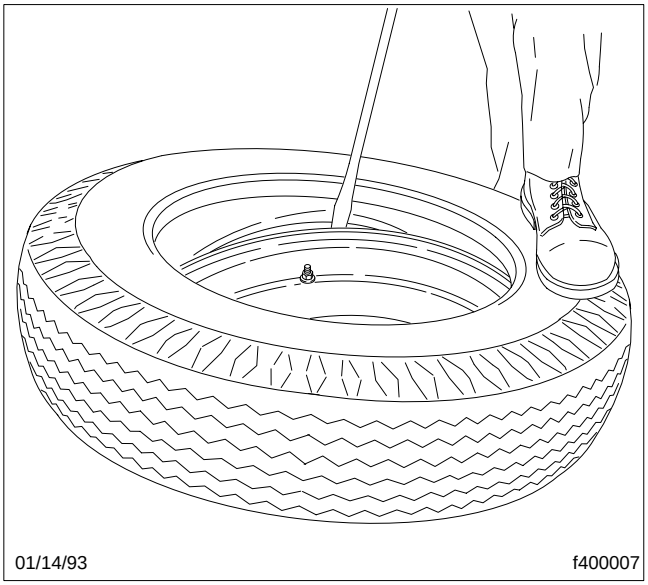


Fig. 5

Demounting and Mounting Tubeless Tires on One-Piece Drop Center Wheels or Rims



Fig. 6

Demounting and Mounting Tubeless Tires on One-Piece Drop Center Wheels or Rims

Fifteen Degree Tapered Drop Center

⚠ WARNING

WARNING: Read the information under Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst causing equipment damage and personal injury.

DEMOUNTING

1. Deflate the tire being serviced by removing the valve core. Check the valve stem by running a piece of wire through the stem to make sure it is not plugged.
2. Loosen both beads from the rim by driving the flat end of the tire tool between the tire bead and the rim flange. Holding the tool upright, hammer on the neck to free the tire bead from the rim **(Fig. 1).** Repeat at 20-cm (8-inch) intervals around the flanges, until both beads are free from the rim.
3. Place the wide side of the rim down. Lubricate the tire bead and the rim. Insert the curved end of two tire tools between the bead and the rim, and just to one side of the tire valve. Step on the side of the tire, opposite from the valve, to force the first bead into the rim well **(Fig. 2).** Hold one of the tools in place with your foot and pry with the second tool, forcing the bead over the rim flange. Continue to work the first bead off of the rim.
4. When the first bead is off the rim, and the second bead is in the rim well, stand the assembly upright with the valve stem near the top. Lubricate the second bead and rim. Insert the straight end of the tool between the tire bead and the back rim flange, hooking the tool over the second flange. Lean the tire assembly toward the tool and use a rocking or bouncing action to pry the rim out of the tire. **See Fig. 3.**
5. Clean and inspect all parts. Refer to **Subject 160** and **Subject 170** for procedures.

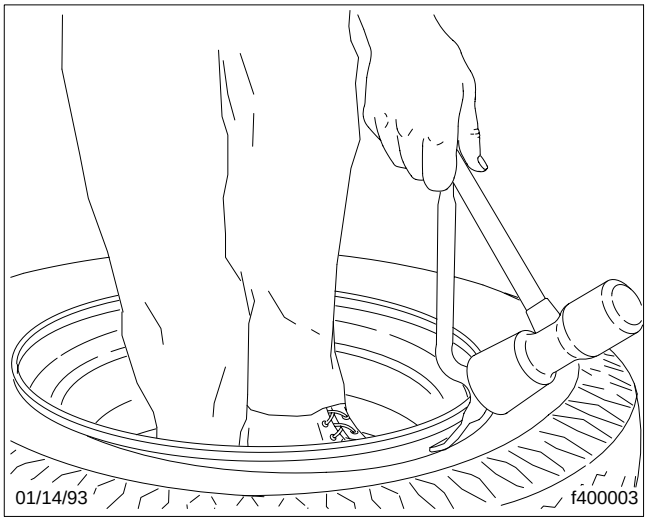


Fig. 1

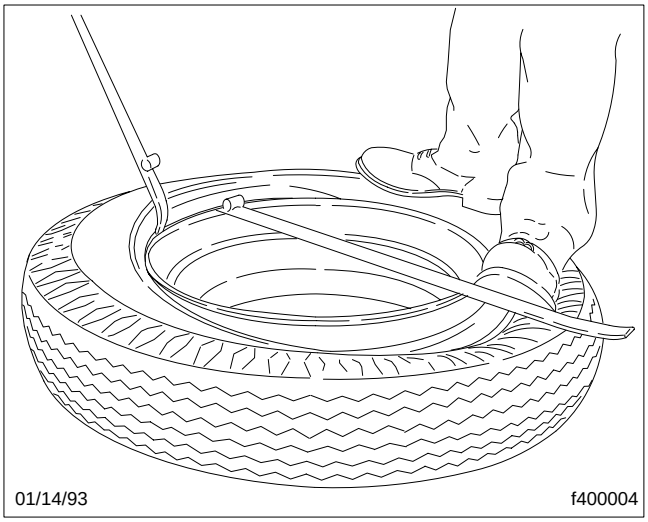


Fig. 2

MOUNTING

1. Place the valve stem, with a rubber washer, through the valve hole from the tire side of the rim. Screw on the valve nut from the opposite side. Make sure the rubber bushing and metal collar or nut are centered and fit snugly in the valve hole **(Fig. 4).** Tighten the nut securely.
2. Place the rim on the floor with the wide side down. Using a brush or swab, lubricate both bead seats (flanges) of the rim, and both tire beads, with an approved lubricant. Apply enough

Demounting and Mounting Tubeless Tires on One-Piece Drop Center Wheels or Rims

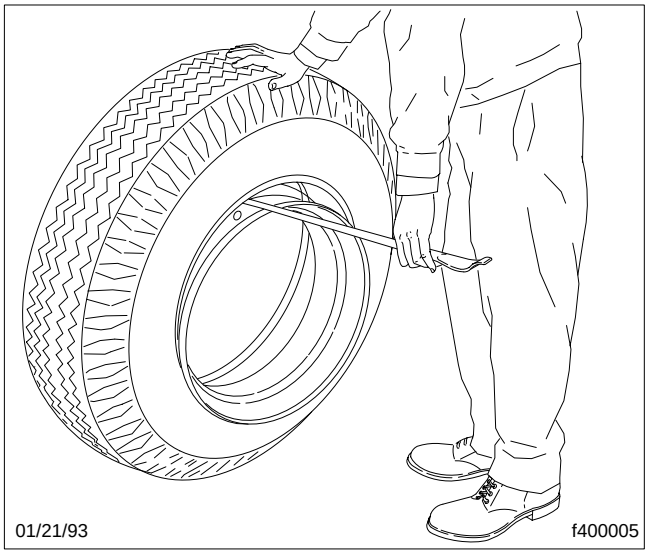


Fig. 3

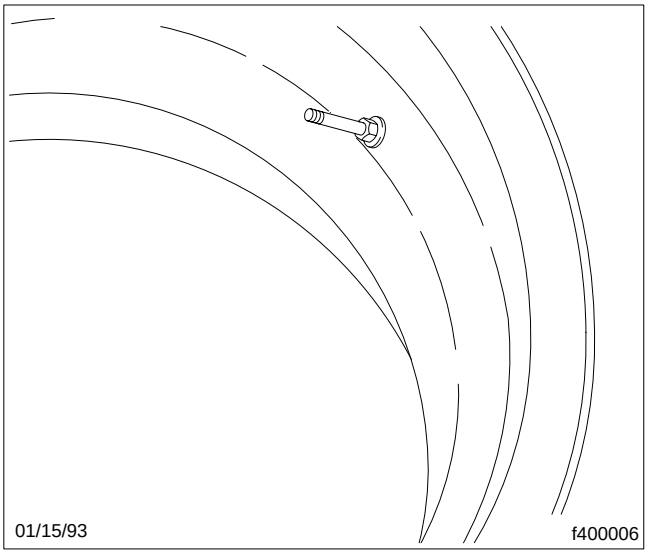


Fig. 4

lubricant to enable correct bead seating, and to make mounting easier. Don't let excess lubricant run inside the tire.

3. Lay the tire on the rim. If there is a balance mark on the tire, line up this mark with the valve stem. Push the lower bead over the flange and into the rim well. Using the straight end of the tire tool (with the stop resting on the rim flange), take small bites to work the remaining section of the bead into the rim. **See Fig. 5.**
4. Start the upper bead over the rim flange and into the rim well by standing on the tire. If necessary, push a section of the bead into the rim well, and anchor it by attaching Vise-Grip® pliers to the rim flange (snub side toward the tire). Using the spoon end of the tire iron, with the stop toward the rim, work around the bead **(Fig. 6).** Use small bites until the bead slips over the flange and into the rim well. If necessary, insert a second tire iron and relubricate the last 8 inches (20 cm) of bead.
5. Inflate the tire. Refer to **Subject 180** for procedures.

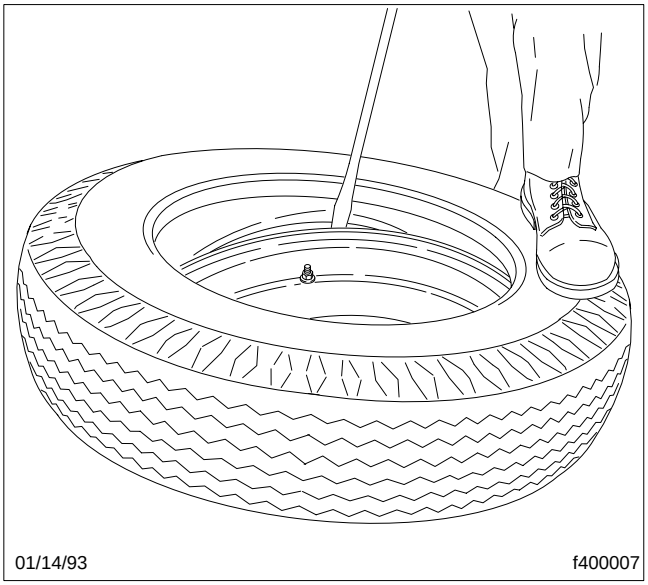


Fig. 5

Demounting and Mounting Tubeless Tires on One-Piece Drop Center Wheels or Rims



Fig. 6

Inspection

WARNING

WARNING: Failure to inspect the tires and wheels and correct any problems, could cause tire or rim damage while servicing or while in use. An incorrectly mounted tire can burst causing equipment damage and personal injury.

Inspect the inside and outside of the tire for out-of-roundness, loose cords, cuts, foreign objects, and other damage. Repair as needed. Contact the tire manufacturer for repair procedures.

Do not repair tires with the following problems:

- Cuts in the tread that are wire or breaker fiber deep.
- Tread worn to the wire or breaker fibers.
- Tread that is scalloped or otherwise worn unevenly.
- Visible, broken, deformed, or otherwise damaged bead wires.
- Deteriorated rubber.
- Rubber cracked to the wire or cord.
- Separations in the casing.
- Exposed cord (for example, due to weather checking or sidewall scuffing).

Inspect the tread for abnormal or excessive wear. **Refer to "Troubleshooting, 300"** for possible causes of abnormal wear. If the tires are wearing irregularly, they should be rotated. If the front axle tires become irregularly worn, they should be moved to the drive axle. The front-end alignment should be checked. In a dual assembly, if one tire wears faster than its mate, the position of the two tires should be reversed. Refer to the vehicle maintenance manual for tire rotation procedures.

Government regulations require the removal of any tire with less than 1.5-mm (2/32-inch) tread remaining. Retread the tire (if possible), regroove it (only if marked " Regroovable " on the sidewall), or discard it.

Michelin Tire Corporation recommends using only new valve cores, caps, and O-rings in a new mounting.

Tire Inflation

⚠ WARNING

WARNING: During initial tire inflation, there is the possibility of an explosion of the assembly. Observe the following safety rules to reduce the possibility of serious physical injury in the event of an explosion.

NOTE: Inflate tires in a safety cage **(Fig. 1)** or an approved portable restraining device. Always use a clip-on chuck with an inline valve and gauge. Make sure the inflation hose is long enough to permit standing to the side of the tire during inflation. Never sit on or stand in front of an assembly that is being inflated.

1. Check all parts to make sure they are correctly seated prior to inflation.

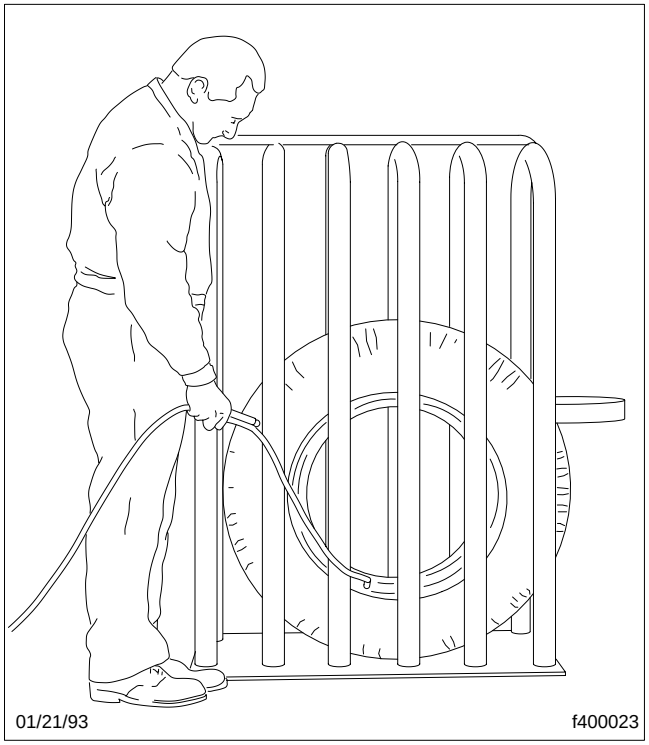


Fig. 1, Safety Cage

IMPORTANT: Inflate tires immediately after mounting, before the tire lubricant dries. Once the lubricant dries, bead positioning is not possible, even with increased inflation pressure.

2. Water in the tire can cause ply separation. During tire inflation, air tank reservoirs and lines must be dry. Use well-maintained air line moisture traps, and service them regularly.

   After placing the tire in a safety cage, or an approved portable restraining device, inflate the tire to 69 kPa (10 psi). Check the parts for correct seating. If the seating is not correct, completely deflate the tire and correct the problem. Never attempt to seat rings or other parts by hammering on an inflated or partially inflated tire.

3. If there are no problems with the assembly at 69 kPa (10 psi), continue to inflate the tire to the recommended pressure. Refer to the applicable tables under **"Specifications, 400"** for correct cold inflation pressures. Michelin Tire Corporation recommends an initial inflation pressure of 620 to 690 kPa (90 to 100 psi) to correctly seat the tire beads.

IMPORTANT: Due to the different flex characteristics of radial sidewalls, it may be necessary to use an inflation aid to help seat tubeless tire beads:

- Metal rings, which use a blast of compressed air to seat the beads.
- Rubber rings, which seal between the tire bead and rim, allowing the bead to move out and seat correctly. A well-lubricated, heavy-duty bicycle tube can be used to help seal between the tire bead and rim.

4. After the initial inflation, completely deflate the tire by removing the valve core. This ensures correct bead seating. Then inflate the tire to the applicable recommended cold inflation pressure listed in tables under **"Specifications, 400."** Install valve caps and tighten them finger-tight.

⚠ WARNING

WARNING: Tire underinflation or overinflation will damage wheels and tires, and could result in a blowout causing possible property damage and personal injury.

Tire Inflation

Use tires of the same size, type, and capacity to carry the load at the recommended cold pressure. Attempting to increase the load capacity of a tire by overinflation will damage the tire assembly.

NOTE: Inflate the tires to the recommended pressure. Driving on overinflated tires will weaken the cords by reducing their ability to absorb road shocks, and will increase the danger of cuts, snags, and punctures. Overinflation will overstress and damage the rims. Driving on underinflated tires will generate excessive heat. This weakens the tire body, and reduces tire strength.

5. Check the inflation pressure 24 hours after mounting new tires.

NOTE: When testing a vehicle on a dynamometer, severe tire damage can occur. Because the manufacturers differ in their recommendations for preventing tire damage, refer to the manufacturer's instructions for testing a vehicle on a dynamometer.

Troubleshooting

This subject contains the following troubleshooting tables:

- Abnormal Tire Wear
- Vehicle Vibration
- Excessive On-the-Road Tire Failures

Problem—Abnormal Tire Wear

Possible Cause	Remedy
Tires are not inflated to the correct pressure.	Operate the tires at the recommended inflation pressure and use the proper size tires, wheels, and rims for the load to be carried. Refer to the applicable tables in **"Specifications, 400"** for specifications.
Inflation pressures in a dual assembly are unequal.	Inflate all tires to a uniform pressure , within 35 kPa (5 psi). Refer to the applicable tables in **"Specifications, 400"** for the proper cold inflation pressures.
Dual tires are mismatched.	Examine all tires and match them according to the specifications in this section.
Vehicle is vibrating severely.	Follow the recommendations under "Vehicle Vibration" in this chart.
Brakes are grabbing.	Examine and adjust the brakes according to the instructions in the **brakes group.**
Axles are improperly aligned.	Align the axles. **Refer to the front axle group** and **the rear axle group** for instructions.
Wheel bearings are loose or damaged, or bushings are excessively worn.	Examine, and repair or replace according to the instructions in **the front axle group** and **the rear axle group.**
Wear is uneven among tire sets.	Rotate the tires according to the instructions in the wheels and tires group of the vehicle maintenance manual.
Driver is abusing equipment.	Caution the driver .

Problem—Vehicle Vibration

Possible Cause	Remedy
Axles are improperly aligned.	Align the axles. **Refer to the front axle group** and **the rear axle group** for instructions.
Wheels, rims, or tires are out-of-round, bent, or distorted.	Replace damaged components.
Tires, wheels, rims, or brake drums are out-of-balance.	Determine the out of balance component and balance.
Tire beads are not properly seated.	Demount and mount the tire. Make certain adequate lubrication is used and, if necessary, use an inflation aid to help seat tubeless tire beads.
Tire and rim assembly is improperly installed on a spoke wheel.	Remove the tire and rim assembly and inspect it for out-of-round or rim chording. Replace the rim if it is damaged. Follow closely the tightening sequence and torque values listed.
Rim spacers are worn or distorted.	Replace the rim spacers.
Driveline, suspensions, or steering components are loose or worn.	Determine the location of the vibration, then repair or replace the loose or worn components.

Troubleshooting

Problem—Excessive On-the-Road Tire Failures

Possible Cause	Remedy
Tires are not inflated to the correct pressure.	Operate the tires at the recommended inflation pressure and use the proper size tires, wheels, and rims for the load to be carried. Refer to the applicable tables in "Specifications, 400" for specifications.
Dual tires are mismatched.	Examine all tires and match them according to the specifications in this section.
Water or foreign material is inside the casing.	Clean and dry the tires prior to mounting. Make sure excess lubricant does not flow down into the tire. Store unmounted tires indoors, or under cover, to prevent moisture from collecting inside.
Tires are contaminated with oil.	Clean the tires and inspect the engine seals, transmission seals, axle-end and drive axle seals, oil filters and oil lines for leakage. Make sure the lubricant used in mounting does not contain a petroleum derivative.
Vehicle is vibrating severely.	Follow the recommendations under "Vehicle Vibration" in this chart.
Wheel or rim components are mismatched.	Check the catalog issued by the applicable wheel or rim manufacturer for the proper part numbers and sizes of approved components. Make sure that all parts of an assembly match in size, manufacturer, and classifications within a manufacturer's line. Never use a component which does not bear clear, legible, and proper numbers and manufacturer's identification, even if it appears to fit.
Parts are corroded, worn, or otherwise damaged.	Clean or replace parts as necessary.

IMPORTANT: Do not reduce the pressure of a hot tire if it exceeds the specified pressure. In normal driving, tire temperature and inflation pressure increase. Increases of 10 to 15 psi (70 to 105 kPa) are common. Higher pressures may be signs of overloading, underinflation, excessive speed, improper tire size, or any combination of these factors, and must be checked when the tire is cool.

The load and cold inflation pressure must not exceed the rim or wheel manufacturer's recommendations, even though the tire may be approved for a higher load or inflation. Some rims and wheels are stamped with a maximum load and maximum cold inflation rating. Consult the rim or wheel manufacturer if they are not stamped. If the load exceeds the maximum rim or wheel capacity, the load must be adjusted or reduced.

For further data on rims and tires, and for inflation and load limits not given here, see the "Tire and Rim Association Yearbook." Contact the tire manufacturer for further information on their tires.

NOTE: To obtain metric equivalents, use the following conversions:

- kg = lbs x 0.454
- kPa = psi x 6.890

Tire Load Limits, Goodyear Bias Ply Tubeless Tires, Front Axle (Maximum Speed 60 mph [97 km/h])													
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures										
			50 psi	55 psi	60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi
9-22.5	E	10	2800	3010	3190	3370	3560	3730	3890	4050	—	—	—	—
10-22.5	E	10	—	3560	3770	4000	4210	4410	4610	—	—	—	—	—
10-22.5	F	12	—	3560	3770	4000	4210	4410	4610	4790	4970	5150	—	—
11-22.5	F	12	—	—	4290	4530	4770	4990	5220	5430	—	—	—	—
11-22.5	G	14	—	—	4290	4530	4770	4990	5220	5430	5640	5840	6040	—
15-22.5	G	14	—	5680	6040	6390	6720	7040	7360	7660	—	—	—	—
15-22.5	H	16	—	5680	6040	6390	6720	7040	7360	7660	7950	8240	8520	—

Table 1, Tire Load Limits, Goodyear Bias Ply Tubeless Tires, Front Axle (Maximum Speed 60 mph [97 km/h])

Tire Load Limits, Goodyear Bias Ply Tubeless Tires, Rear Axle (Maximum Speed 60 mph [97 km/h])													
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures										
			40 psi	45 psi	50 psi	55 psi	60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi
9-22.5	E	10	2460	2640	2800	2960	3120	3270	3410	3550	—	—	—	—
10-22.5	E	10	—	3120	3310	3510	3690	3870	4040	—	—	—	—	—
10-22.5	F	12	—	3120	3310	3510	3690	3870	4040	4200	4360	4520	—	—
11-22.5	F	12	—	—	3760	3970	4180	4380	4580	4760	—	—	—	—
11-22.5	G	14	—	—	3760	3970	4180	4380	4580	4760	4950	5120	5300	—

Table 2, Tire Load Limits, Goodyear Bias Ply Tubeless Tires, Rear Axle (Maximum Speed 60 mph [97 km/h])

Specifications

Variations in Load and Inflation Limits According to Speed				
Speed Range mph (km/h)	Inflation Pressure Increase		Percent Increase/(Decrease) in Load	
	Bias Ply Tires psi (kPa)	Radial Ply Tires psi (kPa)	Regular Width Tires	Wide Base Tires
71–75 (114–120)	10 (69) *	10 (69) *	(10)	(10)
61–70 (98–112)	10 (69) *	10 (69) *	0	0
51–60 (82–96)	0	0	0	0
41–50 (66–80)	0	0	9	7
31–40 (50–64)	0	0	16	9
21–30 (34–48)	0	10 (69) *	24	12
11–20 (18–32)	0	15 (103) *	32	17

* Not to exceed the maximum rim or wheel capacity specified by the manufacturer of the rim or wheel.

Table 3, Variations in Load and Inflation Limits According to Speed

Tire Load Limits, Michelin Radial Ply Tubeless Tires, Front Axle															
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures													
			55 psi	60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi	110 psi	115 psi	120 psi
9R22.5X	F	12	2860	3090	3317	3502	3700	3912	4050	4307	4500	—	—	—	—	—
10R22.5X	F	12	—	—	—	—	4255	4490	4725	4963	5150	—	—	—	—	—
10R22.5X	G	14	—	—	—	—	4255	4490	4725	4963	5150	5430	5510	—	—	—
11R22.5X	G	14	—	—	—	—	4693	4950	5215	5470	5755	6040	—	—	—	—
11R22.5X	H	16	—	—	—	—	4693	4950	5215	5470	5755	6040	6245	6428	6610	—
11R24.5X	G	14	—	—	—	—	4960	5235	5513	5780	6105	6430	—	—	—	—
12R22.5X	H	16	—	—	—	—	4958	5235	5513	5705	6055	6295	6590	6835	7200	—

Table 4, Tire Load Limits, Michelin Radial Ply Tubeless Tires, Front Axle

Tire Load Limits, Michelin Radial Ply Tubeless Tires, Rear Axle															
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures													
			55 psi	60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi	110 psi	115 psi	120 psi
9R22.5X	F	12	2610	2840	3113	3261	3473	3671	3830	4050	4220	—	—	—	—	—
10R22.5X	F	12	—	—	—	—	3914	4130	4349	4566	4740	—	—	—	—	—
10R22.5X	G	14	—	—	—	—	3914	4130	4349	4566	4740	4995	5080	—	—	—
11R22.5X	G	14	—	—	—	—	4224	4550	4693	4923	5180	5440	—	—	—	—
11R22.5X	H	16	—	—	—	—	4224	4550	4693	4923	5180	5440	5620	5880	5950	—
11R24.5X	G	14	—	—	—	—	4534	4740	4976	5200	5495	5790	—	—	—	—
12R22.5X	H	16	—	—	—	—	4390	4635	4880	5130	5361	5575	6000	6055	6360	—

Table 5, Tire Load Limits, Michelin Radial Ply Tubeless Tires, Rear Axle

Tire Load Limits, Michelin Pilote X Radial Ply Tubeless Tires, Front Axle																
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures													
			55 psi	60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi	110 psi	115 psi	120 psi
225/70R19.5	G	12	—	—	—	3040	3220	3405	3640	—	—	—	—	—	—	—
235/80R22.5	G	14	—	—	3593	3815	4035	4278	4543	4675	—	—	—	—	—	—
245/70R19.5	F	12	2640	2870	3075	3270	3455	3660	3870	4080	—	—	—	—	—	—
245/70R19.5	G	14	—	—	—	3270	3455	3660	3870	4080	4425	4545	—	—	—	—
255/70R22.5	H	16	—	—	3385	3598	3810	4020	4235	4448	4652	4805	4940	5273	5510	—
255/80R22.5	G	14	—	—	—	4000	4235	4465	4710	4960	5205	—	—	—	—	—
275/80R22.5	G	14	—	—	—	4560	4825	5090	5365	5625	5920	6175	—	—	—	—
275/80R22.5	H	16	—	—	4155	4435	4715	4990	5260	5535	5805	6080	6345	6615	6940	—
275/80R24.5	G	14	—	—	—	4560	4825	5090	5365	5625	5920	6175	—	—	—	—
295/80R22.5	H	16	—	—	—	4705	4990	5285	5570	5870	6155	6450	6740	7030	7390	—
315/80R22.5	J	18	—	—	5400	5715	6045	6405	6675	6995	7310	7630	7950	8270	—	—
315/80R22.5	J	20	—	—	—	—	—	—	6675	6995	7310	7630	7950	8270	8485	8750
385/65R22.5	J	18	—	—	—	6310	6640	6940	7280	7580	7890	8220	8530	9000	9150	9370

Table 6, Tire Load Limits, Michelin Pilote X Radial Ply Tubeless Tires, Front Axle

Tire Load Limits, Michelin Pilote X Radial Ply Tubeless Tires, Rear Axle																
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures													
			55 psi	60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi	110 psi	115 psi	120 psi
225/70R19.5	G	12	—	—	—	2762	2970	3185	3415	—	—	—	—	—	—	—
235/80R22.5	G	14	—	—	3395	3594	3814	4035	4278	4410	—	—	—	—	—	—
245/70R19.5	F	12	2530	2722	2910	3102	3290	3482	3670	3860	—	—	—	—	—	—
245/70R19.5	G	14	—	—	—	3102	3290	3482	3670	3860	4062	4300	—	—	—	—
255/70R22.5	H	16	—	—	3135	3329	3522	3712	3905	4096	4280	4420	4540	4852	5070	—
255/80R22.5	G	14	—	—	—	3695	3910	4135	4355	4575	4810	—	—	—	—	—
275/80R22.5	G	14	—	—	—	4112	4350	4588	4833	5070	5335	5675	—	—	—	—
275/80R22.5	H	16	—	—	3680	3920	4168	4425	4675	4930	5175	5415	5650	5883	6175	—
275/80R24.5	G	14	—	—	—	4113	4350	4588	4833	5070	5335	5675	—	—	—	—
295/80R22.5	H	16	—	—	—	4210	4465	4740	5008	5283	5548	5805	6055	6305	6610	—

Table 7, Tire Load Limits, Michelin Pilote X Radial Ply Tubeless Tires, Rear Axle

Specifications

Tire Load Limits, Bridgestone Standard Profile Radial Ply Tubeless Tires, Front Axle																
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures													
			55 psi	60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi	110 psi	115 psi	120 psi
9R22.5	F	12	—	3010	3190	3370	3560	3730	3890	4050	4210	4350	4500	—	—	—
10R22.5	F	12	—	3560	3770	4000	4210	4410	4610	4790	4970	5150	—	—	—	—
10R22.5	G	14	—	3560	3770	4000	4210	4410	4610	4790	4970	5150	5320	5490	5670	—
11R22.5	G	14	—	—	—	4530	4770	4990	5220	5430	5640	5840	6040	—	—	—
11R22.5	H	16	—	—	—	4530	4770	4990	5220	5430	5640	5840	6040	6240	6430	6610
11R24.5	G	14	—	—	—	4820	5070	5310	5550	5780	6000	6210	6430	—	—	—
12R22.5	H	16	—	—	—	4940	5200	5450	5690	5920	6140	6370	6590	6790	7010	7200

Table 8, Tire Load Limits, Bridgestone Standard Profile Radial Ply Tubeless Tires, Front Axle

Tire Load Limits, Bridgestone Standard Profile Radial Ply Tubeless Tires, Rear Axle																
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures													
			55 psi	60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi	110 psi	115 psi	120 psi
9R22.5	F	12	—	2960	3120	3270	3410	3550	3690	3820	3950	—	—	—	—	—
10R22.5	F	12	—	3510	3690	3870	4040	4200	4360	4520	—	—	—	—	—	—
10R22.5	G	14	—	3510	3690	3870	4040	4200	4360	4520	4670	4820	4970	—	—	—
11R22.5	G	14	—	—	—	4380	4580	4760	4950	5120	5300	—	—	—	—	—
11R22.5	H	16	—	—	—	4380	4580	4760	4950	5120	5300	5470	5630	5800	—	—
11R24.5	G	14	—	—	—	4660	4870	5070	5260	5450	5640	5820	6000	6170	—	—
12R22.5	H	16	—	—	—	4780	4990	5190	5390	5590	5780	5960	6150	6320	—	—

Table 9, Tire Load Limits, Bridgestone Standard Profile Radial Ply Tubeless Tires, Rear Axle

Tire Load Limits, Bridgestone Low Profile Radial Ply Tubeless Tires, Front Axle																
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures													
			55 psi	60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi	110 psi	115 psi	120 psi
245/70R19.5	F	12	2640	2870	3075	3270	3455	3660	3870	4080	—	—	—	—	—	—
245/75R22.5	G	14	—	—	—	3470	3645	3810	3975	4140	4300	4455	4610	4675	—	—
255/70R22.5	H	16	—	—	—	—	—	—	4410	4600	4780	4970	5150	5330	5510	—
265/75R22.5	G	14	—	—	—	3875	4070	4255	4440	4620	4800	4975	5150	5205	—	—
285/75R24.5	G	14	—	—	—	4545	4770	4990	5210	5420	5675	5835	6040	6175	—	—
295/75R22.5	G	14	—	—	—	4500	4725	4945	5155	5370	5575	5780	5980	6175	—	—
315/80R22.5	J	18	—	—	5400	5715	6045	6405	6675	6995	7310	7630	7950	8270	—	—
385/65R22.5	J	18	—	—	—	6380	6710	7040	7350	7650	7950	8230	8510	8790	9050	9370

Table 10, Tire Load Limits, Bridgestone Low Profile Radial Ply Tubeless Tires, Front Axle

Specifications

Tire Load Limits, Bridgestone Low Profile Radial Ply Tubeless Tires, Rear Axle															
Size	Load Range	Ply Rating	Maximum Tire Loads (lbs) at Various Cold Inflation Pressures												
			55 psi	60 psi	65 psi	70 psi	75 psi	80 psi	85 psi	90 psi	95 psi	100 psi	105 psi	110 psi	115 psi	120 psi
245/70R19.5	F	12	2530	2722	2910	3102	3290	3482	3670	3860	—	—	—	—	—	—
245/75R22.5	G	14	—	—	—	3465	3615	3765	3915	4055	4195	4300	—	—	—	—
255/70R22.5	H	16	—	—	—	—	—	—	4050	4230	4400	4570	4740	4910	5070	—
265/75R22.5	G	14	—	—	—	3875	4040	4205	4370	4525	4685	4805	—	—	—	—
285/75R24.5	G	14	—	—	—	4540	4740	4930	5205	5310	5495	5675	—	—	—	—
295/75R22.5	G	14	—	—	—	4500	4725	4945	5155	5370	5510	5780	5980	6175	—	—

Table 11, Tire Load Limits, Bridgestone Low Profile Radial Ply Tubeless Tires, Rear Axle

Disc-Type Wheel Fastener Torques for Accuride Wheels		
Description	**Nut Size**	**Torque (dry threads) lbf·ft (N·m)**
8-Hole Disc Wheel With Two-Piece Flange Nuts		
Front and Rear Wheel Nut	M22 x 1.5	450–500 (610–678) *
10-Hole Disc Wheel With Two-Piece Flange Nuts		
Front and Rear Wheel Nut	M22 x 1.5	450–500 (610–678) *
10-Hole Disc Wheel With Inner and Outer Nuts		
Front Wheel Nut	1-1/8–16	400–500 (540–678) † 450–500 (610 –678) ‡ 450–500 (610–678)
	3/4–16	450–500 (610–678) *
Rear Wheel Inner Nut	3/4–16	400–500 (540–678) † 450–500 (610–680)
Rear Wheel Outer Nut	1-1/8–16	400–500 (540–678) † 450–500 (610–680)
Wheel Stud Retainer Nut	3/4–16	175–200 (235–270)

* Torque values are given for lubricated threads.
† Lubricated threads should be tightened 405 to 510 N·m (300 to 375 lbf·ft). Lubricate threads with a mixture of 25 percent colloidal graphite in cup grease or equivalent. Do not apply thread lubricant to ball seats of the nuts and wheels. Wipe it off if it is applied accidentally.
‡ On 1-1/8–16 size wheel studs with a head (**Fig. 1**), tighten the wheel nuts 650 to 750 lbf·ft (880 to 1020 N·m).

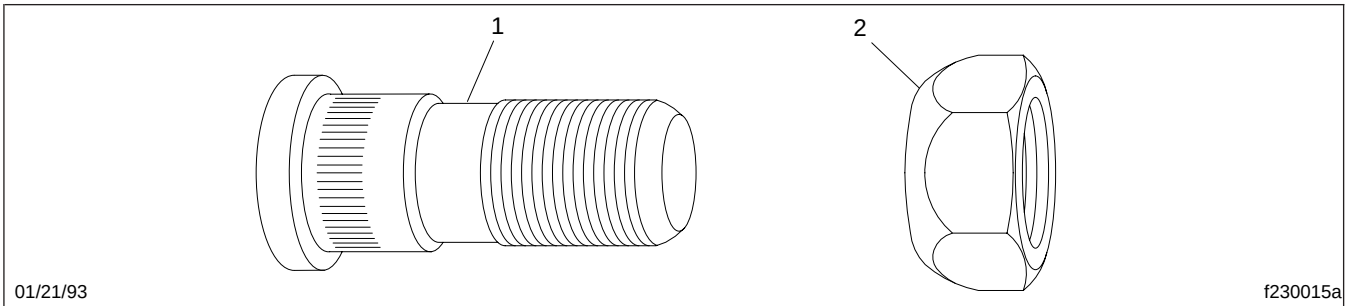
Table 12, Disc-Type Wheel Fastener Torques for Accuride Wheels

Specifications

Spoke-Type Wheel Mounting Torques for Gunite		
Description	**Nut Size**	**Torque (dry threads) lbf·ft (N·m)**
Front Wheel Nut, 5- and 6-Spoke	5/8–11	160–175 (215–235) 150–175 (205–235)
	3/4–10	240–260 (325–355) 200–225 (270–305) * 200–250 (270–340)
Rear Wheel Nut, 5- and 6-Spoke	5/8–11	160–175 (215–235) 150–175 (205–235)
	3/4–10	190–210 (260–285) † 200–225 (270–305) 200–250 (270–340)

* On front axles with over 12,000 lb (5448 kg) capacity, tighten nuts 240 to 265 lbf·ft (325 to 360 N·m). Gunite part number W-854 nut, with a phosphate and oil coating, must be used.
† 190 to 210 lbf·ft (260 to 285 N·m) recommended when using channel spacers (**Fig. 2**). 240 to 260 lbf·ft (325 to 355 N·m) permitted when using corrugated or corrugated-channel spacers. See **Fig. 3**.

Table 13, Spoke-Type Wheel Mounting Torques for Gunite



1. Head-Type Wheel Stud (1-1/8–16)
2. Wheel Nut

Fig. 1, Head-Type Wheel Nut

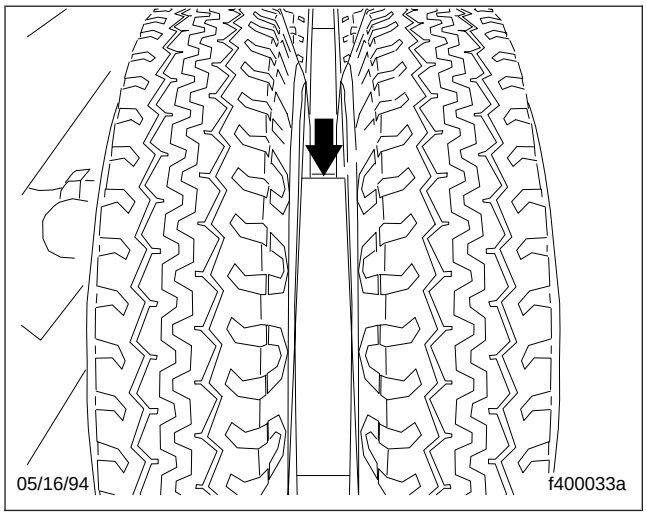


Fig. 2, Channel Spacer

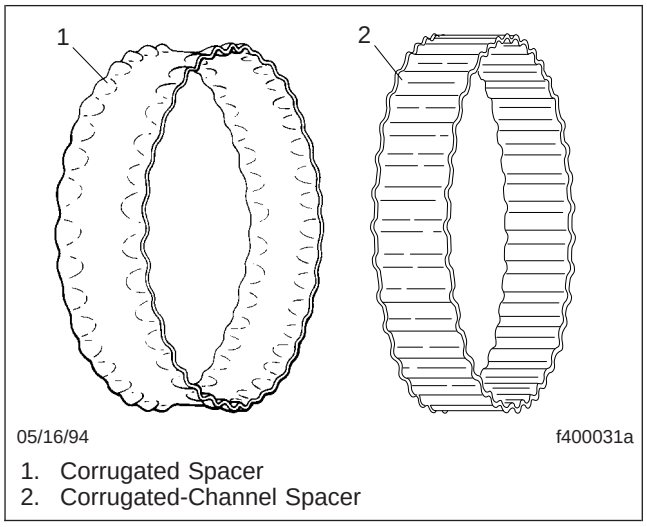


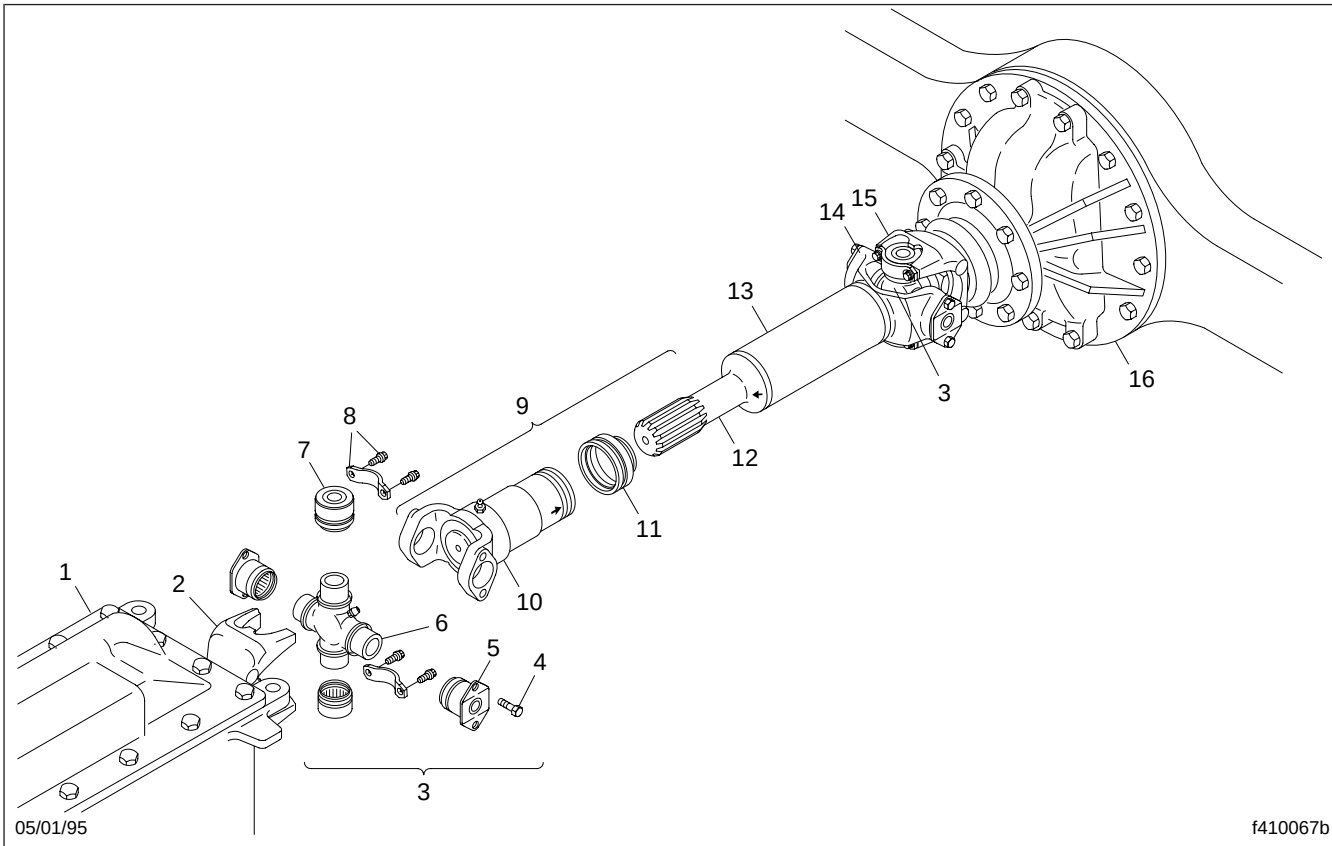
Fig. 3, Corrugated Spacers

General Information

The simplest driveline consists of a transmission output-shaft end-yoke, an axle input-shaft end-yoke, and a single slip-jointed driveshaft connecting the two end-yokes. See **Fig. 1**. The driveshaft is made up of a universal joint (U-joint), a sleeve-yoke, a splined stub shaft, a driveshaft tube, a tube-yoke, and a second U-joint.

DRIVELINE CONFIGURATIONS

The specific type and number of drivelines used on each vehicle depends on its number of transmissions, its number of drive axles, and its wheelbase. See **Fig. 2**. A driveline is used between each driving and driven component. A driveline connecting a main transmission (or anauxiliary transmission) to a single drive axle or forward-rear axle of a dual-drive vehicle is always referred to as a no. 2 driveline. See **Fig. 2**, examples A, B, C,D, and E. An interaxle driveline of a dual-drive vehicle is always called a no. 3 driveline.



NOTE: Not all fasteners are shown.

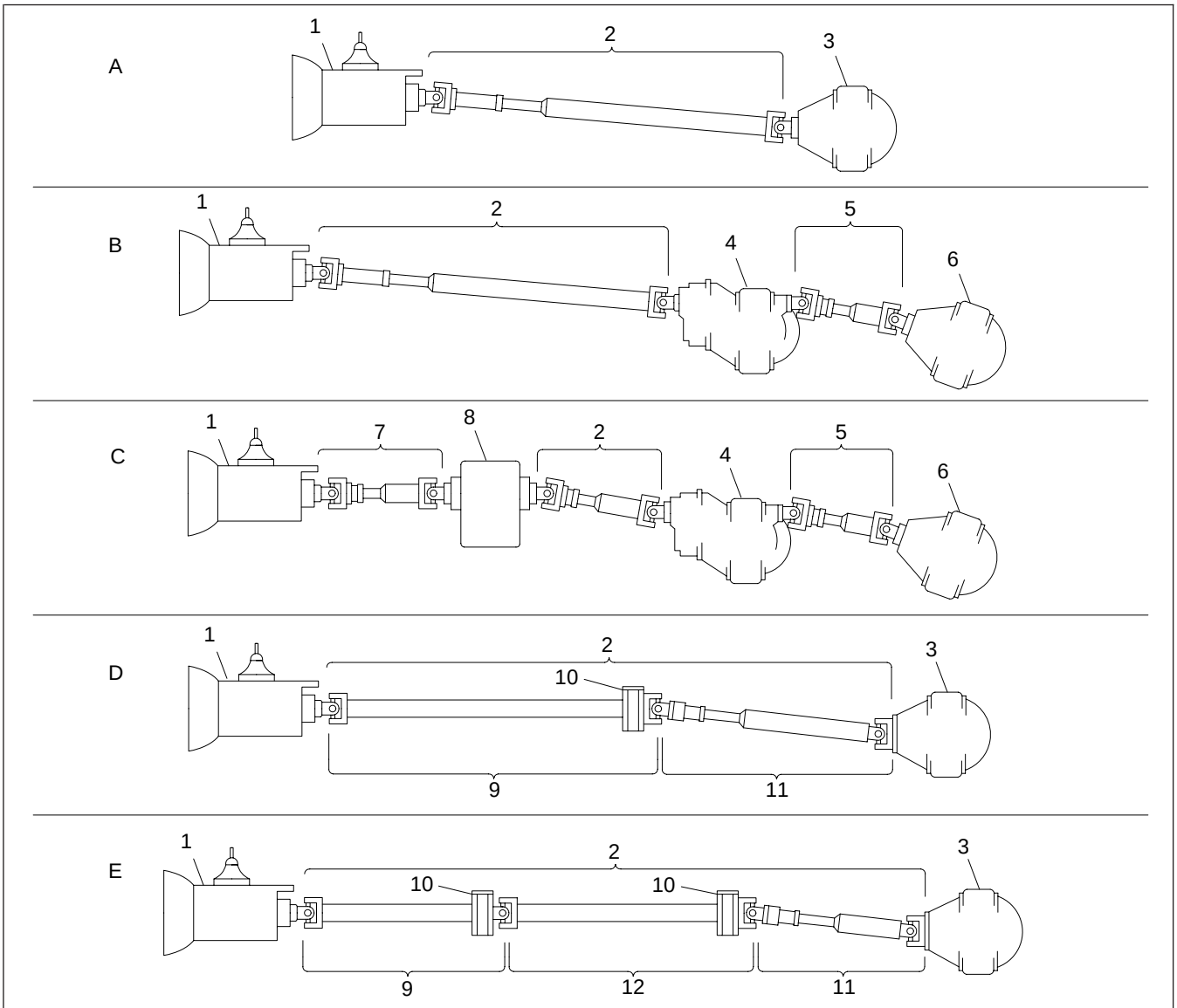
1. Transmission
2. Transmission Output-Shaft End-Yoke (half-round)
3. U-Joint Assembly
4. Bearing Plate Self-Locking Capscrew
5. Bearing Cup (for full-round yoke)
6. U-Joint Cross
7. Bearing Cup (for half-round yoke)
8. Bearing Strap and Bearing-Strap Capscrew
9. Slip-Joint Assembly
10. Sleeve-Yoke (full-round)
11. Dust Cap
12. Splined Stub Shaft
13. Driveshaft Tube
14. Tube-Yoke (full-round)
15. Axle Input-Shaft End-Yoke (half-round)
16. Rear Axle

Fig. 1, Components of a Basic Driveline

General Information

See **Fig. 2**, examples *B*and *C*. A driveline connecting a main transmission to an auxiliary transmission is alwaysreferred to as a no. 1 driveline. See **Fig. 2**, example *C*. Business Class Trucks are not equipped with no. 1 drivelines or auxiliarytransmissions.

A long driveshaft, supported only at its ends, will sag in the middle from its own weight. When turning at high rpm, it will flex, causing an out-of-balance vibration. Therefore, vehicles having a long wheelbase use a midship bearing, mounted on a frame cross-



09/14/95 f410069a

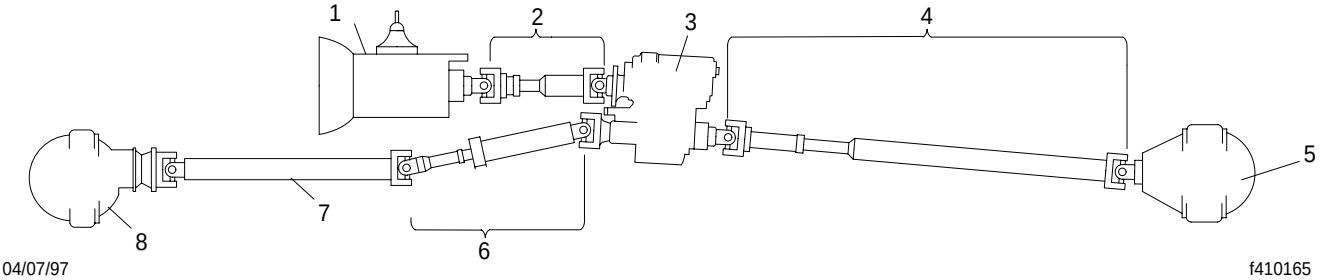
1. Main Transmission
2. No. 2 Driveline
3. Rear Axle
4. Forward-Rear Axle
5. No. 3 Driveline
6. Rearmost Axle
7. No. 1 Driveline
8. Auxiliary Transmission
9. Primary Coupling Shaft
10. Midship Bearing
11. No. 2 Driveshaft
12. Intermediate Coupling Shaft

Fig. 2, Driveline Configurations

member, for additional support. See **Fig. 2**, example *D*. This allows the no. 2 driveline to be separated into two, shorter shafts (a coupling shaft and a no. 2 driveshaft), thus improving balance and stability.

Vehicles having an even longer wheelbase use two crossmember-mounted midship bearings, allowing the no. 2 driveline to be separated into three short shafts, joined by four U-joints. See **Fig. 2**, example *E*. The first shaft is the primary coupling shaft, the second is the intermediate coupling shaft, and the third is the no. 2 driveshaft.

Vehicles manufactured with all-wheel-drive use a transfer case to provide power to the front driveaxle. See **Fig. 3**.



1. Engine
2. No. 1 Driveline
3. Transfer Case
4. No. 2 Driveshaft
5. Rear Axle
6. AWD Driveshaft No. 1
7. AWD Driveshaft No. 2
7. Front Drive Axle

Fig. 3, All-Wheel-Drive Driveline Configuration

SLIP-JOINTS, U-JOINTS, AND YOKES

The basic function of the driveline is to send torque from the transmission to the axle in a smooth and continuous action. Because the vehicle axles are not attached directly to the frame, but are suspended by springs, theyride in an irregular, floating motion (when going over bumps or depressions), thus changing the distance between the transmission (or coupling shaft) and the rear axle, and the distance between the rear axles. The slip-joints of the no.2 and no. 3 driveshafts, by expanding and contracting, allow for length changes between drivetrain components. Couplingshafts do not require a slip-joint.

Motion of the rear axle(s) also causes changes to the relative angles between drivetrain components. U-jointsallow transfer of torque from an output shaft (or coupling shaft) to the driveshaft, and from the driveshaft to an input shaft, even though the angles between the shafts may be constantly changing.

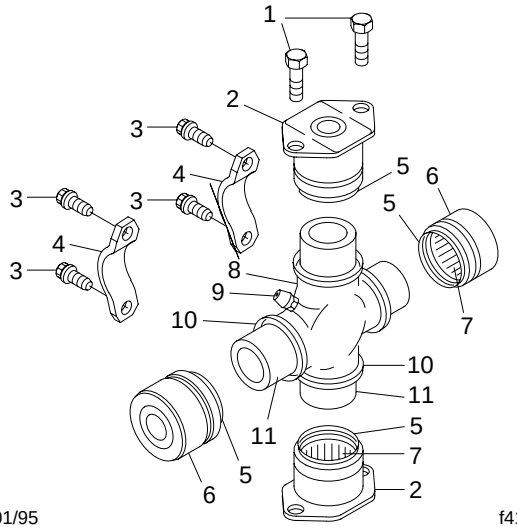
Each U-joint consists of a cross with a close-tolerance ground cylindrical surface (trunnion) at the end of each of the four arms. Installed on each trunnion is a bearing cup lined with bearing needles. All bearing cups are sealed to retain lubricants, and to prevent entry of foreign material. See **Fig. 4**. In operation, the four bearing cups are held stationary in a pair ofyokes, while the U-joint cross pivots on its trunnions.

Full-round yokes are installed at the front of coupling shafts and at both ends of the no. 2 and no.3 driveshafts. All tube-yokes (yokes that are welded into driveshaft tubes) and all sleeve-yokes (yokes that are part of the internally splined half of slip-joints) are full-round yokes. See **Fig. 5**, Refs. 4 and 9.

An end-yoke is an internally splined yoke, held on an externally splined shaft by a locknut. As standard equipment, all end-yokes used on Business Class Trucks are half-round; full-round end-yokes are optional. End-yokes areinstalled on the transmission output shaft, on each axle input and output shaft, and behind the midship bearing of most coupling shafts. See **Fig. 5**, Refs. 2, 7, 12,and 14. A half-round flange-yoke is used with the driveline parking brake, and fastens with locknuts to the studs of a companion flange that installs on the transmission output shaft or the rear axle input shaft in the same manner as an end-yoke. See **Fig. 6**.

Spicer SPL90 (1590), 1610, 1710, 1760, and 1810 U-joints, and Rockwell 17T, 176T, and 18T U-joints are coupled to half-round end-yokes and flange-yokes by capscrews inserted through semicircular bearing straps that hold the bearing cups in place under tabs in the yoke cross-holes. See **Fig. 7**.

General Information



NOTE: Components shown are typical of all U-joints installed in Freightliner vehicles with half-round end-yokes, except Spicer SPL90 (1590) U-joints.

1. Bearing-Plate Capscrews
2. Bearing Cup (for full-round yoke)
3. Bearing-Strap Capscrew
4. Bearing Strap
5. Bearing-Cup Seal
6. Bearing Cup (for half-round yoke)
7. Bearing Needles
8. U-Joint Cross
9. Grease Fitting
10. U-Joint Cross Slinger
11. Trunnion

Fig. 4, Typical U-Joint

A Spicer SPL90 (1590) U-joint is installed in a full-round tube-yoke or sleeve-yoke by installing the cross and bearing cups into the yoke cross-holes, then installing a snap ring into a groove in each cross-hole. See **Fig. 8**.

Spicer 1610, 1710, 1760, and 1810 U-joints, and Rockwell 17, 176, and 18 series U-joints are installed in full-round tube-yokes, sleeve-yokes, and end-yokes, by inserting the cross through from the inside of both yoke cross-holes, then installing the bearing cups into the outsides of the yoke and over the ends of the trunnions.Capscrews, inserted through a bearing plate at the back of each cup, thread into the yoke to secure the cups. For bothSpicer and Rockwell U-joints installed from April 1, 1994, the capscrews are self-locking; for U-joints installed before April 1, 1994, non-self-locking capscrews are used with lockstraps to secure the capscrews. See **Fig. 9**.

U-JOINT ANGLES, PHASING, AND DRIVELINE BALANCE

Correct U-joint working angles, U-joint phasing, and driveline balance are vital to maintaining a quiet-running drivetrain and long life of drivetrain components (including driveline components).

The U-joint working angle is the angle formed by the intersection of the driveshaft centerline and the extended centerline of the shaft of any component (or other driveshaft) to which the U-joint connects. See **Fig. 10**. Because the double oscillating motionof a U-joint that connects angled shafts causes a fluctuating speed difference between the shafts, the effect created by the U-joint at one end of the shaft must cancel the effect created by the U-joint at the other end. This is done bymaking U-joint working angles at both ends of the driveshaft approximately equal, with the U-joints in phase. If theyoke lugs at both ends of the shaft are lying in the same plane (a plane which bisects the shaft lengthwise) theU-joints will be in phase. See **Fig. 11**.

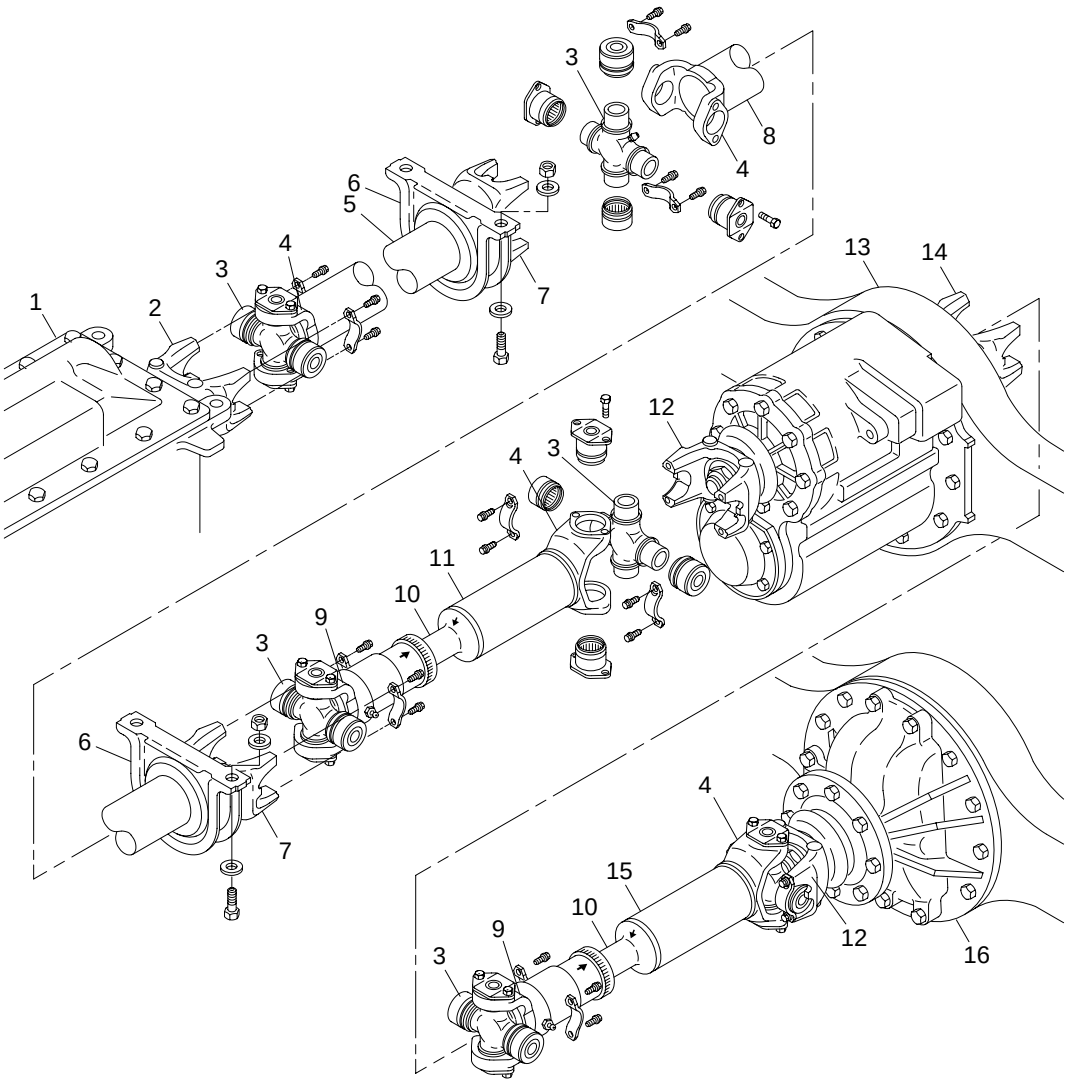
After manufacture, each driveline yoke is statically balanced. After assembly, each driveshaft and coupling shaft is checked for out-of-roundness, straightened as necessary, then dynamically balanced.

AVOIDING DRIVELINE PROBLEMS

To ensure that U-joints turn in phase, sleeve-yokes, splined shafts, coupling shaft end-yokes, and coupling shafts, should be marked for assembly reference before disassembly. A misaligned slip-joint will seriously affect driveline balance (and U-joint phasing). Even if a slip-joint is assembled 180 degrees from its original position (which will keep the U-joints in phase), the dynamic balance of the driveshaft will be negatively affected.

A driveline can become unbalanced or greatly weakened if a driveshaft has been dented, bent, twisted, orotherwise damaged. Operating a vehicle at speeds which exceed the speed of the driveshaft's design specifications willcause an out-of-balance vibration. Any condition which allows excessive movement of a driveshaft will cause drivelineimbalance: loose end-yoke nuts, loose midship bearing mounts, loose U-joint bearing cup retaining capscrews, wornU-joint trunnions and bearings, and worn slip-joint splines.

Among the most common causes of U-joint and slip-joint damage is lack of lubrication.



05/01/95 f410068b

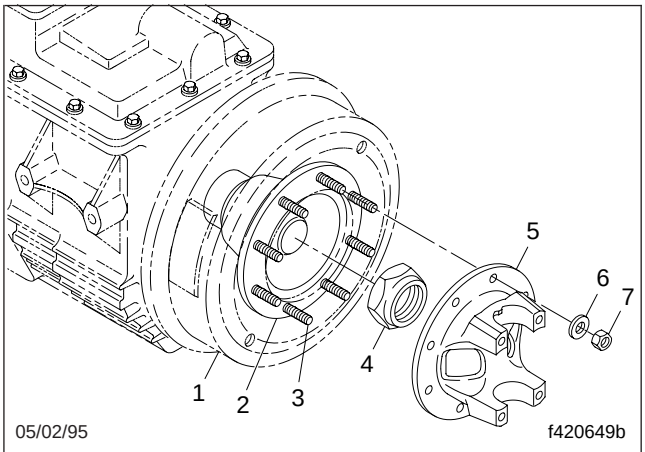
NOTE: Not all fasteners are shown.

1. Transmission
2. Transmission Output-Shaft End-Yoke (half-round)
3. U-Joint Assembly
4. Full-Round Tube-Yoke
5. Primary Coupling Shaft Tube
6. Midship Bearing Assembly
7. Coupling Shaft End-Yoke (half-round)
8. Intermediate Coupling Shaft Tube
9. Sleeve-Yoke (full-round)
10. Slip-Joint Assembly
11. No. 2 Driveshaft Tube
12. Axle Input-Shaft End-Yoke (half-round)
13. Forward-Rear Axle
14. Axle Output-Shaft End-Yoke (half-round)
15. No. 3 Driveshaft Tube
16. Rearmost Axle

Fig. 5, Dual-Drive Installation With Primary and Intermediate Coupling Shafts

To keep a vehicle operating smoothly and economically, the driveline must be carefully checked and lubricated at regular intervals. For inspection and lu-

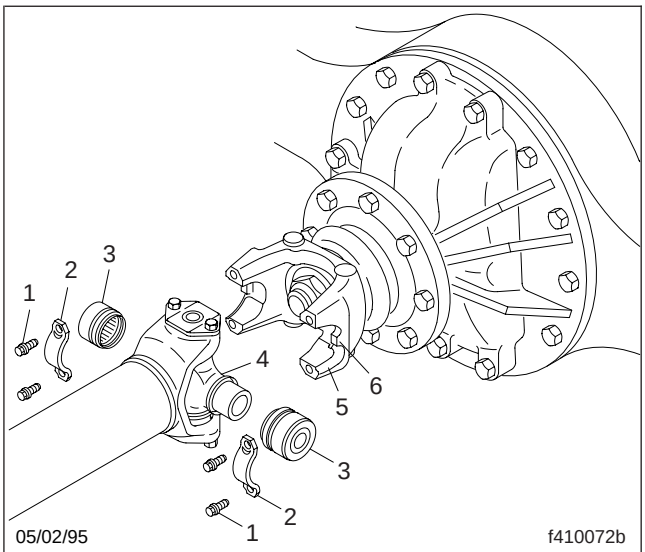
General Information



NOTE: Not all fasteners are shown.

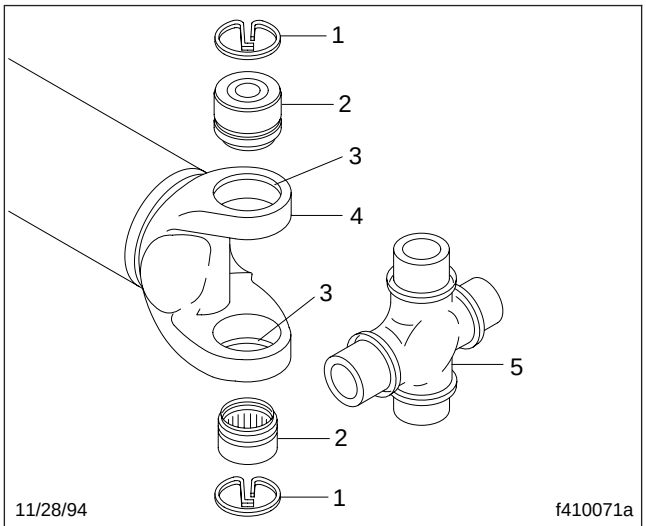
1. Parking Brake Drum
2. Companion Flange
3. 3/8–24 Threaded Stud
4. Companion-Flange Locknut
5. Half-Round Flange-Yoke
6. Bearing Washer
7. Flange-Yoke Locknut

Fig. 6, Companion Flange and Flange-Yoke Installation



1. Bearing-Strap Capscrew
2. Bearing Strap
3. Bearing Cup
4. U-Joint Cross
5. Half-Round Yoke
6. Yoke Cross-Hole Tab

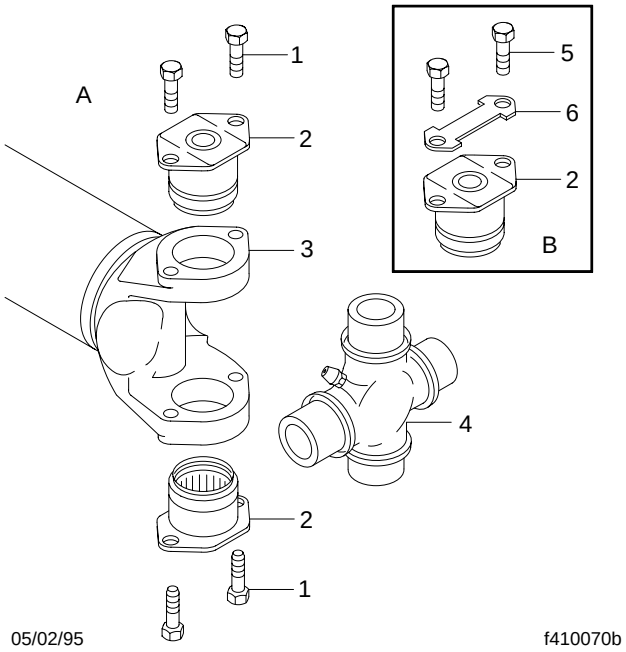
Fig. 7, Coupling of a Spicer or Rockwell U-Joint With a Half-Round End-Yoke



1. Snap Ring
2. Bearing Cup
3. Snap-Ring Groove
4. Full-Round Yoke
5. U-Joint Cross

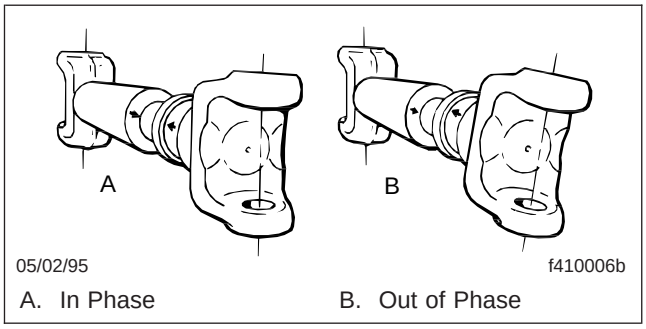
Fig. 8, Installation of a Spicer SPL90 (1590) U-Joint in a Full-Round Yoke

brication intervals and procedures, see Group 41 of the *Business Class Trucks Maintenance Manual*.



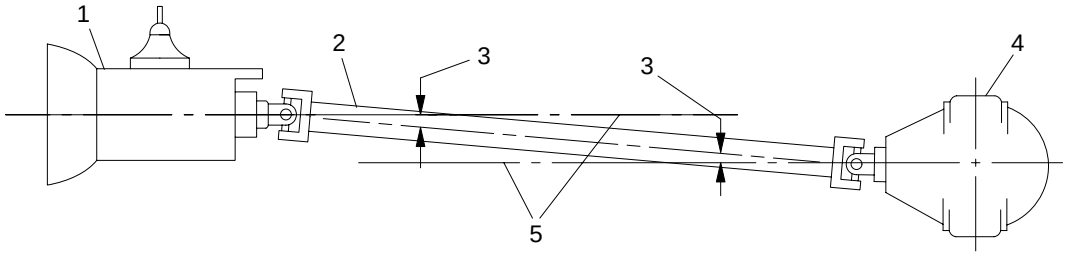
A. U-joint installed from April 1, 1994.
B. U-joint installed before April 1, 1994.
1. Bearing-Plate Self-Locking Capscrew
2. Bearing Cup (bearing-plate-type)
3. Full-Round Yoke
4. U-Joint Cross
5. Bearing-Plate Capscrew
6. Lockstrap

Fig. 9, Installation of a Spicer 1610/1710/1760/1810 U-Joint or Rockwell 17/176/18-Series U-Joint in a Full-Round Yoke



A. In Phase
B. Out of Phase

Fig. 11, U-Joint Phasing



1. Transmission
2. No. 2 Driveshaft
3. U-Joint Working Angles
4. Rear Axle
5. Extended Centerlines

Fig. 10, U-Joint Working Angles

U-Joint Uncoupling and Coupling With a Half-Round End-Yoke

NOTE: It is easier to check driveline parts, and to replace a U-joint or midship bearing assembly if the driveshaft is removed from the vehicle. If a driveshaft requires straightening or balancing, it must be removed, and installed on a lathe or a balance machine. Removal is required for replacement of slip-joint parts, a driveshaft tube, or a tube-yoke. To remove the driveshaft, see **Subject 120**.

Many service operations do not require driveshaft removal from the vehicle: end-yoke or companion-flange nut tightening; drive component shaft seal, end-yoke, or flange-yoke replacement; changing U-joint phasing at the slip-yoke; and transmission or axle removal (for overhaul, repair, or replacement). To perform these operations, uncouple the U-joint at the applicable end of the appropriate driveshaft.

U-Joint Uncoupling (See Fig. 1)

1. Apply the parking brakes, and chock the tires.
2. Turn the appropriate end-yoke (or flange-yoke) until the centerline through its cross-holes is horizontal. See **Fig. 1**, details *A* and *B*. If the half-round bearing cups do not already have a retaining wire installed, install a bearing-cup retaining wire. See **Fig. 1**, detail *C*. Or, install safety wire from the retaining-wire groove of one half-round bearing cup to the other.
3. Support the driveshaft with a nylon support strap.

   When uncoupling a coupling shaft, install two or three support straps, as needed. Remove the fasteners that attach the midship bearing(s) to its bracket(s). See **Fig. 1**.
4. Remove the capscrews that secure the bearing straps to the half-round yoke. Remove the bearing straps.
5. Compress the slip-joint to remove the U-joint from the yoke.

CAUTION

Do not expose the U-joint trunnions or bearing-cup needles to dirt or grit. The smallest bits of dirt or grit can cause rapid wear and serious damage to the U-joint.

U-Joint Coupling (See Fig. 1)

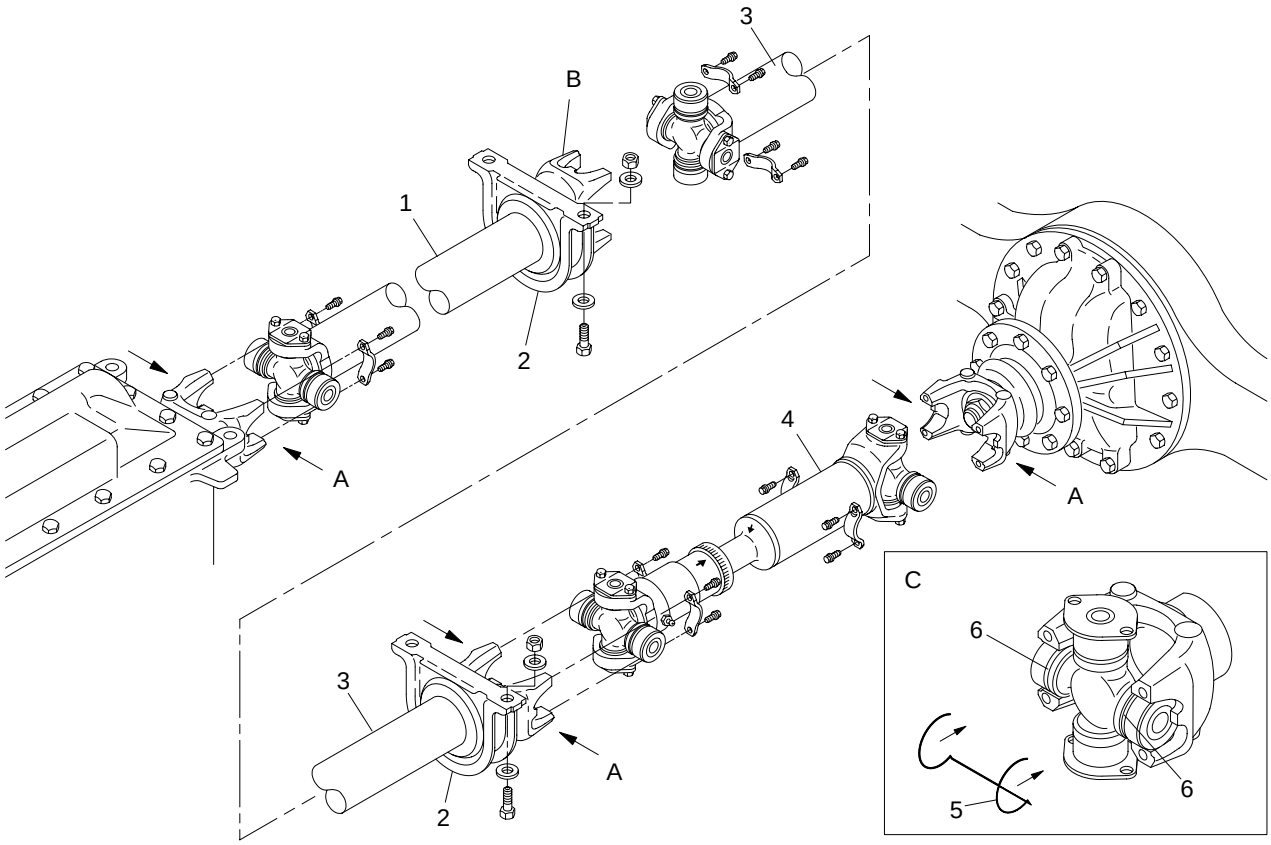
1. Check and clean the end-yoke.
   - 1.1 Check the torque on the end-yoke nut; see the applicable table in **Specifications 400**.
   - 1.2 Check the end-yoke (or flange-yoke) cross-holes for burrs or raised metal. Using a half-round file, remove burrs or raised metal. See **Fig. 2**.
   - 1.3 Using fine emery cloth, smooth and clean the entire surface of the yoke cross-holes and bearing straps. See **Fig. 3**.
   - 1.4 Turn the end-yoke (or flange-yoke) until its cross-holes are horizontal. See **Fig. 1**.
2. Check, clean, and lubricate the U-joint.
   - 2.1 Remove the bearing-cup retaining wire or safety wire. See **Fig. 1**, detail *C*.

CAUTION

Do not expose the U-joint trunnions or bearing-cup needles to dirt or grit. The smallest bits of dirt or grit can cause rapid wear and serious damage to the U-joint.

   - 2.2 Using fine emery cloth, smooth and clean the outside surfaces of both bearing cups. See **Fig. 4**.
   - 2.3 Check the U-joint trunnions and bearing cups for minute particles of dirt or grit. Clean if necessary; see **Subject 130**.
   - 2.4 Using NLGI grade 2 grease with EP additives, wipe a small amount of grease on the needles in the bearing cups.
   - 2.5 Using a light-weight oil, lubricate the lips of the bearing-cup seals. See **Fig. 5**.
   - 2.6 Install the bearing cups on the cross.
   - 2.7 Install a bearing-cup retaining wire. See **Fig. 1**, detail *C*. Or, install safety wire from the retaining-wire groove of one half-round bearing cup to the other.
3. Extend the slip-joint, while pressing the cross and bearing cups into place in the yoke cross-

U-Joint Uncoupling and Coupling With a Half-Round End-Yoke



08/11/95 f410074b

NOTE: Not all fasteners are shown.

A. End-yoke cross-hole centerline is horizontal.
B. Before uncoupling/coupling the U-joint, turn the end-yoke until its cross-hole centerline is horizontal.
C. Install a half-round bearing-cup retaining wire (or safety wire) before removing the bearing straps.

1. Primary Coupling Shaft
2. Midship Bearing
3. Intermediate Coupling Shaft
4. No. 2 Driveshaft
5. Half-Round Bearing-Cup Retaining Wire
6. Retaining-Wire Groove

Fig. 1, U-Joint Uncoupling/Coupling for Drivelines With Half-Round End-Yokes

holes. Using a rubber or plastic mallet, gently tap the bearing cups to seat them in the yoke. See **Fig. 6**.

⚠ CAUTION

Do not use the capscrews and bearing straps to seat the bearing cups in the yoke. Seating the cross by tightening the bearing straps can deform the bearing straps, allowing the bearing cups to spin, which will cause rapid wear and serious damage to the U-joint.

4. Place the bearing straps over the cups, and install the new strap capscrews, finger-tight.

⚠ WARNING

The self-locking bearing-strap capscrews must not be reused. Replace the capscrews with new ones. Also, do not undertighten or overtighten the capscrews; use proper torque values. A loose or broken fastener at any point in the driveline weakens the driveline connection and can result in a driveshaft separating from the vehicle. Drive-

U-Joint Uncoupling and Coupling With a Half-Round End-Yoke

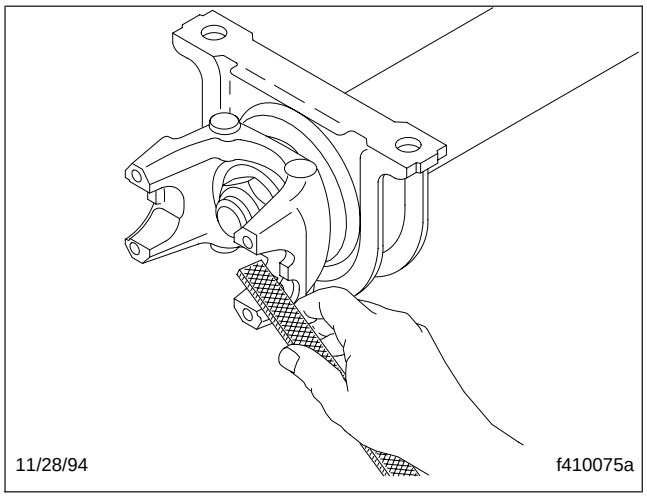
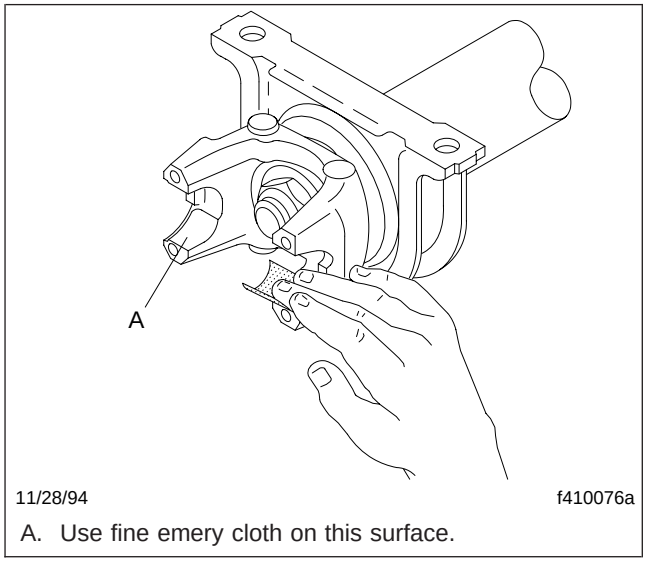


Fig. 2, Removing Burrs From a Half-Round End-Yoke Cross-Hole



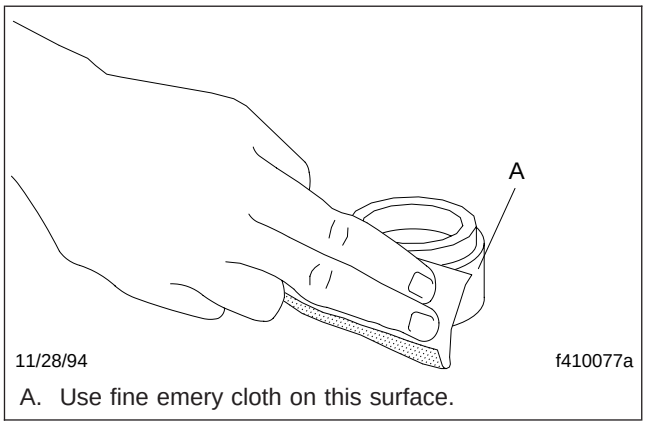
A. Use fine emery cloth on this surface.

Fig. 3, Smoothing a Half-Round End-Yoke Cross-Hole

line separation can cause loss of vehicle control that could result in serious personal injury or death.

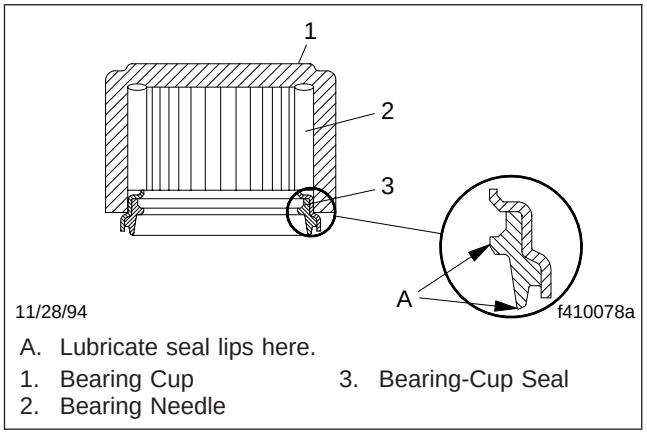
Separation of the driveline can also cause damage to the driveline, driveline components, or other areas of the vehicle.

5. Alternately tighten the bearing-strap capscrews in increments of 20 lbf·ft (27 N·m) to the applicable torque value in **Specifications, 400**.



A. Use fine emery cloth on this surface.

Fig. 4, Smoothing a Half-Round End-Yoke U-Joint Bearing Cup

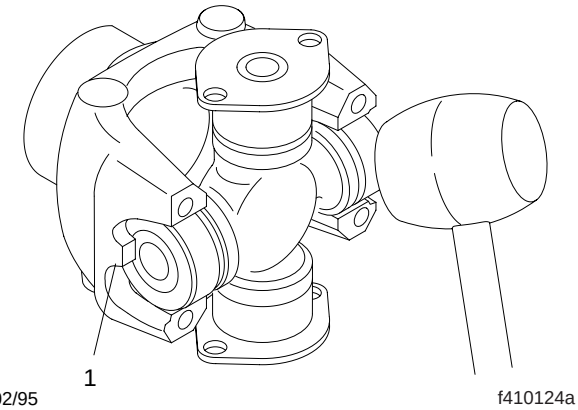


A. Lubricate seal lips here.
1. Bearing Cup
2. Bearing Needle
3. Bearing-Cup Seal

Fig. 5, Sectional View of a Half-Round End-Yoke U-Joint Bearing Cup

6. If they were removed, install the fasteners that attach each midship bearing to its bracket; tighten the flanged locknuts 91 lbf·ft (123 N·m).
7. Lubricate the U-joint, following the procedure in Group 41 of the *Business Class Trucks Maintenance Manual*.
8. Remove the nylon support straps, then remove the chocks.

U-Joint Uncoupling and Coupling With a Half-Round End-Yoke



1. Retaining Tab

Fig. 6, Seating a U-Joint in a Half-Round End-Yoke

U-Joint Uncoupling and Coupling With a Full-Round End-Yoke

NOTE: It is easier to check driveline parts, and to replace a U-joint or midship bearing assembly if the driveshaft is removed from the vehicle. If a driveshaft requires straightening or balancing, it must be removed, and installed on a lathe or a balance machine. Removal is required for replacement of slip-joint parts, a driveshaft tube, or a tube-yoke. To remove the driveshaft, see **Subject 120**.

Many service operations do not require driveshaft removal from the vehicle: end-yoke or companion-flange nut tightening; drive component shaft seal, end-yoke, or flange-yoke replacement; changing U-joint phasing at the slip-yoke; and transmission or axle removal (for overhaul, repair, or replacement). To perform these operations, uncouple the U-joint at the applicable end of the appropriate driveshaft.

U-Joint Uncoupling (See Fig. 1)

1. Apply the parking brakes, and chock the tires.
2. Turn the appropriate end-yoke until the centerline through its cross-holes is vertical. See **Fig. 1**.
3. Support the driveshaft with a nylon support strap.

   When uncoupling a coupling shaft, install two or three support straps, as needed. Remove the fasteners that attach the midship bearing(s) to its bracket(s).
4. For a vehicle built from April 1, 1994, remove and discard all four bearing-cup-plate self-locking capscrews.

   For a vehicle built before April 1, 1994, use a pin punch to bend the tabs of the lockplates away from all four of the bearing-cup-plate capscrews. See **Fig. 2**. Remove the capscrews and lockplates.
5. Using one of the U-joint pullers listed in **Specifications 400**, remove both bearing assemblies from the end-yoke cross-holes. See **Fig. 3**.
6. Compress the slip-joint and pivot the end of the U-joint cross to remove it from the yoke. Install the bearing cups, then use tape to secure them to the U-joint cross.

CAUTION

Do not expose the U-joint trunnions or bearing-cup needles to dirt or grit. The smallest bits of dirt or grit can cause rapid wear and serious damage to the U-joint.

U-Joint Coupling (See Fig. 1)

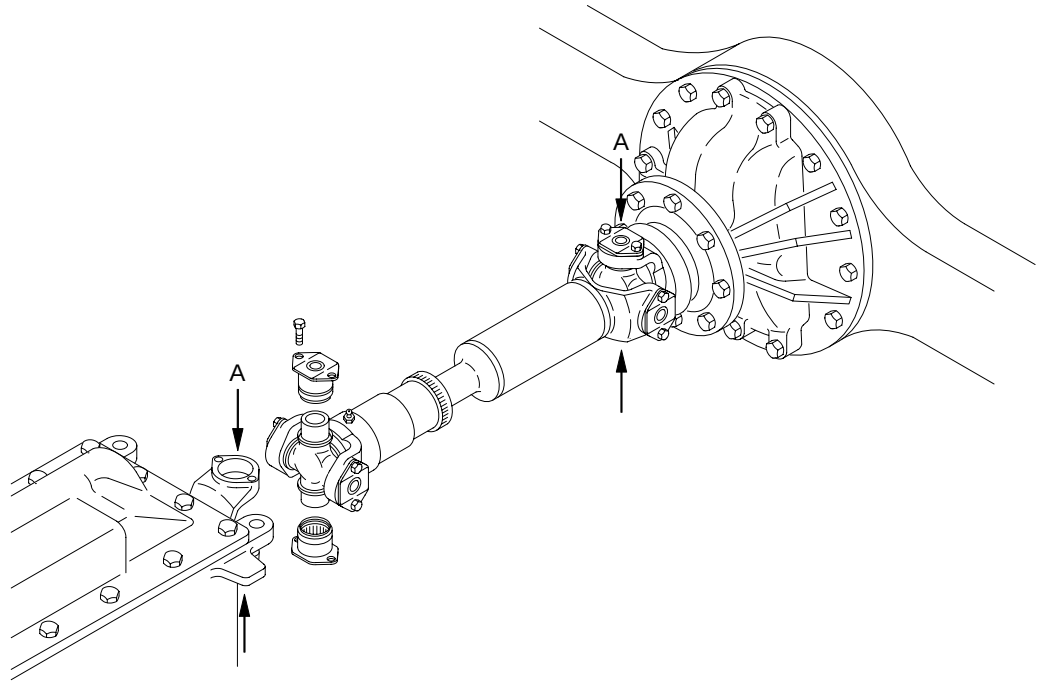
1. Check and clean the end-yoke.
   - 1.1 Check the torque on the end-yoke nut; see the applicable table in **Specifications 400**.
   - 1.2 Check the end-yoke cross-holes for burrs or raised metal. Using a rat-tail or half-round file, remove burrs or raised metal. See **Fig. 4**.
   - 1.3 Using a mill file, and holding it flat against the machined surface of the yoke lug, remove any burrs or raised metal. See **Fig. 5**.
   - 1.4 Using fine emery cloth, smooth and clean the entire surface of the yoke cross-holes. See **Fig. 6**.
   - 1.5 Turn the end-yoke until the centerline through its cross-holes are vertical. See **Fig. 1**.
2. Check, clean, and lubricate the U-joint.
   - 2.1 Using fine emery cloth, smooth and clean the outside surfaces of both bearing cups. See **Fig. 7**.
   - 2.2 Check the U-joint trunnions and bearing cups for minute particles of dirt or grit. Clean if necessary; see **Subject 130**.

CAUTION

Do not expose the U-joint trunnions or bearing-cup needles to dirt or grit. The smallest bits of dirt or grit can cause rapid wear and serious damage to the U-joint.

   - 2.3 Using NLGI grade 2 grease with EP additives, wipe a small amount of grease on the needles in the bearing cups.
   - 2.4 Using a light-weight oil, lubricate the lips of the bearing-cup seals. See **Fig. 8**.

U-Joint Uncoupling and Coupling With a Full-Round End-Yoke



05/02/95 f410148

NOTE: Not all fasteners are shown.
A. End-yoke cross-hole centerline is vertical.

Fig. 1, U-Joint Uncoupling/Coupling of a Driveline With Full-Round End-Yokes

3. Couple the U-joint cross to the end-yoke.

   3.1 Extend the slip-joint, while pivoting the U-joint cross into place in the yoke cross-holes.

   3.2 Move one end of the cross until a trunnion projects through the cross-hole, beyond the outer machined face of the yoke lug. Using a Spicer trunnion (journal) locator (see **Specifications 400**), hold the trunnions in alignment with the cross-holes, while placing a bearing assembly over the projected trunnion, and aligning it with the cross-hole. See **Fig. 9**.

   IMPORTANT: A Spicer trunnion (journal) locator should be used, to prevent damage to the U-joint trunnions and slingers.

   3.3 By hand, press the bearing assembly flush with the face of the yoke. If the bearing assembly binds in the cross-hole, tap the *center* of the bearing plate with a rubber or rawhide mallet; do not tap the outer edges of the bearing plate. See **Fig. 10**.

   3.4 As equipped, install *new* bearing-cup-plate self-locking capscrews (**Fig. 11** for a Spicer U-joint; **Fig. 12** for a Rockwell U-joint), or the lockstrap and bearing-cup-plate (not self-locking) capscrews. Tighten the capscrews until all the parts are drawn down tight, with no gaps; do not tighten the capscrews to their final torque value.

⚠ WARNING

Self-locking bearing-cup-plate capscrews must not be reused; replace the capscrews with new ones. Also, do not undertighten or overtighten any bearing-cup-plate capscrews. A loose or broken fastener at any point in the driveline weakens the driveline connection, which could cause serious vehicle damage, or could result in a driveshaft separating from the vehicle, possibly caus-

U-Joint Uncoupling and Coupling With a Full-Round End-Yoke

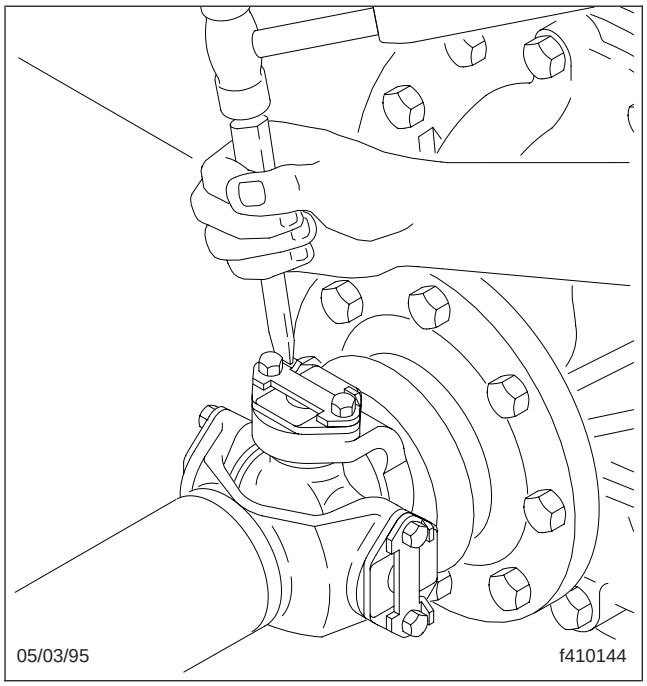


Fig. 2, Bending a Lockplate Tab Away From a U-Joint Capscrew

ing loss of vehicle control that could result in serious personal injury or death.

3.5 Move the cross until it projects beyond the machined surface of the opposite yoke lug. Repeat applicable substeps to install the opposite bearing.

3.6 Alternately tighten the bearing-cup-plate capscrews in increments of 5 lbf·ft (7 N·m), to the torque value in **Specifications 400**.

If equipped with lockplates, use a hammer and a pin punch to bend all four tabs of both lockplates upward until the tabs are firmly against a flat side of each capscrew. See **Fig. 13**.

4. If they were removed, install the fasteners that attach each midship bearing to its bracket; tighten the flanged locknuts 91 lbf·ft (123 N·m).
5. Lubricate the U-joint, following the procedure in Group 41 of the *Business Class Trucks Maintenance Manual*.
6. Remove the nylon support straps, then remove the chocks.

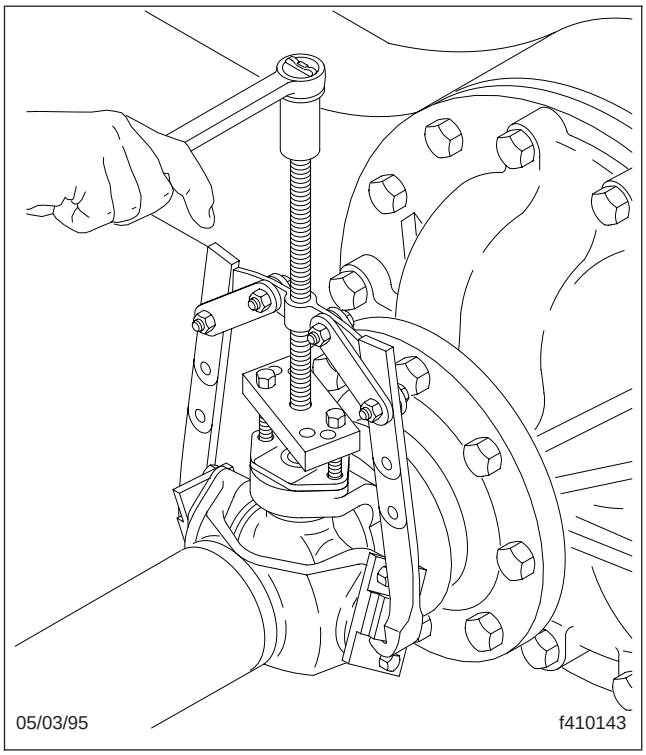


Fig. 3, Removing a Bearing Cup From a Full-Round End-Yoke

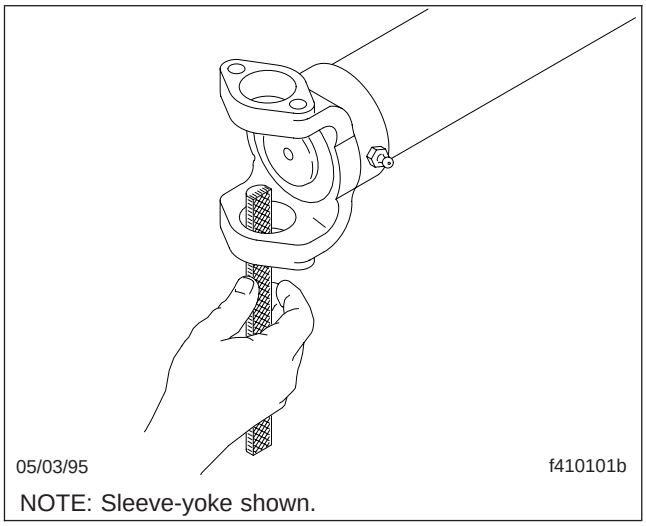
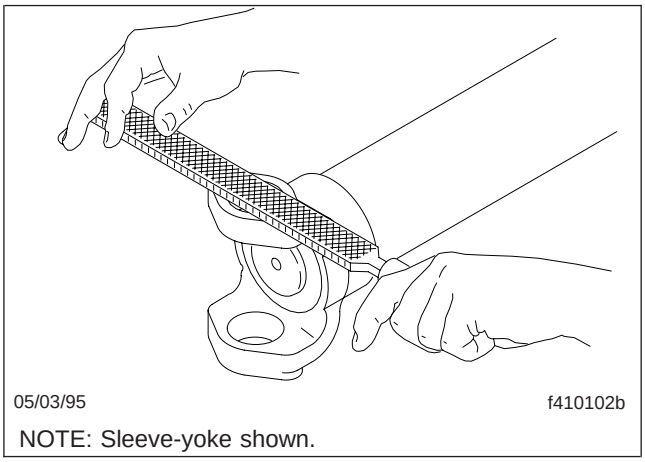


Fig. 4, Removing Burrs From a Full-Round Yoke Cross-Hole

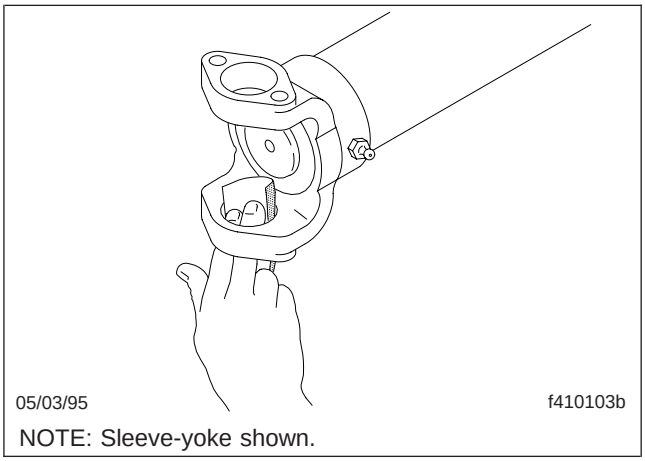
U-Joint Uncoupling and Coupling With a Full-Round End-Yoke



05/03/95 f410102b

NOTE: Sleeve-yoke shown.

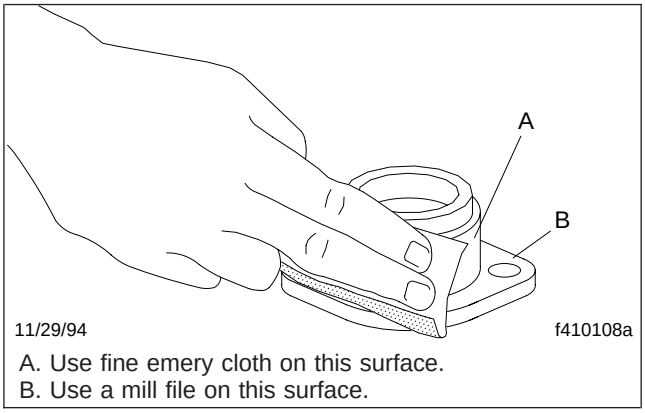
Fig. 5, Removing Burrs From the Machined Surface of a Full-Round Yoke Lug



05/03/95 f410103b

NOTE: Sleeve-yoke shown.

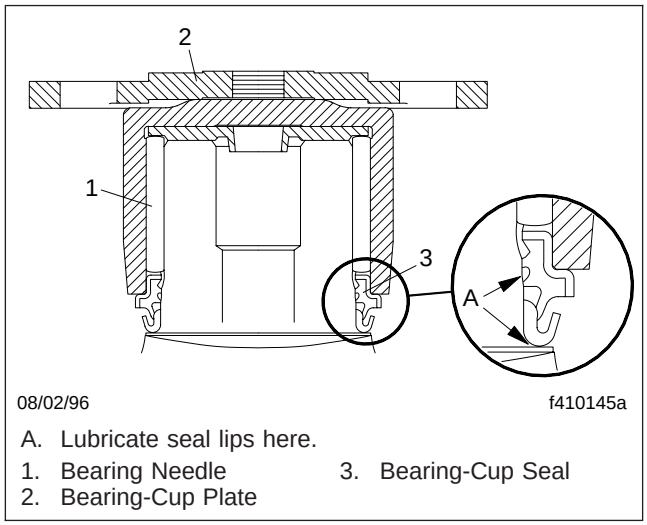
Fig. 6, Smoothing a Full-Round Yoke Cross-Hole



11/29/94 f410108a

A. Use fine emery cloth on this surface.
B. Use a mill file on this surface.

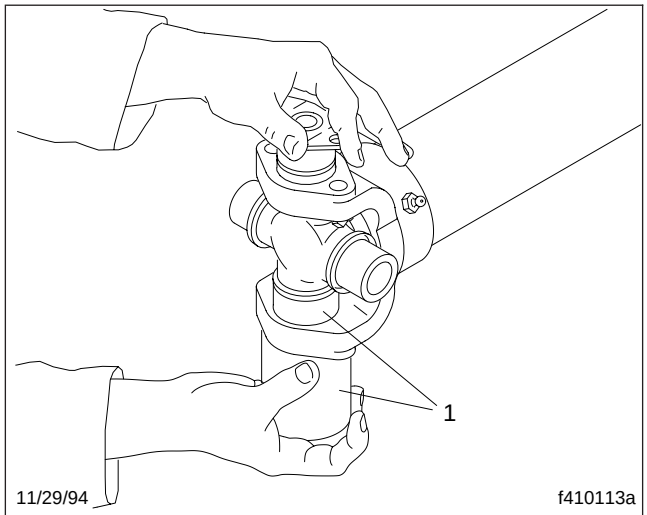
Fig. 7, Smoothing a Full-Round Yoke U-Joint Bearing Cup



08/02/96 f410145a

A. Lubricate seal lips here.
1. Bearing Needle
2. Bearing-Cup Plate
3. Bearing-Cup Seal

Fig. 8, Sectional View of a Full-Round Yoke U-Joint Bearing Cup

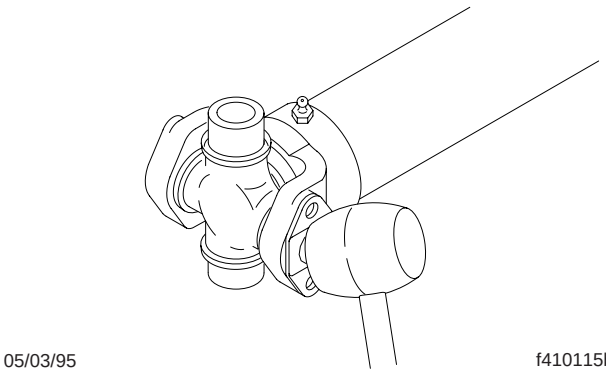


11/29/94 f410113a

NOTE: Sleeve-yoke shown.
1. Trunnion Locator

Fig. 9, Using a U-Joint Trunnion Locator

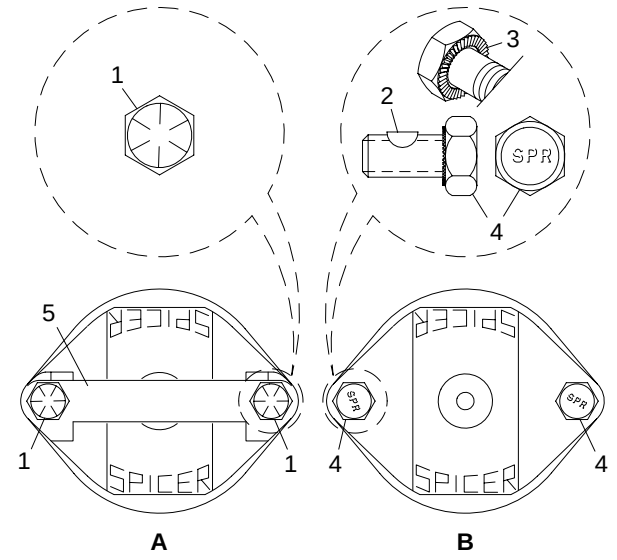
U-Joint Uncoupling and Coupling With a Full-Round End-Yoke



05/03/95 f410115b

NOTE: Sleeve-yoke shown.

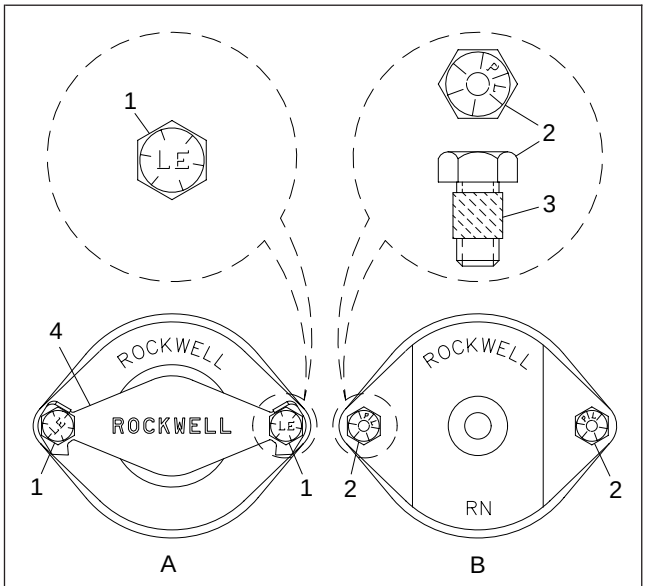
Fig. 10, Seating a U-Joint Bearing Cup in a Full-Round Yoke



05/03/95 f410140a

A. U-Joint With a Lockplate (for a vehicle built before April 1, 1994).
B. U-Joint With Self-Locking Capscrews (for a vehicle built from April 1, 1994).
1. Capscrew (not self-locking)
2. Lock Patch
3. Serrations
4. Self-Locking Capscrew
5. Lockplate

Fig. 11, Spicer U-Joint Fasteners for Full-Round Yokes

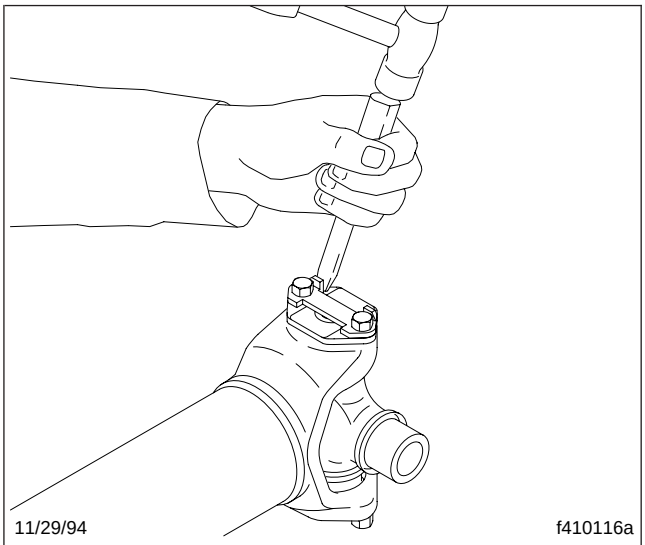


08/13/96 f410033b

A. U-Joint With a Lockplate (for a vehicle built before April 1, 1994).
B. U-Joint With Self-Locking Capscrews (for a vehicle built from April 1, 1994).
1. Capscrew (not self-locking)
2. Self-Locking Capscrew
3. Adhesive Band
4. Lockplate

Fig. 12, Rockwell U-Joint Fasteners for Full-Round Yokes

U-Joint Uncoupling and Coupling With a Full-Round End-Yoke



NOTE: Sleeve-yoke shown.

Fig. 13, Bending a Lockplate Tab Against a U-Joint Capscrew

NOTE: Many service operations do not require driveshaft removal from the vehicle: end-yoke or companion-flange nut tightening; drive component shaft seal, end-yoke, or flange-yoke replacement; changing U-joint phasing at the slip-yoke; and transmission or axle removal (for overhaul, repair, or replacement). To perform these operations, uncouple the U-joint at the applicable end of the appropriate driveshaft; see **Subject 100**, for uncoupling from a *half-round* end-yoke, or see **Subject 110**, for uncoupling from a *full-round* end-yoke.

It is easier to check driveline parts, and to replace a U-joint or midship bearing assembly if the driveshaft is removed from the vehicle. If a driveshaft requires straightening or balancing, it must be removed, and installed on a lathe or balance machine. Removal is required for replacement of slip-joint parts, a driveshaft tube, or a tube-yoke.

No. 3 Driveshaft Removal

(See Fig. 1)

1. Uncouple the no. 3 driveshaft from the rearmost axle. If the no. 3 driveshaft is coupled to *half-round* end-yokes, follow the uncoupling procedure in **Subject 100**. If the no. 3 driveshaft is coupled to *full-round* end-yokes, follow the uncoupling procedure in **Subject 110**.
2. Uncouple the no. 3 driveshaft from the forward-rear axle. If the no. 3 driveshaft is coupled to half-round end-yokes, follow the uncoupling procedure in **Subject 100**. If the no. 3 driveshaft is coupled to full-round end-yokes, follow the uncoupling procedure in **Subject 110**.
3. Lift the no. 3 driveshaft out of the chassis.

No. 2 Driveshaft Removal

(See Fig. 2)

1. Uncouple the no. 2 driveshaft from the single or forward-rear axle. If the no. 2 driveshaft is coupled to *half-round* end-yokes, follow the uncoupling procedure in **Subject 100**. If the no. 2 driveshaft is coupled to *full-round* end-yokes, follow the uncoupling procedure in **Subject 110**.
2. For a vehicle with a Spicer SPL90 (1590) *coupling shaft*, use a marking stick or paint to mark the sleeve-yoke and coupling shaft with alignment marks, as shown in **Fig. 3**. Then, pull the driveshaft sleeve-yoke off of the midship bearing splined shaft.

   For all other installations, uncouple the no. 2 driveshaft from the transmission or coupling shaft. If the no. 2 driveshaft is coupled to half-round end-yokes, follow the uncoupling procedure in **Subject 100**. If the no. 2 driveshaft is coupled to full-round end-yokes, follow the uncoupling procedure in **Subject 110**.
3. Lift the no. 2 driveshaft out of the chassis.

Intermediate Coupling Shaft Removal **(See Fig. 4)**

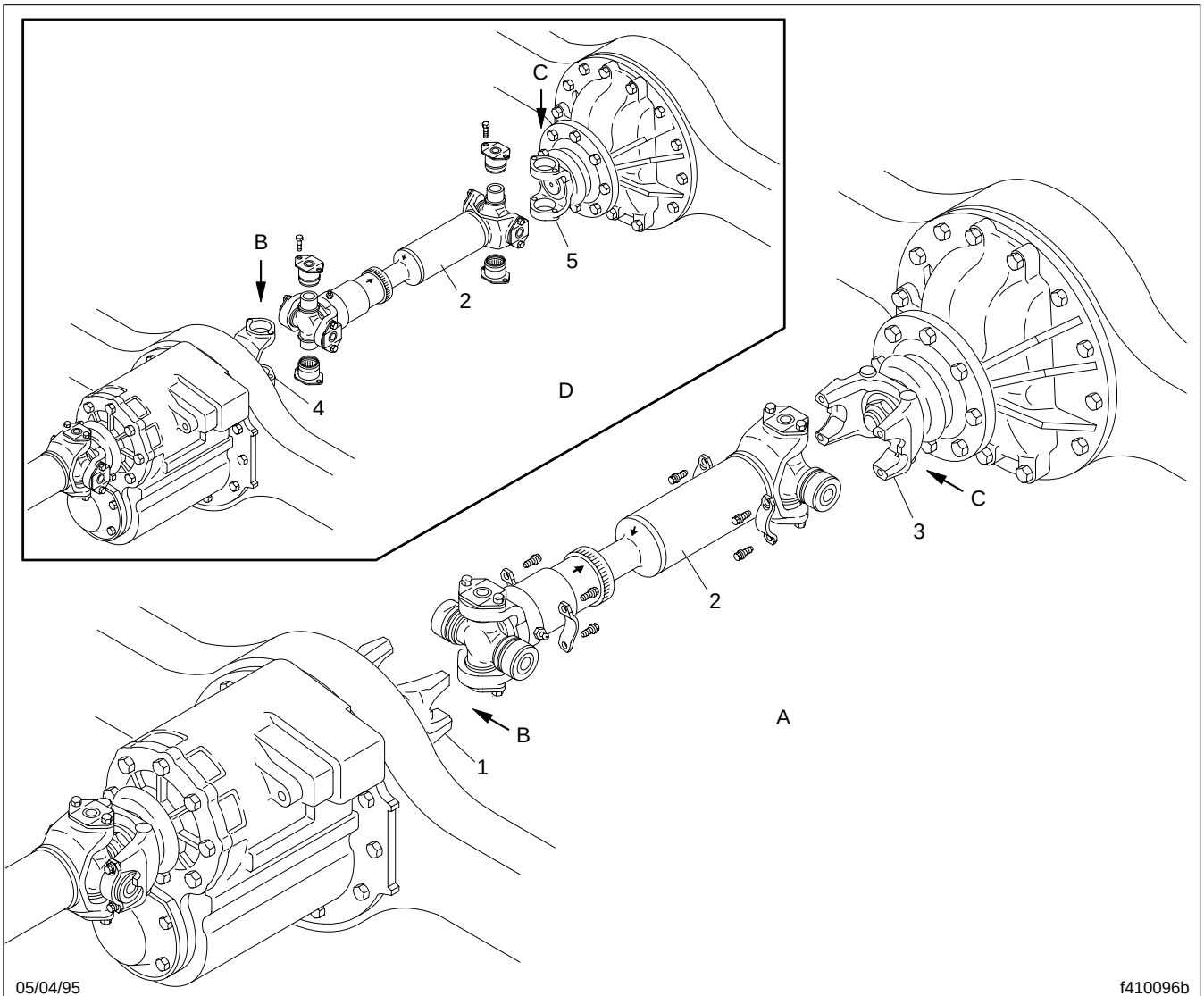
1. If the no. 2 driveshaft is also being removed, remove it first.

   If the no. 2 driveshaft is not being removed, use a nylon support strap to support its forward end.
2. For a vehicle with a Spicer SPL90 (1590) coupling shaft, use a marking stick or paint to mark the sleeve-yoke and coupling shaft with alignment marks, as shown in **Fig. 3**.

   For all other installations, uncouple the intermediate coupling shaft from the no. 2 driveshaft. If the intermediate coupling shaft has a *half-round* end-yoke, follow the uncoupling procedure in **Subject 100**. If the intermediate coupling shaft has a *full-round* end-yoke, follow the uncoupling procedure in **Subject 110**.
3. Uncouple the intermediate coupling shaft from the primary coupling shaft. See **Fig. 5**. If the primary coupling shaft has a half-round end-yoke, follow the uncoupling procedure in **Subject 100**. If the primary coupling shaft has a full-round end-yoke, follow the uncoupling procedure in **Subject 110**.

NOTE: If the no. 2 driveshaft was not removed from a vehicle with a Spicer SPL90 (1590) driveline, pull the midship bearing splined shaft out of the no. 2 driveshaft sleeve-yoke. See **Fig. 3**.

Driveshaft Removal and Installation



NOTE: Not all fasteners are shown.

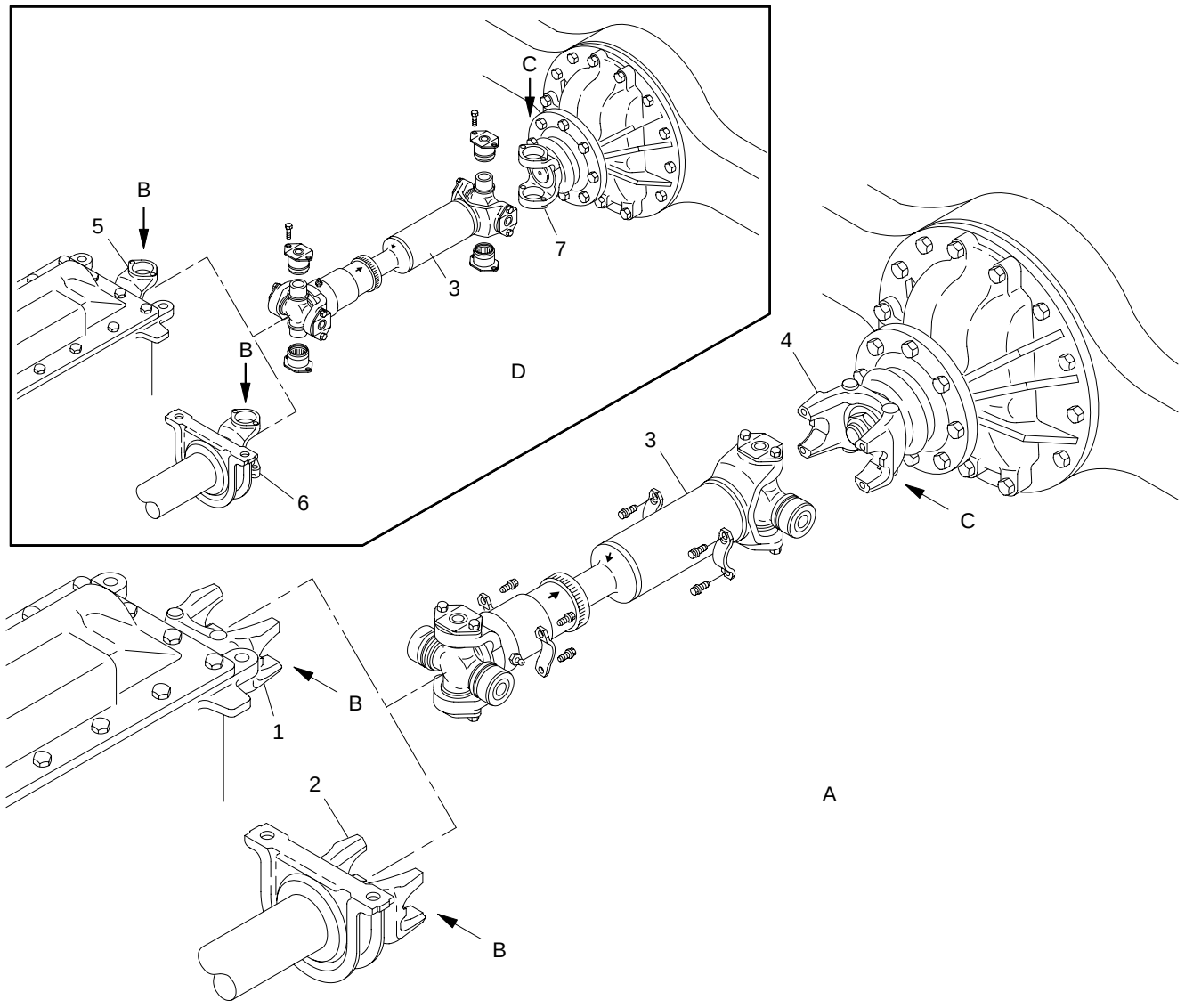
A. No. 3 Driveshaft Coupled to Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
1. Forward-Rear Axle Output-Shaft Half-Round End-Yoke
2. No. 3 Driveshaft
C. Uncouple this end first; couple this end last.
D. No. 3 Driveshaft Coupled to Full-Round End-Yokes
3. Rearmost Axle Input-Shaft Half-Round End-yoke
4. Forward-Rear Axle Output-Shaft Full-Round End-Yoke
5. Rearmost Axle Input-Shaft Full-Round End-yoke

Fig. 1, Removal/Installation of a No. 3 Driveshaft

4. Lift the intermediate coupling shaft out of the chassis.

Primary Coupling Shaft Removal (See Fig. 5)

1. *For a vehicle with one coupling shaft:*



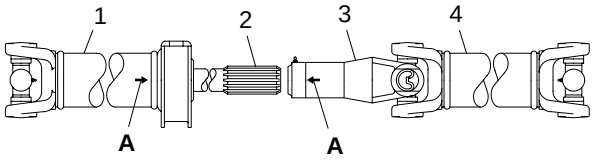
05/05/95 f410080b

NOTE: Not all fasteners are shown.

A. No. 2 Driveshaft Coupled to Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
C. Uncouple this end first; couple this end last.
D. No. 2 Driveshaft Coupled to Full-Round End-Yokes
1. Transmission Output-Shaft Half-Round End-Yoke
2. Coupling Shaft Half-Round End-Yoke
3. No. 2 Driveshaft
4. Single Axle or Forward-Rear Axle Input-Shaft Half-Round End-Yoke
5. Transmission Output-Shaft Full-Round End-Yoke
6. Coupling Shaft Full-Round End-Yoke
7. Single Axle or Forward-Rear Axle Input-Shaft Full-Round End-Yoke

Fig. 2, Removal/Installation of a No. 2 Driveshaft

Driveshaft Removal and Installation



05/04/95 f410081b

A. Add alignment marks at these locations before separating the parts of the slip-joint.
1. Spicer SPL90 (1590) Coupling Shaft
2. Splined Shaft
3. Sleeve-Yoke
4. No. 2 Driveshaft

Fig. 3, Spicer SPL90 (1590) Coupling Shaft Slip-Joint

If the no. 2 driveshaft is also being removed, remove it first.

If the no. 2 driveshaft is not being removed, use a nylon support strap to support its forward end. For a vehicle with a Spicer SPL90 (1590) coupling shaft, use a marking stick or paint to mark the sleeve-yoke and coupling shaft with alignment marks, as shown in **Fig. 3**.

For a vehicle with two coupling shafts:

If the no. 2 driveshaft is also being removed, remove it first; then, remove the intermediate coupling shaft.

If the intermediate coupling shaft is also being removed (but not the no. 2 driveshaft), remove the intermediate coupling shaft first.

If only the primary coupling shaft is being removed, use nylon support straps to support the forward end of the no. 2 driveshaft and both ends of the intermediate coupling shaft. Then, remove the fasteners that attach the intermediate coupling shaft midship bearing to its bracket. See **Fig. 5**.

2. If not already done, uncouple the primary coupling shaft from the no. 2 driveshaft or intermediate coupling shaft. If the primary coupling shaft has a *half-round* end-yoke, follow the uncoupling procedure in **Subject 100**. If the primary coupling shaft has a *full-round* end-yoke, follow the uncoupling procedure in **Subject 110**.
3. Using two nylon support straps, support the primary coupling shaft. Then remove the fasteners that attach the primary coupling shaft midship bearing to its bracket. See **Fig. 5**.
4. Uncouple the primary coupling shaft from the transmission. If the primary coupling shaft is coupled to a half-round end-yoke, follow the uncoupling procedure in **Subject 100**. If the primary coupling shaft is coupled to a full-round end-yoke, follow the uncoupling procedure in **Subject 110**.

NOTE: If the no. 2 driveshaft was not removed from a vehicle with a Spicer SPL90 (1590) single-coupling-shaft driveline, pull the midship bearing splined shaft out of the no. 2 driveshaft sleeve-yoke. See **Fig. 3**.

5. Lift the primary coupling shaft out of the chassis.

Primary Coupling Shaft Installation (See Fig. 5)

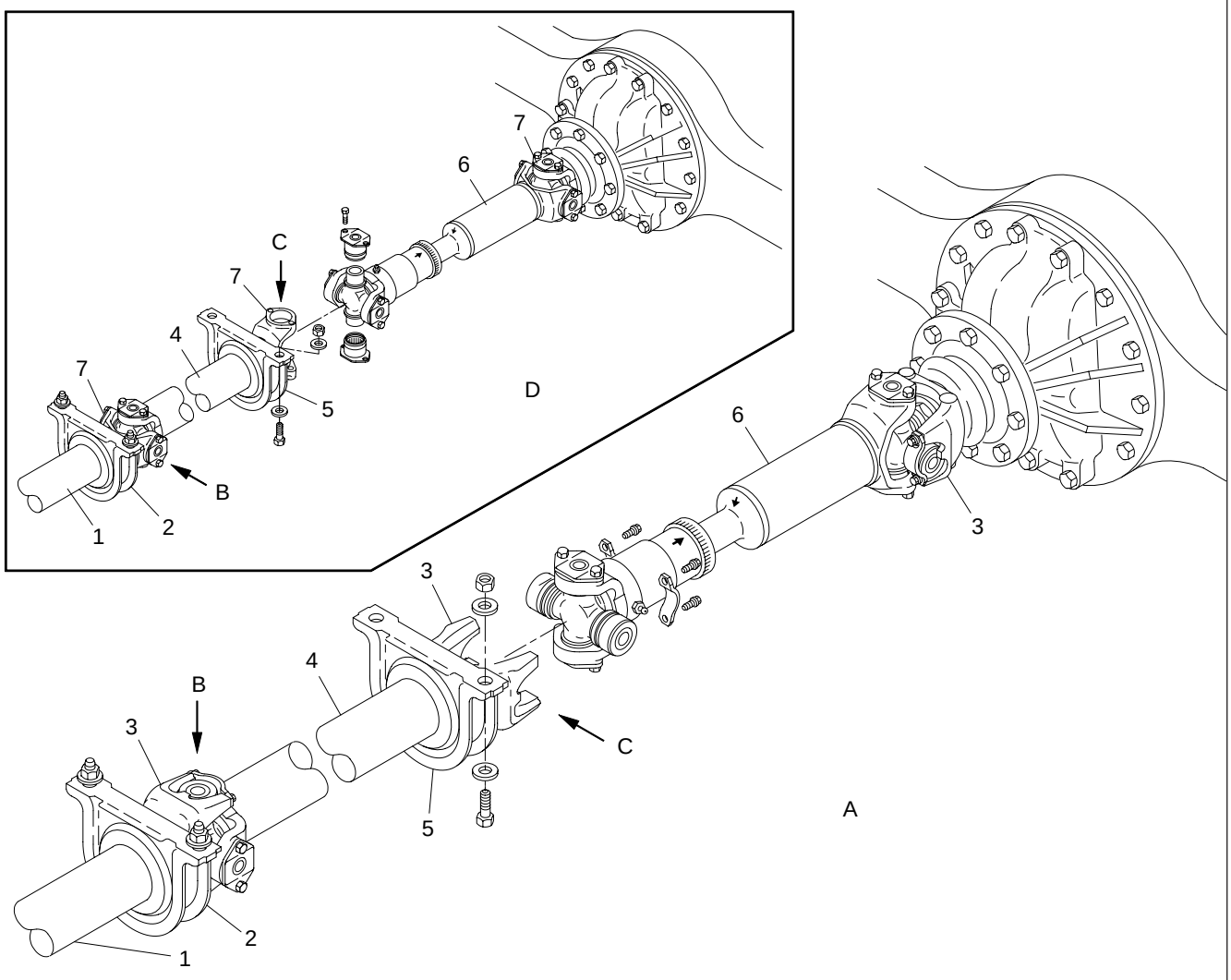
IMPORTANT: Before installing a coupling shaft that has a fixed end-yoke (not a splined reverse-slip shaft), make sure the yokes are aligned to keep the U-joints in phase; see **Fig. 6**.

1. Place the primary coupling shaft under the vehicle and support it with nylon support straps so it can be coupled to the transmission end-yoke.

   If the no. 2 driveshaft was not removed from a vehicle with a Spicer SPL90 (1590) single-coupling-shaft driveline, align the alignment marks **(Fig. 3)** of the coupling shaft and the driveshaft sleeve-yoke, slide the sleeve-yoke over the splined reverse-slip shaft.
2. Couple the shaft to the transmission end-yoke (or flange-yoke). If the primary coupling shaft was coupled to a *half-round* end-yoke, follow the coupling procedure in **Subject 100**. If the primary coupling shaft was coupled to a *full-round* end-yoke, follow the coupling procedure in **Subject 110**.
3. *For a vehicle with one coupling shaft:*

   If the no. 2 driveshaft was also removed, install it, as instructed in this subject.

   If the no. 2 driveshaft was not removed from a vehicle equipped with other than a Spicer SPL90 (1590) driveline, couple it to the primary coupling shaft end-yoke. If the primary coupling shaft has a half-round end-yoke, follow the coupling proce-



05/04/95 f410084b

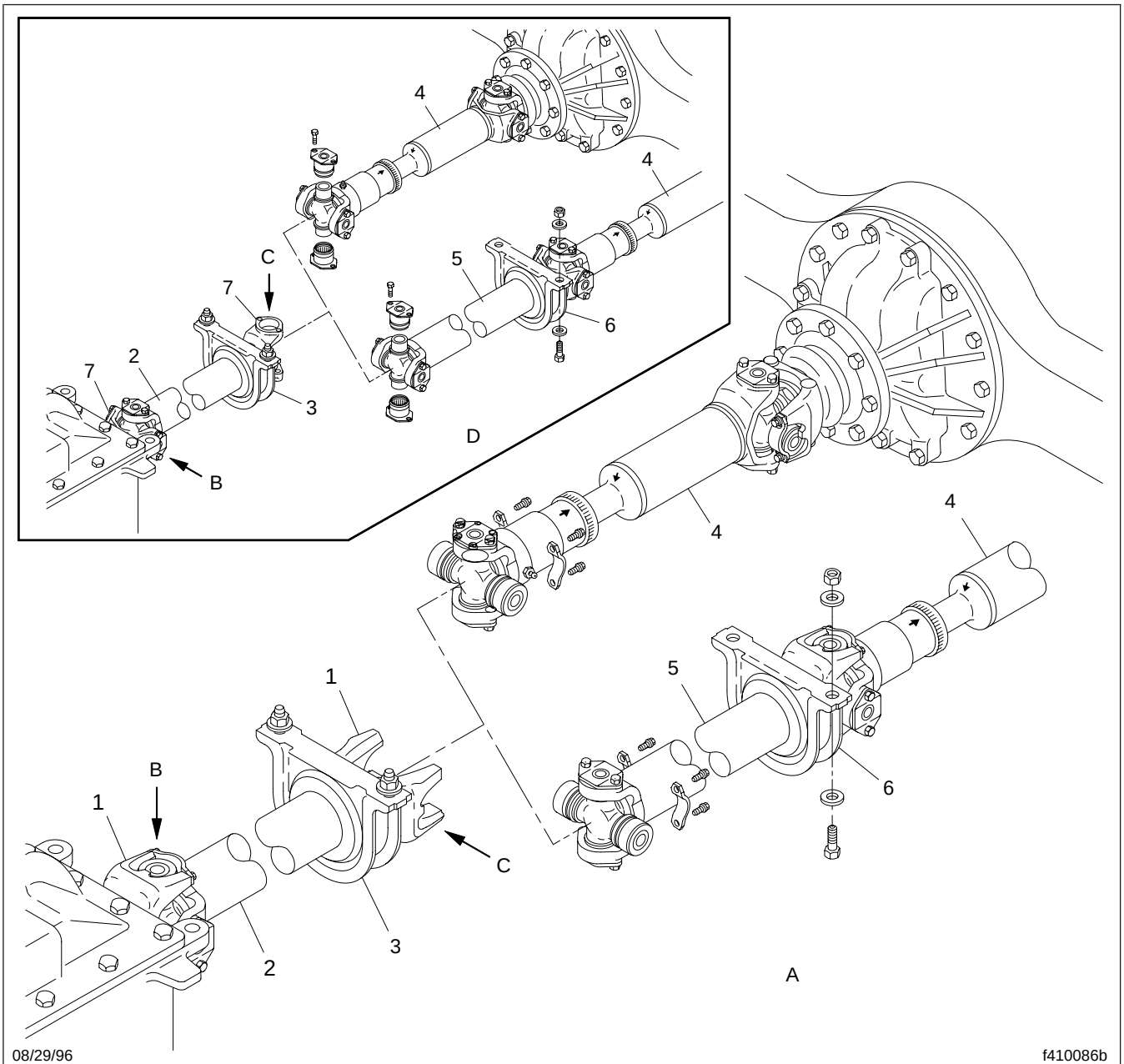
NOTE: Not all fasteners are shown.

A. No. 2 Driveline With Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
C. Uncouple this end first; couple this end last.
D. No. 2 Driveline With Full-Round End-Yokes
1. Primary Coupling Shaft
2. Primary Coupling Shaft Midship Bearing
3. Half-Round End-Yoke
4. Intermediate Coupling Shaft
5. Intermediate Coupling Shaft Midship Bearing
6. No. 2 Driveshaft
7. Full-Round End-Yoke

Fig. 4, Removal/Installation of an Intermediate Coupling Shaft

dure in **Subject 100**. If the primary coupling shaft has a full-round end-yoke, follow the coupling procedure in **Subject 110**.

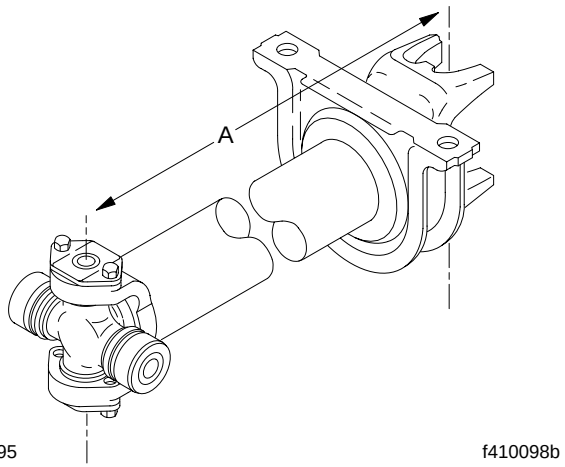
Driveshaft Removal and Installation



NOTE: Not all fasteners are shown.

A. No. 2 Driveline With Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
1. Half-Round End-Yoke
2. Primary Coupling Shaft
3. Primary Coupling Shaft Midship Bearing
4. No. 2 Driveshaft
C. Uncouple this end first; couple this end last.
D. No. 2 Driveline With Full-Round End-Yokes
5. Intermediate Coupling Shaft
6. Intermediate Coupling Shaft Midship Bearing
7. Full-Round End-Yoke

Fig. 5, Removal/Installation of a Primary Coupling Shaft



A. Cross-hole centerlines of both yokes must be in alignment.

Fig. 6, U-Joint Phasing of a Coupling Shaft Equipped With an End-Yoke

For a vehicle with two coupling shafts:

If the intermediate coupling shaft was also removed, install it, as instructed in this subject.

If only the primary coupling shaft was removed, couple the intermediate coupling shaft to the primary coupling shaft end-yoke. If the primary coupling shaft has a half-round end-yoke, follow the coupling procedure in **Subject 100**. If the primary coupling shaft has a full-round end-yoke, follow the coupling procedure in **Subject 110**.

Intermediate Coupling Shaft Installation (See Fig. 4)

IMPORTANT: Before installing a coupling shaft that has a fixed end-yoke (not a splined reverse-slip shaft), make sure the yokes are aligned to keep the U-joints in phase; see **Fig. 6**.

1. If the primary coupling shaft was also removed, install it first, as instructed in this subject.
2. Place the intermediate coupling shaft under the vehicle and support it with nylon support straps so it can be coupled to the primary coupling shaft end-yoke.

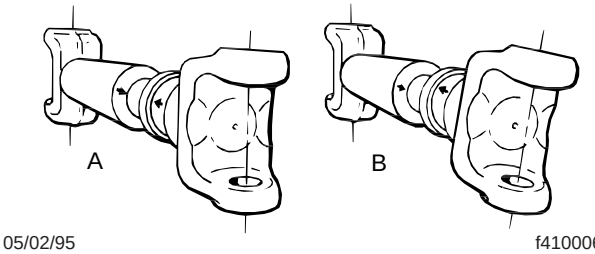
   If the no. 2 driveshaft was not removed from a vehicle with a Spicer SPL90 (1590) driveline, align the alignment marks (**Fig. 3**) of the coupling shaft and the driveshaft sleeve-yoke, slide the sleeve-yoke over the splined reverse-slip shaft.
3. Couple the intermediate coupling shaft to the primary coupling shaft end-yoke. If the intermediate coupling shaft was coupled to a *half-round* end-yoke, follow the coupling procedure in **Subject 100**. If the intermediate coupling shaft was coupled to a *full-round* end-yoke, follow the coupling procedure in **Subject 110**.
4. If the no. 2 driveshaft was also removed, install it, as instructed in this subject.

   If the no. 2 driveshaft was not removed from a vehicle equipped with other than a Spicer SPL90 (1590) driveline, couple it to the intermediate coupling shaft end-yoke. If the intermediate coupling shaft has a half-round end-yoke, follow the coupling procedure in **Subject 100**. If the intermediate coupling shaft has a full-round end-yoke, follow the coupling procedure in **Subject 110**.

No. 2 Driveshaft Installation

(See Fig. 2)

IMPORTANT: Before installing a no. 2 driveshaft that has a sleeve-yoke (not a splined reverse-slip shaft) at its forward end, make sure the alignment marks on the slip-joint assembly are aligned, to keep the U-joints in phase; see **Fig. 7**.



A. In Phase B. Out of Phase

Fig. 7, U-Joint Phasing

1. If a primary coupling shaft was also removed, install it first, as instructed in this subject.

Driveshaft Removal and Installation

2. If an intermediate coupling shaft was also removed, install it before installing the no. 2 driveshaft.
3. Place the no. 2 driveshaft under the vehicle with its sleeve-yoke at the forward end, and support its rear end with a nylon support strap.
4. For a vehicle with a Spicer SPL90 (1590) coupling shaft, align the alignment marks (**Fig. 3**) of the coupling shaft and the no. 2 driveshaft sleeve-yoke, then slide the sleeve-yoke over the splined reverse-slip shaft.

   For all other vehicles, couple the sleeve-yoke to the coupling shaft end-yoke or transmission output-shaft end-yoke, as applicable. If the no. 2 driveshaft was coupled to *half-round* end-yokes, follow the coupling procedure in **Subject 100**. If the no. 2 driveshaft was coupled to *full-round* end-yokes, follow the coupling procedure in **Subject 110**.
5. Couple the no. 2 driveshaft to the axle input-shaft end-yoke. If the no. 2 driveshaft was coupled to half-round end-yokes, follow the coupling procedure in **Subject 100**. If the no. 2 driveshaft was coupled to full-round end-yokes, follow the coupling procedure in **Subject 110**.

No. 3 Driveshaft Installation

(See Fig. 1)

IMPORTANT: Before installing a no. 3 driveshaft, make sure the alignment marks on the slip-joint assembly are aligned, to keep the U-joints in phase; see **Fig. 7**.

1. Place the no. 3 driveshaft under the vehicle with its sleeve-yoke at the forward end, and support its rear end with a nylon support strap.
2. Couple the sleeve-yoke to the forward-rear axle output-shaft end-yoke. If the no. 3 driveshaft was coupled to *half-round* end-yokes, follow the coupling procedure in **Subject 100**. If the no. 3 driveshaft was coupled to *full-round* end-yokes, follow the coupling procedure in **Subject 110**.
3. Couple the no. 3 driveshaft to the axle input-shaft end-yoke. If the no. 3 driveshaft was coupled to half-round end-yokes, follow the coupling procedure in **Subject 100**. If the no. 3 driveshaft was coupled to full-round end-yokes, follow the coupling procedure in **Subject 110**.

Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly

Driveline Parking Brake Flange-Yoke or Companion Flange Removal

For removal of a driveline parking brake flange-yoke or companion flange, see **Group 42**.

Spicer 1610/1710/1760/1810 U-Joint or Rockwell 17/176/18-Series U-Joint Removal

1. Remove the driveshaft from the vehicle; see **Subject 120**.
2. Place the driveshaft in V-blocks or a soft-jawed vise; do not distort the tube with excessive grip.
3. For a vehicle built from April 1, 1994, remove and discard all four bearing-plate self-locking capscrews. See **Fig. 1**, for Spicer U-joints or **Fig. 2** for Rockwell U-joints.

   For a vehicle built before April 1, 1994, use a pin punch to bend the tabs of the lockplates away from all four bearing-cup-plate capscrews. See **Fig. 3**. Remove all four capscrews and both lockplates.

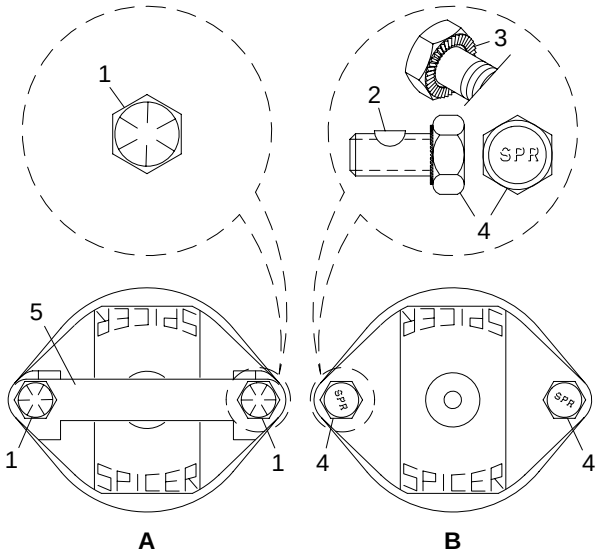
IMPORTANT: If the U-joint will be reinstalled, use care not to nick the cross trunnions or damage the slingers. See **Fig. 4**.

4. Using one of the U-joint pullers listed in **Subject 400**, remove both bearing cups from the yoke cross-holes. See **Fig. 5**. Remove the cross from the yoke.

Spicer SPL90 (1590) U-Joint Removal

1. Remove the driveshaft from the vehicle; see **Subject 110**.
2. Clamp the driveshaft in a soft-jawed vise; do not distort the tube with excessive grip.

NOTE: When removing a U-joint that connects the sleeve-yoke to the forward tube-yoke of the no. 2 driveshaft, mark the sleeve-yoke and driveshaft tube with alignment marks, clamp the driveshaft tube in the vise, and disconnect the U-joint from the tube-yoke, first. Then, clamp the sleeve-yoke in the vise, and remove the U-joint from the sleeve-yoke. See **Fig. 6**.

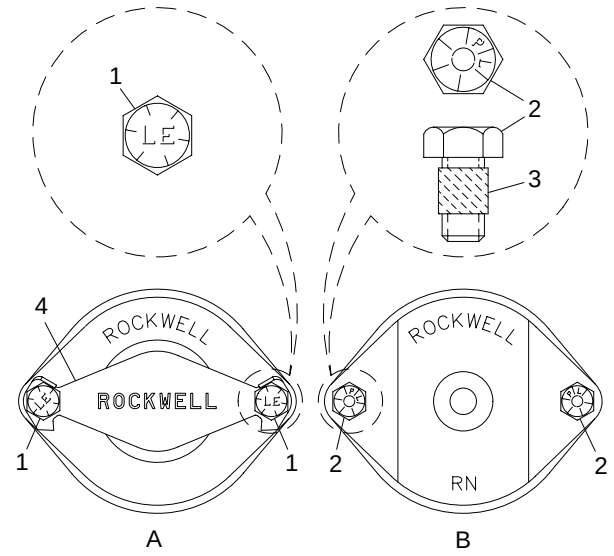


A. U-Joint With a Lockplate (for a vehicle built before April 1, 1994).
B. U-Joint With Self-Locking Capscrews (for a vehicle built from April 1, 1994).
1. Capscrew (not self-locking)
2. Lock Patch
3. Serrations
4. Self-Locking Capscrew
5. Lockplate

Fig. 1, Spicer U-Joint Fasteners for Full-Round Yokes

3. Remove the U-joint snap rings from the yoke.
   - 3.1 Using a hammer and a soft drift, tap the outside of the bearing cup to loosen the snap ring. See **Fig. 7**. Tap the bearing only hard enough to break the assembly away from the snap ring.
   - 3.2 Using pliers, remove the snap ring. See **Fig. 8**.
   - 3.3 Turn the shaft (or sleeve-yoke) over, then repeat this step for the opposite snap ring.
4. Press the U-joint bearing assemblies and cross out of the yoke. See **Fig. 9**.

Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly



08/13/96 f410033b

A. U-Joint With a Lockplate (for a vehicle built before April 1, 1994).
B. U-Joint With Self-Locking Capscrews (for a vehicle built from April 1, 1994).
1. Capscrew (not self-locking)
2. Self-Locking Capscrew
3. Adhesive Band
4. Lockplate

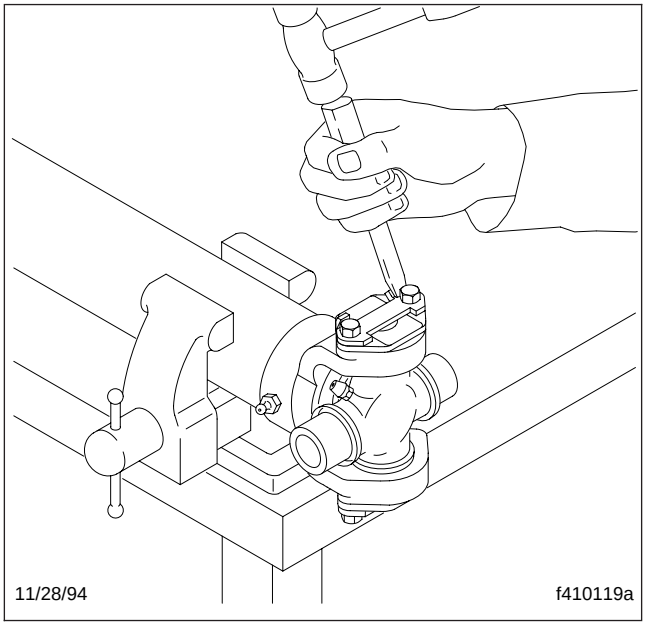
Fig. 2, Rockwell U-Joint Fasteners for Full-Round Yokes

4.1 Set the yoke in an arbor press, on a piece of tube stock with an inside diameter larger than the outside diameter of the bearing cup. See **Fig. 9**.

4.2 Place a solid plug with an outside diameter slightly smaller than the inside diameter of the yoke cross-holes, on the upper bearing assembly. Press it through the upper cross-hole to release the lower bearing assembly.

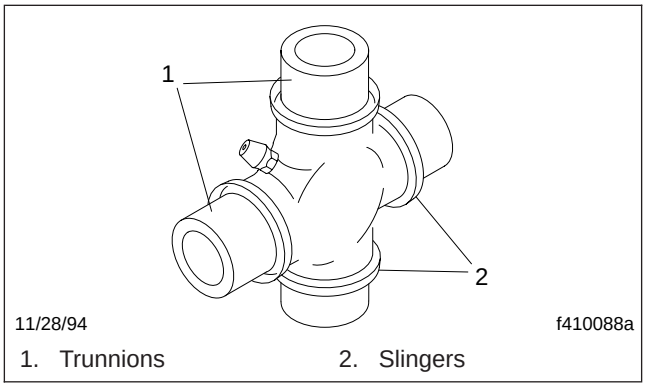
If the bearing assembly will not pull out by hand after pressing, tap the base of the yoke lug near the bearing assembly to dislodge it.

4.3 Remove the opposite bearing assembly by turning the yoke over, and straightening the cross in the open cross-hole. Then carefully press on the end of the cross so the remaining bearing assembly moves straight out of the cross-hole.



11/28/94 f410119a

Fig. 3, Bending a Lockplate Tab Away From a U-Joint Capscrew



11/28/94 f410088a

1. Trunnions 2. Slingers

Fig. 4, U-Joint Cross

IMPORTANT: If the cross or bearing assembly is cocked, the bearing assembly will score the walls of the cross-hole and ruin the yoke.

Slip-Joint Disassembly

1. Check that the driveshaft yokes are aligned to hold the U-joints at either end in phase, as shown in **Fig. 10**. Using a marking stick or paint,

Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly

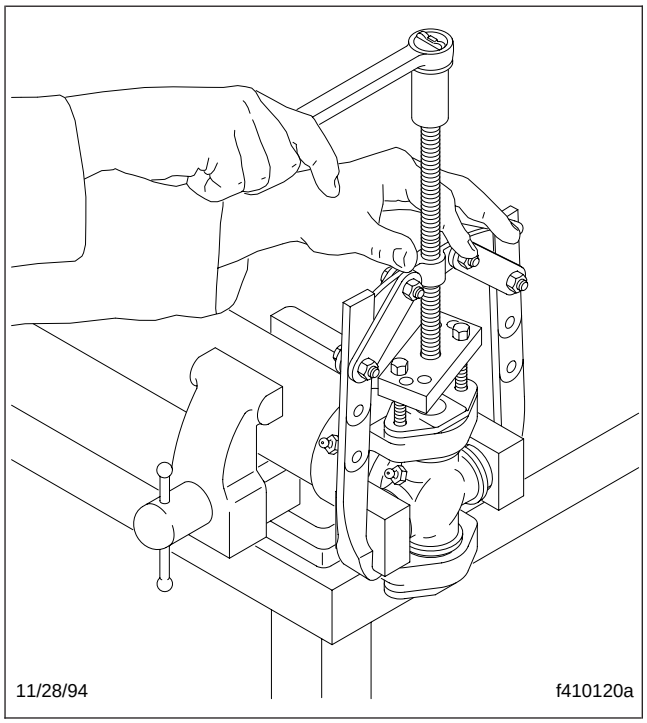


Fig. 5, Removing a Bearing Cup From a Full-Round Yoke

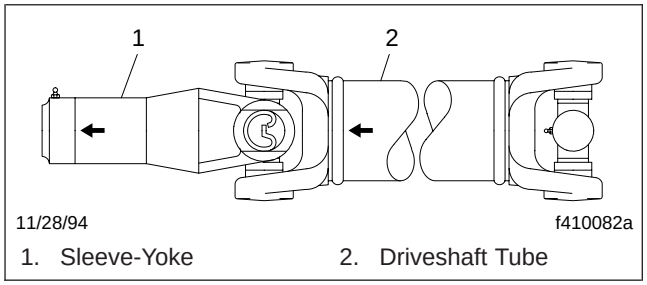


Fig. 6, Spicer SPL90 (1590) No. 2 Driveshaft (as used with a coupling shaft)

mark the sleeve-yoke and splined shaft with alignment marks, as shown in **Fig. 11**. This will ensure proper alignment of the slip-joint components when the driveshaft is assembled.

IMPORTANT: Misaligned driveshaft yokes will cause the U-joints to be out of phase, which will cause vibration in the driveline.

2. With the driveshaft uncoupled at one end, *or* removed from the vehicle, use a strap wrench to unscrew the slip-joint dust cap from the sleeve-yoke, then pull the sleeve-yoke off of the splined shaft. Remove the dust cap, and (if so equipped) the steel washer and cork seal. See **Fig. 12**.

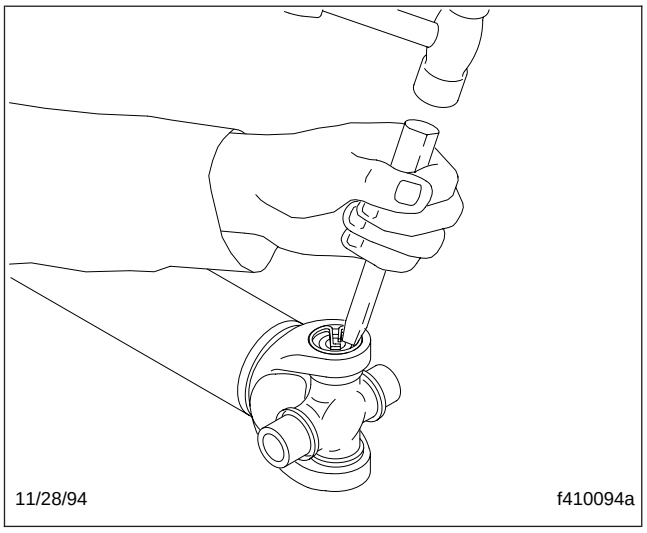


Fig. 7, Loosening a Spicer SPL90 (1590) U-Joint Snap Ring

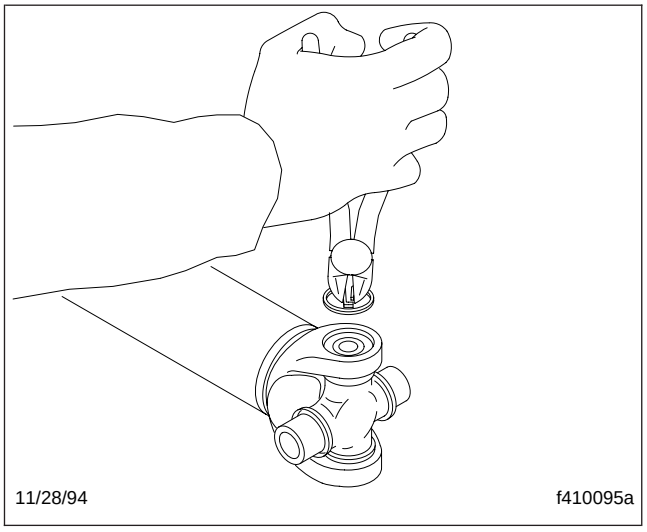


Fig. 8, Removing/Installing a Spicer SPL90 (1590) U-Joint Snap Ring

Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly

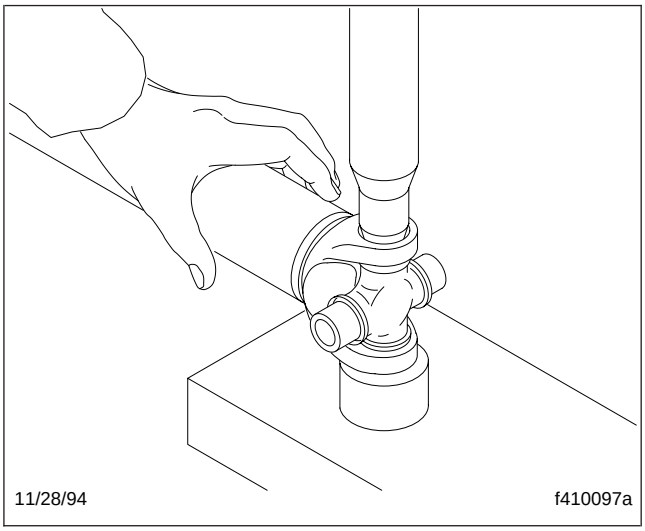
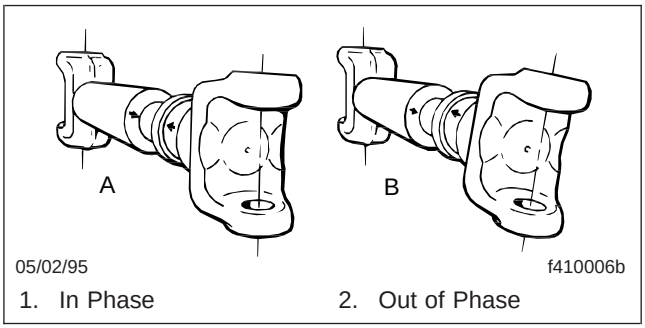
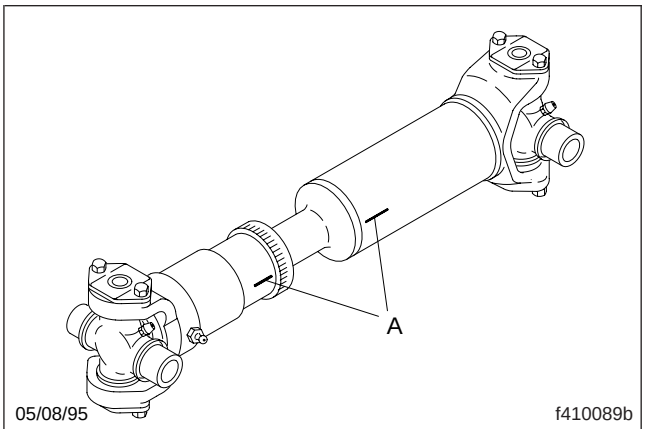


Fig. 9, Pressing a Spicer SPL90 (1590) U-Joint Out-of/ Into a Yoke



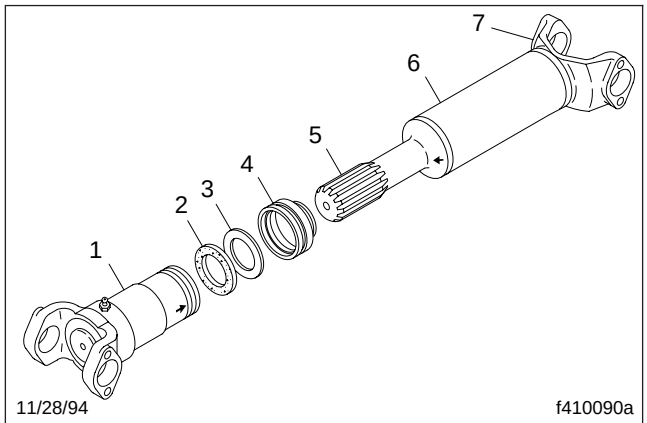
1. In Phase
2. Out of Phase

Fig. 10, U-Joint Phasing



A. Use a marking stick or paint to add alignment marks.

Fig. 11, Slip-Joint Alignment Marks



1. Sleeve-Yoke
2. Cork Washer
3. Steel Washer
4. Dust Cap
5. Splined Stub Shaft
6. Tube
7. Tube-Yoke

Fig. 12, Slip-Joint Components

Transmission/Axle End-Yoke Removal

IMPORTANT: Before removing a transmission output-shaft end-yoke or an axle shaft end-yoke, do the steps under "End-Yoke Cleaning and Inspection."

1. Uncouple the driveshaft from the end-yoke (**Subject 100** for a half-round yoke or **Subject 110** for a full-round yoke), or remove the driveshaft from the vehicle (**Subject 120**).
2. Remove the end-yoke locknut. See **Fig. 13**.

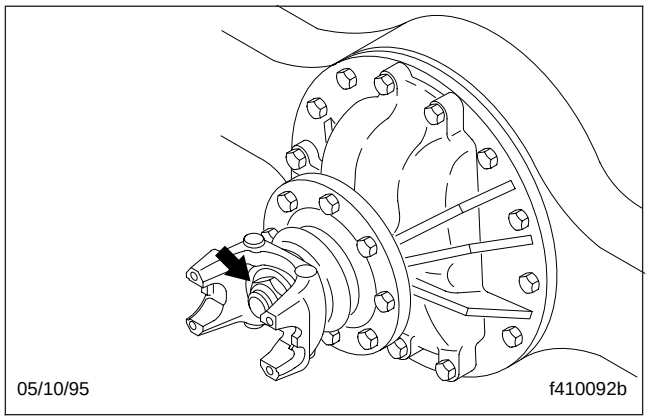
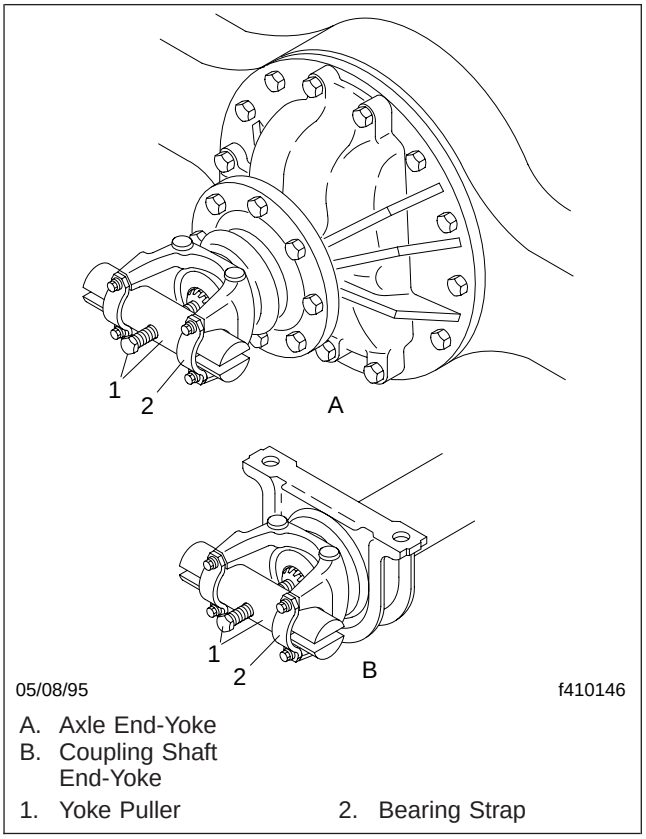


Fig. 13, Axle End-Yoke Locknut

Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly

3. Using a yoke puller, remove the end-yoke. See **Fig. 14** for a half-round end-yoke, or **Fig. 15** for a full-round end-yoke.



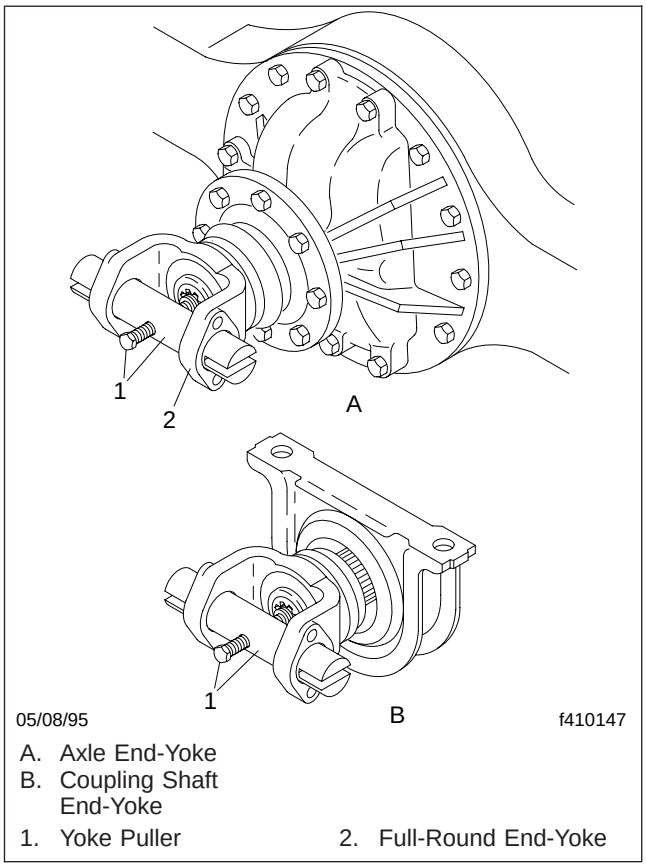
A. Axle End-Yoke
B. Coupling Shaft End-Yoke
1. Yoke Puller
2. Bearing Strap

Fig. 14, Removing a Half-Round End-Yoke

Coupling Shaft End-Yoke and Midship Bearing Removal

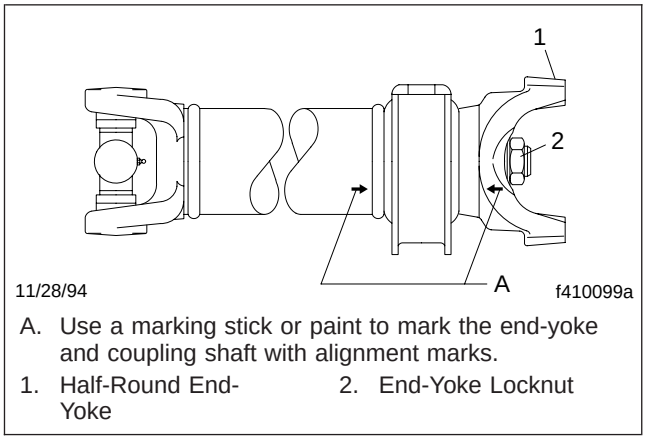
1. Remove the coupling shaft from the vehicle; see **Subject 120**.
2. Clamp the coupling shaft in a soft-jawed vise; do not distort the tube with excessive grip.
3. If the coupling shaft has an end-yoke (**Fig. 16**), not a splined reverse-slip shaft, go to the next step.

   If the coupling shaft has a splined reverse-slip shaft, not an end-yoke (**Fig. 17**), use a hammer and a brass drift to remove the midship bearing and slingers. See **Fig. 18**.



A. Axle End-Yoke
B. Coupling Shaft End-Yoke
1. Yoke Puller
2. Full-Round End-Yoke

Fig. 15, Removing a Full-Round End-Yoke



A. Use a marking stick or paint to mark the end-yoke and coupling shaft with alignment marks.
1. Half-Round End-Yoke
2. End-Yoke Locknut

Fig. 16, Alignment Marks on a Coupling Shaft With an End-Yoke

4. If the coupling shaft has an end-yoke, remove the end-yoke; see **Fig. 14** for a half-round end-

Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly

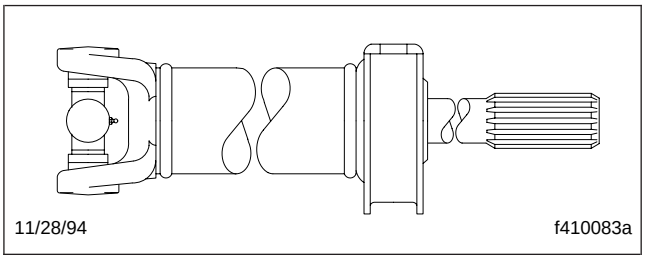
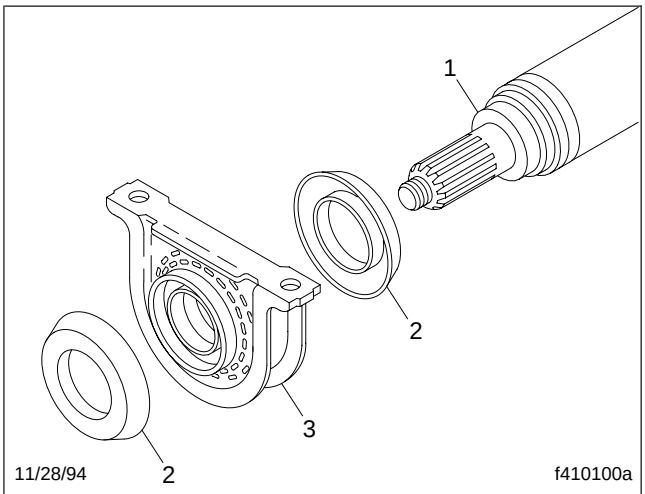


Fig. 17, Spicer SPL90 (1590) Coupling Shaft With a Splined Reverse-Slip Shaft



1. Midship Bearing Shaft
2. Slinger
3. Midship Bearing

Fig. 18, Midship Bearing and Slingers

yoke, or **Fig. 15** for a full-round end-yoke. Then, remove the midship bearing and slingers; see **Fig. 18**.

4.1 Use a marking stick or paint to mark the end-yoke and coupling shaft with alignment marks. See **Fig. 16**.

4.2 Remove the coupling shaft end-yoke locknut.

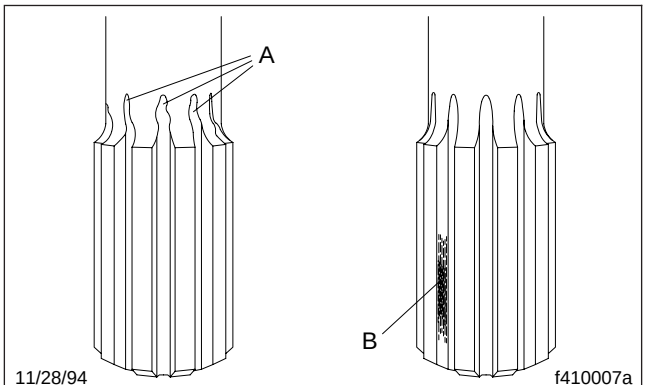
4.3 Using a yoke puller, remove the end-yoke. See **Fig. 14** for a half-round end-yoke, or **Fig. 15** for a full-round end-yoke.

4.4 Use a hammer and a brass drift to remove the midship bearing and slingers. See **Fig. 18**.

Driveshaft Tube, Slip-Joint, Sleeve-Yoke, and Tube-Yoke Cleaning and Inspection

1. With the driveshaft removed, scrape or soak away any foreign material.
2. Examine the driveshaft tube for dents, bends, twists, splitting weld-seams, and signs of missing balance weights.

   Replace the driveshaft tube if damaged; see "Driveshaft Tube, Stub Shaft (Slip-Joint), or Tube-Yoke Replacement." If balance weights appear to be missing, have the driveshaft balanced to a maximum tolerance of one inch-ounce per ten pounds weight per end, at 3000 rpm.
3. Clean the slip-joint (male and female) splines, then check them for twisting and galling. See **Fig. 19**. Replace both the sleeve-yoke and the splined shaft if the slip-joint is damaged; see "Slip-Joint Replacement or Assembly" and "Driveshaft Tube, Stub Shaft (Slip-Joint), or Tube-Yoke Replacement." Remove any burrs or rough spots using fine emery cloth.

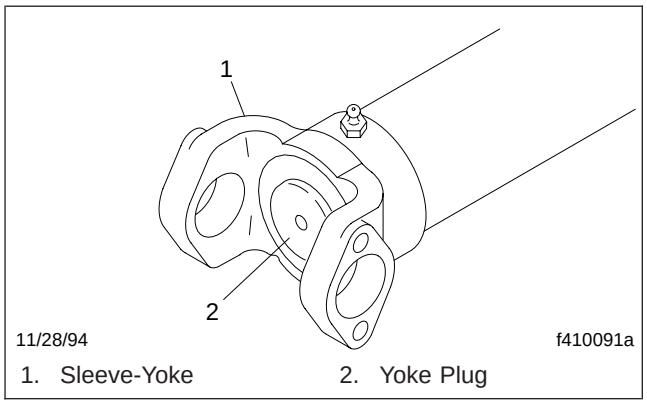


A. Twisted Splines
B. Galling

Fig. 19, Damaged Slip-Joint Splines

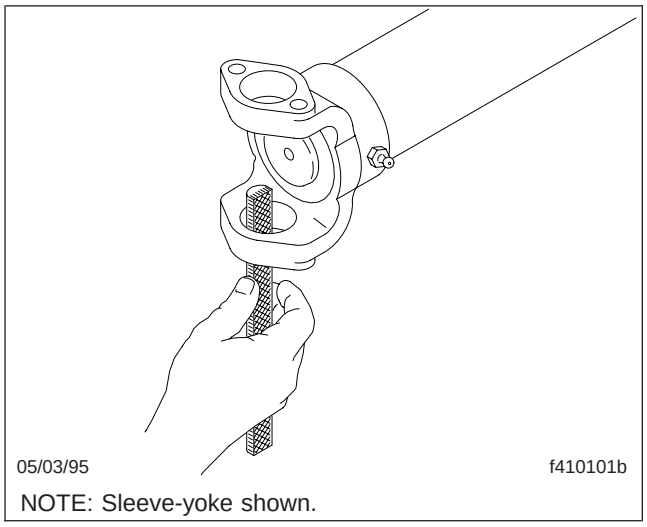
4. Check for a loose or missing sleeve-yoke plug. See **Fig. 20**. Repair or replace the plug as needed.
5. With the U-joint assemblies removed, check all driveshaft yoke cross-holes for raised metal. Using a rat-tail or half-round file, remove burrs or raised metal. See **Fig. 21**.

Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly



1. Sleeve-Yoke 2. Yoke Plug

Fig. 20, Sleeve-Yoke Plug



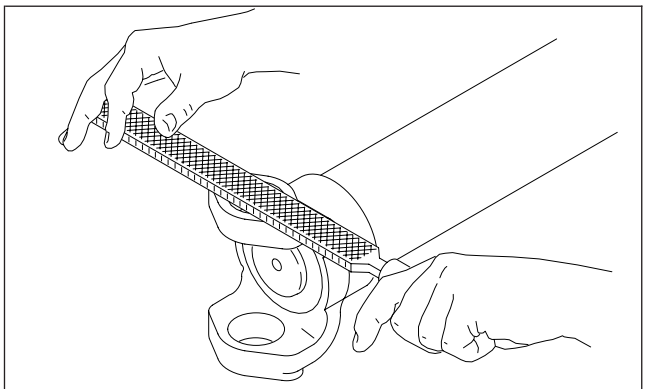
NOTE: Sleeve-yoke shown.

Fig. 21, Removing Burrs From a Full-Round Yoke Cross-Hole

6. Using a mill file, and holding it flat against the machined surface of the driveshaft yoke lug, file each yoke lug, to remove any burrs or raised metal. See **Fig. 22**.
7. Using fine emery cloth, smooth and clean the entire surface of all driveshaft yoke cross-holes. See **Fig. 23**.

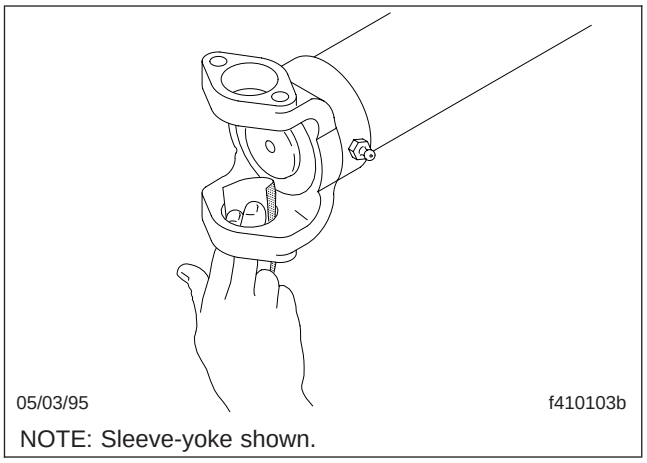
Midship Bearing Cleaning and Inspection

1. With the midship bearing removed from the coupling shaft, use clean rags or paper towels to wipe off the outside of the midship bearing, rubber cushion, and slingers.



NOTE: Sleeve-yoke shown.

Fig. 22, Removing Burrs From the Machined Surface of a Full-Round Yoke Lug



NOTE: Sleeve-yoke shown.

Fig. 23, Smoothing a Full-Round Yoke Cross-Hole

IMPORTANT: Do not immerse the midship bearing in cleaning solvent. The solvent will wash out the lubricant, requiring bearing-assembly replacement.

2. Check the midship bearing for roughness or rattles by holding the outside of the bearing while manually turning the inner bearing race. Replace the bearing assembly if there are any rough spots or rattles.
3. Check the rubber cushion for deterioration or oil-soaking, and replace the midship bearing assembly if needed.

Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly

End-Yoke Cleaning and Inspection

1. With the transmission output-shaft and axle shaft end-yokes installed, check them for cracks and looseness.

   Replace cracked yokes. If the end-yoke can be moved in or out on its shaft, or can be rocked on its shaft, uncouple the driveshaft from the end-yoke. Check the drive component's shaft seal for leakage or other visible damage that may have been caused by the loose yoke. Replace the shaft seal if needed. Tighten the end-yoke nut to the torque value given in **Subject 400**. If the end-yoke is still loose after tightening the yoke nut, install a new yoke and yoke nut.

NOTE: If the end-yoke locknut is removed for any reason, install a new one.

2. With the U-joints uncoupled from the end-yokes, check all driveshaft and input/output shaft end-yoke cross-holes for raised metal. Using a rat-tail or half-round file, remove burrs or raised metal. See **Fig. 21** for full-round yokes, or **Fig. 24** for half-round yokes.

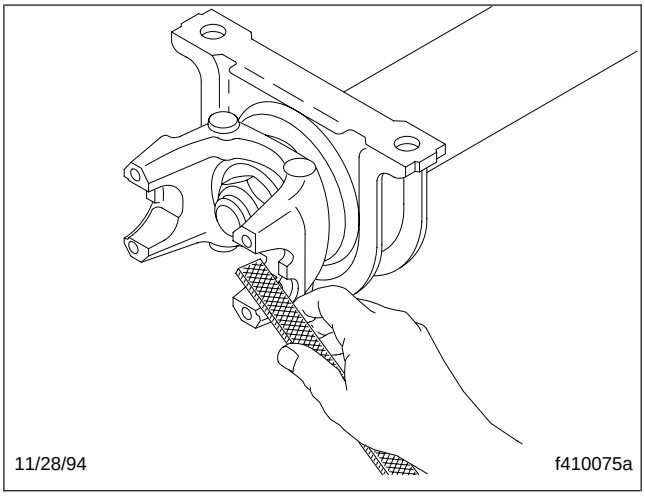
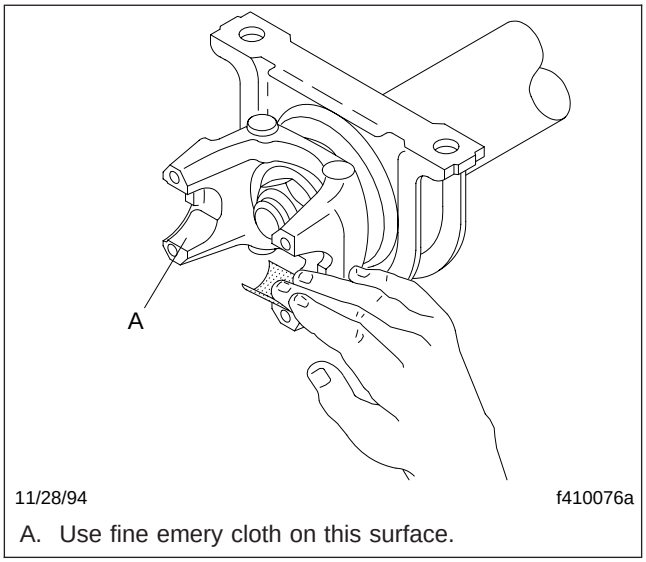


Fig. 24, Removing Burrs From a Half-Round End-Yoke Cross-Hole

3. Using a mill file, and holding it flat against the machined surface of the *full-round* end-yoke lug, file each yoke lug, to remove any burrs or raised metal. See **Fig. 22**.

4. Smooth and clean the entire surface of all end-yoke cross-holes, using fine emery cloth. See **Fig. 23** for full-round yokes, or **Fig. 25** for half-round yokes.



A. Use fine emery cloth on this surface.

Fig. 25, Smoothing a Half-Round End-Yoke Cross-Hole

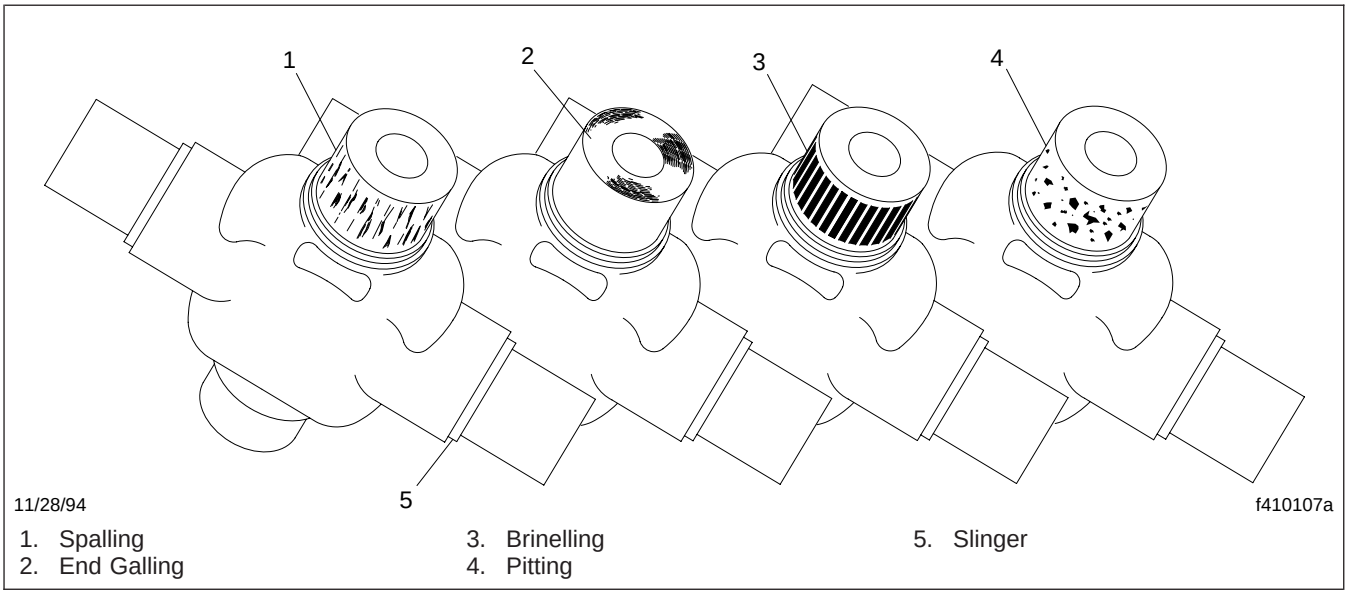
U-Joint Cleaning and Inspection

1. With the U-joints removed from the yokes, and the bearing cups removed from the crosses, inspect the U-joint cross slingers for damage, then inspect the U-joint trunnions for spalling (flaking metal), end galling (displacement of metal), brinelling (grooves caused by bearing needles), and pitting (small craters caused by corrosion). See **Fig. 26**. If damaged, replace the U-joint assembly.

2. Using a hand-type grease gun, apply multipurpose chassis grease to the fitting on each U-joint cross until all old lubricant is forced out. See **Fig. 27**. Examine the old lubricant. If it appears rusty, gritty, or burnt, replace the U-joint assembly.

3. Soak the bearing cups in a non-flammable cleaner until particles of grease and foreign matter are loosened or dissolved. Do not disassemble the bearing cups; clean the bearing needles with a short, stiff brush, then blow them

Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly



1. Spalling
2. End Galling
3. Brinelling
4. Pitting
5. Slinger

Fig. 26, Damaged U-Joint Crosses

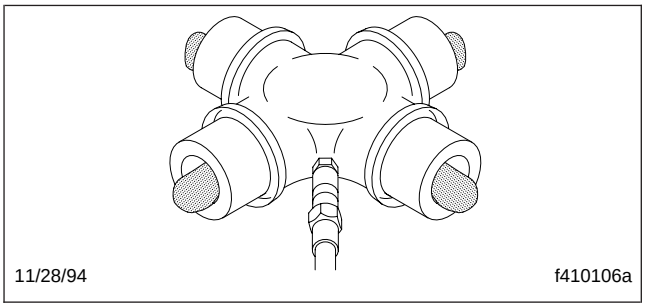
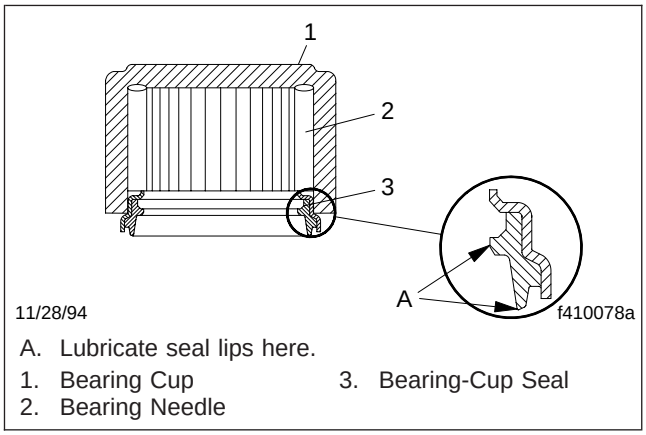


Fig. 27, Forcing Out Old Lubricant From a U-Joint Cross

dry with compressed air. Check for minute particles of dirt or grit, and clean again if necessary.

4. Check each bearing cup for missing bearing needles. Check the bearing-cup seals for nicks. See **Fig. 28** for a half-round-yoke U-joint bearing cup, or **Fig. 29** for a full-round-yoke U-joint bearing cup. Replace the U-joint assembly if any bearing needles are missing or any seals are damaged.
5. Apply a small quantity of multipurpose chassis grease to the bearing needles in each cup, then apply a small amount of light-weight oil to the lips of the bearing-cup seals. Rotate each bearing cup on the cross to check for wear. Replace the U-joint assembly if any bearing surfaces are worn.



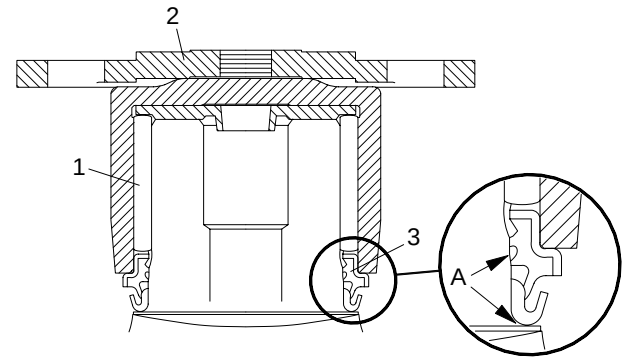
A. Lubricate seal lips here.

1. Bearing Cup
2. Bearing Needle
3. Bearing-Cup Seal

Fig. 28, Sectional View of a Half-Round End-Yoke U-Joint Bearing Cup

6. Check the underside of each bearing-cup plate for burrs or raised metal. Use a mill file to remove any burrs or raised metal. See **Fig. 30**.
7. Using fine emery cloth, smooth and clean the outside surfaces of all bearing cups. See **Fig. 30** and **Fig. 31**.

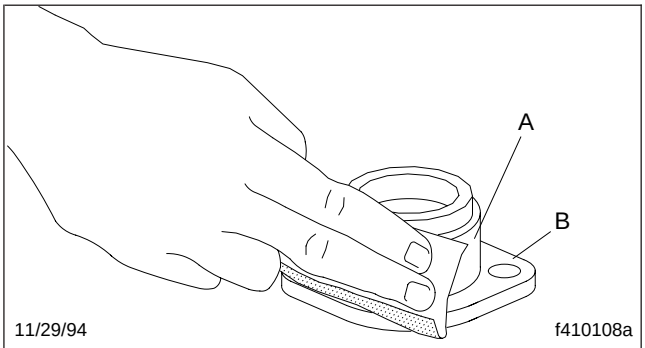
Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly



08/02/96 f410145a

A. Lubricate seal lips here.
1. Bearing Needle
2. Bearing-Cup Plate
3. Bearing-Cup Seal

Fig. 29, Sectional View of a Full-Round Yoke U-Joint Bearing Cup



11/29/94 f410108a

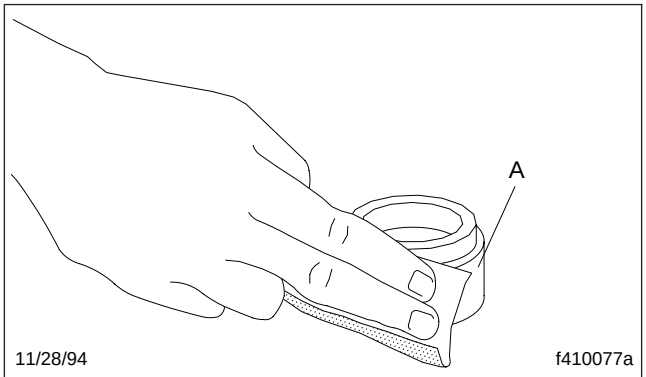
A. Use fine emery cloth on this surface.
B. Use a mill file on this surface.

Fig. 30, Smoothing a Full-Round Yoke U-Joint Bearing Cup

Driveshaft Tube, Stub Shaft (Slip-Joint), and Tube-Yoke Replacement

IMPORTANT: Parts for different series drivelines must not be intermixed. Incorrectly assembled or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

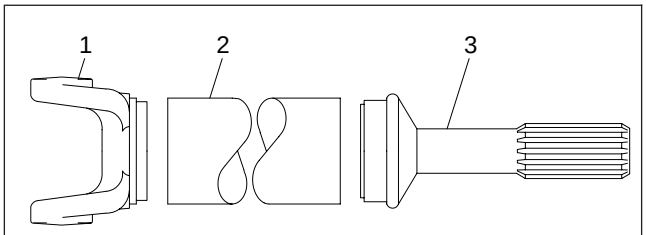
To replace a driveshaft tube, a tube-yoke, or a stub shaft (**Fig. 32**), the driveshaft must be chucked in a lathe, so the welds can be removed. Driveshaft rebuilding should be done by a machine shop that specializes in driveline repair.



11/28/94 f410077a

A. Use fine emery cloth on this surface.

Fig. 31, Smoothing a Half-Round Yoke U-Joint Bearing Cup



11/29/94 f410109a

1. Tube-Yoke
2. Driveshaft Tube
3. Stub Shaft

Fig. 32, Driveshaft Tube, Stub Shaft, and Tube-Yoke

Runout limits for a new (rebuilt) driveshaft (**Fig. 33**) are:

0.005 in (0.127 mm) T.I.R. (Total Indicator Reading) on the smooth portion of the stub shaft neck;

0.010 in (0.254 mm) T.I.R. on the tube 3 in (76 mm) from the front and rear welds;

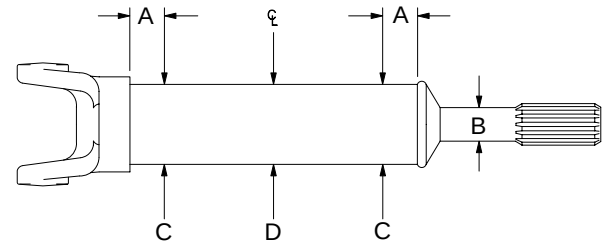
0.015 in (0.381 mm) T.I.R. at the center of the tube.

Balance the rebuilt driveshaft to a maximum tolerance of one inch-ounce per ten pounds weight per end, at 3000 rpm.

Slip-Joint Replacement or Assembly

IMPORTANT: Parts for different series drivelines must not be intermixed. Incorrectly assembled

Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly



A. Measurement: 3" (76 mm)
B. Measurement: 0.015" (0.38 mm)
C. Measurement: 0.020" (0.51 mm)
D. Measurement: 0.025" (0.635 mm)

Fig. 33, Driveshaft Runout Specifications

or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

1. Place the slip-joint dust cap, and (if so equipped) steel washer and cork seal, over the splined shaft. See **Fig. 12**.
2. Coat the splines of the shaft with multipurpose chassis grease.
3. Insert the splined shaft in the sleeve-yoke, so that the alignment marks are aligned, and the U-joints at each end of the driveshaft will be in phase. See **Fig. 10** and **Fig. 11**.

IMPORTANT: If no alignment marks are visible, or new slip-joint components have been installed, align the yokes, assemble the slip-joint, then have the driveline balanced to a maximum tolerance of one inch-ounce per ten pounds weight per end, at 3000 rpm.

4. Using a strap wrench, tighten the slip-joint dust cap. Use only enough torque to seat the steel washer and cork seal (if so equipped) snug against the end of the sleeve-yoke; do not overtighten.

NOTE: The splines should slide freely, with only a slight drag from the slip-joint dust cap.

Midship Bearing and Coupling Shaft End-Yoke Replacement or Assembly

IMPORTANT: Parts for different series drivelines must not be intermixed. Incorrectly assembled or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

1. Place the coupling shaft in a soft-jawed vise; do not distort the tube with excessive grip.
2. Fill the entire cavity around the midship bearing with a waterproof grease, to shield the bearing from water and contaminants. Use enough grease to fill the cavities to the extreme edge of the slingers that surround the front and rear of the bearing. See **Fig. 34**.

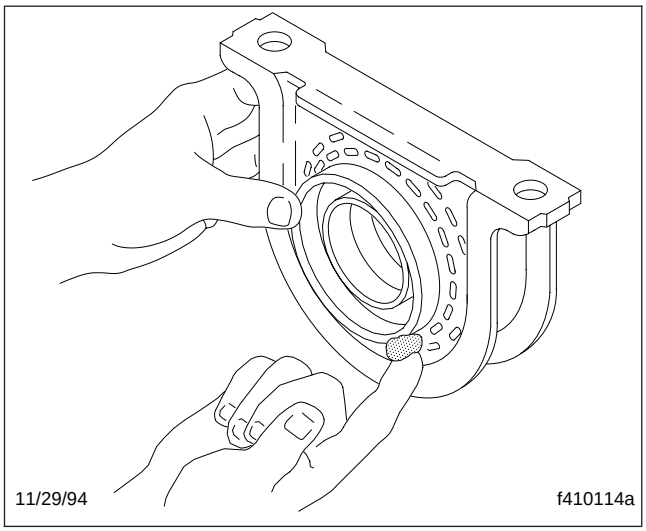


Fig. 34, Greasing a Midship Bearing

NOTE: Both Spicer and Rockwell midship bearings are permanently lubricated when manufactured; it is not necessary to pack the bearing with grease.

3. Install one of the slingers, the midship bearing, then the other slinger on the coupling shaft. Press the bearing and slingers on by hand, as far as they will go.

Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly

4. If the coupling shaft has a splined reverse-slip shaft (not an end-yoke), coat the shaft splines with multipurpose chassis grease. See **Fig. 17**.

   If the coupling shaft has an end-yoke, install the end-yoke. See **Fig. 16**.

   4.1 Apply Loctite® 242 to the shaft threads where the end-yoke locknut will be installed.

   4.2 Align the marks added to the coupling shaft and end-yoke during removal, then place the end-yoke on the shaft so the yoke bores are aligned at both ends of the shaft. See **Fig. 16**.

   4.3 Install the end-yoke nut, and tighten it 475 to 525 lbf·ft (645 to 710 N·m). Then back the nut off slightly, and tighten it to the same torque.

Spicer 1610/1710/1760/1810 U-Joint or Rockwell 17/176/18-Series U-Joint Replacement or Installation

IMPORTANT: Parts for different series drivelines must not be intermixed. Also, components of the various makes of U-joints may not be interchangeable, and must be assembled only with compatible products. Incorrectly assembled or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

Worn bearing assemblies used with a new cross, or new bearing assemblies used with a worn cross will wear rapidly, making another replacement necessary in a short time. Always replace the cross and all four bearing assemblies at the same time.

If the slip-joint of a no. 2 or no. 3 driveshaft has been disassembled, assemble the slip-joint before installing the U-joints.

1. Place the assembled driveshaft in V-blocks or a soft-jawed vise; do not distort the tube with excessive grip.

2. For a no. 2 or no. 3 driveshaft, check that the slip-joint alignment marks are aligned, so that the U-joints at each end of the driveshaft will be in phase. See **Fig. 10** and **Fig. 11**.

   For a coupling shaft, check that the end-yoke and tube-yoke are aligned, so that the U-joints at each end of the coupling shaft will be in phase. See **Fig. 16**.

IMPORTANT: Misaligned driveshaft yokes will cause the U-joints to be out of phase, which will cause vibration in the driveline.

3. Inspect and lubricate the U-joint.

   3.1 Remove the bearing cups from the cross. Inspect the bearing-cup seals for nicks or other damage. See **Fig. 28** for a half-round-yoke U-joint bearing cup, or **Fig. 29** for a full-round-yoke U-joint bearing cup.

⚠ CAUTION

CAUTION: Do not expose the U-joint trunnions or bearing-cup needles to dirt or grit. The smallest bits of dirt or grit can cause rapid wear and serious damage to the U-joint.

   3.2 Using a hand-type grease gun, or a high-pressure gun equipped with a low-pressure adapter, fill the lube passages in the cross with multipurpose chassis grease (lithium 12-hydroxy stearate, NLGI grade 2 with EP additives). See **Fig. 27**.

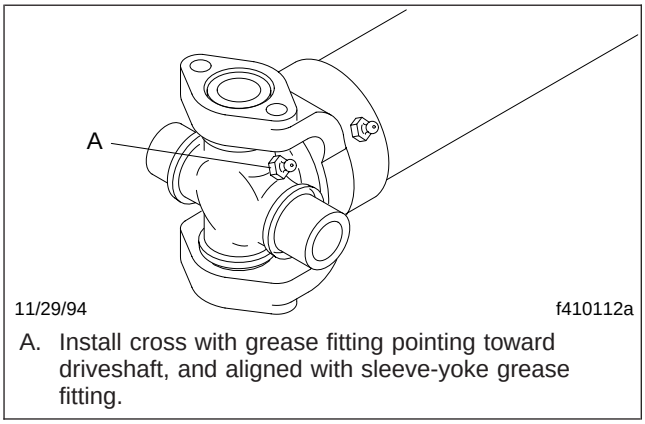
   3.3 Wipe a heavy coating of the same grease on the needles and the inside end of each bearing cup; then, using a lightweight oil, lubricate the lips of the bearing-cup seals. See **Fig. 28** for a half-round-yoke U-joint bearing cup, or **Fig. 29** for a full-round-yoke U-joint bearing cup.

4. Install the U-joint cross and bearing assemblies in the yoke.

   4.1 Position the U-joint cross in the driveshaft yoke so one grease fitting points toward the driveshaft, and aligns with the grease fitting on the sleeve-yoke (if so equipped). See **Fig. 35**.

   4.2 Move one end of the cross until a trunnion projects through the cross-hole, beyond the outer machined face of the yoke lug. Using a Spicer trunnion (journal) locator (see **Subject 400**), hold the trun-

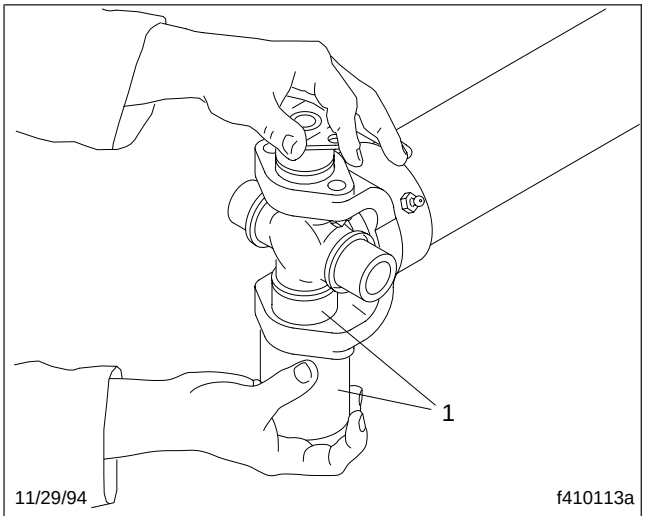
Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly



A. Install cross with grease fitting pointing toward driveshaft, and aligned with sleeve-yoke grease fitting.

Fig. 35, U-Joint Grease Fitting Positioning

nions in alignment with the cross-holes, while placing a bearing cup (plate-type) over the projected trunnion, and aligning it with the cross-hole. See **Fig. 36**.



NOTE: Sleeve-yoke shown.
1. Trunnion Locator

Fig. 36, Using a U-Joint Trunnion Locator

IMPORTANT: A Spicer trunnion (journal) locator should be used, to prevent damage to the U-joint trunnions and slingers.

4.3 By hand, press the bearing-cup-plate flush with the face of the yoke. If the bearing cup binds in the cross-hole, tap the *center* of the bearing-cup plate with a leather or rubber mallet; do not tap the outer edges of the plate. See **Fig. 37**.

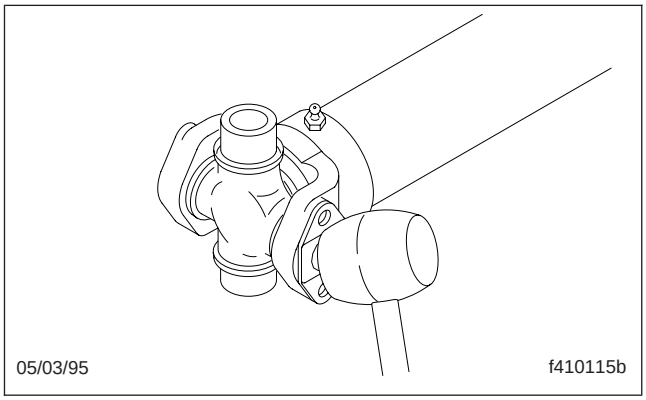


Fig. 37, Seating a U-Joint Bearing Cup In a Full-Round Yoke

4.4 As equipped, install *new* bearing-cup-plate self-locking capscrews, or the lock-plate and bearing-cup-plate (not self-locking) capscrews. See **Fig. 1** for Spicer U-joints, or **Fig. 2** for Rockwell U-joints. Tighten the capscrews until all the parts are drawn down tight, with no gaps; do not tighten the capscrews to their final torque value.

⚠ WARNING

WARNING: Self-locking bearing-cup-plate capscrews must not be reused; replace the capscrews with new ones. Also, do not undertighten or overtighten any bearing-cup-plate capscrews. A loose or broken fastener at any point in the driveline weakens the driveline connection, which could cause serious vehicle damage, or could result in a driveshaft separating from the vehicle, possibly causing loss of vehicle control that could result in serious personal injury or death.

4.5 Move the cross until it projects beyond the machined surface of the opposite yoke lug. Using the above procedure, install the opposite bearing assembly and its fasteners.

4.6 Slightly back off all four capscrews, then alternately tighten them in increments of 5 lbf·ft (7 N·m), to the applicable torque value in **Subject 400**.

Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly

4.7 If so equipped, bend the tabs of both lockplates upward (using a hammer and a pin punch) until they are firmly against a flat side of each capscrew. See **Fig. 38**.

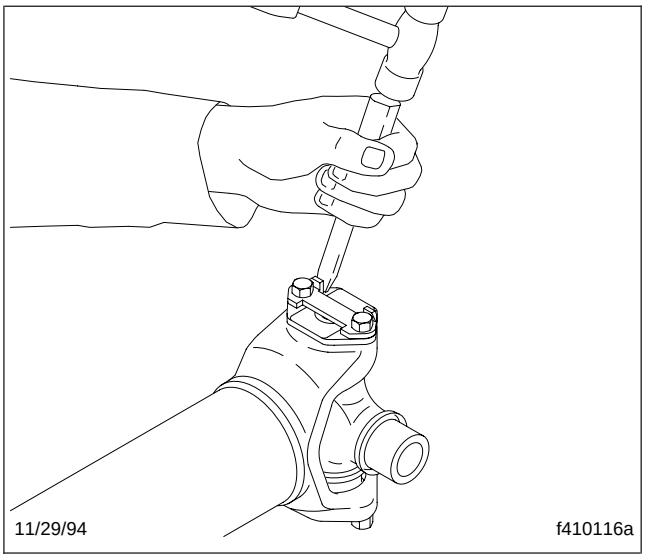


Fig. 38, Bending a Lockplate Tab Against a U-Joint Capscrew

NOTE: The U-joint should flex, and be free of excessive bind. A slight drag is the most desirable condition for new U-joints. Excessive looseness is not desirable, and may result in an unbalanced driveshaft.

Spicer SPL90 (1590) U-Joint Replacement or Installation

IMPORTANT: Worn bearing assemblies used with a new cross, or new bearing assemblies used with a worn cross will wear rapidly, making another replacement necessary in a short time. Always replace the cross and all four bearing assemblies at the same time.

1. Place the driveshaft in V-blocks or a soft-jawed vise; do not distort the tube with excessive grip.
2. For a no. 2 driveshaft that has a sleeve-yoke (not a splined reverse-slip shaft) at its forward end, make sure the alignment marks on the slip-joint assembly are aligned, to keep the U-joints in phase. See **Fig. 10** and **Fig. 11**.

IMPORTANT: Misaligned driveshaft yokes will cause the U-joints to be out of phase, which will cause vibration in the driveline.

NOTE: For a no. 2 driveshaft that has a splined reverse-slip shaft, install the U-joint in the sleeve-yoke first. Next, align the alignment marks that were added to the sleeve-yoke and driveshaft tube, then connect the U-joint to the forward tube-yoke of the driveshaft. See **Fig. 6**.

For a coupling shaft that has an end-yoke and a tube-yoke, check that the yokes are aligned, so that the U-joints at each end of the coupling shaft will be in phase. See **Fig. 16**.

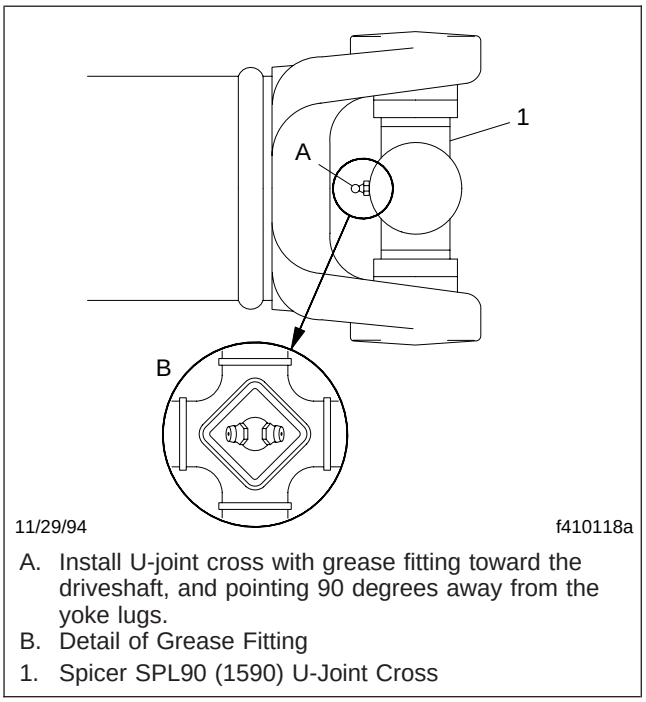
3. Lubricate the U-joint.
   - 3.1 Using a hand-type grease gun, or a high-pressure gun equipped with a low-pressure adapter, fill the lube passages in the cross with multipurpose chassis grease (lithium 12-hydroxy stearate, NLGI grade 1 or 2 with EP additives). See **Fig. 27**.
   - 3.2 Wipe a heavy coating of the same grease on the needles of each bearing cup, and pack each bearing cup about one-quarter full of grease. See **Fig. 28**.

⚠ CAUTION

CAUTION: Do not expose the U-joint trunnions or bearing-cup needles to dirt or grit. The smallest bits of dirt or grit can cause rapid wear and serious damage to the U-joint.

4. Install the U-joint cross and bearing assemblies in the yoke.
   - 4.1 Position the U-joint cross in the yoke with its lube fitting on the inboard side (toward the driveshaft) and pointing 90 degrees away from the driveshaft yoke lugs. See **Fig. 39**.
   - 4.2 Move one end of the cross until a trunnion projects through the cross-hole, beyond the outer machined face of the yoke lug. Hold the trunnions in alignment with the cross-holes, while placing a bearing cup over the projected trunnion, and aligning it with the cross-hole. See **Fig. 40**.

Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly



A. Install U-joint cross with grease fitting toward the driveshaft, and pointing 90 degrees away from the yoke lugs.
B. Detail of Grease Fitting
1. Spicer SPL90 (1590) U-Joint Cross

Fig. 39, Spicer SPL90 (1590) U-Joint Grease Fitting Positioning

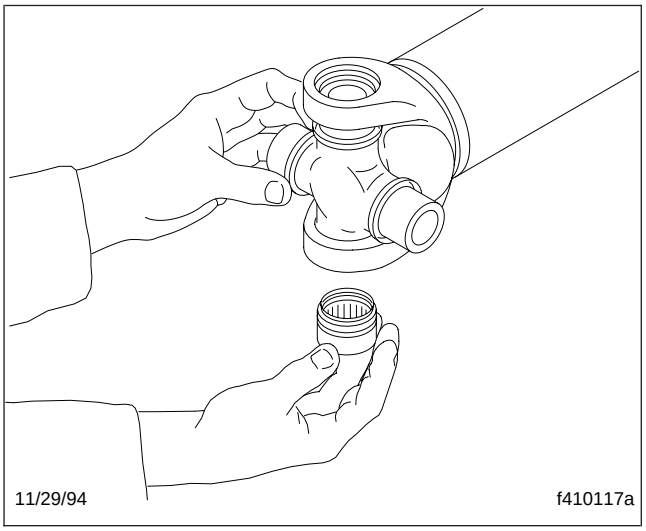


Fig. 40, Installing a Spicer SPL90 (1590) U-Joint Bearing Cup In a Full-Round Yoke

4.3 Using an arbor press, and holding the trunnion in alignment with the cross-hole, place a solid plug (with an outside diameter slightly smaller than the inside diameter of the cross-holes) on the upper bearing cup. See **Fig. 9**. Press the bearing cup into the cross-hole enough to install a snap ring.

4.4 Install the snap ring. See **Fig. 8**.

IMPORTANT: Be sure the snap ring is properly seated in its groove.

4.5 Turn the yoke over, and install the opposite bearing cup and snap ring.

If movement of the U-joint is stiff, strike the yoke ears with a soft hammer to seat the bearing needles.

Transmission/Axle End-Yoke Replacement or Installation

IMPORTANT: Parts for different series drivelines must not be intermixed. Incorrectly assembled or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

1. Apply Loctite 242 to the input- or output-shaft threads where the end-yoke locknut will be installed. See **Fig. 13**.
2. By hand, install the end-yoke on the input or output shaft as far as it will go.
3. Install a new end-yoke locknut, and tighten it to the applicable torque value in **Subject 400**.

Driveline Parking Brake Flange-Yoke or Companion Flange Replacement or Installation

For replacement or installation of a driveline parking brake flange-yoke or companion flange, see **Group 42**.

Troubleshooting Procedure

Noise or vibration associated with the driveline can be caused by non-driveline parts. To find the cause of noise or vibration, first road test the loaded vehicle. Drive in all gears and at all speed ranges for which the vehicle was designed, including those at which problems are reported.

NOTE: Operating a vehicle at speeds that exceed its drivetrain design specifications may cause an out-of-balance vibration.

The following is a troubleshooting elimination process; checks should be made in the order listed. At each step where a problem is found, correct the problem before proceeding to the next step, then test drive the vehicle to see if other problems still exist. If no other problems exist, the elimination process may be ended at that step.

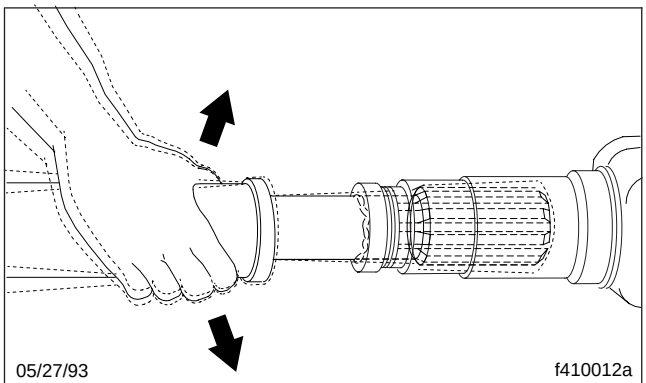
1. Check all tires for uneven wear and for out-of-roundness. Check for mismatched tires. Look for wheels and rims that are out of alignment. For instructions, see **Group 40**.
2. Check the rear suspension for loose or broken U-bolts; broken, shifted, or mismatched rear springs; or broken spring seats. If so equipped, check the air suspension for incorrect air spring height. Look for anything that could cause angular misalignment of the rear axle pinion(s). For instructions, see **Group 32**.
3. Check the frame rails and crossmembers for bends, twists, or breaks; for frame-alignment-checking and crossmember-replacement instructions, see **Group 31**.
4. Check the engine and transmission mounts; see **Group 01** (Engine) and **Group 26** (transmission). Check the coupling shaft's midship bearing mounts. Replace mountings that are deteriorated or oil-soaked; tighten loose mounting bolts. Oil-soaked or deteriorated mountings, or loose mounting bolts, can cause driveline angular misalignment.
5. Check for loose U-joint bearing-cup-plate and bearing-strap capscrews, and for loose flange-yoke locknuts. Tighten any loose fastener to the applicable torque value in **Subject 400**. Then, on U-joint bearing-cup-plates equipped with lockplates, bend a lockplate tab upward until it is firmly against a flat side of the tightened capscrew head.

CAUTION

CAUTION: Do not overtighten the bearing-cup-plate or bearing-strap capscrews, or the flange-yoke locknuts. A loose or broken fastener at any point in the driveline weakens the driveline connection, which could result in serious vehicle damage.

6. Check all U-joint assemblies, slip-joint splines, and midship bearings for wear.
   - 6.1 Try to move each driveshaft up and down, and from side to side. If movement is greater than 0.006 in (0.15 mm) of a U-joint cross in its bearings, replace the U-joint assembly.
   - 6.2 If the midship bearing rattles or is loose on its shaft, replace it.
   - 6.3 Try to bend the sleeve-yoke and splined shaft up and down, and from side to side. See **Fig. 1**. If looseness is greater than 0.007 in (0.18 mm), replace the sleeve-yoke and splined shaft.

     If driveline components must be replaced, see **Subject 130**.



Try to bend the sleeve-yoke and splined shaft up and down, and from side to side.

Fig. 1, Checking for Slip-Joint Spline Wear

7. Check each driveshaft for an indication of missing balance weights. If any weights appear to be missing, have the driveshaft balanced to a maxi-

Troubleshooting

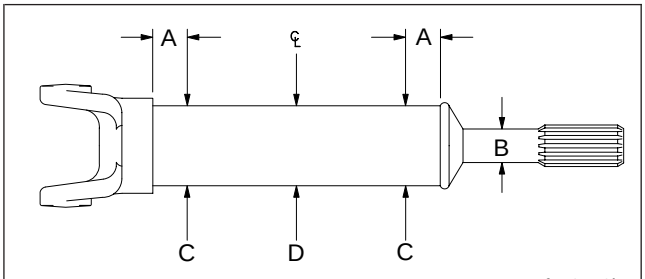
mum tolerance of one inch-ounce per ten pounds weight per end, at 3000 rpm.

8. Check each driveshaft for dents, bends, twists, or other damage.

   If damaged, jack up the rear axle, support it on jackstands, place the transmission in neutral, and turn the driveshaft by hand to check runout.

   The driveshaft must be straight within 0.015 in (0.38 mm) on the slip-joint seal surface of the splined shaft, 0.020 in (0.51 mm) on the tube 3 in (76 mm) from the front and the rear welds, and 0.025 in (0.635 mm) at the center of the tube. See **Fig. 2**.

   If the driveshaft is not straight within specifications, replace the tube. See **Subject 130** for runout specifications for a *new* (or rebuilt) driveshaft.



06/13/96 f410110b

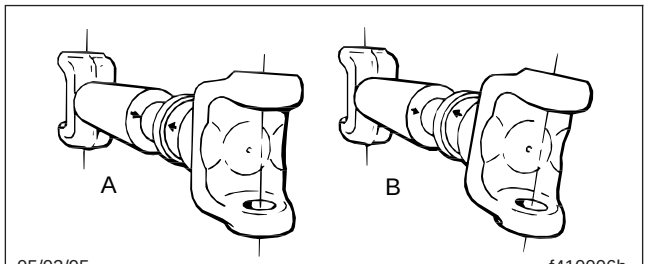
A. Measurement: 3" (76 mm)
B. Measurement: 0.015" (0.38 mm)
C. Measurement: 0.020" (0.51 mm)
D. Measurement: 0.025" (0.635 mm)

Fig. 2, Used Driveshaft Runout Specifications

9. Check each driveline for proper U-joint phasing. See **Fig. 3**.

   9.1 On no. 2 and no. 3 driveshafts, if the U-joints are out of phase, check the slip-joint for alignment marks. If necessary, disassemble the slip-joint, and align the marks.

   NOTE: To disassemble the slip-joint, uncouple the U-joint at one end of the driveshaft, unscrew the slip-joint seal from the sleeve-yoke, then pull the sleeve-yoke and splined shaft apart. Reverse the procedure to assemble the slip-joint.



05/02/95 f410006b

A. In Phase B. Out of Phase

Fig. 3, U-Joint Phasing

   9.2 If no alignment marks are present, disassemble the slip-joint, and reassemble it with the U-joints in one of the two in-phase positions (180 degrees apart).

   Test drive the vehicle, then assemble the slip-joint in the other in-phase position. Test drive the vehicle again.

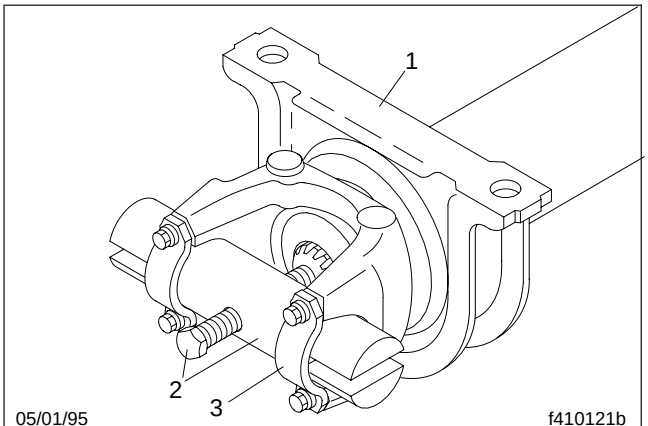
   Determine which in-phase position provides vibration-free operation; then, assemble the slip-joint in the correct in-phase position, and mark the slip-joint with alignment marks.

   9.3 If the U-joints are out of phase on a coupling shaft, uncouple the U-joint from the coupling shaft end-yoke, then remove the end-yoke nut. Remove the end-yoke, using a yoke puller. See **Fig. 4** for a half-round end-yoke, or see **Fig. 5** for a full-round end-yoke. Align the end-yoke, then install it by hand. Install the end-yoke nut, and tighten it 475 to 525 lbf·ft (645 to 710 N·m). Slightly back off the nut, and again tighten it to the same torque. Couple the coupling shaft to the driveshaft U-joint.

10. Check the torque on all of the end-yoke nuts in the drivetrain; see the applicable torque values in **Subject 400**.

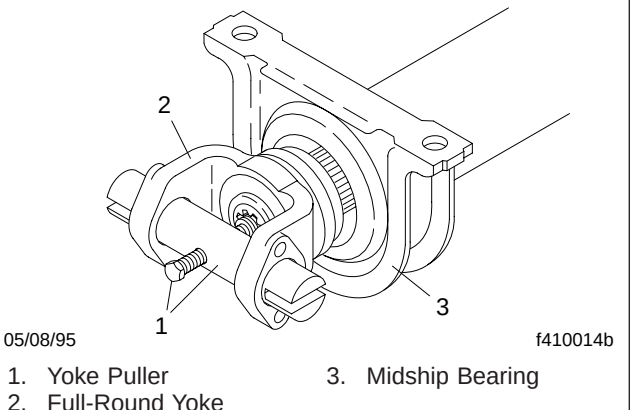
    If any yoke nut was not at its specified torque, check the yoke for wear by trying to move it up and down, and back and forth. If the yoke can be rocked on its shaft, or moved in or out on its shaft, replace the yoke and yoke nut; see **Subject 130**.

    If the yoke is not worn, tighten the yoke nut to its torque value.



1. Midship Bearing
2. Yoke Puller
3. Bearing Strap

Fig. 4, Removing a Half-Round End-Yoke From a Coupling Shaft



1. Yoke Puller
2. Full-Round Yoke
3. Midship Bearing

Fig. 5, Removing a Full-Round End-Yoke From a Coupling Shaft

11. *On single-drive vehicles:*

    Have the no. 2 driveshaft balanced to a maximum tolerance of one inch-ounce per ten pounds weight per end, at 3000 rpm.

    On dual-drive vehicles:

    11.1 Remove the no. 3 driveline; then, with the interaxle differential locked, test drive the vehicle.

    11.2 If vibration still exists, install the no. 3 driveline, then have the no. 2 driveshaft balanced to a maximum tolerance of one inch-ounce per ten pounds weight per end, at 3000 rpm.

    If *no* vibration exists, check that both rear axle gear ratios are matched. If the gear ratios do not match, replace one of the gear sets with a gear set having the correct ratio, then install the no. 3 driveline.

    11.3 Have the no. 3 driveshaft balanced to a maximum tolerance of one inch-ounce per ten pounds weight per end, at 3000 rpm.

    11.4 Have the no. 2 driveshaft balanced to a maximum tolerance of one inch-ounce per ten pounds weight per end, at 3000 rpm.

12. If so equipped, balance the coupling shaft(s) to a maximum tolerance of one inch-ounce per ten pounds weight per end, at 3000 rpm.

Specifications

Description			Size	Torque: lbf·ft (N·m)
End-Yoke Nut				
Transmission Output Shaft	Fuller	FS 4005, 5005, 5106, 6105, and 6206	1-1/4–18	300–350 (405–475)
		RT 6609	1-1/2–18	400–450 (540–610)
	Allison	MD Series	2–16	600–800 (815–1085)
Single Axle Input Shaft	Rockwell	RS-15-120, RS-15-210, RS-17-140, RS-17-220	M32 x 1.5	740–920 (1000–1250)
		RS-23-160	M45 x 1.5	1000–1230 (1355–1670)
		RS-23-240	M39 x 1.5	920–1130 (1250–1530)
Forward-Rear Axle Input Shaft	Rockwell	RD-17-145 (of RT-34-145), RD-20-145 (of RT-40-145)	M39 x 1.5	600–800 (815–1085)
Forward-Rear Axle Output Shaft	Rockwell	RD-17-145 (of RT-34-145), RD-20-145 (of RT-40-145)	M39 x 1.5	450–600 (610–815)
Rearmost Axle Input Shaft	Rockwell	RR-17-145 (of RT-34-145), RR-20-145 (of RT-40-145)	M39 x 1.5	920–1130 (1250–1530)
Midship Bearing (coupling shaft)	Spicer	1590, 1610, and 1710	1-1/4–18	475–525 (645–710)
Companion-Flange Nut				
Transmission Output Shaft	Fuller	FS 4005, 5005, 5106, 6105, and 6206	1-1/4–18	300–350 (405–475)
U-Joint Capscrew				
Bearing Plate (for full-round end-yoke)	Spicer	1610	5/16–24	20 (27)
		1710	3/8–24	36 (49)
Bearing Strap (for half-round end-yoke)	Spicer	1590 and 1610	3/8–24	53 (72)
		1710	1/2–20	125 (169)
Flange-Yoke Locknut				
Flange-Yoke to Companion Flange	Spicer	1590, 1610, and 1710	3/8–24	40–48 (54–65)
Midship Bearing Flanged Locknut				
Bracket to Crossmember	Spicer	1590, 1610, and 1710	1/2–13	91 (123)
Bearing Mount to Bracket	Spicer	1590, 1610, and 1710	1/2–13	91 (123)

Table 1, Fastener Torques

Specifications

Special Tools

JOURNAL LOCATOR

(For installing Spicer 1610, 1710, 1760, and 1810 U-joints in full-round yokes)

To order, Contact your Dana Corporation Spicer Service Representative.

U-JOINT REMOVAL TOOL KIT

(For removing Spicer 1610, 1710, 1760 and 1810 U-joints and Rockwell 17N, 17T, 176T and 18T U-joints from full-round yokes)

To order Owatonna Tool Kit No. 7057, Contact:

Owatonna Tool Company
Owatonna, Minnesota 55060

END-YOKE/FLANGE-YOKE PULLER

(For removing end-yokes from transmission output shafts, coupling shafts, and rear-axle input and output shafts)

To order End-Yoke Puller J 7804–01, contact:

Kent-Moore Tool Division
29784 Little Mack
Roseville, MI 48066-2298
Telephone: 1–800–328–6657 Telex: 244040 KMTR
UR FAX: (313) 774–9870

To order Yoke and Flange Remover SP–450, contact:

G & W Tool Company
907 South Dewey
Wagoner, OK 74467

See **Fig. 1** for a full view of the air brake plumbing (cab) diagram. See **Fig. 2** or **Fig. 3** for partial (detailed) views of this diagram.

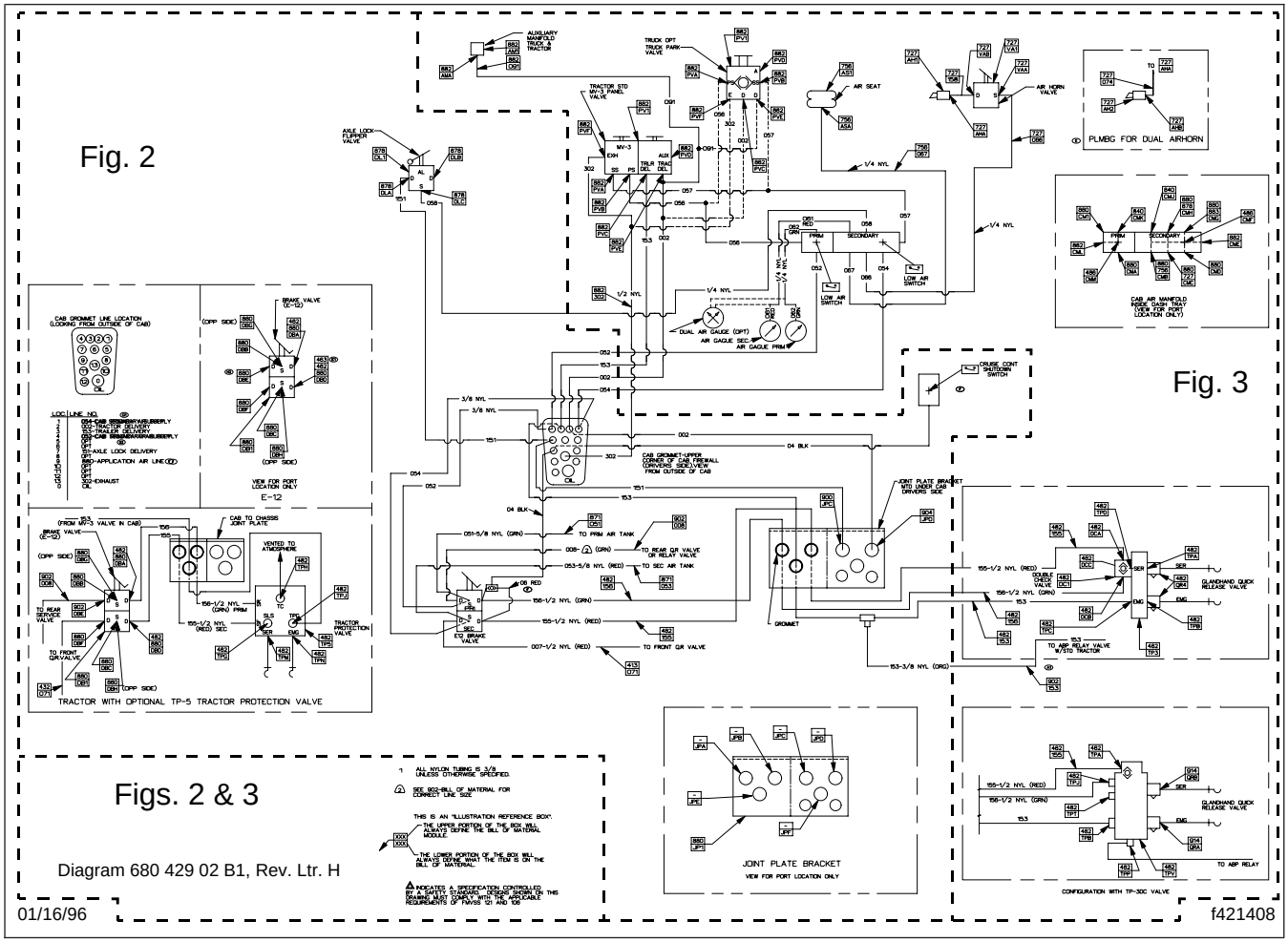


Fig. 1, Cab Air Brake Plumbing Diagram

Cab Diagram

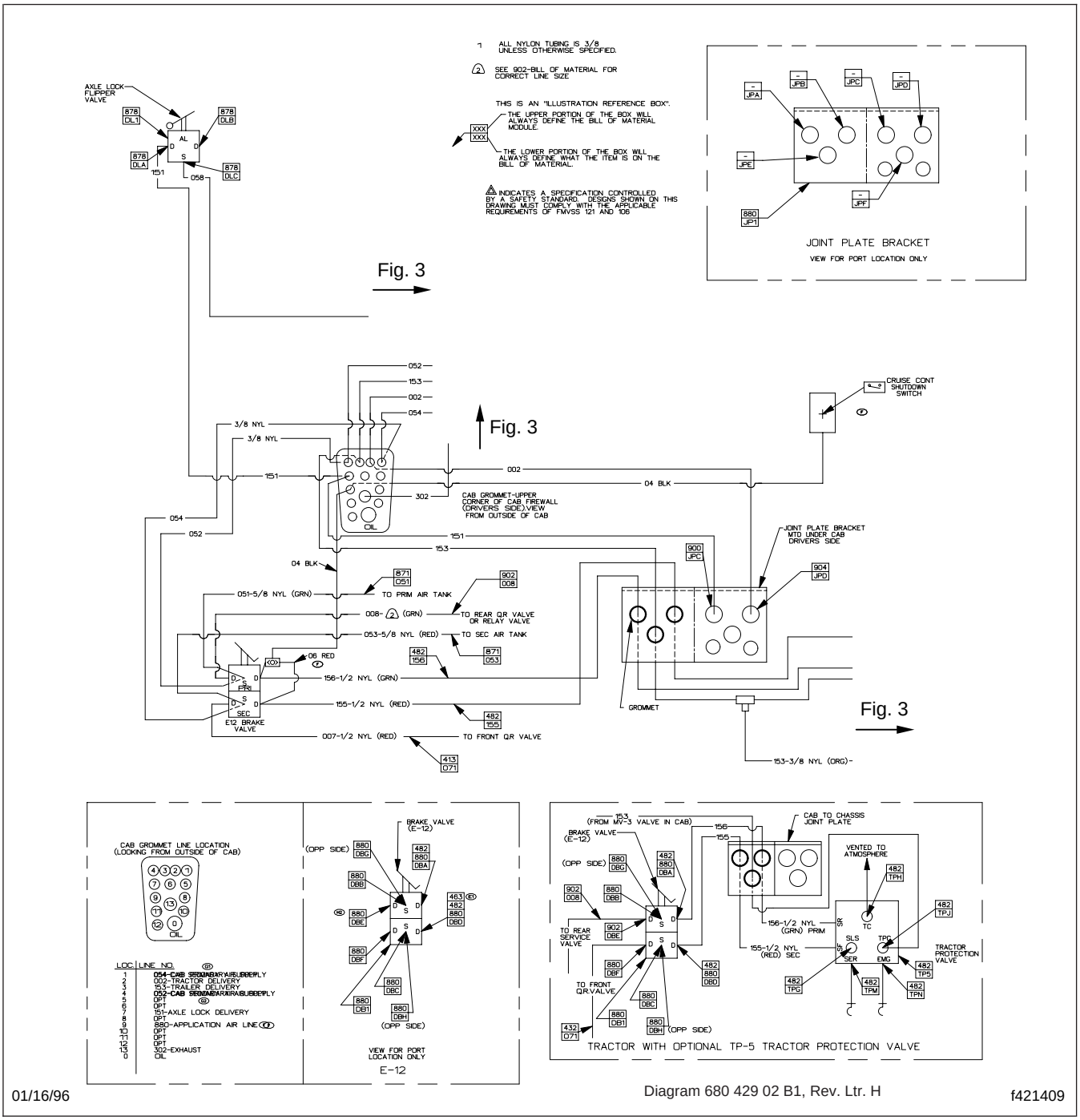
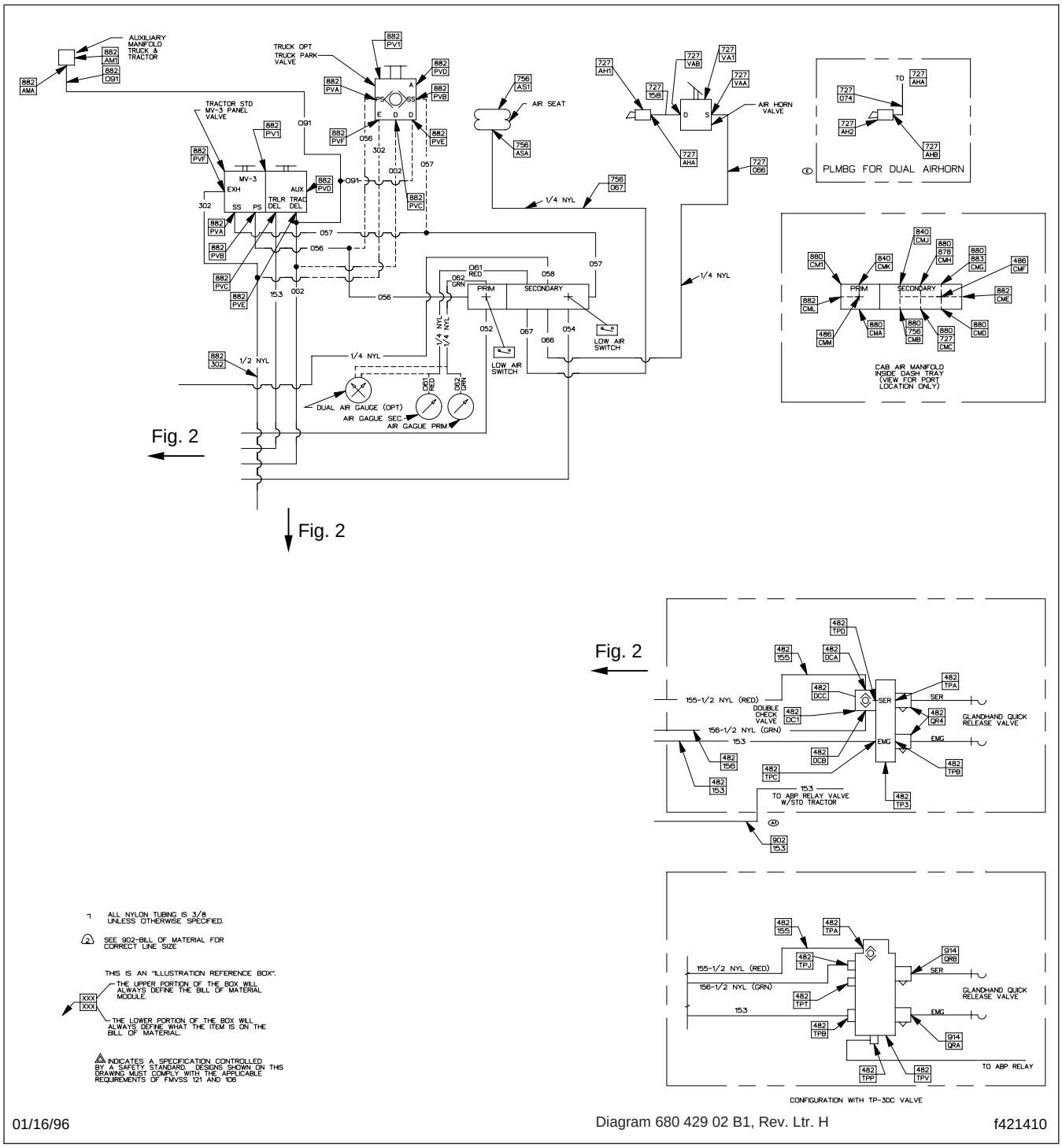


Fig. 2, Cab Air Brake Plumbing Diagram (detailed view)



01/16/96

Diagram 680 429 02 B1, Rev. Ltr. H

f421410

Fig. 3, Cab Air Brake Plumbing Diagram (detailed view)

See **Fig. 1** for a full view of the air brake plumbing (chassis) diagram. See **Fig. 2**, **Fig. 3** or **Fig. 4** for partial (detailed) views of this diagram.

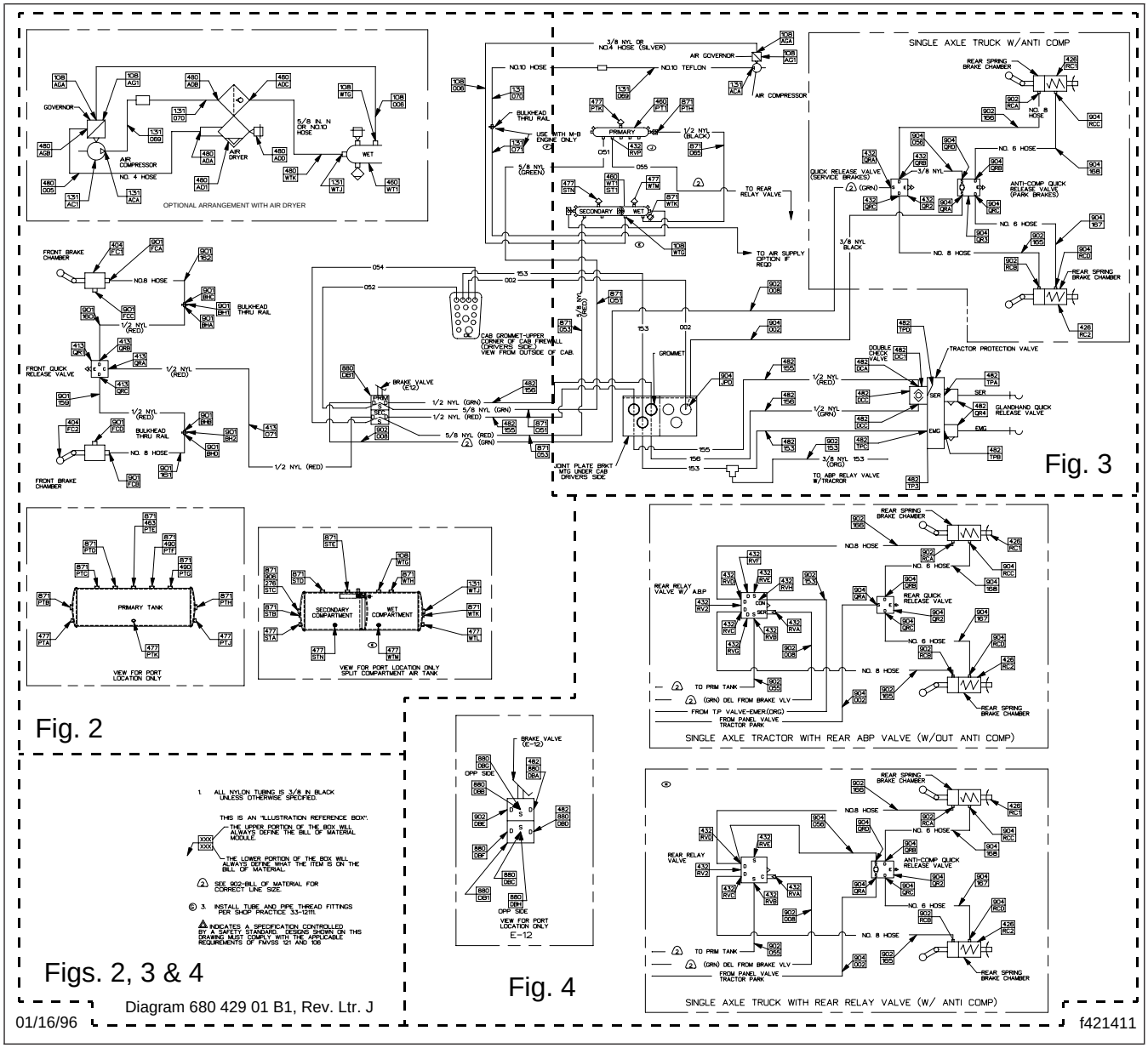


Fig. 1, Air Brake Plumbing, Chassis Diagram

Chassis Diagram

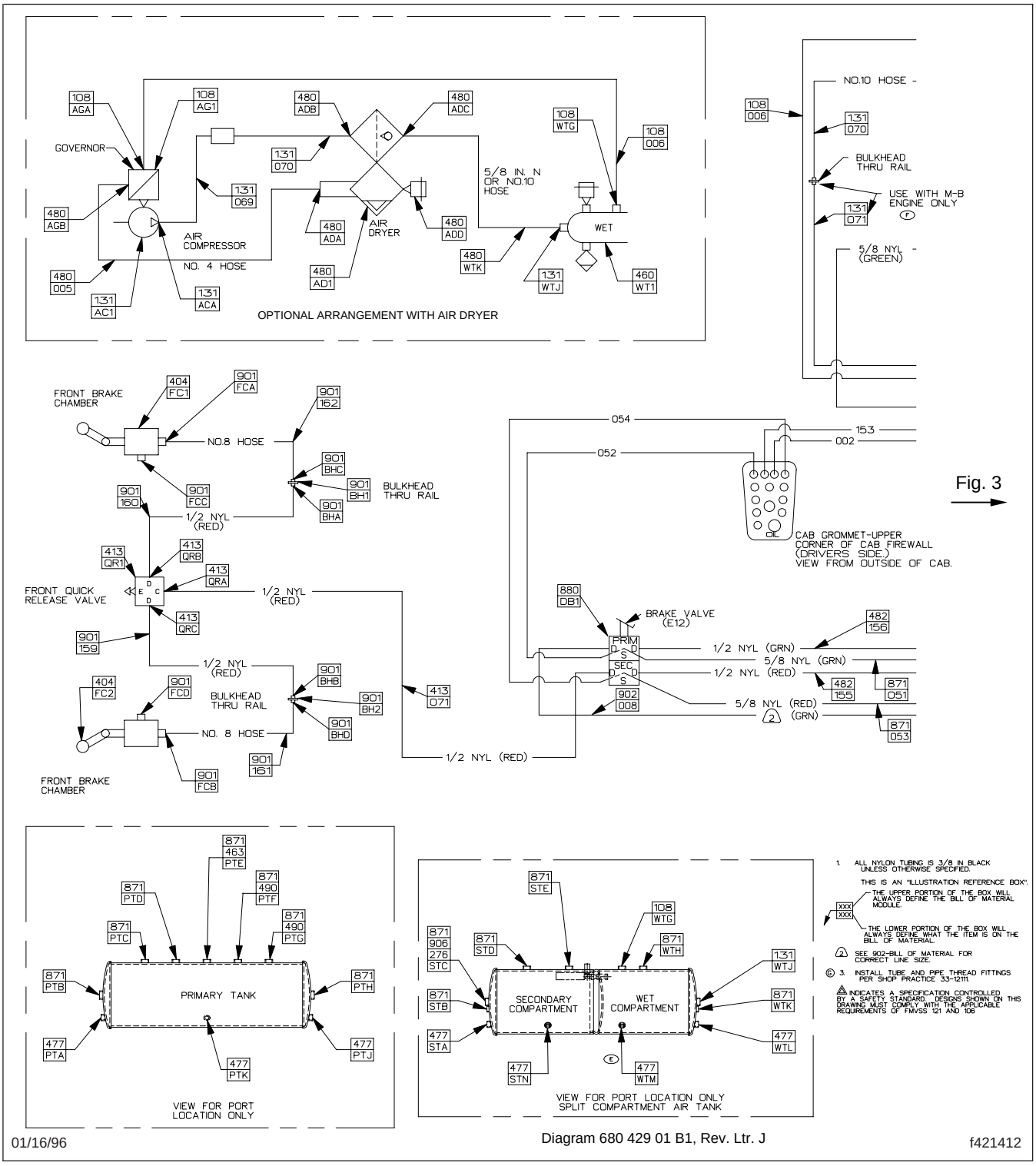


Fig. 2, Air Brake Plumbing, Chassis Diagram (detailed view)

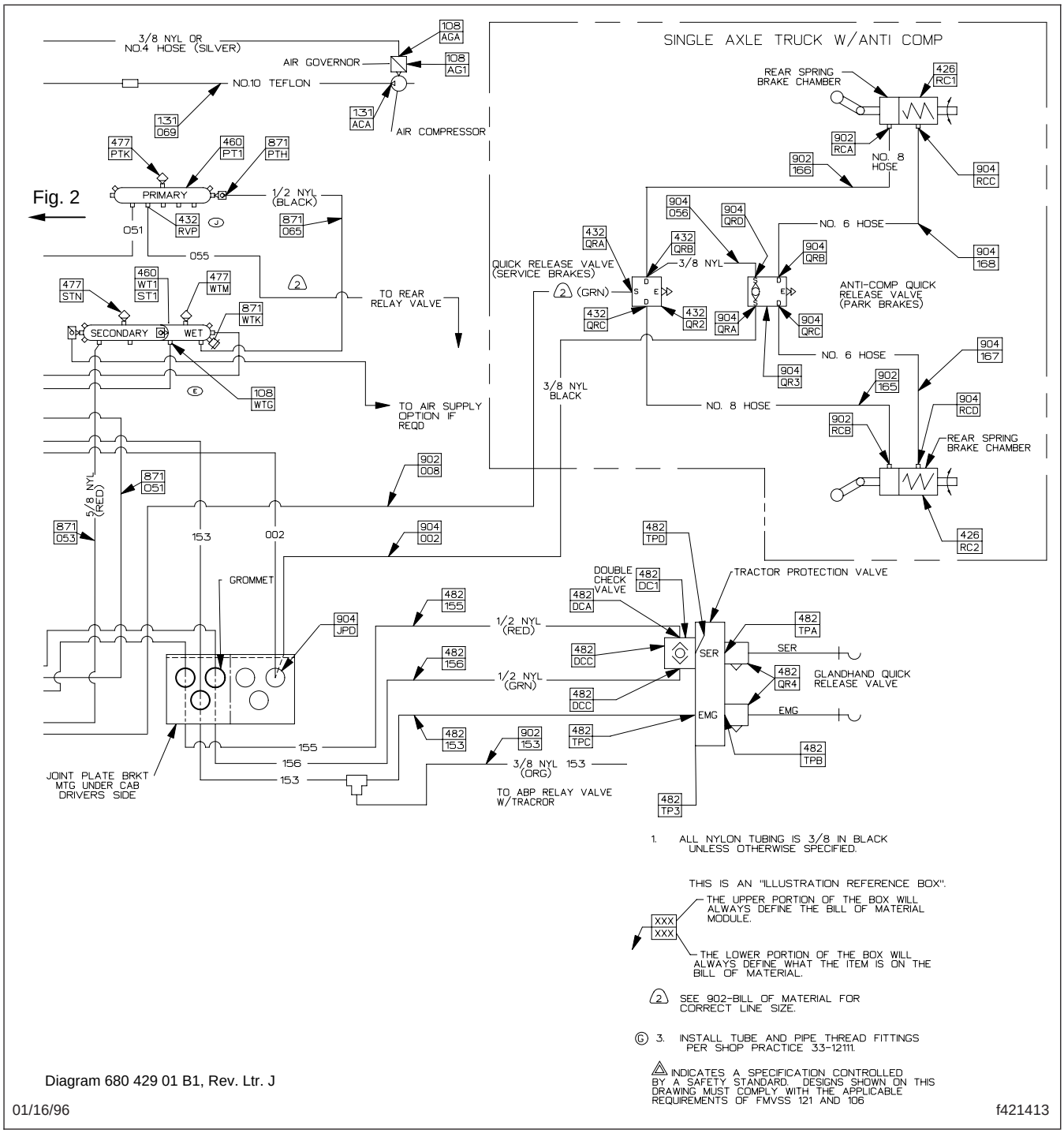


Fig. 3, Air Brake Plumbing, Chassis Diagram (detailed view)

Chassis Diagram

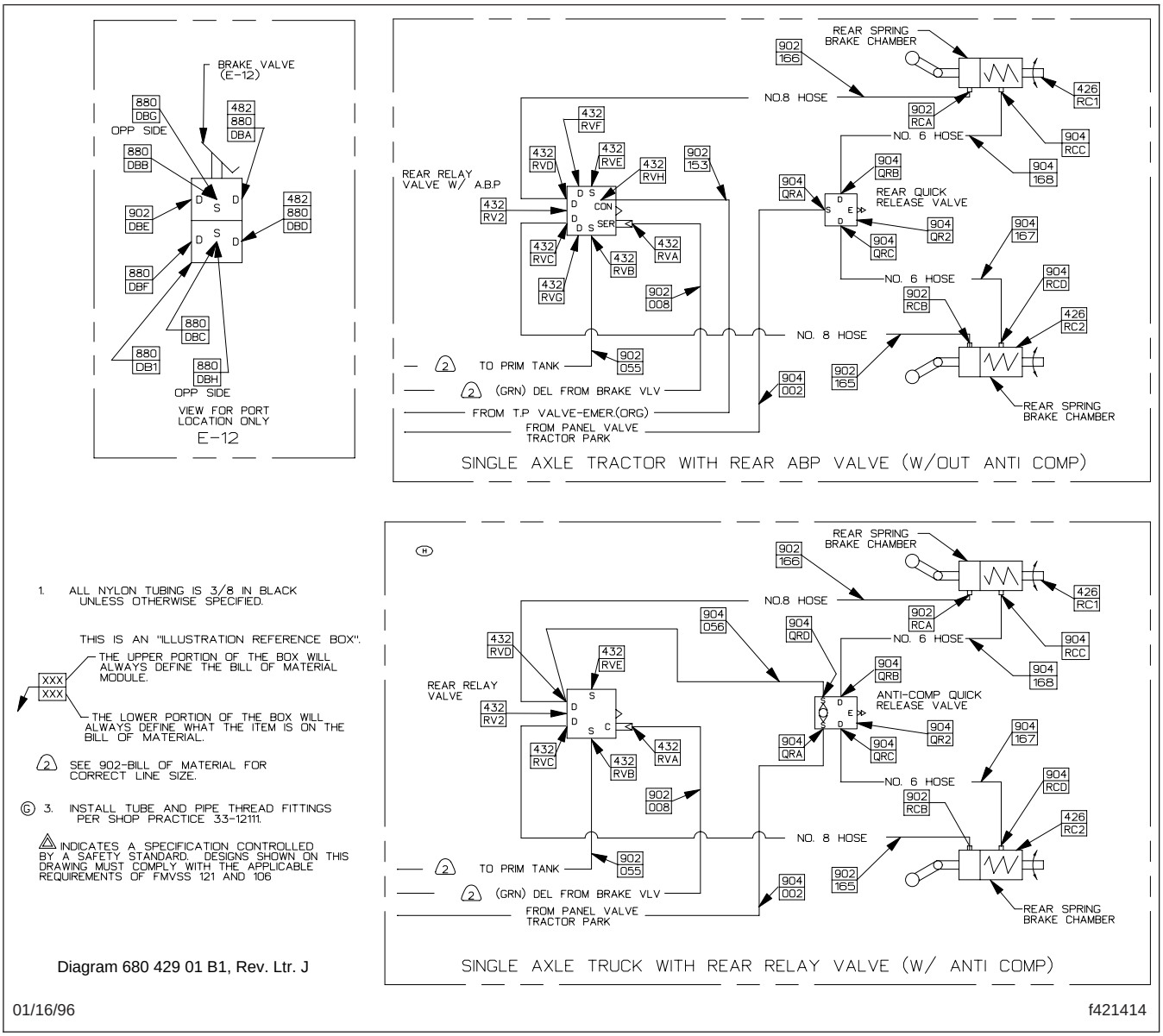


Fig. 4, Air Brake Plumbing, Chassis Diagram (detailed view)

General Information

This troubleshooting guide is designed to help locate causes of problems originating in the air brake system. The corrective measures given are not intended to replace the detailed service information found in other sections of this manual or in the component manufacturer's service manuals.

Before attempting to isolate the causes of an air brake system problem, do the following:

1. Check the operation of the air compressor. Refer to the engine manufacturer's service manual.

   Check the pressure levels of the air reservoirs. Refer to the vehicle driver's manual.
2. Be sure that all relay valves are operating. For instructions, refer to the vehicle maintenance manual.
3. Check the operation of the brake chambers as instructed in the vehicle maintenance manual.
4. Examine all tubing for kinks, dents, and other damage. Replace damaged tubing.
5. Examine all hoses for cracks, drying out, overheating, and other damage. Replace damaged hoses.
6. Examine all air line fittings. Tighten loose connections; replace fittings that are damaged. For instructions, refer to the applicable section in this manual.
7. Examine leaking pipe connections for cracks or thread damage; replace as needed. If there is no damage, retighten the fitting. For instructions, refer to the applicable section in this manual.

Safety Precautions

Compression and storage of air in the air brake system is comparable to the energy in a coiled spring: when released, it may be hazardous. Because of this, certain precautions are required:

1. Chock the tires. This will prevent accidental rolling of the vehicle when air is released from the brake system.
2. Don't disconnect pressurized hoses because they will whip as air escapes from the line. Drain the air system before disconnecting the air hoses.
3. When draining the air system, do not look into the air jets or direct them toward anyone: dirt particles or sludge may be carried in the air stream.
4. As air pressure is drained and the parking/ emergency brakes apply, keep your hands away from the brake chamber push rods and parking brake chambers, which will activate automatically with the loss of pressure. This also applies to the service brake system.

⚠ WARNING

WARNING: Follow the manufacturer's procedures while working on any air device so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion. Failure to take all necessary precautions during servicing of the air brake system can result in personal injury.

Problem—Vehicle Does Not Slow Down Quickly Enough When Brakes Are Applied

Possible Cause	Remedy
The vehicle is overloaded.	Observe the recommended maximum load limits.
There is low air pressure in the brake system, about 413 kPa (60 psi) or lower.	The drain cock on the air reservoir was left open; close the drain cock.
	Check the compressor output pressure; correct as necessary.
	Check the setting of the air governor with an accurate test gauge. Adjust the air governor to the recommended specification.
The application air lines are leaking excessively.	Check the application air line, brake valve, and the service and parking brake chambers for air leaks. Repair or replace the damaged component(s).
Brake valve delivery pressure is below normal.	Lubricate the brake valve parts; overhaul the unit, if necessary.
The brake linings are worn or glazed.	Install new brake linings on the brake shoes on both sides of the axle.
The brakes need adjustment or lubrication.	Adjust or lubricate the brakes.
The automatic slack adjusters (if so equipped) are not operating.	Lubricate the automatic slack adjusters and check for binding, damaged, or inoperative slack adjuster parts. Replace damaged or inoperative parts, or eliminate the cause of the binding.
The cam has flipped over.	Replace the linings and the cam on each end of the axle. Replace the brake drums if needed.
Flat spots or dents on the roller surface were caused by skidding of the roller or incorrect handling of the rollers during installation.	Clean, then inspect the bearing rollers. Replace the rollers if damaged.
One or more of the brake drums is broken or cracked.	Replace the brake drum(s).
Wrong size brake linings were installed.	Replace the brake linings with the recommended size.
Wrong size brake chambers were installed.	Replace the brake chambers with the recommended size.
A camshaft bracket or chamber mounting bracket is bent or broken.	Replace the camshaft bracket or chamber mounting bracket.
The brake chamber mounting stud nuts or brake chamber mounting bracket is loose.	Tighten the brake chamber to its mounting bracket or the mounting bracket to the foundation brake housing.
There is a ruptured diaphragm in the service brake.	Replace the diaphragm.
The brake drums are glazed.	Turn the brake drums, if possible. If the maximum allowable diameter is exceeded, replace the drum. Do the same for both ends of the axle.

Problem—Service Brakes Release Too Slowly

Possible Cause	Remedy
The brake shoe anchor pins are frozen.	Inspect the anchor pins. If damaged, replace them; if not damaged, lubricate them.
Lubrication of the brake system components is inadequate.	Lubricate those components requiring periodic lubrication.
The brake foot valve push rod may be incorrectly adjusted.	Readjust the push rod and/or pedal stop bracket.

Troubleshooting

Possible Cause	Remedy
The brake foot valve is not returning to the fully released position.	Check for obstructions which might prevent the brake foot valve from returning to the fully released position. Remove any obstructions.
The exhaust port of the brake foot valve or quick-release valve is plugged.	Clear the exhaust port of obstructions.
The brake foot valve or quick-release valve is not working.	Overhaul or replace the applicable valve, as needed.
The camshaft and bushings are binding.	Clean and lubricate the camshaft bushings.
The brake shoe return spring is weak or broken.	Replace the spring.
Flat spots or dents on the roller surface were caused by skidding of the roller or incorrect handling of the rollers during installation.	Clean, then inspect the rollers. Replace the rollers if damaged.

Problem—Service Brakes Do Not Apply or Apply Too Slowly

Possible Cause	Remedy
Lubrication of the foundation brake assembly is needed.	Lubricate those components requiring periodic lubrication.
There is insufficient air pressure in the brake system.	Check all parts of the air pressure system for leaks or inoperative components.
The brake foot valve or quick-release valve is not working.	Repair or replace the brake foot valve or quick-release valve.
The camshaft bushings are binding.	Clean and lubricate the camshaft bushings.

Problem—Service Brakes Apply When the Parking Brakes Are Released With Air Pressure

Possible Cause	Remedy
The air delivery lines to the brake chamber have been reversed.	Reverse the connections of the brake chamber air lines.
There is a leaking push rod seal between the parking brake and the service brake.	Replace the push rod seal.
The braking mechanism is binding.	Lubricate the brake mechanism and make sure all parts are aligned with each other and are securely fastened.
	Check for obstructions; remove any obstructions.

Problem—Service Brakes Do Not Release

Possible Cause	Remedy
The brake shoes are incorrectly adjusted.	Adjust the brakes. Also, make sure the slack adjuster is operating correctly. If not, overhaul or replace the slack adjuster.
The brake foot valve may not be in the fully released position.	Lubricate the brake foot valve if needed. Check the adjustment of the brake foot valve push rod.
The brake foot valve is not working.	Overhaul or replace the brake foot valve.

Possible Cause	Remedy
There is a restriction in the tubing, hose, or exhaust port of the brake foot valve or quick-release valve.	Check for bends or obstructions on the exhaust side of the service brakes. Remove any obstructions; plumb the air lines so that bends are minimal.
A broken power spring may be blocking the parking brake piston movement.	Replace the power spring or replace the parking brake assembly, whichever is recommended by the parking brake manufacturer.

Problem—Service Brakes Grab or Pull

Possible Cause	Remedy
There is not enough weight on the vehicle (underloaded).	Add weight to the vehicle, reducing brake sensitivity.
Adjustment of the brakes on one axle is uneven.	Adjust the brakes.
Lubrication of the brake system components is inadequate.	Lubricate those components requiring periodic lubrication.
The brake mechanism is binding.	Lubricate the brake mechanism and make sure all parts are aligned with each other and are securely fastened.
The clevis pin or camshaft is binding at one or more wheels.	Clean and lubricate the camshaft bushings.
A brake spider is loose.	Tighten the mounting bolts or replace the brake spider.
A slack adjuster is damaged.	Replace the damaged component.
The air chamber push rods or slack adjusters are a different length.	Replace the components with the correct size and material.
The brake foot valve is not working.	Overhaul or replace the brake foot valve, as needed.
If equipped with cam brakes, there is a flat or dent on the S-head camshaft or on the cam roller(s).	Replace the damaged component(s).
Grease has saturated the brake linings or the linings are glazed.	Install a matched set of linings on both sets of brake shoes on that axle. Clean, replace, or turn both brake drums. For instructions on turning drums, refer to the brake manufacturer's service manual. Find out what is causing the saturation and repair as needed.
The brake linings are loose or broken.	Install a matched set of linings on both sets of brake shoes on that axle.
The brake linings are not a matched set. Different friction codes or different brands of brake linings are installed.	Install a new, matched set of brake linings. Clean, replace, or turn both brake drums on that axle. For instructions on turning drums, refer to the brake manufacturer's service manual.
A brake shoe is distorted or broken.	Replace the brake shoe. Install a new, matched set of linings on both sets of brake shoes on that axle.
The pilot pads are damaged, allowing the brake drum to be installed out-of-round.	Replace the wheel hub.
A brake drum is out-of-round to unacceptable limits.	Turn both the brake drums on that axle. If the maximum allowable diameter of either drum has been exceeded, replace that drum. For instructions on turning drums, refer to the brake manufacturer's service manual.
One or more brake drums is scored or broken.	Replace both of the drums on that axle.

Troubleshooting

Problem—Uneven Service Brakes

Possible Cause	Remedy
The wrong brake linings were installed, or the linings were not replaced in pairs.	Replace the brake linings with the recommended size. Install new linings on both sets of axle brake shoes.
Grease has saturated the brake linings or the linings are glazed.	Install new linings on both axle brake shoes. Clean the brake drums. Find the cause of saturation, and repair as needed.
The return spring for the brake shoe release or the service brake has broken.	Replace all broken springs.
The brake drum is out-of-round to unacceptable limits.	Turn the brake drum(s), if possible. If the maximum allowable diameter of the brake drum(s) has been exceeded, replace the drum. Also, turn or replace the other drum on the axle. For turning the drum(s), refer to the brake manufacturer's service manual.
A service brake chamber diaphragm is leaking.	Tighten the clamp ring. If leaks persist, replace the service brake diaphragm.
The wheel bearings are out of adjustment.	Adjust the wheel bearings, or replace them if damaged. For instructions, refer to the front axle group or the rear axle group of the vehicle maintenance manual.
A brake spider is damaged.	Replace the brake spider.
The brake shoes are bent or stretched.	Replace the axle brake shoes on each wheel.
Grease, oil, or dirt is on the linings.	Replace the linings on each set of axle brake shoes. Clean the brake drums. Find the cause of contamination and remedy it.

Problem—Dragging Service Brake

Possible Cause	Remedy
The service brake return spring is broken.	Replace the service brake return spring.
The service-application air is not exhausting or not exhausting fast enough, due to blockage in the control valve, the quick-release valve, or the limiting and quick-release valve.	Test the air system valves for leakage and operation.
A brake shoe retracting spring is broken.	Replace the brake shoe retracting spring.
Binding is occurring in the camshaft linkage.	Lubricate the camshaft linkage. Replace bent or broken parts.
The brake foot valve is not returning to the fully released position.	Check for obstructions which might prevent the brake foot valve from returning to the fully released position. Remove any obstructions.
The brake foot valve push rod may be incorrectly adjusted.	Readjust the push rod and/or pedal stop bracket.

Problem—Insufficient Parking Brake Application When Dash Control Valve Is Activated

Possible Cause	Remedy
The parking brake is not set for full stroke.	Adjust the brakes.
A power spring is broken.	Replace the parking brake chamber.
A power spring in a parking brake is manually caged.	Uncage the power spring, using the release bolt.

Problem—Dragging Brakes Due to Parking Brake Mechanism

Possible Cause	Remedy
The system air pressure is insufficient to fully release the parking brake.	Be sure that all air lines are clear. Check that the air governor cutout settings meet recommended specifications.
A parking brake diaphragm is ruptured or a piston seal is ineffective.	Replace the diaphragm or parking brake piston seal.
There is a broken return spring in the parking brake (double-diaphragm type brake chambers only).	Replace the parking brake chamber.

Problem— Air Pressure Will Not Rise to Normal

Possible Cause	Remedy
The air pressure gauge(s) on the dash is (are) registering inaccurately.	Check the dash gauge with an accurate test gauge. Replace the dash gauge(s) as needed.
There is excessive leakage (not including the air compressor).	Check all valves, air lines, and connections for leakage. Repair or replace valves and lines until leakage is eliminated.
The compressor is not working (including excessive leakage of the compressor).	Rebuild or replace the compressor.
The air reservoir drain cock has been left open.	Close the drain cock.
The air governor cutout setting is not adjusted correctly.	Check the setting with an accurate test gauge, then adjust the air governor to the recommended specification.
There is inadequate clearance at the compressor unloading valve.	Repair or adjust the compressor at the unloading valve.
If so equipped, the compressor drive belt is slipping.	Adjust or replace the compressor drive belt.
Carbon is building up in the compressor cylinder head or discharge line.	Remove the carbon. If disassembly is not recommended by the compressor manufacturer, replace the air compressor with a factory rebuilt or a new unit.

Problem— Air Pressure Rises Above Normal

Possible Cause	Remedy
The air reservoir pressure dash gauge is inaccurate.	Check the dash gauge with an accurate test gauge. Replace the dash gauge, as needed.
The compressor air governor is out of adjustment.	Check the setting with an accurate test gauge, then adjust the air governor to the recommended specification.
The air governor is not operating.	Repair or replace the air governor.
There is too much clearance at the air compressor unloading valve.	Repair or adjust the compressor at the unloading valve.
The air compressor unloading valve is stuck closed.	
The air compressor unloading valve cavities or the unloading valve passage is blocked with carbon.	

Troubleshooting

Problem—Air Pressure Drops Quickly With the Engine Stopped and the Brakes Released

Possible Cause	Remedy
The brake foot valve is leaking.	Repair or replace the brake foot valve.
The air compressor discharge valve is leaking.	Repair or replace the discharge valve. If disassembly is not recommended by the compressor manufacturer, replace the air compressor with a factory-rebuilt or a new unit.
The air governor is leaking.	Repair or replace the air governor.
There is excessive leakage (not including the air compressor).	Check all valves, air lines, and connections for leakage. Repair or replace valves and lines until leakage is eliminated.

Problem—Air Pressure Drops Quickly With the Engine Stopped and the Brakes Fully Applied

Possible Cause	Remedy
A service or parking brake chamber is leaking.	Tighten the clamp ring(s). If leaks persist, replace the service brake diaphragm or the parking brake chamber, as applicable.
The brake foot valve or quick-release valve is leaking.	Repair or replace the component(s) or assembly.
There is excessive leakage (not including the air compressor).	Check all valves, air lines, and connections for leakage. Repair or replace valves and lines until leakage is eliminated.

Problem—Compressor Knocks (Continuously or Intermittently)

Possible Cause	Remedy
There is a loose drive pulley, belt, coupling, or gear (as indicated).	Tighten or replace the component. If applicable, inspect the pulley shaft for damage. Replace the shaft, if damaged.
Backlash is in the compressor drive gears on the drive coupling.	Repair or replace the compressor drive gears or drive coupling.
The air compressor bearings are damaged or worn.	Replace the bearings.
There are carbon deposits in the compressor cylinder head.	Remove the carbon deposits or replace the compressor.

Problem—Safety Valve Activates

Possible Cause	Remedy
The safety valve is out of adjustment.	Adjust the safety valve, or install a new one.
There is too much air pressure in the brake system.	Refer to the problem "Air Pressure Rises Above Normal."
The air reservoirs need to be drained more often.	Drain the air reservoirs daily.

Problem—Oil or Water in the Brake System

Possible Cause	Remedy
Excessive oil is passing through the air compressor.	Rebuild or replace the compressor.

Possible Cause	Remedy
If so equipped, the air compressor air strainer is dirty.	Clean the strainer or install a new one.

WARNING

Make sure the air system has been reduced to 0 psi before attempting to remove an air line. Do not disconnect pressurized air lines as they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

Replacement

CAUTION

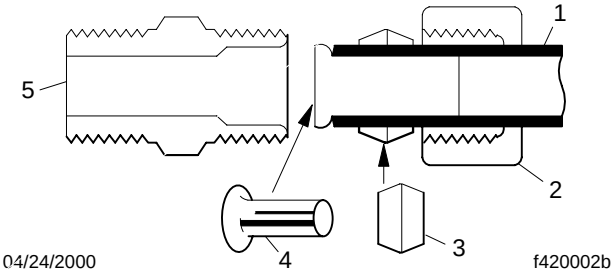
Before working on or around air brake systems and components, see "Safety Precautions" in Subject 100.

CAUTION

If the air line is bent to a radius smaller than the specified minimum bend radius, it may kink and shut off normal airflow to the component.

NOTE: When installing a nylon or a wire braid air line, be careful not to bend it past its minimum bend radius. For minimum bend radius values, see **Specifications, 400**.

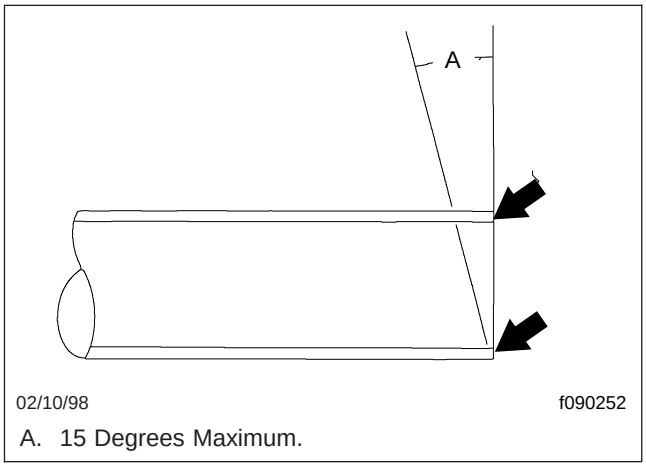
Nylon Air Lines and Compression Fittings (See Fig. 1)



1. Nylon Air Line
2. Nut
3. Sleeve
4. Stainless Steel Insert
5. Body

Fig. 1, Nylon Air Line and Compression Fitting

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Drain the air system.
3. Remove the air line.
   - 3.1 Loosen the fitting nut.
   - 3.2 Pull the air line out of the fitting.
4. Use pliers to remove the stainless steel insert from the fitting. Discard the insert.
5. Clean all of the fitting components.
6. Place a new stainless steel insert into the fitting body. Use thumb pressure to press it into position.
7. Check the air line end for a square cut-off that does not exceed a 15-degree angle. Check that the air line is not distorted or damaged. See **Fig. 2**.

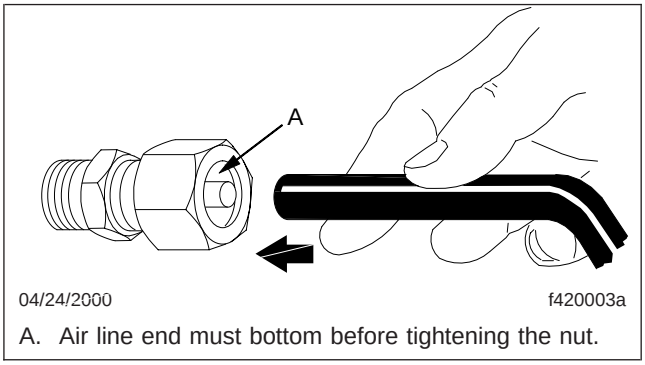


A. 15 Degrees Maximum.

Fig. 2, Check Air Line End Angle

   - 7.1 If the angle exceeds the specification, recut the air line.
   - 7.2 Use a sharp blade to prevent collapsing the air line or leaving burrs.
8. Make sure the nylon air line ends and fittings are free of grease and debris. If the air line is crimped or otherwise damaged, replace it with a new air line.
9. Install a new sleeve in the nut. Start the threads of the nut on the fitting body.
10. Insert the squared end of the air line in the fitting until it bottoms in the body of the fitting. See **Fig. 3**.

Air Lines Replacement



A. Air line end must bottom before tightening the nut.

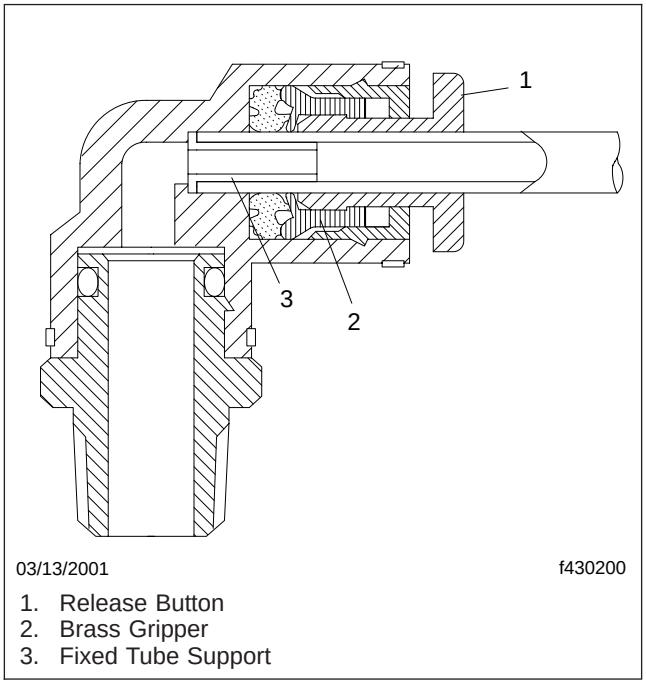
Fig. 3, Installing Nylon Air Line into Compression Fitting

11. Tighten the nut until one thread remains visible.
12. Pull back on the air line to make sure it is fully seated.
13. Pressurize the air system. Check the air system for leaks.
14. Remove the chocks from the tires.

Nylon Air Lines and KV2 One-Touch Fittings

IMPORTANT: The use of a sharp air line cutter is highly recommended. This tool will insure a clean, perpendicular cut of the air line.

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Drain the air system.
3. Push the air line into the fitting.
4. Press and hold the release button against the body of the fitting. See **Fig. 4**.
5. Remove the air line.
6. Clean any dirt or contamination from the leading edge of the air line.
7. Lubricate the leading end of the air line with light oil, petroleum jelly or silicone lubricant.
8. Insert the end of the air line into the fitting until it bottoms.
9. Pull on the air line to verify it is properly retained.



1. Release Button
2. Brass Gripper
3. Fixed Tube Support

Fig. 4, KV2 One-Touch Fitting

10. Pressurize the air system. Check the air system for leaks.
11. Remove the chocks from the tires.

Wire Braid Air Lines

1. Park the vehicle on a level surface and set the parking brake. Shut down the engine. Chock the tires.
2. Drain the air system.
3. Remove the air line.
   - 3.1 Unthread the swivel fitting nut.
   - 3.2 Remove the air line assembly from the mating fitting.
4. Make sure the wire braid air line assembly is free of grease and dirt. Replace the assembly if the air line or fitting is crimped or otherwise damaged.
5. Install the air line and finger-tighten the nut.
6. Using two wrenches to prevent twisting of the air line, tighten the nut until it seats solidly. Tighten the nut one-sixth turn more.

7. Pressurize the air system. Check the air system for leaks.
8. Remove the chocks from the tires.

Safety Precautions

Before attempting to work on the air brake system, observe the following precautions:

- Since the compression and storage of air can be compared to energy in a coiled spring, when released, it can present a hazard if not properly recognized. The wheels of the vehicle must always be chocked so that depletion of air will not permit the vehicle to roll.
- When draining the system, do not look into the air jets or direct them toward a person, as dirt or sludge particles can be carried in the air stream.
- Air lines will whip dangerously if disconnected under pressure. Follow the manufacturer's recommended procedures when working on any air devices so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion.
- As system pressure is drained and the emergency brakes apply, hands must be away from the air chamber pushrods and spring actuators that apply automatically with the loss of pressure. This also applies when checking the service brake system.
- Reservoirs that are closest to the sources of compressed air (compressors or auxiliary sources) must contain a safety valve in known working order and sufficient capacity to limit the reservoir pressure to a safe maximum level.
- Used reservoirs must not be used as replacements in order to eliminate the possibility of component failure.
- The safety valves must not be reset higher than specified by the reservoir manufacturer, vehicle manufacturer, or code to which the reservoir had been manufactured in order to prevent valve failure.
- Various actuators contain powerful internal springs that require special handling procedures. Note and be guided by the warning tags on such units to avoid personal injury or property damage.
- To avoid injury, keep clear of the air chamber pushrod when brakes are applied or when air is exhausted from the system.

WARNING

Make sure the air system has been reduced to 0 psi before attempting to remove an air line. Do not disconnect pressurized air lines as they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

Replacement

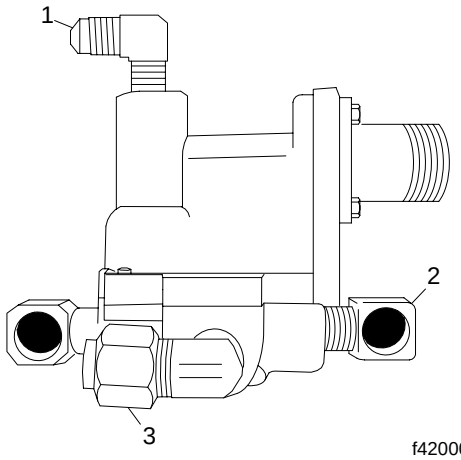
CAUTION

Before working on or around air brake systems and components, see "Safety Precautions" in Subject 100.

CAUTION

Never use diagonal pliers, a saw or dull cutting tool to cut nylon air lines. The use of such tools leaves the air line with a sharp edge, burr or out-of-round condition which can damage the seal when the air line is inserted into the fitting. This reduces the sealing ability of the fitting. The use of a sharp air line cutter is highly recommended. This tool will insure a clean, perpendicular cut of the air line.

Brass or Steel Pipe Fittings (See Fig. 1)



1. Wire Braid Hose Fitting
2. Brass or Steel Pipe Fitting
3. Nylon Tube Compression Fitting

Fig. 1, Screw-On Fittings

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Drain the air system.
3. Remove the air line from the fitting. For instructions, see Subject 110.
4. Using an open-end wrench or similar tool, rotate the fitting counterclockwise until it is completely disengaged from the fitting port.
5. Make sure the fitting is free of grease, dirt, and old sealant. Apply liquid thread sealant (white) to the threads and finger-tighten securely.

NOTE: Always apply the sealant to the external thread, so that any excess will be scraped off externally rather than internally to the joint.

6. Install the fitting:
   - *For a fitting that must be positioned*, tighten one additional turn from finger-tight using a wrench. Continue to tighten the fitting clockwise until it is correctly positioned. Never turn the fitting counterclockwise to position it.
   - *For a fitting that does not require positioning*, tighten 1-1/2 additional turns from finger-tight.
7. Install the air line in the fitting. For instructions, see Subject 110.
8. Pressurize the air system. Check the air system for leaks.
9. Remove the chocks from the tires.

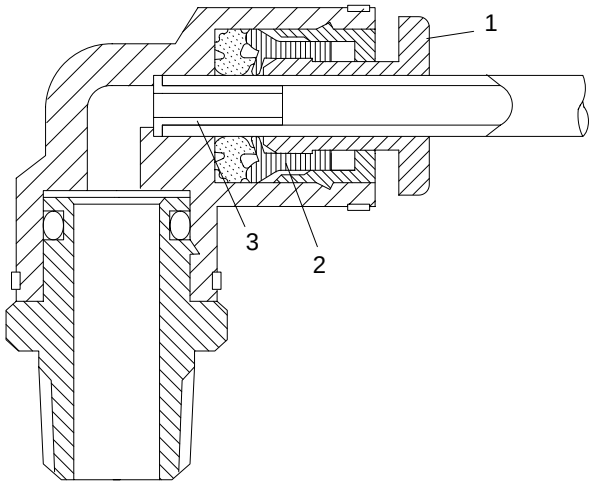
Brass or Steel Pipe Fittings on Plastic Components

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Drain the air system.
3. Remove the air line from the fitting. For instructions, see Subject 110.
4. Remove the fitting.
5. Install the fitting. For tightening specifications, see the applicable table in Specifications, 400.

Fittings Replacement

6. Install the air line in the fitting. For instructions, see **Subject 110**.
7. Pressurize the air system. Check the air system for leaks.
8. Remove the chocks from the tires.

KV2 One-Touch Fittings **(See Fig. 2)**



1. Release Button
2. Brass Gripper
3. Fixed Tube Support

Fig. 2, KV2 One-Touch Fitting

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the tires.
2. Drain the air system.
3. Remove the air line from the fitting. For instructions, see **Subject 110**.
4. Using an open-end wrench or similar tool, rotate the fitting's hexstud end counterclockwise until it is hand-loose.
5. Continue to rotate the fitting by hand until it is completely disengaged from the fitting port.
6. Clean any dirt or thread sealant from the fitting and fitting port.
7. If required, apply liquid thread sealant (white) to the threads.
8. Insert the fitting into the port and rotate it clockwise until it is hand-tight.
9. Using an open-end wrench or similar tool, tighten the fitting to the manufacturer's recommended torque. For torque specifications, see the applicable table in **Specifications, 400**.
10. Rotate the fitting body by hand to the correct position.
11. Install the air line in the fitting. For instructions, see **Subject 110**.
12. Pressurize the air system. Check the air system for leaks.
13. Remove the chocks from the tires.

Specifications

213 Wire Braid Air Lines *			
Number	Inside Diameter Inch	Outside Diameter Inch	Minimum Bend Radius inches (mm)
4	3/16	0.49	0.75 (20)
5	1/4	0.55	1.00 (25)
6	5/16	0.62	1.25 (30)
8	13/32	0.74	1.75 (45)
10	1/2	0.83	2.25 (55)
12	5/8	0.96	2.75 (70)
16	7/8	1.21	3.50 (90)
20	1-1/8	1.49	4.50 (115)

* 213 air lines are identified by two green stripes 180 degrees apart, part numbers, and size (for example, part numbers 213-4, 213-5, and so on).

Table 1, 213 Wire Braid Air Lines

Nylon Air Lines			
Number	Inside Diameter Inch	Outside Diameter Inch	Minimum Bend Radius inches (mm)
4	0.170	1/4	1.00 (25)
6	0.251	3/8	1.50 (38)
8	0.376	1/2	2.00 (51)
10	0.441	5/8	2.50 (64)
12	0.566	3/4	3.00 (76)

Table 2, Nylon Air Lines

KV2 Stud End Torque into Metallic Ports *		
Thread, NPTF Inch	Torque †	
	lbf·in (N·cm)	lbf·ft (N·m)
1/16	62–80 (700–900)	—
1/8	62–80 (700–900)	—
1/4	106–124 (1200–1400)	—
3/8	—	16–18 (22–24)
1/2	—	21–22 (28–30)

* Aluminum, zinc, steel and brass ports.
† The component in which the KV2 One-Touch fitting is being installed may have torque values lower than those listed here. Please see the component supplier's recommended torque specifications.

Table 3, KV2 Stud End Torque into Metallic Ports

Brass or Steel Pipe Fittings on Plastic Components			
Description	Port Size Inch	Torque	
		lbf·in (N·cm)	lbf·ft (N·m)
Midland Quick Release Valve	3/8	60–90 (680–1020) *	—
	1/2	—	13–17 (18–23) *
Bendix MV-2/MV-3 Valve	1/4	—	10 (14)

* Tighten to the lower torque value. If needed, turn the fittings to allow for the proper routing of the air lines.

Table 4, Brass or Steel Pipe Fittings on Plastic Components

General Description and Principles of Operation

(Refer to Fig. 1)

The dual circuit brake valve (foot valve) controls the air supply and delivery of the dual circuit brake system. The brake valve is mounted on the firewall .

APPLYING

The primary circuit of the brake valve is controlled by the brake pedal and a push rod. When the brake pedal is depressed, the push rod applies pressure on the spring retainer (Ref. 1), rubber spring, and the primary (upper) piston (Ref. 2). The downward movement of the primary piston closes the upper exhaust valve, and then opens the upper inlet valve, allowing high-pressure air from port 11 (Ref. 5) to flow to low-pressure port 21 (Ref. 12).

The secondary circuit is air operated by the pressure from the primary circuit. Primary circuit pressure on top of the secondary piston (Ref. 6) first closes the lower exhaust valve, and then opens the lower inlet valve, allowing high-pressure from port 12 (Ref. 7) to flow to low-pressure port 22 (Ref. 11).

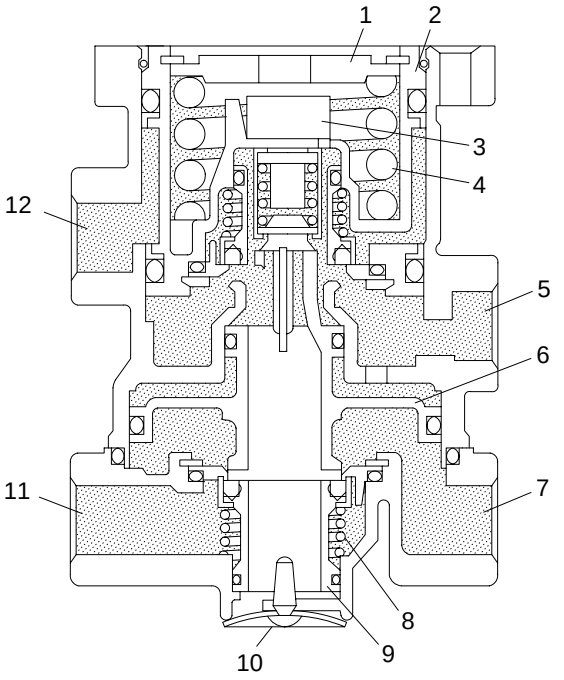
HOLDING

As air pressure builds in the primary circuit, the pressure under the primary piston will match the pressure of the rubber spring. This allows the piston to move up enough to close the upper inlet valve, and prevent the flow of air from the primary air tank into the brake valve. The exhaust port remains closed.

RELEASING

When the pedal is released, the push rod releases pressure from the spring retainer, rubber spring, and the primary (upper) piston. Air pressure builds to push the piston up, opening the upper exhaust valve and allowing air from the primary circuit to escape through the exhaust port.

In the secondary circuit, the release of primary air pressure allows air under the secondary piston, pushing the piston up and opening the lower exhaust valve (Ref. 9). All remaining air pressure is vented through the exhaust port (Ref. 10).



1. Spring Retainer
2. Primary Piston
3. Rubber Spring
4. Graduating Spring
5. Primary Supply Port (Port 11)
6. Secondary Piston
7. Secondary Supply Port (Port 12)
8. Return Spring
9. Lower Exhaust Valve
10. Exhaust Port
11. Secondary Delivery Port (Port 22)
12. Primary Delivery Port (Port 21)

07/16/93 f420486

Fig. 1, Bendix E-12 Dual Circuit Foot Valve (sectional view)

Operating Check

IMPORTANT: If there is a change in the way a vehicle brakes, or if low pressure warnings occur, check the operation of the brake air system. Although the brake system may continue to work, do not operate the vehicle until the braking circuits, including the pneumatic and mechanical devices, have been repaired and are operating normally. Always check the brake system for correct operation after doing brake work, and before returning the vehicle to service.

Check for the correct brake valve operation as follows:

1. Apply the parking brake, then chock the tires.
2. Connect test gauges to the primary and secondary delivery ports on the brake valve. **See Fig. 1.**

NOTE: When checking the delivery pressure of the primary and secondary circuits, use test gauges that are accurate.

3. Start the engine and build air pressure to 827 kPa (120 psi).

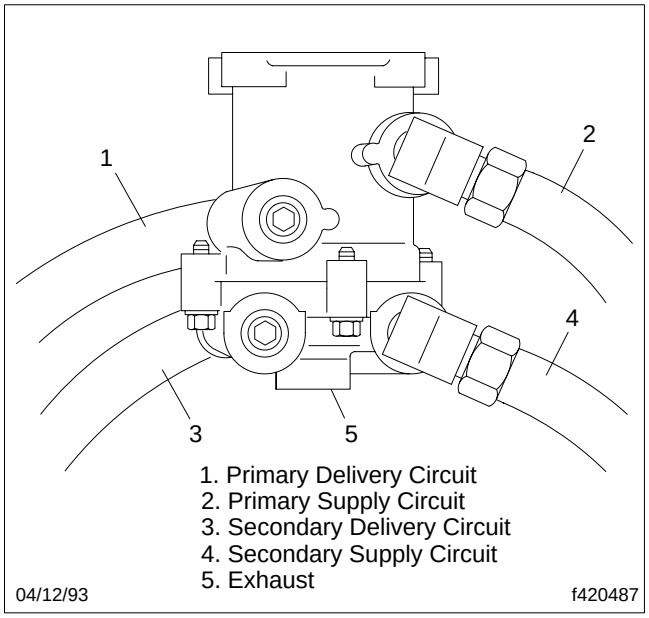


Fig. 1

4. Depress the pedal to several different positions; check the pressure on the test gauges to ensure that it varies equally and proportionally with the movement of the brake pedal.
5. Fully depress the brake pedal, then release it. After a full application is released, the reading on the test gauges should promptly fall to zero.

NOTE: Pressure in the primary delivery circuit will be about 14 kPa (2 psi) greater than pressure in the secondary delivery circuit (if both supply reservoirs are at the same pressure). This is normal for this valve.

6. Go to "Leakage Check."

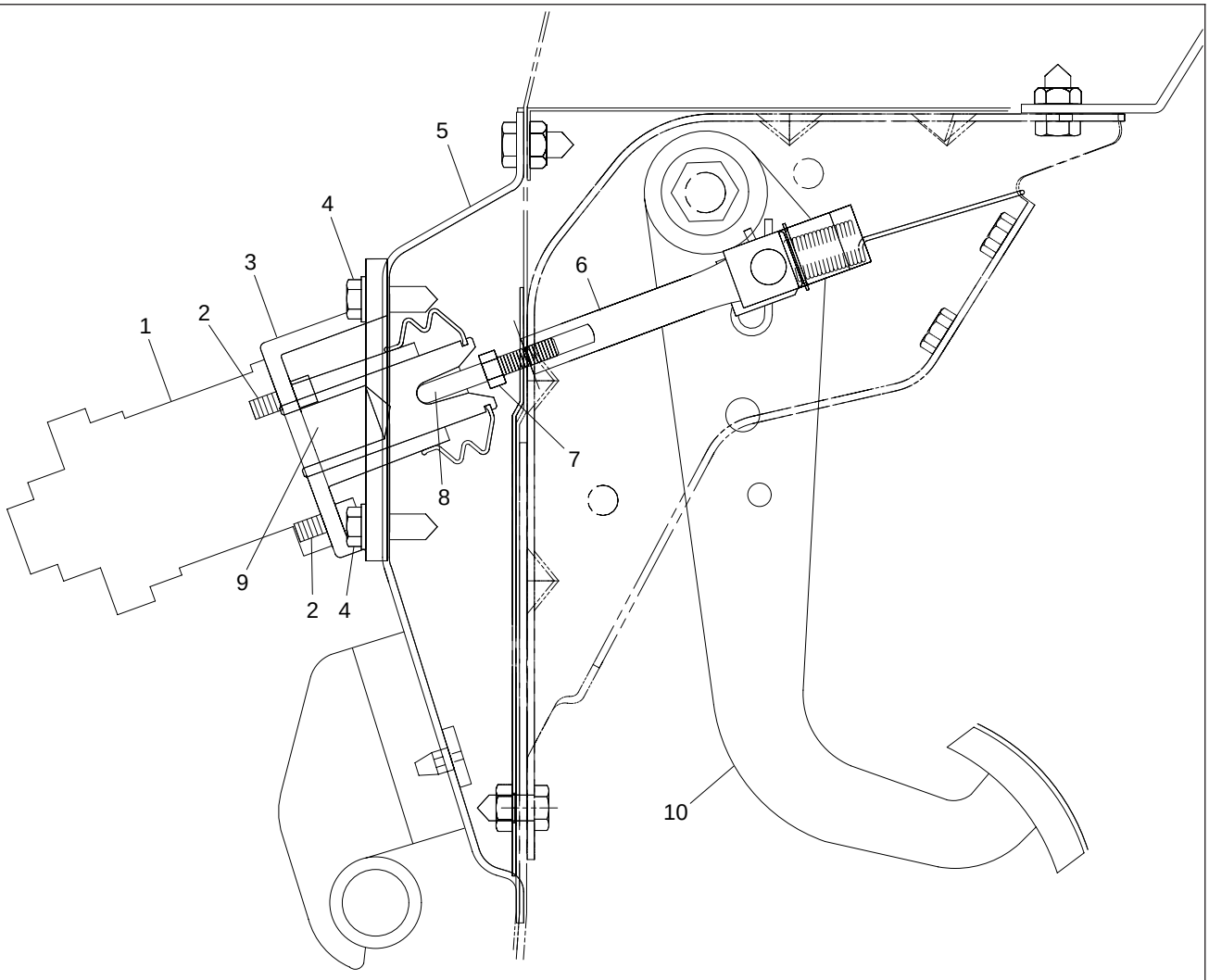
Leakage Check

1. Make and hold a pressure application of 552 kPa (80 psi).
2. Check the air line fittings for leaks: tighten or replace fittings as needed.
3. Coat the exhaust port and body of the valve with a soap solution, and check for leakage. The leakage permitted is a 2.5-cm (1-inch) bubble in 3 seconds.

   If the brake valve does not function as described above, or if leakage is excessive, replace it with a new or remanufactured unit.

   Repeat the leakage test before placing the brake valve in service.
4. Remove the chocks from the tires.

Removal (See Fig. 1 and Fig. 2)



1. Brake Valve
2. Brake Valve Mounting Fasteners
3. Mounting Adaptor
4. Capscrew and Flatwasher
5. Front Cab Mount Plate
6. Push Rod Clevis
7. Push Rod Jam Nut
8. Brake Pedal Push Rod
9. Plunger
10. Brake Pedal Assembly

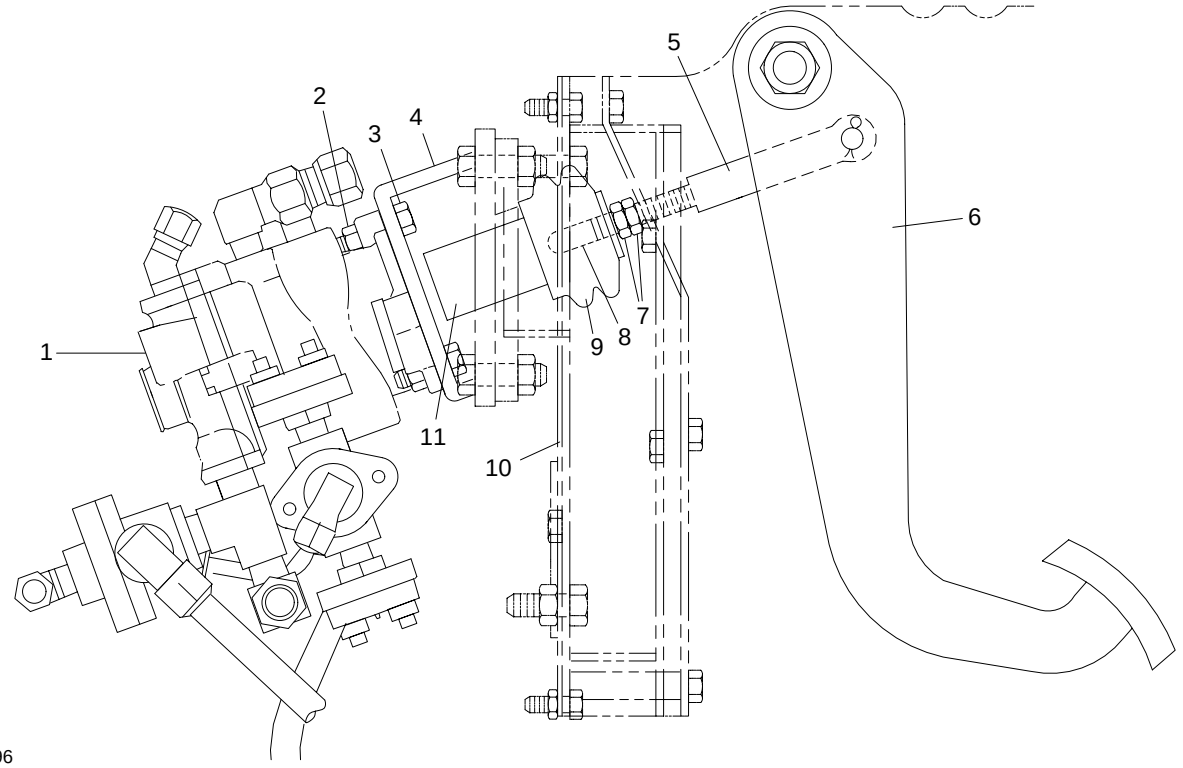
Fig. 1, Brake Valve Mounting, Left-Hand-Drive Vehicles

1. Chock the tires, then tilt the hood. For instructions, refer to the vehicle driver's manual.

⚠ WARNING

WARNING: When draining the air system, don't look into the air jets or direct them toward anyone, because dirt or sludge particles may be in

Removal and Installation



1. Brake Valve
2. 5/16–18 Hexnut
3. 5/16–18 Capscrew
4. Mounting Adaptor
5. Push Rod Clevis
6. Brake Pedal
7. Push Rod Jam Nuts
8. Brake Pedal Push Rod
9. Boot
10. Mounting Bracket Assembly
11. Plunger

Fig. 2, Brake Valve Mounting, Right-Hand-Drive Vehicles

the airstream. Don't disconnect pressurized hoses because they may whip as air escapes from the line. Failure to take all necessary precautions during service operations of the air brake system can result in personal injury.

2. Drain all of the air reservoirs.
3. Mark the brake valve air supply and delivery lines for assembly reference. Carefully disconnect the air lines from the brake valve, and plug them to keep out contaminants.
4. Remove the capscrews and flatwashers that attach the brake valve and mounting adaptor to the front cab mount plate or the mounting bracket assembly.

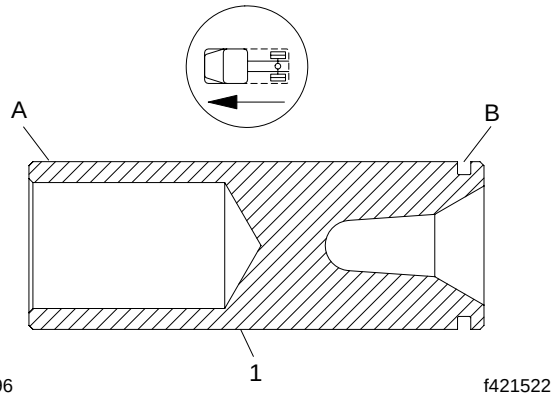
   Remove the fasteners that attach the brake valve to the mounting adaptor.
5. Remove the plunger (and boot, if equipped) from the mounting adaptor. Wipe off the old grease from the plunger, boot, and adaptor.
6. Check the bore of the adaptor and the sliding surface of the plunger for corrosion; there should be no pitting or roughness. Check the boot (if equipped) for damage. Replace parts as needed.
7. Note the locations and positions of the elbows, then remove them from the brake valve. Clean off the dirt and old sealant from the threads of the elbows.

Installation (See Fig. 1 and Fig. 2)

⚠ WARNING

WARNING: When applying sealant, make sure that excess sealant doesn't get inside either the male or the female fittings. Loose foreign material inside the air plumbing may clog a valve, causing a loss of brake control, which could result in personal injury.

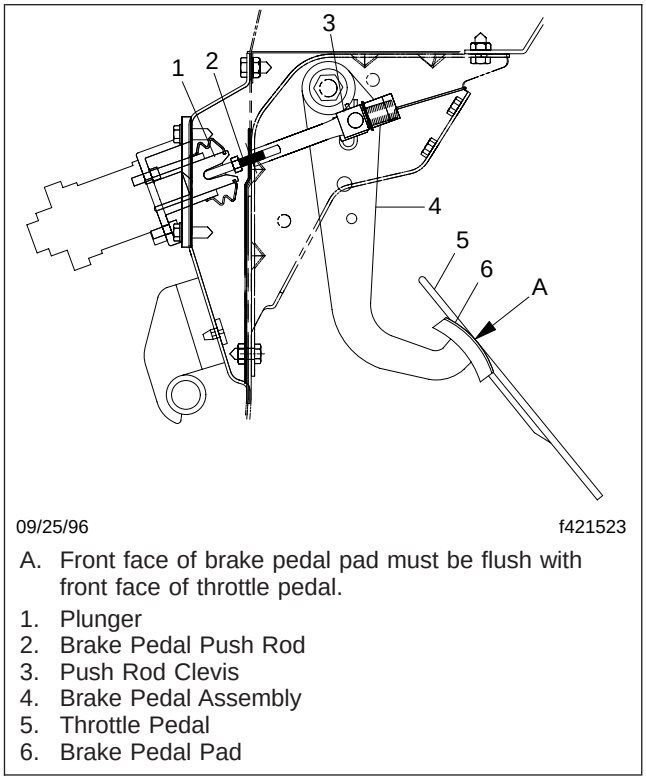
1. Apply a small quantity of Loctite® Pipe Sealant (with Teflon® 59241), or an equivalent sealant, to the male threads of each of the elbows.
2. Install the elbows in the ports of the brake valve. Tighten them finger-tight, then tighten them one additional turn with a wrench. As needed, further tighten them until they are correctly positioned.
3. Lubricate the sliding surface of the brake plunger and the adaptor bore with a silicone-based grease, Dow Corning 55 O-Ring Lubricant or Loctite V–755 O-Ring Lubricant. Install the plunger in the mounting adaptor. Make sure the plunger is positioned correctly (see **Fig. 3**). Install the boot (if equipped) on the mounting adaptor.



A. This end toward brake valve.
B. This end toward brake pedal push rod.
1. Plunger

Fig. 3, Plunger Installation

4. Attach the mounting adaptor to the brake valve. Tighten the hexnuts 15 lbf·ft (20 N·m).
5. Loosen the jam nuts on the brake pedal push rod, then turn the push rod into the clevis at least three full turns.
6. Check that the front face of the brake pedal pad is flush with the front face of the throttle pedal. See **Fig. 4**. If it isn't, adjust the brake pedal height as follows:



A. Front face of brake pedal pad must be flush with front face of throttle pedal.
1. Plunger
2. Brake Pedal Push Rod
3. Push Rod Clevis
4. Brake Pedal Assembly
5. Throttle Pedal
6. Brake Pedal Pad

Fig. 4, Brake Pedal and Valve Installation (left-hand-drive shown)

⚠ CAUTION

CAUTION: If you loosen the pedal stop bracket capscrews or remove the pedal stop bracket, don't lift the brake pedal past where the stop bracket was located. To do so could bend the push rod.

6.1 Loosen the pedal stop bracket capscrews.

6.2 Adjust the position of the pedal stop bracket, until the front face of the brake pedal pad is flush with the front face of the throttle pedal.

Removal and Installation

6.3 Tighten the pedal stop bracket capscrews 13 lbf·ft (18 N·m).

7. Install the brake valve, mounting adaptor, and new adaptor gasket (if equipped) on the outside of the front cab mount plate or mounting bracket assembly. Make sure the forward end of the brake pedal push rod enters the plunger. Install the adaptor mounting capscrews and flatwashers. Tighten the capscrews 23 lbf·ft (31 N·m).
8. Connect the air lines as previously marked. Tighten the nuts finger-tight. Using a wrench, further tighten the nuts until there is resistance, then tighten one-sixth additional turn.
9. Inside the cab, push the plunger into the mounting adaptor until increased resistance is felt. Turn the push rod into the clevis until you are certain that there is space between the end of the push rod and its seat in the plunger.
10. With the brake pedal released (in the up position), use your fingers and turn the push rod out of the clevis until it bottoms in the plunger without pushing the plunger further.

IMPORTANT: Be sure the push rod and plunger aren't "preloading" the brake valve, which could keep the brake valve from exhausting.

11. Check the pedal for free play. There should be no pedal free play and no brake valve preloading. Use a wrench to hold the push rod to keep it from turning, then tighten the double jam nuts against the clevis 15 lbf·ft (20 N·m).
12. Check and secure the air lines and electrical wires so they can't interfere with the movement of the brake pedal or push rod.
13. Lower the hood.
14. Do the operating and leakage checks. For instructions, refer to **Subject 100**.
15. Remove the chocks from the tires.
16. Test drive the vehicle in a safe area at low speed. Make several brake applications to be sure the vehicle comes to a safe stop.

Disassembly, Cleaning and Inspecting, and Assembly

Disassembly (See Fig. 1)

1. Remove the valve from the vehicle, following instructions in **Subject 110**.
2. Mark the upper and lower valve bodies for later assembly, then remove the four capscrews that hold them together.
3. Pull the secondary piston (Ref. 21) out of the upper valve body, then remove and discard the O-ring (Ref. 22) from it.
4. While manually depressing the valve seat (Ref. 24), remove and discard the beveled retaining ring (Ref. 23) from the lower valve body (Ref. 29).
5. Carefully release the valve seat (Ref. 24), then remove it from the lower valve body.
6. Remove and discard the O-ring (Ref. 25).
7. Remove and discard the valve assembly and its O-ring (Refs. 26 and 27) from the lower valve body.
8. Remove the valve assembly return spring (Ref. 28).
9. Remove the retainer, plunger, plunger return spring, and O-ring (Refs. 17, 18, 19, and 20) from the secondary piston.
10. Remove and discard the exhaust diaphragm retainer and the exhaust diaphragm (Refs. 32 and 33) from the lower valve body.

⚠ WARNING

WARNING: The primary piston is held down by a graduating spring, which is under tension. Be careful when removing the retaining ring and graduating spring retainer, because the spring or the piston may release suddenly, which could cause personal injury. Hold the graduating spring and the primary piston down when removing the retaining ring and spring retainer.

11. Push the primary piston (Ref. 8) into the upper body until the retaining ring (Ref. 1) is visible.
12. Being careful not to damage the piston bore, remove the retaining ring.
13. Gently tap the upper body on a padded surface to remove the primary piston. Re-move and discard the two O-rings and wear rings (Refs. 6 and 7).
14. Put the primary piston on a flat surface, then hold down the spring retainer (Ref. 2). Remove and discard the retaining ring (Ref. 1) from the piston.
15. Slowly release the spring retainer, and ease it out of the piston. Remove it and the graduating spring (Ref. 5) from the piston.
16. Remove and discard the rubber spring (Ref. 4) from inside the piston.
17. While holding down the valve seat (Ref. 13), remove and discard the beveled retaining ring (Ref. 14) from the primary piston.
18. Slowly release the valve seat, and ease it out of the piston. Remove and discard the O-ring (Ref. 10).
19. Remove and discard the valve assembly and its O-ring (Refs. 11 and 10) from the primary piston, then remove the return spring (Ref. 9).

Cleaning and Inspecting

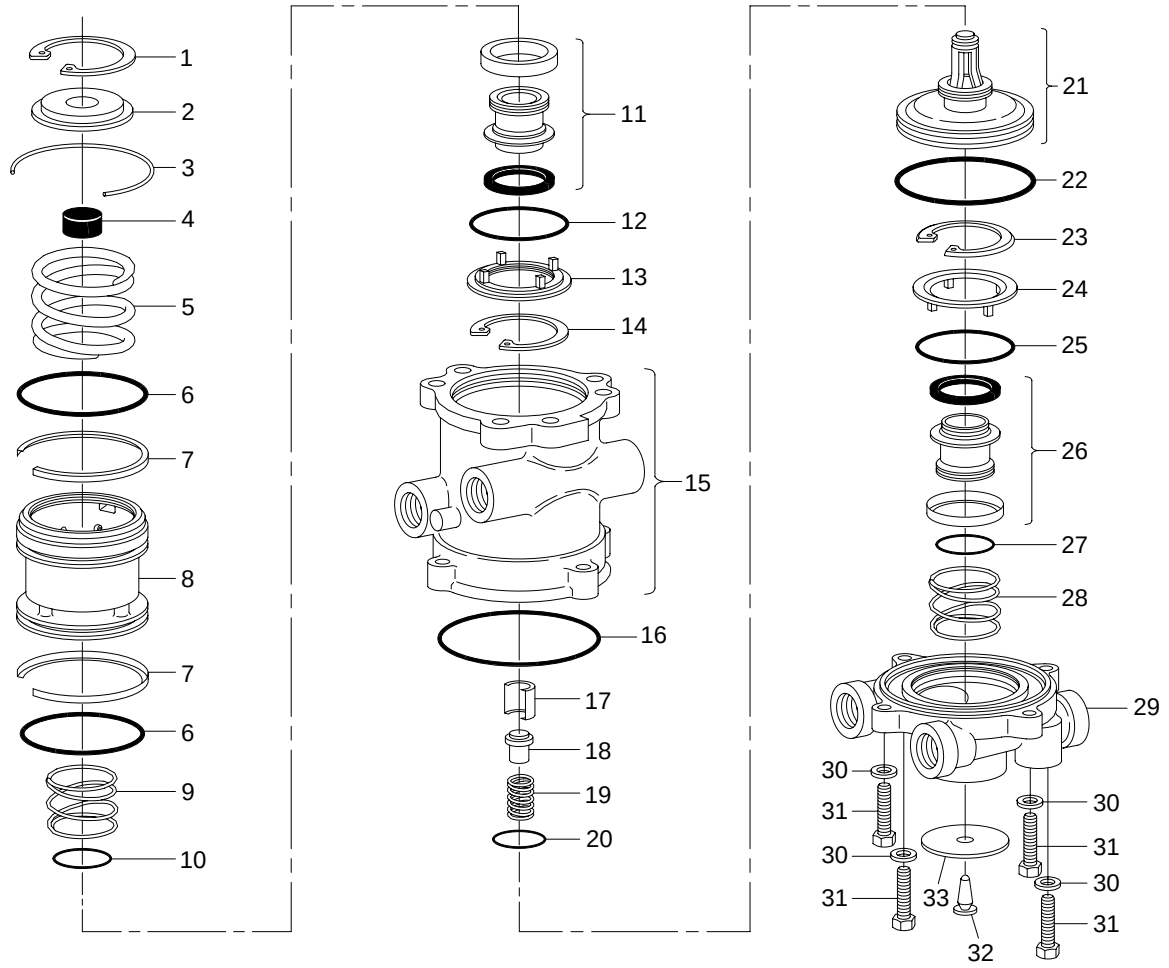
⚠ WARNING

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

1. Clean all the metal parts in mineral spirits, then dry them with compressed air.
2. Check all the parts. If any corrosion, wear, or damage is found, replace the part.
   - 2.1 Check the bores of both valve bodies for deep scoring.
   - 2.2 Make sure the vents on the primary piston are free of obstructions.
   - 2.3 Make sure the vent in the upper valve body is open.
   - 2.4 Check the plunger (**Fig. 2**) for wear or damage.

Disassembly, Cleaning and Inspecting, and Assembly

2.5 Check all the air line fittings, and clean any thread sealant from them.



1. Retaining Ring
2. Graduating Spring Retainer
3. Piston Retaining Ring
4. Rubber Spring
5. Graduating Spring
6. O−Ring
7. Wear Ring
8. Primary Piston
9. Valve Assembly Return Spring
10. O−Ring
11. Valve Assembly
12. O−Ring
13. Valve Seat
14. Beveled Retaining Ring
15. Upper Valve Body
16. O−Ring
17. Retainer
18. Plunger
19. Plunger Return Spring
20. O−Ring
21. Secondary Piston
22. O−Ring
23. Beveled Retaining Ring
24. Valve Seat
25. O−Ring
26. Valve Assembly
27. O−Ring
28. Valve Assembly Return Spring
29. Lower Valve Body
30. Washer
31. Capscrew
32. Exhaust Diaphragm Retainer
33. Exhaust Diaphragm

07/23/93 f420489

Fig. 1

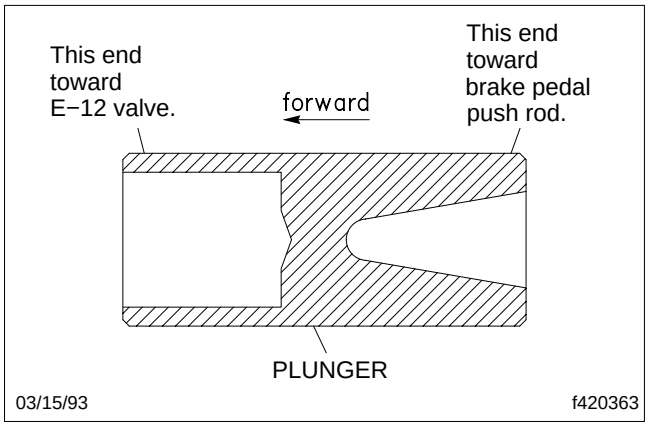


Fig. 2

Assembly (See Fig. 1)

IMPORTANT: Keep the work area, tools, and brake valve parts clean during assembly.

1. Using Dow Corning 55-M pneumatic grease or equivalent, lightly grease all the new O-rings, O-ring grooves, piston bores, and all sliding surfaces.
2. Put the primary piston on a flat surface, then install the rubber spring (Ref. 4) and the metal graduating spring (Ref. 5).
3. Install the graduating spring retainer (Ref. 2) on top of the graduating spring.
4. While holding down the spring retainer in the primary piston, install the retaining ring (Ref. 1). Make sure it's completely seated in its groove.
5. Install new O-rings on both valve assemblies.
6. Install the valve assembly return spring (Ref. 9) in the primary piston, then install the valve assembly (Ref. 11).
7. Install a new O-ring into its groove on the primary piston, then install the valve seat (Ref. 13) onto the valve assembly.
8. Hold down the valve seat in the piston, then install the beveled retaining ring (Ref. 14) with the flat side of the ring against the valve seat (beveled side of the ring up). Make sure the ring is seated completely.

IMPORTANT: Make sure the beveled retaining ring is installed correctly. The flat side of it must be against the valve seat, and the beveled side must be facing up. If it's not, remove the ring and install it again.

9. Install new O-rings on the primary piston.
10. Install the wear rings (Ref. 7) on the primary piston.
    - 10.1 Position a wear ring so one flange of it is in the O-ring groove, and the opposite flange faces away from the end of the piston (toward the middle of the piston).

      Repeat this step for the other wear ring.
    - 10.2 Check the wear rings; make sure they are not overlapping or covering the O-rings. If they are, remove them and install them again.
11. Being careful not to damage the piston O-rings and wear rings, install the primary piston— valve end first— in the upper valve body. Push the piston down until the piston retaining groove at the top of the bore is visible.

⚠ CAUTION

CAUTION: Don't force the piston into its bore, or you will damage its sealing surfaces. If the piston doesn't fit correctly, check the wear rings. If they were installed incorrectly, remove them and install them again.

12. Install the piston retaining ring (Ref. 3) in its groove. Make sure it's fully seated.
13. Install the plunger (Ref. 18) in the plunger return spring (Ref. 19), then install them both on the secondary piston.
14. While holding the plunger and return spring on the secondary piston, install the retainer (Ref. 17) on the piston. Make sure the retainer flanges are secure around the piston lip and the plunger groove.
15. Install new O-rings on the secondary piston.
16. Install a new exhaust diaphragm (Ref. 33) on the lower valve body, then install the diaphragm retainer.
17. Install the valve assembly return spring (Ref. 28) in the lower valve body, then install the valve assembly (Ref. 26).

Disassembly, Cleaning and Inspecting, and Assembly

18. Install the O-ring in its groove on the primary piston, then install the valve seat (Ref. 24) on the valve assembly.
19. While holding the valve seat in the lower valve body, install the beveled retaining ring with the flat side of the ring against the valve seat (beveled side of the ring up). Make sure it is seated completely.

IMPORTANT: Make sure the beveled retaining ring is installed correctly. The flat side of it must be against the valve seat, and the beveled side must be facing up. If it's not, remove the ring and install it again.

20. Being careful not to damage the O-rings, install the secondary piston in the upper valve body.
21. Install a new O-ring in the upper valve body.
22. Using the reference marks made during disassembly, install the lower valve body on the upper valve body. Tighten the capscrews 60 N·m (45 lbf·ft).
23. Install the valve on the vehicle, following instructions in **Subject 110**.

General Description and Principles of Operation

(Refer to Fig. 1 and Fig. 2)

The BP-R1 bobtail proportioning relay valve is a combination of two individual valves in a single housing. The lower portion (body) of the BP-R1 contains a standard service brake relay valve, which functions as a relay station to speed up brake application and release. The upper portion (cover) houses a brake proportioning valve, which adjusts the proportion of normal service brake application pressure to the rear brake chambers when the tractor is not towing a trailer.

Used in tractor air brake systems only, the BP-R1 is installed in place of a standard relay valve. It functions as a standard service relay during operation of a tractor-trailer combination. During bobtail tractor operation, the BP-R1 improves controllability and reduces stopping distances by limiting air pressure to the rear brake chambers, whose axle load has been greatly reduced, while retaining normal air pressure to the front brake chambers. This reduces the chance of wheel lock and instability in emergency stops.

The rear brake proportioning system is standard on all class 6 and 7 tractors. The valve is mounted on the crossmember between the rear brake chambers. See the plumbing diagram in **"Specifications, 400."**

A control line from the control port of the BP-R1 valve is connected by a tee to the inlet supply port of the tractor protection valve. This line is charged with full line pressure when a trailer is connected and its spring brakes are released; or is completely exhausted when the tractor is bobtailed and the dash valve trailer charge knob is not applied.

TRAILER SUPPLY VALVE APPLIED (TRACTOR/TRAILER MODE)

On vehicles equipped with a proportioning system, air pressure at the control port allows full service air from the foot valve to pass through the proportioning portion of the valve. This gives full braking effort to the rear axles when a trailer is connected.

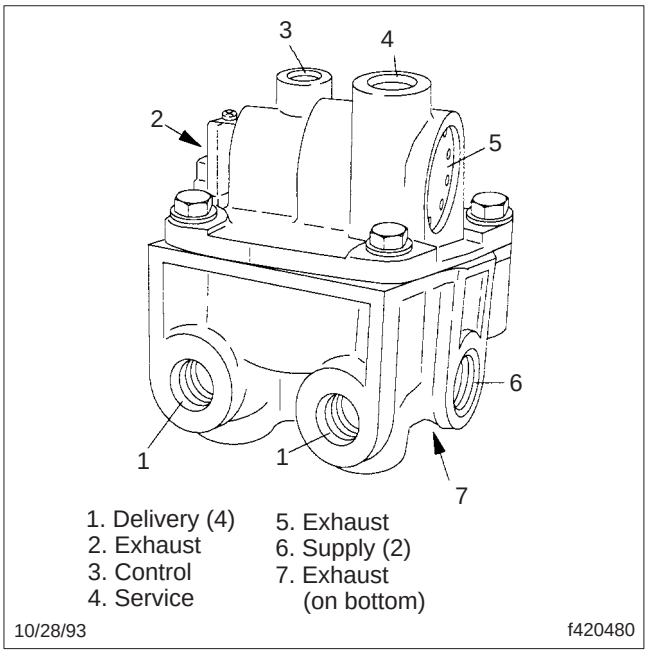


Fig. 1

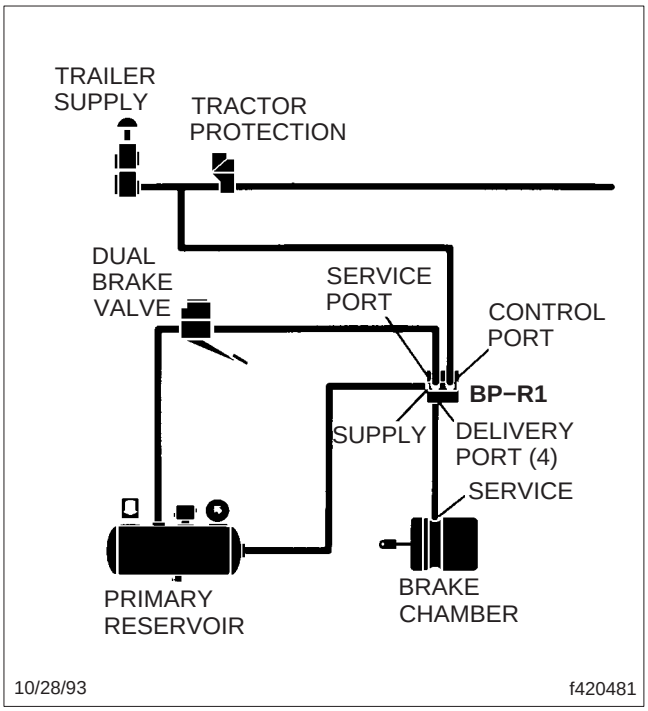


Fig. 2

General Description and Principles of Operation

TRAILER SUPPLY VALVE PULLED OUT (BOBTAIL MODE)

When the trailer supply valve is activated to disconnect the trailer, air in the BP-R1 control port is exhausted to atmosphere. In this mode, service application air exerts force on one side of the blend-back piston and also flows through the piston to exert force on the proportioning piston. The blend-back piston remains stationary at application pressures below 551 kPa (80 psi). Air also flows through the proportioning piston to exert force on both sides of it. Proportioning occurs due to the difference in effective area on each end of the proportioning piston. Service applications of more than 551 kPa (80 psi) cause the blend-back piston to begin to move. Above 551 kPa (80 psi) the different pressures on each side of this piston cause a "blend back" from proportioned delivery to a full one-to-one delivery.

Safety Precautions

⚠ WARNING

WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

When working on or around air brake systems and components, observe the following precautions.

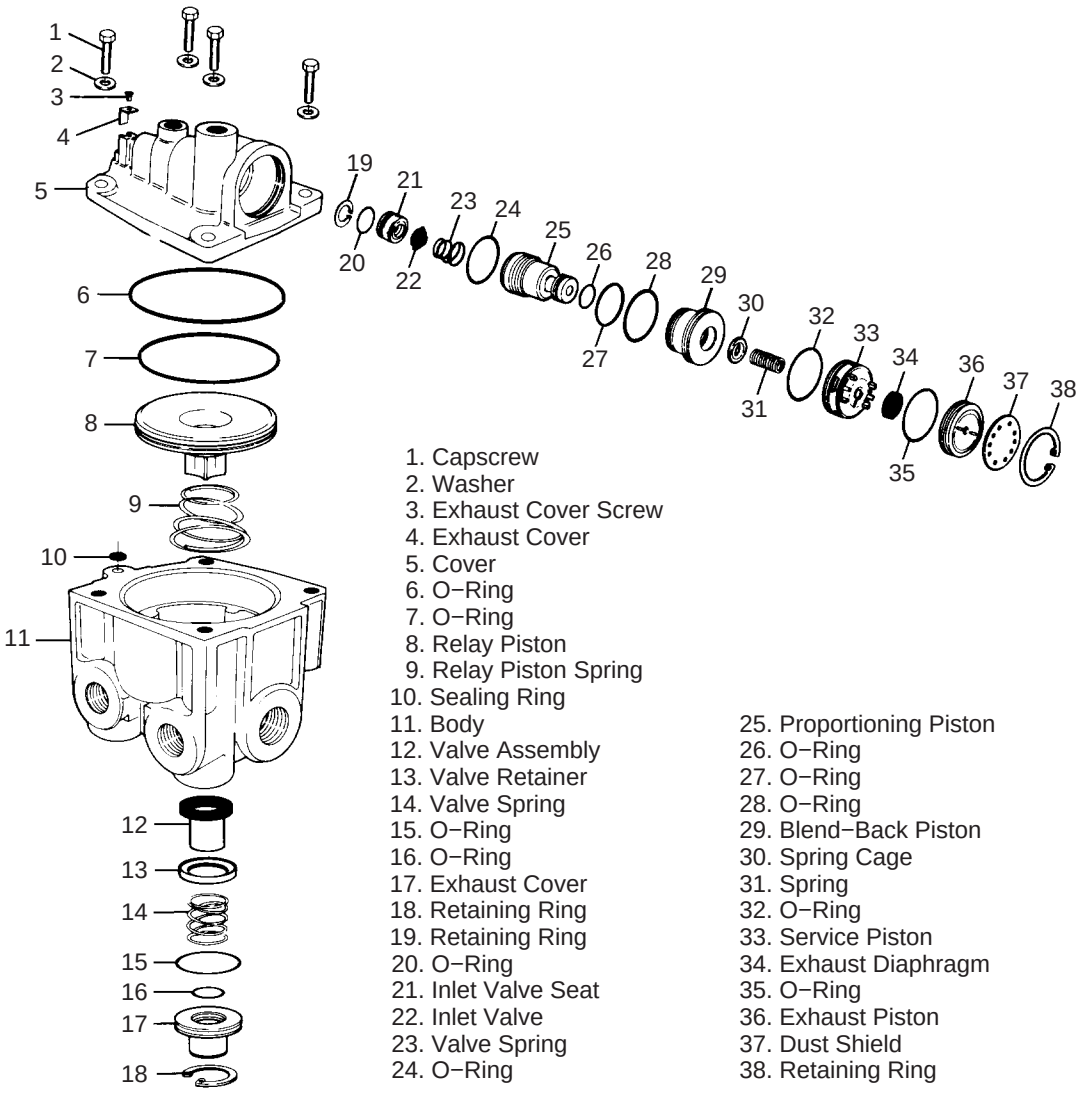
1. Apply the parking brakes, chock the tires, and stop the engine when working under the vehicle. Keep hands away from brake chamber push rods and slack adjusters, which may apply as air system pressure drops.
2. Wear safety goggles.
3. Never connect or disconnect a hose or line containing air under pressure; it may whip as air escapes. Never remove a component or pipe plug unless you are sure all system pressure has been depleted.
4. Don't disassemble a component before reading and understanding recommended procedures. Use only the correct tools and follow basic tool safety.
5. Replacement hardware, tubing, hose, fittings, etc. should be the same size, type, length, and strength as the original equipment. When replacing tubing or hose, be sure that all of the original supports, clamps, or suspending devices are installed or replaced.
6. Replace any components that have stripped threads or damaged parts. Don't attempt to repair parts by machining.
7. Never exceed recommended air pressure.

Operating Tests

1. Park the vehicle on a level surface and chock the tires.
2. Before testing the air brake proportioning system, do the following:
   - 2.1 Check the operation of the air compressor. Check the pressure levels of the air reservoirs.
   - 2.2 Be sure that all related valves are operating, and the system is plumbed as shown in **"Specifications, 400."**
   - 2.3 Check the operation of the brake chambers following the instructions in the brakes group of the vehicle maintenance manual.
   - 2.4 Inspect all tubing for kinks, dents, and other damage. Replace damaged tubing.
   - 2.5 Inspect all hoses for cracks, drying out, overheating, and other damage. Replace damaged hoses.
   - 2.6 Inspect all air line fittings. Tighten loose connections; replace fittings that are damaged.
3. Drain all air tanks to zero pressure.
4. Install a "tee" at the BP-R1 service port and at one of the delivery ports, then install a gauge in each.
5. Connect the tractor service and emergency gladhands to hose couplings that have been plugged; or, connect them to a trailer. Build the tractor system air pressure to governor cut-out.
6. With the dashboard trailer supply valve and system park control valve activated for tractor/trailer operation, apply, *hold,* and then release the brakes several times, varying the application pressures while watching the reaction of the gauges installed on the BP-R1. Note that a prompt application occurs and that it can be held, then promptly released.
7. Check the BP-R1 differential pressure by applying 69 kPa (10 psi) to the service port and noting the pressure registered at the delivery port. Subtract delivery port pressure from the 69 kPa (10 psi) service pressure to obtain the differential.

   NOTE: For BP-R1 valves that *don't incorporate* a relay piston spring (**Fig. 1**, Ref. 9), the measured differential should be about 28 kPa (4 psi). When a spring is in use, the differential will be higher.
8. Make and hold a full brake application of 689 kPa (100 psi) or greater, and note that full pressure is delivered to the chambers.
9. Activate the dash mounted trailer supply valve for bobtail tractor operation. Then make a *slow* brake application, increasing the pressure at the BP-R1 service port to 138 kPa (20 psi) while watching the reaction at the delivery port gauge. Note that delivery pressure rises to about 34 to 69 (5 to 10 psi) and remains constant while service pressure continues to rise to 138 kPa (20 psi). Release the application.
10. Make another brake application and *slowly* increase the pressure at the BP-R1 service port to between 414 to 483 kPa (60 and 70 psi) while observing the gauge installed at the delivery port. Note that when service port pressure rises to between 138 to 207 kPa (20 and 30 psi), delivery pressure begins to rise above the initial pressure noted above. The rise of delivery pressure should be at a proportioned rate of *about* three-to-one. At 483 kPa (70 psi) service pressure, delivered pressure should be 103 to 172 kPa (15 to 25 psi).
11. Make a full brake application, and note that both test gauges register the same pressure.
12. Remove the test gauges from the BP-R1.
13. Remove the chocks from the tires. Test drive the vehicle in a safe area at slow speed with the trailer supply valve pulled out (bobtail position). Make several brake applications to become familiar with the feel of the system before placing the vehicle back in service.

BP-R1 Brake Proportioning Valve Operating Tests



1. Capscrew
2. Washer
3. Exhaust Cover Screw
4. Exhaust Cover
5. Cover
6. O−Ring
7. O−Ring
8. Relay Piston
9. Relay Piston Spring
10. Sealing Ring
11. Body
12. Valve Assembly
13. Valve Retainer
14. Valve Spring
15. O−Ring
16. O−Ring
17. Exhaust Cover
18. Retaining Ring
19. Retaining Ring
20. O−Ring
21. Inlet Valve Seat
22. Inlet Valve
23. Valve Spring
24. O−Ring
25. Proportioning Piston
26. O−Ring
27. O−Ring
28. O−Ring
29. Blend−Back Piston
30. Spring Cage
31. Spring
32. O−Ring
33. Service Piston
34. Exhaust Diaphragm
35. O−Ring
36. Exhaust Piston
37. Dust Shield
38. Retaining Ring

10/28/93 f420482

Fig. 1

BP–R1 Brake Proportioning Valve Removal and Installation

Removal

1. Park the vehicle on a level surface, apply the parking brake, chock the tires, and drain all air tanks to zero pressure.

⚠ WARNING

WARNING: Wear safety glasses when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

2. Mark and then disconnect the air lines from the valve.
3. Remove the two bolts attaching the valve to the vehicle. Remove the valve.

Installation

1. Install the valve on the vehicle. Tighten the bolts 20 N·M (15 lbf·ft).
2. Connect the air lines to the proper ports, as marked during removal.
3. Check the proportioning valve operation **using the instructions in Subject 110**.

BP-R1 Brake Proportioning Valve Disassembly, Cleaning and Inspecting, and Assembly

Disassembly

⚠ CAUTION

CAUTION: The BP-R1, See Fig. 1, may be lightly clamped in a bench vise during disassembly, however, over-clamping will cause damage to the valve and result in leakage or malfunction.

If a vise is to be used, position the valve so that the jaws bear on the supply ports on opposing sides of the valve's body.

1. Remove all air fittings and plugs from the valve.
2. Mark the relationship of the valve cover to the body, and if the valve is equipped with a mount-

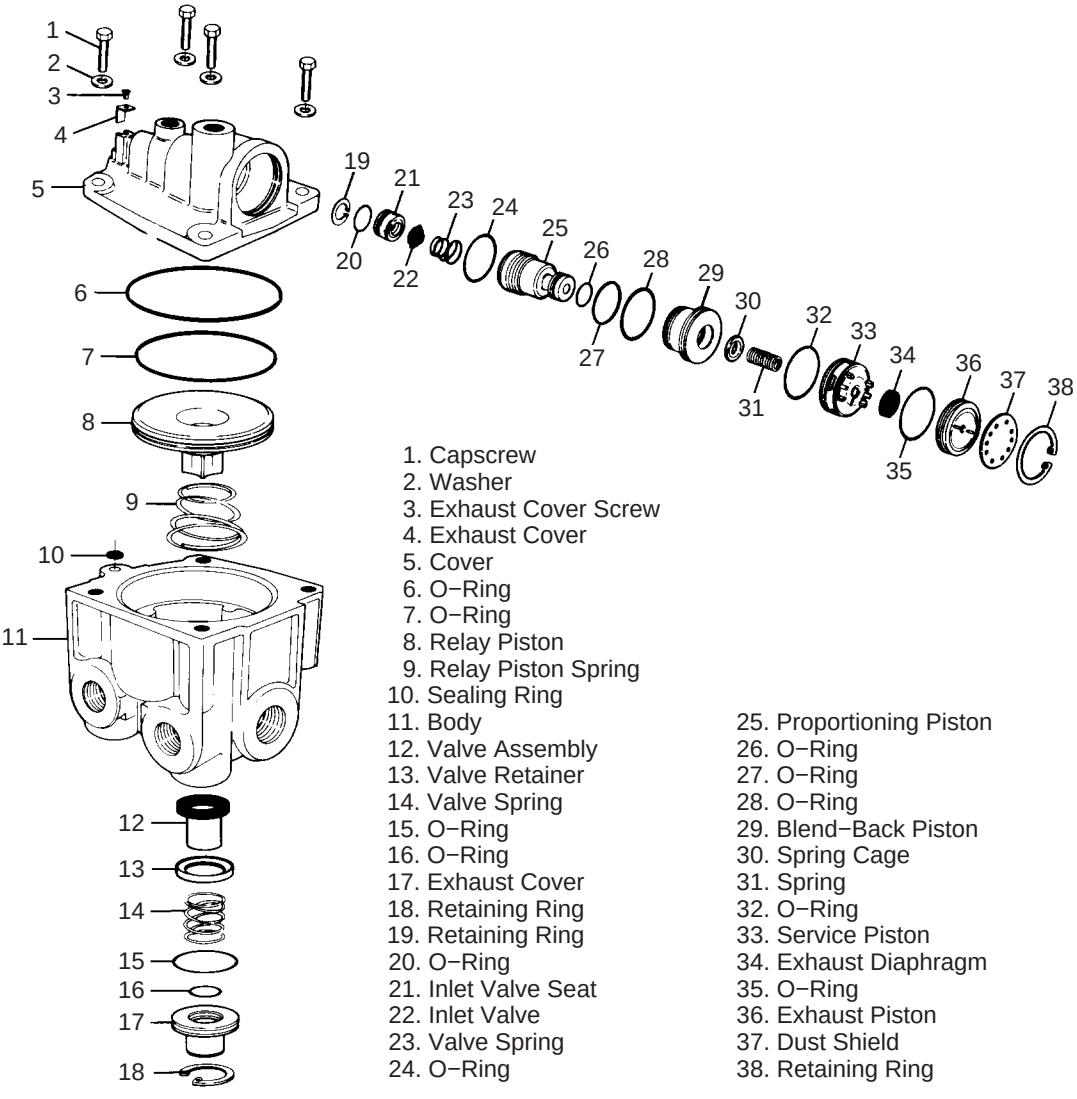


Fig. 1, BP-R1 Brake Proportioning Valve (exploded view)

BP-R1 Brake Proportioning Valve Disassembly, Cleaning and Inspecting, and Assembly

ing bracket, mark the relationship of the bracket to the cover.

3. While holding the exhaust cover (Ref. 17), remove and discard the retaining ring (Ref. 18) that secures it to the body (Ref. 11).
4. Remove and discard the exhaust cover along with both O-rings (Refs. 15 and 16).
5. Remove and discard the valve spring (Ref. 14), valve retainer (Ref. 13), and the valve assembly (Ref. 12) from the body.
6. Remove and retain the four capscrews and washers (Refs. 1 and 2) that secure the cover (Ref. 5) to the body.
7. Separate the cover from the body, then remove and discard the sealing ring and O-ring (Refs. 10 and 6).
8. Remove and retain the relay piston (Ref. 8) and relay piston spring (Ref. 9) from the body.

NOTE: The relay piston spring is *not used in all valves* .

9. Remove and discard the O-ring (Ref. 7) from the relay piston.
10. Remove and discard the dust shield (Ref. 37) and the retaining ring (Ref. 38) from the valve cover, then remove and save the exhaust piston (Ref. 36).
11. Remove and discard the exhaust piston O-ring (Ref. 35) and the exhaust diaphragm (Ref. 34).
12. Remove and save the service piston (Ref. 33) from the valve cover, then remove and discard the service piston O-ring (Ref. 32).
13. Remove the spring (Ref. 31) and spring cage (Ref. 30) from the valve cover. Discard the spring and retain the spring cage.
14. Remove and retain the blend-back piston (Ref. 29) from the valve cover, then remove and discard both O-rings (Refs. 27 and 28).
15. Remove and save the proportioning piston (Ref. 25) from the valve cover, then remove and discard both O-rings (Refs. 26 and 24).
16. While holding the inlet valve seat (Ref. 21) in place, remove and discard the retaining ring (Ref. 19) from the proportioning piston.
17. Remove the inlet valve seat, the inlet valve (Ref. 22), and the valve spring (Ref. 23) from the proportioning piston, then remove and discard the O-ring (Ref. 20) from the valve seat. Discard the valve and spring also.
18. Remove and discard the exhaust cover screw (Ref. 3) and exhaust cover (Ref. 4).

Cleaning and Inspection

⚠ WARNING

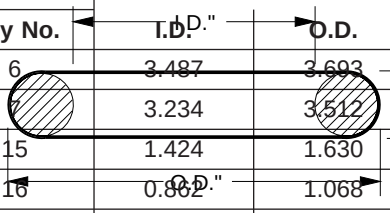
WARNING: Commercial cleaning solvents are toxic, can cause severe skin irritation, and may be fire hazards. When using solvents, follow the safety precautions recommended by the solvent manufacturer.

1. Using mineral spirits or an equivalent solvent, clean and thoroughly dry all metal parts. Don't damage any bores with metal tools.
2. Wash all non-metallic parts (Refs. 8, 17, 21, 25, 29, 30, 33, and 36) in a soap and water solution, making certain to rinse and dry thoroughly.
3. Inspect the interior and exterior of all metal parts that will be re-used. Check for severe corrosion, pitting, gouges and cracks. Superficial corrosion or pitting of the exterior portion of the body and cover is acceptable. Replace the entire valve if the interior of the body or cover show signs of corrosion or pitting.
4. Inspect each non-metallic part for cracks, wear or distortion. Replace the entire valve if these conditions exist.
5. Replace all rubber parts.
6. Make certain the air channel running between the top surface of the body and its supply port is clear and free of blockages.
7. Make certain all air channels and exhaust passages in the valve cover are clear and free of blockages.
8. Inspect the pipe threads in the body and valve cover. Make certain they are clean and free of thread sealant.
9. If the valve was equipped with a relay piston spring, check it for signs of corrosion, pitting, and cracks. Replace as needed.

10. Inspect all air line fittings for corrosion; replace as needed. Be sure to remove all old thread sealant before re-use.

Assembly

1. Prior to assembly, lubricate all O-rings (identify them by referring to **Table 1**), seals, and pistons, as well as body and cover bores, using the lubricant provided in the Bendix maintenance kit. Use all of the lubricant, and spread it evenly on the rubbing surfaces.



Key No.	I.D.	O.D.	W
6	3.487	3.693	0.103
7	3.234	3.512	0.139
15	1.424	1.630	0.103
16	0.862	1.068	0.103
20	0.489	0.629	0.070
24	0.739	0.879	0.070
26	0.412	0.552	0.070
27	0.737	0.943	0.103
28	1.112	1.318	0.103
32	1.176	1.316	0.070
35	1.356	1.496	0.070

Table 1, O-Ring Identification (Sectional View)

2. Install the O-ring (**Fig. 1**, Ref. 20) on the inlet valve seat (Ref. 21).
3. Install the small end of the valve spring (Ref. 23) over the rubber of the inlet valve (Ref. 22), making sure the spring coils rest on the valve's four tabs.
4. Insert the spring and valve into the valve seat, making sure the four tabs are inside the seat's bore.
5. Insert the valve, seat, and spring assembly into the proportioning piston (Ref. 25)— large end of the spring first.
6. While holding the seat in place, install the retaining ring (Ref. 19) to secure it in the piston. Make certain the retaining ring is fully seated in its groove. Make sure the valve is straight against the exhaust seat and free to move.
7. Install both the large and small diameter O-rings (Refs. 24 and 26) on the proportioning piston.
8. Install both the large and small diameter O-rings (Refs. 28 and 27) on the blend-back piston (Ref. 29), then insert the small diameter of the proportioning piston into the small diameter end of the blend-back piston.
9. Carefully insert the assembled proportioning and blend-back pistons to the edge of the bore in the cover (Ref. 5). Don't cut or pinch the O-rings.
10. With the bore of the cover facing up, install the spring cage (Ref. 30) in the blend-back piston so that its flat side rests against the blend-back piston (its depressed side out towards spring [Ref. 31]).
11. Install the O-ring (Ref. 32) on the service piston (Ref. 33), then install the spring (Ref. 31) in the cage (Ref. 30) so that its coils are in the inside diameter of the cage.
12. Install the O-ring (Ref. 35) on the exhaust piston (Ref. 36), and place the exhaust diaphragm (Ref. 34) between the six posts of the service piston.
13. Place the exhaust piston on the service piston with its six-ribbed side facing the service piston. Then install both pistons while pushing the proportioning and blend-back pistons all the way into the cover.
14. Install the dust shield (Ref. 37) in the cover.
15. While holding the dust shield in the cover, install the retaining ring (Ref. 38), making certain it is fully seated in its groove.
16. Install the exhaust cover (Ref. 4) using the screw (Ref. 3) to retain it. Torque the screw 100 to 160 N·cm (8 to 15 lbf·in).
17. Install the valve retainer (Ref. 13) on the valve assembly (Ref. 12) so that the flange of the retainer (Ref. 13) surrounds the rubber portion of the valve. Install the valve assembly in the body.
18. Install the valve spring (Ref. 14) in the body.
19. Install the large and small diameter O-rings (Refs. 15 and 16) in the exhaust cover (Ref. 17), then install the exhaust cover in the body, taking

BP-R1 Brake Proportioning Valve Disassembly, Cleaning and Inspecting, and Assembly

care not to damage the O-rings. Hold the exhaust cover in place.

20. While depressing the exhaust cover, install the retaining ring (Ref. 18) in the body. Make sure this ring is fully seated in its groove in the body.
21. If the BP-R1 was equipped with a relay piston spring (Ref. 9), install the spring in the body, large diameter first.
22. Using lubricant to hold them in place, install the large O-ring and small sealing ring (Refs. 6 and 10) on the cover.
23. Install the O-ring (Ref. 7) on the relay piston (Ref. 8), then install the piston in the body.
24. After noting the relationship marks made prior to disassembly, install the mounting bracket (not shown) on the cover, then secure the cover and mounting bracket on the body using the four capscrews and washers (Refs. 1 and 2). Torque the capscrews 1360 to 1700 N·cm (120 to 150 lbf·in).

Refer to Fig. 1 for a diagram of the Bendix air brake proportioning system.

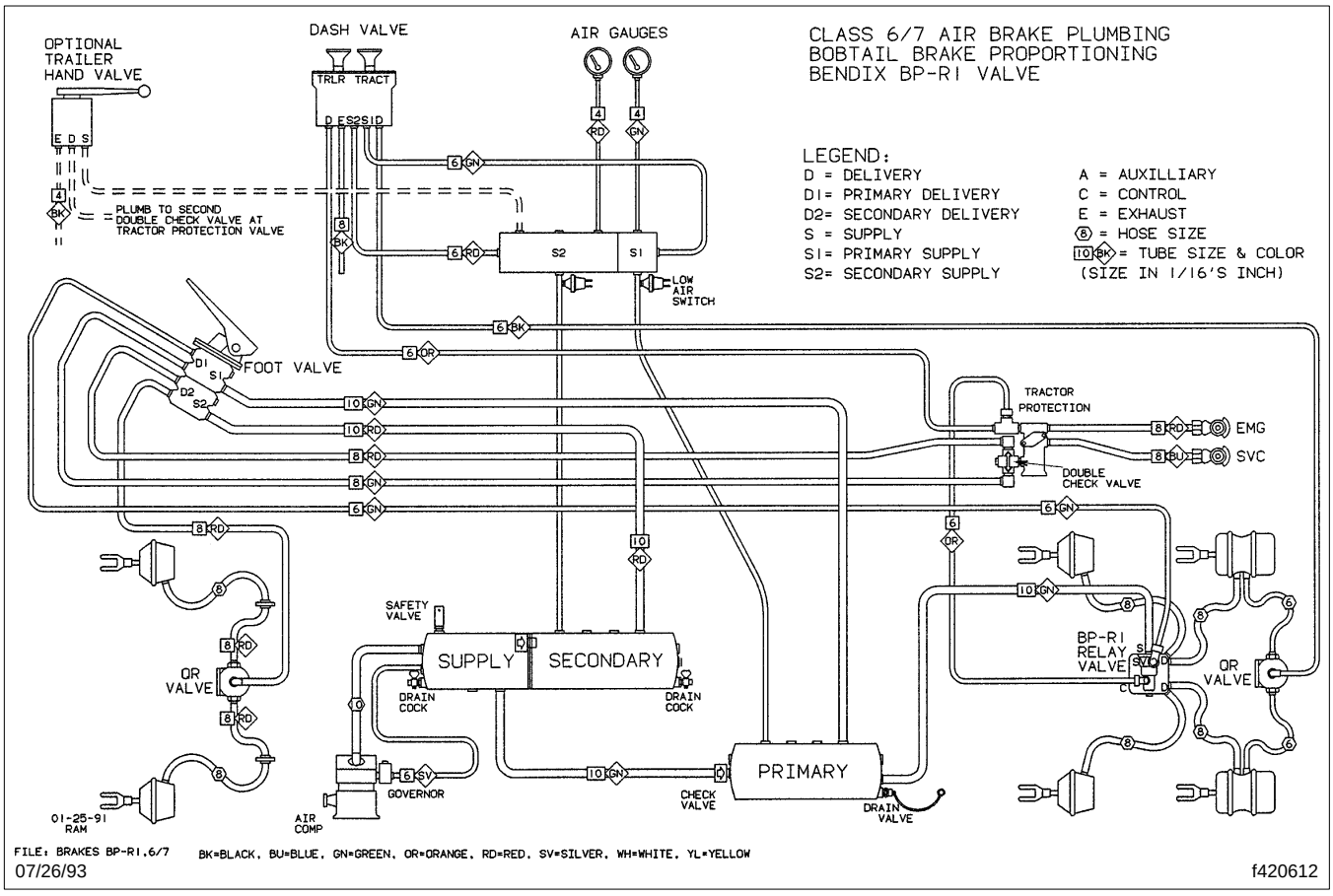


Fig. 1

General Description

The function of the Bendix AD-9 air dryer (**Fig. 1**) is to collect and remove air system contaminants in solid, liquid, and vapor form before they enter the brake system.

the heater and thermostat assembly, and the discharge check valve assembly, can be serviced without removing the air dryer from the vehicle. The screw-in desiccant cartridge requires removal of the air dryer assembly from the vehicle.

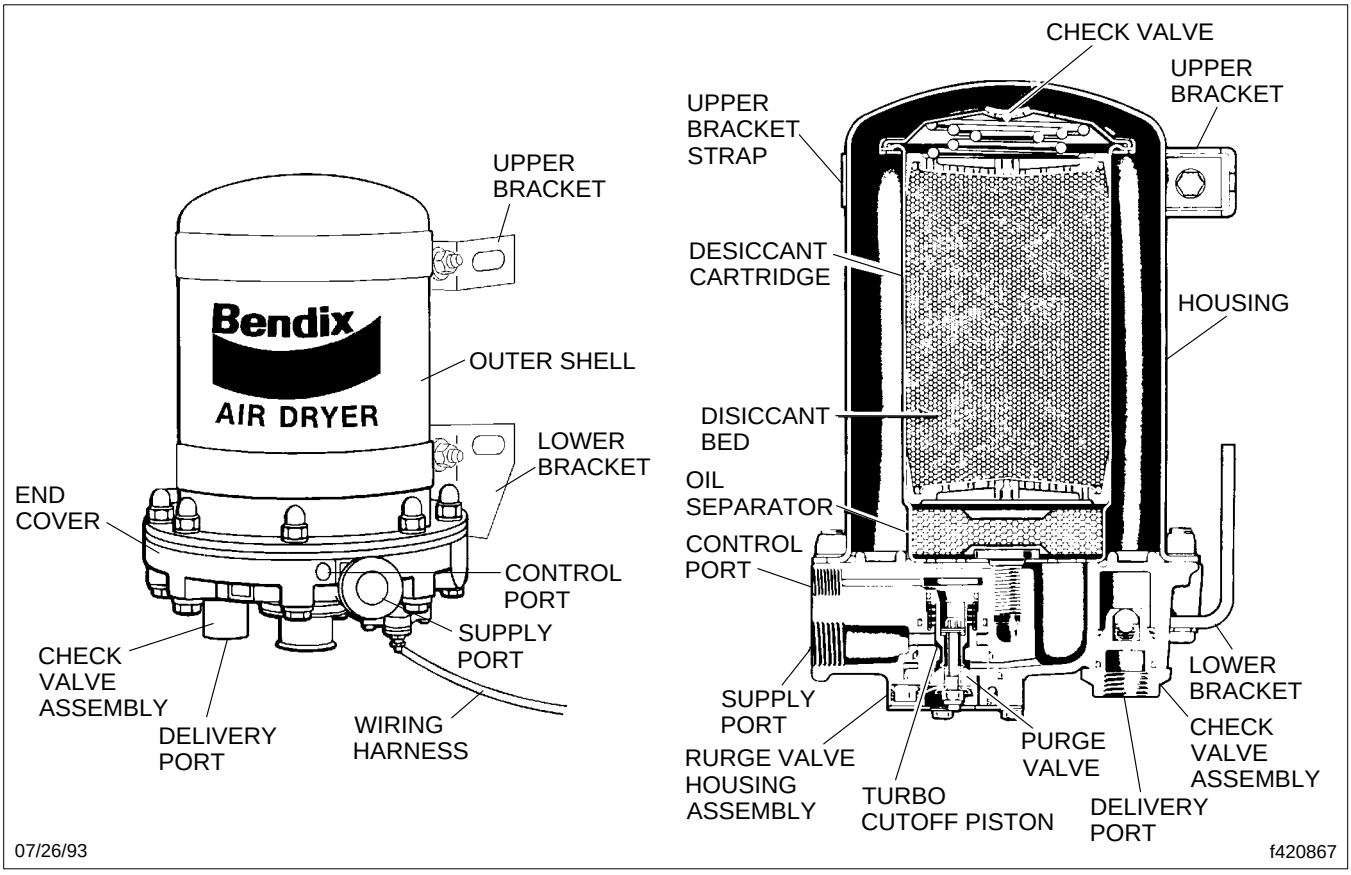


Fig. 1, Bendix AD-9 Air Dryer and Cutaway View

The AD-9 air dryer consists of the desiccant cartridge and a die-cast aluminum end cover secured to a cylindrical steel outer shell with eight capscrews and nuts. The end cover contains a check valve assembly, a safety valve, three threaded air connections and the purge valve housing assembly. The removable purge valve housing assembly features a purge valve mechanism and a turbocharger cutoff that are designed to prevent loss of engine turbo boost pressure during the purge cycle of the air dryer.

To ease servicing, the desiccant cartridge and discharge check valve assembly are screw-in types. The purge valve housing assembly, which includes

The AD-9 has three female pipe thread air connections; each is identified as follows (see **Table 1**):

Port I. D.	Function/Connection
4–CON	Control Port (purge valve control and turbo cutoff)
11–SUP	Supply Port (air in)
2–DEL	Delivery Port (air out)

Table 1, AD-9 Pipe Thread Connections

General Description and Principles of Operation

Principles of Operation

The AD-9 air dryer alternates between two operational modes or cycles during operation: the charge cycle and the purge cycle.

CHARGE CYCLE (See Fig. 2)

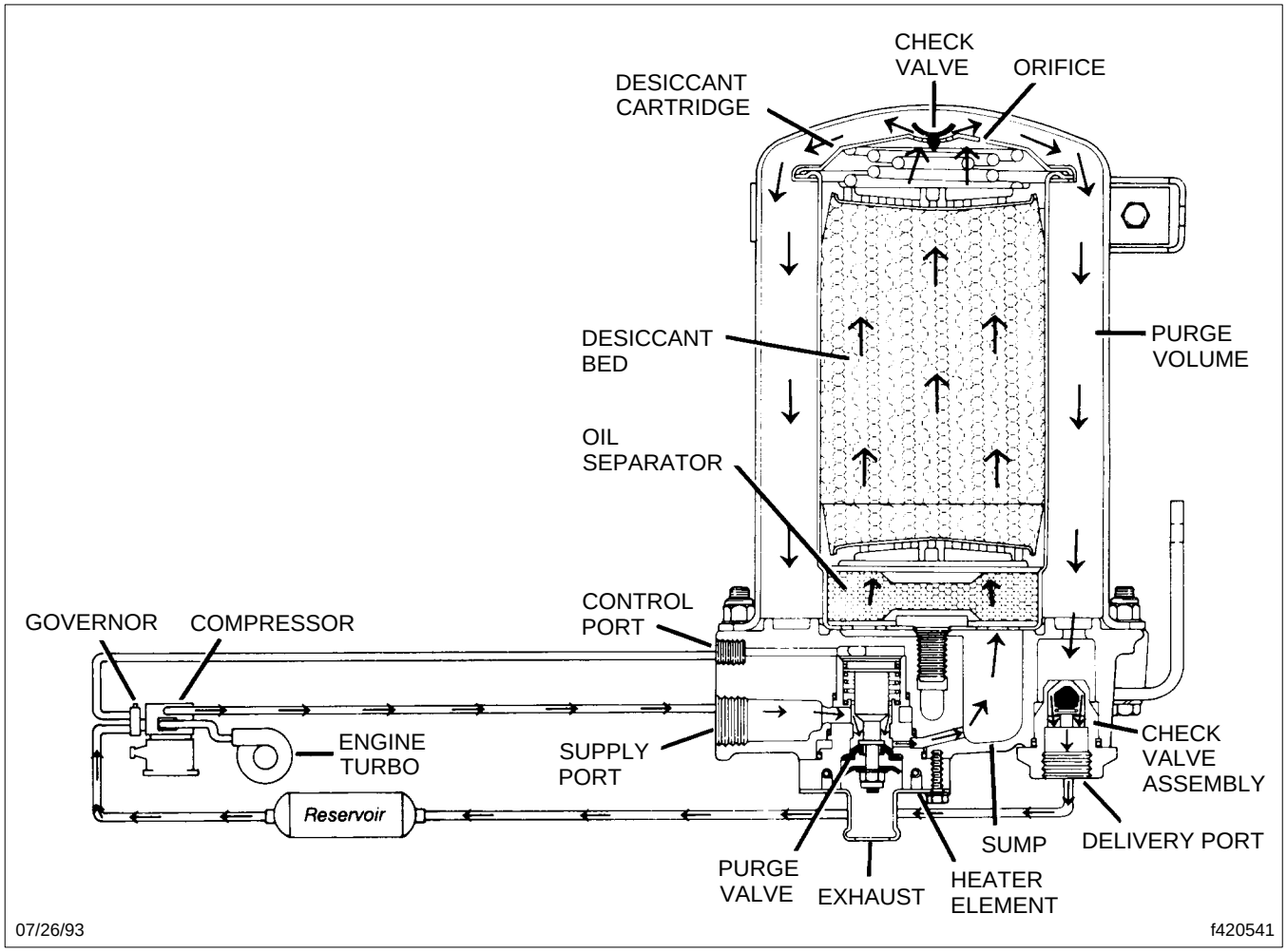


Fig. 2, AD-9 Charge Cycle

When the compressor is loaded (compressing air), pressurized air, along with oil, oil vapor, water, and water vapor flow through the compressor discharge line to the supply port of the air dryer end cover. As air travels through the end-cover assembly, its direction of flow changes several times, reducing the temperature, causing contaminants to condense and drop to the bottom or sump of the air dryer end cover.

After exiting the end cover, air flows into the desiccant cartridge. Once in the cartridge, air first flows through an oil separator, which removes water, oil, oil vapor, and solid contaminants.

Air exits the oil separator and enters the desiccant drying bed. Air flowing through the column of desiccant becomes progressively drier as water vapor sticks to the desiccant material in a process known as adsorption. The desiccant cartridge, using the adsorption process typically removes 95 percent of the water vapor from the pressurized air.

Most of the dry air exits the desiccant cartridge through its integral single check valve to fill the purge volume between the desiccant cartridge and outer shell. Some air also exits the desiccant cartridge through the purge orifice adjacent to the check valve.

Dry air flows out of the purge volume through the single check valve assembly and out the delivery port to the first (supply) reservoir of the air system.

The air dryer remains in the charge cycle until air brake system pressure builds to the governor cutout setting.

PURGE CYCLE **(See Fig. 3)**

When the brake system pressure reaches the governor cutout setting, the compressor unloads (air compression stopped), and the purge cycle of the air dryer begins. When the governor unloads the compressor, it pressurizes the unloader mechanism and line connecting the governor unloader port to the AD-9 end cover control port. The purge piston moves in response to air pressure causing the purge valve to open to atmosphere and partially close off the suppl of air from the compressor. This is further discussed under "Turbo Cutoff Feature."

Contaminants in the end cover sump are expelled immediately when the purge valve opens. Also, air that was flowing through the desiccant cartridge changes direction and begins to flow toward the open purge valve. Oil and solid contaminants collected by the oil separator are removed by air flowing from the desiccant drying bed to the open purge valve.

The initial purge and desiccant cartridge decompression last only a few seconds and are signaled by an audible burst of air at the AD-9 exhaust. The actual reactivation of the desiccant drying bed begins as dry air flows from the purge volume through the desiccant cartridge purge orifice and into the desiccant drying bed. Pressurized air from the purge volume expands after passing through the purge orifice; its pressure is lowered and its volume increased. Dry air flowing through the drying bed reactivates the desiccant material by removing the water vapor sticking to it. Generally, it takes 15 to 30 seconds for the entire purge volume of a standard AD-9 to flow through the desiccant drying bed.

The end cover single check valve assembly prevents compressed air in the brake system from returning to the air dryer during the purge cycle. After the 30 second purge cycle is complete, the air dryer is ready for the next charge cycle to begin.

The purge valve will remain open after the purge cycle is complete, and will not close until air brake system pressure is reduced and the governor signals the compressor to charge.

NOTE: The air dryer should be periodically checked for operation and tested for leaks. See Group 42 of the *Business Class Trucks Maintenance Manual* for intervals and procedures.

General Description and Principles of Operation

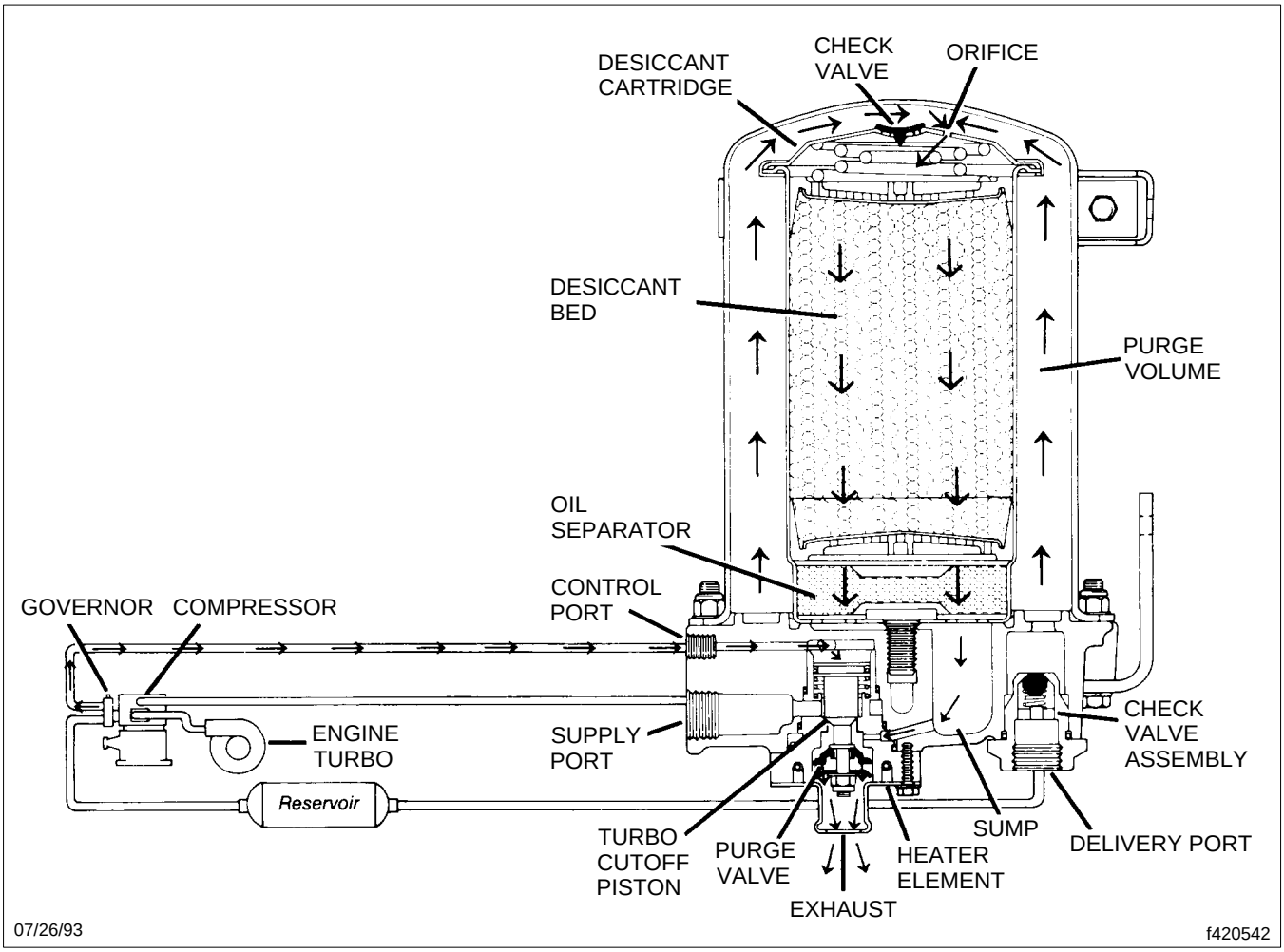


Fig. 3, AD-9 Purge Cycle

TURBO CUTOFF FEATURE (See Fig. 4)

Primarily, the turbo cutoff valve prevents loss of engine turbocharger air pressure through the AD-9 in systems where the compressor intake is connected to the engine turbocharger. The turbo cutoff valve also reduces the puffing of air out the open exhaust when a naturally aspirated, single cylinder compressor equipped with an inlet check valve is in use.

At the beginning of the purge cycle, the downward travel of the purge piston is stopped when the turbo cutoff valve (tapered portion of the purge piston) contacts its mating metal seat in the purge valve housing. With the turbo cutoff valve seated (closed position), air in the discharge line and AD-9 supply port is restricted from entering the air dryer. While the turbo cutoff *effectively* prevents loss of turbocharger boost pressure to the engine, some seepage of air may be detected under certain conditions of compressor, engine, and turbocharger operation. Even so, there will be low pressure trapped in the discharge line.

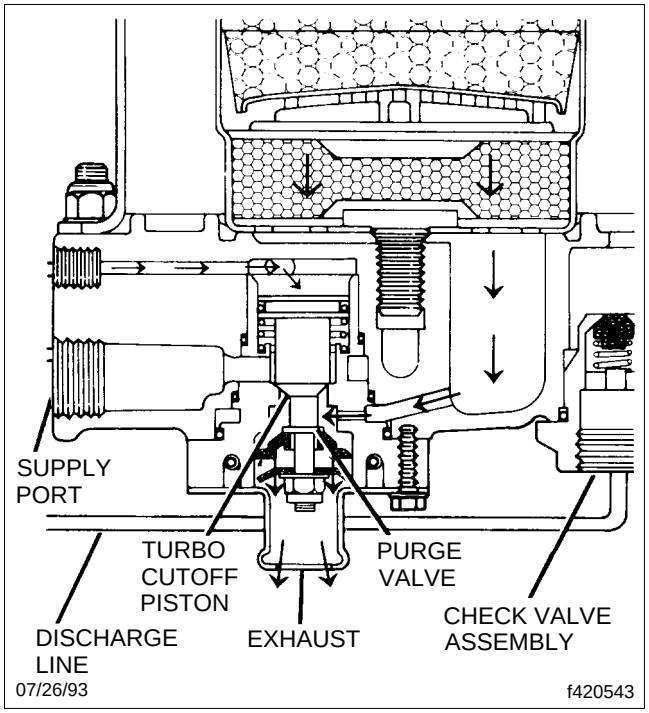


Fig. 4, AD-9 Turbo Cutoff

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Chock the tires and stop the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters, which may apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure, and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Don't disassemble a component until you have read and understood the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools, and observe all precautions pertaining to use of those tools.
5. Replacement hardware, tubing, hose, fittings, etc. should be the equivalent size, type, length, and strength of the original equipment.

   Make sure that when replacing tubing or hose, all of the original supports, clamps, or suspending devices are installed or replaced.
6. Replace devices with stripped threads or damaged parts. Repairs requiring machining should not be attempted.

Removal

IMPORTANT: Before working on or around air brake systems and components, read **"Safety Precautions, 100."**

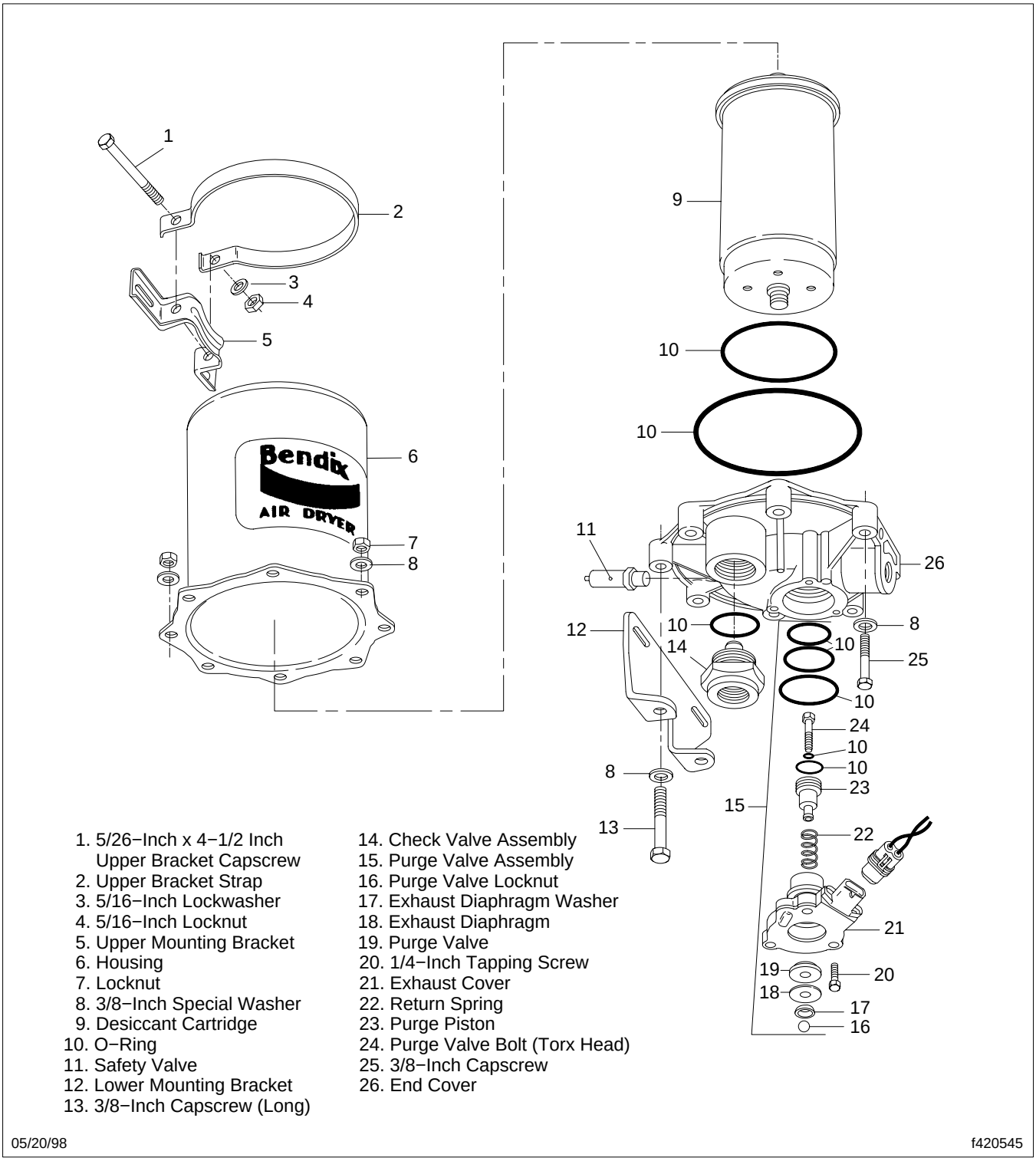
1. Park the vehicle on a level surface and chock the tires.
2. Drain all reservoirs to zero pressure.
3. Remove the air dryer.
   - 3.1 Identify and disconnect the three air lines from the end cover, and note the position of end cover ports relative to the vehicle.
   - 3.2 Unplug the vehicle wiring harness from the heater and thermostat assembly connector on the purge valve housing assembly.
   - 3.3 Loosen the hex bolt securing the upper mounting strap.
   - 3.4 Remove, save, and *mark* the two end cover capscrews, locknuts, and four special washers that retain the lower mounting bracket to the end cover. Also mark the two holes of the end cover. (These bolts are longer than the other six bolts.)
   - 3.5 Remove the air dryer from its mounting brackets.

Installation (Refer to Fig. 1)

IMPORTANT: Before working on or around air brake systems and components, read **"Safety Precautions, 100."**

1. Install the assembled air dryer on the vehicle.
   - 1.1 Position the air dryer up into the upper mounting bracket and strap. Align the two unused holes in the end cover with the bottom mounting bracket so that the bottom bracket supports the air dryer. The end cover should rest on the bracket.
   - 1.2 Using the remaining two capscrews (Ref. 16), four special washers (Ref. 15), and two locknuts (Ref. 17), secure the air dryer to the lower bracket. Tighten the two remaining capscrews 3060 to 4340 N·cm (270 to 385 lbf·in).
   - 1.3 Tighten the bolt and nut on the upper mounting bracket strap 900 to 1360 N·cm (80 to 120 lbf·in).
   - 1.4 As referenced earlier in "Removal", connect the three air lines to the ports on the end cover.
   - 1.5 Connect the vehicle wiring harness to the air dryer heater and thermostat assembly connector by plugging it into the air dryer connector until its lock tab snaps in place.
2. Test the air dryer following instructions in the brakes group of the vehicle maintenance manual.

Removal and Installation



1. 5/26−Inch x 4−1/2 Inch Upper Bracket Capscrew
2. Upper Bracket Strap
3. 5/16−Inch Lockwasher
4. 5/16−Inch Locknut
5. Upper Mounting Bracket
6. Housing
7. Locknut
8. 3/8−Inch Special Washer
9. Desiccant Cartridge
10. O−Ring
11. Safety Valve
12. Lower Mounting Bracket
13. 3/8−Inch Capscrew (Long)
14. Check Valve Assembly
15. Purge Valve Assembly
16. Purge Valve Locknut
17. Exhaust Diaphragm Washer
18. Exhaust Diaphragm
19. Purge Valve
20. 1/4−Inch Tapping Screw
21. Exhaust Cover
22. Return Spring
23. Purge Piston
24. Purge Valve Bolt (Torx Head)
25. 3/8−Inch Capscrew
26. End Cover

05/20/98 f420545

Fig. 1, AD-9 Exploded View

Disassembly, Cleaning and Inspection, and Assembly

When a major rebuild of the air dryer is undertaken, several replacement parts and maintenance kits are available that do not require full disassembly. Use the instructions provided with these parts or kits. **Refer to Fig.1** during disassembly.

Disassembly

IMPORTANT: Before working on or around air brake systems and components, read **"Safety Precautions, 100."**

CAUTION

CAUTION: While servicing the air dryer, don't use a clamping device (vise, C-clamp, etc.) to hold any die cast aluminum part, as damage may result. To hold the end cover, install a pipe nipple in the supply port, and clamp the nipple in a vise.

1. Remove the air dryer from the vehicle. **Refer to "Removal and Installation, 110."**
2. Remove the check valve assembly (Ref. 13) and O-ring (Ref. 1). Remove the O-ring from the check valve assembly.
3. Remove the purge valve housing assembly.
   - 3.1 Remove the three self-tapping screws (Ref. 3) that secure the purge valve housing assembly to the end cover assembly.
   - 3.2 Pull the purge valve housing assembly out of the end cover assembly.
   - 3.3 Remove the three O-rings (Refs. 5, 6, and 7) from the exterior of the purge valve housing assembly.

   NOTE: O-rings (Refs. 5 and 6) may lodge in and have to be removed from the end cover bores.
4. Disassemble the purge valve housing assembly.
   - 4.1 If a flat non-extended exhaust cover (Ref. 28) is used, leave it intact while servicing the purge valve housing assembly.

     If an extended type exhaust cover is used for the attachment of an exhaust hose, *carefully* peel off the exhaust cover from the purge valve housing. *Use a thin flat blade to pry the exhaust cover off, taking care not to damage the potting material (RTV sealant) under the cover.*
   - 4.2 Remove the locknut (Ref. 4) from the bottom of the purge valve housing assembly. A Torx head or 12-point socket is used to hold the head of the bolt (Ref. 29). If present, remove the diaphragm washer (Ref. 30) and diaphragm (Ref. 2), and the purge valve (Ref. 10) from the purge valve housing.
   - 4.3 Remove the Torx head bolt (Ref. 29) from the opposite end, then the purge piston (Ref. 31), the return spring (Ref. 11) and two O-rings (Refs. 9 and 12) (one on the outside diameter and the other in the inside of the purge piston).

CAUTION

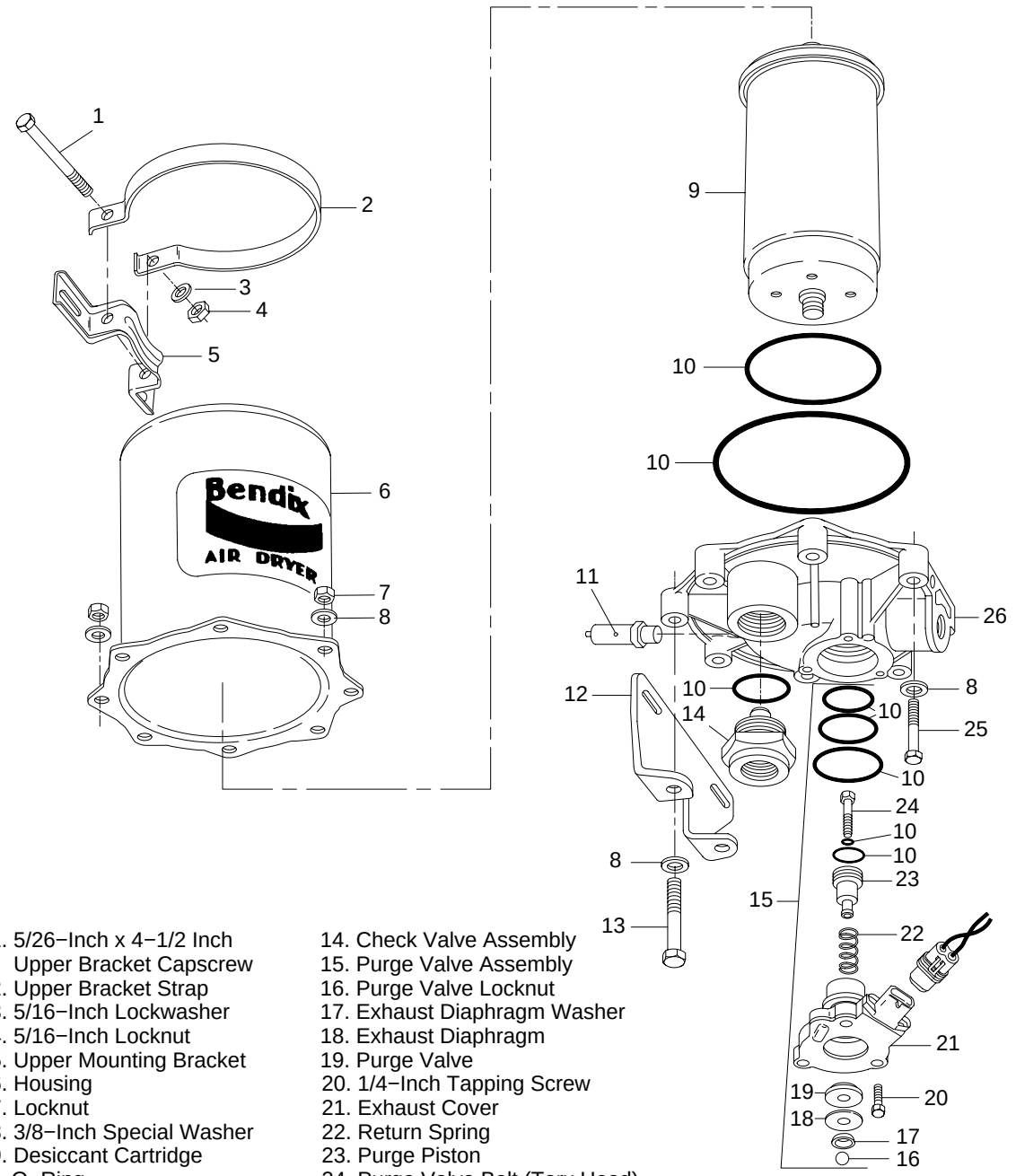
CAUTION: The heater and thermostat assembly is not available as a service part. Don't remove it; if the heater and thermostat are inoperative, replace the entire purge valve housing assembly, which includes these parts.

5. Remove the remaining six capscrews (Ref. 14), locknuts (Ref. 17), and twelve special washers (Ref. 15) that secure the end cover to the housing (Ref. 22). Separate the end cover and desiccant cartridge (Ref. 20) from the housing (Ref. 22).
6. Remove the end-cover-to-outer-housing O-ring (Ref. 21).
7. Don't remove the safety valve from the end cover unless it is known to be inoperative. If replacement is needed, apply thread sealant or Teflon® tape on the threads of the replacement valve and tighten 1360 to 4520 N·m (120 to 400 lbf·in). Make sure the drain hole (slot) is facing down.
8. Place a strap or chain wrench around the desiccant cartridge (Ref. 20) so that it is about 5 to 8 cm (2 to 3 inches) away from the end cover. Rotate the cartridge counterclockwise until it completely separates from the end cover.

NOTE: Torque of up to 68 N·m (50 lbf·ft) may be needed to do this disassembly.

9. Remove the desiccant cartridge O-ring (Ref. 19) from the end cover.

Disassembly, Cleaning and Inspection, and Assembly



1. 5/26−Inch x 4−1/2 Inch Upper Bracket Capscrew
2. Upper Bracket Strap
3. 5/16−Inch Lockwasher
4. 5/16−Inch Locknut
5. Upper Mounting Bracket
6. Housing
7. Locknut
8. 3/8−Inch Special Washer
9. Desiccant Cartridge
10. O−Ring
11. Safety Valve
12. Lower Mounting Bracket
13. 3/8−Inch Capscrew (Long)
14. Check Valve Assembly
15. Purge Valve Assembly
16. Purge Valve Locknut
17. Exhaust Diaphragm Washer
18. Exhaust Diaphragm
19. Purge Valve
20. 1/4−Inch Tapping Screw
21. Exhaust Cover
22. Return Spring
23. Purge Piston
24. Purge Valve Bolt (Torx Head)
25. 3/8−Inch Capscrew
26. End Cover

05/20/98 f420545

Fig. 1

Cleaning and Inspection

IMPORTANT: Before working on or around air brake systems and components, read **"Safety Precautions, 100."**

⚠ WARNING

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

1. Wash all metal parts thoroughly, using a quality commercial solvent, such as mineral spirits.
2. Check for severe corrosion, pitting, and cracks on the inside and outside of all metal parts that will be reused. Superficial corrosion and pitting on the outside of the upper and lower body halves is acceptable.
3. Inspect the bores of both the end cover and the purge-valve housing for deep scuffing or gouges.
4. Make sure that all purge-valve housing and end cover passages are open and free of blockages.
5. Inspect the pipe threads in the end cover. Make sure they are clean and free of thread sealant.
6. Inspect the purge-valve housing bore and seats for excessive wear and scuffing.
7. Inspect the purge valve piston seat for excessive wear.
8. Inspect all air line fittings for corrosion. Clean all old thread sealant from the pipe threads.
9. Replace all removed O-rings with new ones that are provided in the kits.

   Replace parts that show any of the conditions described.

Assembly (Refer to Fig.1)

IMPORTANT: Before working on or around air brake systems and components, read **"Safety Precautions, 100."**

1. Before assembly, coat all O-rings, O-ring grooves, and bores with a generous amount of barium-base lubricant. **Refer to Fig.1** during assembly unless otherwise advised.
2. Assemble the purge-valve housing.
   - 2.1 Install the O-ring (Ref. 12) on the purge piston. Place the return spring (Ref. 11) in the purge-valve housing. Place the O-ring (Ref. 9) in the bore of the purge piston. Install the Torx head bolt (Ref. 29) in the purge piston. Insert the purge piston (Ref. 31) in the inside diameter of the spring (Ref. 11). Push the piston into the purge-valve housing until it bottoms.
   - 2.2 While holding the purge piston in, install the following parts over the purge valve bolt (Ref. 29) from the opposite end of the purge-valve housing: the purge valve (Ref. 10) with its rubber side first, followed by the diaphragm (Ref. 2) (if present) and the diaphragm washer (Ref. 30) (if present) or the flatwasher, and finally the locknut (Ref. 4). Torque the purge valve locknut and bolt (Refs. 4 and 29) 680 to 900 N·cm (60 to 80 lbf·in).
   - 2.3 Install the three O-rings (Refs. 5, 6, and 7) in their correct locations on the purge-valve housing.
   - 2.4 If the exhaust cover (Ref. 28) was removed, install it on the purge-valve housing assembly, making sure the "bubble" portion is positioned over the thermostat.
   - 2.5 Install the assembled purge-valve housing in the end cover; make sure you orient both parts so that the connector is about 10 degrees clockwise from the supply port. Also, make sure the purge-valve housing is fully seated against the end cover.
   - 2.6 Secure the purge-valve housing to the end cover using the three self-tapping screws (Ref. 3). Start all three screws by hand, then torque 960 to 1400 N·cm (85 to 125 lbf·in).
3. Install the O-ring (Ref. 1) on the check-valve assembly (Ref. 13), then install the assembly in the end cover using a socket. Tighten 2260 to 2820 N·cm (200 to 250 lbf·in).
4. Install the desiccant cartridge in the end cover.

Disassembly, Cleaning and Inspection, and Assembly

4.1 Install the desiccant O-ring (Ref. 19) in its groove in the end cover. Using a light coat of barium grease, lubricate the bottom of the desiccant cartridge in the area that will contact the O-ring and end cover.

4.2 Screw the desiccant cartridge into the end cover until the cartridge contacts the O-ring. Using a strap or chain wrench positioned 5 to 8 cm (2 to 3 inches) from the bottom of the cartridge, turn the desiccant cartridge clockwise 180 to 225 degrees beyond the position where initial contact was made with the end cover O-ring. Torque should not exceed 68 N·m (50 lbf·ft).

5. Install the end cover housing over the desiccant cartridge.

5.1 Install the end cover outer housing O-ring (Ref. 21) on the shoulder in the end cover. Place the housing (Ref. 22) over the desiccant cartridge and align the holes.

5.2 Install the six capscrews (Ref. 14), locknuts (Ref. 17), and the twelve special washers (Ref. 15), making sure they are positioned as referenced earlier. The two longer capscrews (Ref. 16) will be used to secure the air dryer to its mounting bracket.

5.3 Tighten the six capscrews and nuts in a star pattern **as shown in Fig.2,** depending on lower bracket location. Tighten 3060 to 4340 N·cm (270 to 385 lbf·in).

NOTE: The two remaining bolt holes in the end cover and two 3/8-inch capscrews must be the ones marked during disassembly to ensure correct orientation of the ports and adequate length of the capscrews.

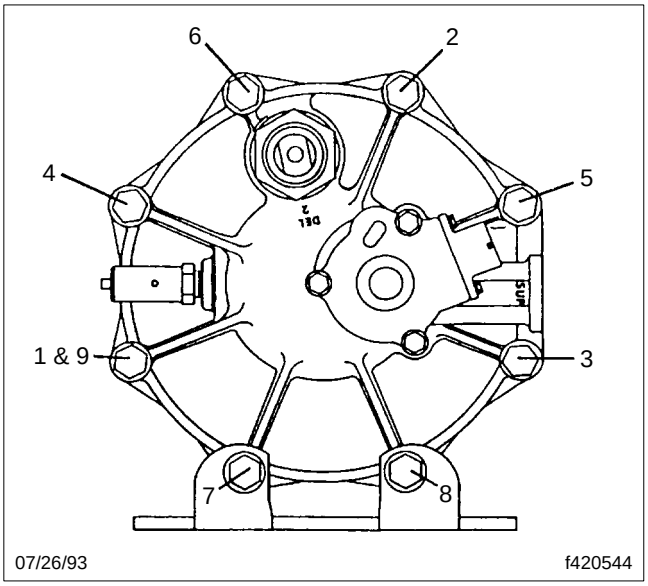


Fig. 2, End Cover to Housing Torque Pattern

Testing

During cold-weather operation, check the operation of the end cover heater and thermostat assembly.

1. With the ignition on, check for voltage to the heater and thermostat assembly. Unplug the electrical connector at the air dryer, and place the test leads on each of the pins of the male connector. If there is no voltage, look for a blown fuse, broken wires, or corrosion in the vehicle wiring harness. Check that a good ground path exists.
2. Check the thermostat and heater operation. Turn off the ignition switch and cool the end cover assembly to below 4°C (40°F). Using an ohmmeter, check the resistance between the electrical pins in the female connector. The resistance should be 1.5 to 3.0 ohms for the 12-volt heater assembly.

NOTE: Some early models of the AD-9 will have resistance readings of 1.0 to 2.5 ohms for the 12-volt heater assembly. If the resistance is higher than this, replace the purge-valve housing assembly, which includes the heater and thermostat assembly.

3. Warm the end cover assembly to over 32°C (90°F) and again check the resistance. It should exceed 1000 ohms. If it does, the thermostat and heater assembly is operating properly. If it doesn't, replace the purge-valve housing assembly, which includes the heater and thermostat assembly.

Problem—Air Dryer Is Constantly Cycling or Purging

Possible Cause	Remedy
Excessive system leakage.	Test for excessive leakage. Eliminate leaks, as needed. Allowable leakage is as follows: • Single Vehicle—7 kPa/min (1 psi/min) per service reservoir • Tractor/Trailer—21 kPa/min (3 psi/min) per service reservoir
There is excessive leakage in the fittings, hoses, and tubing connected to the compressor, air dryer, and wet tank.	Using a soap solution, test for leakage at the fittings, drain valve, and safety valve in the wet tank. Repair or replace as needed.
Check valve assembly in the air dryer end cover is not working.	Remove the check valve assembly from the end cover. Apply compressed air to the delivery side of the valve. Apply a soap solution at opposite end, and check for leakage. Permissible leakage is a 2.5-cm (1-inch) bubble in 5 seconds. If there is excessive leakage, replace the check valve assembly.
Governor is inoperative.	Test the governor for proper cut-in or cut-out pressures and excessive leakage in both positions.
Leaking purge-valve housing assembly or O-rings in the air dryer end cover.	With the supply port open to atmosphere, apply 830 kPa (120 psi) at the control port. Apply a soap solution to the supply port and exhaust port (purge valve seat area). Permissible leakage is a 2.5-cm (1-inch) bubble in 5 seconds. Repair or replace as needed.
Compressor unloader mechanism is leaking excessively.	Remove the air strainer or fitting from the compressor inlet cavity. With the compressor unloaded, check for unloader piston leakage. Slight leakage is allowed.
Holset "E" type compressor.	Test the air dryer system. For instructions, refer to Bendix Product Bulletin PRO-08-19 entitled "Troubleshooting the Holset "E" Compressor System with Bendix Air Dryer."
Lack of air at the governor RES port (rapid cycling of the governor).	Test the governor for proper pressure at the RES port. Pressure should not drop below cut-in pressure when the compressor begins the unloaded cycle. If the pressure does drop, check for kinks or restrictions in the line connected to the RES port. The line connected to the RES port on the governor must be the same diameter, or larger than the lines connected to the UNL ports on the governor.

Problem—Water in the Vehicle Reservoirs

Possible Cause	Remedy
Desiccant cartridge assembly contains excessive contaminants.	Replace the desiccant cartridge.
Discharge line is of improper length or material.	Discharge line must consist of at least 1.8 m (6 ft) of wire braid Teflon hose, copper tubing, or a combination of both between the discharge port of the compressor and the air dryer supply port. Discharge line lengths and inside diameter requirements are dependent on the vehicle application. Contact your local Bendix representative for further information.
Air system was charged from an outside air source that did not pass through an air dryer.	If the system must have an outside air fill provision, the outside air should pass through an air dryer. This practice should be minimized.
Air dryer is not purging.	Refer to "Problem—Air Dryer Does Not Purge or Exhaust Air."
Purge (air exhaust) is insufficient due to excessive system leakage.	Refer to "Problem—Air Dryer Is Constantly Cycling or Purging."

Troubleshooting

Possible Cause	Remedy
Air bypasses the desiccant cartridge assembly.	Replace the desiccant cartridge/end cover O-ring. Make sure the desiccant cartridge assembly is properly installed.
Purge (air exhaust) time is significantly less than the minimum allowable.	Replace the desiccant cartridge/end cover O-ring. Make sure the desiccant cartridge assembly is properly installed. Replace the desiccant cartridge assembly.
Excessive air usage—air dryer not compatible with vehicle air system.	Install an accessory bypass system. Consult your Bendix representative for additional information.

Problem—Safety Valve on Air Dryer Is Popping Off or Exhausting Air

Possible Cause	Remedy
Desiccant cartridge is plugged or saturated.	Check the compressor for excessive oil passing, or incorrect installation. Repair or replace as needed.
The check valve in the air dryer air cover is inoperative.	Test to determine if air is passing through the check valve. Repair or replace as needed.
There is a problem in the fittings, hose, or tubing between the air dryer and the wet tank.	See if air is reaching the first reservoir. Inspect for kinked tubing or hose. Check for undrilled or restricted hose or tubing fittings.
Pinging noise is due to a single cylinder compressor with high pulse cycles.	A slight pinging sound may be heard during system build-up when a single cylinder compressor is used. If this sound is deemed objectionable, it can be reduced substantially by increasing the discharge line volume. This is done by adding a 1475 cm^3 (90 in^3)reservoir between the compressor and the air dryer.
Safety valve setting is lower than the maximum system pressure.	Reduce the system pressure, or install a safety valve with a higher pressure setting.

Problem—Constant Exhaust of Air at the Air Dryer Purge Valve Exhaust; Unable to Build System Pressure

Possible Cause	Remedy
Air dryer purge valve is leaking excessively.	With the compressor loaded, apply a soap solution on the purge valve exhaust to test for excessive leakage. Repair the purge valve as needed.
The governor is inoperative.	Check the governor for proper cut-in and cut-out pressures, and excessive leakage in both positions. Repair or replace as needed.
Purge control line is connected to the reservoir or exhaust port of the governor.	Connect the purge control line to the unloader port of the governor.
Purge valve is frozen open due to an inoperative heater or thermostat, bad wiring, or a blown fuse.	Test the heater and thermostat, following instructions in this manual.
Inlet and outlet air connections are reversed—unable to build system pressure.	Reconnect the lines properly.
Discharge line is kinked or blocked.	See if air passes through the discharge line. Check for kinks, bends, or excessive carbon deposits.
There are excessive bends in the discharge line. Water is collecting and freezing.	Discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.

Possible Cause	Remedy
System is leaking excessively.	Test for excessive leakage. Eliminate leaks, as needed. Allowable leakage is as follows: • Single Vehicle—7 kPa/min (1 psi/min) per service reservoir • Tractor/Trailer—21 kPa/min (3 psi/min) per service reservoir
Purge valve stays open; supply air leaks to control side.	Replace the purge valve assembly O-rings.

Problem—Air Dryer Does Not Purge or Exhaust Air

Possible Cause	Remedy
Purge control line is broken, kinked, frozen, plugged, or disconnected.	See if air flows through the purge control line when the compressor is unloaded. The purge control line must be connected to the unloader port of the governor.
Air dryer purge valve isn't working.	See if air reaches the purge valve. If it does, repair the purge valve.
The governor is inoperative.	Check the governor for proper cut-in and cut-out pressures, and excessive leakage in both positions. Repair or replace as needed.
Inlet and outlet air connections are reversed—unable to build system pressure.	Reconnect the lines properly.
Discharge line is kinked or blocked.	See if air passes through the discharge line. Check for kinks, bends, or excessive carbon deposits.
There are excessive bends in the discharge line. Water is collecting and freezing.	Discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible.

Problem—Desiccant Is Being Expelled from the Air Dryer Purge Valve Exhaust (May Look Like Whitish Liquid, Paste, or Small Beads); or, Unsatisfactory Desiccant Life

Possible Cause	Remedy
This problem usually occurs with one or more of the previous problems.	Refer to the appropriate corrections listed previously.
Air dryer is not securely mounted; there is excessive vibration.	Vibration should be held to a minimum. Tighten the mounting fasteners.
Cloth-covered perforated plate in the air dryer desiccant cartridge is damaged, or the cartridge was rebuilt incorrectly.	Replace the plate or cartridge as needed. High operating temperatures may cause deterioration of filter cloth. Check the installation.
Compressor is passing excessive oil.	Check for proper compressor installation; if symptoms persist, replace the compressor.
Heater and thermostat, wiring, or a fuse is at fault, and isn't allowing the air dryer to purge during cold weather.	Test the heater and thermostat, following instructions in this manual.
Desiccant cartridge not attached properly to the end cover.	Check the torque and tighten if necessary. Refer to **Subject 120 for instructions.**

Troubleshooting

Problem—Pinging Noise Is Excessive During Compressor Loaded Cycle

Possible Cause	Remedy
Pinging noise is due to a single cylinder compressor with high pulse cycles.	A slight pinging sound may be heard during system build-up when a single cylinder compressor is used. If this sound is deemed objectionable, it can be reduced substantially by increasing the discharge line volume. This is done by adding a 1475 cm ^{3} (90 in ^{3}) reservoir between the compressor and the air dryer.

Problem—Constant Air Seepage at the Purge Valve (Non-Charging Mode)

Possible Cause	Remedy
Air compressor inlet is pressurized by the engine turbocharger.	Some pressure leakage past the metal seat of the turbocharger cutoff feature of the AD-9 air dryer is normal, and may be heard. This slight loss of air will not affect the engine or turbocharger performance.
Check valve assembly in the air dryer end cover is not working.	Remove the check valve assembly from the end cover. Apply compressed air to the delivery side of the valve. Apply a soap solution at opposite end, and check for leakage. Permissible leakage is a 2.5-cm (1-inch) bubble in 5 seconds. If there is excessive leakage, replace the check valve assembly.

Problem—Air Dryer Purge Piston Cycles Rapidly in the Unloaded Mode

Possible Cause	Remedy
Compressor does not "unload."	Check the governor installation: there is no air line from the governor to the compressor, or the line is restricted. Repair or replace as needed.

General Information

Air reservoirs serve two main purposes:

1. They store compressed air used to apply the brakes and operate other air-powered devices, such as window lifts, windshield wipers, and seats.
2. They provide a place where air, heated during compression, can cool and water vapor can condense into a liquid. Also, air reservoirs collect small amounts of oil passed by the compressor.

Each vehicle is equipped with three air reservoirs. Each reservoir is identified as one of three types: supply, primary, and secondary.

The supply reservoir (or wet tank) receives compressed air directly from the compressor. It collects most of the water and oil condensate from the air, and feeds air to the other reservoirs. At the outlet port of the supply reservoir (the port leading to the primary reservoir) is a safety valve, which protects the air system against excessive air pressure build-up.

The primary reservoir is the air source for the brakes on the rear axle. At the inlet port of the primary reservoir is an inline check valve. The check valve allows air flow in one direction only, and prevents air flow in the reverse direction in case there is a drop in upstream air pressure.

The secondary reservoir is the air source for the front axle brakes. It is equipped with an internal check valve.

The secondary reservoir supplies air to a pressure protection valve. This valve prevents complete loss of secondary air pressure if there is an air leak in any non-brake accessory.

All air reservoirs are equipped with drain valves to eject the water and oil emulsion from the tanks.

On vehicles equipped with an air dryer, the supply reservoir and the secondary reservoir are in a common tank. If there is no air dryer, the supply reservoir is a separate tank, mounted vertically in front of the secondary reservoir.

Tests

NOTE: If equipped with an automatic drain valve, refer elsewhere in this group for leak testing.

Be sure the air system is fully charged. Using a soap solution or leak detector, check for leaks on the outside surfaces of the reservoirs and drain valves. No leakage is permitted.

If leaks exist at the drain valve, note if they occur at the joint of the valve and coupler, or through the valve body. Go to **"Drain Valve Replacement and Leak Elimination, 110."**

If leaks occur on the surfaces of the air reservoir, replace the tank; refer to **"Air Reservoir Replacement, 120."**

Drain Valve Replacement and Leak Elimination

NOTE: If equipped with an automatic moisture-ejection valve, refer elsewhere in this group for instructions.

1. Apply the parking brakes, and chock the tires.
2. Drain the air system, using the instructions in the vehicle driver's manual.
3. Using two wrenches (hold the coupler in place with one of them), unscrew the drain valve from the coupler. Clean off the threads inside the coupler on the reservoir, removing all sludge and sealant build-up.

   Obtain a new drain valve if leaks occurred through the body of the valve.

   If leaks occurred at the joint of the drain valve and coupler, clean off the sludge and sealant from the threads of the valve. Check for damaged threads on the valve and inside the coupler. Replace damaged parts. If no damage exists, leakage was probably due to inadequate tightening of the drain valve in the coupler.
4. Apply Loctite®, or an equivalent sealant, to the end threads of the drain valve or coupler, as applicable, and install finger-tight. Tighten one and one-half additional turns (use two wrenches if installing the drain valve).
5. Perform a leak test after completing the installation. If leaks occur at the joint of the drain valve and coupler, tighten the valve up to one additional turn to stop the leaks.
6. Remove the chocks from the tires.

Air Reservoir Replacement

Replacement

1. Apply the parking brakes, and chock the tires.
2. Drain the air system, using instructions in the vehicle driver's manual.
3. Mark all reservoir air lines, couplers, and valves for later assembly. Carefully disconnect the parts. Cap the exposed ports tightly to keep out contaminants. If access is limited, remove the parts after removing the reservoir from its mount.
4. Remove the reservoir strap fasteners. Remove the reservoir.
5. If access is limited, do the next step first. If not, place a new reservoir in the mount, and install the strap fasteners. On two-piece straps (**Fig. 1**), tighten the nuts 20 to 25 lbf·ft (27 to 34 N·m). On one-piece straps (**Fig. 2**), tighten the nut 20 lbf·ft (27 N·m).
6. As referenced earlier, connect all air lines, couplers, and valves to the new reservoir, removing the caps as each part is installed.
7. Remove the chocks from the tires.

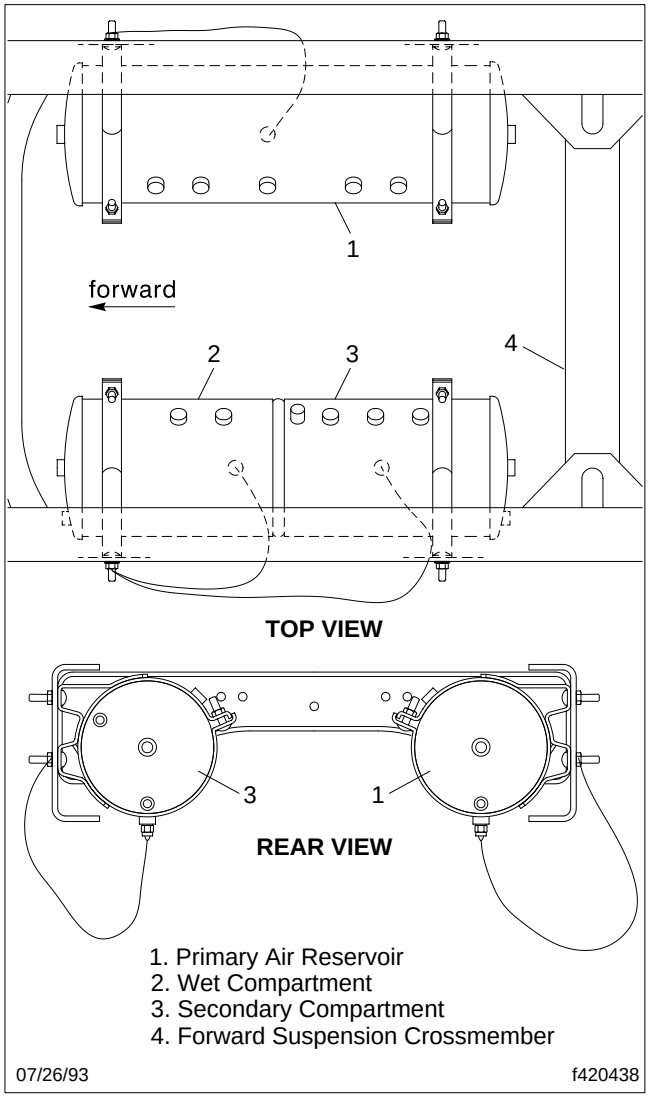


Fig. 1, Chassis Mounted Air Reservoirs (Vehicle Equipped With an Air Dryer)

Air Reservoir Replacement

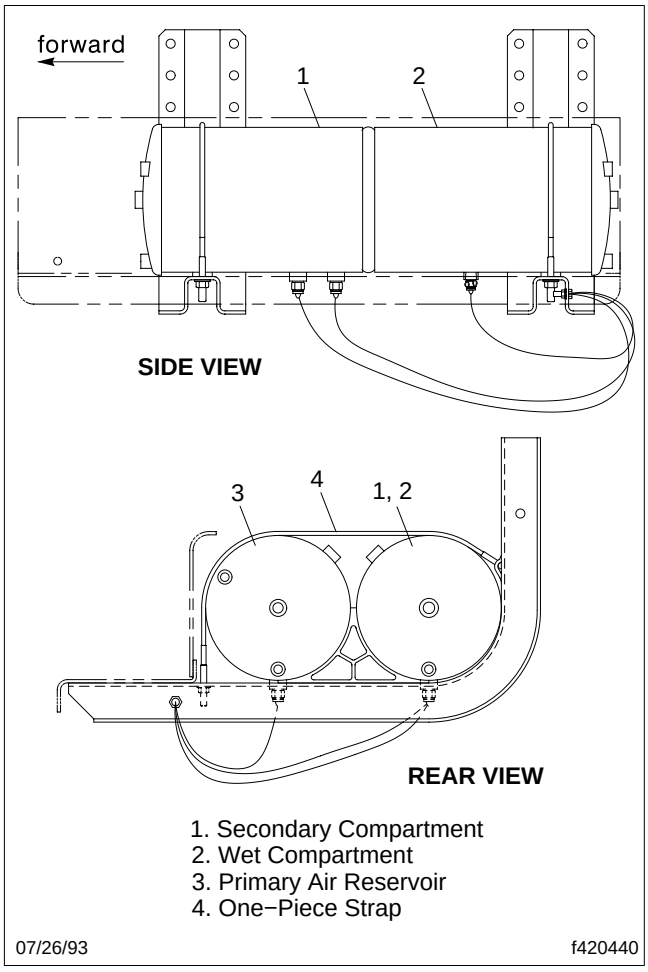


Fig. 2, Air Reservoirs Mounted on Left Step (Vehicle Equipped With an Air Dryer)

General Information

The DV-2 automatic reservoir drain valve **(Fig. 1)** automatically removes contaminants and water from the wet-air tank each time the brakes are applied. The drain valve is attached to a drain cock located on the bottom of either end of the wet-air tank. Since the brake foot valve is protected by a check valve between the wet-and dry-air tanks, any leak or sticking valve will not reduce the supply of air that is in the dry part of the system.

Principles of Operation

With no pressure in the system, the drain valve's inlet and exhaust valves are closed. **See Fig. 2.** Upon charging the system, a slight pressure opens the inlet valve which permits air and contaminants to collect in the sump. **See Fig. 3.** The inlet valve remains open when pressure is rising in the system until the air compressor cuts off, allowing the spring action of the valve guide in the sump cavity to close the inlet valve. The inlet valve and the exhaust valve are now both closed. **See Fig. 4.** When the wet tank pressure drops about 14 kPa (2 psi), the air pressure in the sump cavity opens the exhaust valve and allows moisture and contaminants to be ejected from the sump cavity until pressure in the sump cavity drops enough to close the exhaust valve. **See Fig. 5.**

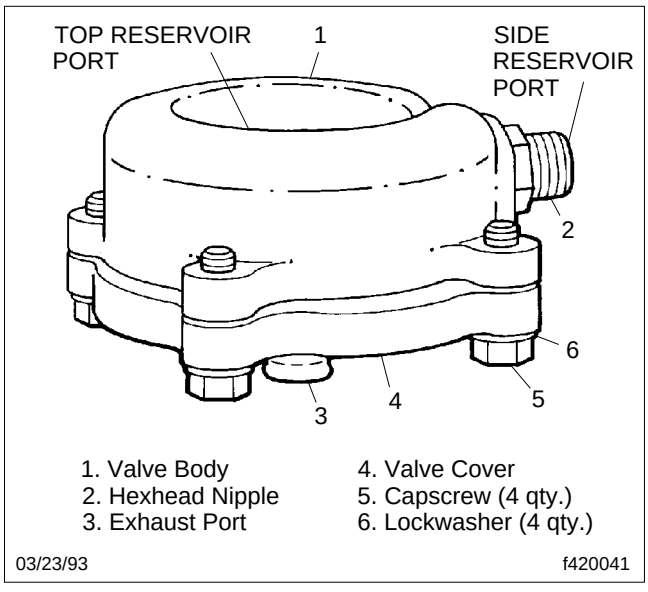


Fig. 1, DV-2 Valve

The length of time the exhaust valve remains open and the amount of moisture and contaminants ejected depends upon the sump pressure and the wet tank pressure drop that occurs each time air is used from the system.

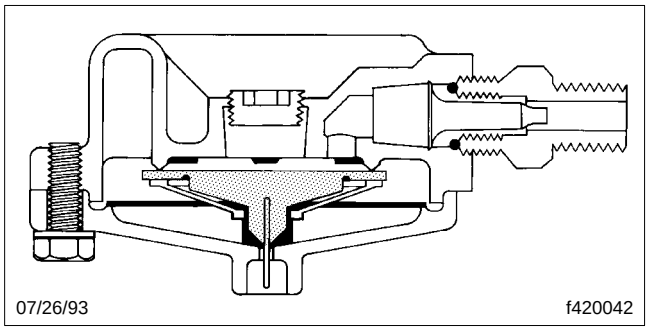


Fig. 2

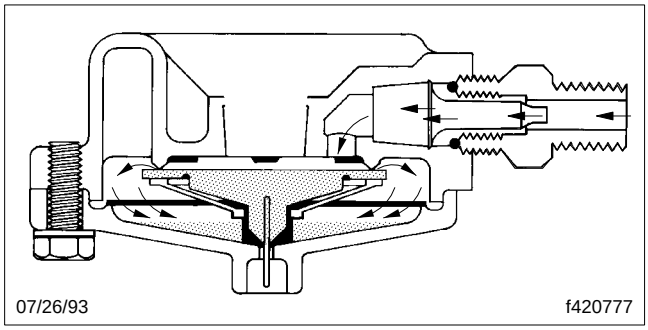


Fig. 3

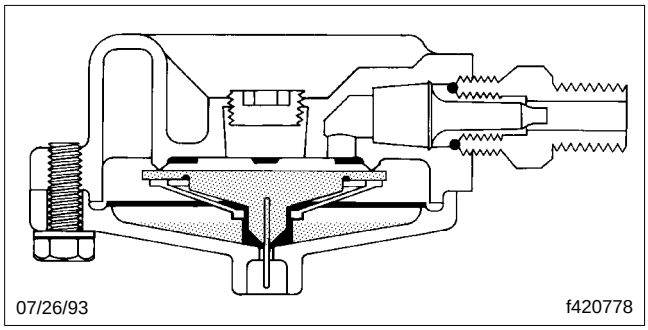


Fig. 4

General Information and Principles of Operation

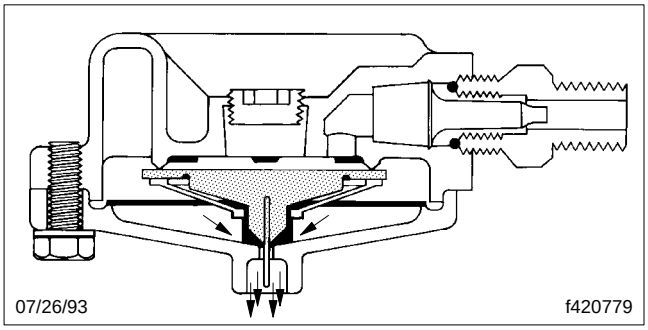


Fig. 5

Safety Precautions

When working on or around air brake systems and components, the following precautions should be observed:

1. Always chock the vehicle's wheels and stop the engine when working under a vehicle. Keep hands away from brake chamber push rods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing air pressure. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with air pressure. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood the recommended procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use only the correct tools and observe all precautions pertaining to use of those tools.

Operating Test

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

Do the following test after repairing or replacing the DV-2 valve to ensure that the valve is functioning correctly.

With the system charged, apply the brakes several times. Each time the brakes are applied, an exhaust of air should occur from the exhaust port of the drain valve. If no air comes out, push the wire stem located inside the exhaust port. If no air comes out after pushing the wire stem, there may be a plugged filter in the adapter which should be replaced.

If the drain valve does not function correctly, repair or replace it following instructions in this section.

Leakage Test

Perform the following test after repairing or replacing the DV-2 valve to ensure that the valve is functioning correctly.

With the system charged and pressure stabilized in the system, there should be no leaks at the drain valve exhaust port. A constant slight exhaust of air at the drain valve exhaust port could be caused by excessive leakage in the air brake system.

If the drain valve is leaking excessively, repair or replace it following instructions in this section.

Removal

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

1. Chock the tires, and drain the reservoirs.
2. Remove the drain valve assembly from the end of the wet tank reservoir.

Installation

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

⚠ WARNING

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

1. Using an approved cleaning solvent, flush and clean the wet tank reservoir to avoid early fouling at the drain valve. Aerate the wet tank completely if solvents were used during cleaning.
2. Install the drain valve assembly on the wet tank by tightening the hexagonal nipple until the drain valve is positioned so that the valve body is parallel to the bottom of the wet tank with the exhaust port facing straight down. Make sure that the exhaust port is clear of any air, electric, or fuel lines. Make sure the drain valve is attached tight enough to prevent leakage.
3. Close the drain cocks to the wet and dry air reservoirs. Start the vehicle engine to pressurize the air system.
4. Leak test the drain valve following the instructions under **"Operating and Leakage Tests, 110."**

Disassembly, Cleaning and Inspection, and Assembly

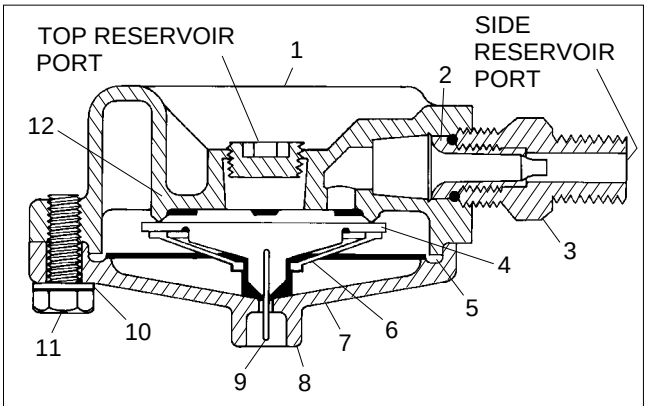
Disassembly (Refer to Fig. 1)

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

1. Remove the drain valve following the instructions under **"Removal and Installation, 120."**
2. Remove the four capscrews (Ref. 11) that hold the valve cover (Ref. 7) to the valve body (Ref. 1).
3. Remove the valve cover (Ref. 7) and sealing ring.
4. Remove the valve guide (Ref. 6) and the inlet and exhaust valve (Ref. 4) from the valve body.
5. Remove the hexhead nipple (Ref. 3) from the valve body.

Cleaning and Inspection

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**



1. Valve Body
2. Filter Retainer
3. Hexhead Nipple
4. Inlet and Exhaust Valve
5. Valve Seating Ring
6. Valve Guide
7. Valve Cover
8. Exhaust Port
9. Wire Stem
10. Lockwasher (4 qty.)
11. Capscrew (4 qty.)
12. Insle Valve Seat

07/27/93 f420780

Fig. 1, DV-2 Valve, Cutaway View

WARNING

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

Use eye protection when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

1. Wash all metal parts of the drain valve in an approved cleaning solvent. Dry the metal parts of the disassembled moisture ejection valve with compressed air.
2. Wipe all rubber parts clean with a clean cloth. Examine all rubber parts. If any rubber parts are worn, cracked, torn or otherwise deteriorated, replace them with new parts.
3. Examine all metal parts. If any metal parts are worn, cracked, or otherwise damaged, replace them with new parts.
4. Clean and examine the filter. If it will not clean completely, or is torn or damaged, replace it with a new filter.

CAUTION

CAUTION: Do not reassemble the drain valve with a dirty filter; to do so could result in failure of the drain valve in service.

Assembly (Refer to Fig. 1)

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

Before assembling the drain valve, apply a light film of grease on the inlet valve seat. See Ref. 12.

IMPORTANT: Do not apply oil to the inlet and exhaust valve.

1. Install the valve sealing ring (Ref. 5) into its groove in the valve cover.
2. Install the valve guide (Ref. 6) over the inlet and exhaust valve (Ref. 4).
3. Install the valve guide, and the inlet and exhaust

Disassembly, Cleaning and Inspection, and Assembly

valve as an assembly into the valve cover. The wire stem (Ref. 9) will project through the exhaust port (Ref. 8).

4. Install the valve body on the valve cover and install the lockwashers and capscrews. Tighten the capscrews 820 to 1080 N·cm (72 to 96 lbf·in).
5. Install the hexhead nipple onto the valve body, and tighten it 540 to 820 N·cm (48 to 72 lbf·in).
6. Install the drain valve on the wet tank following the instructions under **"Removal and Installation, 120."**

Specifications

This subject contains the following table:

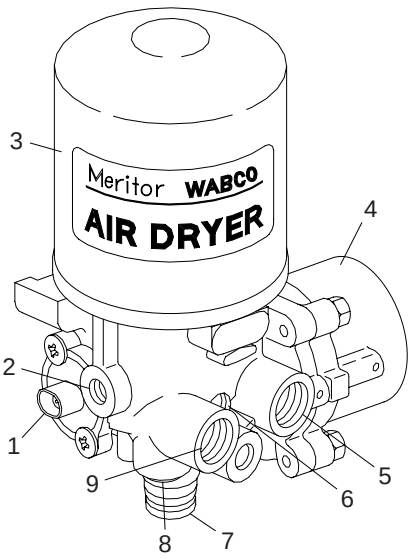
•Torque Values

Description	Torque N·cm (lbf·in)
Valve Cover Capscrews	820-1080 (72-96)
Hexhead Nipple (to valve body)	540-820 (48-72)

Table 1, Torque Values

General Information

The System Saver 1000 air dryer **(Fig. 1)** is a desiccant air dryer, mounted vertically between the air compressor and the supply reservoir. The air dryer receives hot compressed air, which it cools and filters before sending it to the supply reservoir, reducing the build-up of dirt and moisture in the vehicle air system.



1. Heater/Thermostat Assembly
2. Governor Port (to air governor)
3. Desiccant Canister
4. Regeneration Valve Assembly
5. Outlet Port (to air supply reservoir)
6. Bypass Valve Assembly
7. Exhaust Port (Purge Valve Assembly)
8. Turbocharger Cutoff Valve
9. Inlet Port (from air compressor)

Fig. 1

The air dryer consists of a light weight aluminum and steel body. The desiccant cartridge is contained in a spinoff canister at the top of the air dryer.

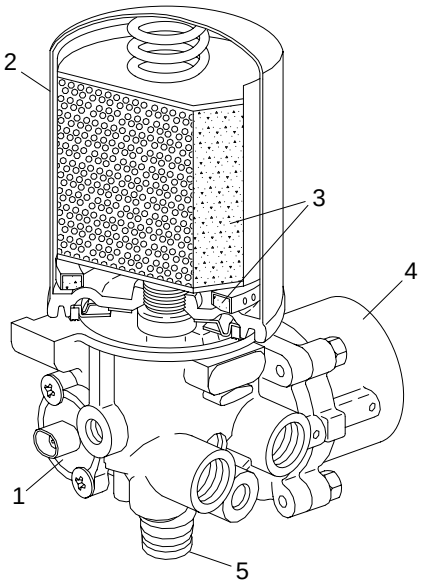
The bottom half of the air dryer houses the following components.

- Bypass Valve–this valve allows air flow in the air dryer to go directly to the outlet port, bypassing the desiccant filter.
- Desiccant Canister–a cylindrical steel housing that contains the filter elements and the desiccant needed to filter and dry the air that passes through it.
- Heater/Thermostat Assembly–located in the air dryer base, this assembly is designed to prevent the collected moisture from freezing.
- Outlet Check Valve–this valve prevents air in the system from flowing back through the air dryer and escaping out the purge valve during the compressor unload cycle.
- Pressure-Controlled Check Valve–this valve is separate from the air dryer and is installed on the secondary air tank. The valve allows air to back flow from the secondary tank to the supply tank as long as air system pressure remains between the normal cut in and cut out range of the air governor.
- Purge Valve–this valve allows the collected moisture and contaminants to be expelled from the air dryer during the purge cycle.
- Regeneration Valve–this valve allows air from the supply and secondary tanks to bypass the outlet check valve and flow into the regeneration valve. Air then flows through an orifice where the air expands and back flushes moisture off of the desiccant. The air is then exhausted through the purge valve.
- Silencer (Muffler)–an optional component that is attached to the purge valve and used to eliminate most of the noise during the air dryer purge cycle.
- Turbocharger Cut-Off Valve–this valve closes the path between the air compressor and the air dryer purge valve to help maintain boost pressure for maximum engine horsepower during the compressor unload cycle.

Principles of Operation

Hot, compressed air enters the air dryer through the inlet port. As the hot air is forced into the desiccant cartridge, the temperature of the compressed air falls to nearly ambient. Oil and water vapor condense and initially settle into the base of the dryer. The moisture-laden air also passes through the desiccant bed, where any remaining moisture is retained by the desiccant. The clean air then passes through the air dryer outlet port to the supply reservoir. **See Fig. 2 .**

General Information and Principles of Operation



1. Heater/Thermostat Assembly
2. Desiccant Canister
3. Filter
4. Regeneration Valve Assembly
5. Exhaust Port (Purge Valve Assembly)

Fig. 2

When the compressor reaches 827 kPa (120 psi), the purge valve opens allowing the initial decompression of the dryer and expels the water and contaminants collected in the base of the dryer. The regeneration valve, along with the pressure-controlled check valve, allows the system air to flow back through the dryer. This back flow dries the desiccant for the next cycle.

Safety Precautions

⚠ WARNING

WARNING: When draining the air system, don't look into the air jets or direct them toward another person, as dirt or sludge particles may be in the airstream. Don't disconnect pressurized hoses because they may whip as air escapes from the line. Failure to take all necessary precautions during service operations of the air brake system can cause personal injury.

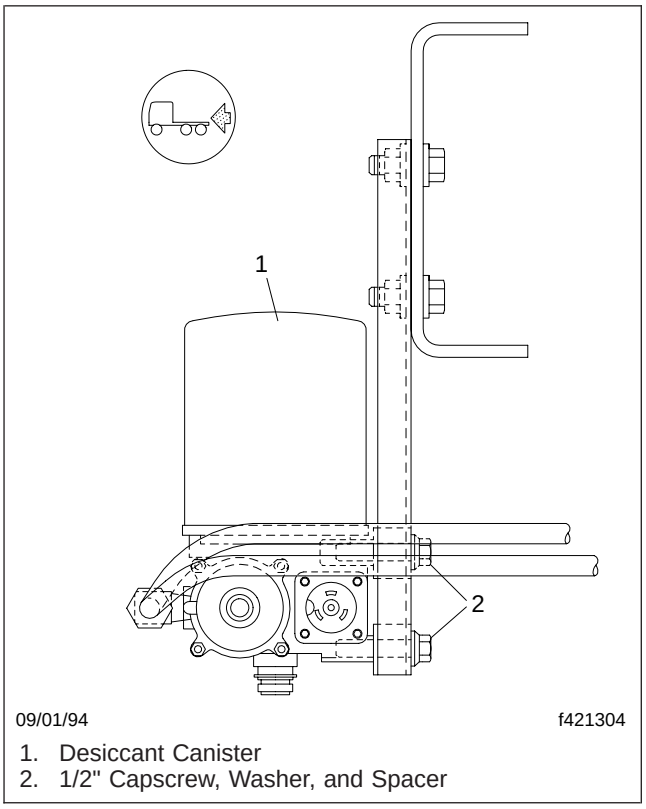
When working on or around air brake systems and components, observe the following precautions.

1. Apply the parking brake, chock the tires, and stop the engine when working under the vehicle. Draining the air system may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters, which may apply as air system pressure drops.
2. Wear safety goggles.
3. Never connect or disconnect a hose or line containing air under pressure; it may whip as air escapes. Never remove a component or pipe plug unless you are sure all system pressure has been depleted.
4. Don't disassemble a component before reading and understanding recommended procedures. Use only the correct tools and follow basic tool safety.
5. Replacement hardware, tubing, hose, fittings, etc. should be the same size, type, length, and strength as the original equipment. When replacing tubing or hose, be sure that all of the original supports, clamps, or suspending devices are installed or replaced.
6. Replace any components that have stripped threads or damaged parts. Don't attempt to repair parts by machining.
7. Never exceed recommended air pressure.

⚠ WARNING

WARNING: Before starting the procedures below, read the information in Safety Precautions 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

Removal (See Fig. 1)



1. Desiccant Canister
2. 1/2" Capscrew, Washer, and Spacer

Fig. 1, Air Dryer Installation (outboard rail mounting shown)

1. Drain the air system.
2. Disconnect the wiring harness from the air dryer.
3. Mark the air lines for later reference; then, disconnect them from the air dryer.
4. Remove the capscrews, washers, and spacers that attach the air dryer to the mounting bracket.
5. Remove the air dryer.

Installation (See Fig. 1)

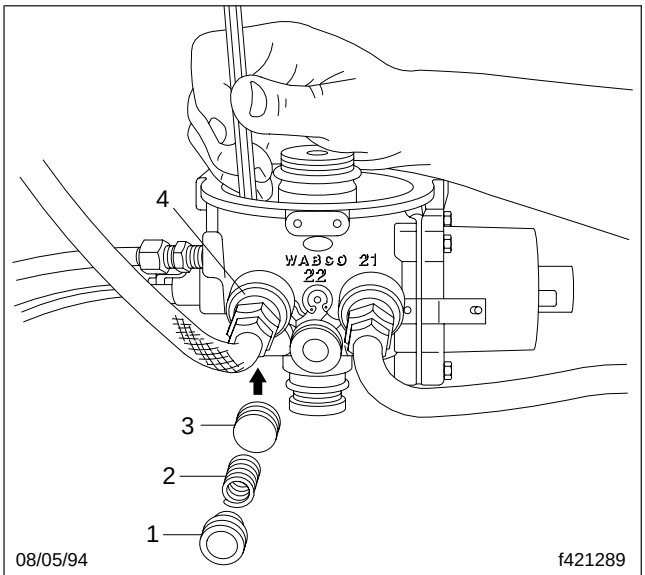
1. Position the air dryer on the mounting bracket. Install the spacers, washers, and capscrews. Tighten them 30 to 41 N·m (22 to 30 lbf·ft).
2. Make sure the air lines are clean. Replace any line or fitting that is crimped or damaged.
3. Connect the remaining air lines to the air dryer as previously marked. Tighten the nut on each fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance.
4. Connect the air dryer wiring harness.

Replacement

⚠ WARNING

WARNING: Before starting the procedures below, read the information in Safety Precautions 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Remove the snap ring at the bottom of the valve assembly. The valve cover and spring may fall out of the cavity when the snap ring is removed. See Fig. 1.



1. Cover
2. Spring
3. Piston
4. Inlet Port

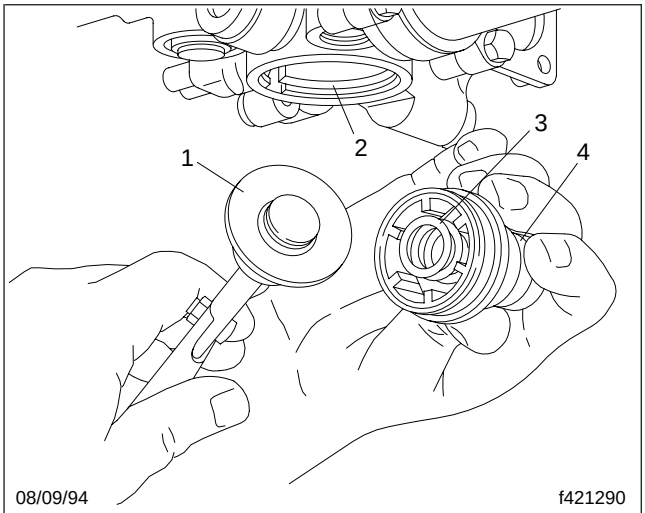
Fig. 1

3. Using a strap wrench, turn the desiccant cartridge counterclockwise and remove it.
4. Using a wooden stick, push the piston, spring, and the cover out of the valve cavity.
5. Clean the valve cavity with a commercial cleaning solvent.
6. Install new O-rings on the piston and the cover.
7. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-rings and the valve cavity.
8. Install the new piston with its hollow side facing out.

If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

9. Install the new spring, cover, and snap ring to hold the components in place.
10. Thread the desiccant cartridge onto the dryer base (turn clockwise). When the seal contacts the base, tighten the cartridge one complete turn more. Do not over tighten.

Replacement (See Fig. 1)



1. Valve Assembly
2. Exhaust Port
3. Spring
4. Valve Head

Fig. 1

WARNING

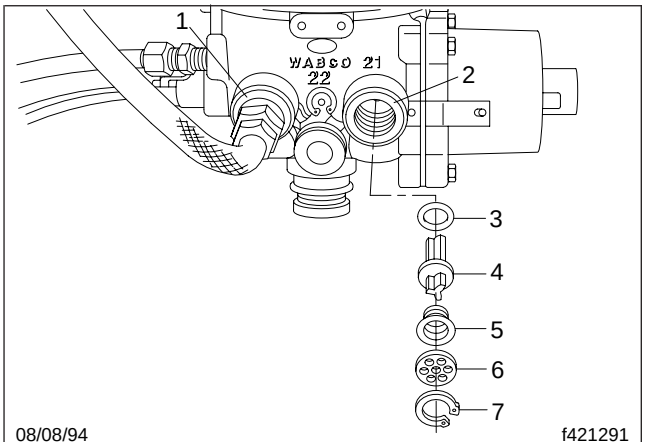
WARNING: Before starting the procedures below, read the information in Safety Precautions 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Remove the snap ring, valve head, and the spring from the exhaust port.
3. Pull the valve assembly out of the exhaust port.
4. Remove the O-ring from the base of the exhaust port.
5. Clean the purge valve cavity area with a commercial cleaning solvent.
6. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the valve cavity and to all of the new O-rings. Install the O-rings in the base of the exhaust port and on the valve head.
7. Position the new valve assembly in the valve cavity.

If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

8. Install the spring in the valve head, and position them in the valve cavity.
9. Install the snap ring to secure the valve head in position.

Replacement (See Fig. 1)



1. Inlet Port
2. Outlet Port
3. O-Ring
4. Valve Body
5. Spring
6. Washer
7. Snap Ring

Fig. 1

⚠ WARNING

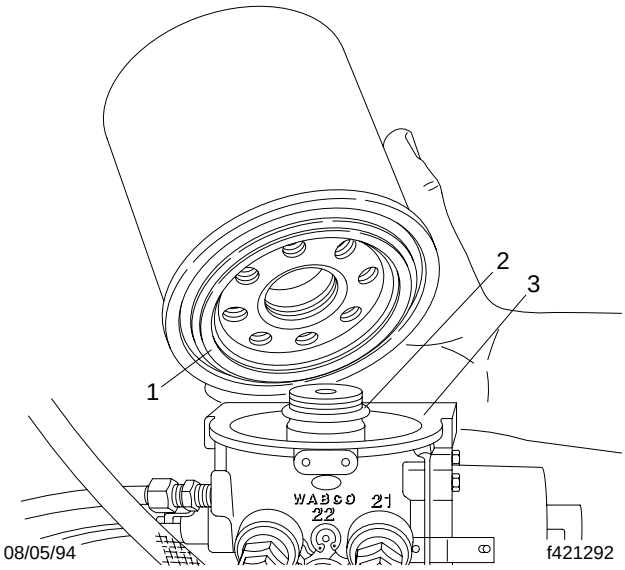
WARNING: Before starting the procedures below, read the information in Safety Precautions 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Disconnect the air line from the outlet port.
3. Remove the snap ring, washer, valve body, and the O-ring.
4. Clean the cavity area with a commercial cleaning solvent.
5. Install a new O-ring on the valve body.
6. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-ring and the valve cavity.
7. Install the new valve body. Make sure that the long end of the body is inserted first into the valve cavity.
8. Install the new spring with its small end around the "Y" shaped fins on the valve body.

If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

9. Install a new washer and snap ring to secure the assembly in the valve cavity.
10. Connect the air line to the outlet port. Tighten the nut on the fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance. Tighten the nut one-sixth turn more.

Replacement (See Fig. 1)



1. Seal
2. O-Ring
3. Air Dryer Base

Fig. 1

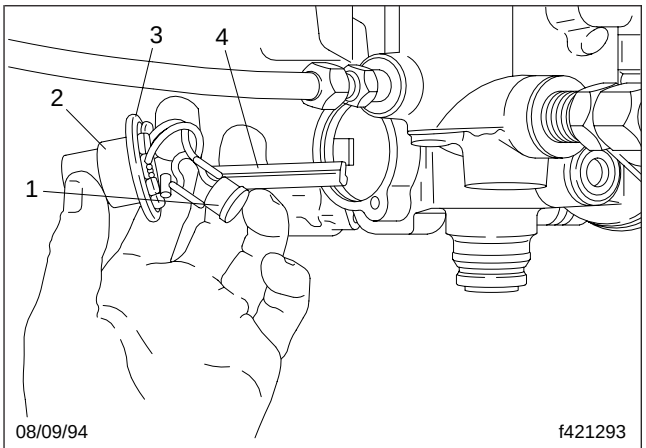
WARNING

WARNING: Before starting the procedures below, read the information in Safety Precautions 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Using a strap wrench, turn the desiccant cartridge counterclockwise and remove it.
3. Remove and discard the O-ring.
4. Clean the top surface of the dryer base with a commercial cleaning solvent.
5. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-ring and the dryer base. Install the O-ring.
6. Thread the desiccant cartridge onto the dryer base (turn clockwise). When the seal contacts the base, tighten the cartridge one complete turn more. Do not over tighten.

If the air dryer base is damaged, preventing a tight seal, replace the air dryer.

Replacement (See Fig. 1)



1. Thermostat
2. Receptacle
3. O-Ring
4. Element

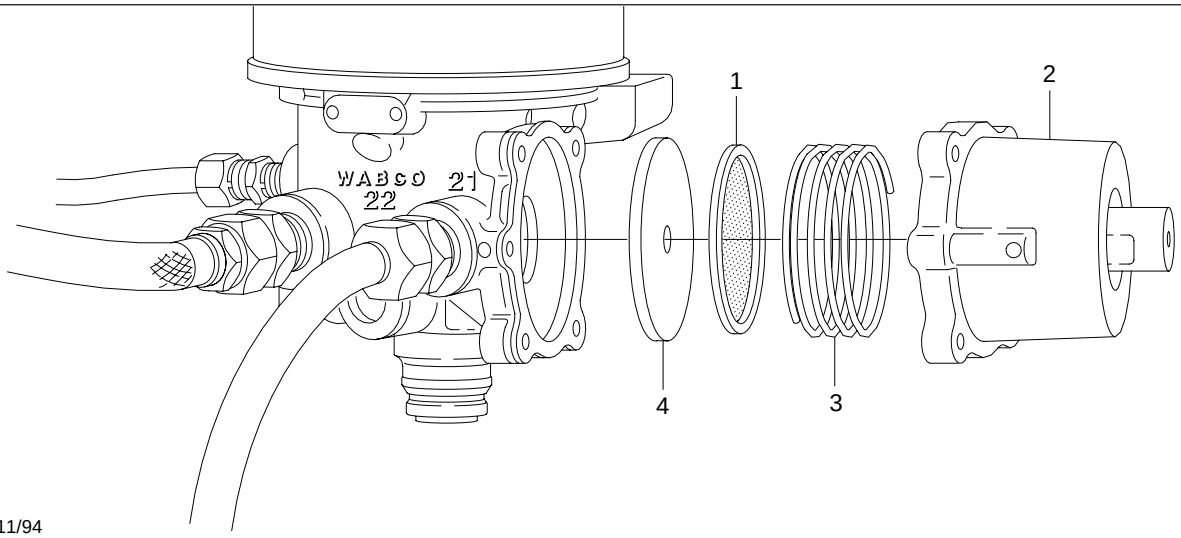
Fig. 1

⚠ WARNING

WARNING: Before starting the procedures below, read the information in Safety Precautions 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Disconnect the wiring harness.
3. Remove the screws that attach the heater/thermostat receptacle. Remove the receptacle and the O-ring.
4. Remove the retaining screw that holds the assembly in place. Remove and discard the heater/thermostat assembly.
5. Clean the heater/thermostat assembly area with a commercial cleaning solvent.
6. Position the new heater/thermostat assembly in the cavity. Install the retaining screw.
7. Position the new receptacle and O-ring, and install the screws. Tighten the screws securely.
8. Connect the wiring harness.

Replacement (See Fig. 1)



1. Retainer
2. Valve Housing Assembly
3. Spring
4. Diaphragm

Fig. 1

WARNING

WARNING: Before starting the procedures below, read the information in Safety Precautions 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.

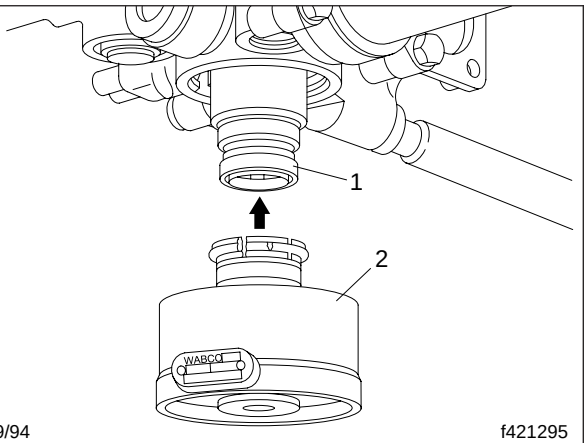
NOTE: When the valve housing is removed, the spring and the retainer will fall out of the housing.

2. Remove the four mounting bolts and remove the valve housing assembly.
3. Remove the rubber diaphragm.
4. Clean the groove where the diaphragm lip fits with a commercial cleaning solvent.
5. Install a new diaphragm with its lip in the groove.

If the groove is damaged, preventing a tight seal, replace the air dryer.

6. Install the new spring and retainer (with the retainer lip facing out).
7. Position the valve housing on the air dryer. Install the bolts and tighten them to 600 N·cm (53 lbf·in).

Replacement (See Fig. 1)



1. Purge Valve Head
2. Silencer

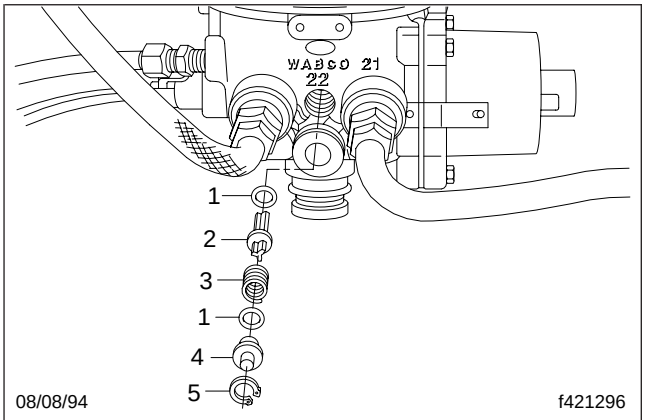
Fig. 1

WARNING

WARNING: Before starting the procedures below, read the information in Safety Precautions 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Using snap ring pliers, expand the snap ring and pull the silencer off of the purge valve head.
2. Push the new silencer onto the purge valve head until the silencer snaps into place.

Replacement (See Fig. 1)



1. O-Ring
2. Valve Body
3. Spring
4. Cover
5. Snap Ring

Fig. 1

⚠ WARNING

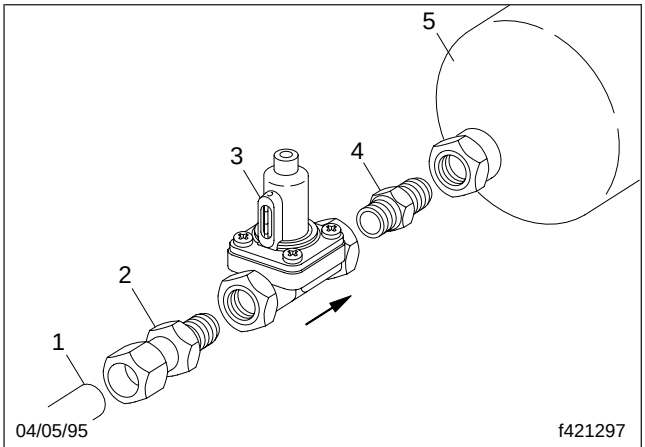
WARNING: Before starting the procedures below, read the information in Safety Precautions 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Remove the snap ring, cover, spring, and valve body.
3. Clean the cavity area with a commercial cleaning solvent.
4. Install new O-rings on the valve body and cover.
5. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-rings and the valve cavity.
6. Install the new valve body. Make sure that the long end of the body is inserted first into the valve cavity.
7. Install the new spring so it fits around the "Y" shaped fins on the valve body.

If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

8. Install the new cover and snap ring to secure the assembly in the valve cavity.

Replacement (See Fig. 1)



1. Air Line
2. Nylon Tube Connector
3. Pressure-Controlled Check Valve
4. Hex Nipple Pipe Fitting
5. Air Tank

Fig. 1

⚠ WARNING

WARNING: Before starting the procedures below, read the information in Safety Precautions 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

1. Drain the air system.
2. Disconnect the air line from the pressure-controlled check valve.
3. Remove the valve and the hex nipple fitting from the air tank.
4. Install the pipe fitting on the new valve.
5. Install the new valve on the air tank with the arrow on the valve pointing towards the tank.
6. Apply liquid Loctite® Hydraulic Sealant (brown), or an equivalent, to the air line threads. Connect the air line to the valve. Tighten the air line securely.

NOTE: Always apply sealant to the external threads so that any excess will be scraped off externally rather that internally to the joint.

Operating Tests

⚠ WARNING

WARNING: Before starting the procedures below, read the information in Safety Precautions 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.

Air Dryer Operating Check

1. Drain the air system.
2. Start the engine and build the air pressure to as close to cutout pressure as possible (about 827 kPa [120 psi]).
3. When the compressor reaches the unload cycle, the air dryer purges, beginning regeneration of the air dryer.
4. During the purge cycle, which lasts about 10 to 15 seconds, the wet tank and secondary tank will drop about 69 kPa (10 psi). Check the secondary air gauge in the cab dash panel.
5. If the gauge needle does not show a pressure drop of about 69 kPa (10 psi), one of the following problems may exist.
   - A pressure-controlled check valve is not installed.
   - The pressure-controlled check valve is installed in the wrong air tank.
   - The pressure-controlled check valve is installed on a one-way check valve, instead of in place of a one-way check valve.
   - There is an extra check valve located somewhere between the air dryer and the secondary air tank (usually at the wet tank).
   - The secondary air gauge is not plumbed to the secondary air system.
6. If secondary air pressure drops 103 kPa (15 psi) or more during the purge cycle, and there are no other air-operated components in use, then there are air leaks or other system problems. Refer to **Troubleshooting 300** for other possible causes.

Pressure-Control Check Valve Operating Check

IMPORTANT: Install a calibrated air gauge (accurate to within 7 kPa [1 psi]) in the secondary air tank to check the control valve. Do not use the cab air gauges.

1. Start the engine and build the air pressure to as close to cutout pressure as possible (about 827 kPa [120 psi]).
2. Stop the engine after the air compressor has unloaded.
3. Drain the primary air tank(s) down to about 552 kPa (80 psi).
4. Check the calibrated air gauge. It should read 655 ± 34 kPa (95 ± 5 psi).

   If the gauge reading is less that 586 kPa (85 psi), either the pressure-control check valve is installed backwards, it is damaged, or there are air leaks in the secondary air system.

   If the gauge reading does not change, or the reading does not fall below 724 kPa (105 psi), make the checks under "Air Dryer Operating Check." If none of those problems exist, replace the control valve.

Troubleshooting Tables

Problem—Purge Cycle is too Long (more than 30 seconds)

Possible Cause	Remedy
The air dryer outlet check valve is stuck open.	Replace the check valve assembly.
The turbocharger cutoff valve is leaking.	Replace the turbocharger cutoff valve.
The regeneration valve is not working correctly.	Replace the regeneration valve.

Problem—Purge Cycle is too Short (less than 8 seconds)

Possible Cause	Remedy
The air governor is not working.	Replace the air governor.
The pressure-control check valve is not working correctly.	Replace the pressure-control check valve.
The regeneration valve is not working correctly.	Replace the regeneration valve.

Problem—System Air Pressure Drops Rapidly

Possible Cause	Remedy
Fittings are loose or damaged.	Tighten or replace loose or damaged fittings.
Air reservoir, tubing, or hoses are damaged.	Repair or replace damaged items.
The air dryer outlet check valve is stuck open.	Clean or replace the outlet check valve assembly.

Problem—Excessive Cycling of the Air Dryer

Possible Cause	Remedy
Fittings are loose or damaged.	Tighten or replace loose or damaged fittings.
Air reservoir, tubing, or hoses are damaged.	Repair or replace damaged items.
The air dryer outlet check valve is leaking or stuck open.	Replace the outlet check valve assembly.
High air usage or demand for a particular system.	Increase air system capacity or reduce air demand.
The governor is not working properly.	Replace the air governor.
The air compressor needs to be serviced or replaced.	Rebuild or replace the air compressor.

Troubleshooting

Problem—Water and/or Oil in the Vehicle Air Reservoirs

Possible Cause	Remedy
The desiccant cartridge contains excessive contaminants.	Replace the desiccant cartridge.
Purge cycle is too short.	Refer to "Problem—Purge Cycle is too Short (less than 8 seconds)."
The bypass (relief) valve is leaking.	Replace the bypass valve.
Too much oil is pumped from the air compressor.	Rebuild or replace the air compressor.
The regeneration valve is not working correctly.	Replace the regeneration valve.
The air dryer is mounted too close to a heat source.	Locate the air dryer away from heat sources and where air can flow around it.
Discharge line is of improper length or material.	Discharge line must consist of at least 6 ft. (1.8 m) of wire braid Teflon hose, copper tubing, or a combination of both between the discharge port of the compressor and the air dryer supply port. Discharge line lengths and inside diameter requirements are dependent on the vehicle application. Contact your local Rockwell WABCO representative for further information.

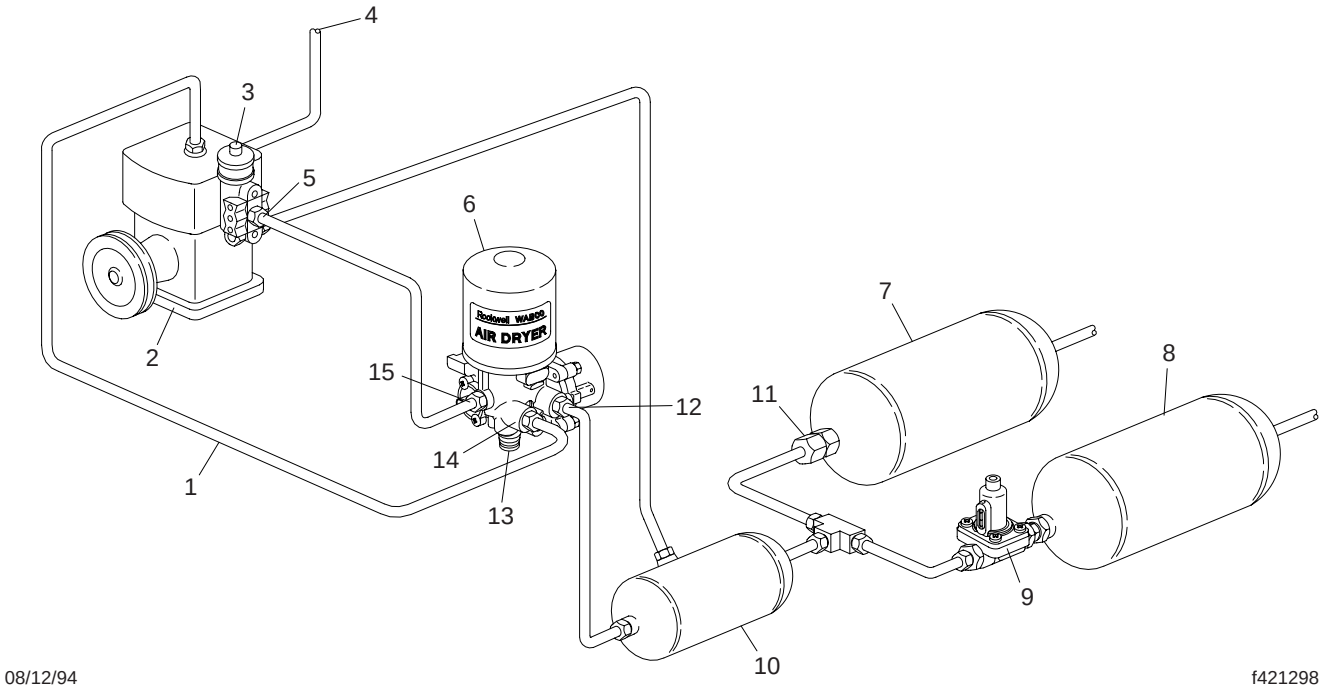
Problem—The Air Compressor Runs Continuously (System Pressure Will Not Build Up)

Possible Cause	Remedy
Fittings are loose or damaged.	Tighten or replace loose or damaged fittings.
Air reservoir, tubing, or hoses are damaged.	Repair or replace damaged items.
The air compressor needs to be serviced or replaced.	Rebuild or replace the air compressor.
The purge valve is stuck open.	Replace the purge valve.
The line between the air compressor and the air dryer is blocked, leaks, or is plumbed incorrectly.	Repair or replace the line as needed.
The governor is not working properly.	Replace the air governor.
The turbocharger cutoff valve or the outlet check valve is stuck in the closed position.	Replace the turbocharger cutoff valve or the outlet check valve.
The desiccant cartridge or cartridge seal is leaking.	Tighten or replace the desiccant cartridge.
The wrong air line is connected to port 4 on the air dryer.	Correct the air line plumbing.
The air dryer outlet port is plumbed incorrectly.	Connect the outlet port line to the supply air tank.
The air dryer base is cracked.	Replace the air dryer.

Problem—The Air Dryer Does Not Unload When the Air Compressor Goes Into Standby Mode

Possible Cause	Remedy
The line between the air governor and the air dryer purge port is missing, loose, or damaged.	Install or replace the air line, or tighten the fittings.
The heater/thermostat assembly is not working.	Replace the heater/thermostat assembly or check the electrical connections.

See Fig. 1 for the plumbing diagram.



1. Compressor Discharge Line
2. Air Compressor
3. Air Governor
4. Compressor Intake Line
5. Unloader Port
6. Air Dryer
7. Primary Reservoir
8. Secondary Reservoir
9. Pressure-Control Check Valve
10. Supply Tank
11. Check Valve
12. Air Dryer Outlet
13. Purge Valve
14. Air Dryer Inlet
15. Air Governor Port

Fig. 1, Air Dryer Plumbing Diagram

General Description

The Sloan PV-1 parking brake air valve is installed on trucks with air brakes, and is used to control the rear axle parking brakes. It is a push-pull type of valve, and is mounted on the right side of the dash. **See Fig. 1.**

Principles of Operation

When the valve knob is pulled out, air is exhausted from the rear parking brake chambers, releasing the springs, and applying the parking brakes. When the knob is pushed in, air flows into the parking brake chambers from one of the reservoirs, and compresses the springs, releasing the parking brakes.

The PV-1 has a double check valve feature. If the pressure drops in either air system (primary or secondary), the valve will automatically use air pressure from the system with the higher pressure for the parking brakes. This prevents the parking brakes from applying unless pressure is lost from both systems.

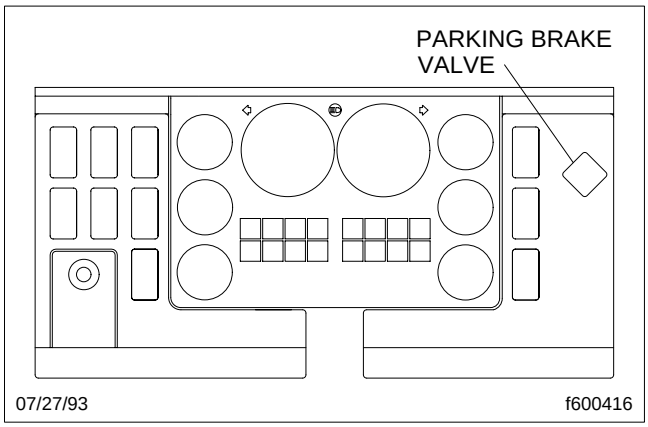


Fig. 1

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Chock the tires and stop the engine before working under a vehicle. Keep hands away from brake chamber push rods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.

Operating Test

1. Chock the tires.
2. Start the engine and build up the air pressure to the normal operating level.
3. Push the parking brake knob in to release the parking brakes.
4. Turn off the engine, then drain one of the air reservoirs.
5. Check if the parking brakes apply.

   If they do, the double check valve feature isn't working; replace the entire PV-1 valve assembly.

   If the parking brakes don't apply, go to the next step.
6. Start the engine again, and build up the air pressure to the normal operating level.
7. With the parking brakes still released, turn off the engine; then drain the other air reservoir.
8. Check if the parking brakes apply.

   If they do, the double check valve feature isn't working; replace the entire PV-1 valve assembly.

   If the parking brakes don't apply, the double check valve feature is working.

Leak Testing

1. Chock the tires.
2. Start the engine, and build up the air pressure to the normal operating level.
3. Coat the delivery line and exhaust line fittings on the parking valve with a soapy solution.
4. Release the parking brakes.
5. Check the leakage. Leakage at the fittings should not exceed a 2.5-cm (1-inch) bubble every three seconds. If it does, replace or rebuild the valve, following instructions under **Subject 120** or **Subject 130.**
6. Apply the parking brakes.

Removal (Refer to Fig.1)

WARNING

WARNING: Review the precautions under "Safety Precautions, 100" before doing any work on the parking brake valve. Failure to do so could result in personal injury.

1. Chock the tires.
2. Discharge the air system reservoirs.
3. Drive out the roll pin (Ref. 5), then remove the knob from the valve stem.
4. Mark the air supply, delivery, and exhaust lines for later reference, then disconnect them from the valve assembly.
5. Remove the panel mounting nut (Ref. 3), then remove the valve assembly from the dash panel.

Installation

1. Put the valve assembly into the dash, then install the panel mounting nut. Don't tighten the nut completely.
2. Turn the valve assembly so the air lines will reach their fittings.
3. Connect the air supply, delivery, and exhaust lines to the applicable fittings.
   - 3.1 Tighten the fitting hand tight.
   - 3.2 Using a wrench, tighten the fitting until the connection feels firm.
   - 3.3 Tighten the fitting an additional one-sixth turn.
4. Tighten the panel mounting nut firmly.
5. Put the knob onto the valve stem, making sure the label on the valve is parallel with the top of the dash, **as shown in Fig.1.** Then drive in the roll pin.
6. Leak test the fittings, following the instructions under **"Leak Testing, 110."**

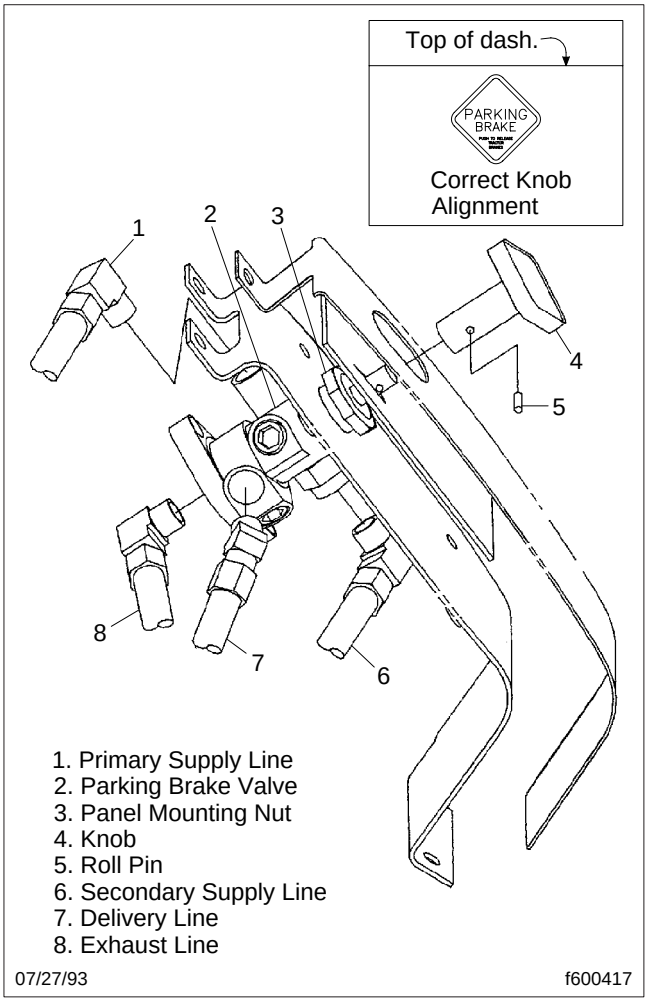


Fig. 1

Disassembly (See Fig. 1)

1. Remove the valve assembly from the dash, following instructions in **Subject 120**.
2. Put the valve assembly in a soft-jawed or padded vise.
3. Remove the screws (Ref. 9) from the cover (Ref. 11).
4. Carefully remove the cover, cover seal (Ref. 12), and spring (Ref. 10). Discard the cover seal.
5. Insert a rod through the pin hole (Ref. 1) of the shaft to keep it from turning, then remove the hexnut (Ref. 8) from the bottom of the shaft.
6. Remove and discard the seal cup (Ref. 14), seal (Ref. 7), and the washer (Ref. 5) from the shaft.
7. Remove the shaft (Ref. 4) from the valve body.
8. Remove and discard the O-ring (Ref. 2) from the shaft.

Assembly (See Fig. 1)

1. Clean and dry all the parts.
2. Check all the parts. If any wear or damage is found, replace the entire valve assembly.
3. Lightly grease all the parts— including the new parts from the seal kit— with Dow Corning 55 silicone pneumatic grease or equivalent.
4. Install a new O-ring (Ref. 2) on the shaft (Ref. 4).
5. Install the shaft in the valve body.
6. Install a new washer (Ref. 5) on the step of the shaft.
7. Assemble a new seal (Ref. 7) into the new seal cup (Ref. 14), then install them on the step of the shaft, with the seal against the washer (Ref. 5).
8. Apply Loctite 222® or equivalent on the threads of the new hexnut (Ref. 8).
9. Install the hexnut— counter-bored side toward the seal (Ref. 7)—on the end of the shaft. Tighten the nut 460 N·cm (40 lbf·in).
10. Install a new cover seal (Ref. 12) in the cover with the raised lip (Ref. 13) on the cover seal toward the valve.
11. Grease the sealing surfaces of the seal cup (Ref. 14), and the cover seal (Ref. 12).
12. Install the spring (Ref. 10) and then the cover (Ref. 11).
13. Install the cover screws. Tighten them firmly.
14. Install the valve in the dash, then leak test it. Follow instructions in **Subject 120** and **Subject 110**.

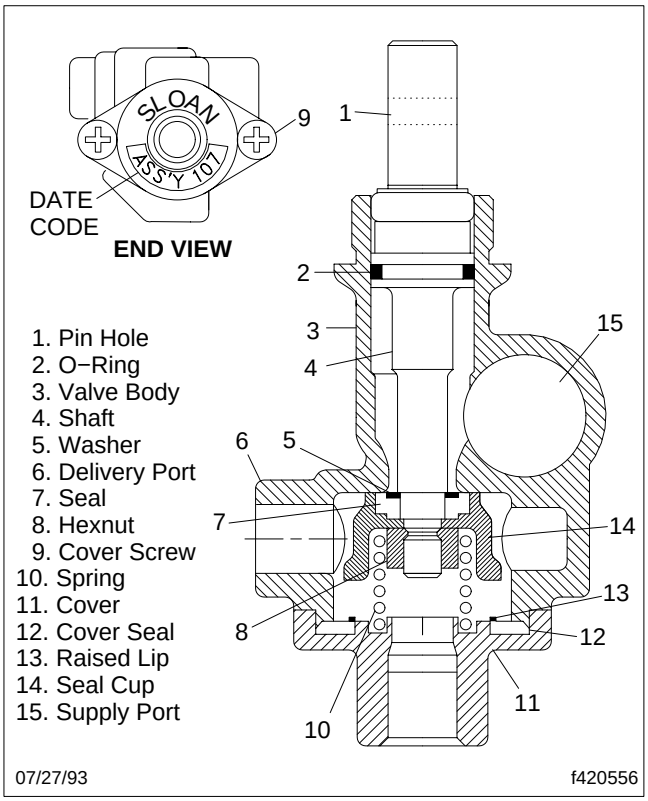


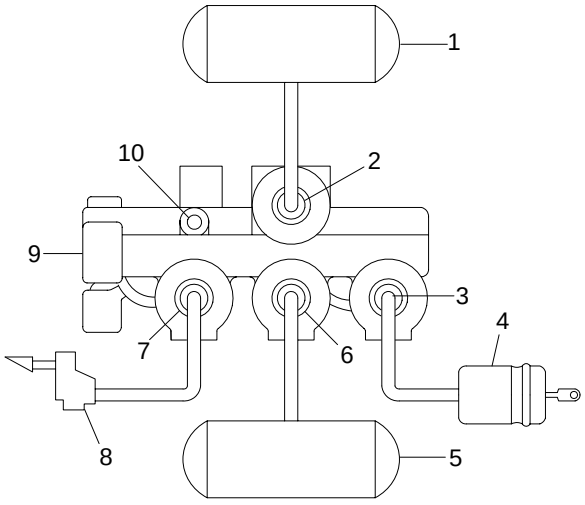
Fig. 1, Valve Assembly

General Description

The dash-mounted MV-3 control module is a two-button, push-pull control valve housed in a single body, which includes a dual circuit supply valve and a check valve.

The valve body, plungers, and spools are made out of a nonmetallic, noncorrosive material. All air connections are at the back of the valve with the exception of the optional auxiliary port, which is located in the side of the valve. **See Fig. 1.**

The MV-3 module has several uses: tractor protection control; trailer service air supply; system park; trailer park only; trailer charge with tractor spring brakes applied (tractor park only); and supply reservoir selection.



1. Primary Reservoir
2. Primary Reservoir Supply Port
3. Delivery−Tractor Port
4. Spring Brake Chamber
5. Secondary Reservoir
6. Secondary Reservoir Supply Port
7. Delivery−Trailer Port
8. Tractor Protecton Valve
9. Auxiliary Air Delivery Port
10. Exhaust Port

04/06/93 f420468

Fig. 1

The MV-3 includes a spring-loaded, dual-circuit supply valve, which selects the primary air reservoir as the air source for both control valves, unless the pressure in the primary air reservoir falls more than 207 kPa (30 psi) below that of the secondary air reservoir. Then, the dual-circuit supply valve will shuttle and establish the secondary air reservoir as the air source.

NOTE: The primary air reservoir supplies the rear tractor axle; the secondary air reservoir supplies the front axle.

The trailer air supply valve **(refer to Fig. 2),** actuated by a red knob, delivers air to the trailer supply line. The parking brake valve, actuated by a yellow knob **(Fig. 2),** controls the spring parking brakes on the tractor, and when exhausted, simultaneously causes the trailer supply valve to trip and exhaust, thus applying both the tractor and the trailer parking brakes as required by federal regulations. The trailer parking brakes may be independently released by pushing only the trailer air supply valve (red) knob in.

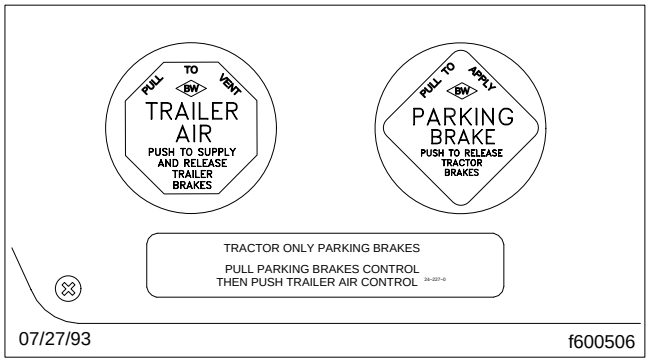


Fig. 2

Principles of Operation

INITIAL CHARGE

With both the primary and the secondary systems completely discharged, both knobs are out. **See Fig. 3.** When system pressure reaches 448 kPa (65 psi), the red knob (trailer air supply) may be pushed in, and should stay in, charging the trailer system and releasing the trailer parking brakes. **See Fig. 4.** The yellow knob (parking brake) may now be pushed in, which will supply air to the tractor parking brakes, releasing them.

NORMAL OPERATION POSITION

When both knobs are pushed in, air is supplied to the trailer and the tractor parking brakes; all parking

General Description and Principles of Operation

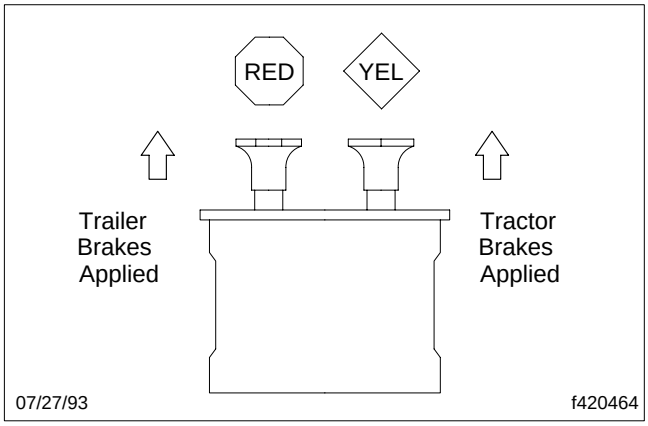


Fig. 3

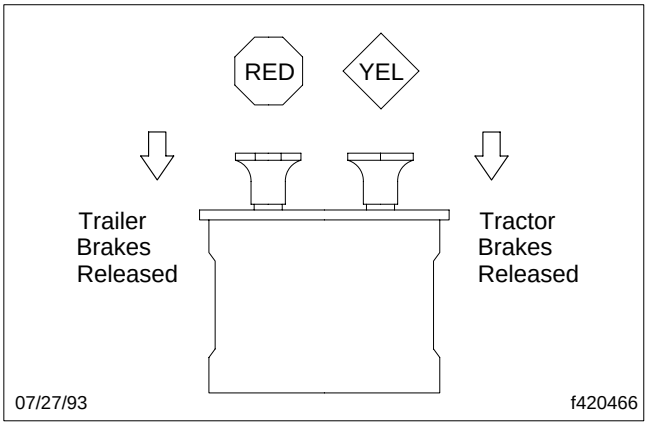


Fig. 5

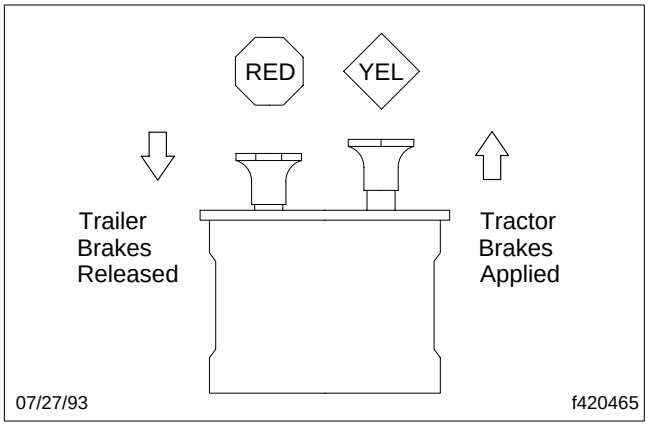


Fig. 4

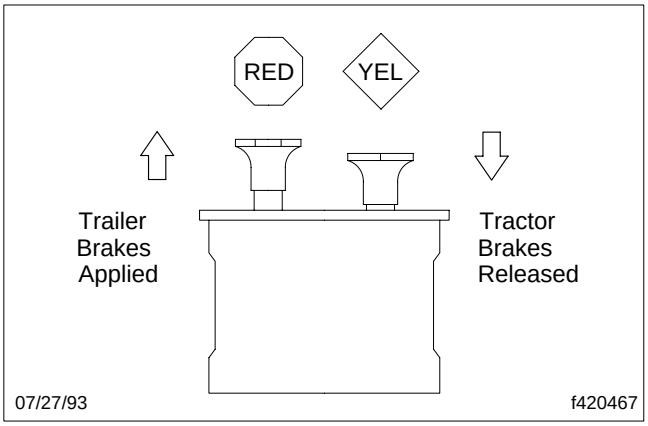


Fig. 6

brakes are released. **See Fig. 5.** This is the normal operating mode.

ACTUATION OF TRAILER PARK OR EMERGENCY BRAKES

To actuate the trailer parking brakes only, the red knob is pulled out, exhausting the trailer supply line. The trailer parking brakes are now applied, either by emergency air or parking brakes, depending on the type of trailer system. This mode would be used to uncouple from the trailer, and during bobtail operation. **See Fig. 6.**

SYSTEM PARK

With both knobs in, the parking brakes on both the tractor and the trailer may be actuated by pulling the yellow (parking brake) knob out. This exhausts the air from the tractor parking brakes and simultaneously causes the red (trailer air supply) knob to pop out, applying the trailer parking brakes. (This complies with federal regulations that one control must apply all the parking brakes on the vehicle.) **See Fig. 3.**

TRAILER CHARGE

If both valves are out, parking the combination vehicle, and it is desired to recharge the trailer (leaving only the tractor parking brakes applied), the red knob may be pushed in, repressurizing the trailer supply line. This mode might also be used to park a combination vehicle with air actuated emergency brakes on the trailer to provide demonstrated parking capability with the tractor spring brakes only. **See Fig. 4.**

AUTOMATIC APPLICATION

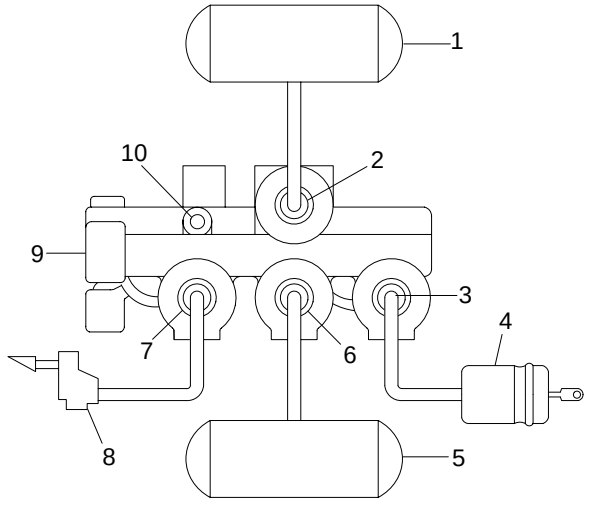
If air pressure drops to 241 to 310 kPa (35 to 45 psi) in both the primary and the secondary systems, the red knob (trailer air supply valve) will automatically pop out, applying the emergency or parking brakes on the trailer. If the red knob is held in manually and the pressure decreases to 172 to 241 kPa (25 to 35 psi), a tripper piston within the MV-3 valve will move upward, exhausting the trailer supply, and applying the trailer parking brakes. If air pressure drops in both the primary and the secondary systems, the yellow (parking brake) knob will pop out at about 138 to 207 kPa (20 to 30 psi), applying the tractor parking brakes.

A warning buzzer and light are activated when pressure in either the primary or the secondary system drops below 441 to 524 kPa (64 to 76 psi).

Tests

With the air brake system charged to 827 kPa (120 psi), check for leaks, using the following instructions. Repair or replace components as needed.

1. Check for leakage between the body and cover plate. No leakage is permitted.
2. Push in the red knob. The knob must stay in. Leakage at the exhaust port (**Fig. 1**, Ref. 10) must not exceed a 25-mm (1-inch) bubble in 5 seconds.
3. Slowly reduce pressure in both service reservoirs. The red knob must pop out at 241 to 310 kPa (35 to 45 psi) and maintain the supply pressure. Leakage at the exhaust port must not exceed a 25-mm (1-inch) bubble in 5 seconds.



1. Primary Reservoir
2. Primary Reservoir Supply Port
3. Delivery−Tractor Port
4. Spring Brake Chamber
5. Secondary Reservoir
6. Secondary Reservoir Supply Port
7. Delivery−Trailer Port
8. Tractor Protecton Valve
9. Auxiliary Air Delivery Port
10. Exhaust Port

04/06/93 f420468

Fig. 1

4. Hold the red knob in and continue to reduce pressure in all service reservoirs. Air must start to escape from the exhaust port when the trailer line pressure reaches 138 to 241 kPa (20 to 35 psi).
5. Release the red knob and rebuild the supply pressure to 827 kPa (120 psi). Push in the yellow knob; the yellow knob must remain in. Leakage at the exhaust port should not exceed a 25-mm (1-inch) bubble in 5 seconds.
6. Pull the red knob out. Slowly reduce pressure in all service reservoirs. The yellow knob must pop out at 138 to 207 kPa (20 to 30 psi) and maintain supply pressure. Leakage at the exhaust port should not exceed a 25-mm (1-inch) bubble in 5 seconds.
7. Charge the system to 827 kPa (120 psi), and push both knobs in. Pull the red knob out. The yellow knob must remain in. Push the red knob in and pull the yellow knob out. The red knob must pop at once.
8. Install a gauge to monitor tractor spring brake delivery pressure. Build 827 kPa (120 psi) pressure in the primary and secondary air reservoirs. Push in the yellow knob. Delivery pressure should equal the pressure in the primary air reservoir. Reduce the pressure in the primary air reservoir. Delivery pressure and the primary air reservoir pressure should descend together to 621 to 724 kPa (90 to 105 psi), at which point the dual-circuit supply valve shuttle should switch to the secondary air reservoir; delivery pressure should increase to the secondary air reservoir pressure. After the primary air reservoir pressure is reduced to zero, there should not be audible leakage at the primary air reservoir opening. Stop the leak that was created in the primary air reservoir.
9. Leaving the yellow knob in, recharge the secondary air reservoir to 827 kPa (120 psi). The delivery pressure should also read 827 kPa (120 psi). Recharge the primary air reservoir to 689 kPa (100 psi). Slowly vent the secondary air reservoir. As the secondary air reservoir pressure and the delivery line pressure descend, pressure should stabilize at about 689 kPa (100 psi).
10. Close all leakage points and charge both reservoirs to 827 kPa (120 psi). Position the red knob out and the yellow knob in. Develop a leak in the spring brake delivery line (**Fig. 1**, Ref. 3) and hold the yellow knob in. The primary air reservoir

Operating Tests

pressure will go to zero; and the secondary air reservoir pressure will drop to 138 to 207 kPa (20 to 30 psi). The dual-circuit supply valve shuttle should cycle several times during the leak-down period.

Removal

1. Park the vehicle on a level surface, apply the parking brakes, chock the tires, and drain all air tanks to zero pressure.

⚠ WARNING

WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

2. Unscrew the red and yellow buttons from the stems of the spools on the MV-3 valve by turning in a counterclockwise direction. Mark these buttons in relation to the valve for later reference.
3. Remove the dash panel and foam gasket, and then remove the dash bracket. Save all six screws.
4. Remove and save the mounting hardware from the four corners of the cover plate.
5. Pull the valve forward, mark and then remove the air lines from the back of the valve.

Installation

1. Connect the air lines to the proper ports as marked during removal.
2. Align the valve in the dash and install the four screws into the corners of the cover plate.
3. Replace the dash bracket, gasket and dash panel with the hardware previously removed.
4. Attach the red and yellow buttons onto the threaded stems of the spools, making sure that they are oriented correctly as noted during removal.

Disassembly, Cleaning and Inspection, and Assembly

Disassembly

1. Remove the six screws (**Fig. 1**, Ref. 3) from the cover plate (Ref. 4) and carefully remove the cover plate from the valve.
2. Remove the cap (Ref. 5) and O-ring (Ref. 6) from the bore of the tripper valve. Remove the piston (Ref. 7), spring (Ref. 8), spring (Ref. 9), and check valve (Ref. 10). These parts will all fall out of the cavity of the MV-3 by tilting the body forward. Remove the O-ring (Ref. 11) from its groove on the piston.
3. Remove the two main spools from the body of the MV-3 valve by grasping the stem and pulling firmly. Remove the two springs (Ref. 21) from the bottom of each spool cavity.
4. Pull the guide cap (Ref. 12) and guide spool (Ref. 14) over the threaded end of one of the plungers (Ref. 18). Remove the O-ring (Ref. 13) from the guide cap and the O-ring (Ref. 15) from the guide spool. Remove O-rings (Refs. 16, 17, and 20) and the exhaust seal (Ref. 19) from the plunger.
5. Repeat step(s) as required on the remaining spool assembly.
6. Remove the retaining ring (Ref. 22) from the cavity of the MV-3 body that contains the dual circuit supply valve.
7. Using a pair of needle nose pliers, grasp the bar in the center of the cap (Ref. 23) and remove the dual circuit valve assembly. Remove the three O-rings (Refs. 24, 25, and 26) from the valve or from the cavity of the body, if some have remained there. Other than the three external O-rings, don't disassemble the piston assembly further.

NOTE: If during the removal of this assembly from the body the cap dislodges from the rest of the valve, the remaining parts can be removed using bent wire. The spring, piston and O-ring that are internal to the dual circuit valve assembly are non-serviceable.

Cleaning and Inspection

The nonmetallic components making up most of the parts of the MV-3 *should not be immersed in any solvent type cleaner*. Old lubricant should be wiped out with a clean dry cloth.

If any visible damage to the body or the spools is found, replace the complete unit.

Assembly

DUAL CIRCUIT SUPPLY VALVE

1. Lubricate all O-rings, bores, and sliding surfaces with silicone lubricant Bendix 291126, Dow Corning 55-M, or equivalent.
2. Install O-rings (Refs. 24, 25, and 26) onto the dual circuit supply valve (Ref. 23). Then install the assembly— small diameter first— into its cavity in the body.
3. Install the retaining ring (Ref. 22) making sure it is fully seated in its groove.

SPOOLS

1. Install the O-rings (Refs. 16, 17, and 20) and the exhaust seal (Ref. 19) onto the stem of plungers (Ref. 18).

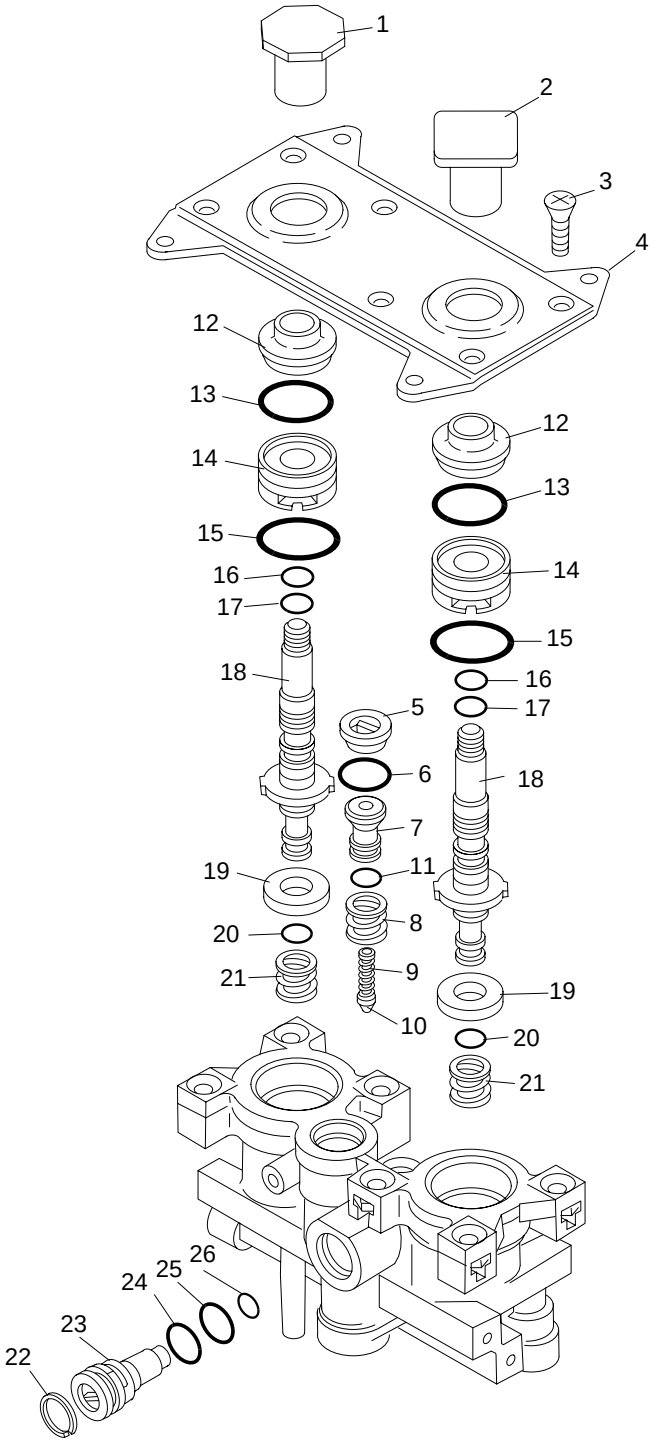
⚠ CAUTION

The exhaust seal (Ref. 19) must be installed so that its beveled surface mates with the beveled surface of the plunger (Fig. 2).

2. Install the O-ring (Ref. 15) onto the guide spool (Ref. 14) and the O-ring (Ref. 13) onto the guide cap (Ref. 12). Place the guide cap on top of the guide spool and install the entire assembly over the threaded end of the plunger (Ref. 18), and press down firmly until it snaps into place.
3. Install the spring (Ref. 21) over the boss in the bottom of the spool cavity in the body of the MV-3 valve. Place the spool assembly into the body, keeping the spool square to the body. Press and turn the stem until the spool is fully seated in its cavity. Note the assembly is keyed and can be installed one way only.
4. Repeat step(s) as required for the opposite spool.

Disassembly, Cleaning and Inspection, and Assembly

1. Red Button
2. Yellow Button
3. Screw
4. Cover Plate
5. Cap
6. O−Ring
7. Tripper Piston
8. Spring, Large Diameter
9. Spring, Small Diameter
10. Check Valve
11. O−Ring
12. Guide Cap
13. O−Ring
14. Guide Spool
15. O−Ring
16. O−Ring
17. O−Ring
18. Plunger
19. Exhaust Seal, Beveled
20. O−Ring
21. Spring
22. Retaining Ring
23. Cap and Dual Circuit Valve Assembly
24. O−Ring
25. O−Ring
26. O−Ring



04/06/93 f420470

Fig. 1

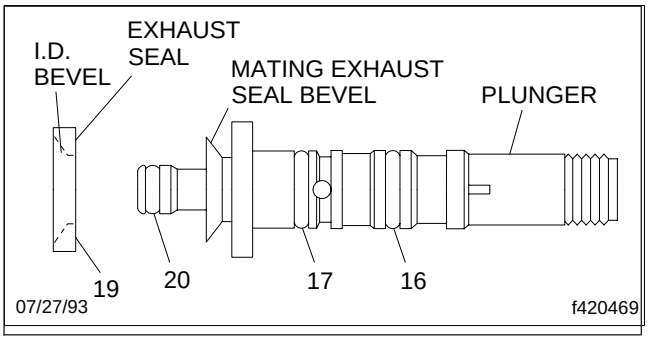


Fig. 2

SHUTTLE AND CHECK VALVE

1. Install the O-ring (Ref. 11) into its groove on the piston (Ref. 7); then install the O-ring (Ref. 6) onto the cap (Ref. 5).
2. Install the spring (Ref. 8) on the piston (Ref. 7) and the spring (Ref. 9) on the boss of the check valve (Ref. 10).
3. Install the spring and check valve into their cavity in the body of the MV-3 valve (tapered end of the valve to enter cavity first). Make sure the spring (Ref. 9) is centered in the bore.
4. Install the piston assembly into the cavity, making sure the spring (Ref. 9) mates with the bore of the piston.
5. Install the cap (Ref. 5) with O-ring (Ref. 6).
6. Attach the cover plate (Ref. 4) to the valve body using the six screws. Torque them 280 N·cm (25 lbf·in).
7. Check the operation of the valve using the instructions under **Subject 100**.

General Information

The function of the QR-1 quick release valve **(Fig. 1)** is to speed up the release of compressed air from the brake chambers. If the front brake chambers, for example, are equipped with a QR-1 valve, and the brakes are released, the exhaust port of the quick release valve opens and the air from the front brake chambers is exhausted through the quick release valve. This speeds up the release of the front brakes.

When the front brake chambers are equipped with a QR-1 valve, it is located on the rear cab mount crossmember.

When the parking brake chambers are equipped with a QR-1 valve, it is located on the rear suspension crossmember.

A delivery line from the foot valve is connected to the port on top of the QR-1 quick release valve; the two side ports are for brake chamber connections, and the exhaust port is located at the bottom of the valve.

Principles of Operation

(Refer to Fig. 1)

When the service brakes are applied, delivery air enters the brake valve port on the QR-1 quick release valve; the diaphragm moves down, sealing the exhaust port. At the same time, air pressure forces the edges of the diaphragm down, allowing air to flow out the brake chamber ports, filling the chambers and applying the front axle brakes.

When the brake chamber air pressure (beneath the diaphragm) equals the air pressure being delivered by the foot valve (above the diaphragm), the outer edge of the diaphragm will seal against the valve body seat. The exhaust port is still sealed by the center portion of the diaphragm. When the foot brake is released, the air above the diaphragm is released back through the foot brake valve exhaust, while the air beneath the diaphragm forces the diaphragm to rise, opening the exhaust port, and allowing air in the brake chambers to exhaust.

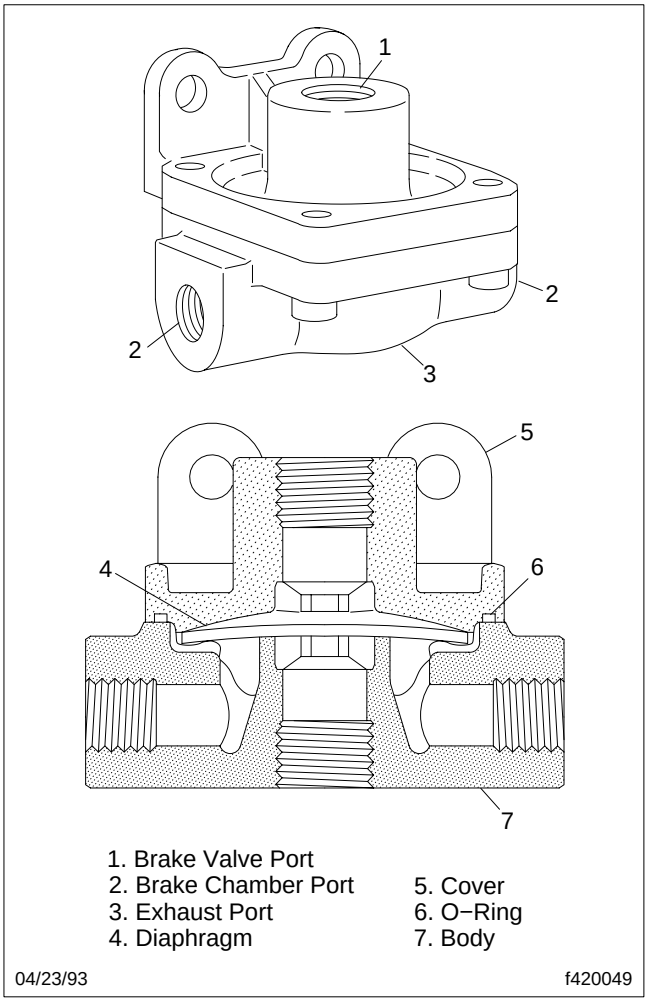


Fig. 1, QR-1 Valve and Cross Section

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Chock the tires and stop the engine before working under a vehicle. Keep hands away from brake chamber push rods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.

Tests

The following tests should also be done after repairing or replacing the QR-1 valve to ensure that it is functioning correctly.

1. With the brakes applied (pedal pushed in) do the following checks:

   1.1 Coat the exhaust port with a soap solution; leakage of a 2.5-cm (1-inch) bubble in three seconds is allowable.

   1.2 Coat the valve body and cover with a soap solution. No leakage is permitted between the valve body and cover.

2. If the valve does not function correctly, or if there is too much leakage, repair or replace it following the instructions in this section.

Removal

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

1. Chock the tires or hold the vehicle by means other than air brakes.
2. Drain the air brake system by opening the reservoir drain cocks.
3. Mark and disconnect the air lines from the quick release valve.
4. Remove the mounting bolts and the valve.

Installation

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

1. Install the quick release valve with the exhaust port facing down. Securely tighten the mounting bolts.
2. Connect the air lines to the quick release valve as previously marked.
3. Do the tests under **"Operating and Leakage Tests, 110."**

Disassembly, Cleaning and Inspection, and Assembly

Disassembly

1. Remove the quick release valve from the vehicle following the instructions under **"Removal and Installation, 120."**
2. Remove the four screws holding the valve cover on the valve body.
3. If equipped, remove the spring and spring seat.
4. Remove the diaphragm.
5. Remove the cover O-ring.

Cleaning and Inspection

⚠ WARNING

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

1. Clean all metal parts in mineral spirits. Wipe all rubber parts clean.
2. It is recommended that all rubber parts and any other part showing signs of wear or deterioration be replaced with genuine Bendix parts.

Assembly

1. If the quick release valve is not equipped with a spring, install the diaphragm into the valve body.

   If the quick release valve is equipped with a spring, position the spring in the valve body. Then, position the diaphragm over the spring seat.
2. Install the O-ring in the valve cover groove and install the valve cover. Tighten the screws 340 to 680 N·cm (30 to 60 lbf·in) evenly and securely.
3. Install the quick release valve, following the instructions under **"Removal and Installation, 120."**

General Description

The GTD 4000-2 quick release valve provides fast release of the trailer brake. It is installed on the tractor protection valve on vehicles equipped with a tractor/trailer air system, and connects to the trailer air brake line.

The valve is screwed into the service delivery port of the tractor protection valve. On some vehicles a second quick-release valve is screwed into the parking brake delivery port of the tractor protection valve. **See Fig. 1.**

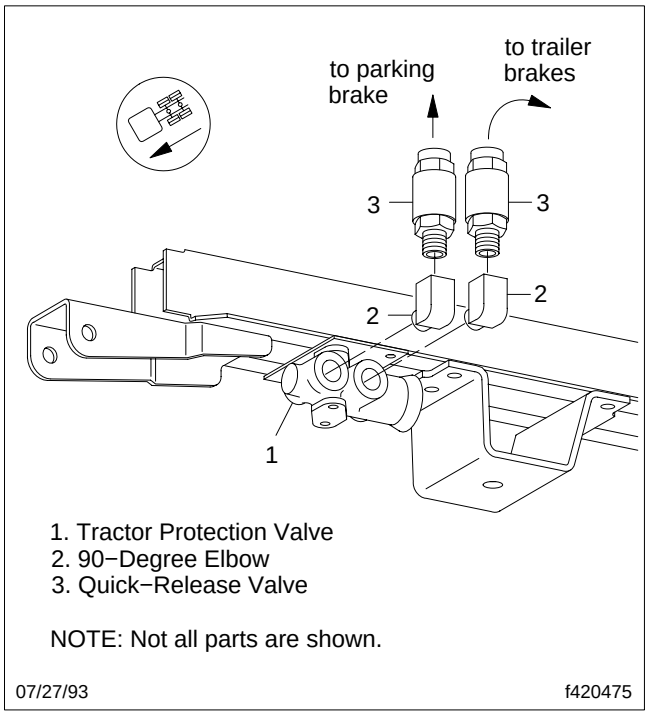


Fig. 1

Principles of Operation

(Refer to Fig. 2)

When the brakes are applied, air passes through the quick-release valve to the trailer service brakes (and to the trailer parking brake, if applicable). When the brakes are released slowly, air passes from the trailer brakes through the quick release valve, and exhausts at the foot valve.

When the brakes are released quickly, the sudden pressure drop moves the diaphragm inside the quick release valve, which prevents the air from exhausting through the foot valve. Instead, it exhausts through the quick-release valve, which releases the trailer brakes more quickly.

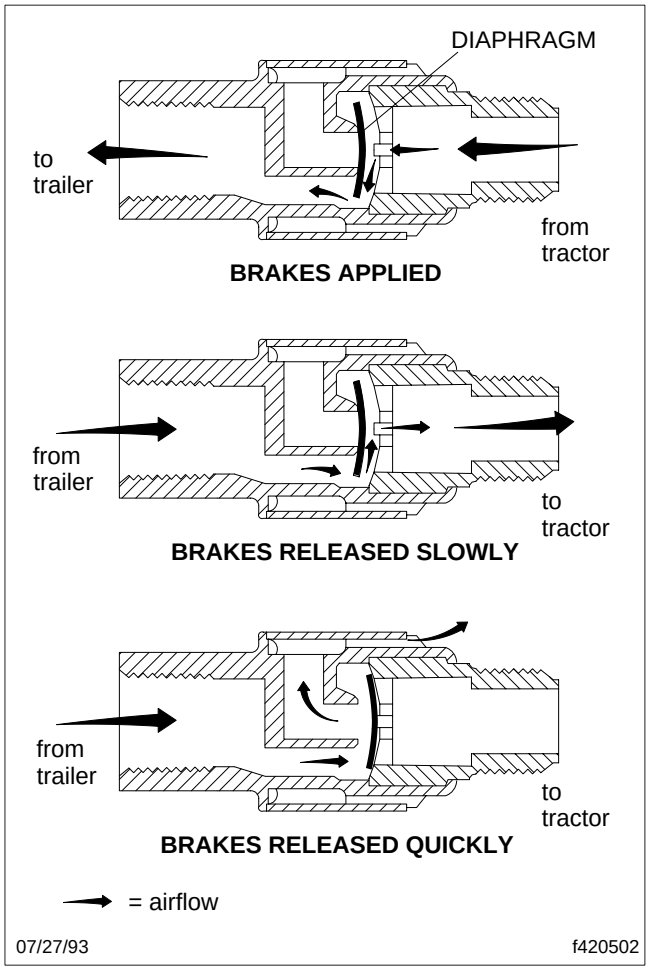


Fig. 2

Operation Test

1. With the system pressurized and the trailer brakes connected, apply the brakes, then slowly release them. There should be no audible leakage or exhaust from the quick-release valve.
2. Apply the brakes a second time, then release them quickly. Air should exhaust through the quick-release valve.

   If the valve fails the above test, replace it.

Leakage Test

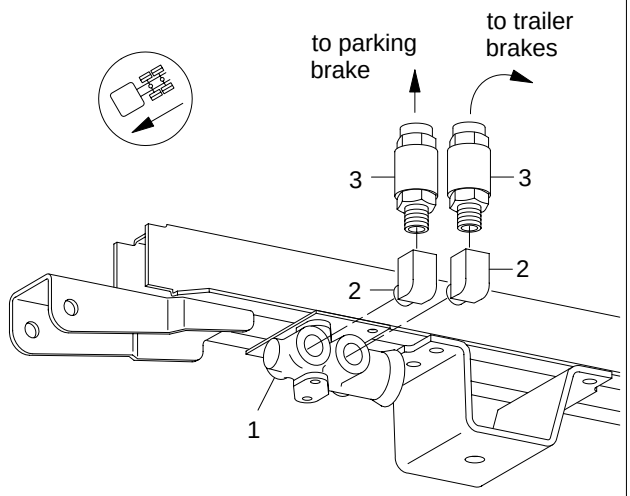
1. Pressurize the air system.
2. Coat the quick-release valve with a soapy solution. Leakage resulting in a 2.5-cm (1-inch) bubble or less every ten seconds is acceptable. If the leakage is more than above, replace the valve.

Removal

WARNING

WARNING: Wear safety goggles when draining the air system or disconnecting an air line because dirt or sludge particles could fly out at high speeds. Don't direct the air stream at other people. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

1. Drain the air from the air reservoirs.
2. Carefully disconnect the air line from the quick-release valve.
3. Unscrew the quick-release valve from the 90-degree elbow on the tractor protection valve. **See Fig. 1.**



1. Tractor Protection Valve
2. 90−Degree Elbow
3. Quick−Release Valve

NOTE: Not all parts are shown.

07/27/93 f420475

Fig. 1

Installation

1. Screw the quick-release valve into the 90-degree elbow on the applicable delivery port of the tractor protection valve.

   Make sure the arrow stamped on the valve is pointing toward the trailer air line.
2. Connect the air line to the quick-release valve. Tighten the connection firmly.

General Description

The Bendix driveline parking brake is designed to hold the vehicle on a grade, and to stop a slow moving vehicle if the service brakes aren't working. The parking brake is manually operated, and has a mechanical linkage; it doesn't rely on hydraulic or air pressure. It is installed only on vehicles with hydraulic brakes.

The parking brake is mounted on the rear of the transmission, between it and the driveshaft. **See Fig. 1**. The main parts of the brake are the drum, brake shoes, return springs, support plate, cam, actuating lever, brake cable, and brake lever assembly. **See Fig. 2** and **Fig. 3**.

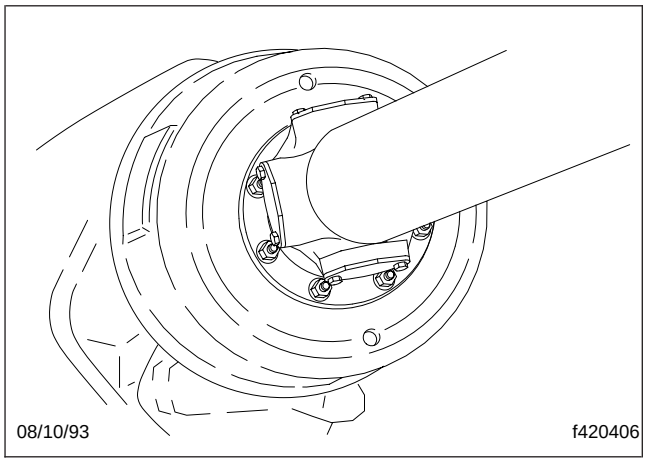
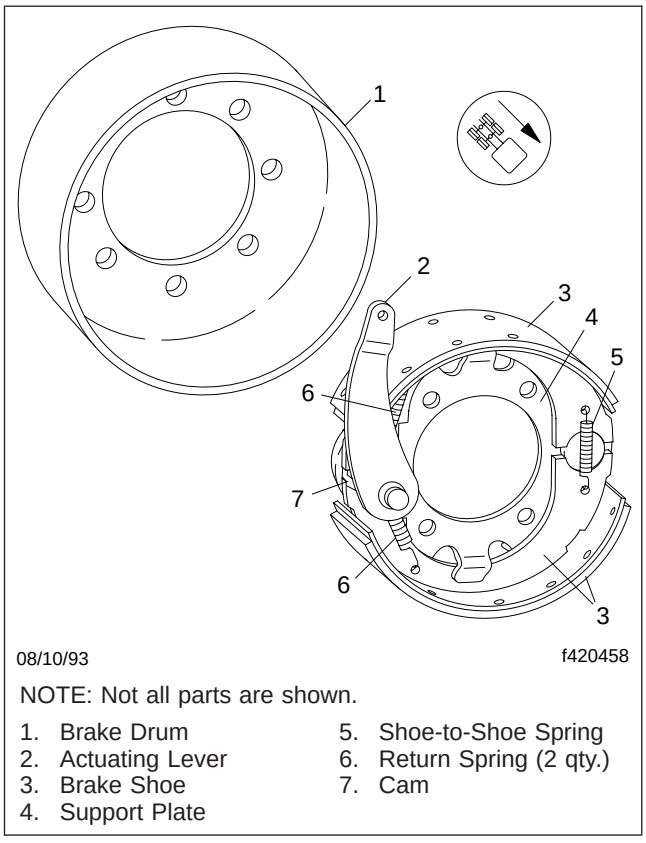


Fig. 1

The brake drum and the driveline companion flange are bolted to the transmission companion flange, which is attached to the transmission shaft. The support plate is bolted to the rear of the transmission. The brake shoes are held in place by the return springs, the shoe-to-shoe spring, and by the support plate. The brake cable runs from the actuating lever to inside the cab, where it is controlled by the parking brake lever assembly. **See Fig. 4**. A ring at the end of the parking brake lever is used to adjust the cable length to compensate for brake shoe wear.

Principles of Operation (Fig. 5)

When the brake lever is pulled up, the brake cable pulls the actuating lever, turning the cam. The cam pushes the brake shoes outward against the brake



NOTE: Not all parts are shown.

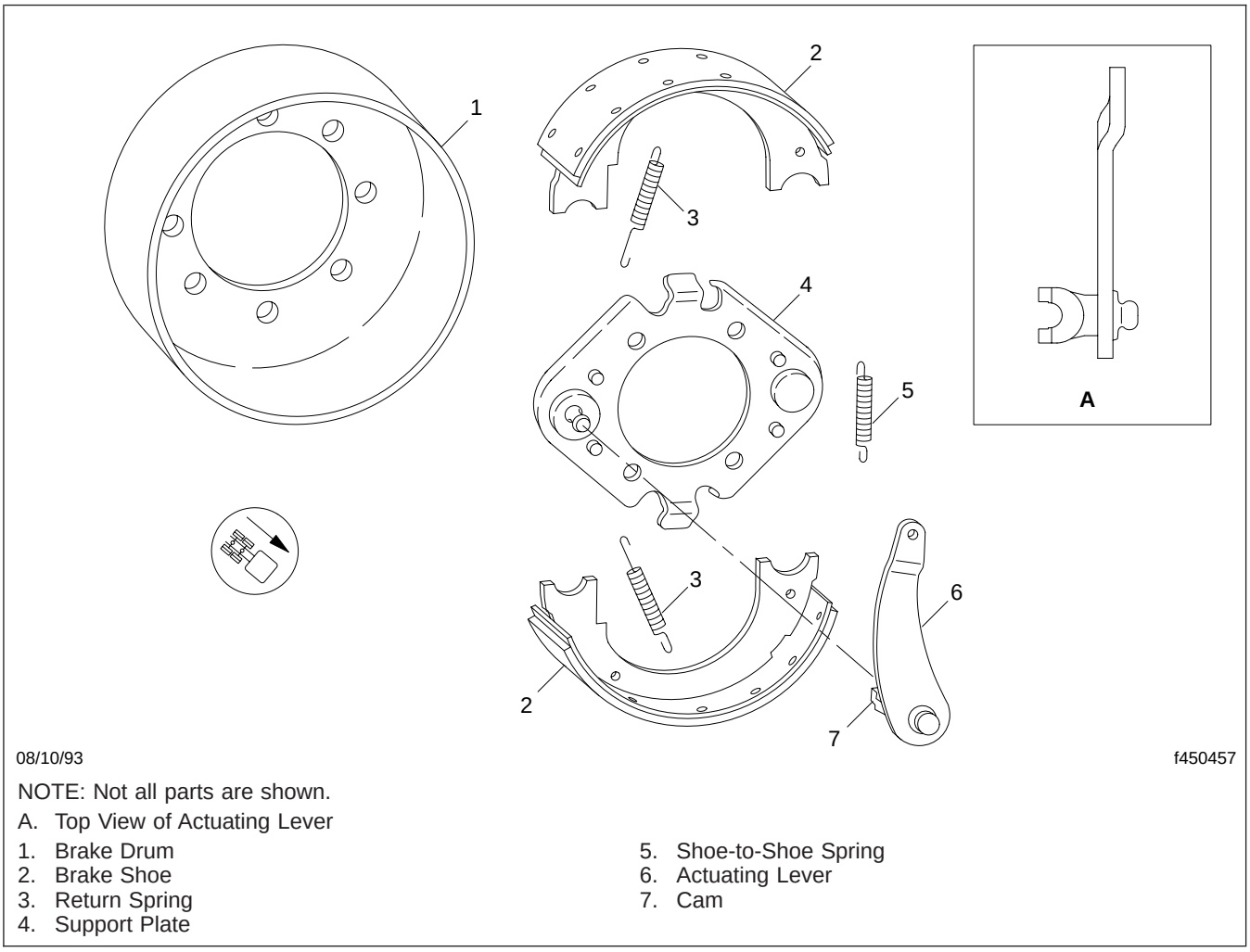
1. Brake Drum
2. Actuating Lever
3. Brake Shoe
4. Support Plate
5. Shoe-to-Shoe Spring
6. Return Spring (2 qty.)
7. Cam

Fig. 2, Assembled Parts

drum. Because the support plate and the shoes are mounted in a fixed position on the transmission, and the brake drum is attached to the end of the driveshaft, the driveshaft is prevented from turning. This keeps the vehicle from rolling.

When the parking brake lever is released, the tension on the cable is removed. The actuating lever and cam return to their original position, and the brake return springs and shoe-to-shoe spring pull the brake shoes away from the brake drum. The driveshaft is then free to move, and the vehicle can be moved.

General Description and Principles of Operation



NOTE: Not all parts are shown.

A. Top View of Actuating Lever

1. Brake Drum
2. Brake Shoe
3. Return Spring
4. Support Plate
5. Shoe-to-Shoe Spring
6. Actuating Lever
7. Cam

Fig. 3, Exploded View

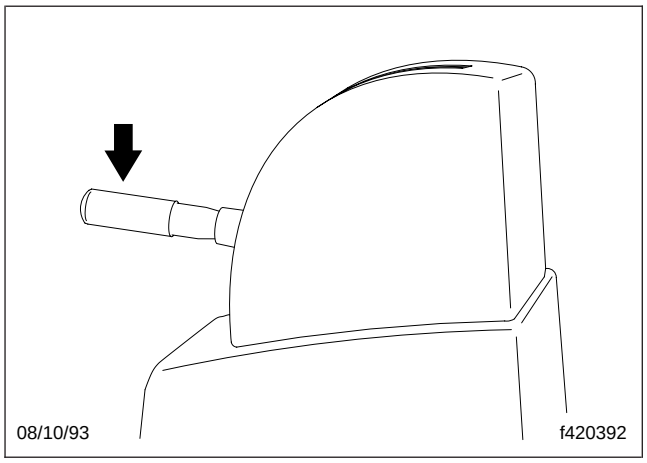
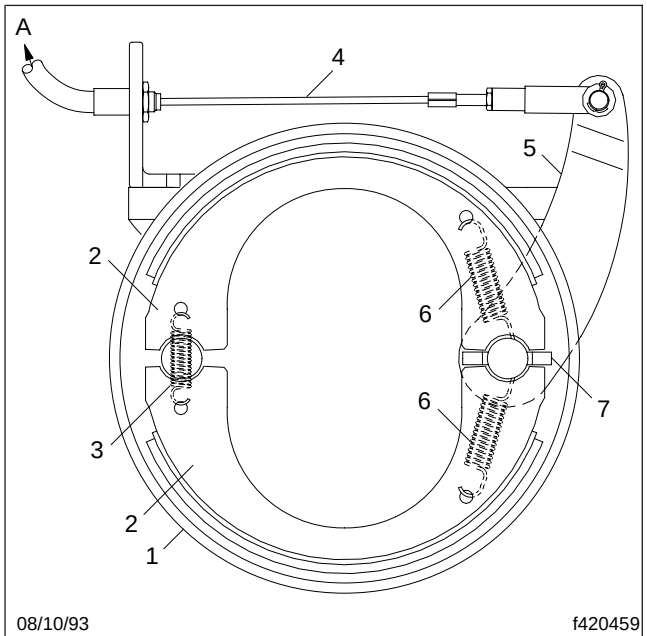


Fig. 4



NOTE: Not all parts are shown.

A. To parking brake lever in the cab.

1. Brake Drum
2. Brake Shoe
3. Shoe-to-Shoe Spring
4. Brake Cable
5. Actuating Lever
6. Return Spring
7. Cam

Fig. 5, Fuller Transmission Installation Shown

Safety Precautions

Because most brake linings contain asbestos, you should know the potential hazards of asbestos and the precautions to be taken. Because medical experts believe that long-term exposure to some non-asbestos fibers could also be a health hazard, also observe the following precautions if servicing non-asbestos brake linings.

Exposure to airborne brake lining dust can cause serious and possibly fatal diseases such as asbestosis (a chronic lung disease) and cancer.

During brake servicing, wear an air purifying respirator with high-efficiency filters. The respirator and filter must be approved by NIOSH or MSHA, and worn during all procedures.

OSHA recommends that enclosed cylinders equipped with vacuums and high-efficiency (HEPA) filters be used during brake repairs. Under this system, the entire brake assembly is placed within the cylinder and the mechanic works on the brake through sleeves attached to the cylinder. Compressed air is blown into the cylinder to clean the assembly, and the dirty air is then removed from the cylinder by the vacuum.

If such an enclosed system is not available, or can't be used, clean the brake assembly in the open air. During disassembly, carefully place all parts on the floor to minimize creating airborne dust. Using an industrial vacuum cleaner with an HEPA filter system, remove dust from all the brake parts. After vacuuming, remove any remaining dust using a rag soaked in water and wrung until nearly dry.

⚠ WARNING

WARNING: Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by NIOSH or MSHA. Wear a respirator at all times when disassembling the parking brake, starting with removal of the drum and continuing through assembly.

Replacement

WARNING

Before starting the procedure below, read the information in "Safety Precautions, 100." Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

1. Chock the tires. Apply the parking brake to keep the brake drum in place when the driveline is disconnected.
2. Remove the driveline midship bearing carrier from the frame crossmember.
   - 2.1 Put a jackstand under the driveline at the rear of the midship bearing.
   - 2.2 Remove the bolts holding the midship bearing carrier to the bracket on the frame crossmember. See Fig. 1.

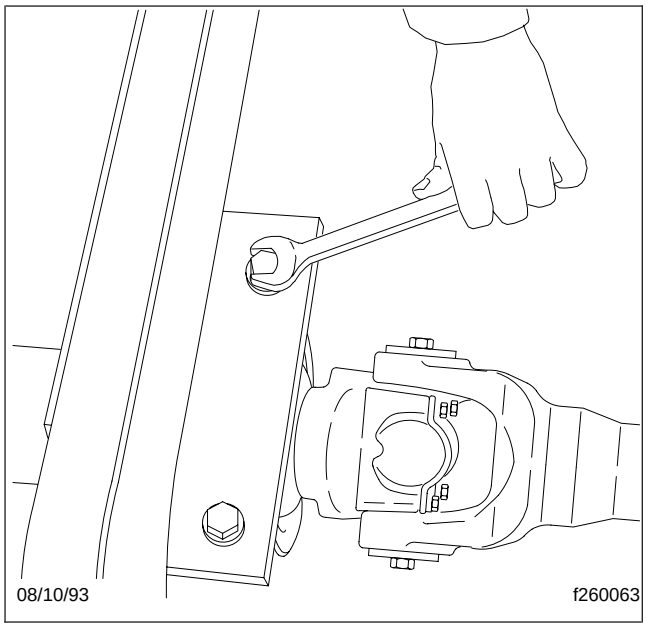


Fig. 1

   - 2.3 Lower the driveline and midship bearing carrier onto the jackstand. It should rest securely on the jackstand.
3. Disconnect the driveline companion flange from the transmission companion flange. See Fig. 2.

Slide out the driveline, and lower it to the floor. See Fig. 3.

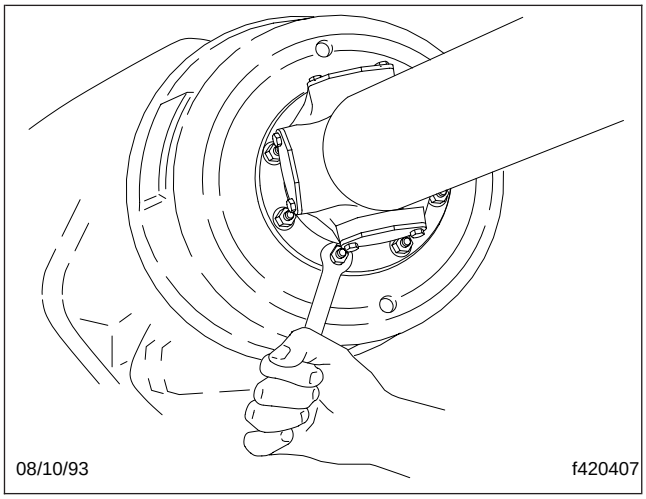


Fig. 2

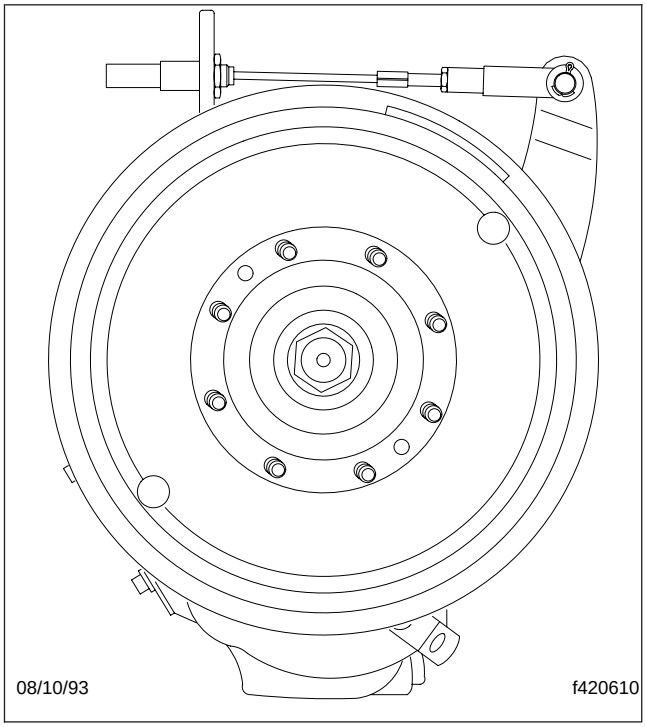


Fig. 3, Driveline Removed

4. Release the parking brake.
5. Pull the brake drum off the transmission companion flange. See Fig. 4.

Brake Shoe Replacement

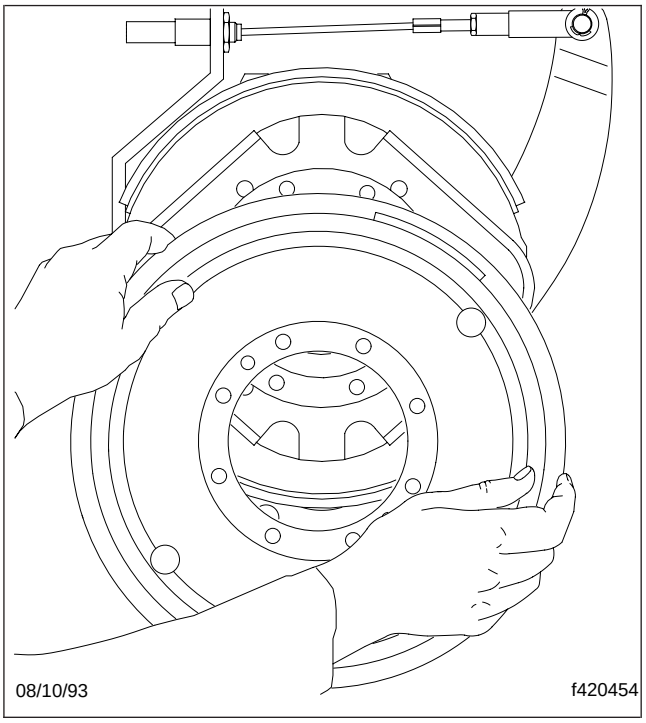


Fig. 4

6. Disconnect the brake cable from the actuating lever. **See Fig. 5**.

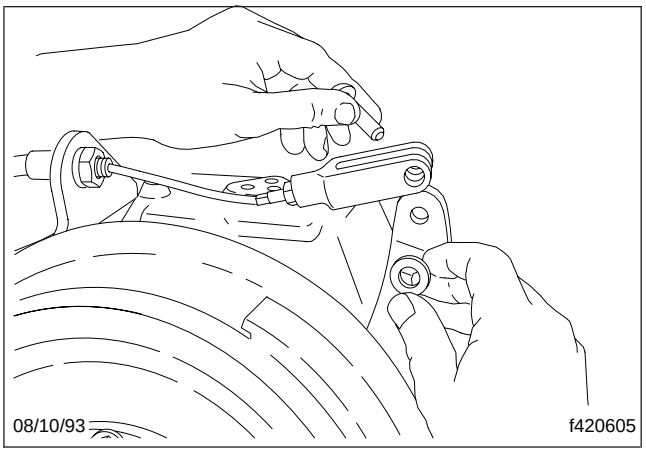
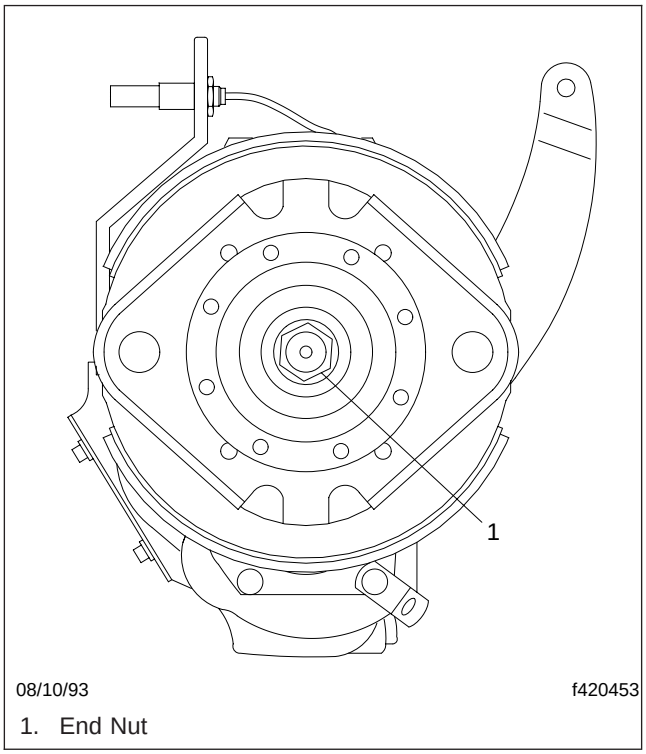


Fig. 5

7. Remove the large end-nut from the transmission shaft. **See Fig. 6**. Remove the companion flange.
8. Remove the supporting plate and brake shoes as a unit.
9. Disassemble the brake parts. **See Fig. 7**.



1. End Nut

Fig. 6

9.1 Remove the actuating lever and cam assembly.

9.2 Remove the brake shoes from the supporting plate.

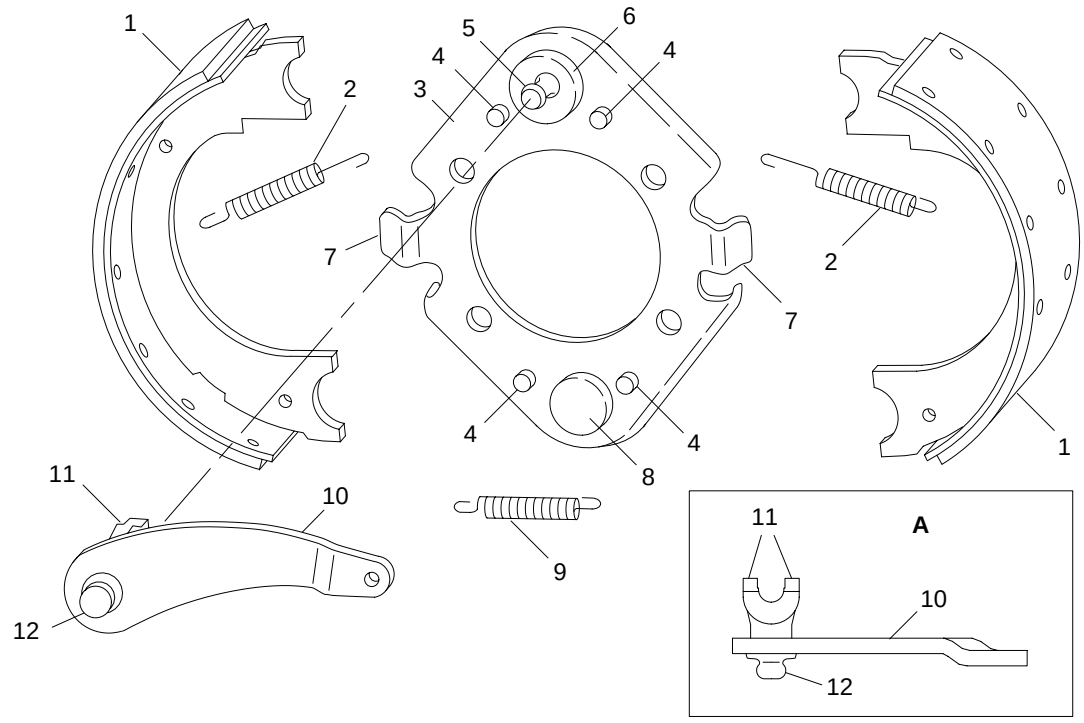
⚠ WARNING

WARNING: Brake shoe return springs are under tension, and may release unexpectedly, which could cause injury. Wear safety glasses when removing them.

9.3 Using a suitable spring removal tool, carefully remove the two brake shoe return springs.

9.4 Spread the brake shoes apart to release tension on the shoe-to-shoe spring.

9.5 Remove both brake shoes from the support plate, then remove the shoe-to-shoe spring.



A. Top view of actuating lever.

1. Brake Shoe
2. Return Spring
3. Support Plate
4. Shoe Bearing Surface
5. Nib
6. Upper Anchor Pin
7. Support Plate Lug
8. Lower Anchor Pin
9. Shoe-to-Shoe Spring
10. Actuating Lever
11. Cam Lugs
12. Cam Ball

Fig. 7

10. Clean all the parts. Check for damage and corrosion, and replace parts if needed. Check the support plate for cracks or bending. Replace it if needed.

CAUTION

CAUTION: Don't let any grease get on the brake drum or linings. Grease on these parts will reduce the effectiveness of the driveline parking brake. If brake linings become contaminated, replace them.

11. Using NLGI grade 2 brake grease, lightly grease the following parts (**see Fig. 7**):
    - the cam lugs and ball;
    - the mating surfaces of the brake shoe webs and the support plate lugs;
    - the support plate anchor pins;
    - the shoe bearing surfaces;
    - the ends of the brake shoe webs.
12. Install new brake shoes. **See Fig. 7** and **Fig. 8**.

    12.1 Position the brake shoes on the support plate.

    NOTE: Position the support plate so the anchor pin with the nib is at the top.

    12.2 Install a new shoe-to-shoe spring in the hole of each brake shoe.

Brake Shoe Replacement

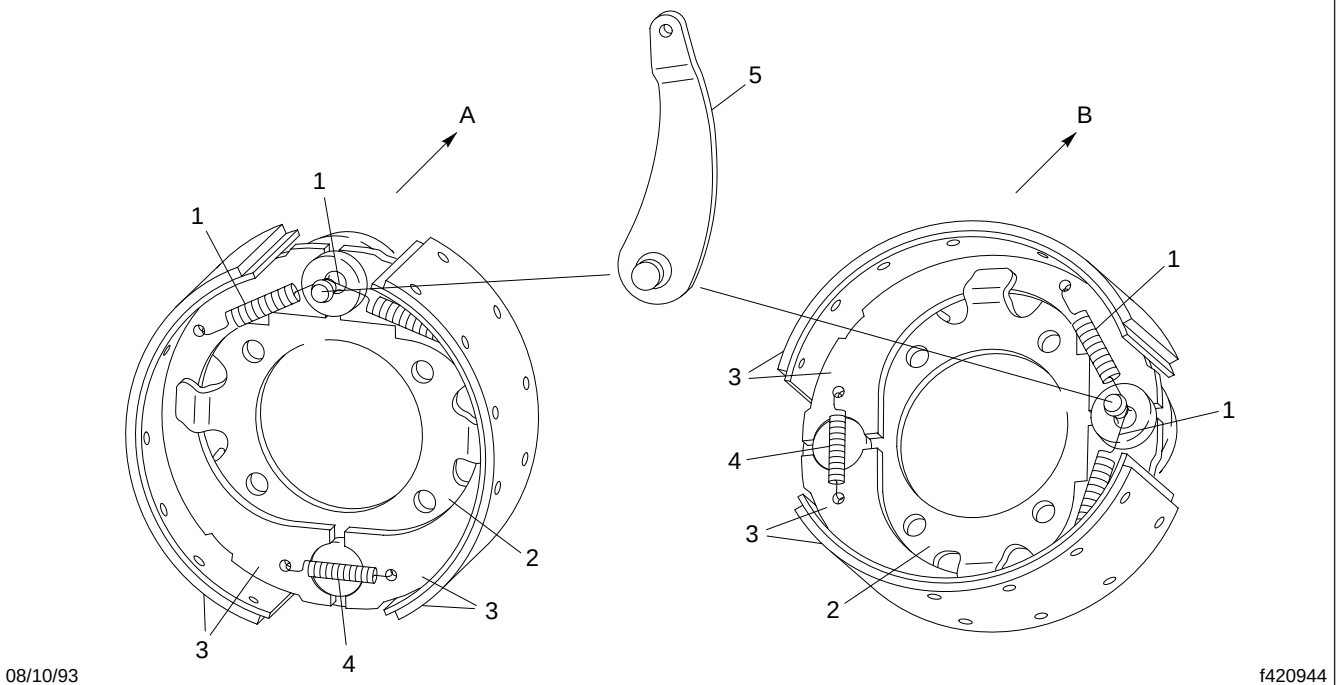
12.3 Using a twisting motion, install the lower ends of the brake shoes over the lower anchor pin.

12.4 Put the upper ends of the brake shoes against the upper anchor pin, making sure the shoe webs are underneath the guide lugs of the support plate.

14. Install the transmission companion flange over the splines of the transmission shaft.

15. Install the large end-nut on the end of the transmission shaft. **See Fig. 6**. Tighten the nut.

- On Fuller transmissions—440 N·m (325 lbf·ft).



A. To Allison transmission.
B. To Fuller transmission.
1. Return Spring
2. Support Plate
3. Brake Shoe
4. Shoe-to-Shoe Spring
5. Actuating Lever and Cam Assembly

Fig. 8

12.5 Install two new return springs on the nib of the upper anchor pin and in the hole of each brake shoe.

12.6 Install the actuating lever and cam assembly on the anchor pin with the nib.

13. Using the four hexbolts, nuts, and washers, position the support plate and brake shoe assembly on the transmission adapter. **See to Fig. 8**. Tighten the nuts 115 N·m (85 lbf·ft).

- On Allison transmissions—197 N·m (145 lbf·ft).

16. Install the brake drum onto the studs of the transmission companion flange.

17. Connect the driveline companion flange to the transmission companion flange.

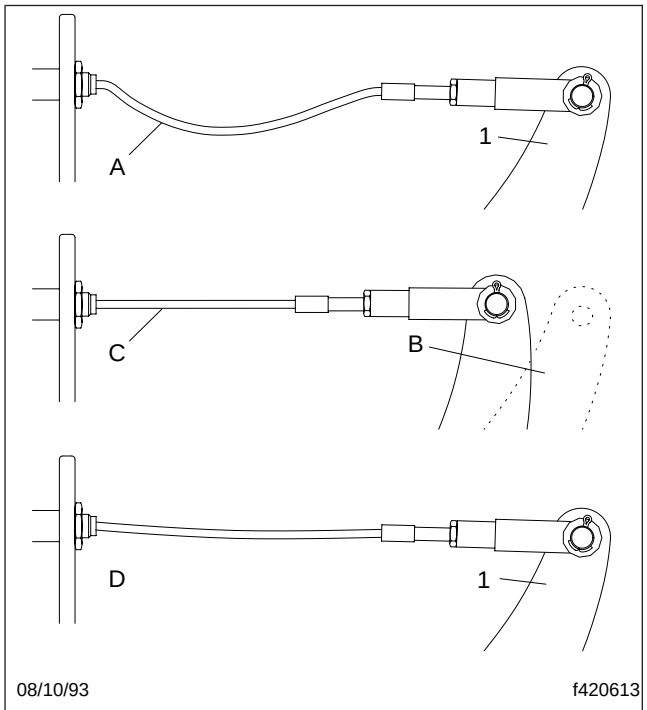
17.1 Place the driveline companion flange so its holes fit over the studs on the transmission companion flange.

17.2 Install the eight nuts and washers on the studs. **See Fig. 2**. Tighten them 61 N·m (45 lbf·ft).

18. Connect the brake cable to the brake lever.

18.1 Check the length of the brake cable. It should be just long enough to let the clevis hole align with the hole in the brake lever, without moving the actuating lever. **See Fig. 9**.

If the brake cable is too loose or too tight, loosen the jam nut, then screw the clevis in or out until its holes line up with the hole in the actuating lever (without moving the lever). **See Fig. 10**.



A. Too loose.
B. Correct position of actuating lever.
C. Too tight.
D. Correct cable adjustment.
1. Actuating Lever

Fig. 9, Brake Cable Tightness

18.2 Tighten the jam nut firmly.

18.3 Install the clevis pin through the clevis and actuating lever holes.

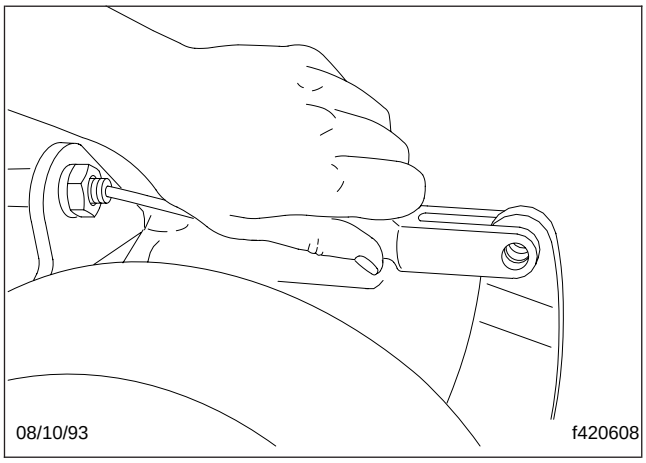


Fig. 10

18.4 Install the washer and a new cotter pin on the clevis pin.

18.5 Check the brake cable again for any slack. If it still needs adjusting, do it in the cab by turning the ring on the handle of the parking brake lever, **See Fig. 11**.

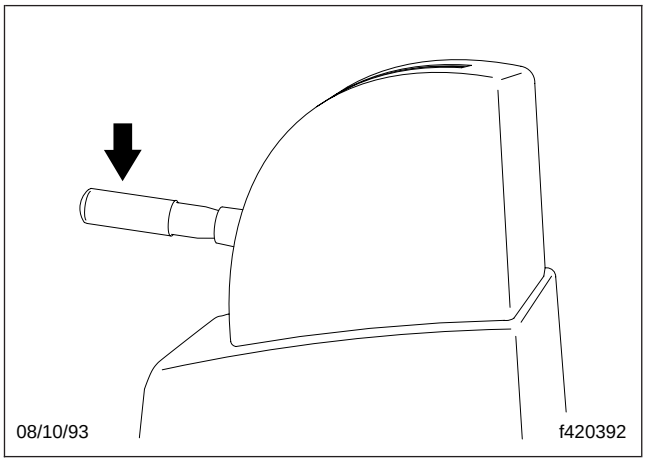


Fig. 11

19. Attach the driveline midship bearing carrier to the bracket on the frame crossmember. Tighten the fasteners 123 N·m (91 lbf·ft).

Parking Brake Cable Replacement

Replacement

1. Chock the front and rear tires.
2. Release the parking brake.
3. At the driveline end, disconnect the brake cable from the actuating lever. **See Fig. 1**.

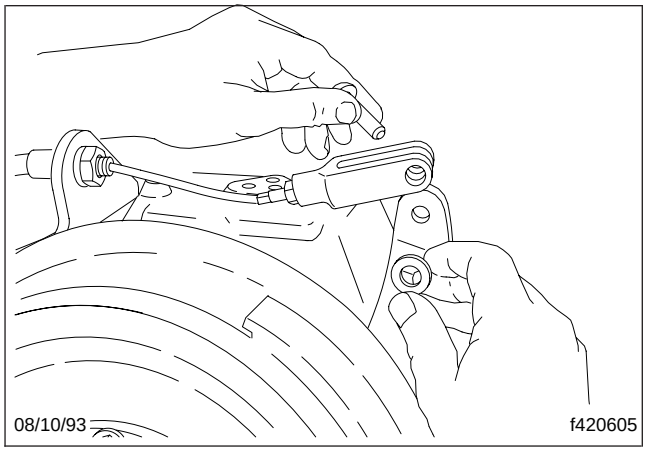


Fig. 1

4. Unscrew the clevis from the cable (**see Fig. 2**); put the clevis aside.

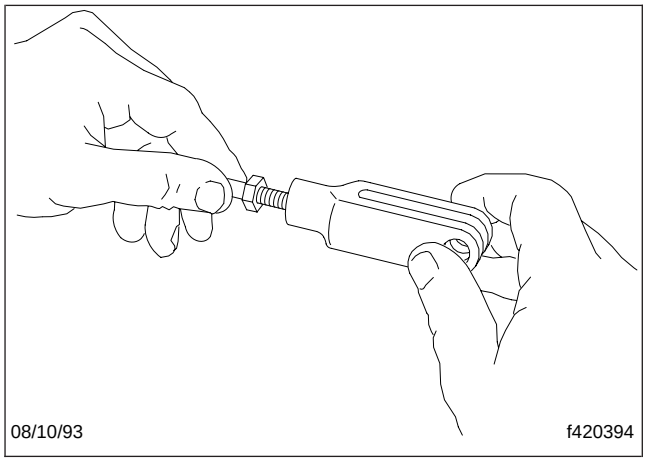


Fig. 2

5. Remove and save the small jam nut from the threaded end of the cable that was installed in the clevis.
6. Remove the brake cable jam nut and lock washer from the cable bracket on top of the transmission. **See Fig. 3**.

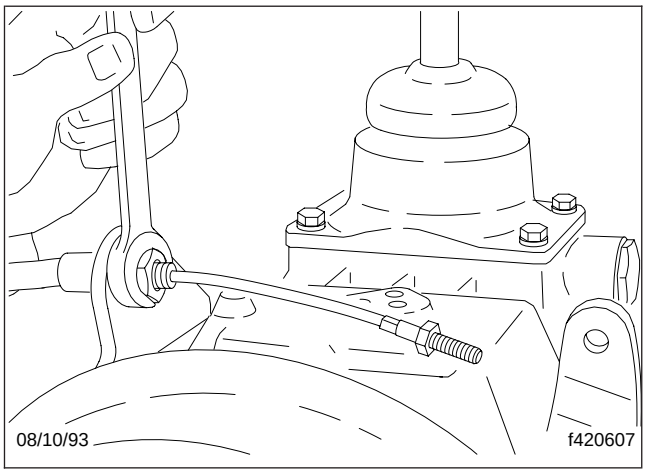


Fig. 3, Fuller Transmission Installation Shown

7. Push the brake cable end through the "D" hole in the bracket. **See Fig. 4**.

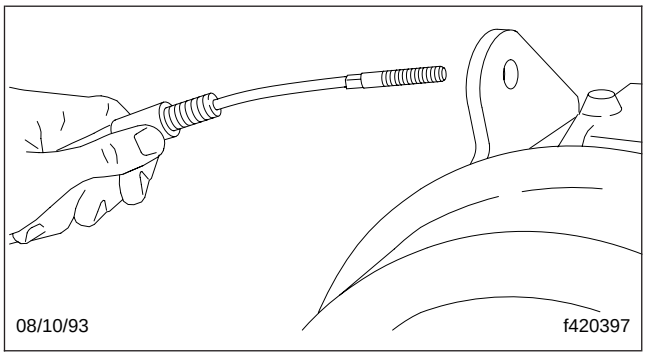


Fig. 4

8. In the cab, remove the plastic boot covering the brake lever assembly.
9. Remove the nut from the double cable clamp on the side of the transmission (**see Fig. 5**), then remove the brake cable from its half of the clamp.
10. Disconnect the parking brake cable from the parking brake lever. **See Fig. 6**.
11. Remove the parking lever assembly from the cab deck.
    - 11.1 Disconnect the electrical wire from the right side of the parking brake lever assembly. **See Fig. 7**.

Parking Brake Cable Replacement

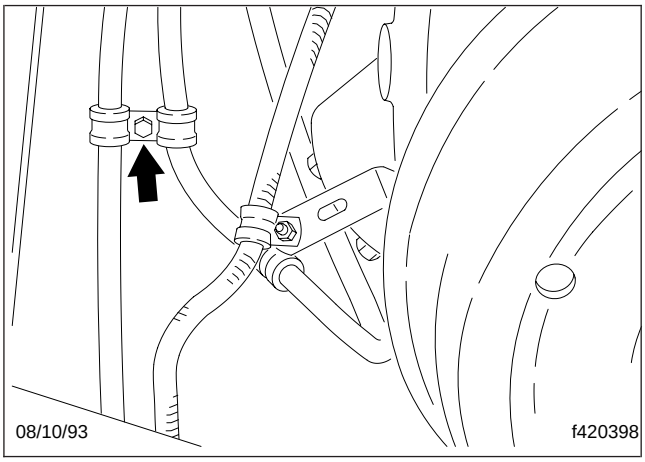


Fig. 5

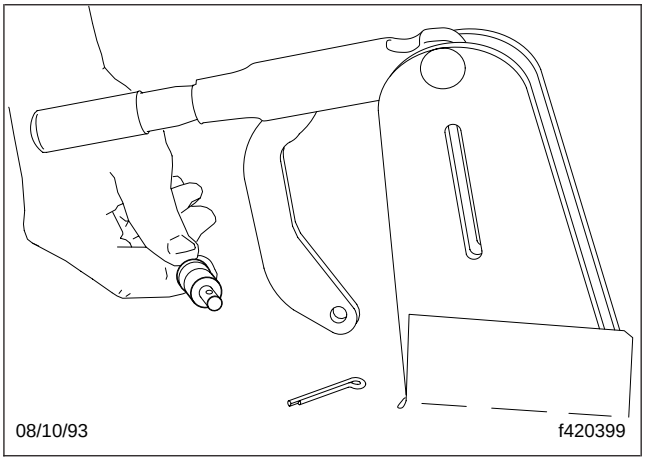


Fig. 6

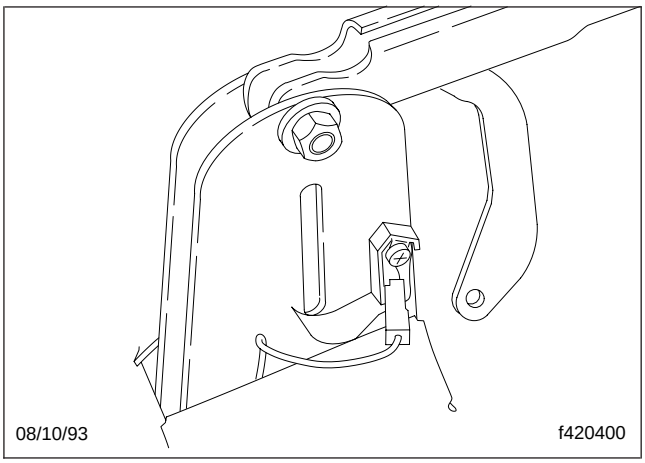


Fig. 7

11.2 Remove the four mounting bolts and washers that hold the lever assembly to the cab floor. **See Fig. 8**.

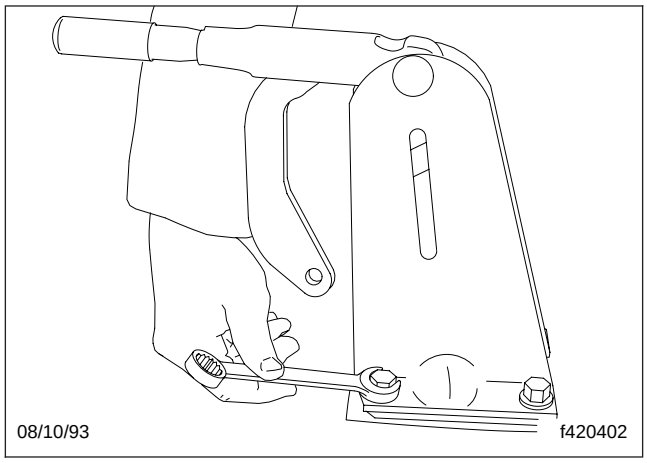


Fig. 8

11.3 Lift the lever assembly off the floor, and set it aside.

12. Remove the jam nut and lockwasher from the threaded end of the cable sheath coming through the hole in the cab deck. **See Fig. 9**.

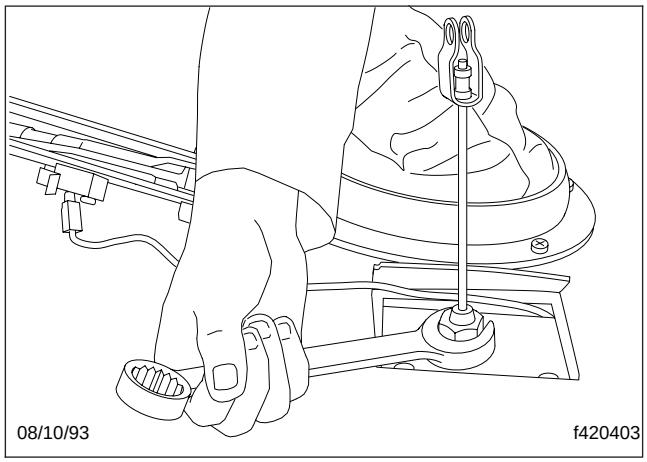


Fig. 9

13. Remove the baseplate by sliding the parking brake cable through the slot in the baseplate. **See Fig. 10**.

14. Pull the entire length of the parking brake cable up through the hole in the cab deck.

Parking Brake Cable Replacement

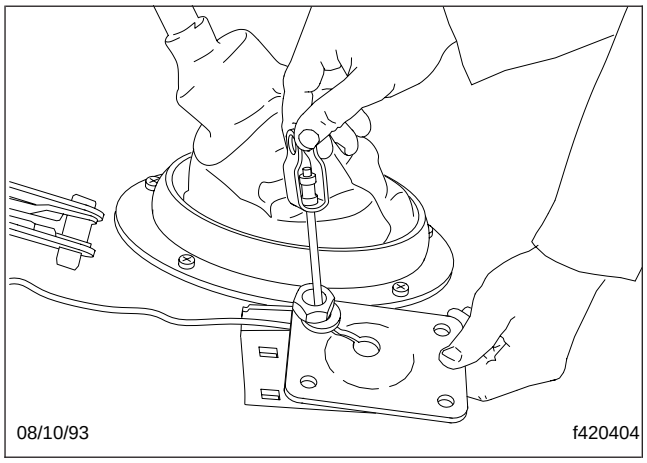


Fig. 10

15. Check the parking brake lever assembly for wear and damage. Replace it if needed.
16. Put the clevis end of the new parking brake cable assembly in the slot of the baseplate, so that the jam nut and washer are on top of the base plate. **See Fig. 10**.
17. Install the lockwasher and jam nut on the cable sheath. Tighten the nut firmly. **See Fig. 9**.
18. Install the free end of the parking brake cable through the hole in the deck. Pull about a foot of the cable up through the sheath.
19. Connect the new cable to the parking brake lever assembly.
    - 19.1 Install the bushing on the clevis pin. **See Fig. 6**.
    - 19.2 Put the clevis end of the cable up through the middle of the parking brake lever assembly.
    - 19.3 Put the curved brake lever arm (**Fig. 6**) into the middle of the brake lever assembly, and into the clevis.
    - 19.4 Line up the slots in the brake lever assembly, the hole in the curved arm, and the holes in the clevis.
    - 19.5 Install the clevis pin (with the bushing on it) from the side of the lever assembly with the electric wire connector (**Fig. 7**).
    - 19.6 Install the washer and cotter pin on the clevis pin.
20. Install the parking brake lever assembly on the cab deck.
    - 20.1 Put the baseplate on the deck, lining up the holes in the plate with those in the deck.
    - 20.2 Put the lever assembly in place so that its holes and those of the baseplate and the deck all line up.
    - 20.3 Install the four mounting bolts and washers. Tighten the fasteners firmly.
21. Connect the electrical wire to the passenger's side of the parking brake lever assembly. **See Fig. 7**.
22. Underneath the cab, route the parking brake cable through the double cable clamp on the side of the transmission (**Fig. 5**), and then up to the cable bracket on the top of the transmission.
23. Put the cable through the "D" hole in the bracket, then install the lockwasher and jam nut on the threaded end of the cable sheath. Don't tighten the nut all the way. **See Fig. 3**.
24. Connect the parking brake cable to the parking brake actuating lever.
    - 24.1 Screw the threaded end of the cable into the clevis far enough so the clevis holes will line up with the hole in the actuating lever. There should be no slack in the cable. **See Fig. 11**.

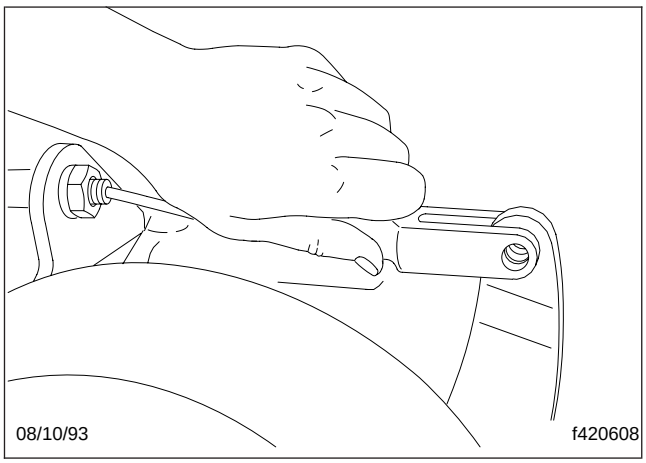


Fig. 11

- 24.2 Install the clevis pin in the holes of the clevis and that of the actuating lever.

Parking Brake Cable Replacement

24.3 Tighten the jam nut 900 N·cm (80 lbf·in).

24.4 Install the washer and a new cotter pin.

25. If a final cable adjustment is needed, make it in the cab, by turning the ring on the parking brake lever. **See Fig. 12**.

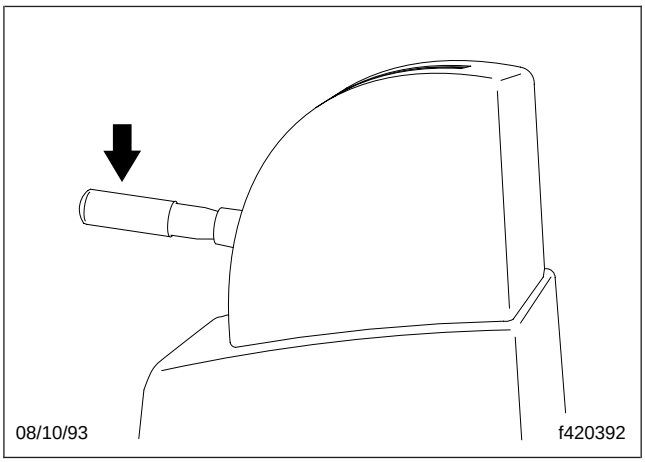


Fig. 12

Parking Brake Cable Adjustment

⚠ WARNING

Before starting the procedure below, read the information in "Safety Precautions, 100." Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

There are two methods of parking brake actuation available for Business Class trucks. Most vehicles have a hand-lever-actuated parking brake with the lever mounted on the cab floor. Some vehicles have an air-actuated system which is operated by a valve on the dash that controls a brake chamber mounted on the frame rail near the parking brake. When actuated, it applies the parking brake via a cable. Determine which method of actuation is used on the vehicle to be serviced, then follow the appropriate procedure below.

Prior to adjusting the parking brake cable, inspect the following components for damage, loose or missing parts, or leaks (in the case of air actuated system):

- Parking brake hand lever
- Brake chamber and plumbing (air-actuated system only)
- Cable
- Cable housing
- All mounting brackets and hardware

Make any necessary repairs before making adjustments to the brake cable.

Hand-Lever-Actuated Parking Brake Cable Adjustment

Prior to making adjustments to the hand-lever-actuated parking brake cable, ensure that the actuation system is in good working order.

1. Park the vehicle on a level surface, shut down the engine, and chock the tires.
2. Release the parking brake if it is applied.
3. Back off any excessive adjustment at the lever handle before making adjustments at the cable clevis. Leave enough for final cable adjustment, in either direction, as needed.
4. Remove the cotter pin and clevis pin from the clevis at the brake actuation lever. See **Fig. 1**.

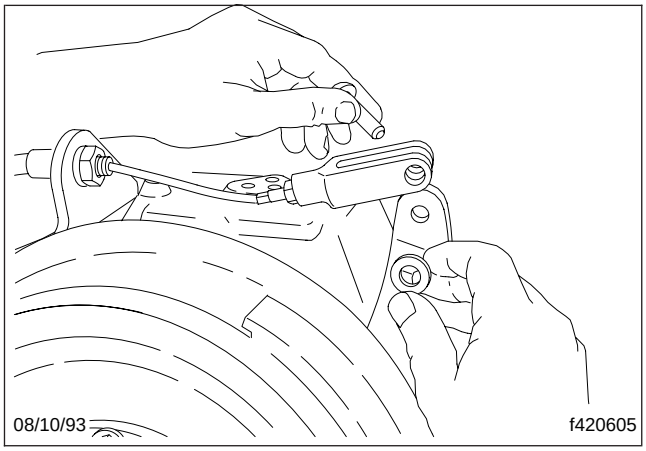


Fig. 1, Remove the Cotter Pin and Clevis Pin

5. Pull the brake actuation lever to the fully released position, then move it slightly back to take up the freeplay, and hold it there.
6. If adjustment is required, loosen the jam nut on the cable and adjust the clevis so that the pin hole in the clevis aligns with the hole in the lever.
7. Install the clevis pin and a new cotter pin.
8. Tighten the clevis jam nut to 80 lbf·in (900 N·cm).
9. If a final cable adjustment is needed, make it in the cab, by turning the ring on the parking brake lever.

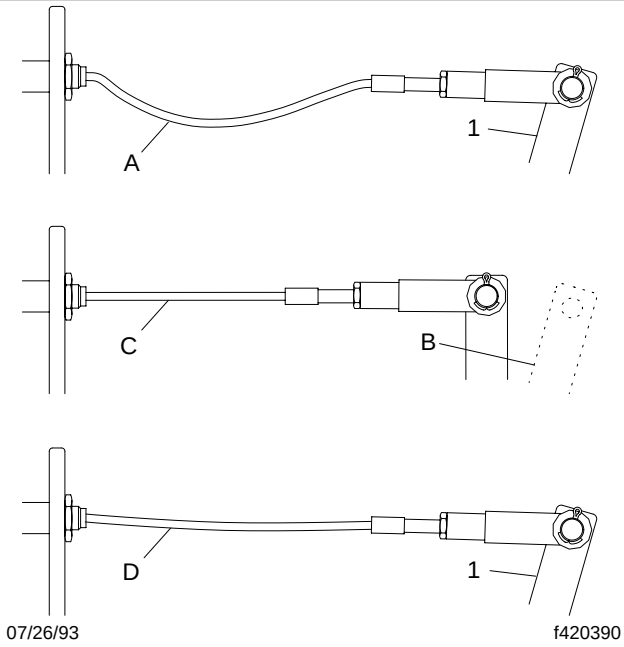
   When properly adjusted, the cable should have a very slight looseness to it. See **Fig. 2**.
10. Set the parking brake and remove the chocks.
11. Test the parking brake before returning the vehicle to service.

Air-Actuated Parking Brake Cable Adjustment

Prior to making adjustments to the air-actuated parking brake cable, insure that the actuation system is in good working order.

1. Park the vehicle on a level surface and chock the tires.

Parking Brake Cable Adjustment



A. Too Loose
B. Correct Position of Actuating Lever
C. Too Tight
D. Correct Cable Adjustment
1. Actuating Lever

Fig. 2, Parking Brake Cable Installation (typical)

2. Make sure the air system is fully charged, then shut down the engine.
3. Release the parking brake if it is applied.
4. Remove the cotter pin and clevis pin from the clevis at the brake lever. See **Fig. 1**.
5. Pull the brake lever until shoe-to-drum contact is made.
6. If adjustment is required, loosen the jam nut on the cable and adjust the clevis so that the pin hole in the clevis aligns with the hole in the lever.
7. Install the clevis pin and a new cotter pin.
8. Tighten the clevis jam nut to 80 lbf·in (900 N·cm).

   When properly adjusted, the cable should have a very slight looseness to it. See **Fig. 2**.
9. Set the parking brake and remove the chocks.
10. Test the parking brake before returning the vehicle to service.

Troubleshooting

This subject contains the following troubleshooting tables:

- The Parking Brake Won't Hold the Vehicle on a Grade
- The Parking Brake Won't Release
- The Parking Brake Makes Noises While the Vehicle Is Moving

Problem—The Parking Brake Won't Hold the Vehicle on a Grade

Possible Cause	Remedy
The brake shoe linings are worn down.	Replace the brake shoes.
The brake drum is cracked.	Replace the drum.
The brake drum lining is worn down, or heavily scored.	Replace the drum.
The brake cable is binding.	Repair or replace the cable.
There is too much slack in the brake cable.	Adjust the brake cable.
The brake shoe linings have grease on them.	Replace the brake shoes, then clean the inside of the drum.

Problem—The Parking Brake Won't Release

Possible Cause	Remedy
The brake cable is too tight.	Adjust the brake cable.
The brake shoe return springs are missing, detached, or broken.	Check the return springs. Install them or replace them as needed.
The contact points between the brake shoe webs and the actuator strut are corroded or dirty.	Check the area, and clean and lubricate as needed.
The parking brake lever in the cab is binding.	Check the parking brake lever assembly for damage or corrosion. Repair or replace as needed.

Problem—The Parking Brake Makes Noises While the Vehicle Is Moving

Possible Cause	Remedy
The parking brake drum is loose.	Check the brake drum mounting bolts. Tighten as needed.
The brake shoes or backing plate is loose.	Check the brake shoes, return springs, and backing plate mounting bolts. Tighten, repair, or replace, as needed.
There is dirt inside the brake drum.	Remove the brake drum and clean it. Also clean the other brake parts.

Specifications

Description	Torque	
	N·m (lbf·ft)	N·cm (lbf·in)
Transmission End-Nut		
Fuller	440 (325)	—
Allison	197 (145)	
Support Plate Mounting Bolts	115 (85)	—
Brake Drum Mounting Bolts	61 (45)	—
Midship Bearing Carrier Mounting Bolts	123 (91)	—
Cable Bracket Jam Nut (on top of transmission)	—	900 (80)

Table 1, Fastener Torques

General Information

The single check valve **(Fig. 1 and Fig. 2)** is installed in an air line to allow air flow in one direction and prevent air flow in the reverse direction. The check valve is installed in the upstream ends of the primary and secondary brake system air reservoirs to protect brake system air pressure in case the compressor, air pressure regulator or other air delivery component malfunctions.

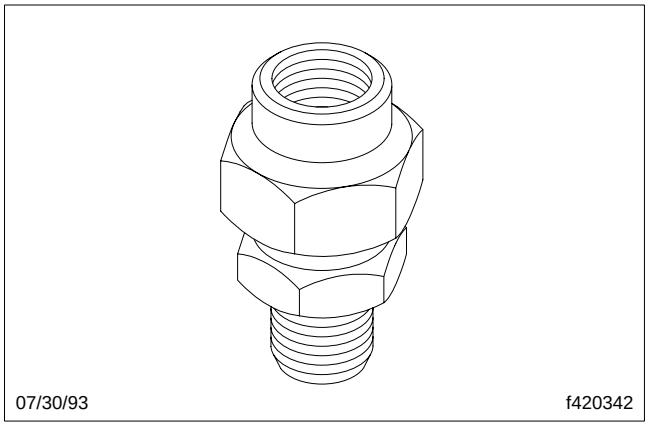


Fig. 1, Single Check Valve, Bendix

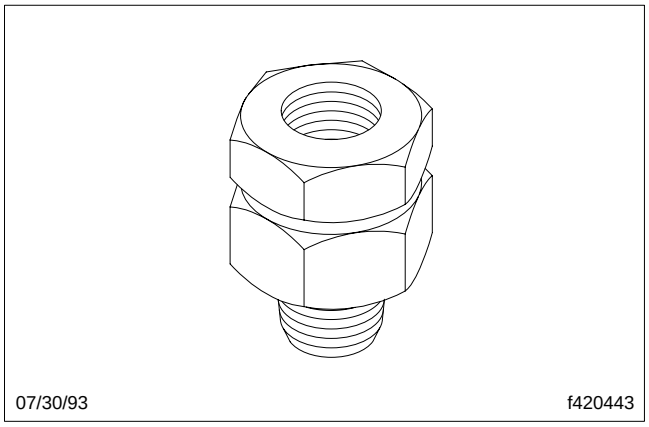


Fig. 2, Single Check Valve, Midland

Principles of Operation

When air in the system moves in the normal direction— from the compressor to the air reservoir— the check valve disk (**Fig. 3**, Ref. 4) compresses the spring (Ref. 2) and allows air to pass. When there is a drop in air pressure on the supply side of the valve, the spring pushes the check valve disk against the valve seat (Ref. 5) and prevents air from leaving the brake system.

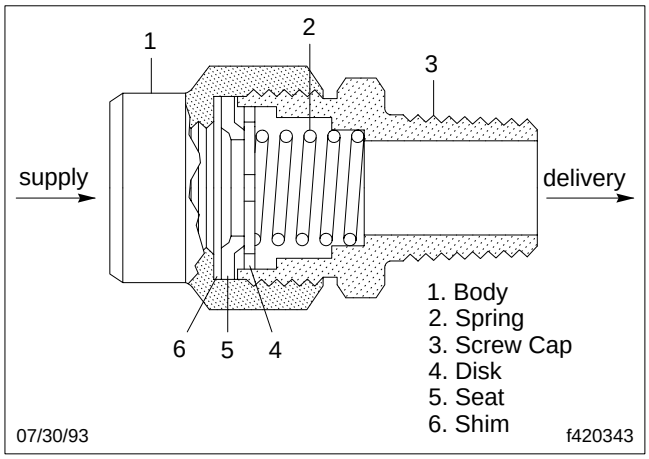


Fig. 3, Cross-Section (Bendix shown)

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Chock the wheels and stop the engine before working under the vehicle. Keep hands away from brake chamber push rods and slack adjusters; they will apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if not correctly disassembled. Use only the correct tools and observe all precautions regarding use of those tools.

Leakage Test

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

After repairing or replacing the single check valve, do the following test:

With the brake air system fully pressurized, drain the air from the supply reservoir (wet tank), and remove the air line from the supply side of the check valve. Coat the open end of the check valve with soap suds. A 2.5-cm (1-inch) or smaller bubble in five seconds is acceptable.

If the check valve is leaking too much, repair or replace it.

IMPORTANT: The Midland check valve is not serviceable. If it leaks or doesn't work, replace it.

Removal

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

1. Chock the tires, then drain the air reservoirs.
2. Remove the supply line from the check valve.
3. Remove the check valve from the air reservoir.

Installation

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

1. Screw the check valve into the supply end of the air reservoir. To ensure the valve is not reversed, the arrow marked on the valve body must point in the direction of air flow.
2. Leak test the check valve following the instructions under **"Leakage Test, 110."**
3. Connect the supply line to the open end of the check valve.

Disassembly, Cleaning and Inspection, and Assembly (Bendix only)

Disassembly

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

1. Remove the check valve following the instructions under **"Removal and Installation, 120."**
2. Remove the screw cap from the body. **See Fig. 1.**
3. Remove the shim, seat, disk, and spring.

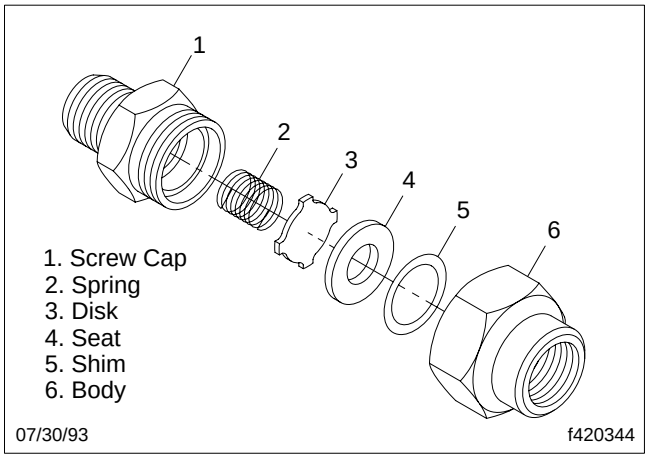


Fig. 1

Cleaning and Inspection

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

⚠ WARNING

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

Use eye protection when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

1. Wash all parts of the check valve in cleaning solvent. Dry the parts of the disassembled check valve with compressed air.
2. Inspect the disk for signs of wear or deterioration.
3. Check the spring for cracks, corrosion, or damage.
4. Inspect the body and screw cap for cracks or damage. Replace all worn or damaged parts with new parts.

Assembly

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

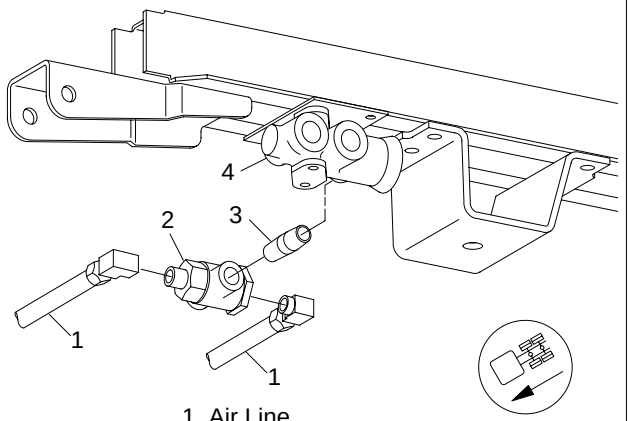
1. Position the shim, seat, disk, and spring in the body.
2. Screw the screw cap into the body over the other parts. Tighten it securely.
3. Install the check valve following the instructions under **"Removal and Installation, 120."**

General Information

The double check valve is used in the air brake system to direct a flow of air into a common line from either of two sources, whichever is at the higher pressure. The double check valve is used only on tractors. It allows the air circuit with the higher pressure to operate the trailer service brakes. Tractors equipped with a trailer control valve have two double check valves installed; otherwise, just one is installed. The valve(s) is installed on the service port of the tractor protection valve, at the back of the cab. **See Fig. 1.**

Principles of Operation

The double check valve has movable shuttles that seal off the lower pressure air source. As pressurized air enters either end of the double check valve inlet port, the moving shuttle responds to the greater pressure source and seals the opposite port. The air flow travels out the delivery port of the valve. The position of the shuttle will reverse if the pressure levels are reversed. The double check valve is designed so the shuttle cannot interfere with the backflow of air in the exhaust mode.



1. Air Line
2. Double Check Valve
3. Nipple
4. Tractor Protection Valve

NOTE: Not all parts are shown.

09/29/94 f420503

Fig. 1

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Chock the tires and stop the engine before working under a vehicle. Keep hands away from brake chamber push rods and slack adjusters; they will apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if they are not correctly disassembled. Use only the correct tools, and observe all precautions regarding use of those tools.

Operating and Leakage Test

1. If the vehicle is not a tractor with a trailer, go to the step for testing the check valve on the bench.

   If the vehicle is a tractor with a trailer, proceed as follows:

   1.1 Depress the foot brake pedal and release it while checking that the brakes apply and release on both the tractor and trailer.

   1.2 Apply and release the trailer control valve while checking that only the trailer brakes apply and release.

   1.3 Apply the trailer control valve and check the exhaust port of the foot brake valve for leakage using a soap solution. A 2.5-cm (1-inch) bubble or less in five seconds is allowable. Release the valve.

   1.4 Disconnect the air line from the trailer control valve exhaust port. Depress the foot brake pedal until it stops and hold it in place. Check the trailer control valve exhaust port for leakage using a soap solution. A 2.5-cm (1-inch) bubble or less in five seconds is allowable.

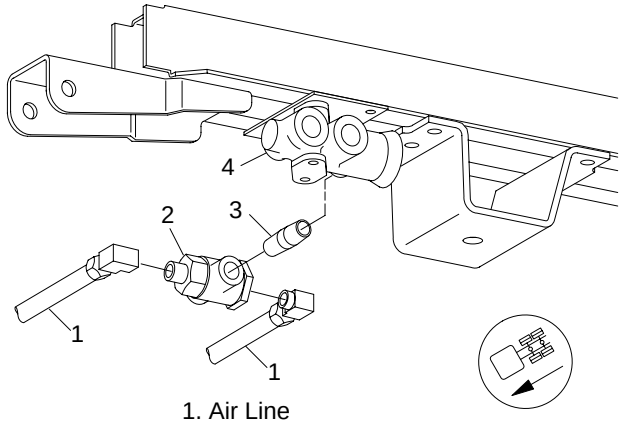
   1.5 Connect the air line to the trailer control valve exhaust port.

2. If the double check valve is to be tested on the bench, connect two separately controlled air supplies to the inlet ports.
3. Connect an accurate test gauge to the double check valve outlet port or to a line from the outlet port.
4. Apply and release air to one inlet port (foot brake pedal) while checking that the test gauge registers the application and release.
5. Apply and release air to the other inlet port (trailer control valve) while checking that the gauge registers the application and release.
6. Disconnect the line from one of the double check valve inlet ports. Apply air to the opposite inlet port while checking the first port for leakage using a soap solution. A 2.5-cm (1-inch) bubble or less in five seconds is allowable. Connect the line to the inlet port. Repeat this step, checking the opposite inlet port for leaks.
7. If the double check valve does not function as described, or if the leakage is excessive, replace it. Refer to **"Removal and Installation, 120"** for instructions.

   The Bendix valve can be also repaired, using Bendix parts. Refer to **"Disassembly, Cleaning and Inspection, and Assembly (Bendix only), 130"** for instructions.

   The Midland valve is not serviceable.

Removal



1. Air Line
2. Double Check Valve
3. Nipple
4. Tractor Protection Valve

NOTE: Not all parts are shown.

09/29/94 f420503

Fig. 1

⚠ WARNING

WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

1. Drain the air from the air reservoirs.
2. For later reference, mark the air lines to the double check valve(s). Then carefully disconnect them **(see Fig. 1.)**.
3. Unscrew the double check valve(s) from the tractor protection valve. **See Fig. 1.**

Installation

1. Screw the double check valve(s) into the tractor service port of the tractor protection valve.
2. Connect the air lines to the double check valve as marked. Tighten the air lines firmly.

Disassembly, Cleaning and Inspection, and Assembly (Bendix only)

Disassembly (Refer to Fig. 1)

1. Remove the valve from the vehicle. Refer to **"Removal and Installation, 120"** for instructions.
2. Remove the end cap from the valve.
3. Remove the O-ring.
4. Remove the shuttle valve and shuttle guide.

Cleaning and Inspection

⚠ WARNING

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

1. Clean all metal parts in a cleaning solvent.
2. Inspect all metal parts for signs of cracks, wear, or deterioration. Replace all parts not considered serviceable.
3. Replace all rubber parts.

Assembly

1. Install the shuttle valve and shuttle guide in the valve body.
2. Coat the O-ring with BW 650M silicone lubricant (BW 291126). It is not necessary to lubricate the shuttle valve.
3. Install the O-ring.
4. Install the end cap on the valve body.
5. Install the valve on the vehicle. Refer to **"Removal and Installation, 120"** for instructions.
6. Test the valve. Refer to **"Operating and Leakage Test, 110"** for instructions.

Disassembly, Cleaning and Inspection, and Assembly (Bendix only)

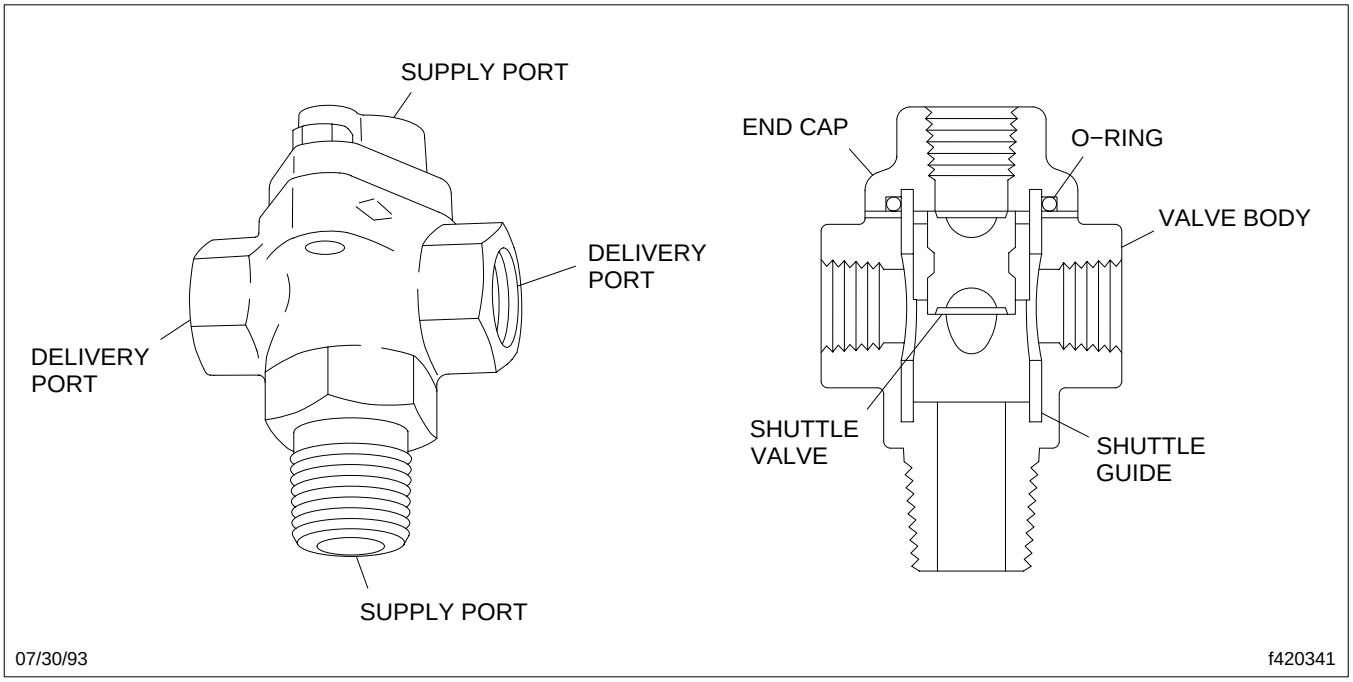


Fig. 1, Double Check Valve, Bendix

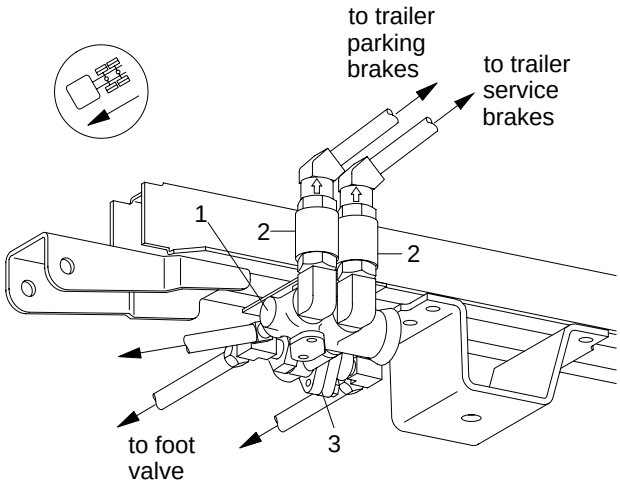
General Information

The Bendix TP-3 tractor protection valve is mounted on the back of the cab. **See Fig. 1.** Air hoses from the foot valve are connected to a double check valve on the tractor service port, and an air hose from the dash valve is connected to the tractor emergency port. **See Fig. 1 and Fig. 2.** One or two quick-release valves are installed between the trailer hoses and the trailer ports on the TP-3. **See Fig. 1.**

Principles of Operation

When the trailer air supply valve is open, air flows through the TP-3 valve emergency ports **(see Fig. 2)** to the trailer air brake system, and releases the trailer parking brakes. The air within the TP-3 valve exerts pressure on a plunger, which unseats an inlet valve, and opens the service ports. **See Fig. 3.** This allows service application of the trailer air brakes.

At least 310 kPa (45 psi) pressure on the plunger is required to open the inlet valve. Whenever the air supply is shut off (at the trailer air supply valve), or the pressure drops below the min-imum 310 kPa (45 psi), the plunger rises, seating the inlet valve and closing the service ports to protect the tractor brake system pressure.

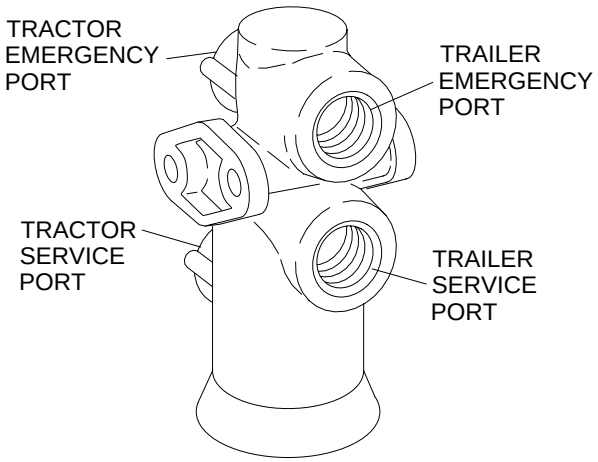


1. TP−3 Valve
2. Quick Release Valve
3. Double Check Valve

NOTE: Not all parts are shown.

07/30/93 f420504

Fig. 1



07/30/93 f420866

Fig. 2

General Information and Principles of Operation

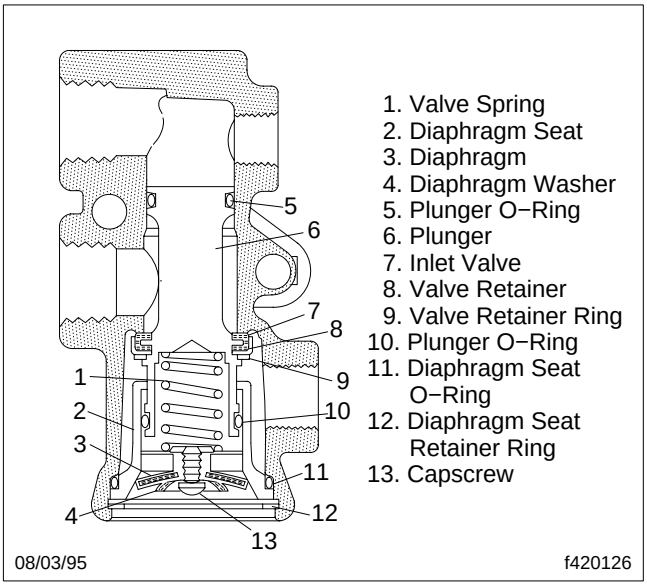


Fig. 3

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Chock the tires and stop the engine before working under the vehicle. Keep hands away from brake chamber push rods and slack adjusters; they will apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if not correctly disassembled. Use only correct tools and observe all precautions regarding use of those tools.

Test

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

1. Chock the tires. Place the trailer air supply valve in the emergency position, and disconnect the trailer air lines from the trailer supply and service couplings. Apply a soap-water solution to the couplings.
2. With tractor reservoirs charged to at least 689 kPa (100 psi) make and hold a full service brake application. Leakage at either tractor hose coupling should not exceed a 2.5-cm (1-inch) bubble in five seconds.
3. Connect the trailer supply line hose coupling, and place the trailer supply valve in the "run" position. Leakage at the service coupling should not exceed a 2.5-cm (1-inch) bubble in five seconds.
4. Connect the service brake coupling, and make and hold a full service brake application. Leakage at the diaphragm end of the TP-3 valve should not exceed a 2.5-cm (1-inch) bubble in three seconds.

IMPORTANT: If leakage is excessive, replace the valve.

5. Remove the chocks.

Removal

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

1. Chock the tires, and drain the air reservoirs.
2. Remove the trailer hose assemblies from the TP-3 valve. Mark the tractor service and supply lines for later assembly reference, and carefully disconnect them. Cap the air lines tightly to keep out contaminants.
3. Remove the fasteners attaching the TP-3 valve to the vehicle, then remove the valve.

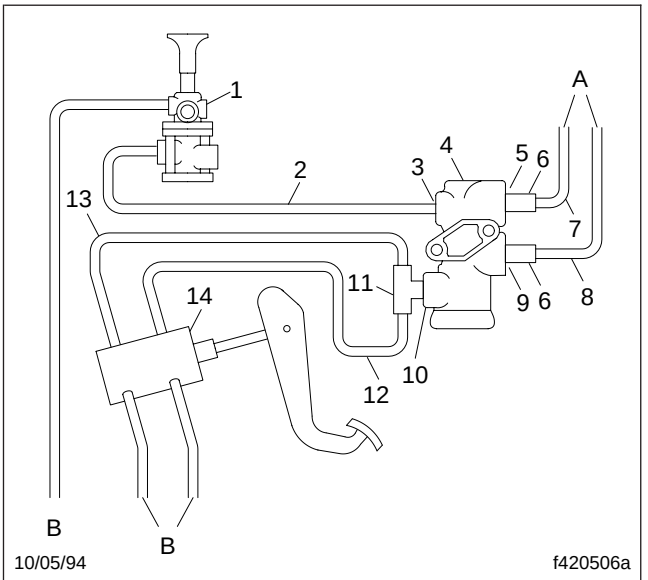
Installation

1. Place the TP-3 valve on the vehicle, and attach it with bolts, washers, and nuts. Tighten the nuts 11 to 15 lbf·ft (15 to 20 N·m).
2. Remove the caps from the air lines, then connect them to the TP-3, the double check valve, and the quick-release valve(s) as shown in **Fig. 1**, and as previously marked.

   NOTE: The trailer emergency line (Ref. 7) may not be connected to a quick-release valve; it may connect directly to the port on the TP-3 valve.

   2.1 Connect the hose fittings to their applicable ports or valves, and tighten them finger-tight.

   2.2 Using a wrench, tighten the nuts at least two turns, or until no threads show on the fitting.
3. Close the drain cocks to the air reservoirs. Start the engine to pressurize the air system.
4. Leak test the TP-3 valve following the instructions under **"Leakage Test, 110."**



A. To trailer hose connections.
B. From air reservoirs.
1. Trailer Air Supply Valve
2. Trailer Air Supply Line
3. Tractor Emergency Port
4. TP–3 Valve
5. Trailer Emergency Port
6. Quick Release Valve
7. Trailer Emergency Line
8. Trailer Service Line
9. Trailer Service Port
10. Tractor Service Port
11. Double Check Valve
12. Primary Foot Valve Service Line
13. Secondary Foot Valve Service Line
14. Foot Valve

Fig. 1, Plumbing Diagram

Disassembly, Cleaning and Inspection, and Assembly

Disassembly

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

1. Remove the valve from the vehicle. For instructions, refer to **"Removal and Installation, 120."**
2. Holding the diaphragm seat in the body, remove the diaphragm seat retainer ring. **Refer to Fig. 1**, Refs. 2 and 12.
3. Allow the valve spring to expand until the valve diaphragm seat assembly, valve spring, and plunger assembly can be removed.
4. Remove the diaphragm seat O-ring (Ref. 11) from the valve housing.
5. Remove the capscrew (Ref. 13) and diaphragm washer (Ref. 4) from the diaphragm seat assembly.
6. Remove the valve retainer ring (Ref. 9), valve retainer (Ref. 8), inlet valve (Ref. 7), and O-rings (Refs. 5 and 10) from the plunger.

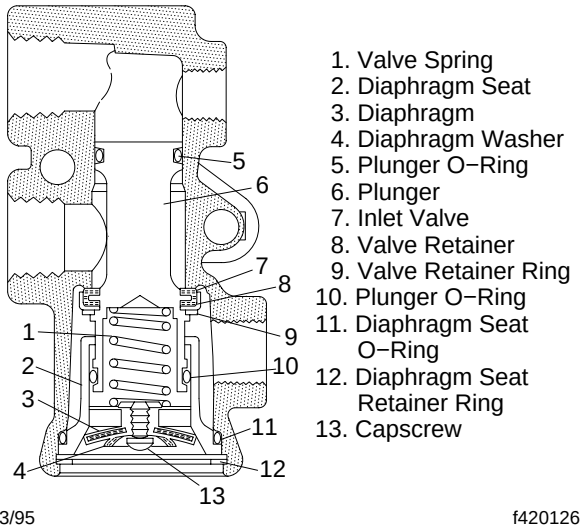


Fig. 1

Cleaning and Inspection

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

⚠ WARNING

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

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

1. Wash all metal parts of the TP-3 valve in cleaning solvent. Dry the metal parts of the disassembled valve with compressed air.
2. Wipe all rubber parts clean with a clean cloth. Examine all rubber parts. If any rubber parts are worn, cracked, torn or otherwise damaged, replace them with new parts.
3. Examine all metal parts. If any metal parts are worn, cracked or otherwise damaged, replace them with new parts.
4. Check the spring. If the spring is distorted or corroded, replace it.

Assembly

IMPORTANT: Before working on or around air brake systems and components, review **"Safety Precautions, 100."**

1. Lubricate the O-rings and all sliding parts with Dow Corning 55-M pneumatic grease or equivalent.
2. Install the inlet valve (**Fig. 1**, Ref. 7) on the plunger.
3. Install the valve retainer (Ref. 8) over the inlet valve.
4. Install the valve retainer ring (Ref. 9) beneath the inlet valve retainer.
5. Install both plunger O-rings (Refs. 5 and 10) in the proper grooves.

Disassembly, Cleaning and Inspection, and Assembly

6. Place the plunger and valve assembly in the valve body.
7. Install the capscrew (Ref. 13), diaphragm washer (concave side down, Ref. 4), and diaphragm (Ref. 3) into the diaphragm seat (Ref. 2).
8. Place the inlet valve spring (Ref. 1) into the plunger.
9. Install the diaphragm seat O-ring (Ref. 11) in the body.
10. Install the diaphragm seat assembly over the spring and plunger assembly, and force them into the valve body.
11. Install the diaphragm seat retainer ring, making sure the retainer ring snaps fully into the groove.
12. Install the TP-3 valve on the vehicle following the instructions under **"Removal and Installation, 120."**

General Description

The Rockwell driveline parking brake is designed to hold the vehicle on a grade, and to stop a slow moving vehicle if the service brakes aren't working. The parking brake is manually operated, and has a mechanical linkage; it doesn't rely on hydraulic or air pressure. It is installed only on vehicles with hydraulic brakes.

The parking brake is mounted either on the rear of the transmission (**Fig. 1**), between it and the driveshaft, or on the rear drive axle (**Fig. 2**). The main parts of the brake are the drum, brake shoes, return springs, backing plate, cam, actuator strut, actuating lever, brake cable, and brake lever assembly. **See Fig. 3.**

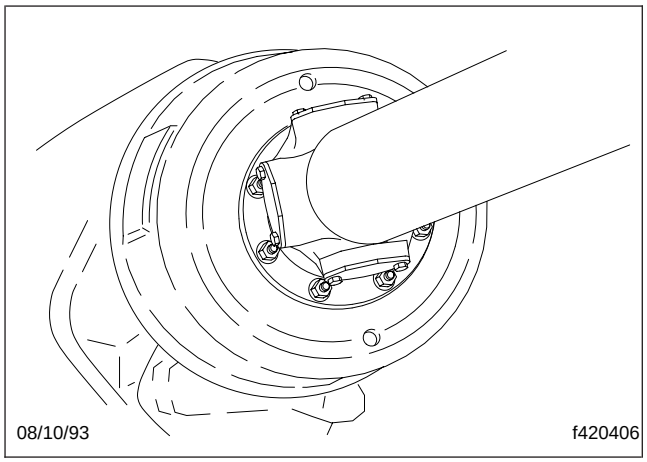


Fig. 1

The brake drum is bolted onto the driveline companion flange, and the backing plate is bolted to the rear of the transmission, or on the rear axle. The brake shoes are held in place by the return springs. The brake cable runs from the actuating lever to inside the cab, where it is controlled by the parking brake lever assembly. **See Fig. 4**. A ring at the end of the parking brake lever is used to adjust the cable length to compensate for brake shoe wear.

Principles of Operation (Fig. 5)

When the brake lever is pulled up, the brake cable pulls the actuating lever, turning the cam. The cam fits into an oblong hole in the actuator strut, and rotates the strut slightly. This pushes the brake shoes

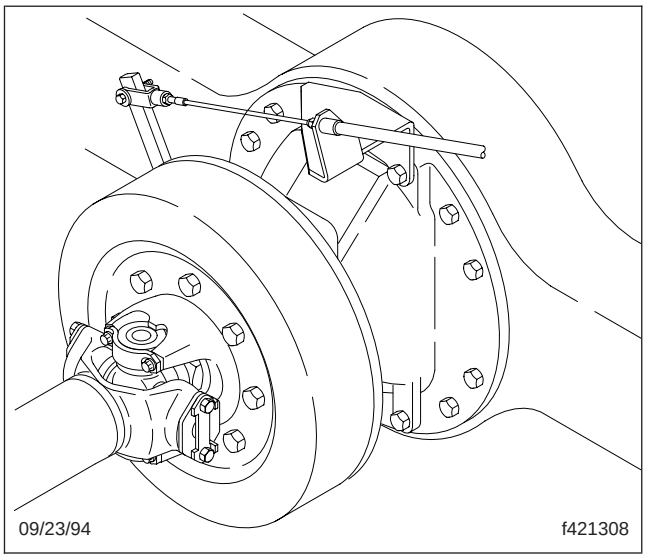
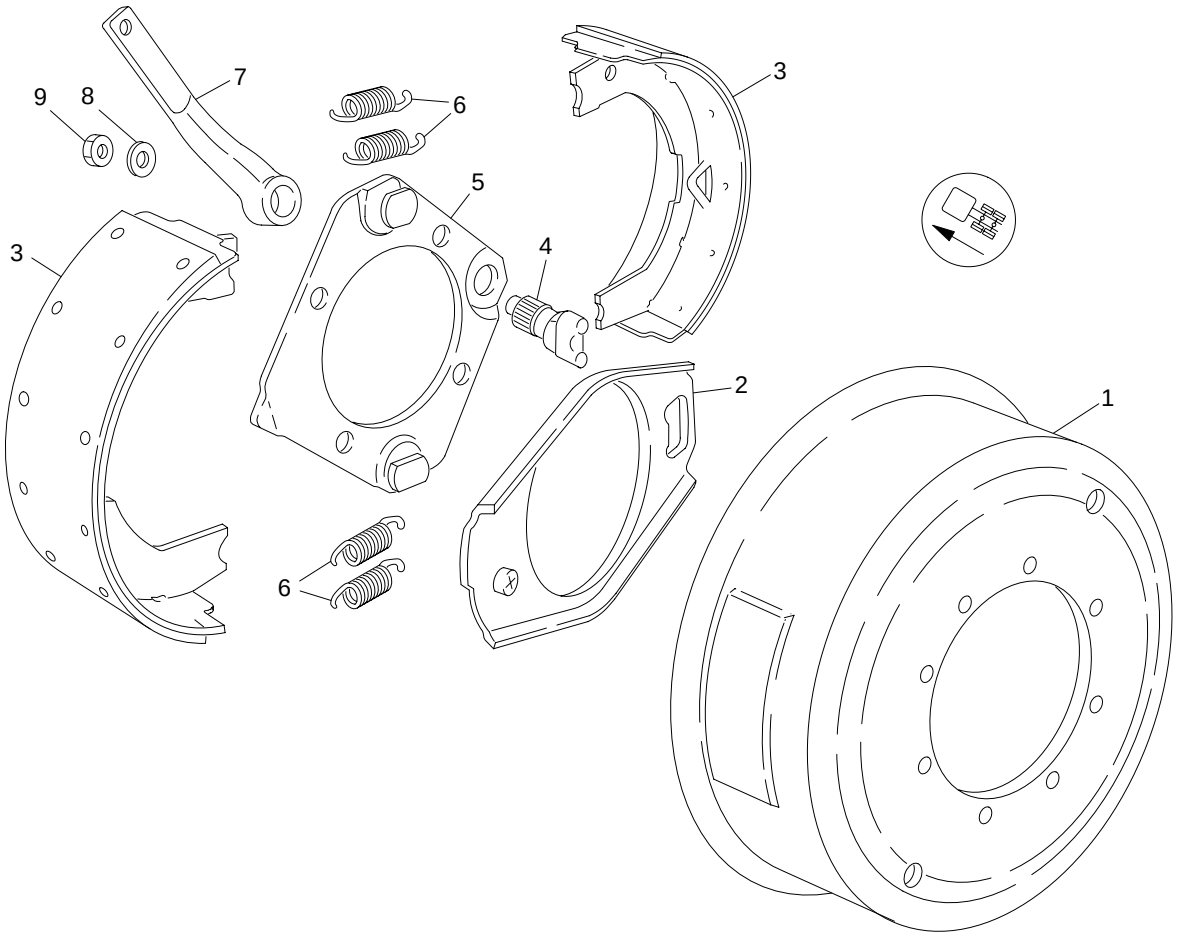


Fig. 2

outward against the brake drum. Because the backing plate and brake shoes are mounted in a fixed position on either the transmission or rear axle, and the drum is attached to the end of the driveshaft, the driveshaft is prevented from turning. This keeps the vehicle from rolling.

When the parking brake lever is released, the tension on the cable is removed. The actuating lever, cam, and actuator strut all return to their original positions, and the brake return springs pull the brake shoes away from the brake drum. The driveshaft is then free to move, and the vehicle can be moved.

General Description and Principles of Operation



09/20/93 f420391

NOTE: Not all parts are shown.

1. Drum
2. Actuator Strut
3. Brake Shoe
4. Cam
5. Backing Plate
6. Return Springs
7. Actuating Lever
8. Washer
9. Nut

Fig. 3

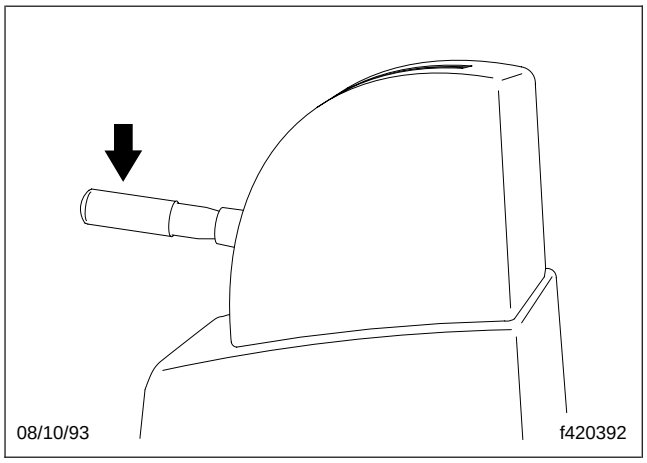
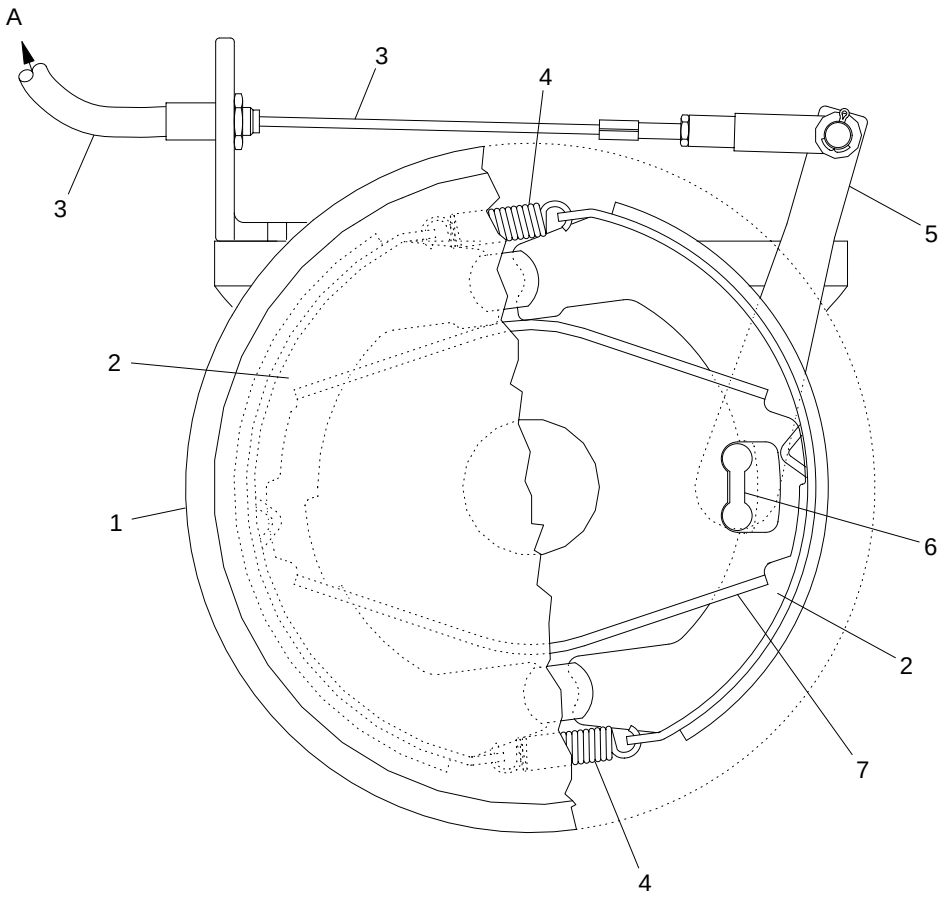


Fig. 4

General Description and Principles of Operation



09/20/93 f420389

A. To parking brake lever in the cab.
1. Brake Drum (shown cut away)
2. Brake Shoe
3. Brake Cable
4. Return Springs
5. Actuating Lever
6. Cam
7. Actuator Strut

Fig. 5, Transmission-Mounted Parking Brake Shown

Safety Precautions

Because most brake linings contain asbestos, you should know the potential hazards of asbestos and the precautions to be taken. Because medical experts believe that long-term exposure to some non-asbestos fibers could also be a health hazard, also observe the following precautions if servicing non-asbestos brake linings.

Exposure to airborne brake lining dust can cause serious and possibly fatal diseases such as asbestosis (a chronic lung disease) and cancer.

During brake servicing, wear an air purifying respirator with high-efficiency filters. The respirator and filter must be approved by NIOSH or MSHA, and worn during all procedures.

OSHA recommends that enclosed cylinders equipped with vacuums and high-efficiency (HEPA) filters be used during brake repairs. Under this system, the entire brake assembly is placed within the cylinder and the mechanic works on the brake through sleeves attached to the cylinder. Compressed air is blown into the cylinder to clean the assembly, and the dirty air is then removed from the cylinder by the vacuum.

If such an enclosed system is not available, or can't be used, clean the brake assembly in the open air. During disassembly, carefully place all parts on the floor to minimize creating airborne dust. Using an industrial vacuum cleaner with an HEPA filter system, remove dust from all the brake parts. After vacuuming, remove any remaining dust using a rag soaked in water and wrung until nearly dry.

⚠ WARNING

WARNING: Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the parking brake, starting with removal of the brake drum and continuing through assembly.

Removal

WARNING

WARNING: Before starting the procedure below, read the information in "Safety Precautions 100." Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

1. Chock the tires. Apply the parking brake to keep the brake drum in place when the driveline is disconnected.
2. Remove the driveline midship bearing carrier from the frame crossmember.
   - 2.1 Put a jackstand under the driveline at the rear of the midship bearing.
   - 2.2 Remove the bolts holding the midship bearing carrier to the bracket on the frame crossmember. **See Fig. 1.**

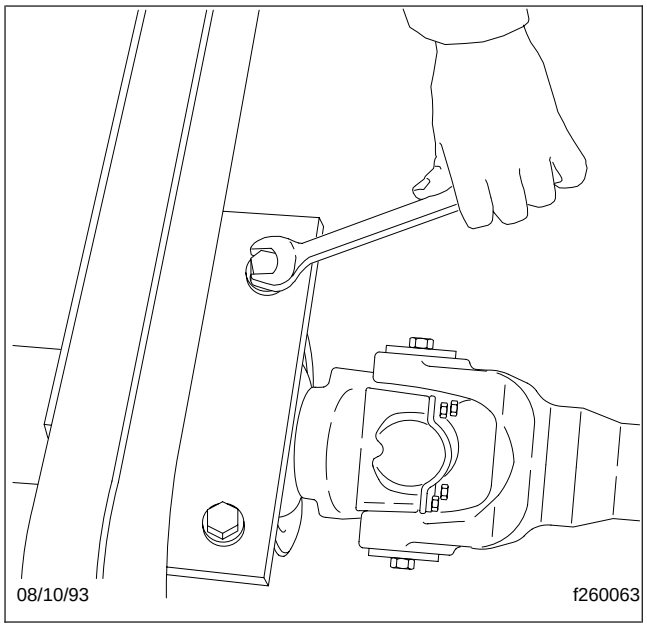


Fig. 1

   - 2.3 Lower the driveline and midship bearing carrier onto the jackstand. It should rest securely on the jackstand.
3. Disconnect the driveline companion flange from either the transmission or rear axle companion flange. **See Fig. 2.**

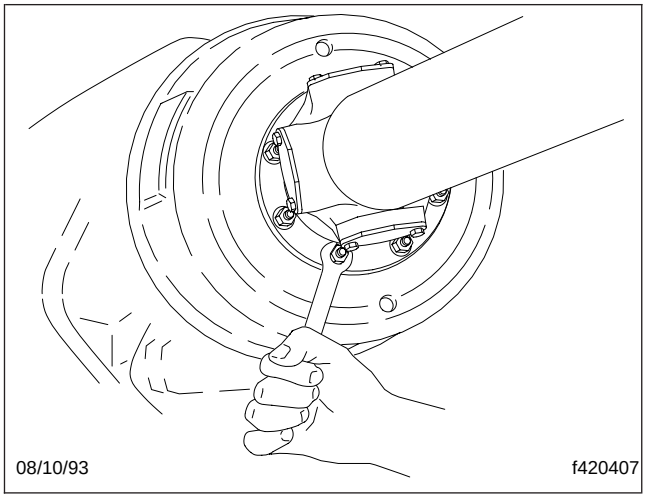


Fig. 2

4. Slide out the driveline, and lower it to the floor. **See Fig. 3.**

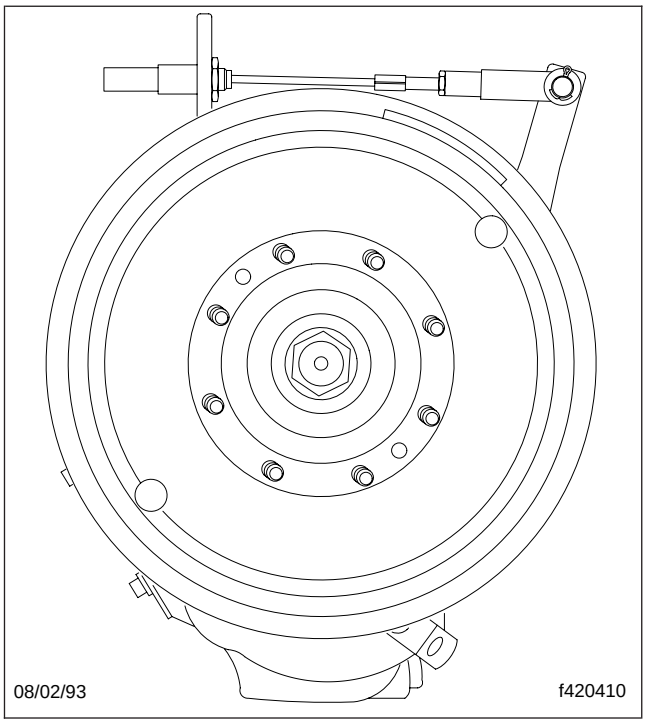


Fig. 3, Driveline Removed (transmision-mounted parking brake shown)

Removal and Installation

5. Release the parking brake.
6. Disconnect the brake cable from the actuating lever. **See Fig. 4.**

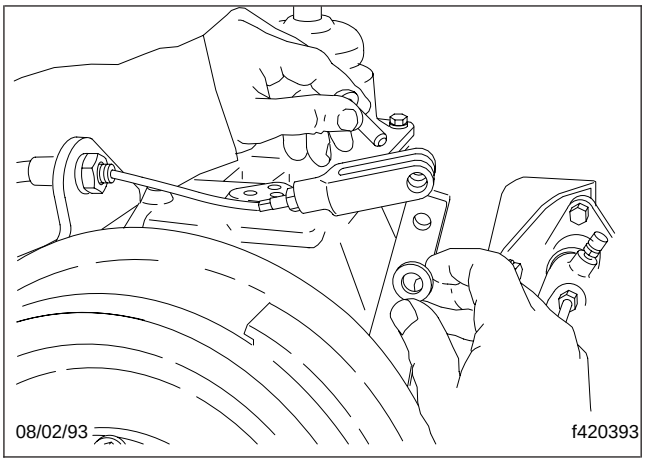


Fig. 4, (Transmision-mounted parking brake shown)

7. Pull the brake drum off either the transmission or rear axle companion flange. **See Fig. 5 .**

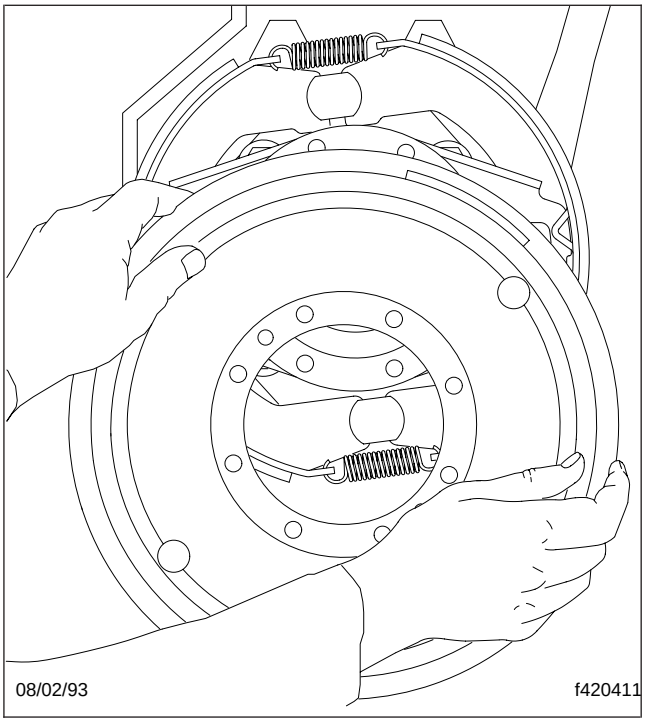


Fig. 5

8. Remove the brake shoes.
   - 8.1 Carefully remove the lower brake shoe return springs. **See Fig. 6.**

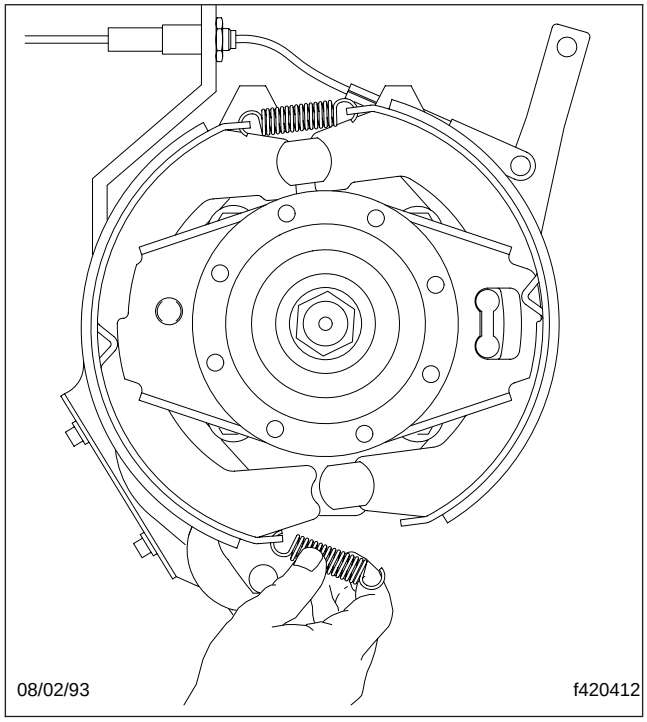


Fig. 6

   - 8.2 Pull the bottom of one brake shoe out, releasing the pressure on the upper return springs. **See Fig. 7**. Then remove the upper return springs.
   - 8.3 Remove both brake shoes.
9. Remove the actuator strut.
   - 9.1 Remove the large end-nut from either the transmission or rear axle shaft. **See Fig. 8.**
   - 9.2 Remove the companion flange that holds the actuator strut in place. **See Fig. 9.**
   - 9.3 Remove the actuator strut. **See Fig. 10.**
10. Remove the four hexbolts, washers, and nuts holding the backing plate to the square adapter on the end of the transmission (or rear axle), then remove the backing plate. **See Fig. 11** and **Fig. 12.**
11. If replacing the actuating lever or cam, remove them from the backing plate.

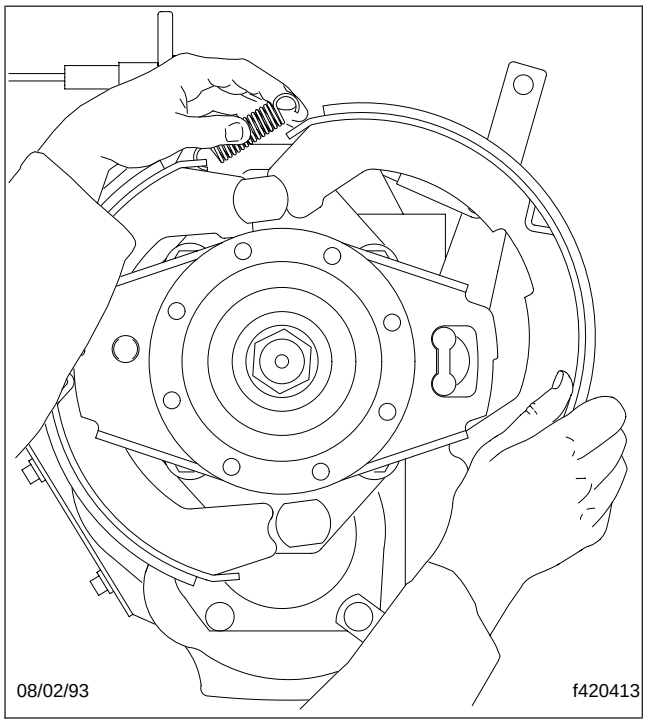


Fig. 7

11.1 Mark the splines of the lever and cam for later reference.

11.2 Put the backing plate in a padded vise, then remove the nut and washer holding the lever and the cam together. Remove them from the backing plate. **See Fig. 13** and **Fig. 14.**

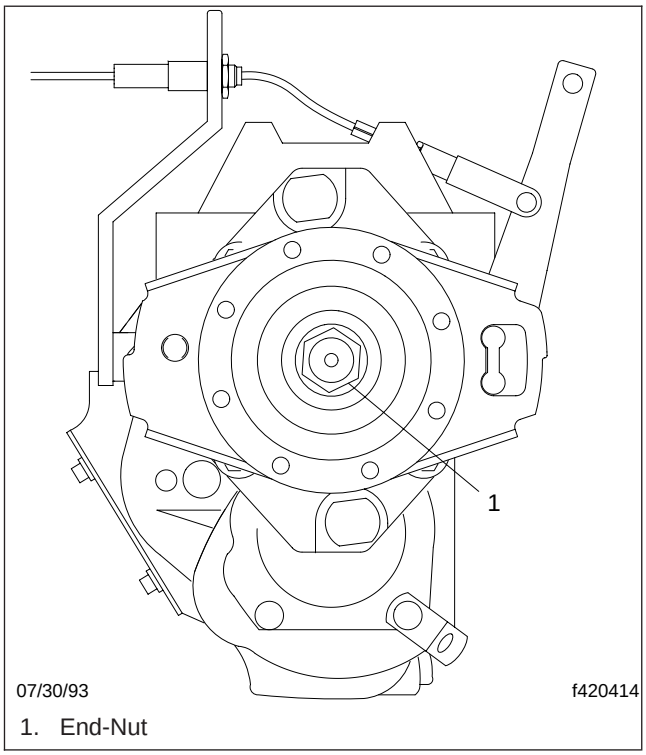
Installation

1. Clean all the parts. Check for damage and corrosion, and replace parts if needed. Check the backing plate for cracks or bending. Replace it if needed.

CAUTION

CAUTION: Don't let any grease get on the brake drum or linings. Grease on these parts will reduce the effectiveness of the driveline parking brake. If brake linings become contaminated, replace them.

2. Using NLGI grade 2 brake grease, lubricate the following parts (**see Fig. 15**):



1. End-Nut

Fig. 8

- cam head face and journals;
- the mating surfaces of the brake shoe webs and the actuator strut;
- at both sides of the cam hole in the backing plate.

3. If the cam and actuating lever were removed, install them on the backing plate.

3.1 Put the cam through the hole in the backing plate. **See Fig. 14.**

3.2 Using the reference marks made during removal, align the splines of the actuating lever with those of the cam, then install the lever on the cam.

3.3 Install the nut and washer on the cam. **See Fig. 13**. Tighten the nut until there is 0.025 to 0.25 mm (0.001 to 0.010 inch) clearance between the actuating lever and the backing plate.

4. Using the four hexbolts, nuts, and washers, install the backing plate on the transmission or rear axle. **See Fig. 11**. Tighten the nuts.

Removal and Installation

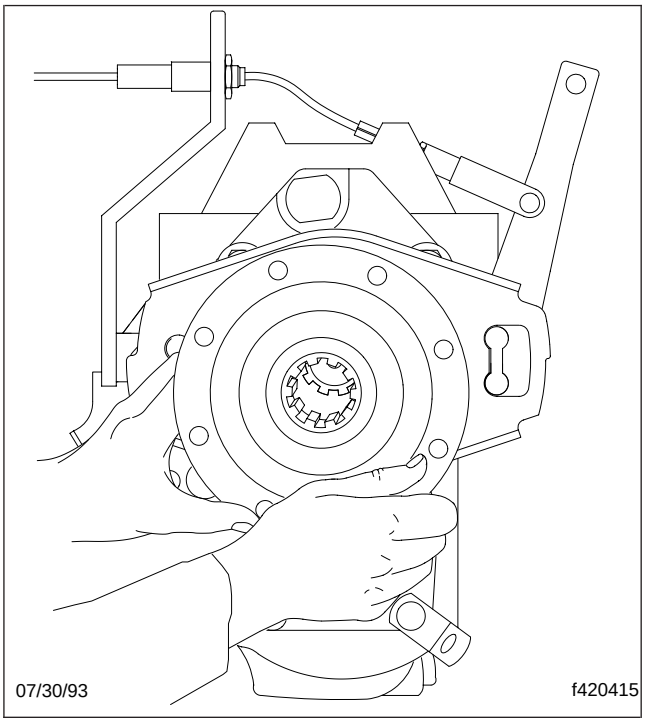
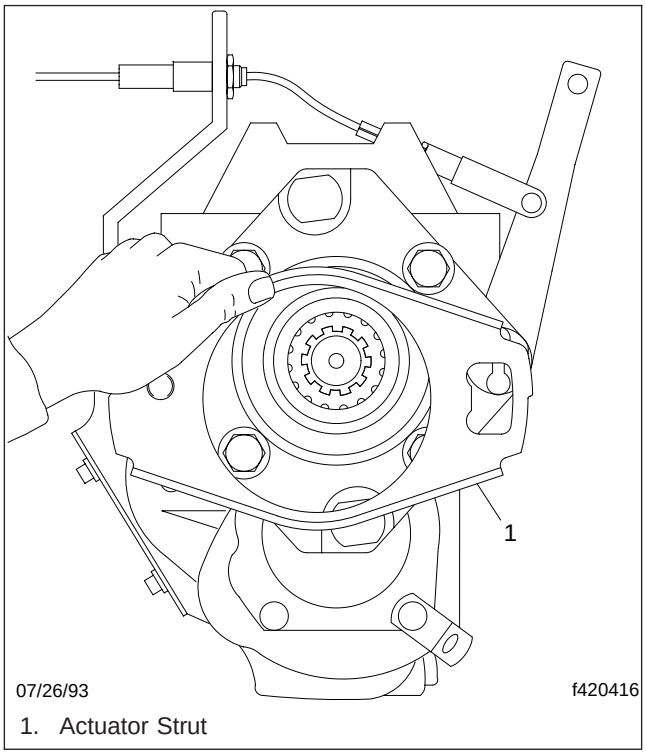


Fig. 9

- If mounted on Fuller transmissions—230 to 251 N·m (170 to 185 lbf·ft)
- If mounted on Allison transmissions—203 to 224 N·m (150 to 165 lbf·ft)
- If mounted on the rear axle—203 to 224 N·m (150 to 165 lbf·ft)

5. Install the brake shoes on the backing plate so that the web ends are up against the bosses on the backing plate.
6. Install four new brake return springs.
7. Install the actuator strut on the backing plate.
   - 7.1 Put the actuator strut on the backing plate so its pressure points are against those of the brake shoe webs, and so the slot in the actuator strut will go over the cam.
   - 7.2 Install the companion flange over the splines of the transmission shaft (or rear axle shaft). **See Fig. 9.**
   - 7.3 Install the large end-nut on the end of the transmission or rear axle shaft. **See Fig. 8** . Tighten the nut.



1. Actuator Strut

Fig. 10

- If mounted on Fuller transmissions—440 N·m (325 lbf·ft)
- If mounted on Allison transmissions—950 N·m (700 lbf·ft)
- If mounted on the rear axle—1000–1250 N·m (740–920 lbf·ft)

8. Install the brake drum onto the studs of the transmission (or rear axle) companion flange. **See Fig. 5.**
9. Connect the driveline companion flange to the transmission (or rear axle) companion flange.
   - 9.1 Place the driveline companion flange so its holes fit over the studs on the transmission (or rear axle) companion flange.
   - 9.2 Install the eight nuts and washers on the studs. **See Fig. 3**. Tighten them 61 N·m (45 lbf·ft).
10. Connect the brake cable to the brake lever.
    - 10.1 Check the length of the brake cable. It should be just long enough to let the cle-

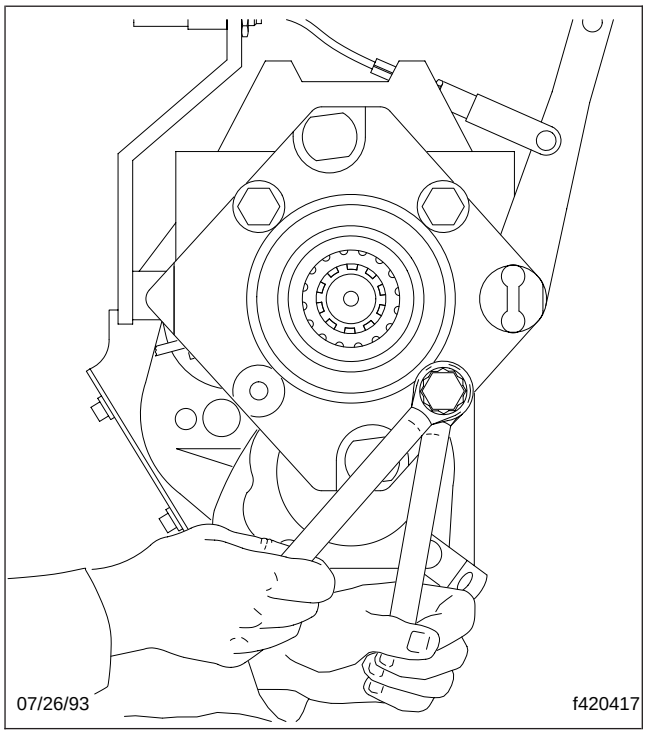


Fig. 11

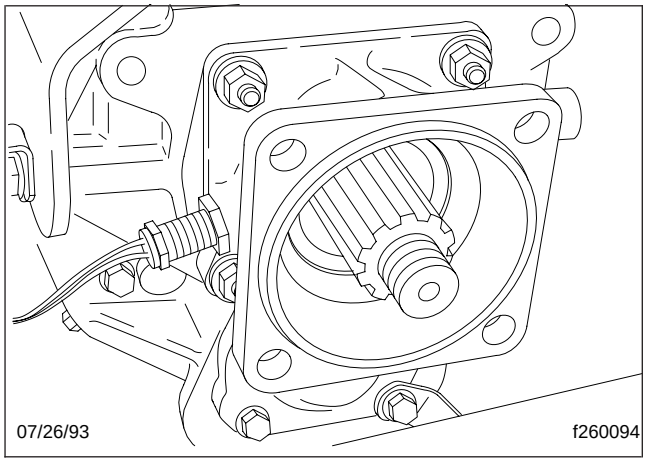


Fig. 12, Backing Plate Removed

vis hole align with the hole in the actuating lever, without moving the actuating lever. **See Fig. 16.**

If the brake cable is too loose or too tight, screw the clevis in or out until the its holes line up with the hole in the actuating lever (without moving the lever). **See Fig. 17.**

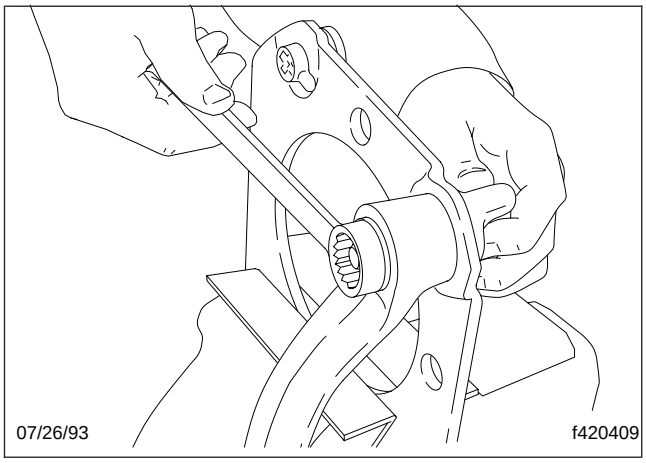


Fig. 13

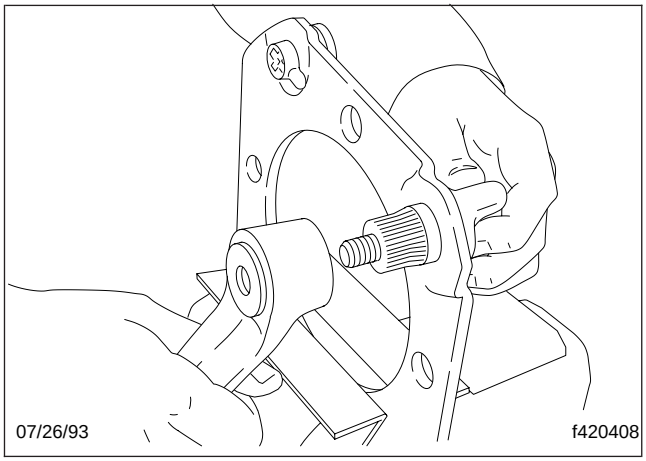


Fig. 14

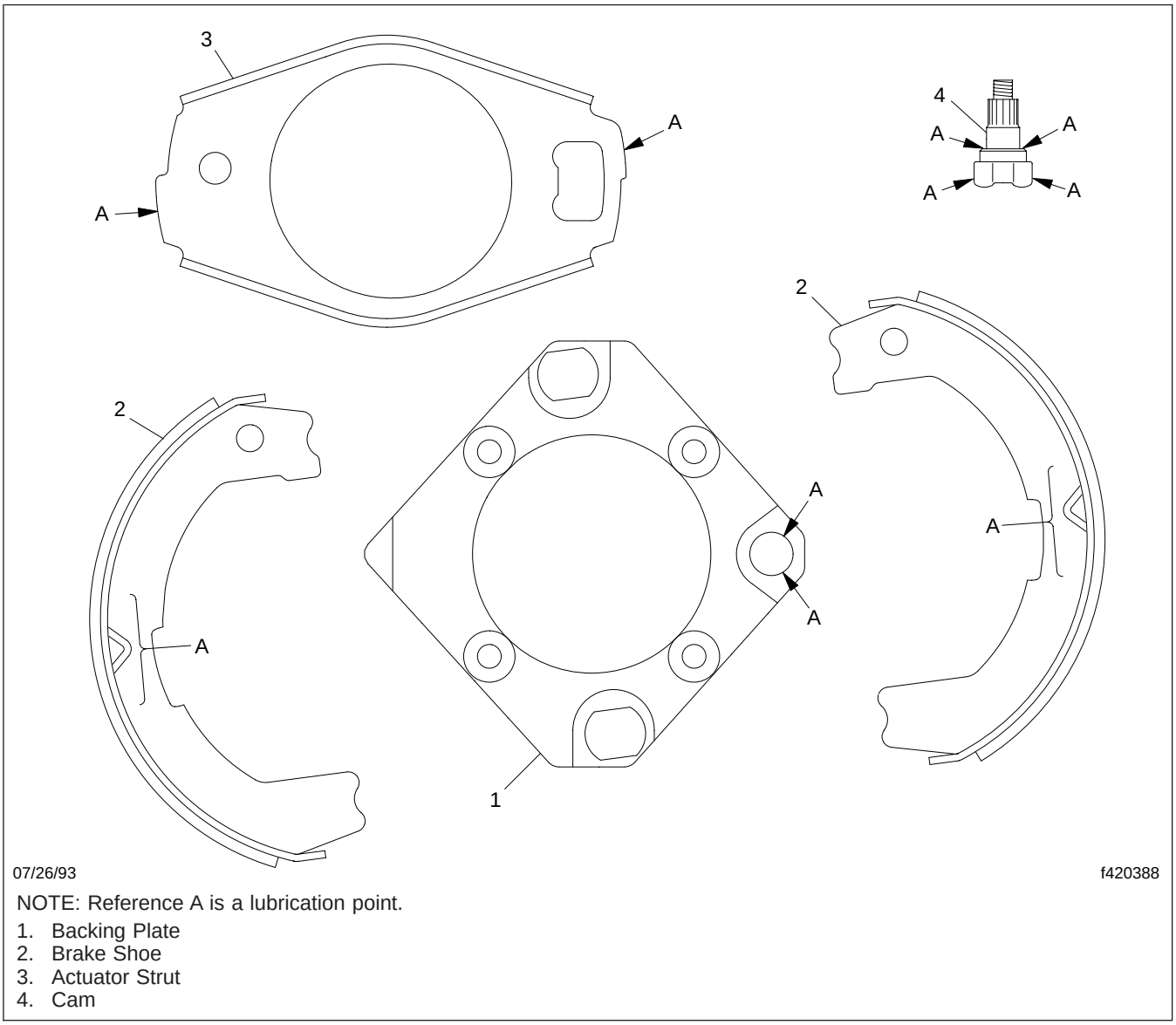
10.2 Install the clevis pin through the clevis and actuating lever holes.

10.3 Install the washer and a new cotter pin on the clevis pin.

10.4 Check the brake cable again for any slack. If it still needs adjusting, do it in the cab by turning the ring on the handle of the parking brake lever. **See Fig. 18.**

11. Attach the driveline midship bearing carrier to the bracket on the frame crossmember. Tighten the fasteners 123 N·m (91 lbf·ft).

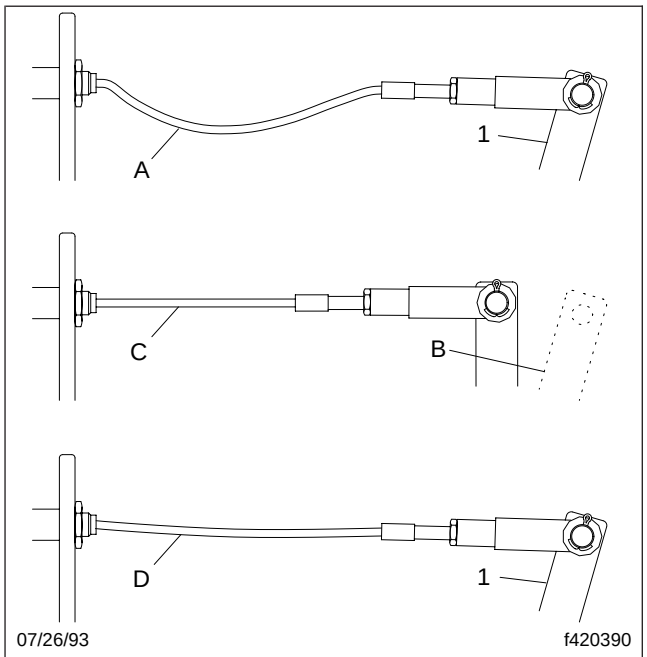
Removal and Installation



NOTE: Reference A is a lubrication point.

1. Backing Plate
2. Brake Shoe
3. Actuator Strut
4. Cam

Fig. 15



A. Too Loose.
B. Correct position of actuating lever.
C. Too Tight.
D. Correct cable adjustment.
1. Actuating Lever

Fig. 16, Brake Cable Tightness

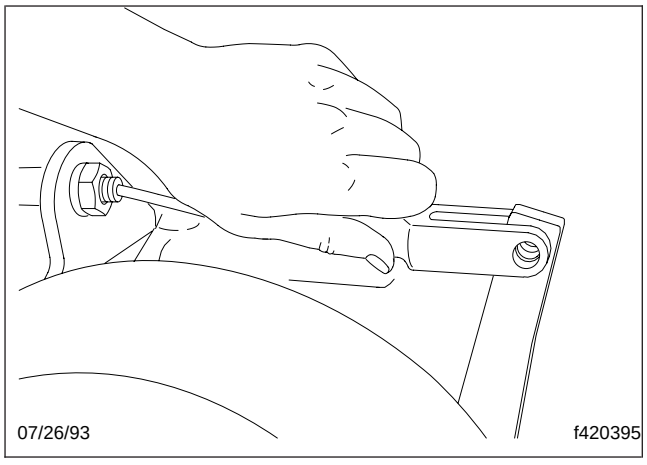


Fig. 17

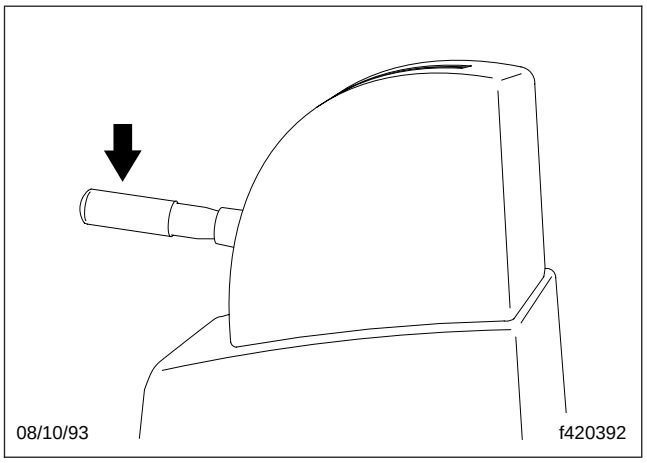


Fig. 18

Replacement

⚠ WARNING

Before starting the procedure below, read the information in "Safety Precautions, 100." Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

1. Chock the tires. Apply the parking brake to keep the brake drum in place when the driveline is disconnected.
2. Remove the brake drum. For instructions, refer to **Subject 110.**
3. Check the inside of the brake drum for cracking, scoring, or other damage. If needed, resurface or replace the drum. If the inside diameter of the drum is more than 307 mm (12.09 inches), replace the drum.
4. Remove the old brake shoes.

   4.1 Carefully remove the lower brake shoe return springs. **See Fig. 1.**

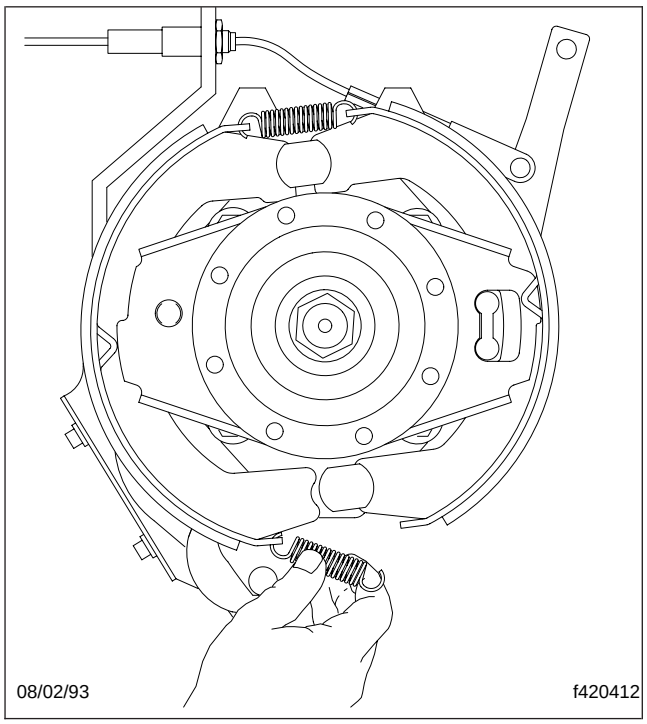


Fig. 1

   4.2 Pull the bottom of one brake shoe out, releasing the pressure on the upper return springs, then remove the upper return springs. **See Fig. 2.**

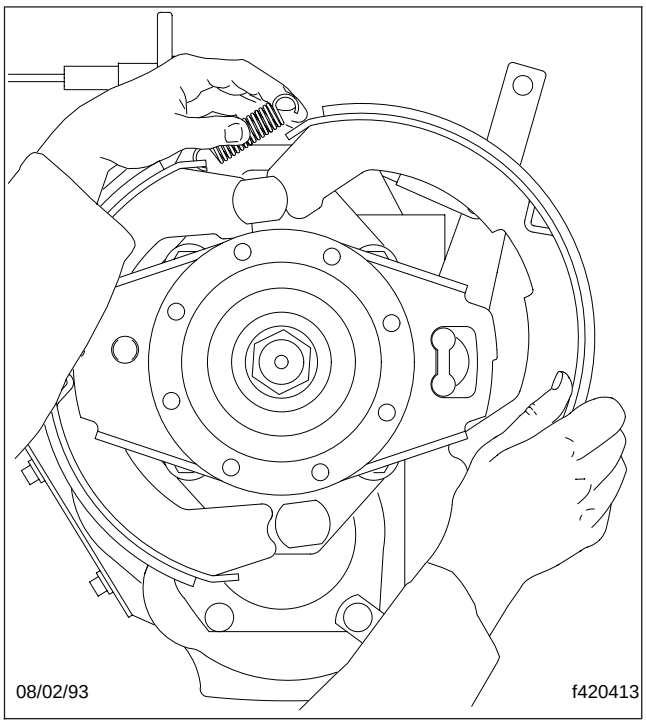


Fig. 2

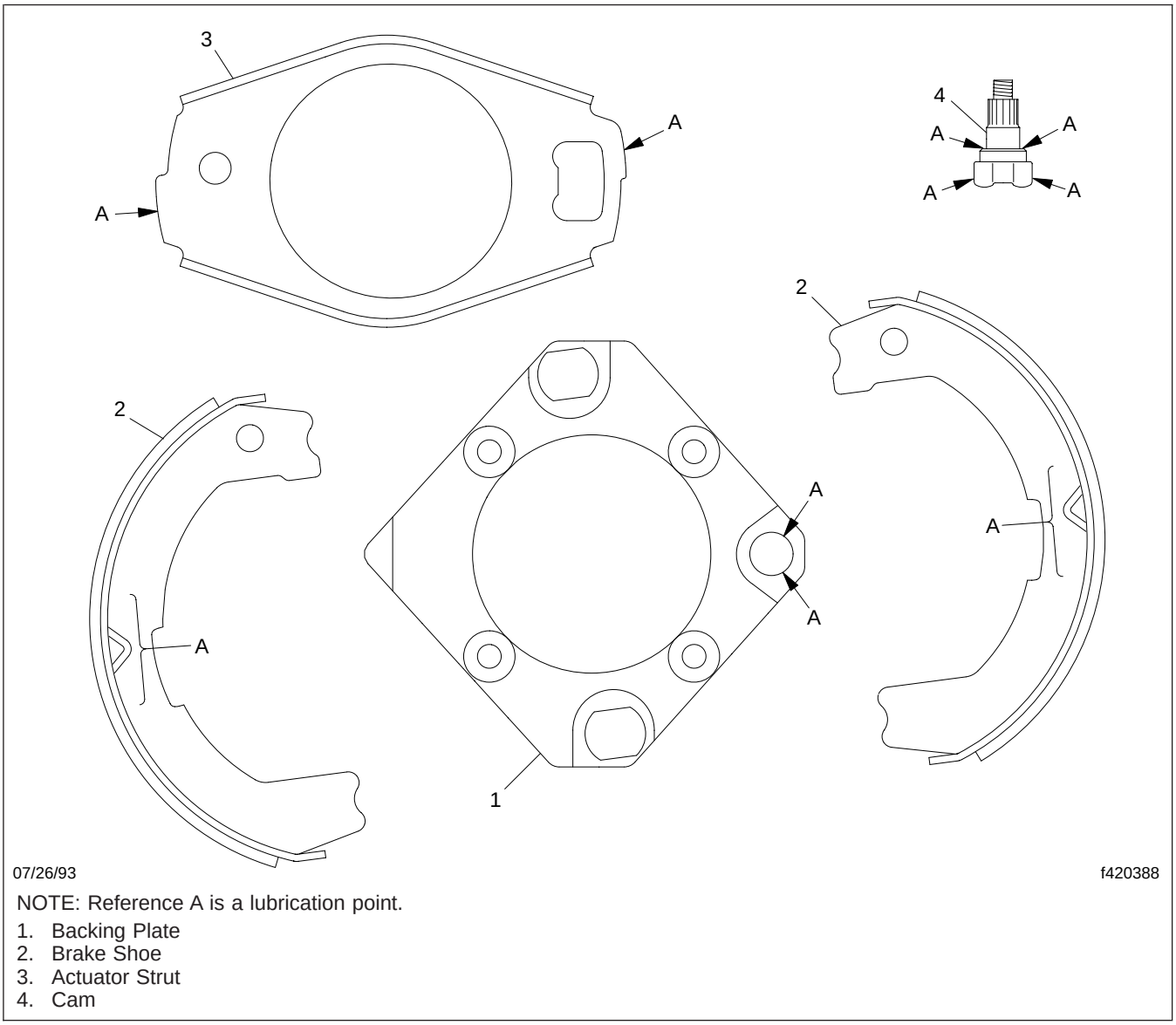
   4.3 Remove both brake shoes.

⚠ CAUTION

CAUTION: Don't let any grease get on the brake drum or linings. Grease on these parts will reduce the effectiveness of the driveline parking brake. If brake linings become contaminated, replace them.

5. Using NLGI grade 2 brake grease, lubricate the following parts (**see Fig. 3**):
   - cam head face and journals;
   - the mating surfaces of the brake shoe webs and the actuator strut;
   - at both sides of the cam hole in the backing plate.
6. Install new brake shoes.

Brake Shoe Replacement



NOTE: Reference A is a lubrication point.

1. Backing Plate
2. Brake Shoe
3. Actuator Strut
4. Cam

Fig. 3

6.1 Install the brake shoes on the backing plate so that the web ends are up against the bosses on the backing plate.

6.2 Install four new brake return springs.

7. Install the brake drum and connect the driveline. For instructions, refer to **Subject 110.**

8. Adjust the brake cable by turning the ring on the end of the parking brake lever in the cab.

Replacement

1. Chock the front and rear tires.
2. Release the parking brake.
3. At the driveline end, disconnect the brake cable from the actuating lever. **See Fig. 1 .**

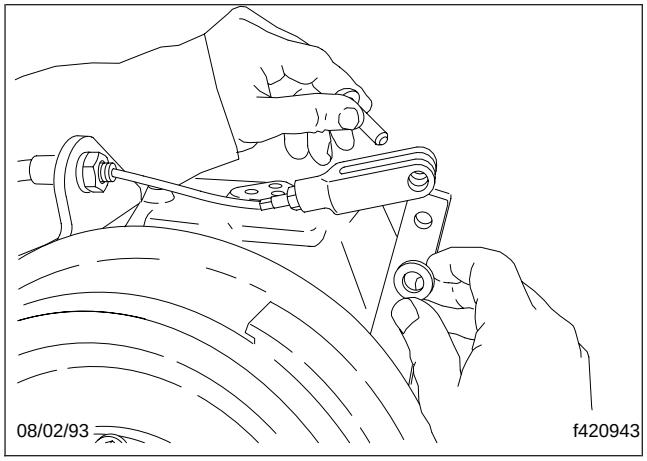


Fig. 1

4. Unscrew the clevis from the cable (**see Fig. 2**); put the clevis aside.

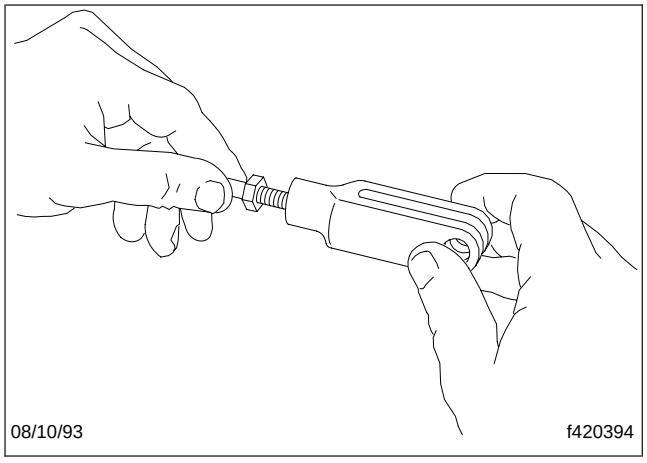


Fig. 2

5. Remove and save the small jam nut from the threaded end of the cable that was installed in the clevis.
6. Remove the brake cable jam nut and lock washer from the cable bracket on top of the transmission. **See Fig. 3.**

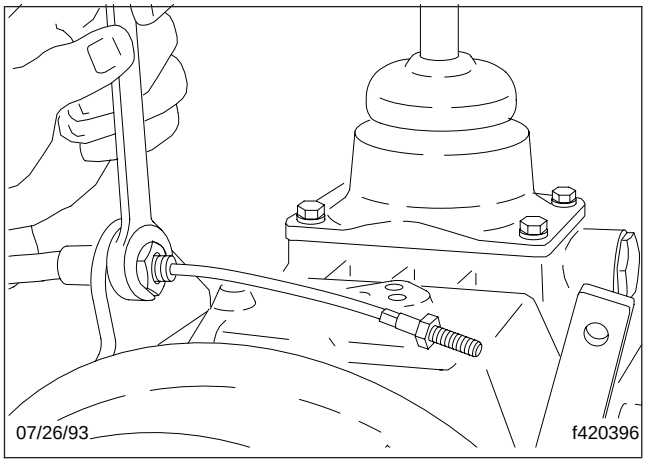


Fig. 3, Fuller Transmission Installation Shown

7. Push the brake cable end through the "D" hole in the bracket. **See Fig. 4.**

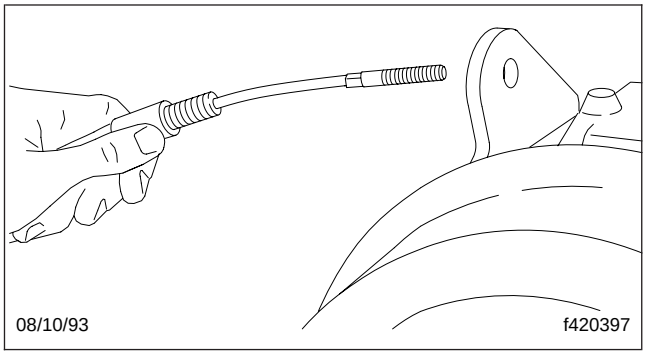


Fig. 4

8. In the cab, remove the plastic boot covering the brake lever assembly.
9. Remove the nut from the double cable clamp on the side of the transmission (**see Fig. 5**), then remove the brake cable from its half of the clamp.
10. Disconnect the parking brake cable from the parking brake lever. **See Fig. 6.**
11. Remove the parking lever assembly from the cab deck.

Parking Brake Cable Replacement

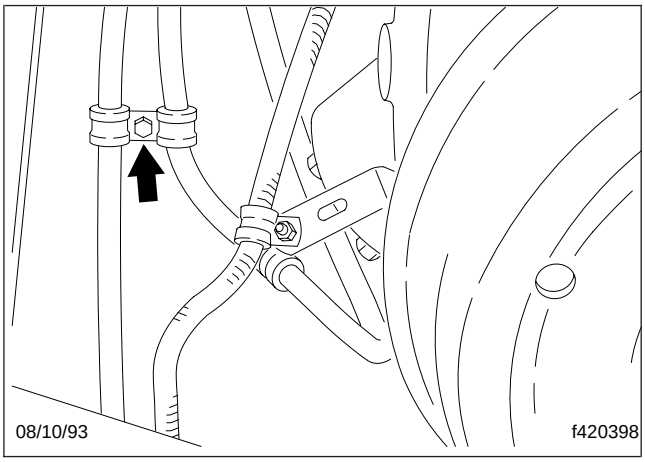


Fig. 5

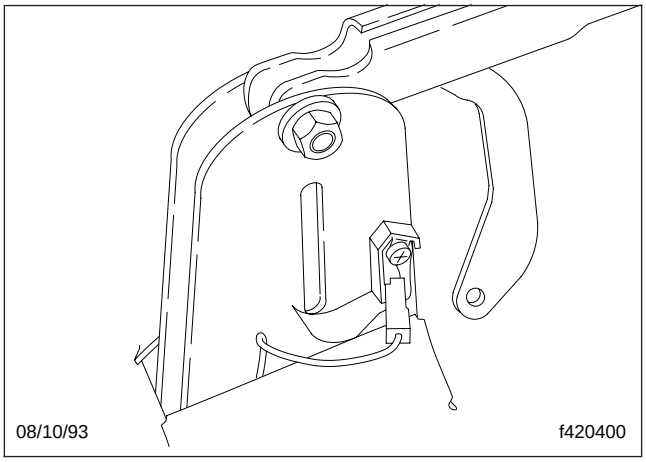


Fig. 7

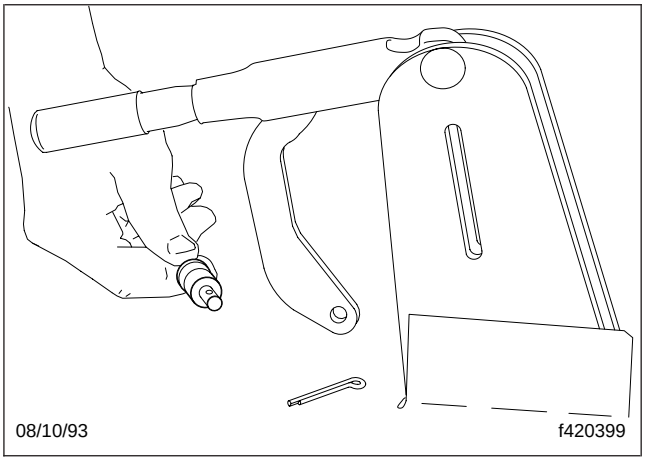


Fig. 6

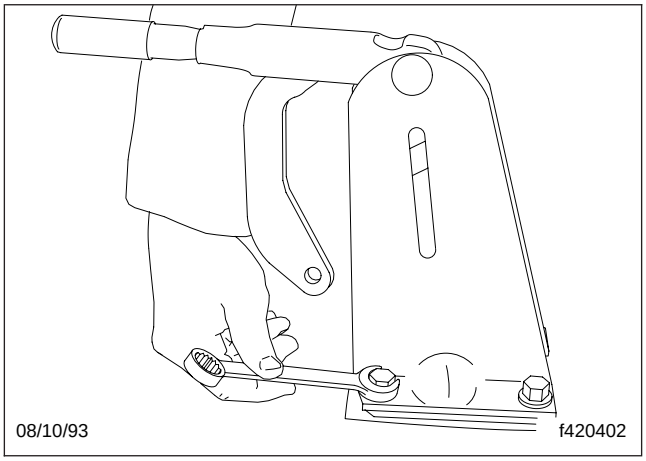


Fig. 8

11.1 Disconnect the electrical wire from the right side of the parking brake lever assembly. **See Fig. 7.**

11.2 Remove the four mounting bolts and washers that hold the lever assembly to the cab floor. **See Fig. 8.**

11.3 Lift the lever assembly off the floor, and set it aside.

12. Remove the jam nut and lockwasher from the threaded end of the cable sheath coming through the hole in the cab deck. **See Fig. 9.**

13. Remove the baseplate by sliding the parking brake cable through the slot in the baseplate. **See Fig. 10.**

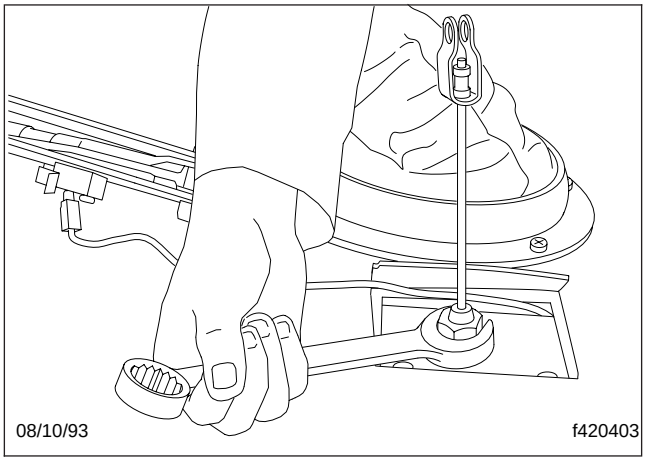


Fig. 9

Parking Brake Cable Replacement

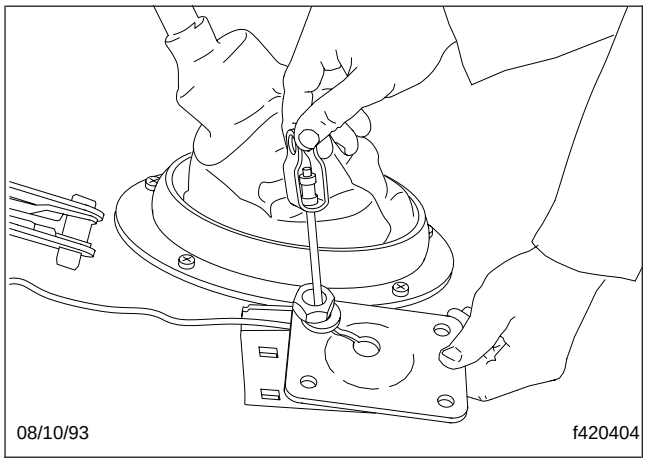


Fig. 10

14. Pull the entire length of the parking brake cable up through the hole in the cab deck.
15. Check the parking brake lever assembly for wear and damage. Replace it if needed.
16. Put the clevis end of the new parking brake cable assembly in the slot of the baseplate, so that the jam nut and washer are on top of the base plate. **See Fig. 10.**
17. Install the lockwasher and jam nut on the cable sheath. Tighten the nut firmly. **See Fig. 9 .**
18. Install the free end of the parking brake cable through the hole in the deck. Pull about a foot of the cable up through the sheath.
19. Connect the new cable to the parking brake lever assembly.
    - 19.1 Install the bushing on the clevis pin. **See Fig. 6.**
    - 19.2 Put the clevis end of the cable up through the middle of the parking brake lever assembly.
    - 19.3 Put the curved brake lever arm (**Fig. 6**) into the middle of the brake lever assembly, and into the clevis.
    - 19.4 Line up the slots in the brake lever assembly, the hole in the curved arm, and the holes in the clevis.
    - 19.5 Install the clevis pin (with the bushing on it) from the side of the lever assembly with the electric wire connector (**Fig. 7**).
    - 19.6 Install the washer and cotter pin on the clevis pin.
20. Install the parking brake lever assembly on the cab deck.
    - 20.1 Put the baseplate on the deck, lining up the holes in the plate with those in the deck.
    - 20.2 Put the lever assembly in place so that its holes and those of the baseplate and the deck all line up.
    - 20.3 Install the four mounting bolts and washers. Tighten the fasteners firmly.
21. Connect the electrical wire to the passenger's side of the parking brake lever assembly. **See Fig. 7.**
22. Underneath the cab, route the parking brake cable through the double cable clamp on the side of the transmission (**Fig. 5**), and then up to the cable bracket on the top of the transmission (or rear axle).
23. Put the cable through the "D" hole in the bracket, then install the lockwasher and jam nut on the threaded end of the cable sheath. Don't tighten the nut all the way. **See Fig. 3.**
24. Connect the parking brake cable to the parking brake actuating lever.
    - 24.1 Screw the threaded end of the cable into the clevis far enough so the clevis holes will line up with the hole in the actuating lever. There should be no slack in the cable. **See Fig. 11.**
    - 24.2 Install the clevis pin in the holes of the clevis and that of the actuator lever.
    - 24.3 Tighten the jam nut (installed previously) 900 N·cm (80 lbf·in).
    - 24.4 Install the washer and a new cotter pin.
25. If a final cable adjustment is needed, make it in the cab, by turning the ring on the parking brake lever. **See Fig. 12.**

Parking Brake Cable Replacement

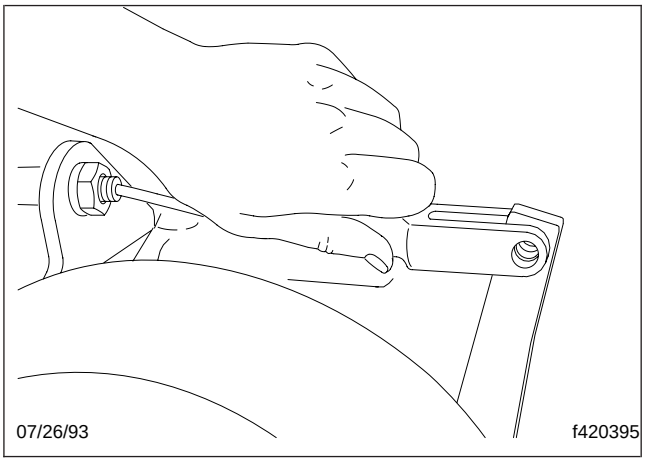


Fig. 11

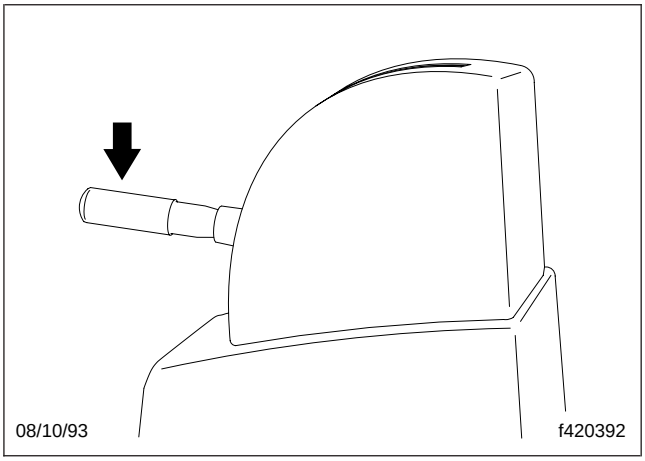


Fig. 12

Park Brake Cable Adjustment

⚠ WARNING

Before starting the procedure below, read the information in "Safety Precautions, 100." Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

There are two methods of parking brake actuation available for Business Class trucks. Most vehicles have a hand-lever-actuated parking brake with the lever mounted on the cab floor. Some vehicles have an air-actuated system which is operated by a valve on the dash that controls a brake chamber mounted on the frame rail near the parking brake. When actuated, it applies the parking brake via a cable. Determine which method of actuation is used on the vehicle to be serviced, then follow the appropriate procedure below.

Prior to adjusting the parking brake cable, inspect the following components for damage, loose or missing parts, or leaks (in the case of air actuated system):

- Parking brake hand lever
- Brake chamber and plumbing (air-actuated system only)
- Cable
- Cable housing
- All mounting brackets and hardware

Make any necessary repairs before making adjustments to the brake cable.

Hand-Lever-Actuated Parking Brake Cable Adjustment

Prior to making adjustments to the hand-lever-actuated parking brake cable, ensure that the actuation system is in good working order.

1. Park the vehicle on a level surface, shut down the engine, and chock the tires.
2. Release the parking brake if it is applied.
3. Back off any excessive adjustment at the lever handle before making adjustments at the cable clevis. Leave enough for final cable adjustment, in either direction, as needed.
4. Remove the cotter pin and clevis pin from the clevis at the brake actuation lever. See **Fig. 1**.

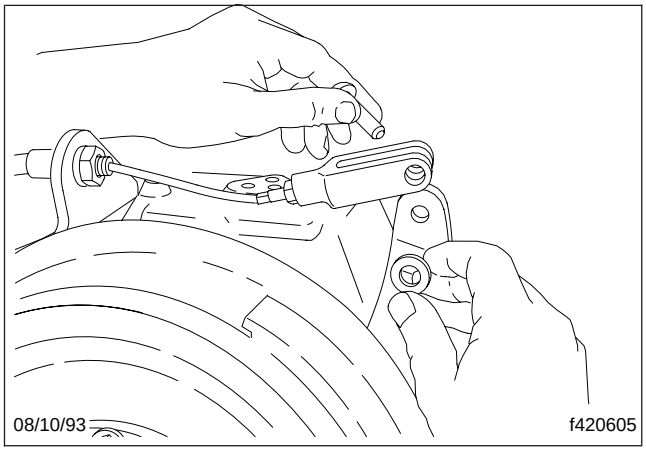


Fig. 1, Remove the Cotter Pin and Clevis Pin

5. Pull the brake actuation lever to the fully released position, then move it slightly back to take up the freeplay, and hold it there.
6. If adjustment is required, loosen the jam nut on the cable and adjust the clevis so that the pin hole in the clevis aligns with the hole in the lever.
7. Install the clevis pin and a new cotter pin.
8. Tighten the clevis jam nut to 80 lbf·in (900 N·cm).
9. If a final cable adjustment is needed, make it in the cab, by turning the ring on the parking brake lever.

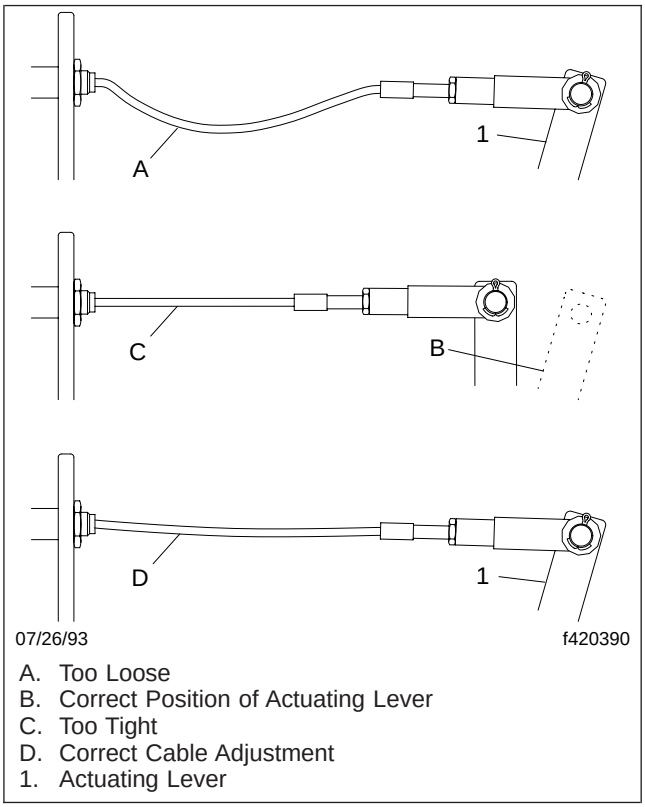
   When properly adjusted, the cable should have a very slight looseness to it. See **Fig. 2**.
10. Set the parking brake and remove the chocks.
11. Test the parking brake before returning the vehicle to service.

Air-Actuated Parking Brake Cable Adjustment

Prior to making adjustments to the air-actuated parking brake cable, insure that the actuation system is in good working order.

1. Park the vehicle on a level surface and chock the tires.

Park Brake Cable Adjustment



A. Too Loose
B. Correct Position of Actuating Lever
C. Too Tight
D. Correct Cable Adjustment
1. Actuating Lever

Fig. 2, Parking Brake Cable Installation (typical)

2. Make sure the air system is fully charged, then shut down the engine.
3. Release the parking brake if it is applied.
4. Remove the cotter pin and clevis pin from the clevis at the brake lever. See **Fig. 1**.
5. Pull the brake lever until shoe-to-drum contact is made.
6. If adjustment is required, loosen the jam nut on the cable and adjust the clevis so that the pin hole in the clevis aligns with the hole in the lever.
7. Install the clevis pin and a new cotter pin.
8. Tighten the clevis jam nut to 80 lbf·in (900 N·cm).

   When properly adjusted, the cable should have a very slight looseness to it. See **Fig. 2**.
9. Set the parking brake and remove the chocks.
10. Test the parking brake before returning the vehicle to service.

Troubleshooting

This subject contains the following troubleshooting tables:

- The Parking Brake Won't Hold the Vehicle on a Grade
- The Parking Brake Won't Release
- The Parking Brake Makes Noises While the Vehicle Is Moving

Problem—The Parking Brake Won't Hold the Vehicle on a Grade

Possible Cause	Remedy
The brake shoe linings are worn down.	Replace the brake shoes.
The brake drum is cracked.	Replace the drum.
The brake drum lining is worn down, or heavily scored.	Replace the drum.
The brake cable is binding.	Repair or replace the cable.
There is too much slack in the brake cable.	Adjust the brake cable.
The brake shoe linings have grease on them.	Replace the brake shoes, then clean the inside of the drum.

Problem—The Parking Brake Won't Release

Possible Cause	Remedy
The brake cable is too tight.	Adjust the brake cable.
The brake shoe return springs are missing, detached, or broken.	Check the return springs. Install them or replace them as needed.
The contact points between the brake shoe webs and the actuator strut are corroded or dirty.	Check the area, and clean and lubricate as needed.
The parking brake lever in the cab is binding.	Check the parking brake lever assembly for damage or corrosion. Repair or replace as needed.

Problem—The Parking Brake Makes Noises While the Vehicle Is Moving

Possible Cause	Remedy
The parking brake drum is loose.	Check the brake drum mounting bolts. Tighten as needed.
The brake shoes or backing plate is loose.	Check the brake shoes, return springs, and backing plate mounting bolts. Tighten, repair, or replace, as needed.
There is dirt inside the brake drum.	Remove the brake drum and clean it. Also clean other brake parts.

Specifications

Description	Torque	
	N·m (lbf·ft)	N·cm (lbf·in)
Transmission End-Nut		
Fuller	440 (325)	—
Allison	950 (700)	
Rear Axle End-Nut (Input Shaft)		
Rockwell RS-13-120, RS-15-120, RS-17-145 and -220, RS-19-145 and -220, and RS-21-145 and -230	1000–1250 (740–920)	—
Backing Plate Mounting Bolts:		
Fuller Transmissions	230–251 (170–185)	—
Allison Transmissions	203–224 (150–165)	
Rear Axle	203–224 (150–165)	
Brake Drum Mounting Bolts	61 (45)	—
Midship Bearing Carrier Mounting Bolts	123 (91)	—
Cable Bracket Jam Nut (on top of transmission or rear axle)	—	900 (80)

Table 1, Fastener Torques

General Description

The Rockwell automatic slack adjuster has two main functions:

- As a lever, it converts the straight-line force of the brake chamber push rod to torque on the brake camshaft. Rotation of the camshaft forces the brake shoes against the brake drum.
- As an automatic adjuster, it automatically maintains brake chamber push-rod stroke, which controls lining-to-drum clearance during operation.

With an automatic slack adjuster, brakes are adjusted only when needed. As long as the push-rod stroke doesn't exceed the desired length, no adjustment takes place. Adjustment is made on the return stroke, as air is released and the forces in the gearset are low. The force to make an adjustment comes directly from the brake shoe return spring and the brake chamber return spring.

Principles of Operation

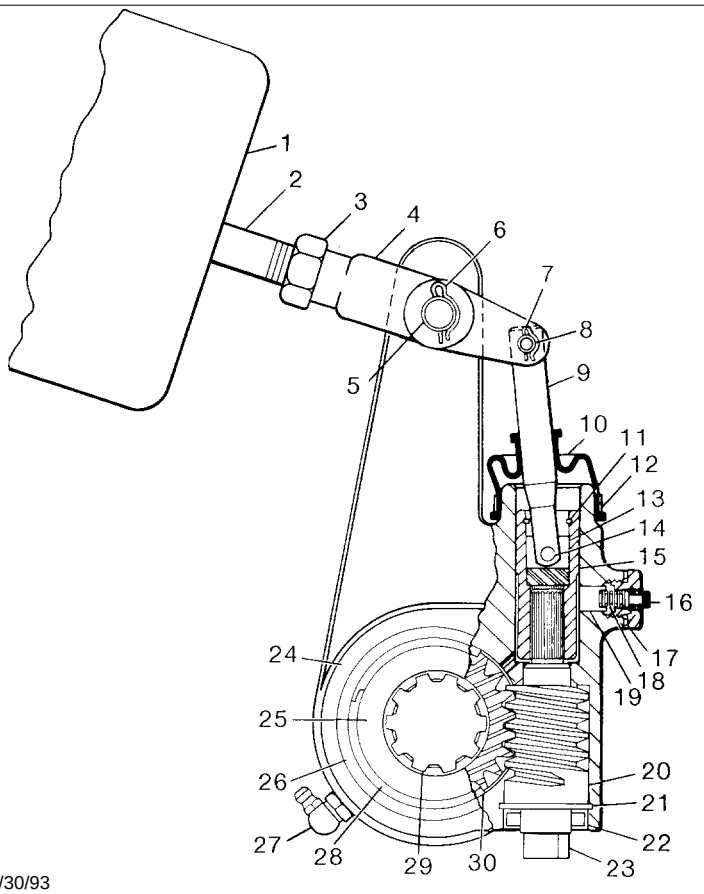
(Refer to Fig. 1)

The externally splined end of the worm (Ref. 20) fits the internal splines on the actuator (Ref. 15). Angled serrations on the spring-held pawl (Ref. 19) correspond with serrations on the actuator exterior. The serrations are formed to allow free upward movement of the actuator, and to lock in on the actuator serrations on a downward movement.

As the brake is applied, the brake chamber push rod, connected to the end of the clevis, moves outward, forcing the slack adjuster arm to turn on the brake camshaft centerline. The actuator rod (Ref. 9) is connected to the clevis at one end, and to a small piston at the other end. As the slack adjuster arm moves, the actuator rod is moved upward and outward, pulling the piston (Ref. 13) upward.

When lining wear becomes excessive, the brake chamber push-rod stroke goes beyond the desired length. The piston then makes contact with the retaining ring (Ref. 11) and pulls up the actuator. As the actuator moves upward and reaches a preset distance, it slides over one serration on the pawl. When the push rod moves back toward the brake chamber, the actuator is forced downward. Because the serrations in the pawl and actuator are now locked in, the actuator, following the curve of its serrations as it moves downward, turns slightly. This action causes the worm to turn, advancing the gear (Ref. 25) and the camshaft to automatically adjust the brake.

General Description and Principles of Operation



1. Brake Air Chamber
2. Brake Chamber Push Rod
3. Clevis Jam Nut
4. Clevis
5. Clevis Pin (large)
6. Cotter Pin (large)
7. Cotter Pin (small)
8. Clevis (small)
9. Actuator Rod
10. Boot
11. Piston Retaining Ring
12. Boot Retaining Clamp
13. Actuator Piston
14. Roller (Pin)
15. Actuator (Adjusting Screw)
16. Pressure Relief Capscrew (shown 90 degrees out of position)
17. Gasket
18. Pawl Spring
19. Pawl Assembly
20. Worm
21. Worm Retaining Snap Ring
22. Worm Seal
23. Manual (Worm) Adjusting Nut End
24. Slack Adjuster
25. Gear
26. Gear Thrustwasher
27. Grease Fitting
28. Gear Retaining Ring
29. Camshaft Splines
30. Gear−to−Body Seal

07/30/93 f420523

Fig. 1

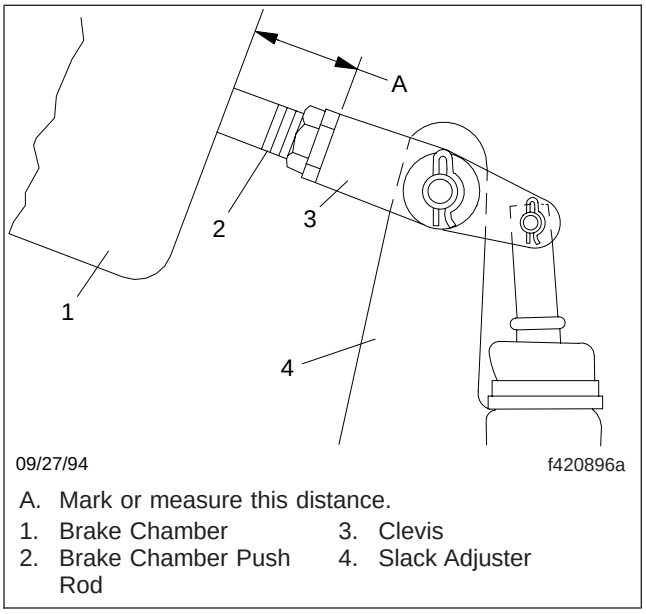
Removal

1. Park the vehicle on a level surface, and chock the tires. If the rear slack adjusters will be removed, release the parking brakes, then cage the power spring of the parking brake chamber.

⚠ WARNING

WARNING: Loss of brake chamber air pressure will cause sudden application of the parking brakes, which could result in personal injury. Manually cage each parking brake chamber power spring in the release (no application) position before continuing.

2. Mark or measure the position of the clevis on the brake chamber push rod. **See Fig. 1.**



A. Mark or measure this distance.
1. Brake Chamber
2. Brake Chamber Push Rod
3. Clevis
4. Slack Adjuster

Fig. 1, Mark or Measure the Clevis Position

3. Remove the cotter pins from the clevis pins. Remove the clevis pins.

4. Remove the pressure relief capscrew, spring, and pawl assembly from the slack adjuster housing. **See Fig. 2**, Refs. 17, 19, and 20. If equipped with a pull-pawl assembly **(Fig. 3),** carefully insert a screwdriver and raise the relief cap about 1/8 inch (3.2 mm).

⚠ CAUTION

CAUTION: Before turning the adjusting nut, remove the pressure relief capscrew, spring, and pawl assembly. If equipped with a pull-pawl assembly, raise the relief cap about 1/8 inch (3.2 mm). Failure to do so could strip the teeth on the pawl.

5. Using a wrench, turn the manual adjusting nut, and move the slack adjuster away from the clevis. **See Fig. 4.**

6. Remove the snap ring and washers that attach the slack adjuster to the brake camshaft and save them for later installation.

7. Remove the slack adjuster from the camshaft.

8. Note the location and number of any remaining spacing washers on the camshaft, and then remove them. Save them for later installation.

9. If replacing the clevis, loosen the clevis jam nut. Remove the clevis and jam nut from the brake chamber push rod.

Installation

1. Inspect parts, and then prepare the slack adjuster for installation.

   1.1 Check the brake camshaft splines for wear or corrosion.

   1.2 Coat the camshaft splines and the splines of the slack adjuster gear with Rockwell lubricant 0-637, Southwest SA 8249496, or an equivalent.

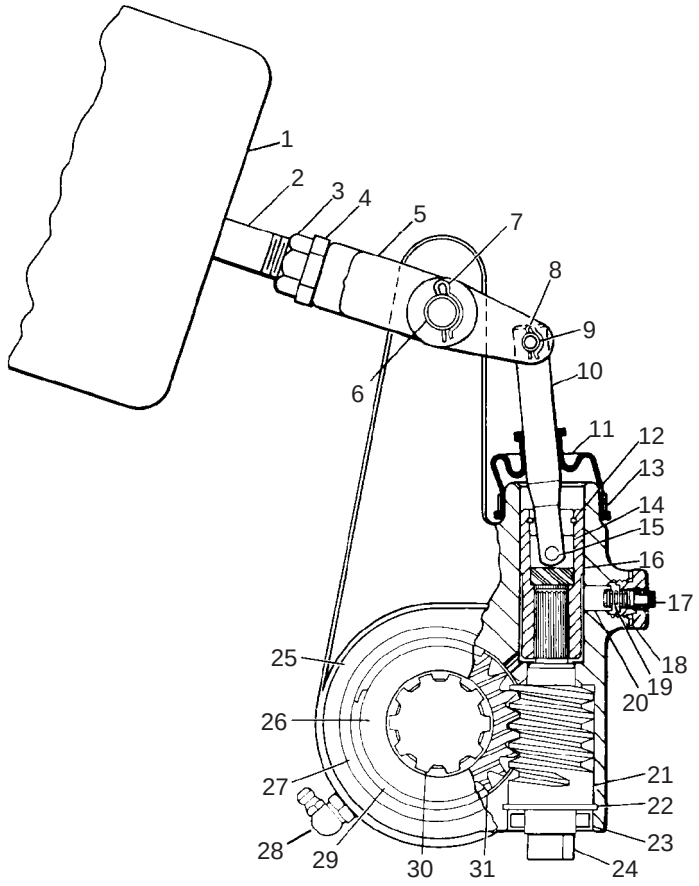
   IMPORTANT: These lubricants provide corrosion protection. Do not mix these lubricants with other types.

   1.3 Apply the service brake and parking brake several times. Make sure the return spring retracts the push rod quickly and completely. Replace the return spring or brake chamber if needed.

2. If previously removed, install the clevis and jam nut.

   Check that the clevis is in the same position on the brake chamber push rod as marked or mea-

Removal and Installation



1. Brake Air Chamber
2. Brake Chamber Push Rod
3. Clevis Jam Nut
4. Quick-Connect Collar (if equipped)
5. Clevis
6. Clevis Pin (large)
7. Cotter Pin (large)
8. Cotter Pin (small)
9. Clevis Pin (small)
10. Actuator Rod
11. Boot
12. Piston Retaining Ring
13. Boot Retaining Clamp
14. Actuator Piston
15. Roller (Pin)
16. Actuator (Adjusting Screw)
17. Pressure Relief Capscrew (shown 90 degrees out of position)
18. Gasket
19. Pawl Spring
20. Pawl Assembly
21. Worm
22. Worm Retaining Snap Ring
23. Worm Seal
24. Manual (Worm) Adjusting Nut End
25. Slack Adjuster
26. Gear
27. Gear Thrustwasher
28. Grease Fitting
29. Gear Retaining Ring
30. Camshaft Splines
31. Gear-to-Body Seal

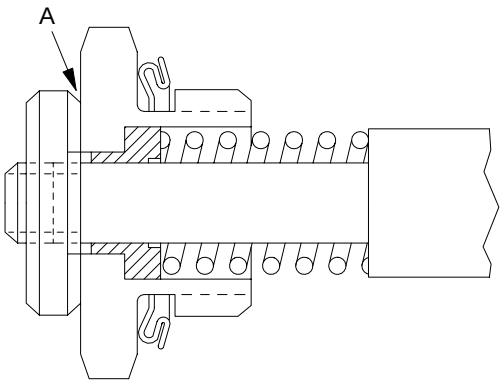
Fig. 2, Rockwell Automatic Slack Adjuster

sured during removal. Do not tighten the jam nut against the clevis.

NOTE: Use a clevis with a 1/2-20 UNF thread if equipped with type 9, 12, or 16 brake chambers. Use a clevis with a 5/8-18 UNF thread size if equipped with type 20, 24, 30, or 36 brake chambers.

3. Install the slack adjuster.

   3.1 If installing a new slack adjuster, use an installation template **(Fig. 5)** and measure the new slack adjuster to make sure it is the same length as the slack adjuster that was removed. Refer to the appropriate table in **Specifications 400** for the



A. Insert screwdriver here.

Fig. 3, Pull-Pawl Assembly (sectional view)

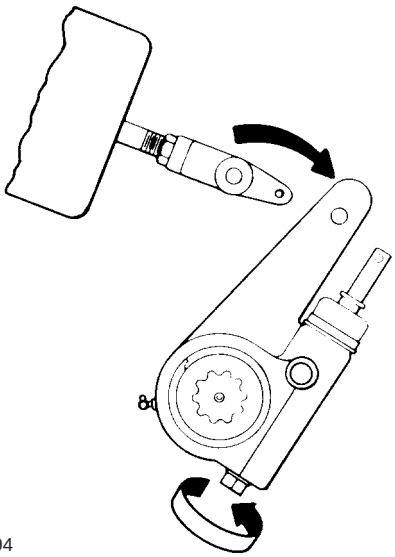
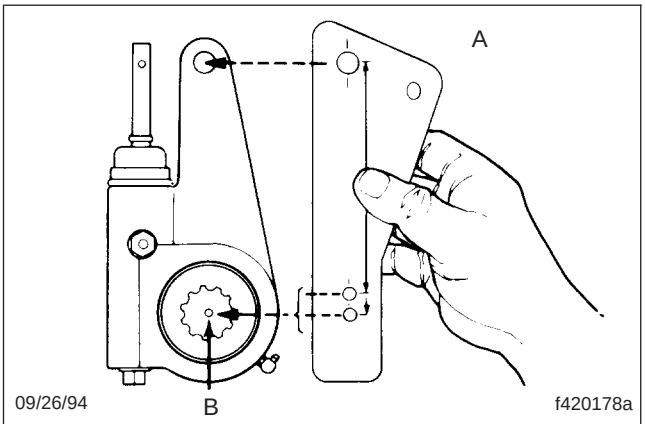


Fig. 4, Move the Slack Adjuster Away from the Clevis

length of slack adjusters that should be used with various sizes of brake chambers.

NOTE: Depending on the type of brakes used (disc or drum) on a tractor or trailer, several types of installation templates are used. They can be made using the measurements provided in **Fig. 6.** Or, they can be ordered from:



A. Measure slack adjuster arm length.
B. Camshaft Center

Fig. 5, Measure the New Slack Adjuster

Attn: Literature Distribution Rockwell International 2135 W. Maple Road Troy, Michigan 48084

3.2 Position the slack adjuster on the camshaft.

3.3 Install the spacing washers and the snap ring that attach the slack adjuster to the camshaft. Add enough washers to limit the camshaft end play to 0.060 inch (1.5 mm). Check the end play using the instructions in the applicable brake chamber section in this manual.

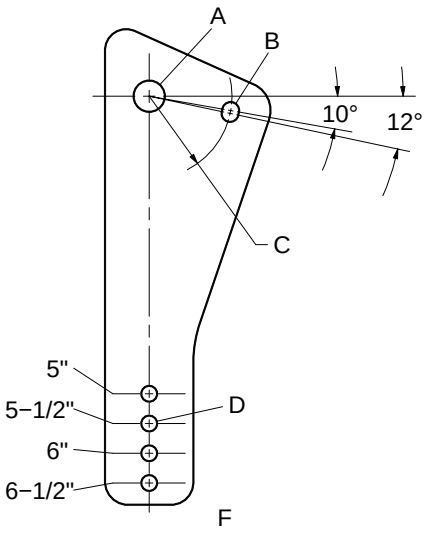
3.4 If installing a new slack adjuster, remove the pressure relief capscrew, spring, and pawl assembly from the slack adjuster housing. If equipped with a pull-pawl assembly **(Fig. 3),** carefully insert a screwdriver and raise the relief cap about 1/8 inch (3.2 mm).

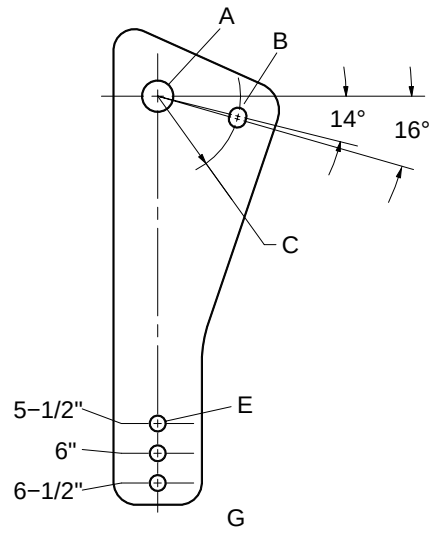
⚠ CAUTION

CAUTION: Before turning the adjusting nut, remove the pressure relief capscrew, spring, and pawl assembly. If equipped with a pull-pawl assembly, raise the relief cap about 1/8 inch (3.2 mm). Failure to do so could strip the teeth on the pawl.

3.5 Using a wrench, turn the manual adjusting nut to align the hole in the slack ad-

Removal and Installation



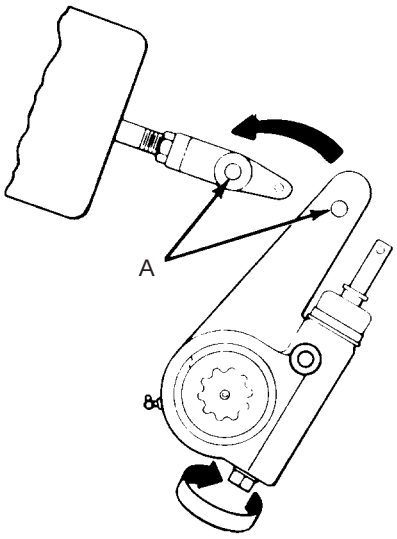


09/27/94 f420177a

A. 0.50" (12.7 mm) Diameter Hole
B. 0.12" (3.0 mm) Radius
C. 1.38" (35 mm) Radius
D. 0.250" (6.4 mm) Diameter Hole (4 qty.)
E. 0.250" (6.4 mm) Diameter Hole (3 qty.)
F. For Tractors
G. For Trailers

Fig. 6, Installation Template Specifications

juster housing with the large hole in the clevis. **See Fig. 7.** Insert the large clevis pin.

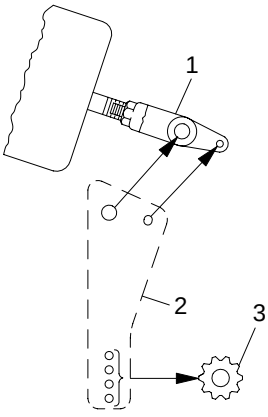


09/26/94 f420179a

A. Align holes.

Fig. 7, Aligning the Holes

3.6 With the brakes fully released, place the applicable installation template over the clevis and camshaft end. **See Fig. 8.**



09/27/94 f420897a

1. Clevis 2. Template 3. Camshaft End

Fig. 8, Position the Installation Template

3.7 Temporarily insert the large clevis pin through the large holes in the template and the clevis.

3.8 Select the hole in the template that matches the length of the slack adjuster. Hold the template in place on the center of the camshaft with a pencil.

3.9 Look through the small hole in the template and see if the small hole in the clevis is completely visible. If the hole in the clevis is not completely visible, adjust the position of the clevis on the push rod until the small clevis hole is completely visible. Temporarily place the small clevis pin through the template and clevis to make sure the alignment is correct. Remove both pins and the template. Insert both clevis pins with the pin head on the inboard side of the slack adjuster. Be sure the small clevis pin is inserted through the hole in the actuator rod. Install and lock new cotter pins to secure the clevis pins.

IMPORTANT: Make sure that there is at least 1/2 inch (13 mm) of thread engagement between the clevis and the push rod. Also, check that the push rod doesn't extend through the clevis more than 1/8 inch (3.2 mm). **See Fig. 9.** If needed, either cut the push rod, install a new push rod, or install a new brake chamber.

3.10 For 1/2-20 UNF threads, tighten the clevis jam nut 20 to 30 lbf·ft (27 to 41 N·m). For 5/8-18 UNF threads, tighten the jam nut 25 to 50 lbf·ft (34 to 68 N·m).

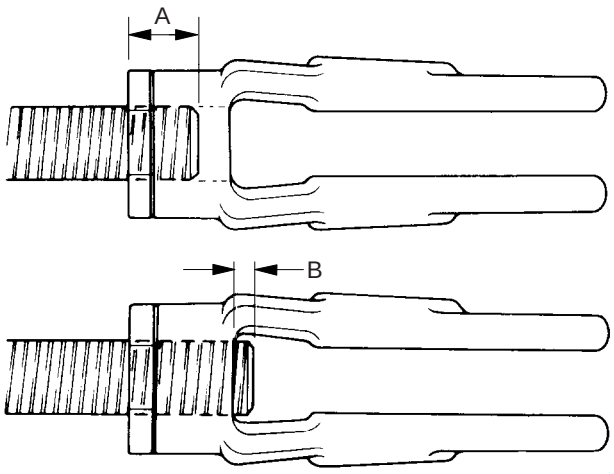
4. Set the free-stroke.

4.1 Turn the manual adjusting nut counterclockwise until the brake linings contact the brake drum.

4.2 Set the approximate clearance between the linings and the drum: turn the adjusting nut clockwise one-half turn.

4.3 With the brakes fully released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. **See Fig. 10**, Ref. B.

4.4 Use a pry bar to move the slack adjuster, and apply the brakes. Again, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. **See Fig. 10** , Ref. A.



A. Minimum 1/2" (13 mm)
B. Maximum 1/8" (3.2 mm)

Fig. 9, Check Thread Engagement

The difference between the two measurements is the initial free-stroke, and sets the clearance between the linings and the drum.

The free stroke must be:

drum brakes—5/8 to 3/4 inch (16 to 19 mm);

disc brakes—7/8 to 1-1/8 inch (22 to 29 mm).

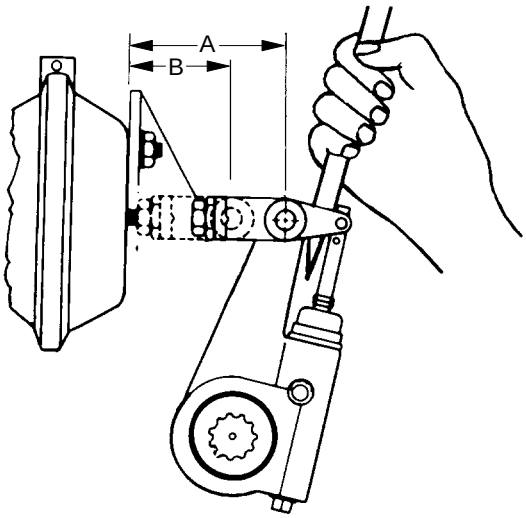
If the free stroke is incorrect, turn the adjusting nut one-eighth turn, as shown in **Fig. 11.** Measure the stroke again, and adjust until it is correct.

5. Measure the brake chamber stroke, and adjust as needed.

5.1 With the brakes fully released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. **See Fig. 12**, Ref. A.

5.2 Build air pressure to 100 psi (689 kPa). Shut down the engine. Fully apply the brakes, then measure the distance from the bottom of the brake chamber to the center of the large clevis pin.

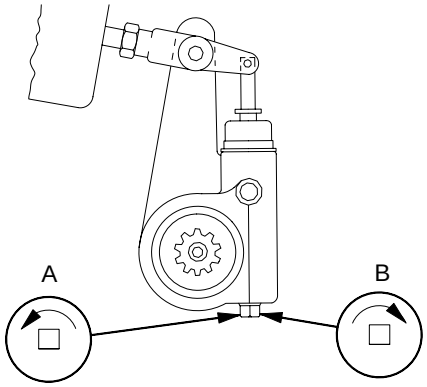
Removal and Installation



09/27/94 f420180a

NOTE: For a drum brake, A minus B must equal 5/8" to 3/4" (16 to 19 mm). For a disc brake, A minus B must equal 7/8" to 1-1/8" (22 to 29 mm).

Fig. 10, Measuring Free-Stroke



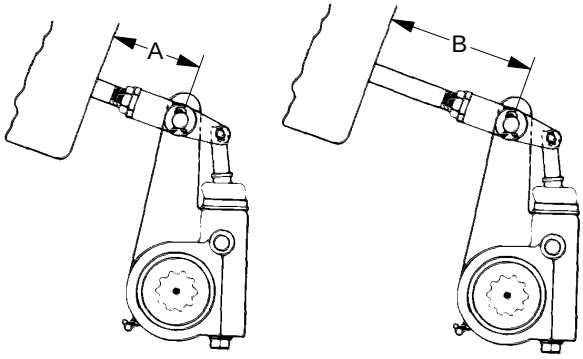
07/05/95 f420181a

A. Shorten stroke.
B. Lengthen stroke.

Fig. 11, Turn the Adjusting Nut

See Fig. 12, Ref. B. The difference between the measurements is the brake chamber stroke.

5.3 The brake chamber stroke must be less than the measurements shown in the appropriate table in **Specifications 400.** If needed, turn the adjusting nut to adjust the brake chamber stroke.



10/20/93 f420182a

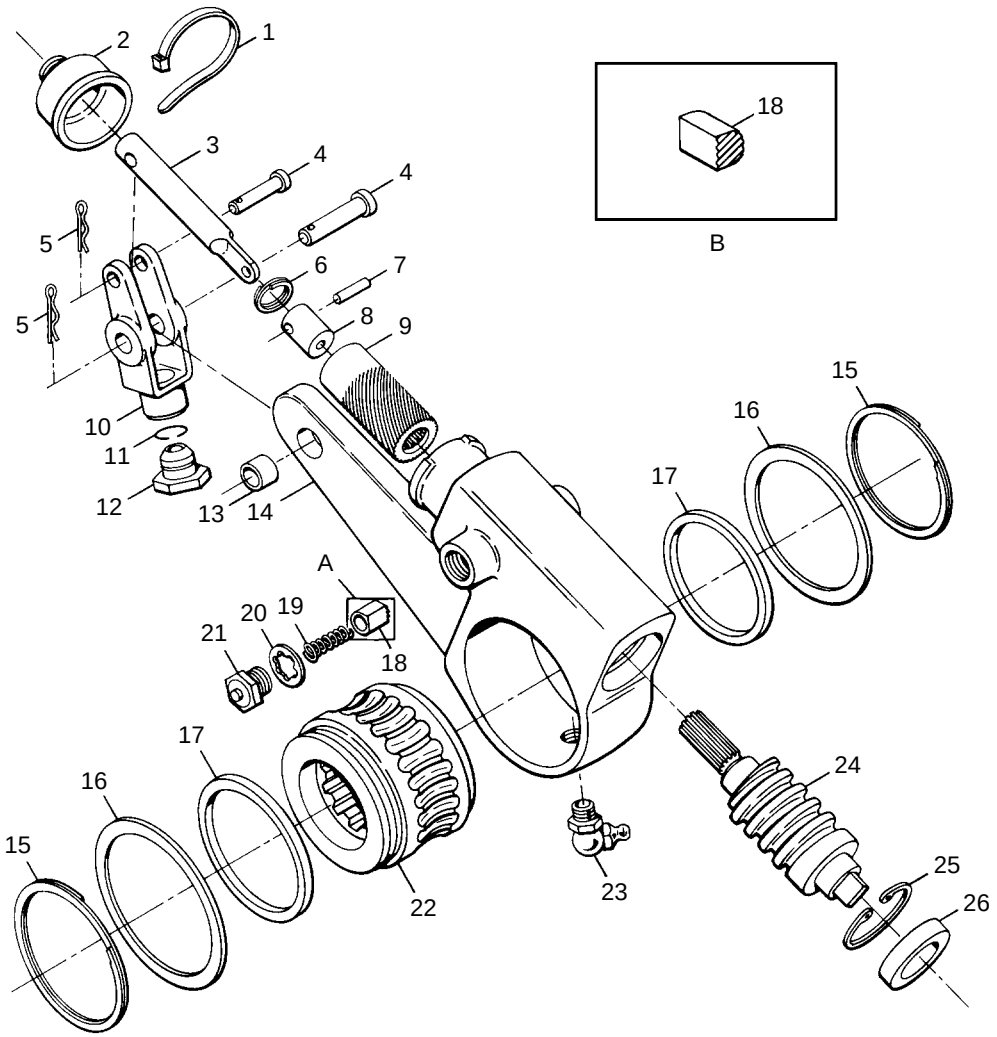
NOTE: Measure distance *A* with the brakes released; measure distance *B* with the brakes applied.

Fig. 12, Measuring Adjusted Brake Chamber Stroke

If the stroke varies or remains greater than the specified range, check the brake components, including the camshafts, camshaft bushings, anchor pins, rollers, chamber brackets, clevis, and clevis pins. For instructions, refer to the brake section in this manual.

6. Install the pawl assembly, spring, and the pressure relief capscrew. Tighten the capscrew 15 to 20 lbf·ft (20 to 27 N·m). Or, remove the screwdriver from the pull-pawl assembly (if equipped).
7. Lube the slack adjuster through the grease fitting until the lubricant is forced out through the pressure relief fitting (or pawl slot), or through the gear splines around the inboard snap ring.
8. If a rear axle slack adjuster was installed, manually uncage the parking brake. For instructions, refer to the applicable brake chamber section in this manual.
9. Remove the chocks from the tires.

Disassembly (See Fig. 1)



A. See Detail B.

B. End view showing serrations.

1. Boot Retaining Clamp
2. Boot
3. Actuator Rod
4. Clevis Pin
5. Cotter Pin
6. Piston Retaining Ring
7. Roller (Pin)
8. Actuator Piston
9. Actuator
10. Clevis
11. Clevis Retaining Ring (if equipped)
12. Quick-Connect Collar (if equipped)
13. Large Clevis Pin Bushing
14. Slack Adjuster Housing
15. Gear Retaining Ring
16. Gear Thrustwasher
17. Gear-to-Body Seal
18. Adjusting Pawl
19. Pawl Spring
20. Gasket
21. Pressure Relief Capscrew
22. Gear
23. Grease Fitting
24. Worm
25. Worm Retaining Snap ring
26. Worm Grease Seal

Fig. 1, Slack Adjuster Assembly (slack adjuster produced before January 1993 shown)

Disassembly, Cleaning and Inspection, and Assembly

1. Remove the slack adjuster. For instructions, refer to **Subject 100.**
2. Cut the boot retaining clamp, and remove the clamp from the rubber boot.
3. Remove the boot and the actuator (adjusting sleeve) from the housing. **See Fig. 2.** You may need to first work the boot off of the housing before removing the actuator.

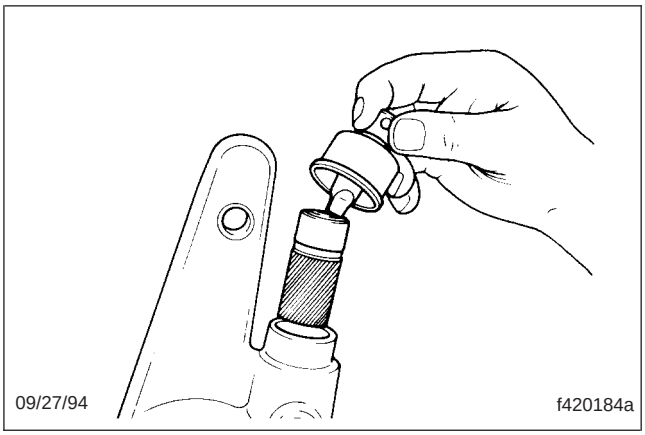
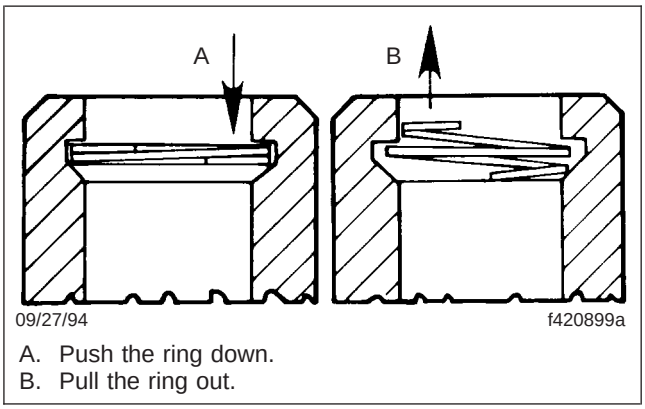


Fig. 2, Removal of the Actuator

4. Using a small screwdriver, press down the piston retaining ring and force it out of the groove **(Fig. 3).** Using pliers, unwind the ring and pull it out.



A. Push the ring down.
B. Pull the ring out.

Fig. 3, Removal of the Internal Piston Retaining Ring

5. Pull the actuator rod, piston, and pin from the actuator bore.
6. Using a small hammer and brass drift punch, remove the pin from the rod and piston. **See Fig. 4.**

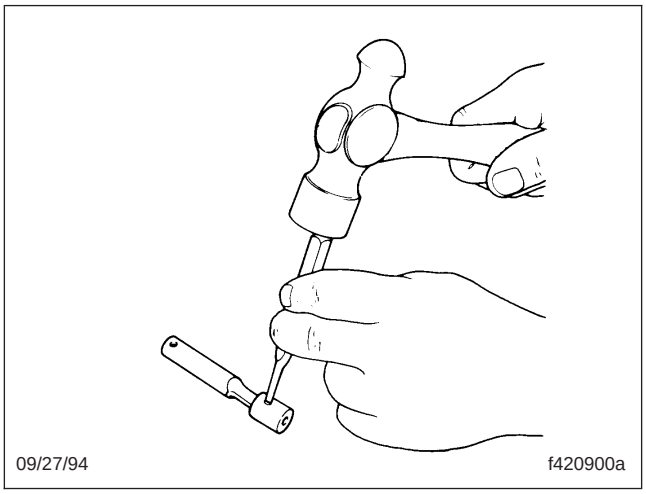


Fig. 4, Remove the Pin from the Rod and Piston

7. Using a small screwdriver, pry the grease seal from around the worm. **See Fig. 5.**

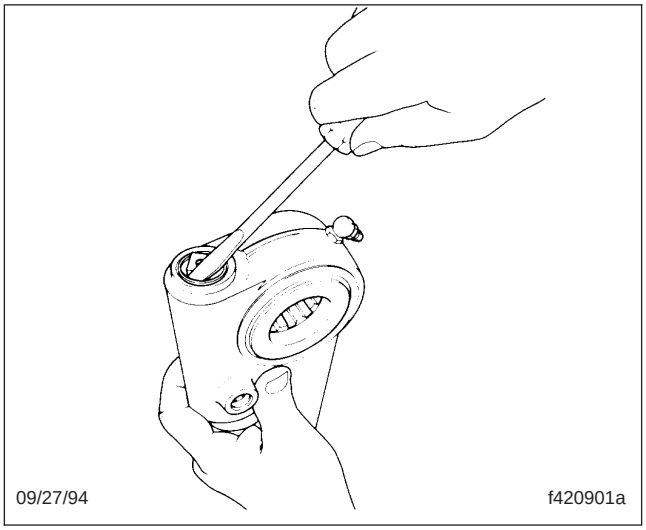


Fig. 5, Pry the Grease Seal from around the Worm

8. Using snap ring pliers, remove the retaining ring from the worm. **See Fig. 6.**

IMPORTANT: The following steps apply only to slack adusters produced before January 1993.

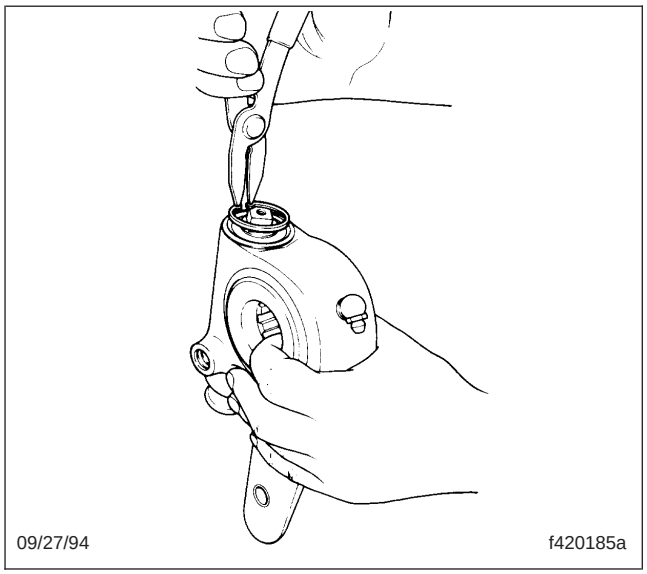


Fig. 6, Remove the Retaining Ring

On slack adjusters produced since January 1993, the gear and seals are not serviceable.

9. Using a wrench, turn the manual adjusting nut, and wind the worm out of the bore.
10. On one side of the housing, insert a small screwdriver into the notch at the end of the gear retaining ring. Remove the end of the retaining ring from the groove.

    Unwind the ring by hand and pull it out of the groove. **See Fig. 7**. Remove the thrustwasher.
11. Push the gear far enough out of the housing to remove one gear seal.

    Push the gear far enough out of the opposite side of the housing to remove the other gear seal. Remove the gear from the housing.

Cleaning and Inspection

CAUTION

CAUTION: Don't clean ground or polished parts in a hot solution tank or with water-and-alkaline solutions, such as sodium hydroxide, orthosilicates, or phosphates. Also, don't use solvent-type cleaners on any nonmetallic parts. Doing so could damage the parts.

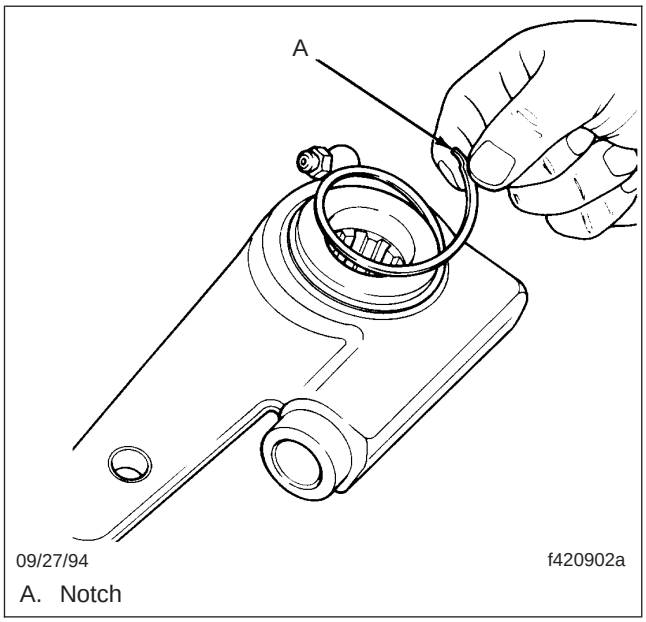


Fig. 7, Removal of the Gear Retaining Rings

1. Clean the slack adjuster parts.
   - 1.1 Clean all parts having ground and polished surfaces (such as the worm, worm gear, and inner bores of the slack housing) with solvent-type cleaners, such as emulsion cleaners, carbon tetrachloride, or petroleum solvents (excluding gasoline).
   - 1.2 Dry all parts immediately after cleaning. Use soft, clean, lint-free absorbent paper towels, or wiping rags free of abrasive material such as lapping compound, metal filings, or contaminated oil.
2. Inspect all parts for wear or damage.
   - 2.1 Inspect all parts for wear or stress. Replace as needed.
   - 2.2 Inspect the seals, and discard if they show any signs of damage.
   - 2.3 Check the condition and fit of the large clevis pin bushing in the arm of the slack adjuster. Don't remove the bushing unless it is worn or egg-shaped.
3. If storing parts for any length of time, treat them with a good rust preventative, and wrap them in

Disassembly, Cleaning and Inspection, and Assembly

special paper or other material designed to prevent corrosion.

Assembly (See Fig. 1)

IMPORTANT: The first two steps that follow apply only to slack adusters produced before January 1993. On slack adjusters produced since January 1993, the gear and seals are not serviceable.

1. Coat all parts and the gear bore with a grease recommended in the appropriate table in **Specifications 400.**
2. Install the gear into the housing.
   - 2.1 Place the gear, without the gear seals, into the housing. Keep one seal groove outside the housing.

     Make sure the gear goes straight into the bore. If needed, use a small rawhide mallet to tap the gear into place.
   - 2.2 Install a seal into the groove. **See Fig. 8.**

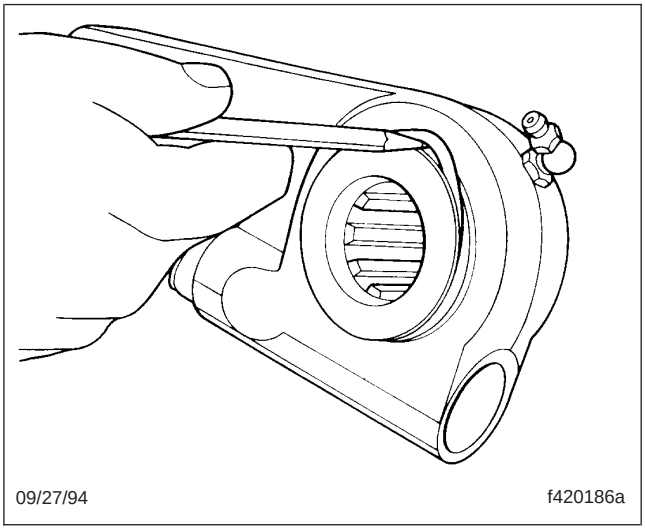


Fig. 8, Install a Seal into the Groove

CAUTION

CAUTION: Do not push the side of the gear that has the seal installed through the housing. Damage to the seal will occur when it passes the sharp edges of the intersecting worm bore.

   - 2.3 Push the gear far enough out the opposite side of the housing so you can see the other seal groove.
   - 2.4 Install the seal in the groove, and push the gear into the housing.
   - 2.5 On one side of the gear, position a thrustwasher around the gear and against the housing. Spread out the retaining ring coil. Put one end of the coil into the groove in the outer diameter of the gear. Work around the gear and press the coil into the groove.
   - 2.6 Repeat this step for the other side of the gear.
3. Install the worm into the housing.
   - 3.1 Place the worm into the bore, then turn the adjusting nut to wind the worm to the bottom of the bore.
   - 3.2 Install the retaining snap ring.
   - 3.3 Place the grease seal over the worm bore, with the lips facing outward and the metal retainer facing toward the inside of the bore. **See Fig. 9.** Using a hammer and a 1-3/16 inch seal driver, install the seal.

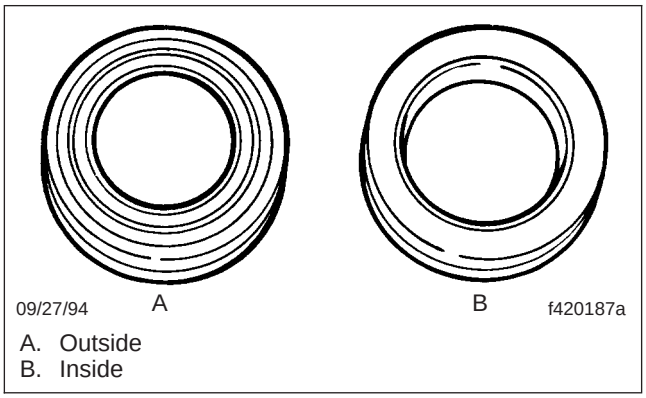


Fig. 9, Worm Seal

CAUTION

CAUTION: Failure to install the grease seal properly could allow contaminants to enter the housing and damage the parts.

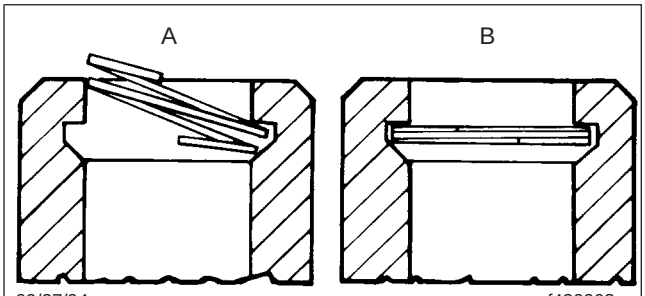
4. Assemble the actuator, rod, and piston.

4.1 Using a small hammer and brass drift punch, install the pin that connects the piston and actuator rod.

4.2 Insert the actuator rod and piston into the actuator (adjusting sleeve).

4.3 Slide the piston retaining ring over the rod. Spread out the coils of the ring. Using a small screwdriver, press one end of the ring into the groove. **See Fig. 10.** Press on the ring and work it around the groove until it is completely seated in the groove.

See if the ring is seated correctly. You will not be able to pull the piston out of the actuator if the ring is seated correctly.



A. Start bottom coil.
B. Tuck ring into groove.

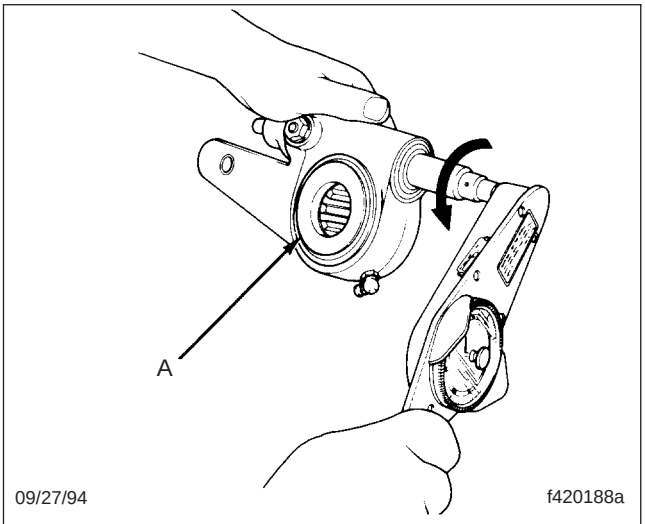
Fig. 10, Installation of the Internal Piston Retaining Ring

5. Slide the actuator assembly along the splines of the worm and into the slack housing.
6. Lubricate the actuator rod with grease, then slip the boot over the rod. Attach the boot to the housing with a silastic coating and a new retaining clamp.

   Make sure that the top of the boot fits on the round part of the rod, not the tapered part.

   Seal the top part of the boot with a silastic coating.
7. If previously removed, install a new bushing into the large clevis pin hole in the arm of the slack adjuster.
8. Lubricate the slack adjuster through the grease fitting until the lubricant is forced out through the pressure relief fitting (or pawl slot), or through the gear splines around the inboard snap ring.
9. Attach a lbf·in/N·cm torque wrench to the adjusting nut. Watch the torque scale while turning the gear 360 degrees. **See Fig. 11.** If the torque remains 25 lbf·in (280 N·cm) or less, the slack adjuster is working correctly.

   If the torque is more than 25 lbf·in (280 N·cm), the slack adjuster is not working correctly. Disassemble the slack, and check for correct assembly and alignment of parts.



A. Rotate the gear 360 degrees.

Fig. 11, Slack Adjuster Torque Check

10. Install the slack adjuster. For instructions, refer to **Subject 100.**

Specifications

Lubricant Type	Temperature
Amoco Super Permalube No. 2 Aralub 3837 Citco Premium Lithium EP No. 2 Exxon Ronex MP No. 2 Kendall L-427 Super Blu No. 2 Mobilith AW No. 1 Rockwell 0-616-A Rockwell 0-692 Shell Darina No. 1 Sohio Factran EP No. 2 Texaco Hytherm EP No. 1 Texaco Thermotex EP No. 1 Tribolube 12, Grade 1	-40°C (-40°F) or Above
Mobil 28 Rockwell 0-645	Below -40°C (-40°F)

Table 1, Lubricant Specifications

Slack Adjuster Arm Length	Chamber Size
127 mm (5 inches)	9, 12, 16, 20, 24, 30
140 mm (5-1/2 inches)	9, 12, 16, 20, 24, 30
152 mm (6 inches)	24, 30
165 mm (6-1/2 inches)	30

Table 2, Slack Adjuster Arm Lengths

Chamber Size	Maximum Chamber Stroke for Cam Brake
9	Less than 38 mm (1-1/2 inches)
12	Less than 38 mm (1-1/2 inches)
16	Less than 44 mm (1-3/4 inches)
20	Less than 44 mm (1-3/4 inches)
24	Less than 48 mm (1-7/8 inches)
24 *	Less than 51 mm (2 inches)
30	Less than 51 mm (2 inches)

* Long stroke.

Table 3, Maximum Adjusted Brake Chamber Strokes

General Description

The Haldex (SAB) automatic slack adjuster serves two main functions:

- As a lever, it converts the straight-line force of the air brake chamber push rod to torque on the brake camshaft. Rotation of the camshaft spreads the brake shoes out against the brake drum, applying the brakes.
- As an adjuster, it maintains cam brake chamber push rod stroke and lining-to-drum clearance automatically during normal use.

Principles of Operation

When the brakes are applied, the slack adjuster rotates and moves the shoes into contact with the drum. The clearance notch (**Fig. 1**, Ref. 4) corresponds to the normal lining-to-drum clearance. Different notches are available to meet the requirements of various vehicles and brake duty cycles. As the brake application continues, the rack (Ref. 3) moves upward and rotates the one-way clutch (Ref. 1) which slips in this direction.

As the brake pressure increases, the torque increase on the slack adjuster causes a relative movement between the body and the camshaft. This motion forces the worm shaft (Ref. 8) over to compress the coil spring (Ref. 7), releasing the cone clutch (Ref. 2). If the brakes are out of adjustment, any further torque will change the position of the one-way clutch in relation to the cone clutch.

When the brake begins its return stroke, the coil spring load returns to normal and the cone clutch is again engaged. The rack is pulled back to its original position in the notch. Any additional travel brought about by brake lining wear causes the rack to turn the locked one-way clutch and rotates the worm shaft through the locked cone clutch. The worm shaft then rotates the worm wheel (Ref. 6) and camshaft, adjusting the brakes.

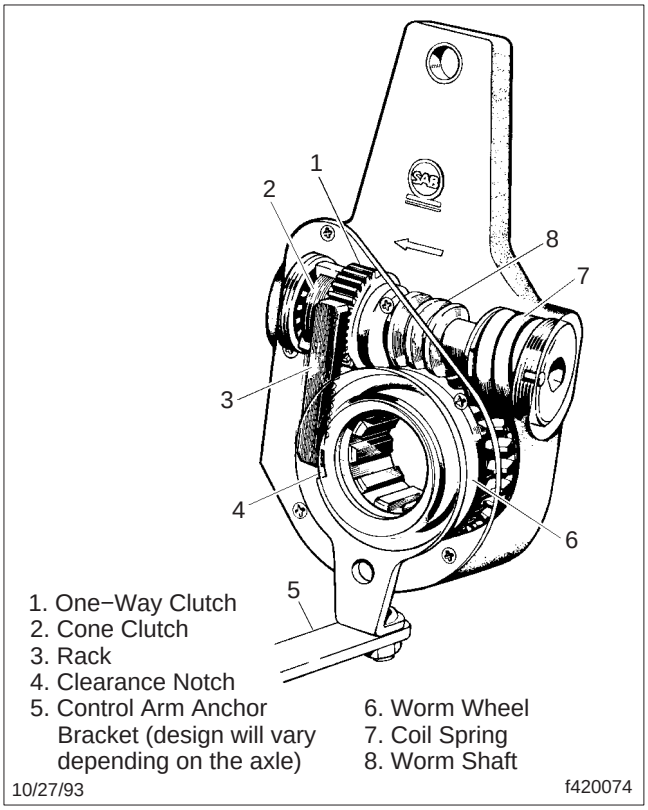


Fig. 1

Removal

1. Park on a level surface and chock the tires.
2. Release the parking brakes.

⚠ WARNING

WARNING: Before continuing, mechanically cage the power spring on each parking brake chamber to prevent the parking brakes from applying unexpectedly during the procedures. The parking brakes could suddenly apply due to a loss of air system pressure, and this could result in personal injury.

3. Remove the anchor bracket fasteners and the anchor bracket (**Fig. 1**).

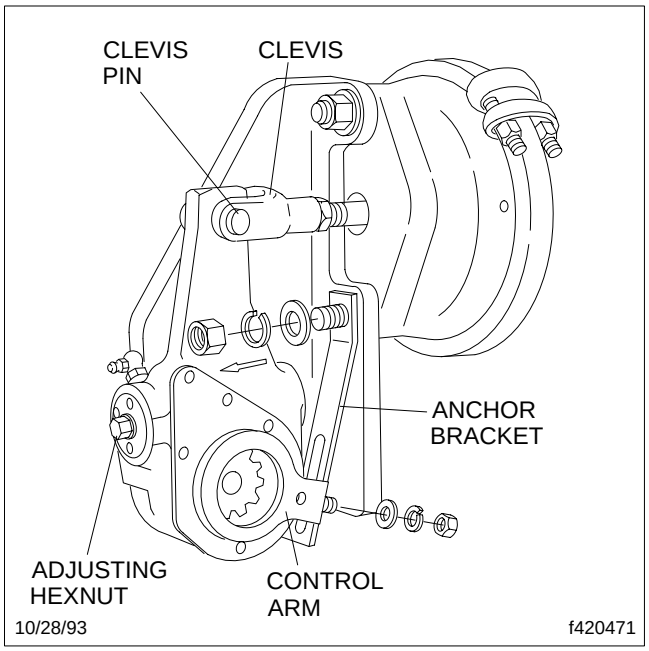


Fig. 1

4. Remove the cotter pin from the clevis pin. Remove the clevis pin.
5. Remove the snap ring holding the slack adjuster to the camshaft.
6. Turn the adjusting hexnut counterclockwise, to move the adjuster arm out of the clevis. A ratcheting sound may occur.
7. Remove the slack adjuster from the camshaft.

Installation

1. Check that the brake chamber push rod is fully released (parking brakes off).
2. Lubricate the camshaft splines with anti-corrosive grease.
3. Install the slack adjuster onto the camshaft with the adjusting hexnut (**Fig. 2**) pointing away from the brake chamber.

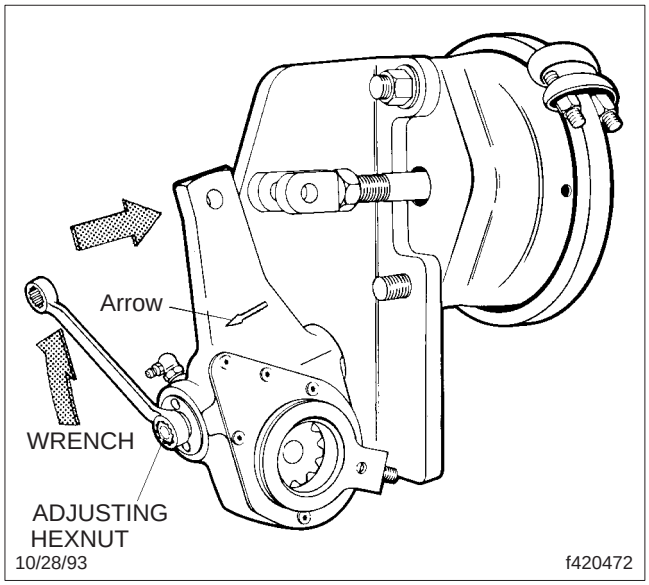


Fig. 2

IMPORTANT: When correctly installed, the brake chamber push rod pushes in the direction of the arrow (**Fig. 2**) on the adjuster arm.

4. Install the snap ring, securing the slack adjuster on the camshaft.
5. Turn the adjusting hexnut as shown in **Fig. 2** until the clevis hole lines up with the slack adjuster hole.
6. Insert the clevis pin, but do not install the cotter pin now.

IMPORTANT: Never push the slack adjuster into position. Always turn the adjusting hexnut for positioning.

7. Rotate the control arm away from the adjusting hexnut towards the brake chamber until it comes to a definite internal stop. See **Fig. 3**.

Removal and Installation

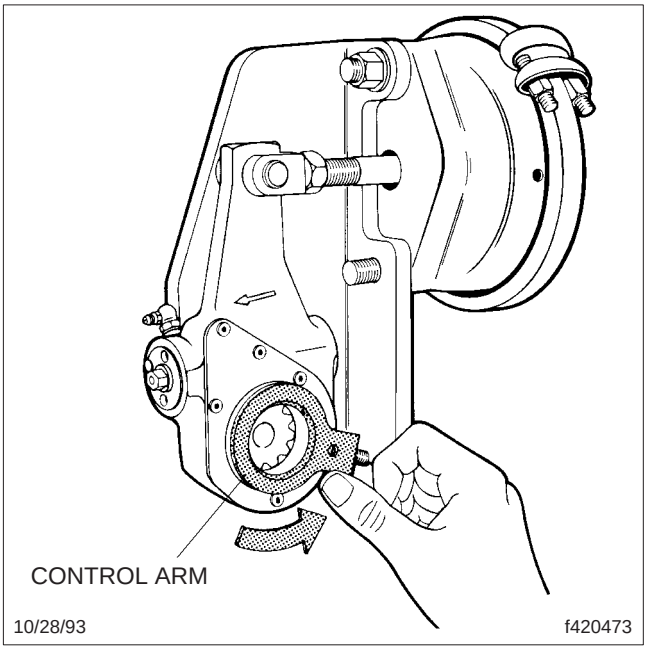


Fig. 3

IMPORTANT: Never hammer the control arm.

8. Install the anchor bracket. See **Fig. 1**.

NOTE: The anchor bracket design will vary, depending on the axle.

9. Tighten the anchor bracket fastener at the control arm 10 to 15 lbf·ft (14 to 20 N·m), making sure the control arm does not move from its position. Tighten the fastener at the brake chamber mounting stud according to the brake chamber manufacturer's specifications.
10. Adjust the brake lining clearance by turning the adjusting hexnut *clockwise* until the brake lining meets the brake drum, then back off *counterclockwise* 3/4 turn. A ratcheting sound may occur.
11. Check the installation by removing the clevis pin. Push the slack adjuster into the clevis, and then release it. See **Fig. 4**.

    If the slack adjuster hole did not stay aligned with the clevis pin hole, move the slack adjuster until the holes are aligned. Replace the clevis pin. Loosen the control arm fasteners, and move the control arm towards the brake chamber until it comes to a definite stop. Tighten the bracket fasteners.

    When the slack adjuster hole and clevis pin hole remain in alignment on release, the installation is correct.

    Insert the clevis pin in the clevis. Install and lock a new cotter pin in the clevis pin.

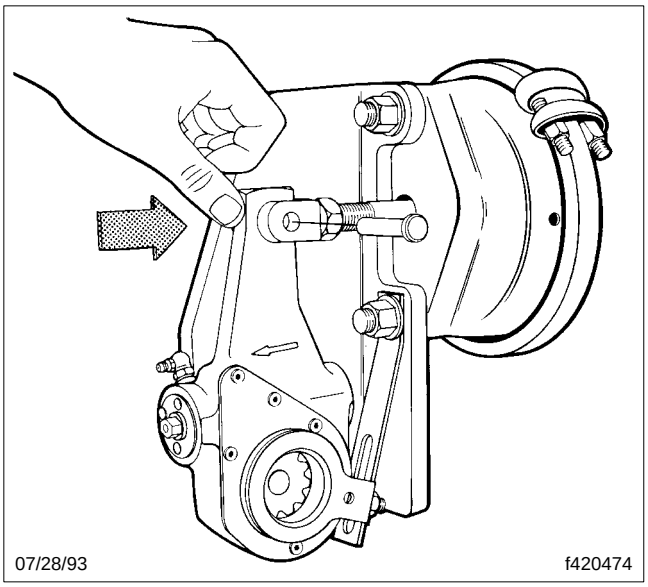


Fig. 4

⚠ WARNING

WARNING: Failure to install and lock a new cotter pin could allow the push rod to disengage from the slack adjuster, resulting in a loss of braking ability.

NOTE: Incorrect installation can cause dragging brakes.

Troubleshooting

This subject contains the following troubleshooting tables:

- Tight or Dragging Brakes
- Brake Chamber Push Rod Travel Is Excessive

Problem – Tight or Dragging Brakes

Possible Cause	Remedy
The control arm anchor bracket is not positioned properly.	See instructions under "Removal and Installation, 100."
System air pressure is too low to fully release the spring brake.	Check that the air governor cuts out at the recommended setting.
A spring brake diaphragm is ruptured or a piston seal is leaking.	Replace the diaphragm or spring brake piston seal.
A return spring in the brake chamber is broken.	Replace the spring brake return spring.
The push rod binds on the chamber housing.	Check for correct alignment and correct chamber mounting bracket. Adjust or replace parts as needed.
The air supply does not exhaust completely.	Test the air system valves for leakage and correct operation.
The brake drums are out-of-round.	Turn the brake drums, if possible. If the maximum allowable diameter of any brake drum has been exceeded, replace the drum. Also, turn or replace the other drum on the axle. For turning the drums, refer to the brake manufacturer's service manual.
Extreme differences exist in lining-to-drum clearances between shoes on the same wheel.	Check for proper operation of the brake mechanism. Lubricate or overhaul as needed.
The wheel bearings are out of adjustment.	Adjust the wheel bearings, or replace them if damaged. For instructions refer to the **front axle group** and the **rear axle group** of the vehicle service manual.
The brake shoe return spring is broken.	Replace the brake shoe return spring.

Problem – Brake Chamber Push Rod Travel Is Excessive

Possible Cause	Remedy
The control arm anchor bracket is loose, broken, or bent.	Tighten or replace the anchor bracket as required.
There is excessive wear between the anchor bracket bolt and the control arm slot.	Replace the worn parts.
The control arm assembly is damaged or worn, resulting in lateral movement between the control arm and the cover plate.	Replace the slack adjuster.
The camshaft bushings are worn.	Replace the worn camshaft bushings.
The camshaft binds.	Lubricate the camshaft or overhaul the brake mechanism as needed.
The brake chamber mounting is loose.	Tighten the brake chamber mounting fasteners.
The slack adjuster is bound against the camshaft housing. There is no end play.	Check that the correct camshaft and camshaft tube have been used and that they are assembled correctly. Overhaul the brake mechanism as needed.

Troubleshooting

Possible Cause	Remedy
The slack adjuster clutch assembly is worn.	Replace the slack adjuster.

General Description

In an S-cam type foundation brake, the final link between the air system and the foundation brake is the slack adjuster **(Fig. 1).** The arm of the slack adjuster fastens (using a yoke) to the push rod of the brake chamber, and the slack adjuster spline is installed on the brake camshaft.

Primarily, the slack adjuster is a lever, converting the linear force of the air chamber push rod into a torque that turns the brake camshaft and applies the brakes.

Standard slack adjusters contain four basic parts: the body, the worm, the gear, and the adjusting screw. The adjusting screw is provided to remove the slack caused by the wear of the brake lining.

All slack adjusters use the worm and gear principle and differ only in torque limit specifications. For example, a type 20 slack adjuster has a limit of 20,000 lbf·in; a type 30 slack adjuster has a limit of 30,000 lbf·in.

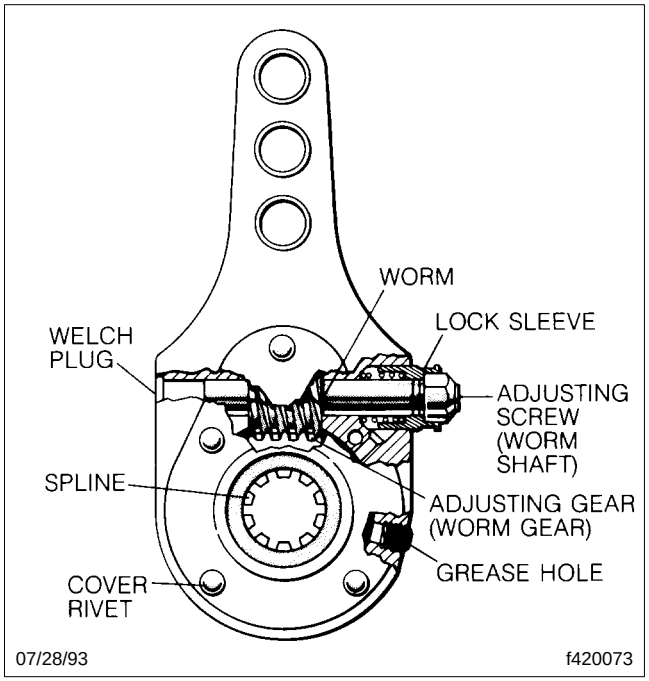


Fig. 1, Manual Slack Adjuster

Slack adjusters are produced in various arm lengths and configurations (such as "straight" and "offset"), to satisfy a variety of installation needs.

Principles of Operation

When the brakes are applied, compressed air forces the air service brake chamber diaphragm and push rod to move, rotating the slack adjuster. This in turn rotates the camshaft, causing the S-cam to spread the brake shoes, which contact the brake drum.

When the brakes are released, air pressure is exhausted from the brake chamber. The chamber return spring and the brake shoe return springs return the brake cam, camshaft, slack adjuster, and chamber push rod to the released positions.

The adjusting mechanism of a slack adjuster consists of an adjusting screw (worm shaft), worm, and slack adjuster worm gear. Turning the adjusting screw nut on the end of the worm shaft rotates the worm shaft and worm. The worm meshes with and rotates the slack adjuster worm gear, which is connected to the brake cam by a splined camshaft. The turning of the worm gear rotates the camshaft and brake cam, spreading the brake shoes, thereby compensating for brake lining wear.

Manual slack adjusters feature a positive lock mechanism to maintain the adjustment setting. This mechanism consists of a spring-loaded lock sleeve, which, when positioned properly, engages the adjusting screw nut to prevent the adjusting screw (worm shaft) from rotating.

Removal

1. Chock the tires and, if a rear-axle slack adjuster is being removed, release the parking brakes, and then cage the power spring of the parking brake chamber. For instructions, **refer to the brakes group.**

⚠ WARNING

WARNING: Possible loss of brake chamber air pressure will cause sudden application of the parking brakes, which could result in personal injury. Manually cage each parking brake chamber power spring in the release (no application) position before continuing.

2. Remove the slack adjuster from the brake camshaft.
   - 2.1 Remove the cotter pin from the brake chamber push-rod yoke pin; remove the yoke pin.
   - 2.2 Remove the snap ring and spacing washers from the end of the brake camshaft, and save them for later installation.
   - 2.3 Wipe off the adjusting screw nut and the locking sleeve area. Place a wrench or socket over the adjusting screw and depress the locking screw sleeve to disengage it. Turn the adjusting screw nut until the slack adjuster is clear of the brake camshaft.
   - 2.4 Pull the slack adjuster off the brake camshaft.
   - 2.5 Note the location and number of any remaining spacing washers from the camshaft, and then remove them. Save them for later installation.

Installation

1. Wipe the camshaft clean of any dirt or old grease.
2. As referenced earlier, install the inner camshaft washers on the camshaft.
3. Apply a thin film of fresh chassis grease to the slack adjuster splines.
4. Install the slack adjuster on the brake camshaft.
   - 4.1 Position the slack adjuster on the camshaft with the adjuster nut on the side opposite of the brake.
   - 4.2 Install the spacing washers and snap ring on the end of the camshaft.
   - 4.3 Check the slack adjuster end play, and add washers as needed to ensure a maximum end play of 1.57 mm (0.062 inch).
   - 4.4 Place a wrench or socket over the adjusting screw and depress the locking sleeve to disengage it. Rotate the adjusting screw nut until the hole in the slack adjuster arm aligns with the yoke pin hole. Install the yoke pin and lock it with a new cotter pin.
5. If a rear-axle slack adjuster was installed, manually uncage the parking brake. For instructions, **refer to the brakes group.**
6. With the parking brakes released, continue to rotate the adjusting screw until the brakes begin to drag when the drum is turned; then, back off the adjustment until the wheel turns freely. Turn the adjusting screw nut until the locking sleeve engages it.
7. Check the slack adjuster for smooth operation.
   - 7.1 Start the engine and bring the air pressure to approximately 550 kPa (80 psi).
   - 7.2 Apply the brakes, and check that the slack adjuster rotates freely and without binding.
   - 7.3 Release the brakes, and check that the slack adjuster returns to the released position without binding.
8. Check the brake chamber stroke.
   - 8.1 Bring the air pressure to approximately 550 kPa (80 psi).
   - 8.2 With the brakes released, measure distance *A* . **See Fig. 1.**
   - 8.3 Make and hold a full brake application. Measure distance *B* . **See Fig. 1.**
   - 8.4 Determine brake chamber stroke (distance *B* minus distance *A*).

Removal and Installation

8.5 Readjust the brakes if the chamber stroke exceeds the maximum stroke. **See Table 1.**

9. Remove the chocks from the tires.

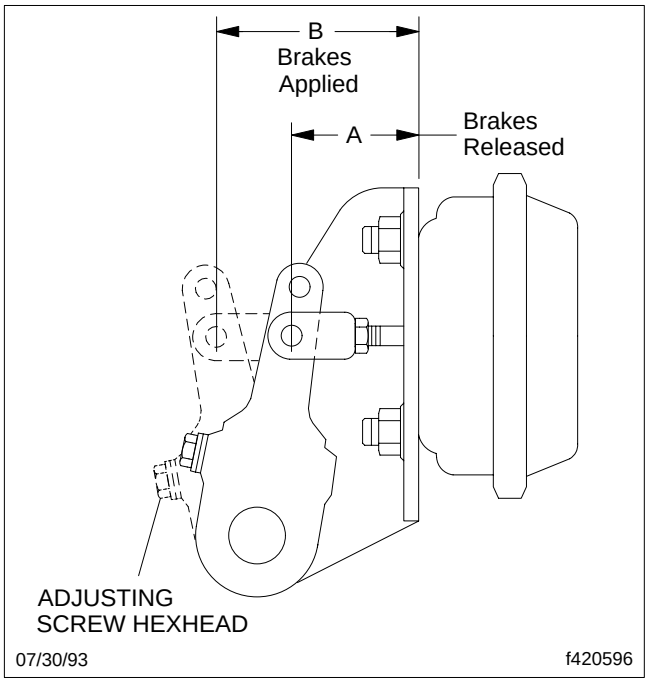


Fig. 1

Chamber Size	Maximum Chamber Stroke for Cam Brake
9	Less than 38 mm (1-1/2 inches)
12	Less than 38 mm (1-1/2 inches)
16	Less than 44 mm (1-3/4 inches)
20	Less than 44 mm (1-3/4 inches)
24	Less than 48 mm (1-7/8 inches)
24 *	Less than 51 mm (2 inches)
30	Less than 51 mm (2 inches)

* Long stroke.

Table 1, Maximum Adjusted Brake Chamber Strokes

General Description

The front and rear axle full-floating wheel hub assembly is made up of four major components: tapered wheel bearings, the wheel hub, wheel studs, and the brake drum. **See Fig. 1 and Fig. 2.**

The brake drum and lining work together as a mated friction pair, with the drum responsible for both heat absorption and dissipation. Lining performance and life largely depend on the condition of the drum and whether it can adequately absorb and dissipate heat generated by braking action.

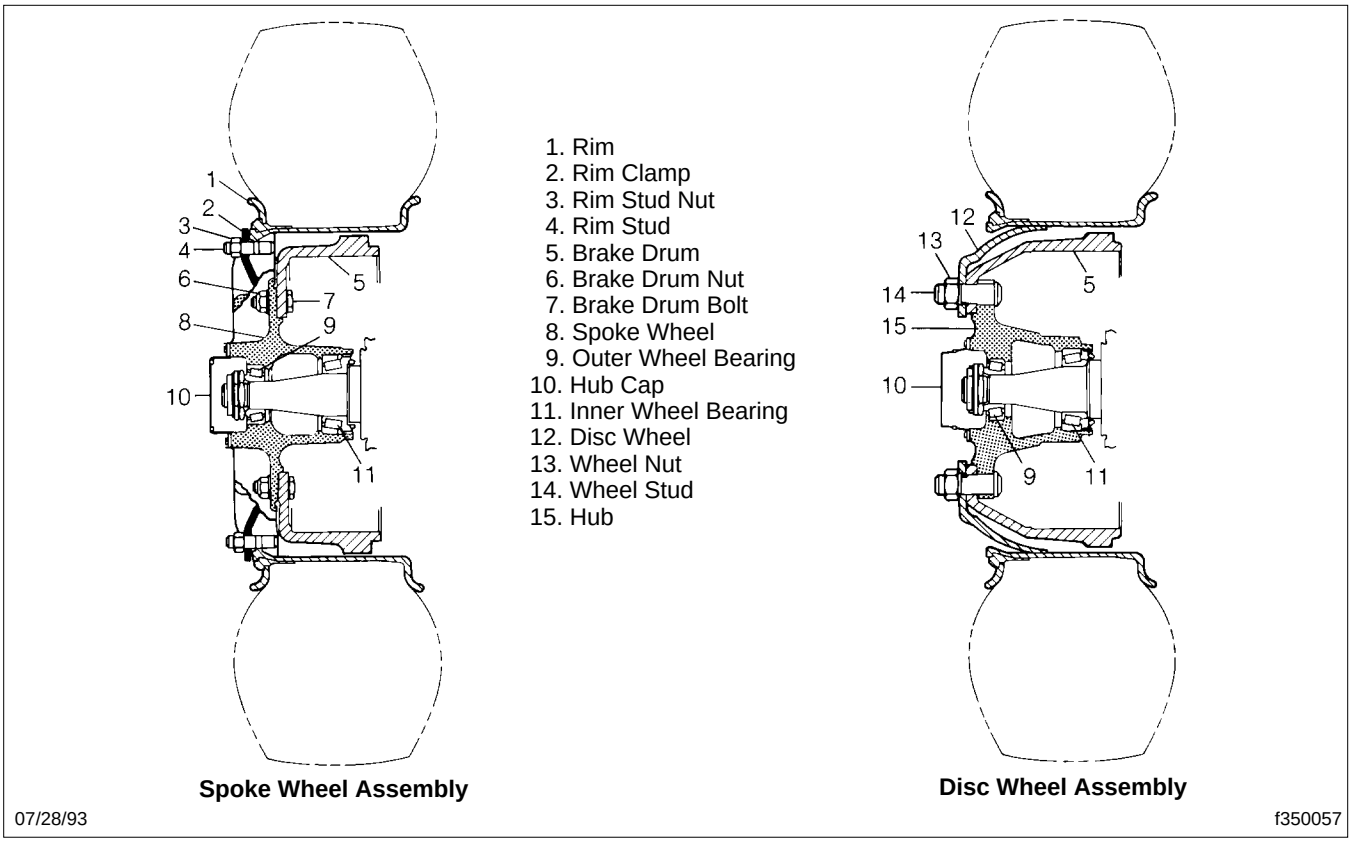
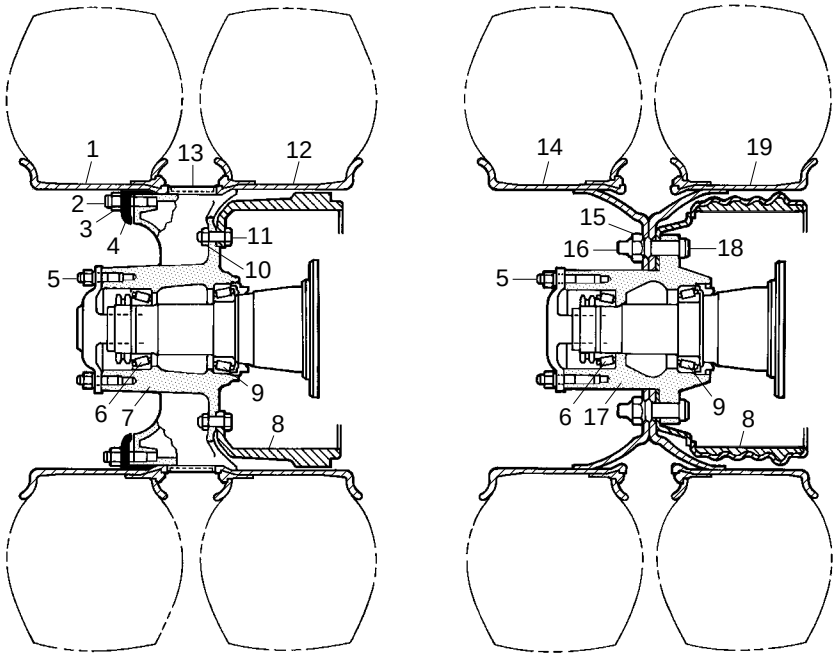


Fig. 1, Sectional View of Spoke and Disc Wheel Assemblies, Front Axle

General Description

1. Outer Rim
2. Rim Stud
3. Rim Stud Nut
4. Rim Clamp
5. Drive Axle Stud
6. Outer Wheel Bearing
7. Spoke Wheel
8. Brake Drum
9. Inner Wheel Bearing
10. Brake Drum Nut
11. Brake Drum Bolt
12. Inner Rim
13. Rim Spacer
14. Outer Wheel
15. Outer Wheel Nut
16. Inner Wheel Nut
17. Wheel Hub
18. Wheel Stud
19. Inner Wheel



SPOKE WHEEL AND BRAKE DRUM ASSEMBLY

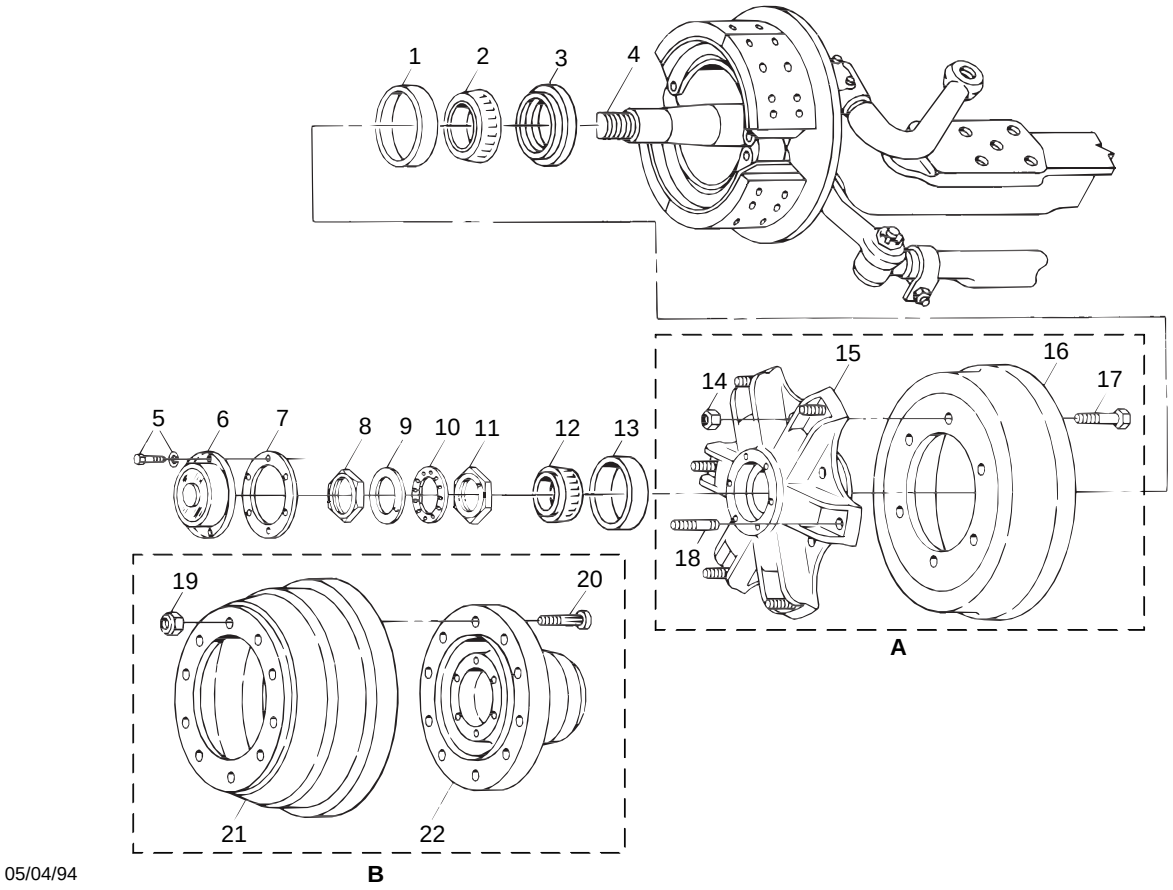
DISC WHEEL, WHEEL HUB, AND BRAKE DRUM ASSEMBLY

07/28/93 f350067

Fig. 2, Sectional View of Spoke and Disc Wheel Assemblies, Drive Axle

Outboard-Mounted Drum Removal and Installation

Removal (See Fig. 1 and Fig. 2)



A. Spoke Wheel and Inboard-Mounted Drum Assembly
B. Disc Wheel, Hub, and Outboard-Mounted Drum Assembly

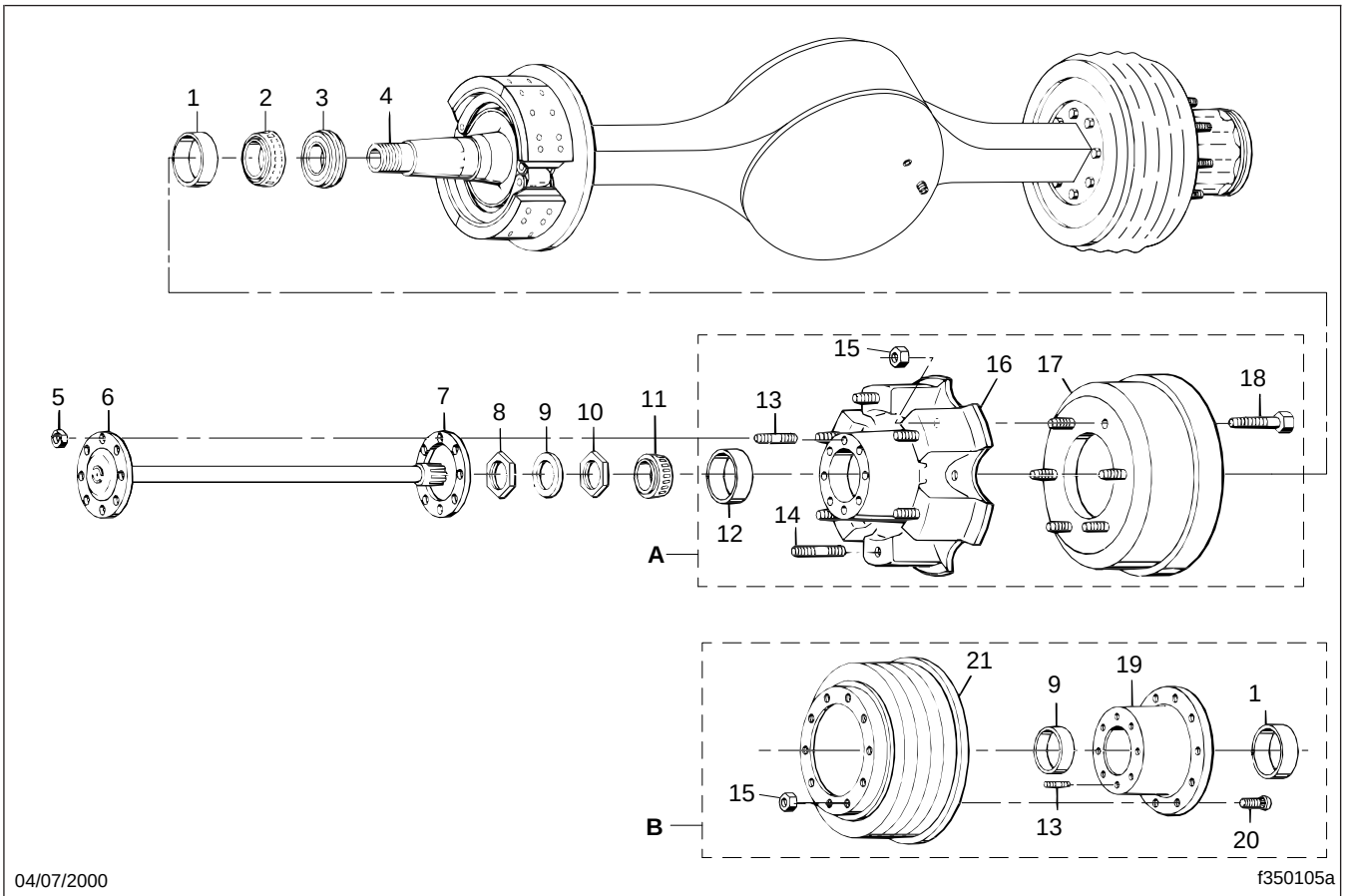
1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle (Steering Knuckle)
5. Hub Cap Capscrew and Washer
6. Hub Cap
7. Hub Cap Gasket
8. Jam Nut
9. Lockwasher
10. Lockring
11. Wheel Bearing Adjusting Nut
12. Outer Wheel Bearing
13. Outer Wheel Bearing Cup
14. Brake Drum Nut
15. Spoke Wheel
16. Brake Drum, Inboard-Mounted
17. Brake Drum Bolt
18. Rim Stud
19. Wheel Nut
20. Wheel Stud
21. Brake Drum, Outboard-Mounted
22. Wheel Hub

Fig. 1, Typical Front Axle (exploded view)

1. Before working on the front axle, chock the rear tires and apply the parking brakes.

   Before working on the rear axle, chock the front tires and release the parking brakes.

Outboard-Mounted Drum Removal and Installation



A. Spoke Wheel and Drum Assembly
1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle
5. Drive Axle Stud Nut
6. Drive Axle Flange and Shaft
7. Gasket
8. Jam Nut
9. Lockring
10. Wheel Bearing Inner Adjusting Nut
11. Outer Wheel Bearing
12. Outer Wheel Bearing Cup
13. Drive Axle Stud
14. Rim Stud

B. Disc Wheel, Hub, and Drum Assembly
15. Brake Drum Nut
16. Spoke Wheel
17. Brake Drum, Inboard-Mounted
18. Brake Drum Bolt
19. Wheel Hub
20. Wheel Stud
21. Brake Drum, Outboard-Mounted

Fig. 2, Typical Drive Axle (exploded view)

2. Raise the vehicle until the tires clear the ground. Then place safety stands under the axle.
3. Back off the slack adjuster to release the brake shoes. For instructions, see the applicable slack adjuster section in **Group 42**.

⚠ WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. Unless exposure can be reduced below legal limits, wear an air purifying respirator approved by MSHA or NIOSH at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

To reduce asbestos exposure below legal limits, apply one of the following methods: (1) An enclosed-cylinder vacuum system equipped with a High Efficiency Particulate Air (HEPA) filter; (2) A solvent spray system that keeps the asbestos-contaminated parts wet until they can be placed in a sealed and labelled plastic bag.

4. Remove wheel and tire assemblies. See **Group 40** for instructions.
5. Remove the brake drum.

   To minimize the possibility of creating airborne brake lining dust, clean the dust from the brake drum, brake backing plate, and brake assembly, using an industrial-type vacuum cleaner equipped with a high-efficiency filter system. Then, using a rag soaked in water and wrung until nearly dry, remove any remaining dust. Don't use compressed air or dry brushing to clean the brake assembly.
6. Inspect the drum. See **Subject 110** for instructions.

Installation

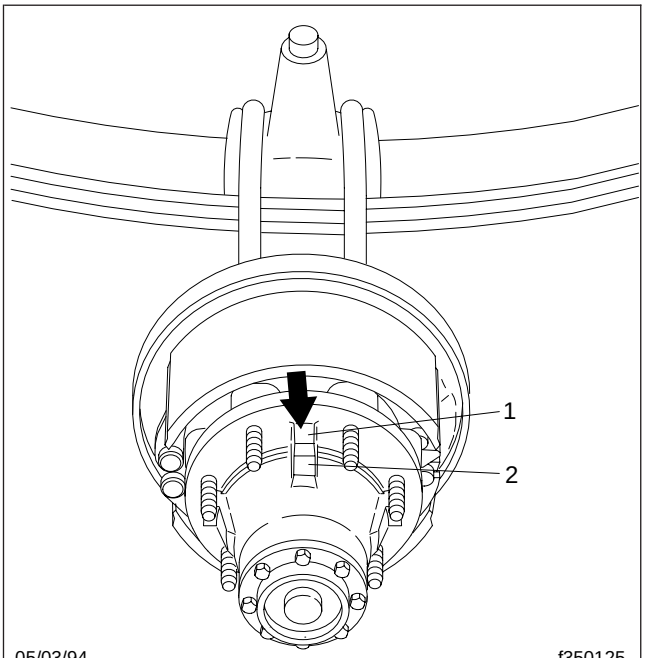
1. Install the brake drum on the wheel hub.

   1.1 On hub-piloted drums, position the brake drum on the top step of the pilot pad. One of the hub's pilot pads should be at the twelve o'clock (top center) position. See **Fig. 3**.

   IMPORTANT: If the drum is not positioned correctly, the pilot pad could be damaged when the wheel nuts are torqued.

   1.2 Make sure that the pilot pads securely center the drum (space between drum and hub is equal all around the hub).

   IMPORTANT: If damage to the pads prevents the drum from centering, replace the hub. If necessary, to hold the drum in position, adjust the brakes before installing the wheels.
2. Install the wheel and tire assemblies. See **Group 40** for instructions.



NOTE: Pilot pad at 12 o'clock position

1. Drum Pilot
2. Wheel Pilot

Fig. 3, Front Axle Drum and Wheel Pilots (rear axle similar)

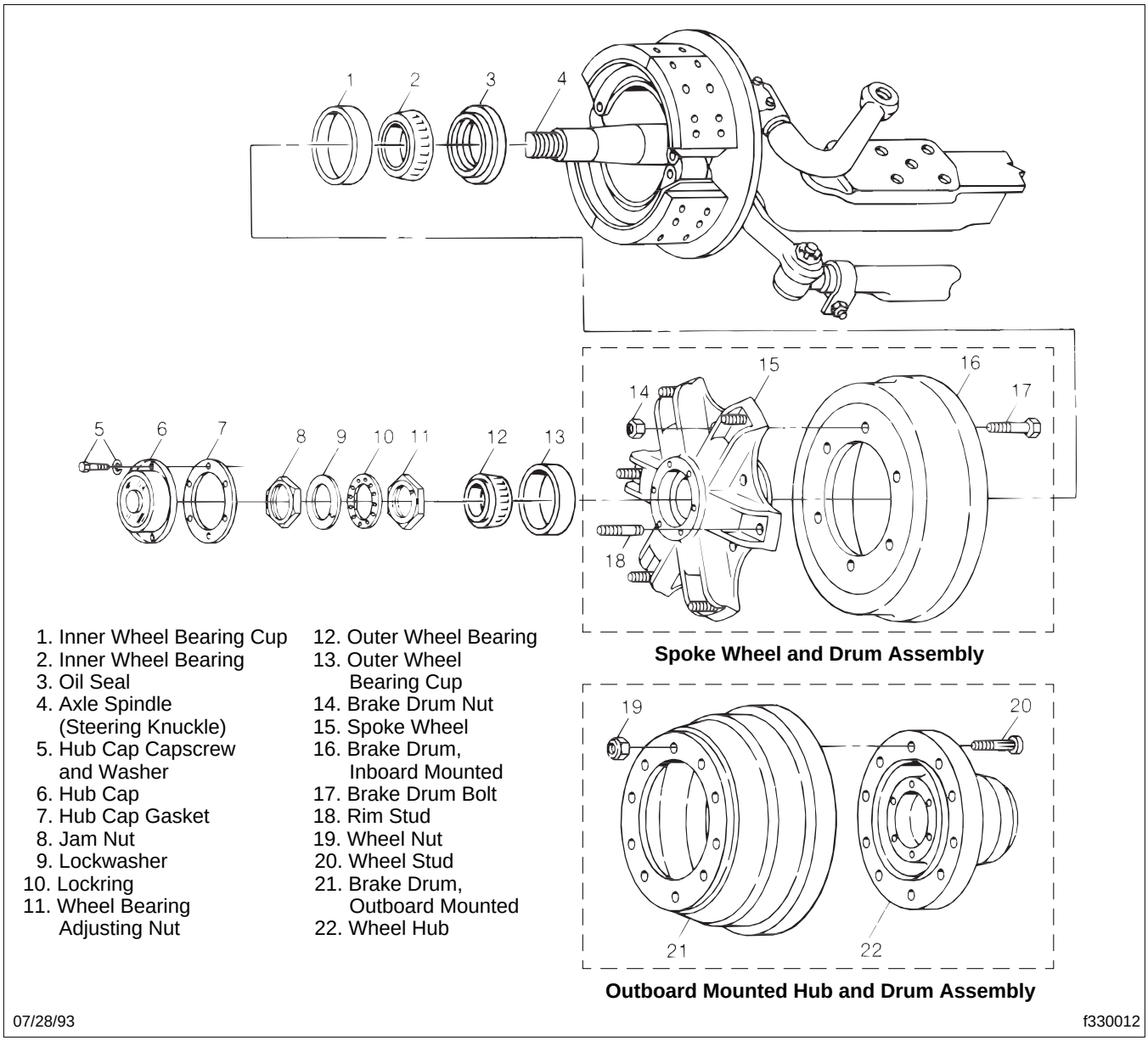
WARNING

If the wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking ability, and the hub flange is probably damaged. In this case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when the conditions described above exist, could result in the loss of a wheel or loss of vehicle control, and possible personal injury.

3. Adjust the brakes at the slack adjusters. For instructions, see Group 42 of the *Business Class Trucks Maintenance Manual*.
4. Remove the safety stands from under the axle; lower the vehicle.
5. Apply the parking brakes (if not already applied); then remove the chocks from the tires.

Inboard Mounted Drum Removal and Installation

Removal (Refer to Fig. 1)



1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle (Steering Knuckle)
5. Hub Cap Capscrew and Washer
6. Hub Cap
7. Hub Cap Gasket
8. Jam Nut
9. Lockwasher
10. Lockring
11. Wheel Bearing Adjusting Nut
12. Outer Wheel Bearing
13. Outer Wheel Bearing Cup
14. Brake Drum Nut
15. Spoke Wheel
16. Brake Drum, Inboard Mounted
17. Brake Drum Bolt
18. Rim Stud
19. Wheel Nut
20. Wheel Stud
21. Brake Drum, Outboard Mounted
22. Wheel Hub

Fig. 1, Typical Front Axle

1. If the front axle is being worked on, chock the rear wheels; if the rear axle is being worked on, chock the front wheels. Release the parking brakes.
2. Raise the vehicle until the tires clear the ground. Then place safety stands under the axle to be serviced. Position a jack or wheel-and-tire dolly under the tires.

Inboard Mounted Drum Removal and Installation

3. Back off the slack adjuster to release the brake shoes. For instructions, refer to the applicable slack adjuster section **in the brakes group** of this manual.
4. Remove rim and tire assemblies. Refer to the **wheels and tires group** for instructions.
5. Remove the wheel hub. Refer to the **front axle group** or the **rear axle group** for instructions.
6. Remove the brake drum nuts **(Fig. 1 and Fig. 2)** and detach the brake drum from the wheel.

WARNING

WARNING: Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

7. To minimize the possibility of creating brake lining dust, clean the dust from the brake drum, brake backing plate, and brake assembly, using an industrial-type vacuum cleaner equipped with a high-efficiency filter system. Then, using a rag

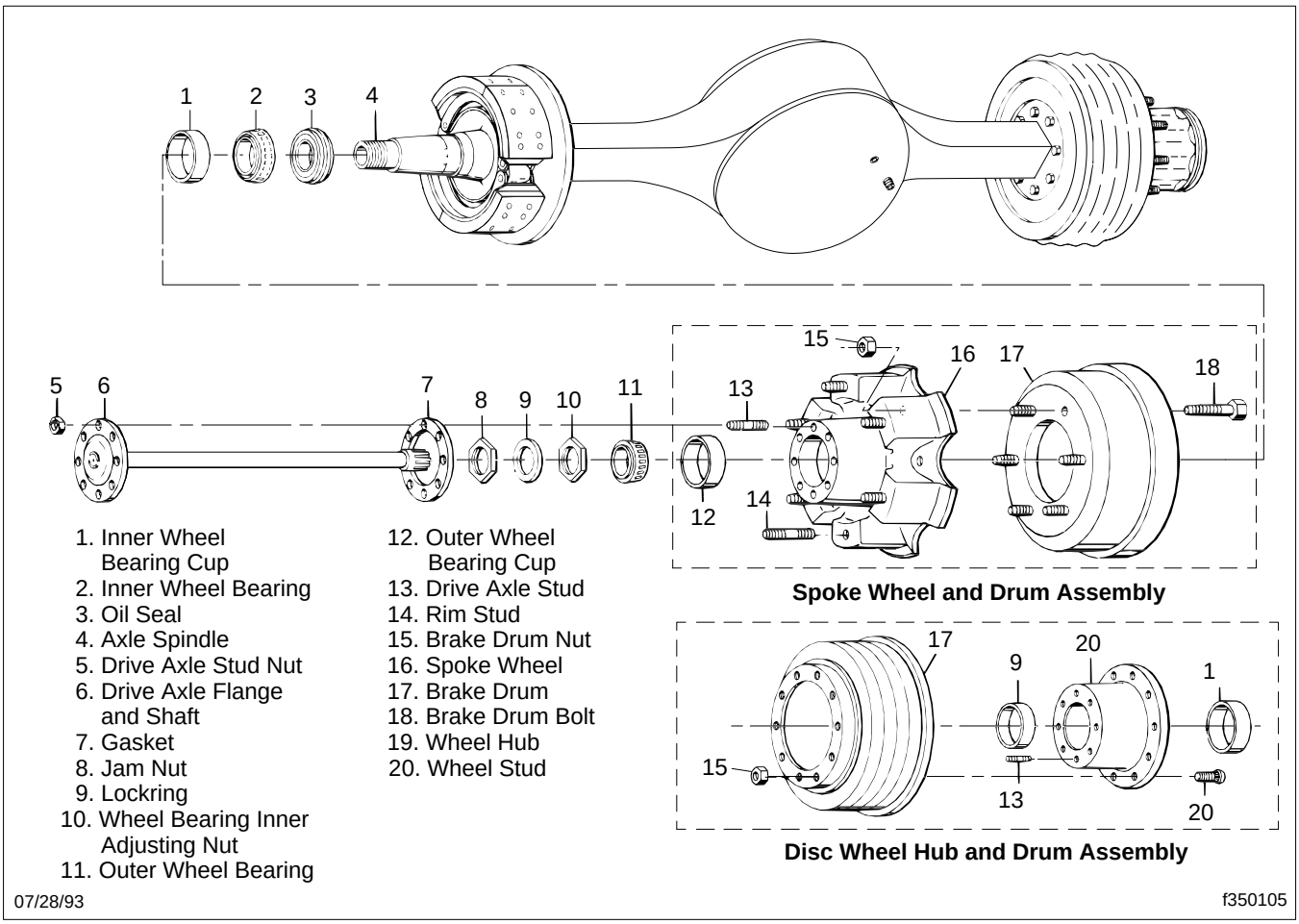


Fig. 2, Typical Drive Axle Exploded View

soaked in water and wrung until nearly dry, remove any remaining dust. Don't use compressed air or dry brushing to clean the brake assembly.

Installation

1. Attach the brake drum to the wheel. Install the brake drum bolts and nuts, then tighten the nuts 325 N·m (240 lbf·ft).
2. Install the hub and wheel bearings. Refer to the **front axle group** or the **rear axle group** for instructions.
3. Install the wheel and tire assembly. Refer to the **wheels and tires group** for instructions.
4. Adjust the brakes at the slack adjusters. For instructions, refer to the brakes group in the vehicle maintenance manual.
5. Remove the safety stands from under the axle; lower the vehicle.
6. Remove the chocks from under the tires.

Inspection

New brake drums are purposely undersized to allow for turning, which may be needed if the drum is non-concentric when mounted on the hub. If a new drum is installed, the protective coating on the inner friction surface must first be removed with a solvent, and then rinsed with a hot water wash. Use a clean rag to remove any oily residue or metal chips from the friction surface.

If a drum must be turned or replaced, the other same-axle drum must be similarly turned or replaced to provide the same braking power on both wheels. Turned drums should not exceed the maximum allowable diameter, which is stamped on the outside surface of the drum. **Refer to Fig. 1** for a typical location of this stamp.

NOTE: Drums that have been turned should then be cleaned by using fine emery cloth followed with a hot water wash. Drums that have been renewed using emery cloth should also be cleaned with a hot water wash.

⚠ WARNING

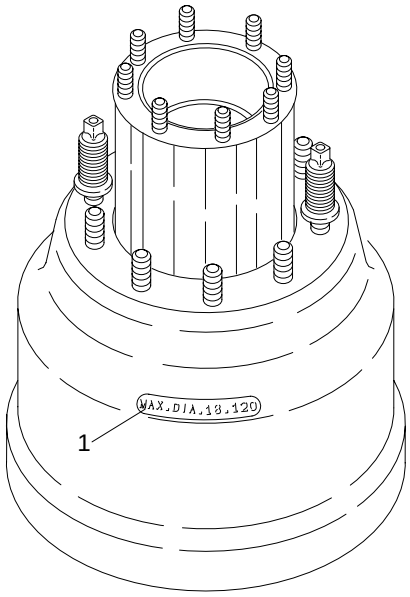
WARNING: Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

Failure to replace drums when worn or turned to limits exceeding the maximum allowable diameter will cause drum weakness and reduced braking capacity, which can lead to distortion, higher drum temperatures, and ultimate drum breakage.

To minimize the possibility of creating airborne brake lining dust, clean the dust from the brake drum, brake backing plate, and brake assembly, using an industrial-type vacuum cleaner equipped with a high-efficiency filter system. Then, using a rag soaked in water and wrung until nearly dry, remove any remaining dust. Don't use compressed air or dry brushing to clean the brake assembly.

If the drums are turned or replaced, replace the brake linings. **Refer to the brakes group** for instructions.

1. Inspect the inner friction surface. If a veneered (highly glossed) or glazed surface exists, renew the drum by using 80-grit emery cloth or by turning the drums. **See Fig. 2.**



1. Maximum Diameter Stamp

07/28/93 f350012

Fig. 1

2. Inspect for heat checking, which is a form of buckling (cracking) resulting from a temperature differential in the drum wall between a relatively cool exterior and a hot friction surface. Heat checking is normal on all drums and may not reduce performance and lining life if the network of fine hairline cracks remains small. **See Fig. 3.** Examine heat checks of drums often to be sure the checks have not widened into drum weakening cracks (substantial cracks extending to the open edge of the drum). **See Fig. 4.**

   Replace the same-axle drums if substantial cracks are present, or if widening of the fine hairline cracks occurs.

Inspection

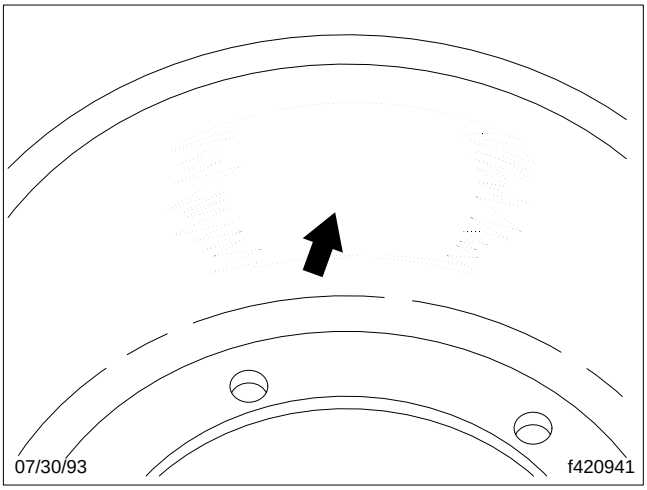


Fig. 2, Polished Drums

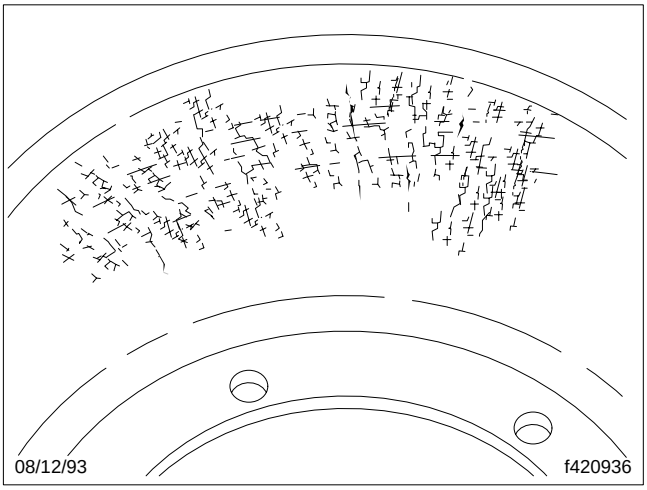


Fig. 3, Heat Checking

NOTE: If there is normal heat checking as described above, inspect the drums at least every 19 300 km (12,000 miles) thereafter. If the vehicle is not equipped with brake dust shields, inspect the drums (using a flashlight from the inboard side of the wheels) every 9700 km (6000 miles). Inspect more often under adverse operating conditions.

3. Check for a contaminated inner friction surface. If fluids are present, such as oil or grease, remove them. Locate and correct the source of the contamination. If the brake drums are contaminated with fluids, the brake linings will also be affected. Since oil-or grease-saturated linings cannot be salvaged, they must be replaced. For instructions, **refer to the brakes group.**

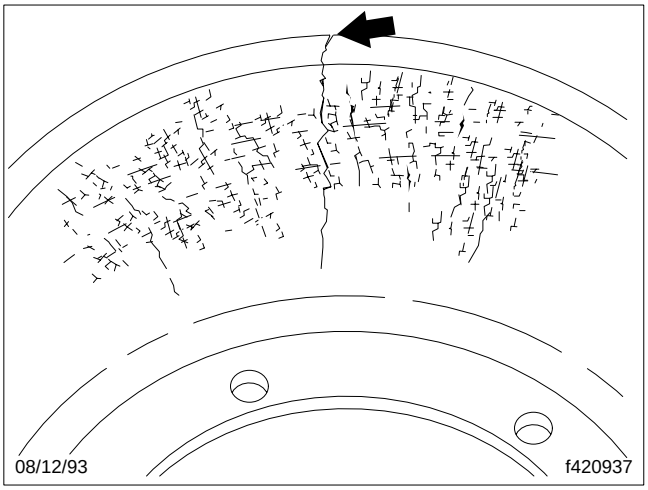


Fig. 4, Cracked Drums

WARNING

WARNING: Failure to replace fluid-contaminated brake linings could result in a partial loss of braking capacity.

4. Measure the inside diameter of the drum. If this measurement is greater than the maximum allowable diameter, replace the same-axle drums and linings. **See Fig. 5.**
5. Check for a variation in gauge readings at different points on the radius of the drum's working surface. If the variation is more than 0.25 mm (0.010 inch) at any point, the drum is out-of-round to unacceptable limits. Remachine or replace the same-axle drums. **See Fig. 5.**
6. Inspect the outside surface of the drum. Remove any accumulation of mud, dirt, or rust; foreign matter acts as an insulator, trapping heat within the drum.
7. Check for hard, slightly raised, dark-colored spots on the inner friction surface **(see Fig. 6)** or for a bluish cast on the brake parts **(see Fig 7),** both of which are caused by high temperatures. If the drums' maximum allowable diameters have not been exceeded, remachine both same-axle drums. If spots or discoloration cannot be removed, or if remachining is not possible, replace

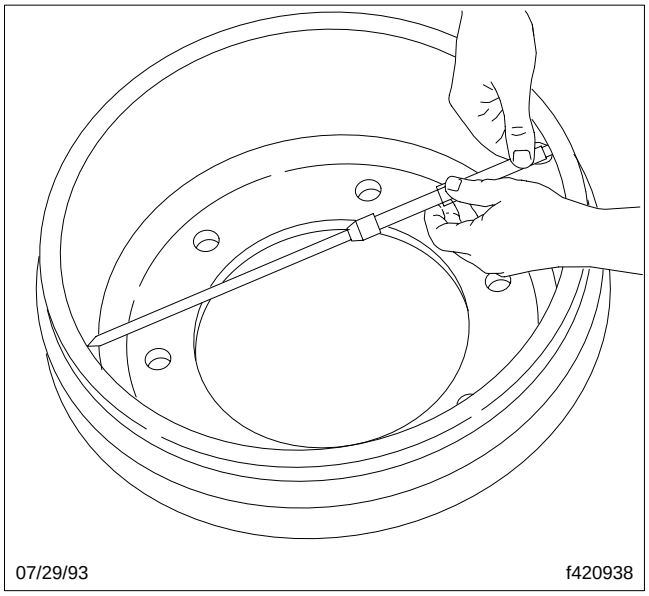


Fig. 5, Oversized Drums

the drums. Also replace the brake shoe return springs. **Refer to the brakes group** for instructions.

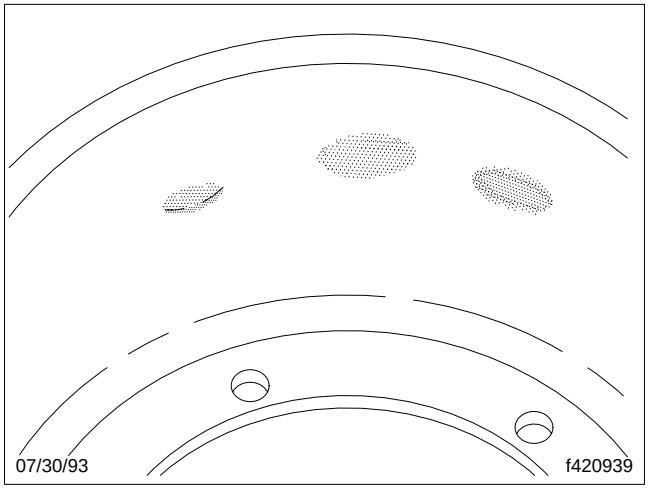


Fig. 6, Heat Spotted Drums

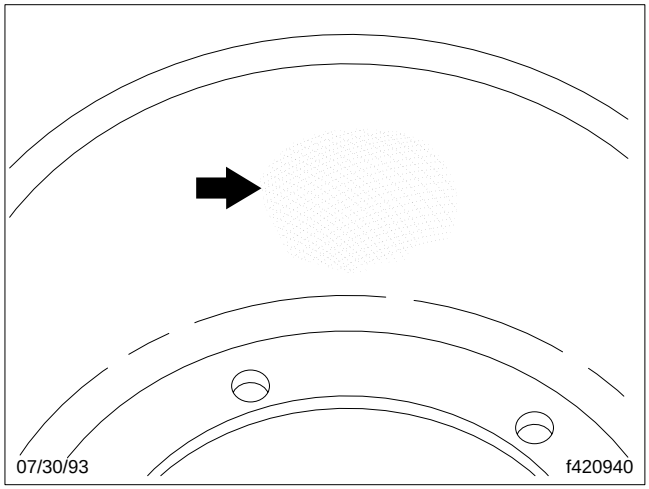


Fig. 7, Blue Drums

Specifications

This subject contains the following table:

•Fastener Torque

Description	Grade	Size	Torque N·m (lbf·ft)
Brake Drum Bolt	8	3/4-10	325 (240)

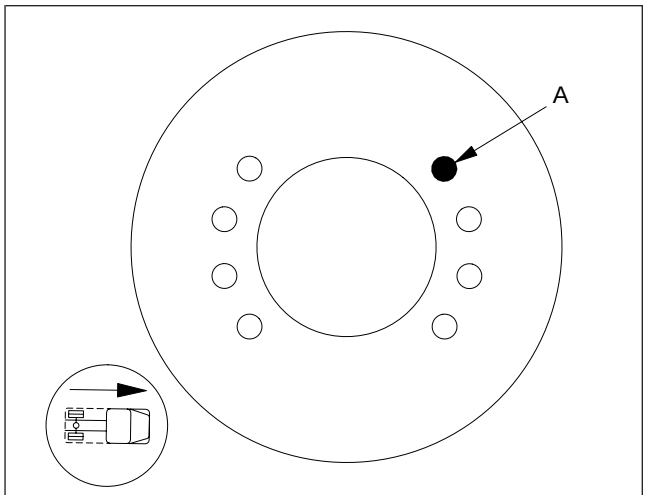
Table 1, Fastener Torque

General Description

Rockwell "Q" and "Q" Plus Series brakes are actuated by an S-type cam head, which is forged integrally with the camshaft and supported with nylon bushings. Cam pressure is applied through the cam rollers.

These brakes are used on both the front steer axle and rear axles.

Rockwell steer axles have seven holes for attaching the spider to the axle flange. There is an eighth hole left open on the brake spider, on both left and right sides of the steer axle. **See Fig. 1.** The seven holes used for attachment of the spider to the axle flange are 0.656 inch in diameter. The eighth hole is oversized at 0.687 inch in diameter.



A. Open

Fig. 1

As of March 1, 1994, Rockwell began attaching an identifying label to the web of all on-highway shoe and lining assemblies. The label is made of Mylar, and is attached with a heat-resistant adhesive. At the same time, the lining edge code changed to the new Rockwell lining designation. The new lining edge code will show the supplier lining designation and the corresponding Rockwell designation. **See Table 1.**

Vendor Code		Rockwell Designation
Abex	931–162	R301
	197	R201
	1083–7	R501
	1083–63	R401
Carlisle	E145–A	R202
	NAB–9ML	R302
	NAB10	R502
	NAB11	R402
Ferodo	NAB456	R403
	867	R203

Table 1, Edge Codes

The label will include three lines of information. **See Fig. 2.** The first line identifies the shoe as "Q PLUS" or "BRAKES" (non-Q Plus). The second line gives the new Rockwell aftermarket lining material designation. See "Rockwell Designation" in **Table 1.** The third line gives the service part number to use for replacing the shoe and lining assembly.

Principles of Operation

When the brake pedal is depressed, compressed air enters the brake chamber, causing the diaphragm to move a push rod assembly.

The push rod, which is connected to a slack adjuster, turns the slack adjuster and brake camshaft. As the camshaft turns, the S-head, which is between the brake shoe rollers, forces the brake shoes against the brake drum, and braking occurs.

When the brakes are released and air is exhausted from the brake chamber, the actuator return spring (within the brake chamber) and the brake shoe return spring, return the camshaft, brake shoes, slack adjuster, and the push rod to their released positions.

General Description and Principles of Operation

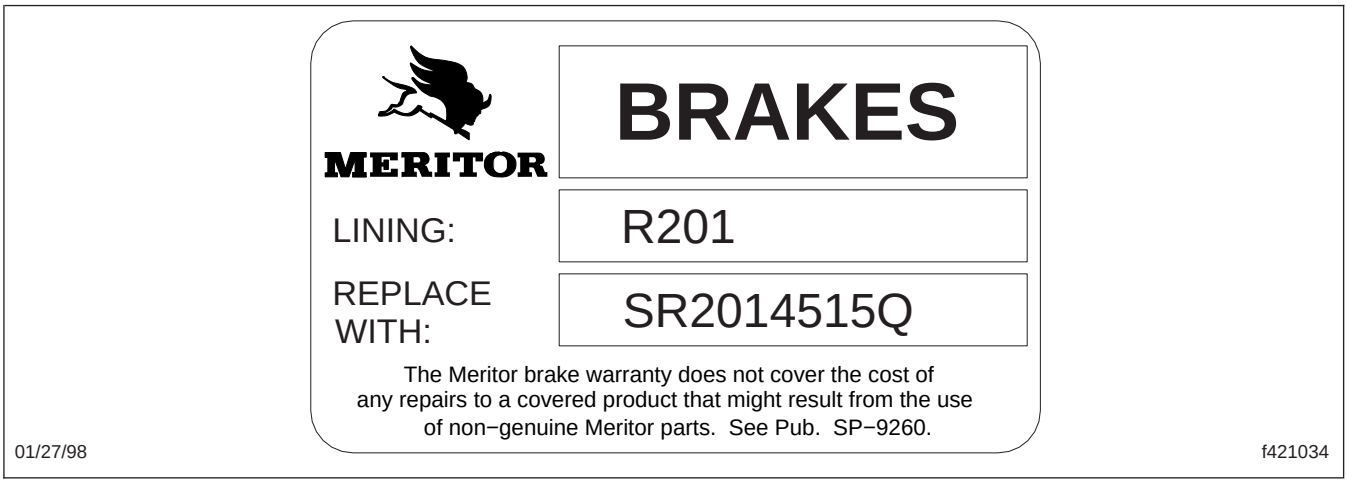


Fig. 2, Rockwell Brake Shoe Lable, Example

Safety Precautions

Because some brake linings contain asbestos, you should know the potential hazards of asbestos and the precautions to be taken. Because medical experts believe that long-term exposure to some *non-asbestos* fibers could also be a health hazard, the following precautions should also be observed if servicing non-asbestos brake linings.

Exposure to airborne brake lining dust can cause serious and possibly fatal diseases such as asbestosis (a chronic lung disease) and cancer.

During brake servicing, an air purifying respirator with high-efficiency filters must be worn. The respirator and filter must be approved by MSHA or NIOSH, and worn during all procedures.

OSHA recommends that enclosed cylinders equipped with vacuums and high-efficiency particulate air (HEPA) filters be used during brake repairs. Under this system, the entire brake assembly is placed within the cylinder and the mechanic works on the brake through sleeves attached to the cylinder. Compressed air is blown into the cylinder to clean the assembly, and the dirty air is then removed from the cylinder by the vacuum.

If such an enclosed system isn't available, the brake assembly must be cleaned in the open air. During disassembly, carefully place all parts on the floor to minimize creating airborne dust. Using an industrial vacuum cleaner with a HEPA filter system, remove dust from the brake drums, brake backing plates, and brake parts. After vacuuming, any remaining dust should be removed using a rag soaked in water and wrung until nearly dry.

⚠ WARNING

WARNING: Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

To minimize the possibility of creating airborne brake lining dust, clean the dust from the brake drum, brake backing plate, and brake assembly, using an industrial-type vacuum cleaner equipped with a high-efficiency filter system. Then, using a rag soaked in water and wrung until nearly dry, remove any remaining dust. Don't use compressed air or dry brushing to clean the brake assembly.

Brake Shoe Removal and Installation

⚠ WARNING

WARNING: Before starting the procedure below, read the information in "Safety Precautions, 100." Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

Removal

1. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Raise the front or rear axle, then place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
3. Remove the wheels and brake drums. For instructions, refer to the **front axle group** or the **rear axle group** in this manual.

⚠ CAUTION

CAUTION: Before you back off automatic slack adjusters, refer to the brakes group in this manual, or to the manufacturer's service information for instructions. Failure to do so could damage the slack adjusters.

4. Back off the slack adjusters.

   On manual slack adjusters, back off each until the cam is in the start or released position.

   On automatic slack adjusters, refer to the brake section in this manual for instructions on backing off the slack adjuster.

5. If equipped with 15-inch "Q" Series brakes, go to step 6.

   If equipped with "Q" Plus Series brakes, or 16-1/2 inch "Q" Series brakes, remove the brake shoes.

   5.1 Push down on the bottom brake shoe, then pull on the roller retaining clip to remove the bottom cam roller. **See Fig. 1.**

   5.2 Lift the top brake shoe and pull on the roller retaining clip to remove the top cam roller.

   5.3 Lift the bottom shoe to release tension on the brake return spring. Remove the spring. **See Fig. 2.**

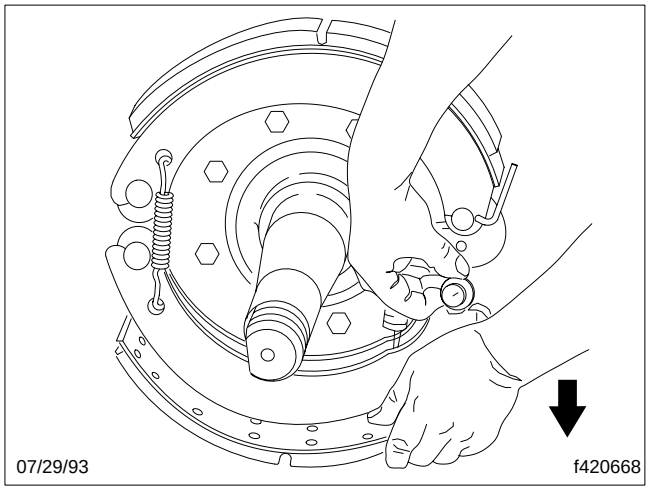


Fig. 1

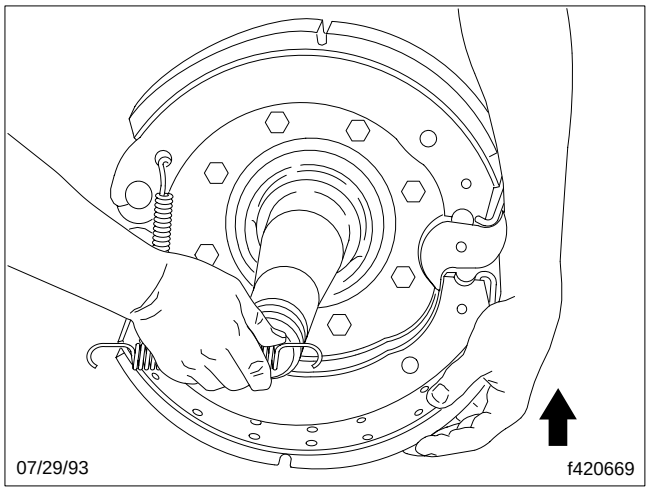


Fig. 2

   5.4 Rotate the bottom shoe to release tension on the two retaining springs. Remove the springs and the brake shoes. **See Fig. 3.**

6. If equipped with 15-inch "Q" Series brakes, remove the brake shoes.

   6.1 Push down on the bottom brake shoe, then remove the bottom cam roller.

   6.2 Lift the top brake shoe and remove the top cam roller.

Brake Shoe Removal and Installation

6.3 Remove the brake shoe return spring.

6.4 Rotate the bottom shoe to release tension on the retaining spring. Remove the spring and the brake shoes.

7. Inspect the brake shoes and linings for wear or damage. **Refer to Subject 120.**

Installation

IMPORTANT: For best brake performance, don't mix "Q" and "Q" Plus Series brakes. Use the same brake series on the entire vehicle.

1. Apply a thin film of a temperature resistant grease (Rockwell 0-616, or an equivalent) on the anchor pins where they touch the brake shoes. Also, apply a multipurpose chassis grease (Rockwell 0-617-A or 0-617-B, or an equivalent) on the retainer clips, spider, and shoe rollers where they touch the brake shoes.

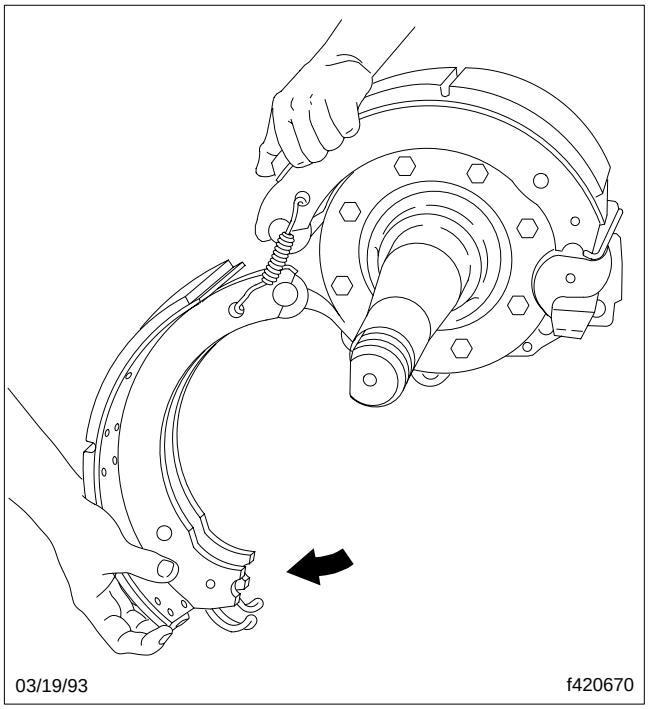


Fig. 3

IMPORTANT: Don't apply any grease on the outer diameter of the roller that touches the cam head.

2. Go to the step for installing the brake shoes on 15-inch "Q" Series brakes, if so equipped.

   If equipped with "Q" Plus Series brakes, or 16-1/2 inch "Q" Series brakes, install the brake shoes.

   2.1 Place the upper brake shoe in position on the top anchor pin. Hold the lower brake shoe on the bottom anchor pin and attach two new brake shoe retaining springs. **See Fig. 4.**

   2.2 Turn the lower brake shoe forward and attach a new brake shoe return spring. **See Fig. 5.**

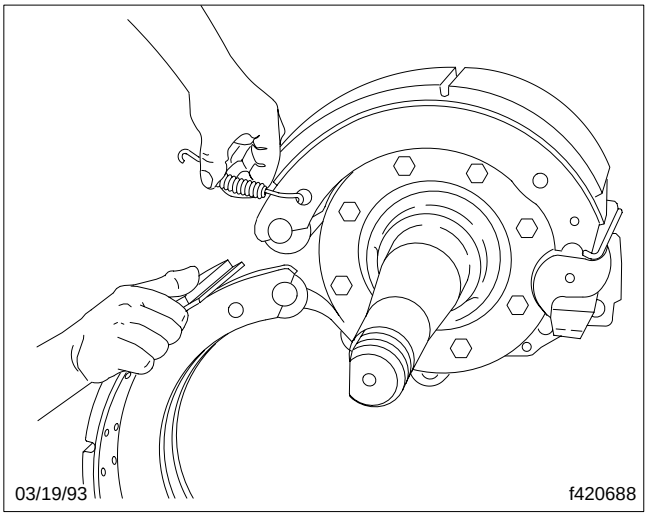


Fig. 4

   2.3 Pull each brake shoe away from the cam to allow enough space to install the cam rollers and retainers. Press the ears of the retainer together to permit the retainer to fit between the brake shoe webs. **See Fig. 6.**

   2.4 Push the retainer into the brake shoe until the ears lock in the holes in the shoe webs. **See Fig. 7.**

3. If equipped with 15-inch "Q" Series brakes, install the brake shoes.

   3.1 Install the retainer spring on the shoes and install the shoes on the anchor pins. **See Fig. 8.** Hold the bottom shoe in position and install the return spring.

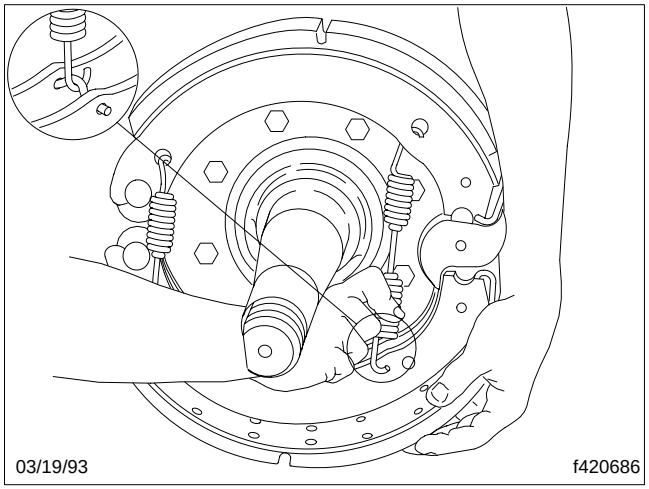


Fig. 5

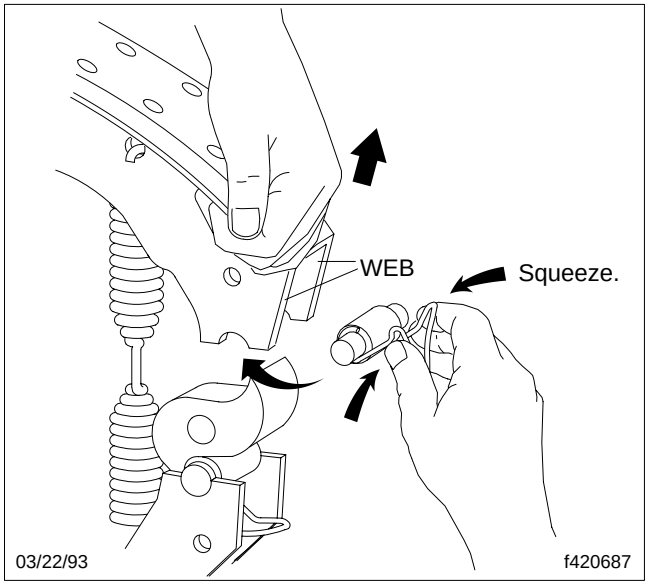


Fig. 6

3.2 Pull each shoe away from the cam to allow enough space, then install the cam rollers.

4. Install the wheels and brake drums. For instructions, refer to the **front axle group** or the **rear axle group** in this manual.

5. Adjust the brakes at the slack adjusters. For instructions, **refer to Subject 125.**

6. Remove the safety stands, lower the vehicle, and remove the chocks from the tires.

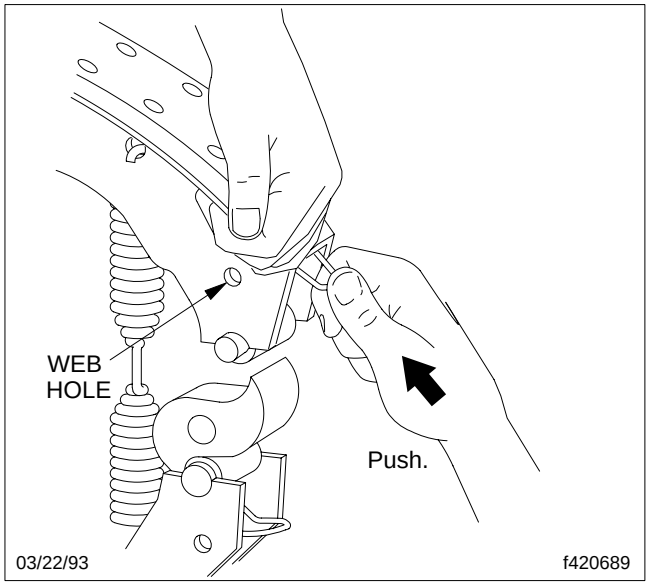


Fig. 7

⚠ WARNING

WARNING: Don't operate the vehicle until you have adjusted the brakes and checked for their proper operation. Failure to do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

7. Check for proper brake operation.

7.1 To ensure that the braking system is working correctly, make ten 60 to 30 km/h (40 to 20 mph) snubs to seat the linings.

7.2 Make ten stops from 30 km/h (20 mph) at 50 percent air pressure.

7.3 Make a full-pressure stop from 30 km/h (20 mph).

7.4 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than the others shows a lack of braking effort on those wheels.

Brake Shoe Removal and Installation

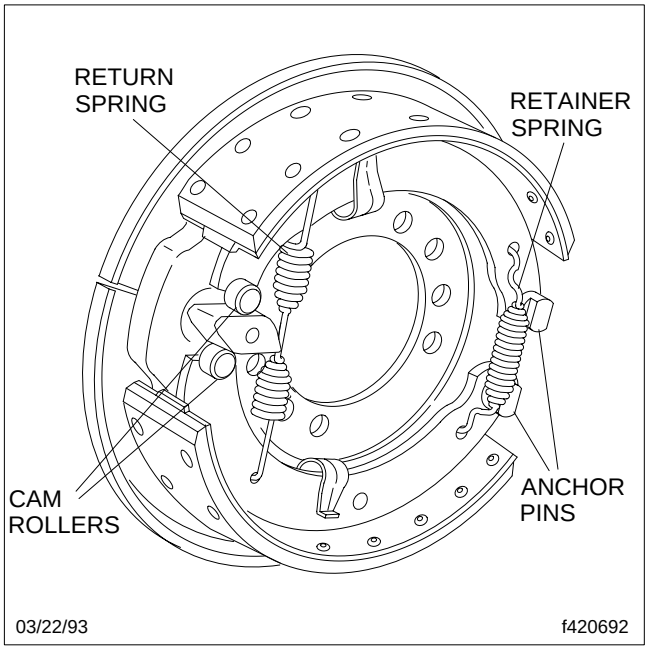


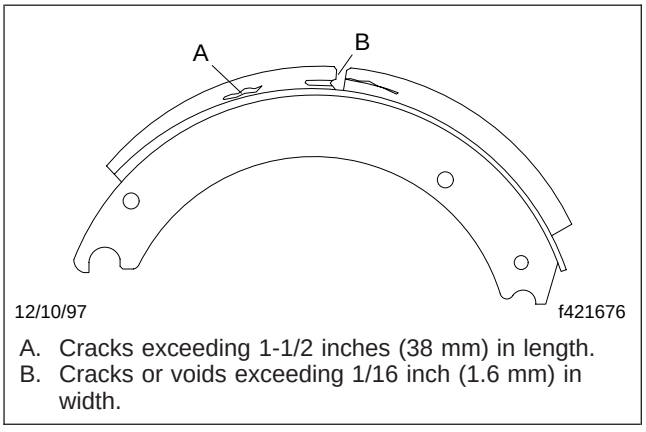
Fig. 8

⚠ WARNING

Before starting the procedure below, read the information in Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

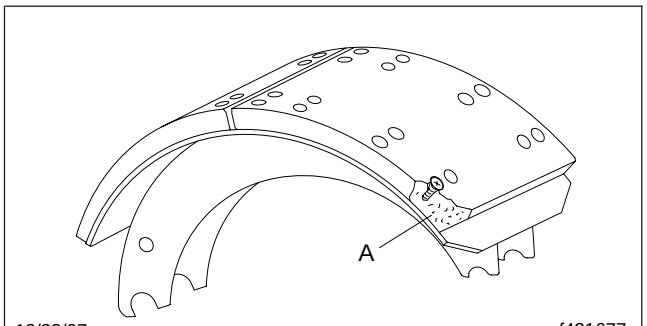
Inspection

1. Remove the brake shoes, using the instructions in **Subject 110**.
2. Check the linings.
   - 2.1 If the linings are grease-or oil-soaked, cracked, or worn to less than 1/4-inch (6.4-mm) thickness at any point, replace them.
   - 2.2 Replace the linings if the lining surface is closer than 1/32 inch (0.8 mm) to any rivet head.
   - 2.3 The lining is considered worn-out and the vehicle should not be driven if:
     - Cracks on the lining surface exceed 1/16 inch (1.6 mm);
     - The lining edge shows cracks or voids over 1/16 inch (1.6 mm) in width and 1-1/2 inches (38 mm) in length. See **Fig. 1**;
     - Portions of the lining are missing exposing a rivet when viewed from the edge. See **Fig. 2**;



A. Cracks exceeding 1-1/2 inches (38 mm) in length.
B. Cracks or voids exceeding 1/16 inch (1.6 mm) in width.

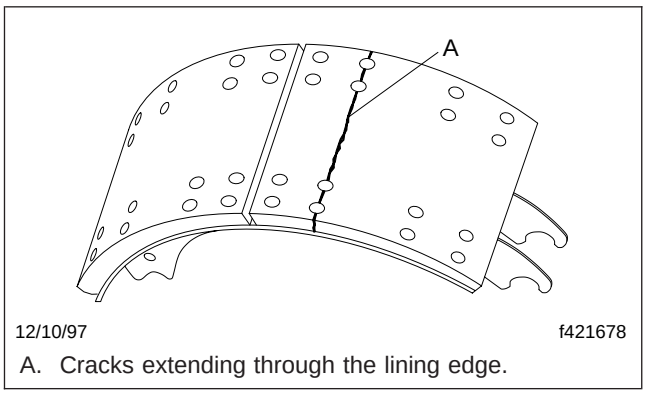
Fig. 1, Cracks and Voids



A. Exposed fastening device.

Fig. 2, Portions of the Brake Lining Missing

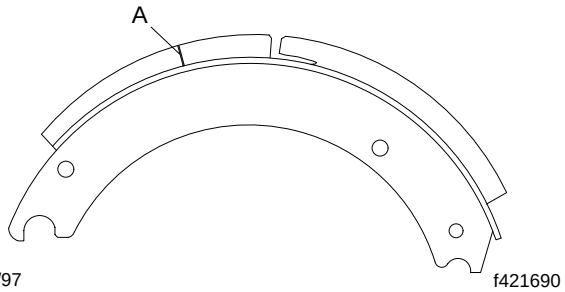
     - Cracks extend across the lining face and through the lining edge, or the lining is loose on the shoe. See **Fig. 3**.
   - 2.4 The vehicle is still operational but linings should be replaced as soon as possible if:
     - Horizontal or vertical cracks in the lining edge exhibit no loss of material and do not exceed 1/16 inch (1.6 mm) in width or 1-1/2 inch (38 mm) in length. See **Fig. 4**;
     - Corner portions of the lining are missing with no fastener exposed. See **Fig. 5**;
     - Surface cracks extend from hole to hole or if there is scoring and contamination from road debris. See **Fig. 6**.



A. Cracks extending through the lining edge.

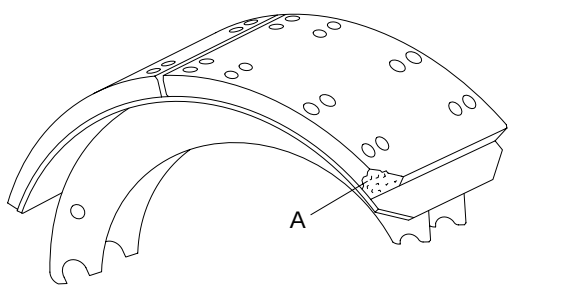
Fig. 3, Cracks in the Brake Lining

Brake Shoe and Lining Inspection



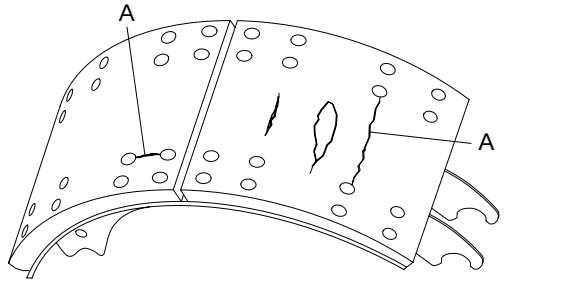
A. Cracks not exceeding 1-1/2 inches (38 mm) in length or 1/16 Inch (1.6 mm) in width.

Fig. 4, Cracks and Voids



A. Corner segment missing with no fastener exposed.

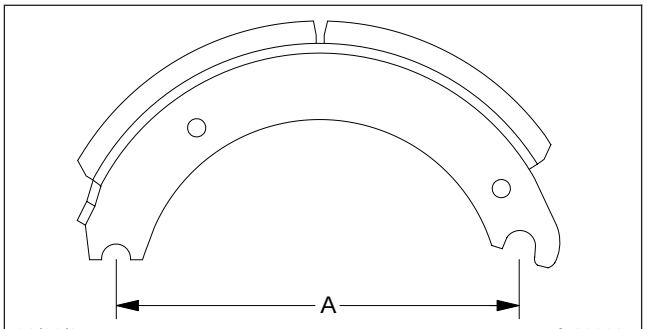
Fig. 5, Portions of the Brake Lining Missing



A. Cracks extending from hole to hole.

Fig. 6, Cracks in the Brake Lining

3. Check the shoes for bent or cracked webs or tables, broken welds, loose or out-of-round rivet or bolt holes. Replace the shoes if any of these conditions exist.
4. Check the anchor pin for looseness and camshaft roller recesses in the shoe webs for visible wear. Replace the shoe if needed.
5. Check the shoe span. Measure the distances between the centerlines of the anchor pin and the camshaft roller pin recesses in the shoe web. If the measurement is more than 12-7/8 inches (327 mm), replace the shoe. See **Fig. 7**.



A. 12-7/8 inches (327 mm)

Fig. 7, Measuring the Shoe Span

Adjustment

ROCKWELL AUTOMATIC SLACK ADJUSTER

1. Check the free-stroke.

   1.1 With the brakes fully released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. **See Fig. 1**, Ref. *A* .

   1.2 Use a pry bar to move the slack adjuster and apply the brakes. Again, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. **See Fig. 1**, Ref. *A* .

   1.3 The difference between the two measurements is the initial free-stroke, and sets the clearance between the linings and the drum.

   1.4 The free-stroke must be 16 to 19 mm (5/8 to 3/4 inch);

   If the free-stroke is correct, go to the step for checking brake chamber stroke.

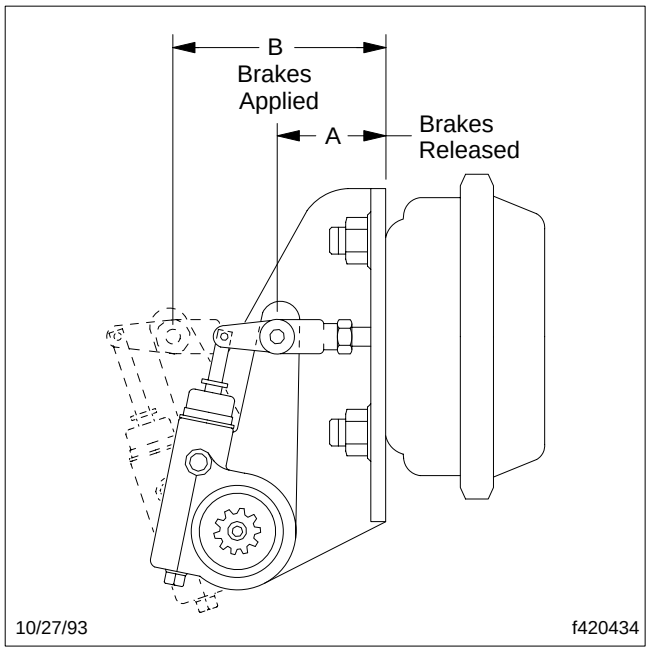


Fig. 1

   1.5 If the free-stroke is incorrect, remove the pressure relief capscrew (**Fig. 2**, Ref. 16), spring (Ref. 18), and pawl assembly (Ref. 19) from the slack adjuster housing. If equipped with a pull-pawl assembly **(Fig. 3),** carefully insert a screwdriver and raise the relief cap about 3.2 mm (1/8 inch).

⚠ CAUTION

CAUTION: Before turning the adjusting nut, remove the pressure relief capscrew, spring, and pawl assembly. If equipped with a pull-pawl assembly, raise the relief cap about 3.2 mm (1/8 inch). Failure to do so could strip the teeth on the pawl.

   1.6 Turn the adjusting nut 1/8 turn, **as shown in Fig. 4 .** Measure the stroke again, and adjust until it is correct.

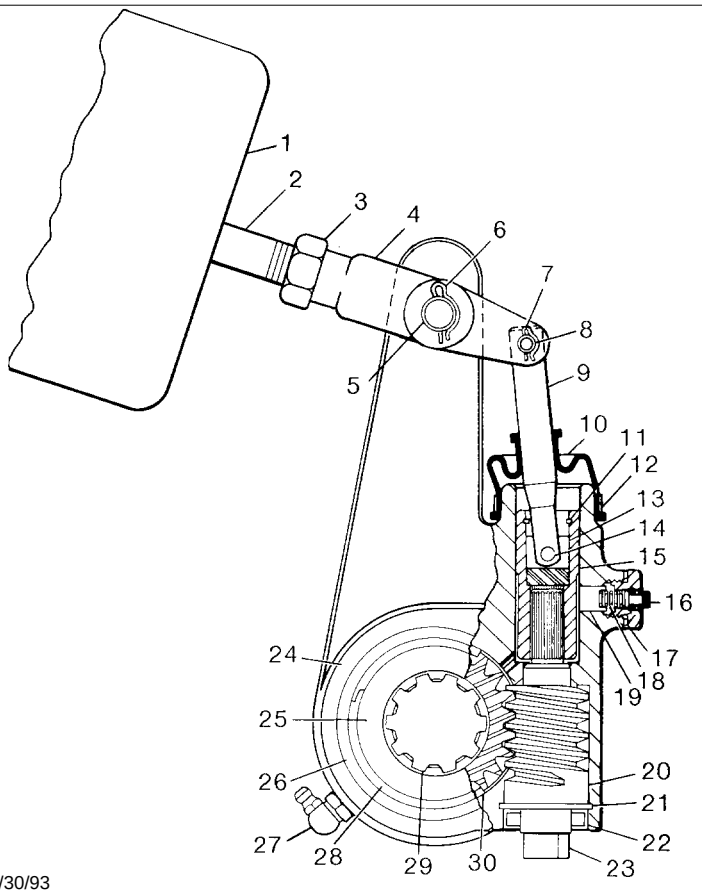
2. Check for correct brake chamber stroke.

   2.1 With the brakes fully released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. **See Fig. 1** , Ref. *A* .

   2.2 Build air pressure to 689 kPa (100 psi). Shut down the engine. Fully apply the brakes, then measure the distance from the bottom of the brake chamber to the center of the large clevis pin. **See Fig. 1** , Ref. *B* . The difference between the measurements is the brake chamber stroke.

   2.3 The brake chamber stroke must be less than the measurements shown in **Table 1.** If the brake chamber stroke is incorrect, remove the pressure relief capscrew **(Fig. 2** , Ref. 16), spring (Ref. 18), and pawl assembly (Ref. 19) from the slack adjuster housing. If equipped with a pull-pawl assembly **(Fig. 3),** carefully insert a screwdriver and raise the relief cap about 3.2 mm (1/8 inch).

Brake Adjustment



1. Brake Air Chamber
2. Brake Chamber Push Rod
3. Clevis Jam Nut
4. Clevis
5. Clevis Pin (large)
6. Cotter Pin (large)
7. Cotter Pin (small)
8. Clevis (small)
9. Actuator Rod
10. Boot
11. Piston Retaining Ring
12. Boot Retaining Clamp
13. Actuator Piston
14. Roller (Pin)
15. Actuator (Adjusting Screw)
16. Pressure Relief Capscrew (shown 90 degrees out of position)
17. Gasket
18. Pawl Spring
19. Pawl Assembly
20. Worm
21. Worm Retaining Snap Ring
22. Worm Seal
23. Manual (Worm) Adjusting Nut End
24. Slack Adjuster
25. Gear
26. Gear Thrustwasher
27. Grease Fitting
28. Gear Retaining Ring
29. Camshaft Splines
30. Gear−to−Body Seal

Fig. 2, Rockwell Automatic Slack Adjuster

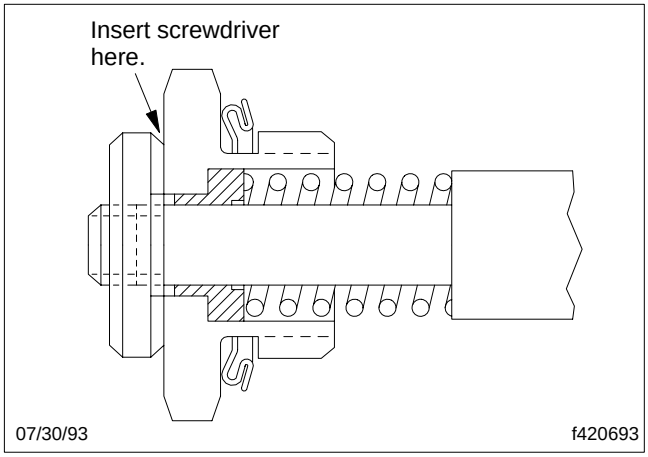


Fig. 3, Pull-Pawl Assembly (sectional view)

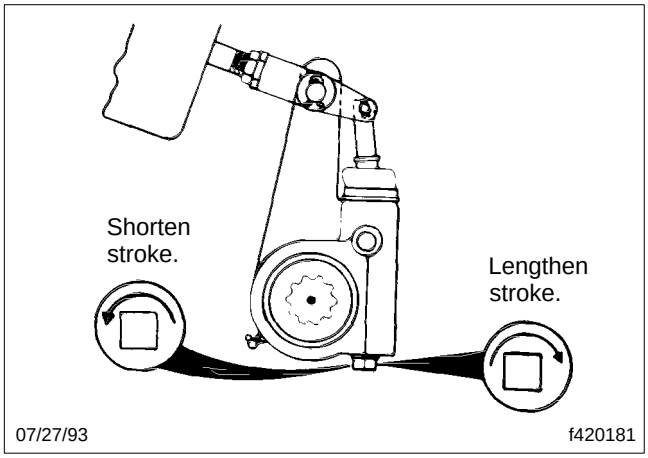


Fig. 4

Chamber Size	Stroke mm (inch)

9, 12	Less than 35 (1-3/8)
16, 20, 24	Less than 44 (1-3/4)
24 *, 30	Less than 51 (2)
36	Less than 57 (2-1/4)

* Long Stroke

Table 1, Maximum Adjusted Brake Chamber Stroke

CAUTION

CAUTION: Before turning the adjusting nut, remove the pressure relief capscrew, spring, and pawl assembly. If equipped with a pull-pawl assembly, raise the relief cap about 3.2 mm (1/8 inch). Failure to do so could strip the teeth on the pawl.

2.4 Turn the adjusting nut 1/8 turn, **as shown in Fig. 4 .** Measure the stroke again, and adjust until correct.

CAUTION

CAUTION: Don't make the adjusted chamber stroke too short. The free-stroke must not be less than 16 to 19 mm (5/8 to 3/4 inch). If the chamber stroke is too short, the linings can drag and damage the brake.

If the stroke varies or remains greater than the specified range, check the brake components. For instructions, refer to Subject 140.

2.5 If necessary, replace the slack adjuster. For instructions, refer to the applicable slack adjuster section in this group.

2.6 If removed, install the pawl assembly, spring, and the pressure relief capscrew. Tighten the capscrew 20 to 27 N·m (15 to 20 lbf·ft). Or, remove the screwdriver from the pull-pawl assembly (if equipped).

HALDEX AUTOMATIC SLACK ADJUSTER

1. Turn the adjusting hexnut clockwise until the brake lining meets the brake drum, then back off counterclockwise 3/4 turn. **Refer to Fig. 5 .** There will be a ratcheting sound.
2. Measure the distance from the bottom of the air chamber to the far side of the clevis-pin hole (**Fig. 6** , Ref. *A*). Record the exact distance as measurement A. Apply and hold a 551 kPa (80 psi) brake application. Measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole (**Fig. 6** , Ref. *B*). Record the exact distance as measurement B. Subtract measurement A from measurement B to determine the applied stroke. Compare this value to the value in **Table 2 .**

   If the stroke varies or remains greater than the specified range, check the brake components. For instructions, **refer to Subject 140.** If necessary, replace the slack adjuster. For instructions, refer to the applicable slack adjuster section in this manual.

Chamber Size	Stroke mm (inch)
16	19 to 44 (3/4 to 1-3/4)
20	25 to 44 (1 to 1-/34)
24	25 to 48 (1 to 1-7/8)
30	38 to 51 (1-1/2 to 2)

Table 2, Maximum Adjusted Brake Chamber Strokes With Haldex Automatic Slack Adjusters

Brake Adjustment

BENDIX MANUAL SLACK

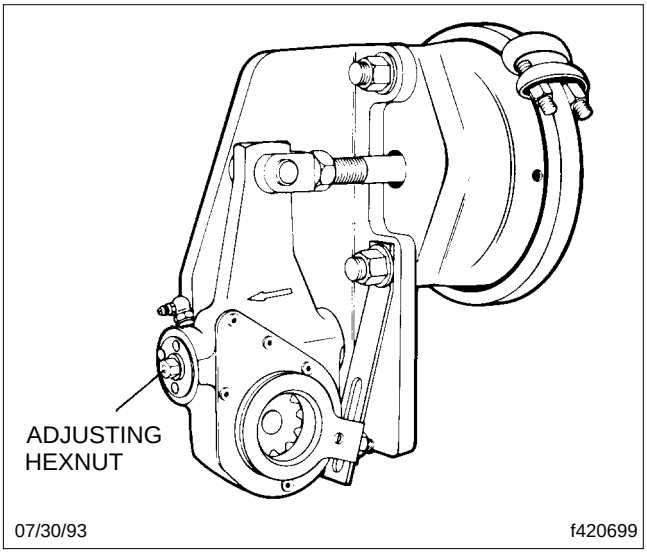


Fig. 5

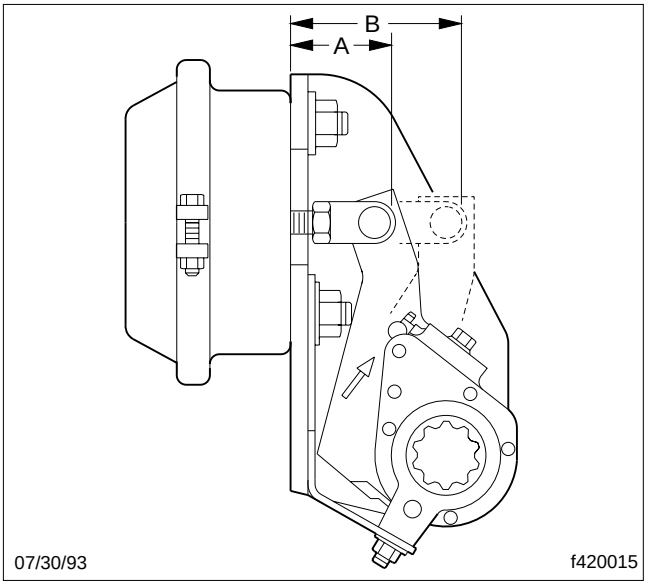


Fig. 6, Brake Stroke Check, Haldex (SAB) Automatic Slack Adjuster

ADJUSTER

1. With the parking brakes released, rotate the adjusting screw until the brakes begin to drag when the drum is turned; then, back off the adjustment until the wheel turns freely. Turn the adjusting screw nut until the locking sleeve engages it.
2. Measure the distance from the bottom of the brake chamber to the centerline of the clevis (**Fig. 7** , Ref. *A*). Record the exact distance as measurement A. Apply and hold a 551 kPa (80 psi) brake application. Measure the distance from the bottom of the brake chamber to the centerline of the clevis-pin (**Fig. 7** , Ref. *B*). Record the exact distance as measurement B. Subtract measurement A from measurement B to determine the applied stroke. Compare this value to the value in **Table 3 .**
3. If the applied stroke equals or exceeds the maximum applied stroke, adjust the brakes.

   3.1 Wipe clean the adjusting screw hexhead. **Refer to Fig. 7.** Position a wrench or socket over the adjusting screw hexhead.

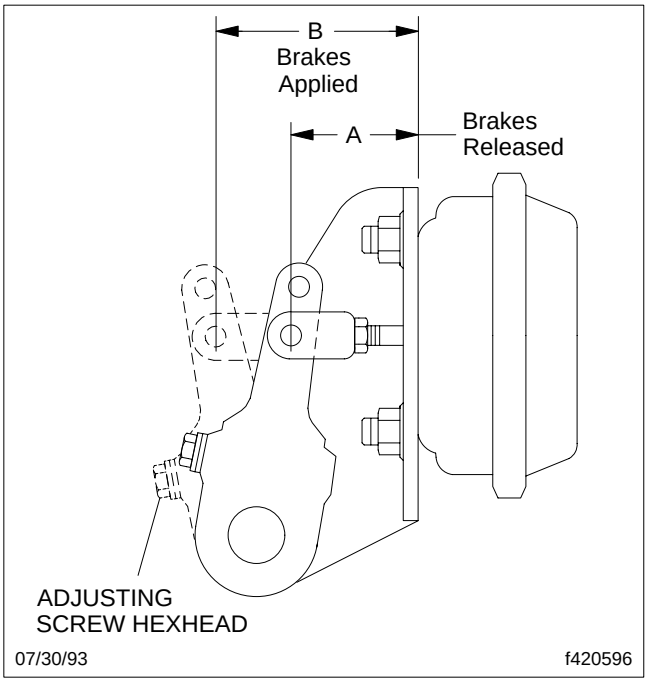


Fig. 7

Chamber Size	Stroke mm (inch)
9, 12	Less than 38 (1-1/2)
16, 20	Less than 44 (1-3/4)
24	Less than 48 (1-7/8)
24 *, 30	Less than 51 (2)

36	Less than 57 (2-1/4)

* Long Stroke

Table 3, Maximum Adjusted Brake Chamber Strokes With Bendix Manual Slack Adjusters

IMPORTANT: On slack adjusters equipped with an adjusting screw locking sleeve, wipe clean the locking sleeve area, and depress the locking sleeve when positioning the wrench or socket over the adjusting screw. Do not try to turn the adjusting screw without fully depressing the locking sleeve.

3.2 Turn the adjusting screw until it is tight; then, back off the adjustment until the drum is free. Normally, the adjusting screw will need to be backed off 2 or 3 clicks.

3.3 To see if the drum is free, strike the brake drum with a steel tool and listen for a clear ringing sound. If a dull thud is heard, the brake is dragging.

IMPORTANT: Checking the brake adjustment when the wheel is off the ground may be unreliable. Looseness or wear anywhere in the wheel bearings will cause the drum to be misaligned while the wheel is off the ground. Check the brake adjustment with the wheel on the ground.

On slack adjusters equipped with an adjusting screw locking sleeve, make sure that the locking sleeve is engaged around the adjusting screw hexhead after adjustment, thus locking the adjusting screw in place.

⚠ WARNING

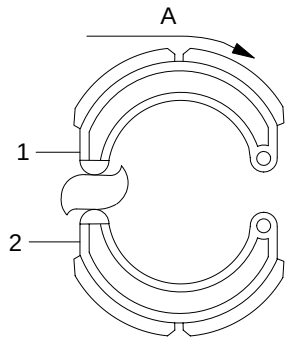
WARNING: Before starting the procedure below, read the information in "Safety Precautions, 100." Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

Replacement

IMPORTANT: For the best brake performance, don't mix brake linings between axles. When relining brake shoes, both wheel ends of each axle must have the same linings. On tandem axles, all four wheel ends must also have the same linings. However, it is not necessary for the steering axle brakes to have the same linings as the rear drive axle brakes. Also, when the minimum thickness is reached for any of the brake linings on an axle, reline both brakes on that axle at the same time.

Combination linings with different friction ratings for the primary and secondary shoes are often used. When combination linings are used, install the forward blocks on the primary shoe (following the rotation of the drum, the first shoe after passing the cam or wheel cylinder is the primary shoe).

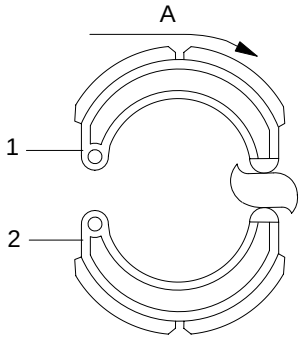
If the cam is behind the axle, the top shoe is the primary and the lower shoe is the secondary shoe. **See Fig. 1.** If the cam is in front of the axle, the lower shoe is the primary shoe. **See Fig. 2.**



09/27/94 f420162a

A. Right wheel rotation
1. Primary Shoe
2. Secondary Shoe

Fig. 1, Camshaft Behind Axle



09/27/94 f420683a

A. Right wheel rotation
1. Secondary Shoe
2. Primary Shoe

Fig. 2, Camshaft Ahead of Axle

Replacement Using Rivets

With the brake shoe removed, do the following:

1. Using a suitable riveting mandrel, push out the old rivets.

⚠ CAUTION

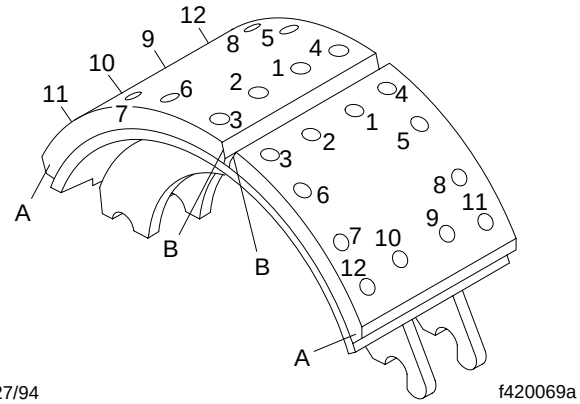
CAUTION: Drilling out rivets or cutting off rivet heads with a chisel can cause the rivet hole to become out-of-round. This could damage the brake shoe.

2. Clean the shoe table. For instructions, refer to **Subject 140**.
3. Align the brake shoe and lining rivet holes. Using a C-clamp, clamp the lining to the brake shoe.
4. Insert the correct sized rivets into all holes and threads, and temporarily hold them in place with masking tape.

IMPORTANT: Use rivets that have the correct material, shank diameter, length, head size, and shape. Use tubular rivets that are 1/4-inch diameter by 9/16-inch long, SAE no. 10, made of plated steel or brass.

5. Begin riveting at the center of each edge of the shoe and lining, and work toward each end. **See Fig. 3.**
6. Check for a close fit between the lining and shoe table.

Brake Shoe Lining Replacement



A. Toe
B. Heel

Fig. 3, Rivet or Bolt Attachment Sequence

Try to insert a 0.25-mm (0.010-inch) feeler gauge between the lining and shoe table along the edges. **See Fig. 4**, Ref. A. It should not be possible to insert the feeler gauge anywhere along the edge, except at each end beyond the last row of rivets. **See Fig. 5**, Ref. A. A larger clearance, up to 0.64 mm (0.025 inch), may exist in these areas.

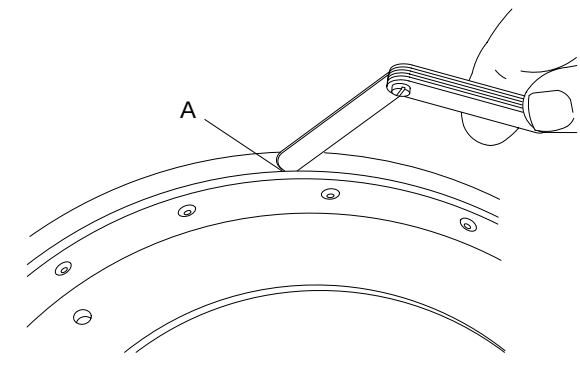


Fig. 4

7. Circle grind the brake lining to obtain the correct lining-to-drum contact. With the cam in the full-release position, the new brake linings must be ground 1.8 mm (0.070 inch) less than the drum diameter. The cam must be adjusted and the lining ground until there is an 80 percent lining-to-drum contact, which must be continuous and in the center of the lining.

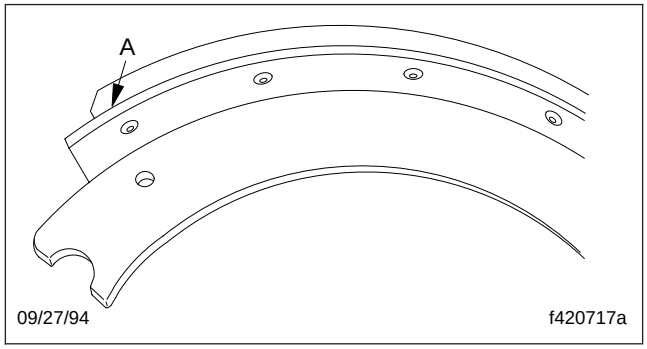


Fig. 5

Replacement Using Bolts

1. Clean the shoe table. For instructions, refer to **Subject 140**.
2. Align the brake shoe and lining bolt holes. Using a C-clamp, clamp the lining to the brake shoe.
3. Insert the correct sized bolts, and new lockwashers, into all holes and threads. Loosely install the nuts.
4. Tighten the nuts as follows in the sequence **shown in Fig. 3**: on 3/8-inch brass bolts 24 to 31 N·m (18 to 23 lbf·ft); on 1/4-inch brass bolts 900 to 1120 N·cm (80 to 100 lbf·in).
5. Circle grind the brake lining to obtain the correct lining-to-drum contact. With the cam in the full-release position, the new brake linings must be ground 1.8 mm (0.070 inch) less than the drum diameter. The cam must be adjusted and the lining ground until there is an 80 percent lining-to-drum contact, which must be continuous and in the center of the lining.

Brake Components Disassembly and Inspection, Cleaning, and Assembly

Disassembly and Inspection

(See Fig. 1)

⚠ WARNING

WARNING: Before starting the procedure below, read the information in Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

1. Check the drum for cracks, heat-checks, glazing, grooving, and run-out. **See Fig. 2.** Measure the drum diameter. Replace the drum if it exceeds the maximum diameter stamped on it. Replace cracked drums. Some drums that are glazed, grooved, or out-of-round can be repaired. For detailed instructions, refer to **Group 33** or **Group 35** in this manual.
2. Disconnect the slack adjuster from the push rod clevis. For manual slack adjusters, remove the cotter pin and clevis pin from the brake chamber push rod clevis. For automatic slack adjusters, refer elsewhere in this group, or to the slack adjuster manufacturer's service information for instructions.
3. With the brake shoes removed, use a dial indicator to measure the up-and-down and side-to-side end play of the camshaft. Replace the bushings if there is more than 0.8 mm (0.030 inch) of movement.
4. Remove the slack adjuster.
   - 4.1 For automatic slack adjusters, refer elsewhere in this group, or to the manufacturer's service information for instructions.
   - 4.2 For manual slack adjusters, while depressing the locking sleeve, turn the adjuster nut until the slack adjuster is clear of the brake chamber push rod clevis. Remove the lockring and the outer spacing washers from the camshaft. Using a suitable puller, remove the slack adjuster.

⚠ CAUTION

CAUTION: Don't hammer on the slack adjuster to remove it. Damage to the adjuster or camshaft spline may result.

5. Check the slack adjuster for damage and for binding.
   - 5.1 Check the slack adjuster clevis for cracks or bushing wear. Check the splines for chipped teeth and deformation. Replace as needed.
   - 5.2 Depress the locking sleeve, and turn the adjuster nut with a wrench at least one turn in each direction. If there is binding, or if excessive force is needed to turn the slack adjuster, replace it. For instructions, refer elsewhere in this group

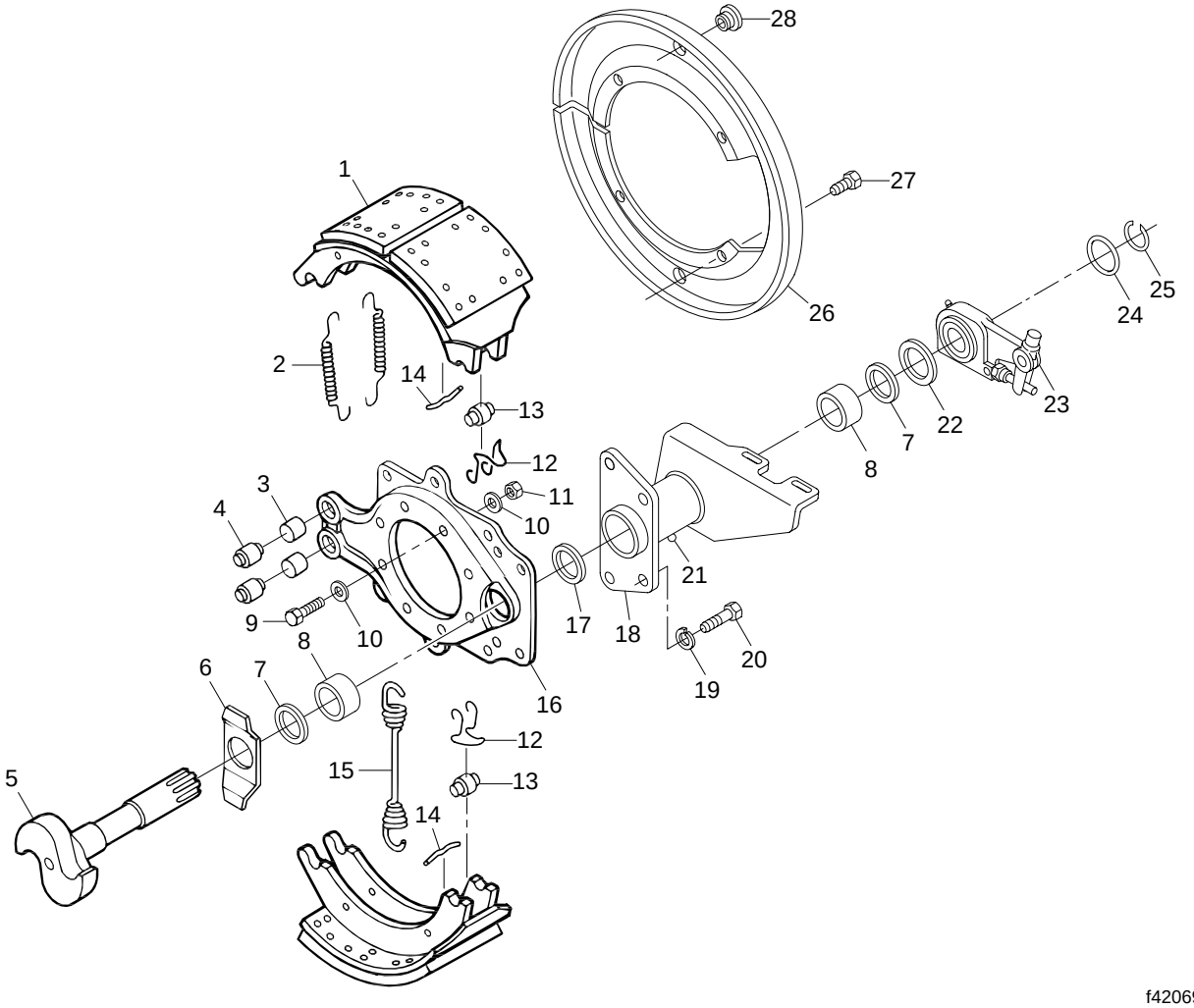
IMPORTANT: If any slack adjuster problem is found, repair or replace the unit, depending on the manufacturer's recommendations.

6. Remove the camshaft by grasping its head and pulling the camshaft outboard.
7. Check the camshaft spline end for cracks, or worn or deformed splines. Replace the camshaft if damaged.
8. Check the camshaft bushing journals for wear or corrosion. Replace the camshaft if it is worn or if roughness is felt in the journal area.
9. Inspect the camshaft head for brinelling, cracking, or flat spots. Replace the camshaft if a ridge can be felt between the worn area and the cam head surface.
10. Remove the brake chamber stud nuts and lockwashers that attach the brake chamber to the camshaft support bracket.

    Check the chamber for a cracked housing, bent push rod, loose clamp ring, loose air fitting, air leaks, or clogged vent holes. Repair or replace brake chamber parts as needed.
11. Remove and inspect the camshaft support bracket. Remove and discard its gasket.

    Check the bracket for a bent, broken or cracked arm, and cracked welds. Replace the bracket if any of these conditions exist.
12. Remove and inspect the old bushing and the grease seal.
    - 12.1 Check the camshaft bushing for wear. The inner surface must be smooth; if rough or abrasive, replace the bushing.

Brake Components Disassembly and Inspection, Cleaning, and Assembly



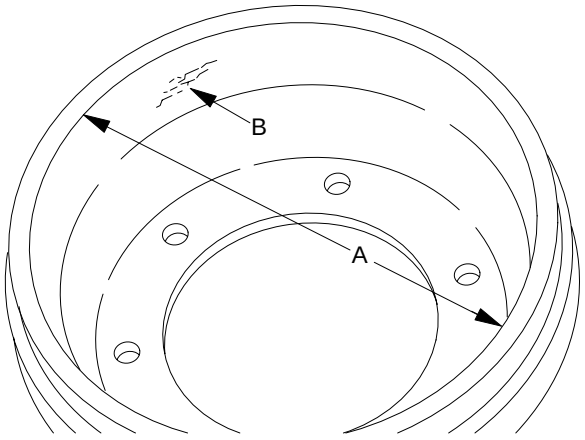
NOTE: 16–1/2 inch "Q" series and all "Q" Plus series shown.

1. Brake Shoe and Lining Assembly
2. Brake Shoe Retaining Spring
3. Anchor Pin Bushing
4. Brake Shoe Anchor Pin
5. S-Head Camshaft
6. Camhead Washer
7. Camshaft Grease Seal
8. Camshaft, Spider, and Bracket Bushing
9. Spider Mounting Bolt
10. Hardened Washer
11. Nut
12. Brake Shoe Roller Retainer
13. Brake Shoe Roller
14. Brake Shoe Return Spring Pin
15. Brake Shoe Return Spring
16. Brake Spider
17. Camshaft Support Bracket Gasket
18. Camshaft Support Bracket
19. Bracket Capscrew Washers
20. Camshaft Support Bracket Capscrew
21. Grease Fitting
22. Camshaft Washer
23. Automatic Slack Adjuster Assembly
24. Spacing Washer
25. Camshaft Lockring
26. Dust Shield
27. Dust Shield Capscrew
28. Plug

Fig. 1, Cam-Master Q Series Brakes

12.2 Inspect the seal. Replace it if the lip is nicked, cut, or distorted.

13. Install the new bushing or seal with a suitable piloted driver.

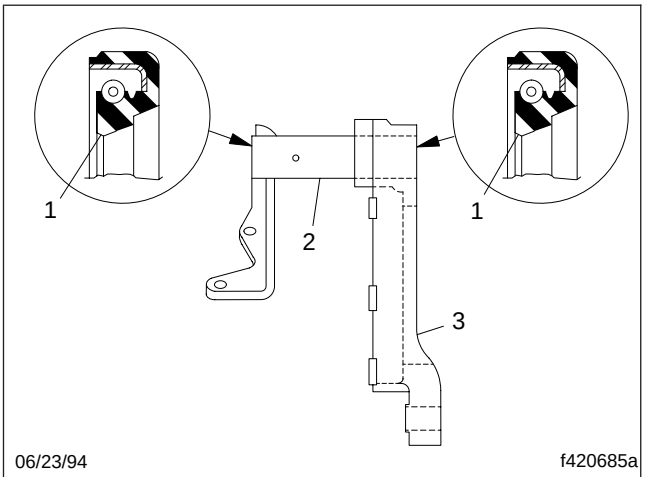


A. Check for diameter and for out-of-round.
B. Check for cracks, heat checks, glazing, and grooves.

Fig. 2

IMPORTANT: Grease seals are installed in both the bracket and the brake spider so that the seal lip is facing toward the slack adjuster end of the bracket tube. **See Fig. 3.**

14. Remove the spider-to-axle attaching nuts, hardened washers, and bolts. Remove the spider from the axle flange.
15. If equipped, remove the four capscrews that attach the dust shield to the spider; remove the dust shield.
16. Inspect the spider and parts for damage; replace as needed.
    - 16.1 Check for cracks at the bolt holes, cam area, and around the anchor pin. Replace if damaged.
    - 16.2 Check the anchor pin. If worn or loose, replace it.
    - 16.3 Check the anchor pin and brake spider bushings for wear. The inner surfaces must be smooth. If any surface is rough or abrasive, replace the part.
    - 16.4 Inspect the seal. Replace it if its lip is nicked, cut, or distorted.
17. Using a suitable piloted driver, install the new bushings and seal.



NOTE: The seal lip is facing toward the slack adjuster.
1. Seal Lip
2. Camshaft Support Bracket
3. Brake Spider

Fig. 3, Positioning of Seals on the Camshaft

IMPORTANT: Grease seals are installed in both the bracket and the brake spider so that the seal lip is toward the slack adjuster end of the bracket tube. **See Fig. 3.**

Cleaning

WARNING

WARNING: Before starting the procedure below, read the information in Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

After removing the brake parts being serviced, do the following:

1. Wire brush all parts exposed to mud, road dirt, and salt, including the exterior of the drum, spider, brake chamber bracket, and dust shields (if equipped). If relining the shoes, thoroughly wire-brush the shoe tables, and paint them with a rust inhibitive coating.

CAUTION

CAUTION: A thick layer of oxidation and dirt on the outside of a brake drum acts as an insulator

Brake Components Disassembly and Inspection, Cleaning, and Assembly

and may hinder normal heat dissipation. Make sure oxidation and dirt are removed by wire brushing, or damage to brake components could occur.

2. Using an industrial vacuum cleaner with a HEPA filter system, pick up excessive dust accumulation. Wipe the interior of the drums with a greaseless solvent to remove lining dust.
3. Thoroughly clean all remaining brake parts with a suitable shop solvent. Wipe dry with a clean, lint-free cloth, or use low-pressure, filtered and compressed air.

Assembly (See Fig. 1)

WARNING

WARNING: Before starting the procedure below, read the information in Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

1. Install the dust shield, if equipped.

   Position the dust shield against the spider, and install the capscrews. Tighten the capscrews to the torque provided in **Specifications 400.**

2. Install the spider.

   Place the spider on the axle flange. Using a hardened washer under the bolt head and the nut, install the mounting fasteners. Tighten the bolts in a cross pattern to the torque provided in **Specifications 400.**

3. Install the brake chamber and bracket.

   3.1 Place the brake chamber on the mounting bracket with the chamber mounting studs through the bracket holes. Install the hardened flatwashers and locknuts. Tighten the nuts to the torque provided in **Specifications 400.**

   NOTE: If replacing a brake chamber, make sure that the new chamber is the same size and make as the brake chamber on the other side of the axle.

   3.2 Place the bracket against the spider, and install the lockwashers and capscrews. Tighten the capscrews to the torque provided in **Specifications 400.**

4. Install the camshaft and parts in the spider; install the slack adjuster.

   4.1 Apply a thin film of chassis grease on the inside of the camshaft bushings and journals. Don't grease the camshaft head area.

   4.2 Apply a thin film of rust preventive grease (Rockwell 0-637, or an equivalent) on the camshaft splines.

   4.3 Carefully slip the camshaft into the spider and the mounting bracket tube.

   4.4 Install the thick camshaft washer on the camshaft.

   4.5 Install the slack adjuster on the camshaft, with the adjuster nut on the side opposite of the brake chamber.

   4.6 Install the outer washers and snap ring.

5. Use a dial indicator to measure the end-play of the camshaft. There should be no more than 1.5 mm (0.060 inch) movement.
6. Pressure lube the camshaft bracket bushings.

   Pump multipurpose chassis grease (NLGI grade 1 or 2) into the chamber bracket until it appears at the slack adjuster end of the bracket. Use care that no grease enters the drum cavity. If grease leaks out under the camhead, the camshaft grease seal is worn or damaged, or is installed backwards.

NOTE: The use of meter-type fittings, having a maximum 276 kPa (40 psi) pressure relief at shutoff, is recommended.

7. For manual slack adjusters, while depressing the locking sleeve, turn the adjusting nut counterclockwise until the appropriate hole in the adjuster is aligned with the hole in the brake chamber push-rod clevis. For automatic slack adjusters, refer elsewhere in this group or to the manufacturer's service information.
8. Install the brake shoes. For instructions, refer to **Subject 110**.

Specifications

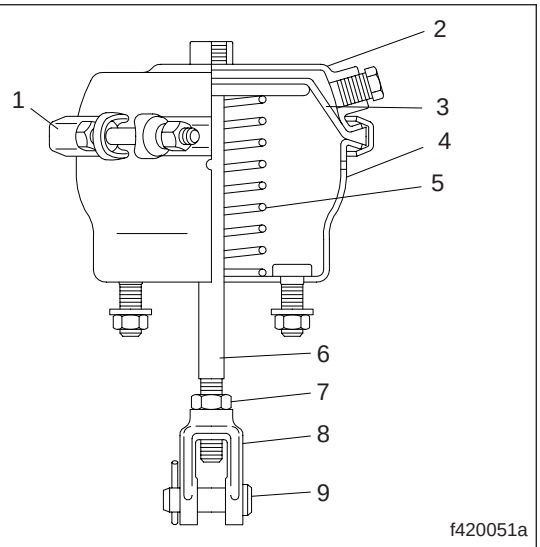
Description	Grade	Size	Torque	
			N·cm (lbf·in)	N·m (lbf·ft)
Brake Shoe Lining Nuts	—	3/8	—	24–31 (18–23)
		1/4	900–1120 (80–100)	—
Dust Shield Capscrews	5	3/8–16	—	34–47 (25–35)
	8			47–68 (35–50)
Spider Mounting Bolts: Customary Thread Capscrew	8	1/2–13	—	81–108 (60–80)
Hexhead Capscrew		5/8–11		176–217 (130–160)
Flanged Hexhead Capscrew		5/8–11		217–271 (160–200)
Midland Brake Chamber Mounting-Stud Locknuts (chamber size in^2)	8		—	
12		7/16–14 stud		52–58 (38–43)
16		7/16–14 stud		52–58 (38–43)
16		1/2–13 stud		81–88 (60–65)
16		1/2–20 stud		88–95 (65–70)
20		5/8–11 stud		162–176 (120–130)
24		5 /8–11 stud		162–176 (120–130)
MGM Brake Chamber Mounting-Stud Locknuts (chamber size in^2)	8		—	
16		7/16–14 stud		47–54 (35–40)
20		5 /8–11 stud		136–156 (100–115)
24		5 /8–11 stud		136–156 (100–115)
Brake Chamber Bracket-to-Spider Capscrews	8	1/2–13	—	81–108 (60–80)
		5/8–11		142–196 (105–145)

Table 1, Torque Values

General Description

Brake chambers convert the energy of compressed air into the mechanical force and motion needed to apply the brakes. Two chambers operate the brakes, one on each side of the axle.

Each brake chamber consists of two dished metal sections: the cover assembly and the body assembly, which are separated by a nylon-neoprene diaphragm. A metal two-segment clamp ring holds the assemblies together. **See Fig. 1.**



1. Clamp Ring
2. Cover Assembly
3. Diaphragm
4. Body Assembly
5. Piston Rod Spring
6. Piston Rod Assembly
7. Piston Rod Nut
8. Clevis
9. Clevis Pin

Fig. 1, Sectional View

In front of the diaphragm are the body, piston rod assembly, and a piston rod spring. The threaded piston rod assembly extends through the bottom of the body and connects to the clevis. **See Fig. 1.**

Different sized brake chambers are identified by numbers, which specify the effective area of the diaphragm. For example, a type 16 brake chamber has 16 square inches of effective area.

Principles of Operation

The greater the air pressure admitted to the brake chamber, the greater the force applied by the piston rod. Piston rod force is determined by multiplying the delivered air pressure by the effective diaphragm area. For example, if 415 kPa (60 psi) is admitted to a type 16 brake chamber, the force on the end of the piston rod is about 436 kg (960 lb).

When the brake pedal is depressed, air pressure from the brake valve passes through the port in the brake chamber cover to move the diaphragm and piston rod assembly forward. This compresses the spring, and applies a straight-line force to the slack adjuster, which converts it to a rotational force. This in turn rotates the camshaft and applies the brakes.

When the brake pedal is released, compressed air behind the diaphragm exhausts through the quick release valve. The spring then allows the piston rod assembly and diaphragm to return to their previous positions.

NOTE: For both of these tests, the air system must be pressurized to at least 550 kPa (80 psi).

Operating Test

1. Chock the tires.
2. Apply the brakes. Check that each piston rod moves out promptly, without binding.
3. Release the brakes. Check that each piston rod returns to the released position promptly, without binding.
4. Check the brake chamber stroke. It should be as short as possible without causing the brakes to drag. If needed, adjust the travel of the piston rod at the slack adjuster. Refer to the vehicle maintenance manual for instructions.

Leakage Test

1. Apply the brakes and hold them on full line pressure of at least 550 kPa (80 psi).
2. Using a soap solution, coat the clamp ring. Leakage is excessive if it produces a 25-mm (1-inch) bubble within five seconds.

⚠ CAUTION

CAUTION: Don't overtighten the clamp ring. This can distort the flange sealing surface, or the clamp ring itself.

3. If the leakage is excessive, tighten the clamp ring flange nuts evenly until the leakage is reduced. For acceptable torque ranges, refer to **Specifications, 400**.
4. Using a soap solution, coat the area around the piston-rod hole. No leakage is permitted. If there is leakage, replace the diaphragm. For instructions, refer to **Subject 110**.

Diaphragm Replacement

NOTE: This procedure is for service of a leaking brake chamber *diaphragm only*. If there are any other problems, refer to the applicable subjects elsewhere in this section.

Replacement

1. Chock the tires.

⚠ WARNING

WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

Follow the manufacturer's recommendations when working on any air device so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or compressed-air propulsion.

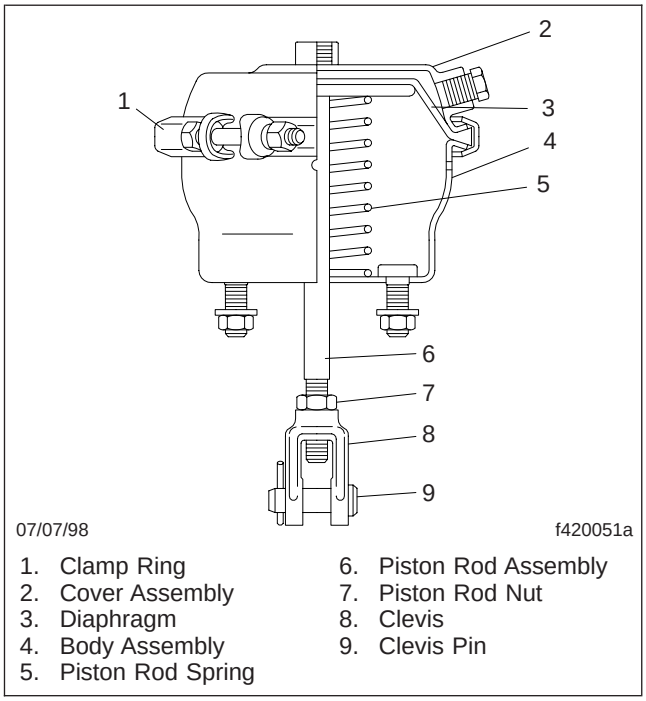
2. Drain the air reservoirs and lines.
3. Back off the slack adjuster; for instructions, refer to the applicable slack adjuster section in this manual. Pull out the piston rod. **See Fig. 1.** Clamp the rod at the chamber body to protect it from damage.
4. Before disassembly, mark a reference line along the chamber to allow the parts to be reassembled later in their old positions. **See Fig. 2.**
5. Replace the diaphragm.
   - 5.1 Remove one clamp ring bolt and flange nut completely and loosen the other bolt and flange nut enough to remove the clamp ring.
   - 5.2 Remove the cover assembly, and replace the diaphragm.

⚠ CAUTION

CAUTION: Don't overtighten the clamp ring. This can distort the flange sealing surface, or the clamp ring itself.

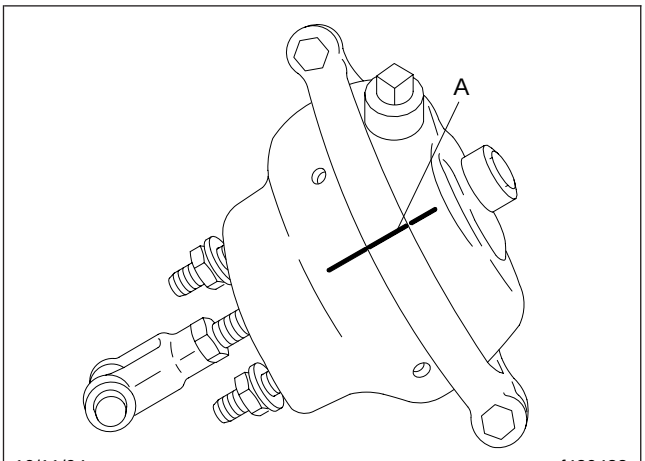
   - 5.3 Position the cover assembly and clamp ring (aligning the reference marks), and install the clamp ring bolt and flange nut. Tighten the flange nuts evenly to eliminate leakage. For acceptable torque ranges, refer to **Specifications, 400**.

6. Release the clamp on the piston rod.



1. Clamp Ring
2. Cover Assembly
3. Diaphragm
4. Body Assembly
5. Piston Rod Spring
6. Piston Rod Assembly
7. Piston Rod Nut
8. Clevis
9. Clevis Pin

Fig. 1, Sectional View



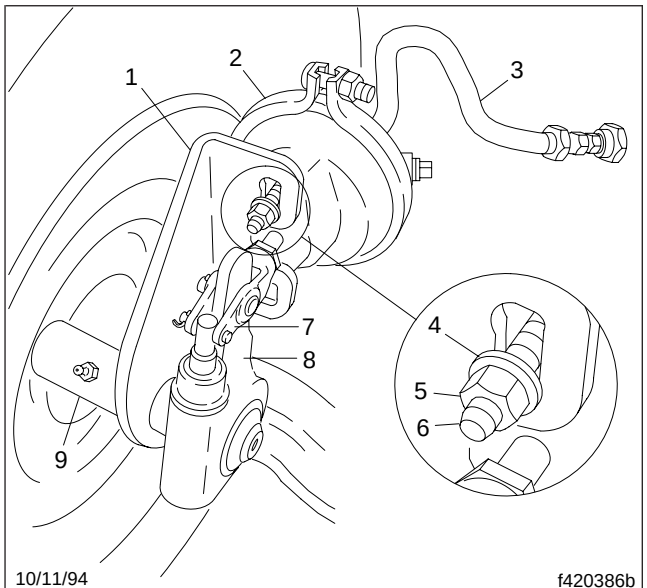
A. Reference Line

Fig. 2

Diaphragm Replacement

7. Do both of the tests **in Subject 100**.
8. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable foundation brake section in this manual.
9. Remove the chocks from the tires.

Removal (See Fig. 1)



1. Chamber Mounting Bracket
2. Brake Chamber
3. Air Line
4. Hardened Flatwasher (2 qty.)
5. Prevailing Torque Locknut (2 qty.)
6. Chamber Mounting Stud (2 qty.)
7. Clevis Assembly
8. Slack Adjuster (Automatic Type)
9. Camshaft Tube

Fig. 1

1. Chock the tires.

⚠ WARNING

WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at other people. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

Follow the manufacturer's recommendations when working on any airdevice so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or compressed-air propulsion.

2. Drain the air reservoirs and lines.
3. Carefully disconnect the air line from the brake chamber.
4. Remove the brake chamber.

   4.1 Remove the cotter pin(s) from the clevis pin(s).

   NOTE: Gunite and Rockwell automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

   4.2 Remove the clevis pin(s) from the slack adjuster.

   4.3 From each mounting stud, remove any installed nuts and washers. Remove the brake chamber from the vehicle.

Installation (See Fig. 1)

1. Before installing a new chamber, be sure the new chamber is the same size and make as the brake chamber on the other side of the axle.
2. Install the brake chamber.

   2.1 Attach the brake chamber to the mounting bracket using a hardened flatwasher and prevailing torque locknut. Install the flatwasher between the locknut and the mounting bracket.

   2.2 Tighten the locknuts. **See Table 1** for the correct torque value.

Brake Chamber Removal and Installation

Description	Chamber Size (in ^{2})	Torque N·m (lbf·ft)
Brake Chamber Mounting-Stud Locknuts	12	52–58 (38–43)
	16 (7/16–14 stud)	52–58 (38–43)
	16 (1/2–13 stud)	81–88 (60–65)
	16 (1/2–20 stud)	88–95 (65–70)
	20	162–176 (120–130)
	24	162–176 (120–130)

Table 1, Mounting-Stud Locknut Torque Values

2.3 Connect the clevis pin(s) to the slack adjuster.

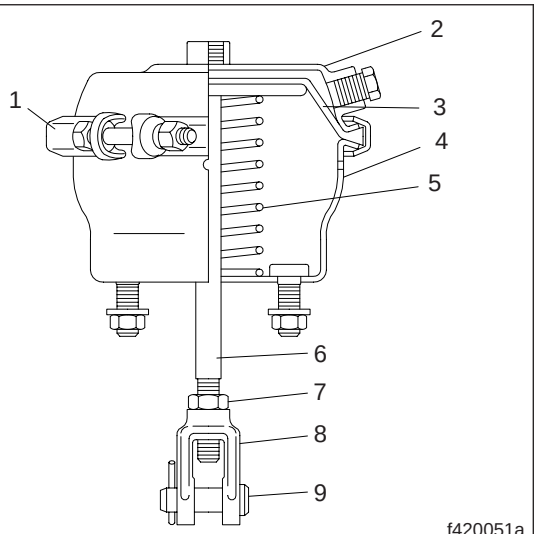
NOTE: Gunite and Rockwell automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

2.4 Install and lock the cotter pin(s) to secure the clevis pin(s).

3. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable foundation brake section in this manual.
4. Connect the air line to the brake chamber.
   - 4.1 Check that the hoses are properly supported and, if needed, clamped to provide good clearance.
   - 4.2 Before connecting the air line, make sure the fittings are clean and free of debris.
   - 4.3 Connect the air line as follows: tighten the nut finger-tight. Using a wrench, further tighten the nut until there is resistance, then tighten one-sixth turn more.
5. Do both of the tests **in Subject 100**.
6. Remove the chocks from the tires.

Brake Chamber Disassembly, Inspection and Cleaning, and Assembly

Disassembly (See Fig. 1)

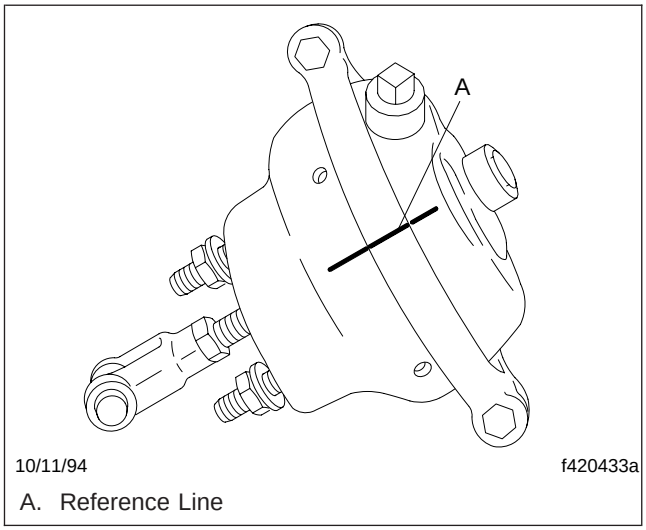


1. Clamp Ring
2. Cover Assembly
3. Diaphragm
4. Body Assembly
5. Piston Rod Spring
6. Piston Rod Assembly
7. Piston Rod Nut
8. Clevis
9. Clevis Pin

Fig. 1, Sectional View

NOTE: If the brake chamber is to be disassembled without removing the body assembly from the vehicle, first back off the slack adjuster. For instructions, refer to the applicable slack adjuster section in this manual.

1. Before disassembly, mark a reference line along the chamber to allow the parts to be reassembled later in their old positions. **See Fig. 2.**
2. Pull out the piston rod. Clamp the rod at the chamber body to protect it from damage.
3. Disassemble the brake chamber.
   - 3.1 Remove one clamp ring bolt and flange nut completely and loosen the other bolt and flange nut enough to remove the clamp ring.
   - 3.2 Remove the cover assembly and the diaphragm.
   - 3.3 Remove the clevis locknut and clevis from the piston rod, and release the clamp on the piston rod, being careful to contain the piston rod assembly and body until the return spring is relaxed.
   - 3.4 Remove the piston rod assembly and spring.



A. Reference Line

Fig. 2

Inspection and Cleaning

1. Clean all metal parts with cleaning solvent.
2. Inspect all parts for wear or damage; replace as needed.
   - 2.1 Check the cover and the body for dents. If any are too deep to be pounded out, replace as needed.
   - 2.2 Check the diaphragm for wear or deterioration and replace it if necessary. Midland recommends replacement of the diaphragm whenever the service brake chamber is opened for inspection.
   - 2.3 Inspect all other parts not considered serviceable. Replace if necessary.

Assembly (See Fig. 1)

1. Stand the piston rod assembly upright on a flat surface (if the chamber was removed from the vehicle).
2. Assemble the brake chamber.

Brake Chamber Disassembly, Inspection and Cleaning, and Assembly

2.1 Place the return spring on the piston rod.

2.2 Place the body on the piston rod assembly, and press the body down, working against the tension of the spring, until the body bottoms out on the flat surface. Clamp the rod at the body, making sure to protect the rod from damage. Insert the piston rod assembly through the body and clamp the rod (if the body wasn't removed from the vehicle).

2.3 Place the diaphragm in the body.

⚠ CAUTION

CAUTION: Don't overtighten the clamp ring. This can distort the flange sealing surface, or the clamp ring itself.

2.4 Position the cover assembly and clamp ring (aligning the reference marks), and install the clamp ring bolt and flange nut. Tighten the flange nuts evenly to eliminate leakage. For acceptable torque ranges, refer to **Specifications, 400**.

3. Install the clevis locknut and clevis, and release the clamp on the piston rod.
4. If the brake chamber was removed from the vehicle, install it. For instructions, refer to **Subject 120**.
5. Do both of the tests found **in Subject 100**.

Description	Chamber Size (in ^{2})	Torque N·m (lbf·ft)
Brake Chamber Mounting-Stud Locknuts	12	52–58 (38–43)
	16 (7/16–14 stud)	52–58 (38–43)
	16 (1/2–13 stud)	81–88 (60–65)
	16 (1/2–20 stud)	88–95 (65–70)
	20	162–176 (120–130)
	24	162–176 (120–130)

Table 1, Mounting-Stud Locknut Torque Values

Description	Chamber Size (in ^{2})	Torque N·cm (lbf·in)
Clamp Ring Flange Nuts	12	2260 to 2820 (200 to 250)
	16	2260 to 2820 (200 to 250)
	20	1240 to 2540 (110 to 225)
	24	1700 to 2540 (150 to 225)

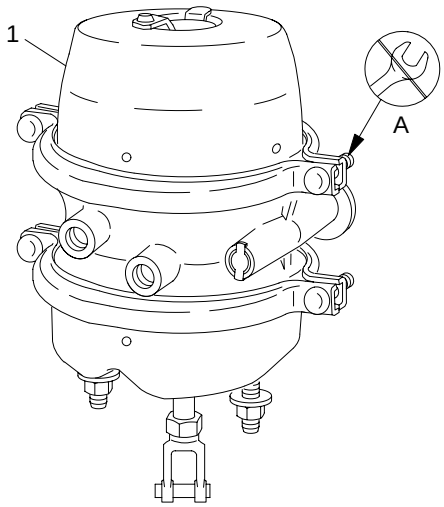
Table 2, Clamp Ring Torque Values

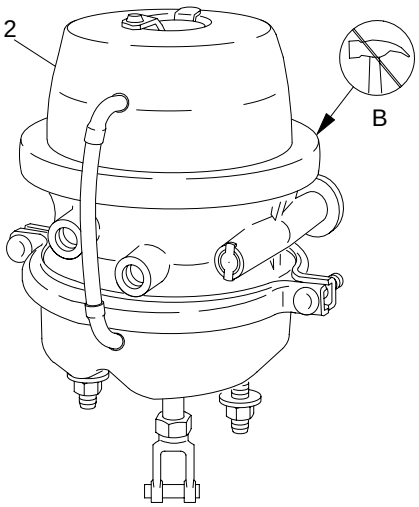
Description	Chamber Size (in ^{2})	Torque N·m (lbf·ft)
Piston Rod Nuts	12	27–41 (20–30)
	16 (7/16-inch Stud)	27–41 (20–30)
	16 (1/2-inch Stud)	27–41 (20–30)
	20	45–122 (33–90)
	24	45–122 (33–90)

Table 3, Piston Rod Nut Torque Values

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.





06/25/93 f420731a

A. Do not remove this clamp ring.
1. Model E (E Series) Brake Chamber
B. Do not remove the factory-sealed clamp ring.
2. Model TR-T (TR Series) Brake Chamber

Fig. 1

IMPORTANT: On MGM "TR" Series chambers, the parking/emergency brake section is factory sealed (no clamp ring) and is a *non-serviceable* unit. On "E" Series chambers, the parking/emergency brake section is attached with a clamp ring. *Do not ever perform any service on this clamp ring.*

General Information

MGM "E" and "TR" Series tandem cam brake chambers consist of a service brake section and a parking/emergency spring brake section. **See Fig. 2** and **Fig. 3**. The service brake section is the smaller section near the clevis assembly.

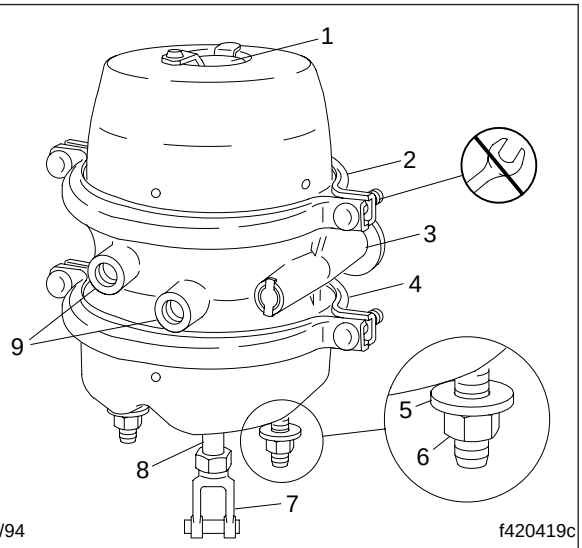
In the service brake section, the flange case and non-pressure chamber contain a service return spring, piston rod assembly, and service brake diaphragm.

In the parking/emergency brake section, the flange case and the head contain a return spring, a push rod assembly, a parking (spring) brake diaphragm, a piston, a power spring, and a detachable release bolt.

All MGM brake chambers are mounted to the frame using prevailing torque locknuts and hardened flatwashers.

MGM "E" and "TR" Series chambers may be equipped with an external breather tube that protects the parking brake chamber from contaminants. These chambers are called Model "E-T" or "TR-T" chambers. **See Fig. 3.**

General Information and Principles of Operation



Do not remove the parking brake clamp ring.

1. End Cover Cap
2. Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Air Inlet Ports

Fig. 2, Model E (E Series) Brake Chamber

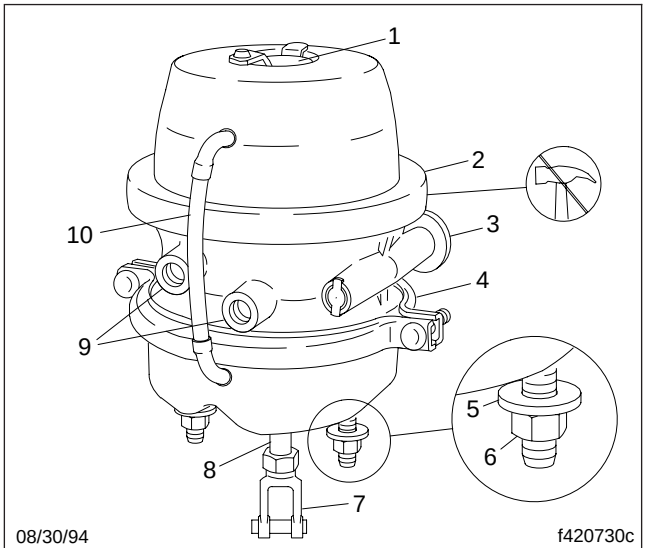
Periodic maintenance of the brake chambers is required. Also, whenever the service brake chamber is disassembled (*do not attempt to disassemble the parking brake chamber*), the parts should be inspected for damage. For maintenance schedules and procedures, and for inspection of brake chamber parts, refer to the vehicle maintenance manual.

Principles of Operation

SERVICE BRAKES

As the brake pedal is depressed, compressed air enters the service brake chamber through a port. Air pressure acts upon a diaphragm, which forces the piston rod toward the non-pressure chamber, applying a straight-line force to the slack adjuster, which converts it to a rotational force. This in turn rotates the camshaft and applies the brakes.

Then, when the brake pedal is released, air is exhausted from the service brake chamber, and the return spring allows the diaphragm, piston rod, and slack adjuster to return to their normal positions, releasing the brakes.



Do not remove the factory-sealed clamp ring.

1. End Cover Cap
2. Factory Sealed Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Air Inlet Ports
10. External Breather Tube

Fig. 3, Model TR-T (TR Series) Brake Chamber

PARKING/EMERGENCY BRAKES

During parking brake release, compressed air enters the parking brake chamber and acts upon the diaphragm and piston, fully compressing the power spring. When the power spring is compressed, the parking brakes are released; the service brakes can then be operated at the brake pedal.

During parking brake application, air is exhausted from the parking brake chamber. The power spring releases, forcing the piston and parking brake diaphragm toward the flange case. The resulting motion on the push rod forces the service brake diaphragm and piston rod outward, applying the brakes.

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

Manual Compression (Parking Brake Release)

1. Chock the tires.
2. Remove the end cover cap from the center-hole in the head of the chamber. See **Fig. 2**.

⚠ DANGER

Do not attempt to cage the power spring if the parking brake chamber is damaged severely enough to lose its structural integrity. If the power spring were to break loose, it could result in death, severe personal injury, or property damage.

A DAMAGED PARKING BRAKE CHAMBER IS EXTREMELY DANGEROUS! Only qualified service personnel should attempt to remove and disarm a damaged chamber. Using a torch, burn off the piston rod in the space between the clevis and the base of the service chamber.

Remove the chamber carefully from its bracket, and disarm it inside a suitable container. For disarming procedures, consult the MGM service manual.

3. Manually release the parking brake (cage the power spring).

   3.1 Using a hand wrench, (*don't use an impact wrench*), unscrew the release nut, and remove the nut, flatwasher, and release bolt from the storage pocket on the side of the chamber. See **Fig. 3**.

   IMPORTANT: If these parts are not stored on the chamber, they must be otherwise obtained or purchased; the parking brake cannot be manually released without them.

   3.2 Apply at least 620 kPa (90 psi) air pressure to the parking brake inlet port (set parking brake in the "release" position).

   3.3 Insert the release bolt into the center-hole in the chamber head (**see Fig. 4**). Insert the bolt until it bottoms out into the hole in the piston inside the chamber.

   IMPORTANT: If you are not absolutely sure that the formed end of the bolt has engaged the piston correctly, repeat this step. Repeat it until you are absolutely sure.

   3.4 Turn the release bolt one-quarter turn clockwise, and pull the bolt out to lock its formed end into the piston.

   IMPORTANT: If the bolt doesn't lock into the piston in less than 13-mm (1/2-inch) outward movement, repeat these steps until you are sure it does lock.

   3.5 Then, holding the bolt locked into the piston, install the flatwasher and release nut on the end of the release bolt, and turn down the nut against the flatwasher until it is finger-tight. See **Fig. 5**.

⚠ CAUTION

Don't exceed 68 N·m (50 lbf·ft) torque on the release nut; and don't use an impact wrench on this nut. Too much torque could distort the head of the chamber and prevent manual release of the parking brake.

   3.6 Using a hand wrench (*don't use an impact wrench*), turn the release nut clockwise until the bolt extends 76 mm (3 inches) above the nut. See **Fig. 6**.

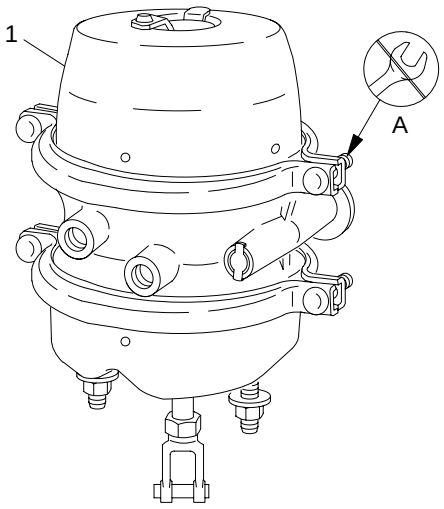
   IMPORTANT: Don't exceed the 76-mm (3-inch) length.

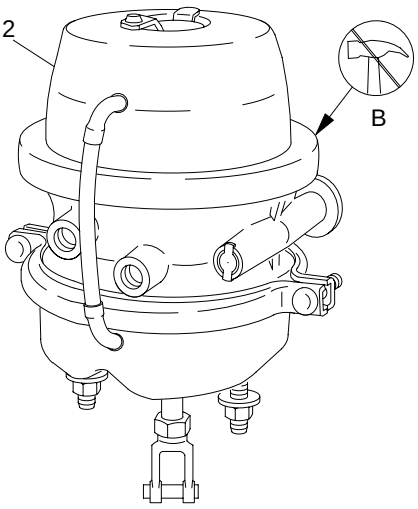
4. Once the power spring has been caged, exhaust the compressed air from the parking brake.

Manual Reset (Parking Brake Reset)

1. Uncage the power spring.

Power Spring Manual Compression and Reset

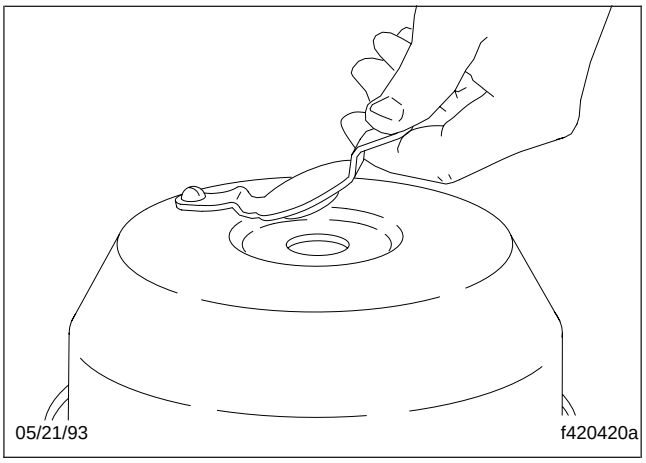




06/25/93 f420731a

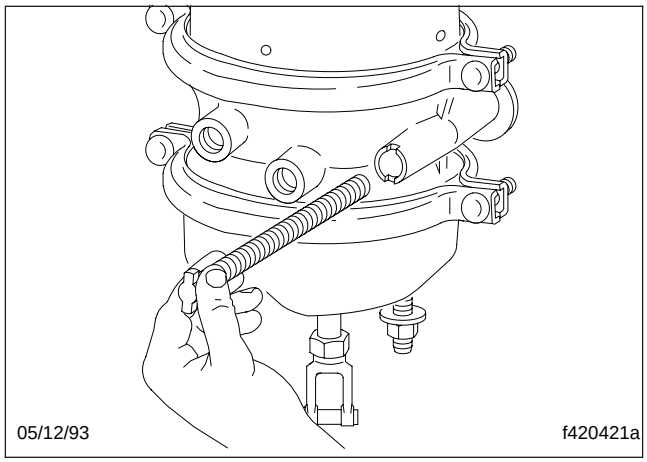
A. Do not remove this clamp ring.
1. Model E (E Series) Brake Chamber
B. Do not remove the factory-sealed clamp ring.
2. Model TR-T (TR Series) Brake Chamber

Fig. 1



05/21/93 f420420a

Fig. 2



05/12/93 f420421a

Fig. 3

1.1 Apply at least 620 kPa (90 psi) air pressure to the parking brake inlet port (set parking brake in the "release" position).

⚠ CAUTION

Don't exceed 68 N·m (50 lbf·ft) torque on the release nut; and don't use an impact wrench on this nut. Too much torque could distort the head of the chamber and prevent manual release of the parking brake.

1.2 With air applied to the parking brake section (the parking brake control valve is in the "release" position), use a hand wrench to turn the release nut *counterclockwise* until the bolt bottoms out in the unit.

1.3 Remove the nut and flatwasher.

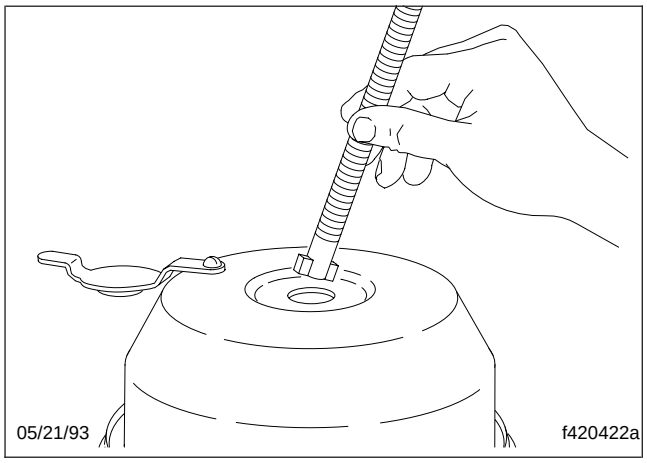


Fig. 4

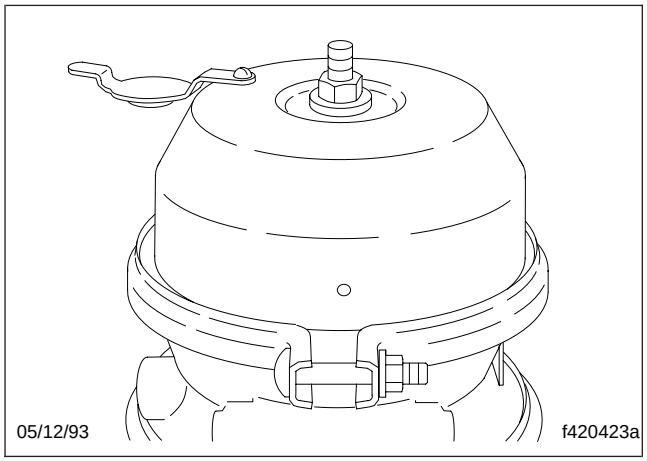
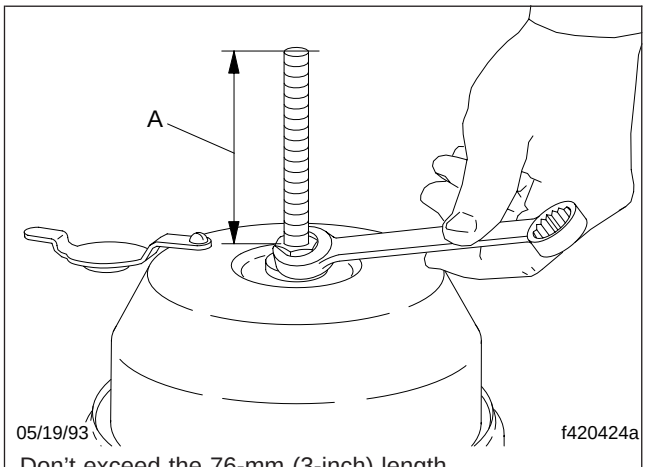


Fig. 5

1.4 Push the release bolt into the piston and turn the release bolt one-quarter turn counterclockwise to unlock its formed end from the piston. Remove the release bolt from the center-hole of the chamber.

2. Using a hand wrench (*don't use an impact wrench*), install the release bolt, flatwasher, and release nut in the storage pocket. MGM recommends 14 N·m (10 lbf·ft) torque on the nut against the flatwasher (see **Fig. 7**).

3. Snap the end cover cap in place over the center-hole in the chamber head. See **Fig. 8**.



Don't exceed the 76-mm (3-inch) length.
A. Measure this distance.

Fig. 6

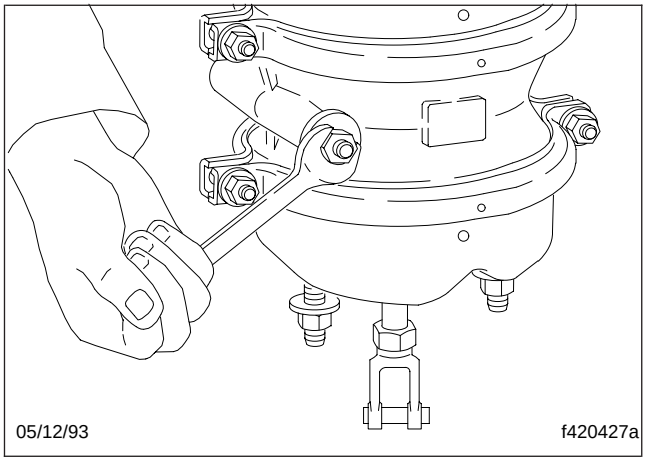


Fig. 7

CAUTION

If the external breather tube or end cover cap is missing or incorrectly installed, road dirt and debris can adversely affect the operation of the brake chamber. Once inside the chamber, dirt and debris cause the internal parts to deteriorate and shorten their lives. Operating the unit without the external breather tube or end cover cap in place voids the MGM warranty.

4. Check the plastic end cover cap periodically, and replace it with a new one at once if damaged or missing. For intervals, refer to the vehicle maintenance manual.

Power Spring Manual Compression and Reset

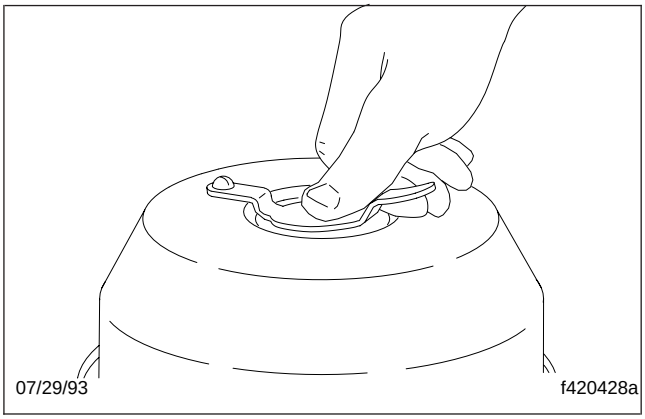


Fig. 8

5. Remove the chocks from the tires.

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

Removal

1. To make removal and installation of the parking brake section easier (without removing the service brake chamber), lock off the service chamber piston rod.

   1.1 Apply the service brakes by actuating the driver's foot brake treadle valve.

   1.2 With the brakes applied, clamp a pair of locking-jaw pliers on the piston rod to lock the rod in place when the air pressure is released (see **Fig. 2**).

⚠ WARNING

Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section (see Subject 100). When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.

2. Manually release the parking brake (cage the power spring). For instructions, see **Subject 100**.

3. Mark the air lines for later reference. Then carefully disconnect them from the brake chamber.

   On chambers equipped with an external breather tube, disconnect the tube and elbow from the service brake chamber.

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

4. Remove the parking brake section from the service brake section.

   4.1 Using a hand wrench (*don't use an impact wrench*), remove the clamp nuts on the *service* clamp ring (*do not disassemble the parking brake section*).

   4.2 While holding the parking brake section securely in place, remove the service clamp ring. Then remove the parking brake section from the service brake non-pressure chamber (see **Fig. 3**).

5. Remove the service brake diaphragm from the bottom of the parking brake section.

Installation

IMPORTANT: At this time, take the opportunity to inspect the parking/emergency brake section, and replace it if it shows signs of damage, corrosion, or rust. Follow the detailed inspection instructions in the vehicle maintenance manual.

1. Inspect all parts in the service (non-pressure) chamber. Replace any damaged or worn parts with genuine MGM-engineered replacement parts.

2. Place the new service brake diaphragm in the bottom recess of the parking brake section (see **Fig. 4**).

3. Install the (new, if needed) parking/emergency brake section.

   3.1 If installing a new parking brake section, be sure it is the same size and make as the old one.

   3.2 Check that the release bolt is fully extended outward. For instructions, refer to **Subject 100**.

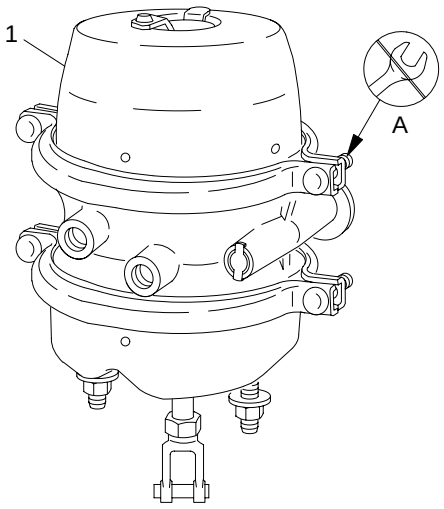
   3.3 Install the parking brake section on the service chamber so that all mating parts are aligned straight and the air lines are positioned to mate with the vehicle air supply lines.

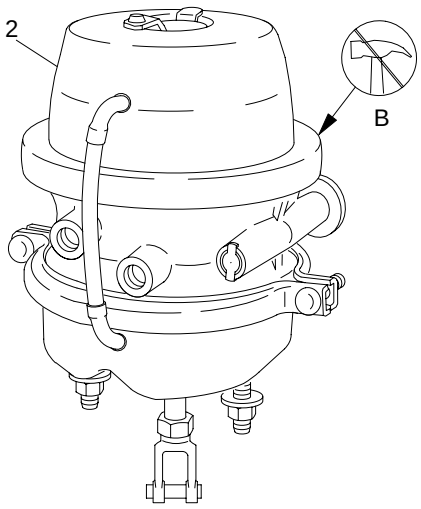
4. Install the service brake clamp ring.

   4.1 With the service brake clamp ring in place, install the clamp bolts and nuts.

   4.2 Using a hand wrench (*don't use an impact wrench*), alternately tighten each clamp nut in increments of 680 to 1360

Service Brake Diaphragm Replacement

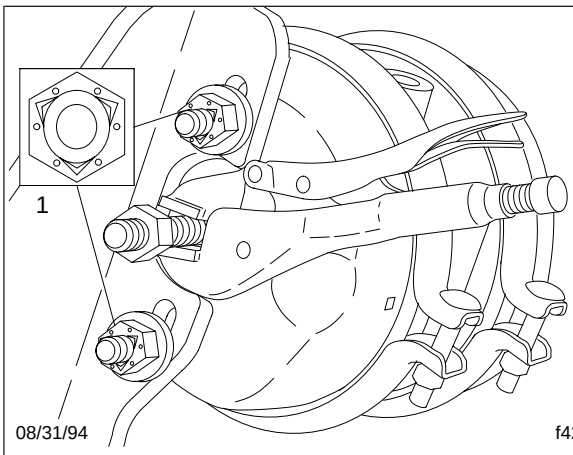




06/25/93 f420731a

A. Do not remove this clamp ring.
1. Model E (E Series) Brake Chamber
B. Do not remove the factory-sealed clamp ring.
2. Model TR-T (TR Series) Brake Chamber

Fig. 1



08/31/94 f421204a

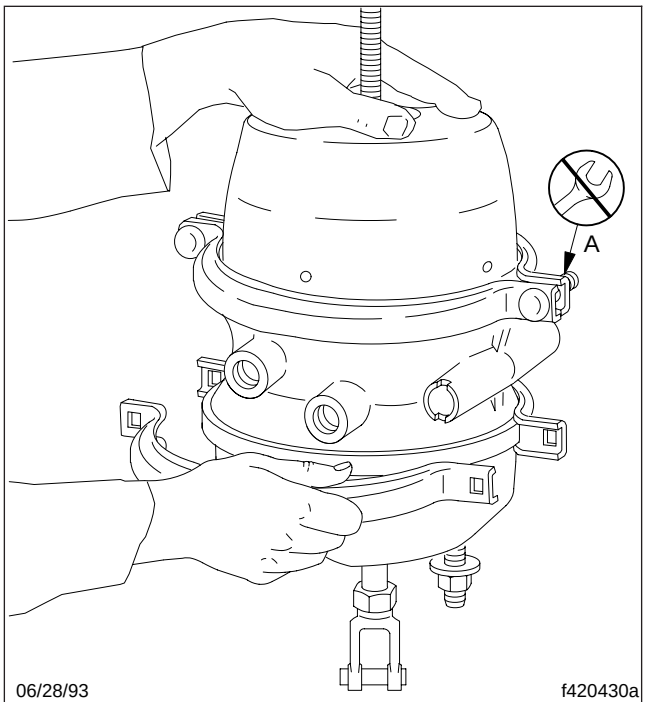
1. Prevailing Torque Locknut

Fig. 2

N·cm (60 to 120 lbf·in) while constantly rechecking the alignment of mating parts.

If realignment is needed, loosen the nuts again, and repeat this substep.

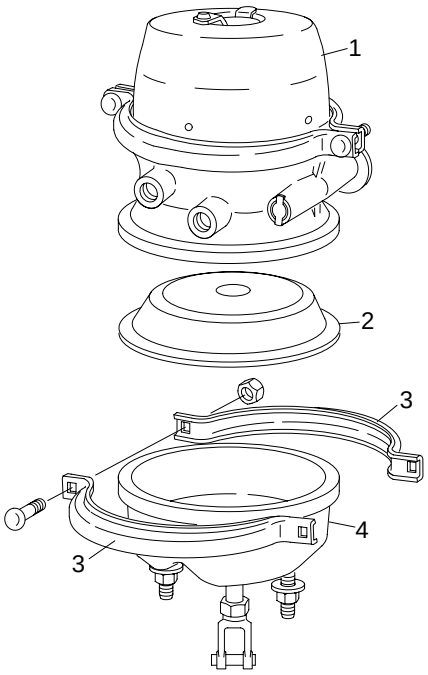
4.3 Firmly tap around the circumference of the service clamp ring with a rubber mallet to ensure full seating of the clamp. Tighten



06/28/93 f420430a

A. Do not remove this clamp ring.

Fig. 3



08/12/94 f420696b

1. Parking/Emergency Brake Section
2. Service Brake Diaphragm
3. Service Brake Clamp Ring
4. Service Brake (Non-Pressure) Chamber

Fig. 4

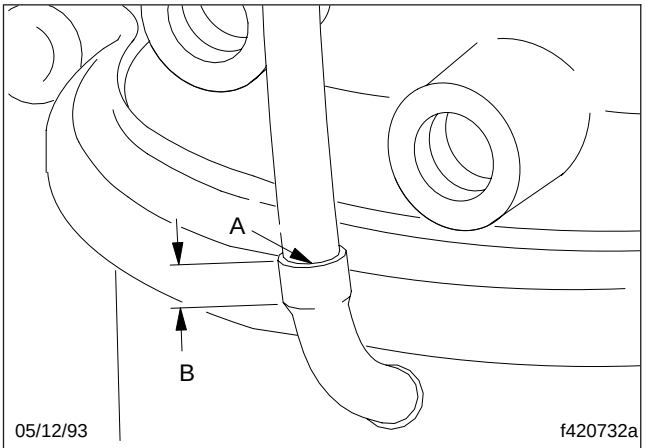
the nuts to a final torque of 34 to 41 N·m (25 to 30 lbf·ft).

5. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench (*don't use an impact wrench*), tighten the fittings 34 N·m (25 lbf·ft).
6. Using the vehicle system air, charge the parking brake with full line pressure—at least 690 kPa (100 psi). Using only soapy water (*never any type of oil,* which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If bubbles or leaks appear, tighten the fittings slightly, but not over 34 N·m (25 lbf·ft).
7. With the parking brake still charged with full line pressure, apply and hold the foot brake treadle valve down to charge the service brake chamber. Remove the locking-jaw pliers from the service piston rod so that the piston returns to a normal position in the chamber.

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

8. Test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, firmly tap the circumference of the clamp ring with a rubber mallet, and retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). MGM recommends 34 to 41 N·m (25 to 30 lbf·ft) torque on the clamp hexnuts.
9. On chambers equipped with an external breather tube, make sure that the open end of the tube is free of grease, dirt, and other debris. Then, apply a high-quality rubber cement to the tube and insert it into the elbow at least 13 mm (1/2 inch). See **Fig. 5**. Insert the tube into the service brake chamber.



05/12/93 f420732a

A. Apply adhesive here.
B. Check for 13 mm (1/2 ") minimum engagement.

Fig. 5

10. With air pressure now exhausted from the service brake chamber, but held on the parking brake, reset the parking brakes by uncaging the power spring, and snap the end cover cap in place. For instructions, see **Subject 100**.
11. Adjust the brakes at the slack adjuster.

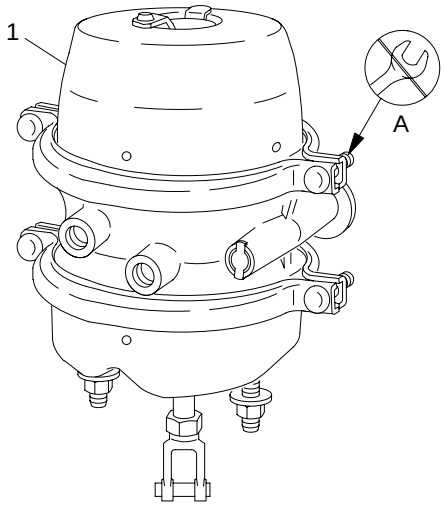
Service Brake Diaphragm Replacement

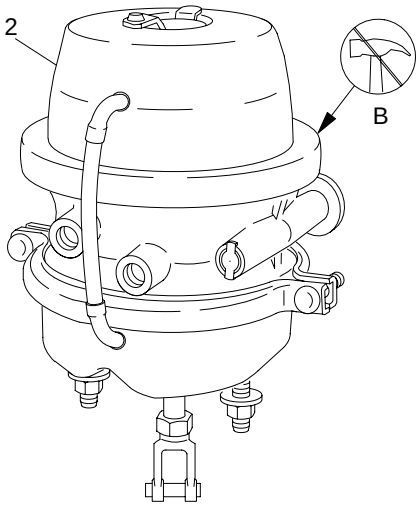
IMPORTANT: After replacing any brake chamber components, check the piston rod stroke and actuating alignment to ensure correct installation and foundation brake adjustment. No foundation brake adjustments, parking brake or service brake, can be made at the chamber and all "stroke" adjustments must be made at the slack adjuster. For instructions, see the applicable slack adjuster section in **Group 42** in this manual.

Replacement

⚠ DANGER

DANGER: Don't loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.





06/25/93 f420731a

A. Do not remove this clamp ring.
1. Model E (E Series) Brake Chamber
B. Do not remove the factory-sealed clamp ring.
2. Model TR-T (TR Series) Brake Chamber

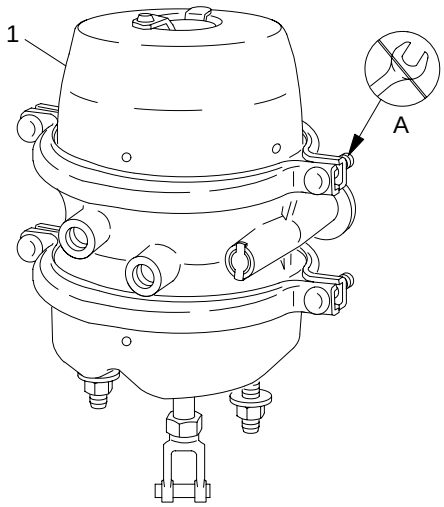
Fig. 1

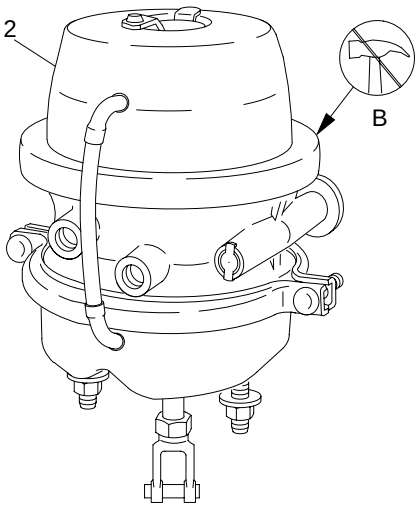
IMPORTANT: The parking/emergency brake section can be replaced as a unit. For instructions, refer to **Subject 110**.

Combination Service and Parking Brake Chamber Removal and Installation

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.





06/25/93 f420731a

A. Do not remove this clamp ring.
1. Model E (E Series) Brake Chamber
B. Do not remove the factory-sealed clamp ring.
2. Model TR-T (TR Series) Brake Chamber

Fig. 1

Removal (See Fig. 2 or Fig. 3)

⚠ WARNING

WARNING: Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section (see Subject 100). When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.

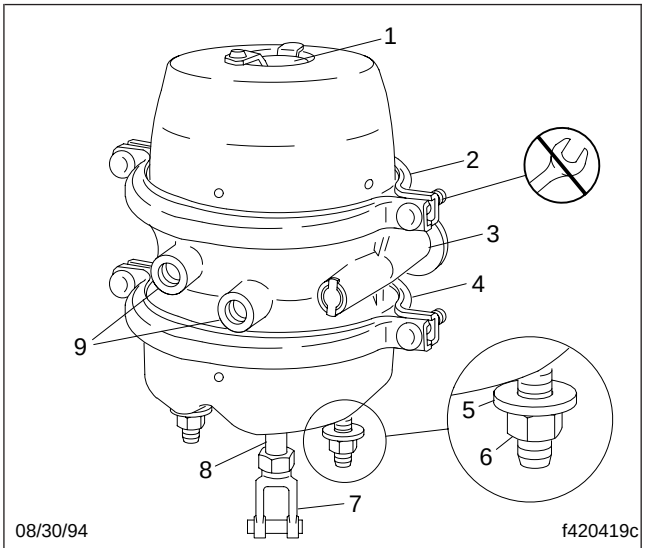
1. Manually release the parking brake (cage the power spring). For instructions, refer to **Subject 100**.
2. Mark the air lines for later reference. Then carefully disconnect them from the brake chambers.
3. Remove the brake chamber from the vehicle.

   3.1 Remove the cotter pin(s) from the clevis pin(s), then remove the clevis pin(s) from the clevis. Disconnect the clevis from the slack adjuster.

   NOTE: Gunite and Rockwell automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

   3.2 Make sure the parking brake has been released manually (the power spring has been caged). For instructions, refer to **Subject 100**. Also, make sure that the service brake piston is fully retracted (in the brakes "OFF" position). Then, record both of the following dimensions in either mm or inches, measuring outward from

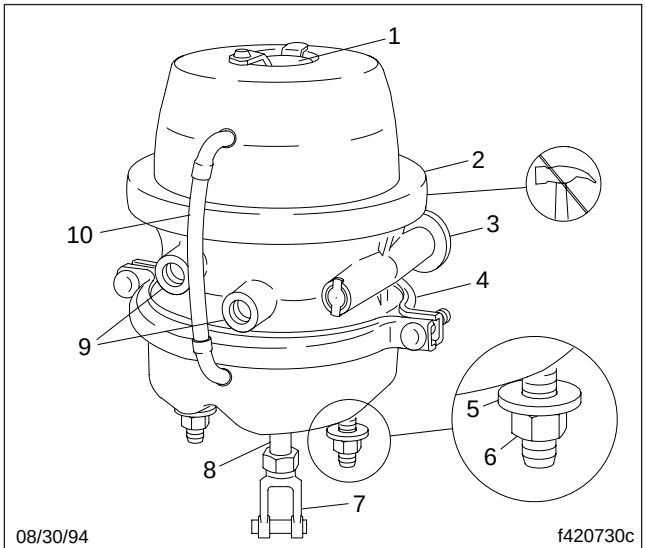
Combination Service and Parking Brake Chamber Removal and Installation



Do not remove the parking brake clamp ring.

1. End Cover Cap
2. Parking Brake Clamp Ring
3. Release Bolt Storage Pccket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Air Inlet Ports

Fig. 2, Model E (E Series) Brake Chamber



Do not remove the factory-sealed clamp ring.

1. End Cover Cap
2. Factory Sealed Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Air Inlet Ports
10. External Breather Tube

Fig. 3, Model TR-T (TR Series) Brake Chamber

the base of the service brake chamber (**see Fig. 4**):

X dimension: to end of threaded piston rod

Y dimension: to centerline of (large) clevis pin

IMPORTANT: If new chambers are to be attached to manual slack adjusters, the Y dimension is the most critical measurement. When installing the new assembly, its service piston rod must be cut (**see Fig. 5**) to exactly duplicate this "rod-plus-clevis" length *after* the clevis assembly is installed on the piston rod.

If new chambers are to be attached to automatic slack adjusters, the X dimension is the most critical measurement. When installing the new assembly, its service piston rod must be cut (**see Fig. 5**) to exactly duplicate the "rod only" length *before* the clevis assembly is installed on the piston rod.

3.3 From each mounting stud, remove any installed nuts and washers. Then, cautiously remove the brake chamber from the mounting bracket.

Installation (See Fig. 2 or Fig. 3)

1. If installing a new brake chamber unit, do the following steps:

   1.1 First, make sure the power spring is caged (release bolt fully extended outward). If not, **go to Subject 100** and do the applicable steps.

   1.2 Make sure that the piston rod is the same length as the rod on the old unit (measure the rods when *both* chambers are caged).

Combination Service and Parking Brake Chamber Removal and Installation

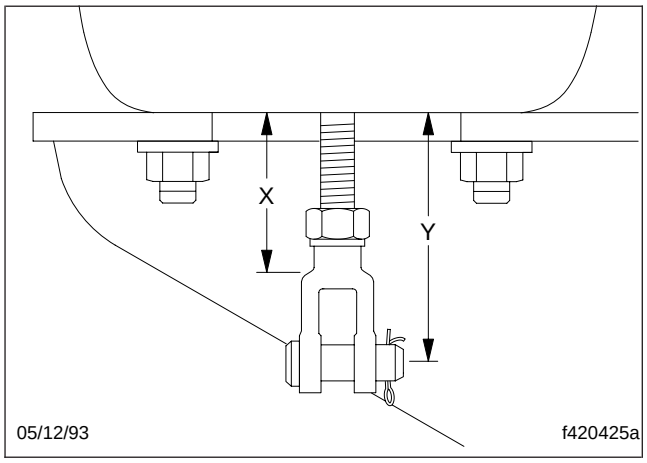


Fig. 4

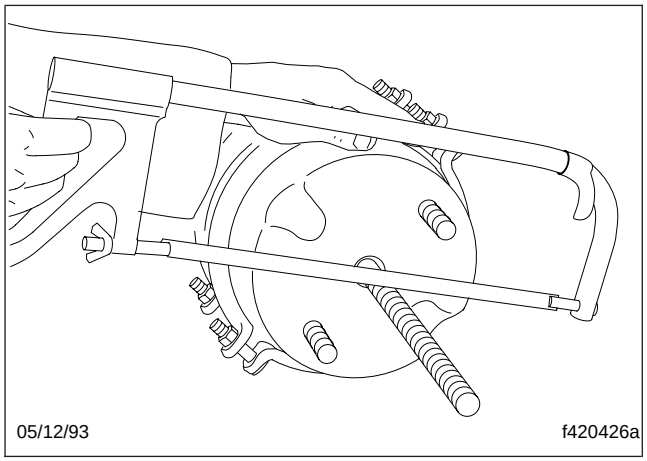


Fig. 5

1.3 Be sure the new chamber is the same size and make as the brake chamber installed on the other side of the axle.

1.4 Remove the prevailing torque locknut and hardened flatwasher from each of the mounting studs on the chamber.

2. Clean the face of the mounting bracket, and install the chamber on the bracket, paying close attention to positioning the chamber air inlet ports for correct alignment to the vehicle air lines.

⚠ WARNING

WARNING: Tighten the mounting nuts with a hand wrench, not an impact wrench. An impact wrench could damage the mounting fasteners, reducing the force of the brakes. This could result in personal injury or property damage.

3. Install one hardened flatwasher and prevailing torque locknut on each mounting stud. Using a hand wrench (*don't use an impact wrench*), tighten the nuts 136 to 156 N·m (100 to 115 lbf·ft). Make sure the flatwasher is installed between the locknut and the mounting bracket.

   On chambers equipped with an external breather tube, make sure that the tube is installed in the side of the chamber that faces away from the road surface. An improperly installed breather tube voids the MGM warranty.

4. Check mating and alignment with the vehicle air lines.

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

4.1 Using a hand wrench (*don't use an impact wrench*), loosen the clamp nuts on the *service* clamp ring (*do not disassemble the parking brake section*).

4.2 Reposition the air inlet ports, as needed, to mate with vehicle air supply lines.

Alternately tighten each clamp nut in increments of 680 to 1360 N·cm (60 to 120 lbf·in) while constantly rechecking the alignment of mating parts.

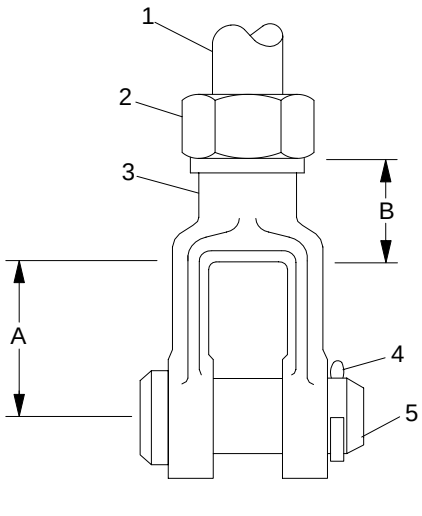
If realignment is needed, loosen the nuts again, and repeat this substep.

4.3 Firmly tap around the circumference of the service clamp ring with a rubber mallet to ensure full seating of the clamp. Tighten the nuts to a final torque of 34 to 41 N·m (25 to 30 lbf·ft).

Combination Service and Parking Brake Chamber Removal and Installation

5. With manual slack adjusters, connect the slack adjuster to the clevis, then install the clevis pin. Insert the cotter pin in the clevis pin, and lock it in place. Check the piston-rod engagement with the clevis. At least seven threads of engagement is required; there should be 25-mm (1-inch) clearance from the centerline of the clevis pin hole to the end of the piston rod. **See Fig. 6.** Adjust if needed.

   With automatic slack adjusters, refer to the applicable slack adjuster section in **Group 42** for installation instructions.



08/20/93 f420225a

A. Minimum of 25 mm (1 inch) clearance between centerline of clevis pin hole and piston rod end.
B. Minimum of 7 threads engagement.
1. Piston Rod
2. Piston Rod Nut
3. Clevis
4. Cotter Pin
5. Clevis Pin

Fig. 6, Piston Rod Engagement With the Clevis

6. Inspect the piston rod to be sure it is working free, not binding, and is square with the chamber bottom within ±3° in any direction from zero to full stroke. If there is misalignment, make corrections by loosening the locknuts and repositioning the chamber on the mounting bracket, or by shimming the slack adjuster to the right or left on the camshaft.
7. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench (*don't use an impact wrench*), tighten the fittings 34 N·m (25 lbf·ft).
8. Using the vehicle system air, charge the parking brake with full line pressure, at least 690 kPa (100 psi). Using only soapy water (*never any type of oil,* which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If bubbles or leaks appear, tighten the fittings slightly, but not over 34 N·m (25 lbf·ft).

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

IMPORTANT: If the service brake clamp ring was loosened to reposition the air inlet ports, apply air to the parking brake, and then apply and hold the foot brake treadle valve down to charge the service brake chamber. Now test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, firmly tap the circumference of the clamp ring with a rubber mallet, and retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). MGM recommends 34 to 41 N·m (25 to 30 lbf·ft) torque on the clamp hexnuts.

9. With air pressure now exhausted from the service brake chamber, but held on the parking brake, reset the parking brakes by uncaging the power spring, and snap the end cover cap in place. For instructions, refer to **Subject 100**.
10. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable slack adjuster section in this manual.

IMPORTANT: After replacing any brake chamber, check the piston rod stroke and actuating alignment to ensure correct installation and foundation brake adjustment. No foundation brake adjustments, parking brake or service brake, can be made at the chamber and all "stroke" adjustments must be made at the slack

adjuster. For instructions, refer to the applicable slack adjuster section in **Group 42** in this manual.

Specifications

This subject contains the following table: •Torque Values

Description	Torque N·m (lbf·ft)
Spring Brake Release Bolt Nut (in storage pocket)	14 (10)
Service Brake Clamp Ring Nut	34-41 (25-30)
Brake Chamber Mounting Stud Nut	136-156 (100-115)
Air Hose Fitting-to-Chamber	34 (25)

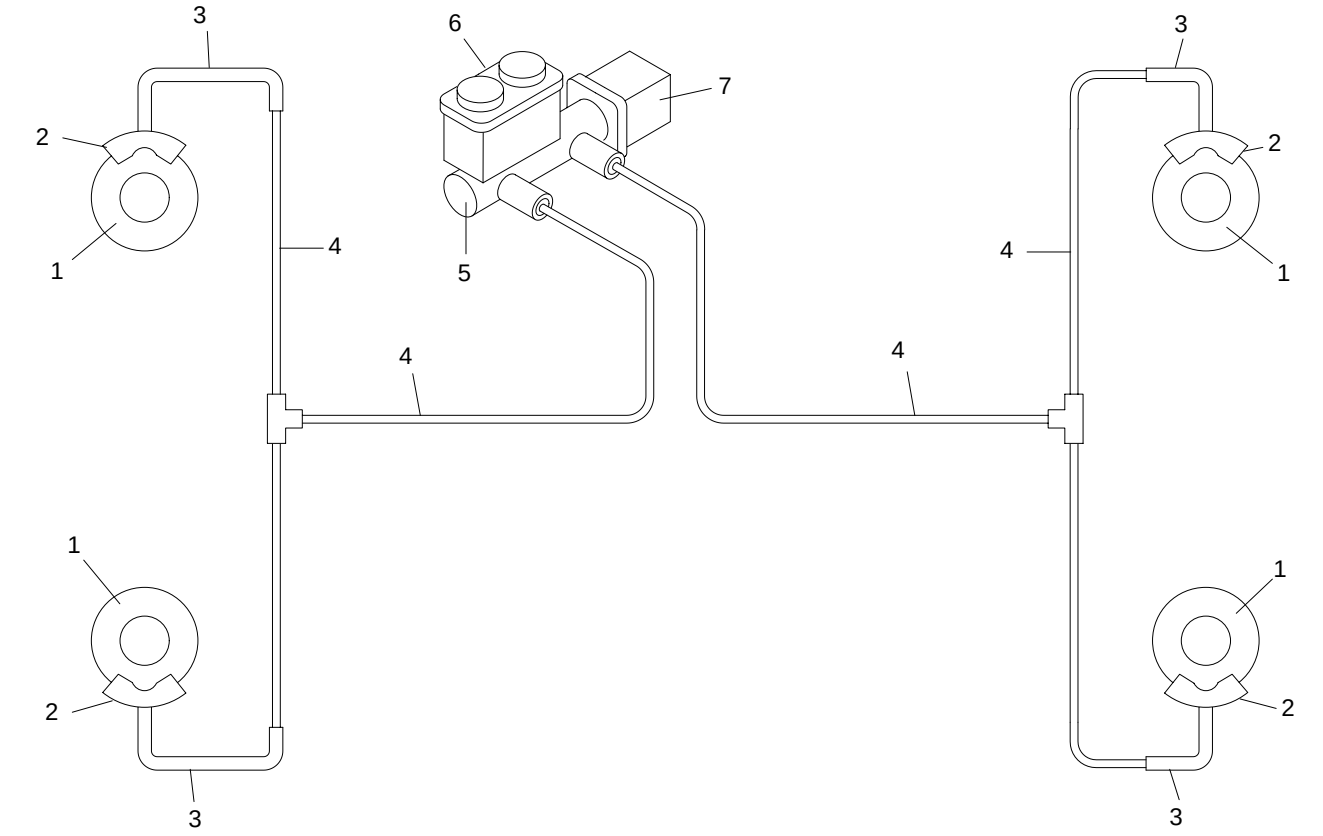
Table 1, Torque Values

General Description

The Bendix hydraulic disk brake system consists of a power booster, a master cylinder and reservoir, hydraulic lines (both rigid and flexible), a brake rotor on each wheel hub, and a brake caliper and pad assembly at each rotor. **See Fig. 1**.

- The service brake system, consisting of the master cylinder, the brake hydraulic lines, and the brake calipers. It uses DOT 3 approved brake fluid.

POWER BOOSTER **(Fig. 3)**



1. Rotor
2. Caliper and Pad Assembly
3. Flexible Brake Line
4. Rigid Brake Line
5. Master Cylinder
6. Reservoir
7. Power Booster

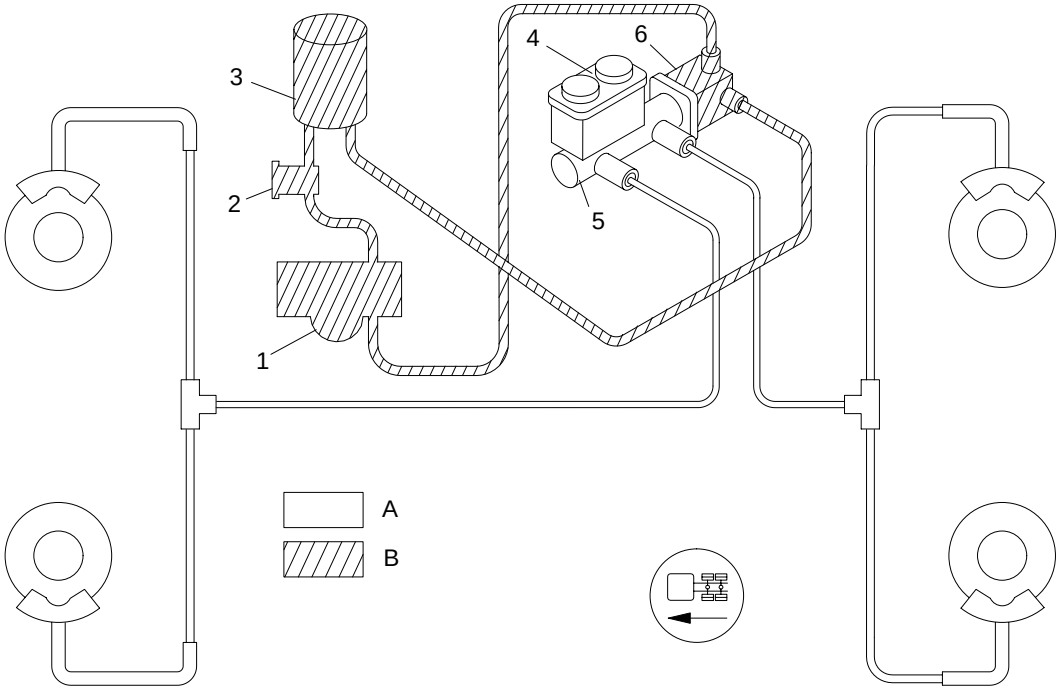
Fig. 1, Brake System Major Parts

There are two completely separate hydraulic systems, which use different and incompatible hydraulic fluids, lines, and seals (**see Fig. 2**):

- The power booster system, which provides power to the brake master cylinder, and uses power steering fluid. It is plumbed into the power steering system.

The Bendix Hydro-Max II® power booster, mounted on the firewall (Ref. 4), is attached to the rear of the master cylinder (Ref. 11). It consists basically of a reaction piston (Ref. 7), a power piston assembly (Ref. 8), an end-cap assembly (Ref. 10), and a back-up electric pump (Ref. 9).

General Description and Principles of Operation



03/07/94 f420369a

A. Brake System (Brake Fluid)
B. Brake Booster and Power Steering System (Power Steering Fluid)

1. Power Steering Gear
2. Power Steering Pump
3. Power Steering Reservoir
4. Brake Master Cylinder Reservoir
5. Brake Master Cylinder
6. Power Booster

Fig. 2, Brake System Major Parts

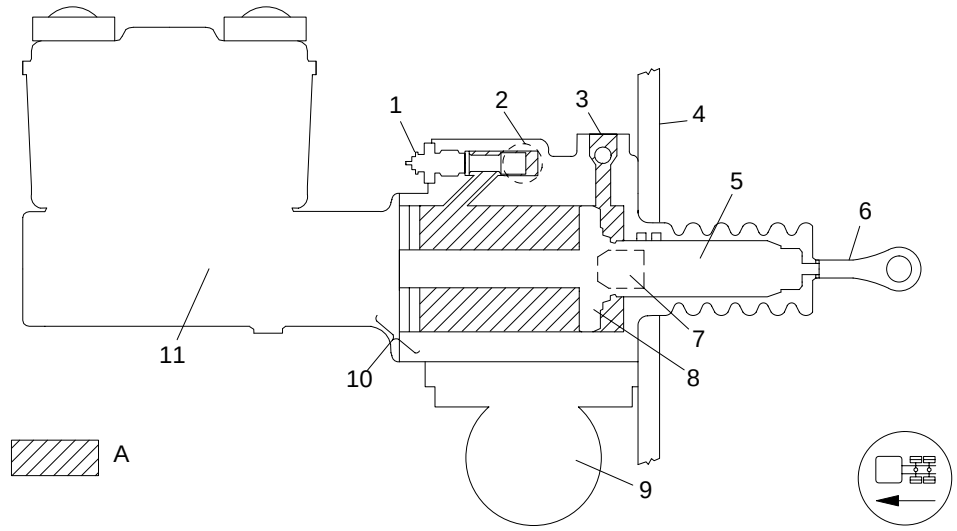
At the rear of the power piston—and inside it—is the reaction piston (Ref. 7). The power piston assembly (Ref. 8) is connected to the brake pedal by way of the brake pedal rod (Ref. 6). Surrounding the reaction piston is the power piston assembly (Ref. 8), the forward end of which fits through the end-cap assembly, and rests against the rear of the brake master cylinder (Ref. 11). The end-cap assembly prevents the power steering fluid in the power booster from mixing with the brake fluid in the master cylinder.

The power booster is connected to the vehicle's power steering system, which supplies it with pressurized power steering fluid. The power booster supply port (Ref. 3) is connected to the power steering pump via the steering gear, and the return port is connected to the power steering reservoir. A flow switch (Ref. 1) activates the back-up pump if, for any reason, the power steering pump doesn't supply the power booster with fluid.

MASTER CYLINDER (Fig. 4 and Fig. 5)

The brake master cylinder functions as a dual supply system: the primary system supplies pressurized brake fluid to the rear brakes; the secondary system supplies it to the front brakes. **See Fig. 4**. For safety, each system is independent of the other, so a problem with one set of brakes won't affect the function of the other.

The master cylinder, attached to the front of the power booster (**Fig. 5**, Ref. 7), consists mainly of the primary pressure chamber (Ref. 9), the primary piston/actuator assembly and return spring (Refs. 10 and 11), the primary reservoir section (Ref. 5), and the secondary pressure chamber, piston/actuator assembly, return spring, and reservoir section (Refs.



NOTE: Not all parts are shown.

1. Flow Switch
2. Return Port
3. Supply Port
4. Firewall
5. Rubber Boot
6. Brake Pedal Rod
7. Reaction Piston
8. Power Piston Assembly
9. Backup Electric Pump
10. End-Cap Assembly
11. Master Cylinder and Reservoir

A. Power Steering Fluid

Fig. 3

13, 12, 15, and 2). Both pressure chambers have outlet ports that connect them to either the front or rear brake caliper assemblies by way of hydraulic lines. At the bottom of each reservoir section is a compensating valve (Refs. 1 and 6), which when open, connects that reservoir section with the applicable pressure chamber in the master cylinder. A pressure differential valve operates a pressure differential switch (not shown), which activates a dash warning system, should one brake system not work.

BRAKE CALIPER ASSEMBLIES (Fig. 6 and Fig. 7)

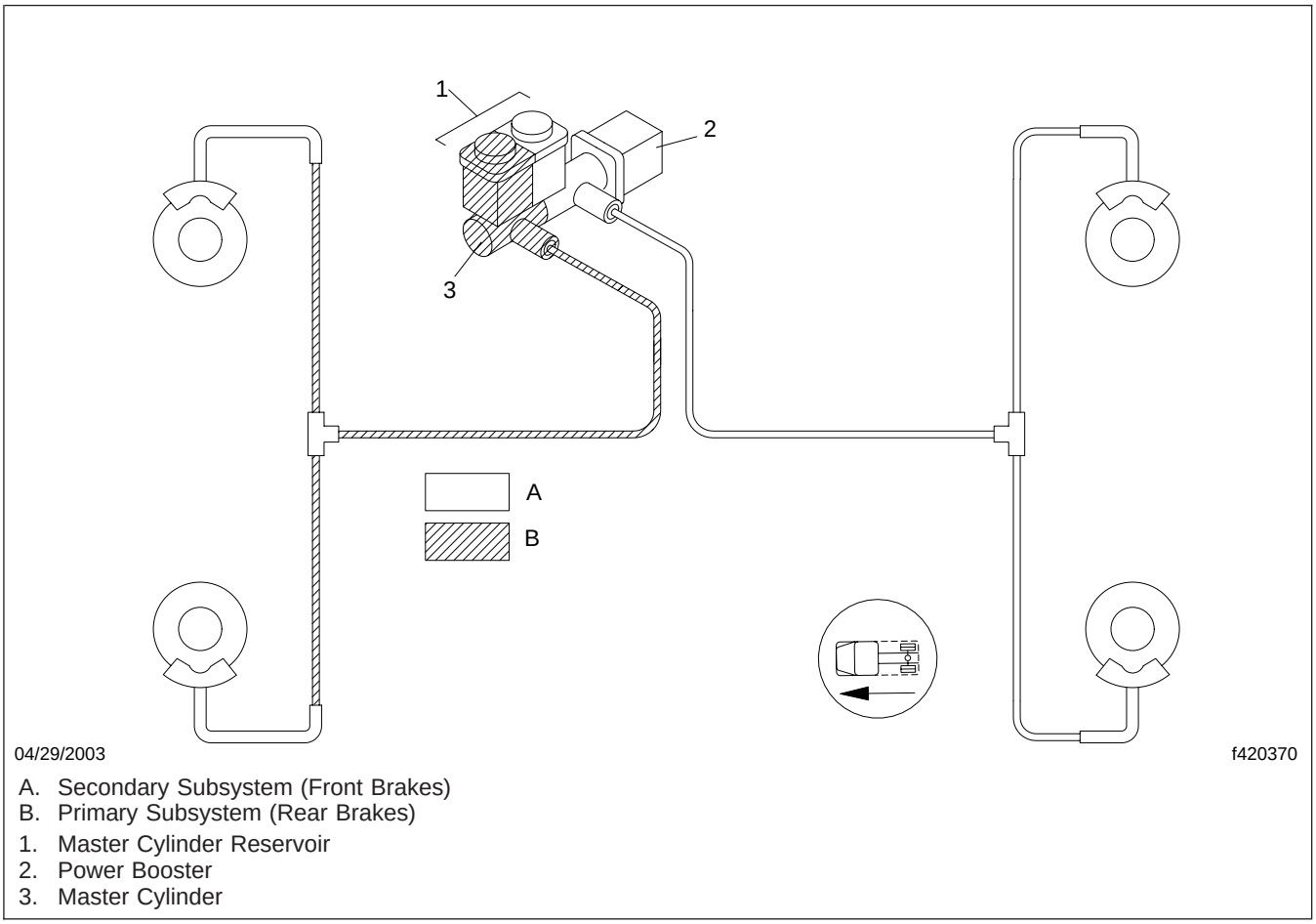
Each brake caliper assembly, attached to a wheel, consists of a housing with dual cylinders and pistons (**Fig. 6**), a supply port (**Fig. 7**, Ref. 11), and a bleeder fitting (Ref. 10). The assembly fits over the rotor (Ref. 1) like a "U", with the pistons on the inboard face of the rotor. The caliper fits onto an anchor plate (Ref. 2) at the top and bottom, and the anchor plate is attached to the axle. The caliper is held in place on the anchor plate by a key (Ref. 4), a spring (not shown), and bolt (Ref. 5). The brake pads (Refs. 6 and 9) fit into slots in the caliper housing.

BRAKE CONTROL MODULE

The brake control module, located behind dash panel B (**see Fig. 8**), monitors electronic signals from various sensors in the brake system. If a problem is detected, the module activates the applicable warning light and buzzer on the dashboard.

The control module has nine input terminals and three output terminals (one terminal is a ground). **See Fig. 9**. The output terminals are used for the brake system pressure and parking brake warning lights (**see Fig. 10**), and a buzzer; the input terminals are connected to sensors in the brake system that detect problems.

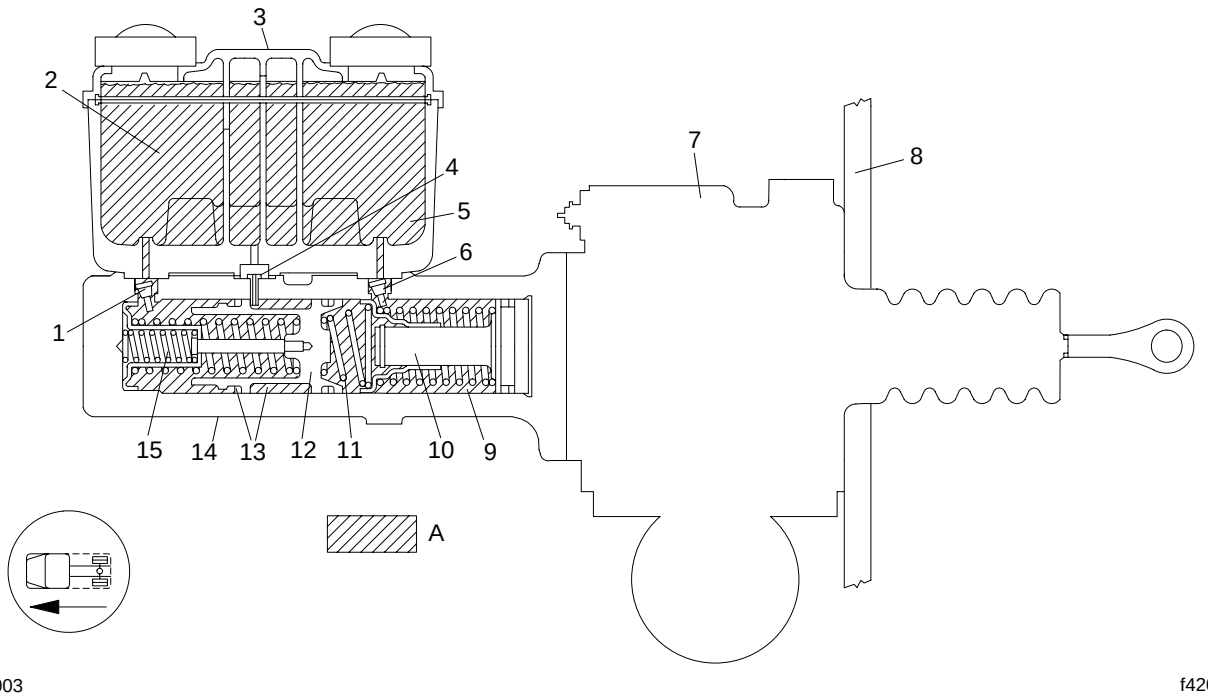
General Description and Principles of Operation



A. Secondary Subsystem (Front Brakes)
B. Primary Subsystem (Rear Brakes)
1. Master Cylinder Reservoir
2. Power Booster
3. Master Cylinder

Fig. 4

See Table 1 for identification of the output and input terminals on the back of the module, and the circuits to which they are connected.



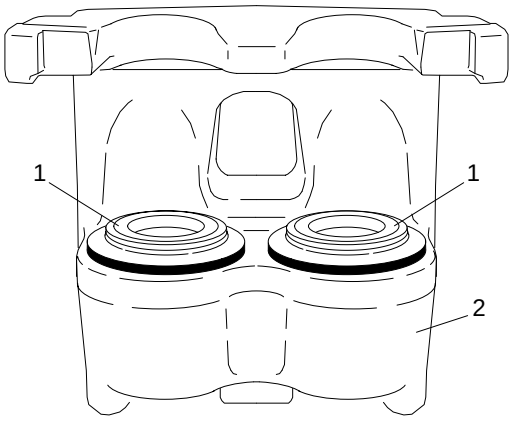
NOTE: Not all parts are shown.

A. Brake Fluid

1. Secondary Compensating Valve (open)
2. Secondary Reservoir Section
3. Brake Fluid Reservoir
4. Piston Stop
5. Primary Reservoir Section
6. Primary Compensating Valve (open)
7. Power Booster Assembly
8. Firewall
9. Primary Pressure Chamber
10. Primary Piston/Actuator Assembly
11. Primary Piston Return Spring
12. Secondary Piston/Actuator Assembly
13. Secondary Pressure Chamber
14. Housing
15. Secondary Piston Return Spring

Fig. 5

General Description and Principles of Operation



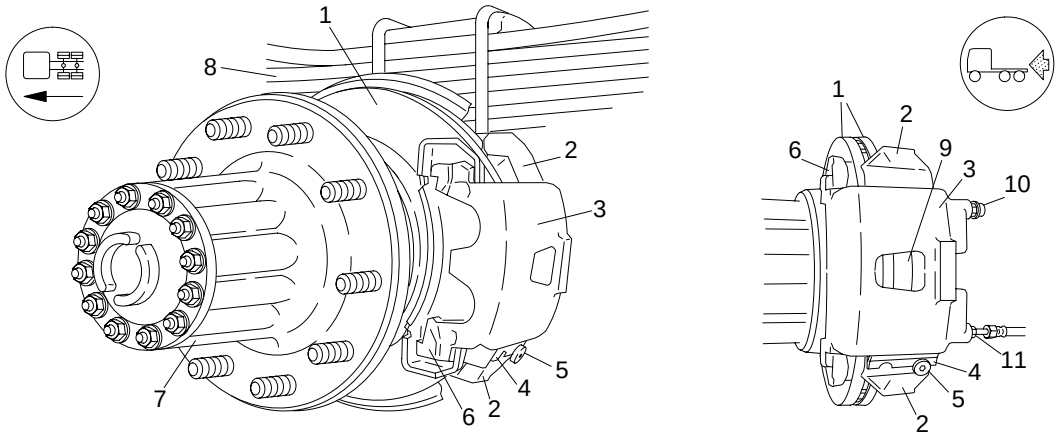
08/10/93 f420945

1. Piston
2. Housing

Fig. 6

Terminal Number	Function	Circuit Number
1	Light "P" (Parking Brake) Output	394
2	Buzzer Output	396
3	Light "R" (Brake System Pressure) Output	390
4	Ground	GND
7	Ignition Input	388
8	Parking Brake Input	309
9	Relay Input	389
10	Door Open Input	397
11	Pressure Differential Switch Input	36F
12	Brake Pedal Input	500
13	Pump Motor Input	398
14	Fluid Level Input	395
15	Flow Switch Input	393

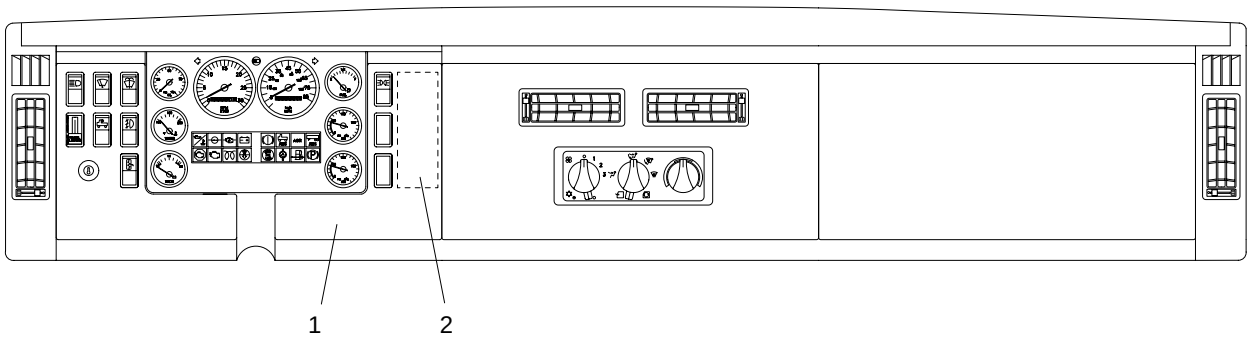
Table 1, Control Module Terminal Identification



08/10/93 f420372

1. Rotor
2. Anchor Plate
3. Caliper Assembly
4. Key
5. Bolt
6. Brake Pad (outboard)
7. Wheel Hub
8. Leaf Spring
9. Brake Pad (inboard)
10. Bleeder Fitting
11. Supply Port

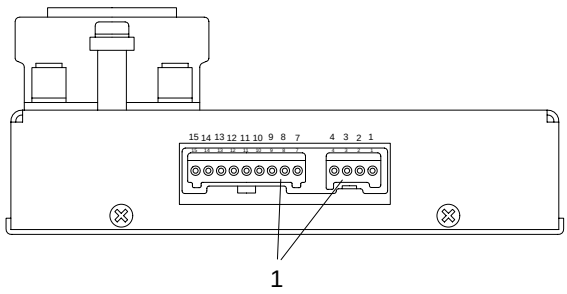
Fig. 7, Rear Brake Caliper



08/10/93 f420758

1. Panel B
2. Control Module

Fig. 8



08/10/93 f420759

1. Terminals

Fig. 9

Principles of Operation (Fig. 11)

APPLYING THE BRAKES

When the brake pedal is applied, the brake pedal rod (Ref. 11) pushes the actuator pin (Ref. 10) which pushes the reaction piston (Ref. 12) forward inside the power piston (Ref. 13). This closes the pressure valve (Ref. 16), which restricts the flow of power steering fluid through the power piston (Ref. 13). The increased fluid pressure pushes the power piston forward, through the end-cap assembly (Ref. 18), and into the master cylinder primary piston/actuator assembly (Ref. 19).

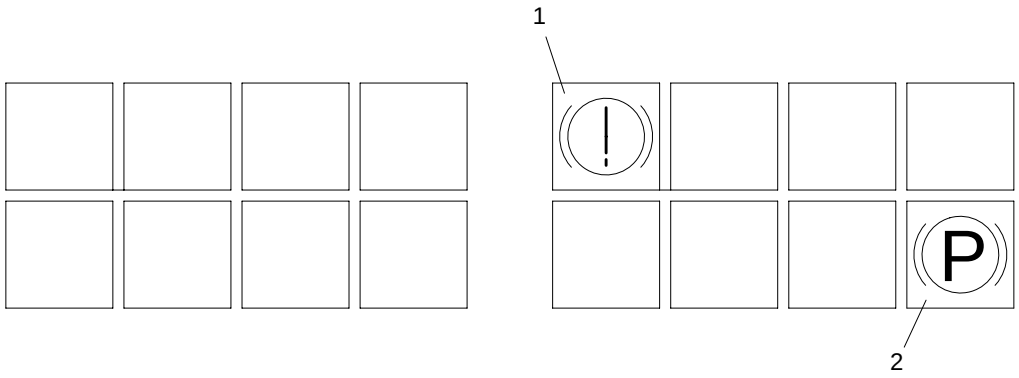
As the primary piston/actuator assembly moves forward in the master cylinder, the primary compensating valve closes (Ref. 4). This closes the outlet to the primary reservoir section (Ref. 3), and causes hydraulic pressure to build up in the primary pressure chamber (Ref. 20).

The primary piston/actuator assembly continues moving forward, and moves the secondary piston/actuator assembly (Ref. 22). This closes the secondary compensating valve (Ref. 1), pressurizing the secondary pressure chamber (Ref. 23).

The primary and secondary pressure chambers are connected by outlet ports (not shown) to the primary and secondary brake lines and caliper assemblies. When pressurized brake fluid enters the caliper housings from the brake lines, the dual pistons in each caliper move outward toward the rotors, pushing the inboard brake pads against the rotors. At the same time, the caliper assemblies slide slightly inboard, causing both inboard and outboard pads to squeeze the rotors tightly, which slows down or stops the wheels.

If for any reason the power steering pump doesn't supply the power booster with fluid, the flow switch assembly (Ref. 5) turns on the electric pump (Ref. 15) and closes the return port (Ref. 6). The check valve (Ref. 8) in the power booster supply port (Ref. 7) closes, and the check valve (Ref. 14) in the electric pump opens. The electric pump then recirculates the fluid in the power booster, maintaining emergency pressure. This provides enough reserve power for the master cylinder to pressurize the brake lines.

General Description and Principles of Operation



1. Brake System Pressure
2. Parking Brake

Fig. 10

RELEASING THE BRAKES

When the brake pedal is released, a return spring (Ref. 17) in the power booster pushes the power piston and the reaction piston (inside the power piston) toward the rear of the booster housing, and away from the master cylinder primary piston/actuator assembly. This reduces the fluid pressure in the power booster.

In the master cylinder, the return springs (Refs. 24 and 21) center the primary and secondary pistons. This opens up the primary and secondary compensating valves (Refs. 4 and 1), decreasing hydraulic pressure throughout the master cylinder. The pressure in the hydraulic lines drops, which allows the dual pistons in each caliper housing to retract. The calipers slide back outboard, and the brake pads no longer squeeze the rotors, allowing the rotors and wheel hubs to turn freely.

BRAKE CONTROL MODULE

The control module, which operates on 9 to 16 volts DC, is active (monitoring the hydraulic brake system) under any of the following conditions:

- When the ignition is on;
- When the brake pedal switch is powered;
- If the ignition is off, but the driver's door is open and the parking brake is not applied.

When the ignition is turned on, the control module starts a self-test mode, which lasts from about one to three seconds. The warning lights and buzzer come on, then go off if the system is working all right. The module then goes into the active mode, monitoring the hydraulic brake system. If a problem is detected, the applicable input or output terminal is activated, and a warning light and buzzer come on. The output terminals are activated as follows:

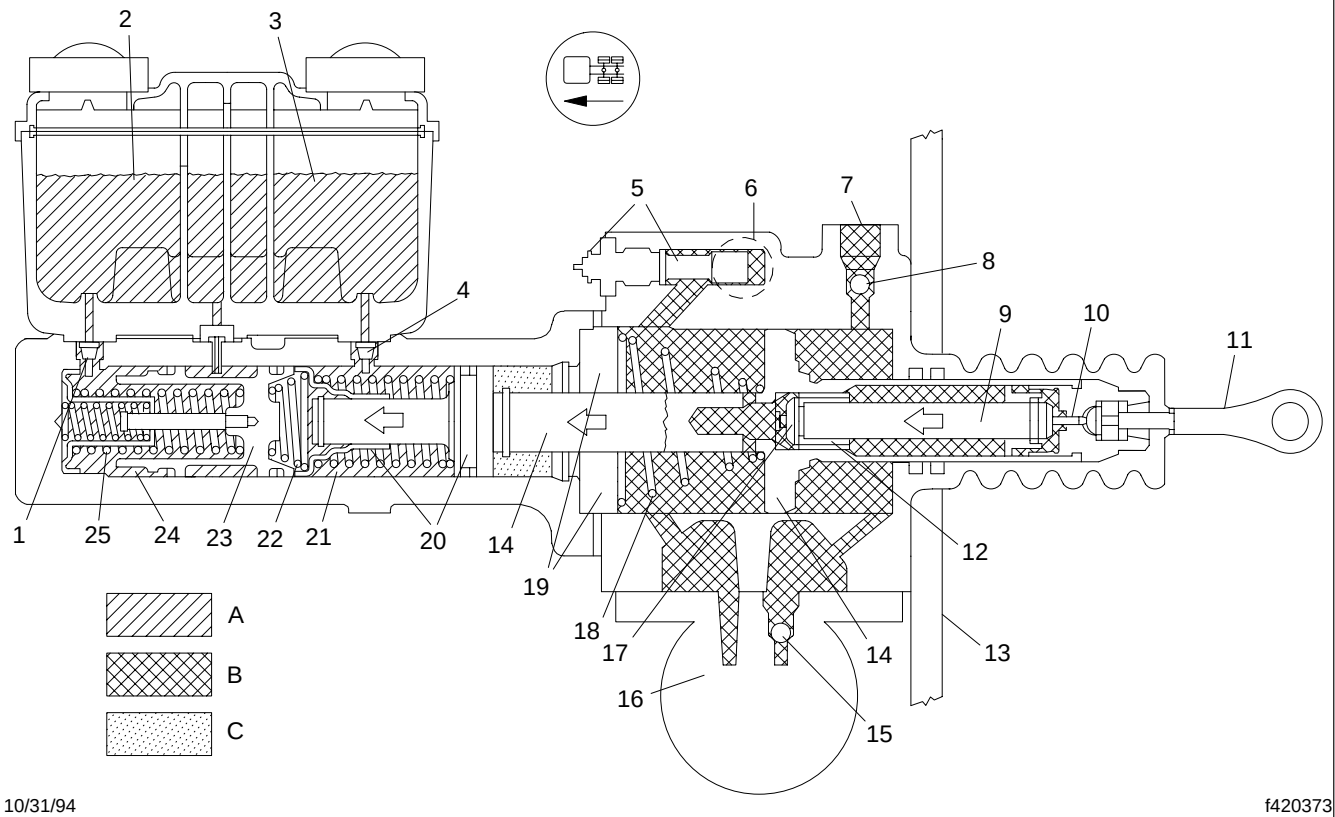
The "R" light (brake pressure) output—terminal 3—is activated when any of the following conditions exist:

- The flow switch on the power booster closes, due to a reduced flow of power steering fluid;
- The pressure differential switch on the master cylinder closes, due to a drop in pressure in either the front or rear brake system;
- The fluid level switch on the master cylinder reservoir closes, due to a drop in the fluid level;
- Too much electrical resistance is in the backup pump motor.

The "P" light (parking brake) output—terminal 2—is activated when any of the following conditions exist:

- The parking brake is applied, and the ignition is on;
- The driver's door is open, the parking brake is not applied, and the ignition is off. This condition will also cause the control module buzzer to come on.

NOTE: The vehicle is equipped with two dash buzzers: one on the control module itself, which comes on when the light "P" output (parking



NOTE: Not all parts shown.

A. Brake Fluid
B. Power Steering Fluid
C. Air Space

1. Secondary Compensating Valve
2. Secondary Reservoir Section
3. Primary Reservoir Section
4. Primary Compensating Valve
5. Flow Switch Assembly
6. Return Port
7. Supply Port
8. Check Valve (shown open)
9. Pressure Regulator Assembly
10. Actuator Pin
11. Brake Pedal Rod
12. Reaction Piston
13. Firewall
14. Power Piston
15. Check Valve (shown closed)
16. Electric Motor Pump Assembly
17. Pressure Valve
18. Return Spring
19. End-Cap Assembly
20. Primary Piston/Actuator Assembly
21. Primary Pressure Chamber
22. Primary Piston Return Spring
23. Secondary Piston/Actuator Assembly
24. Secondary Pressure Chamber
25. Secondary Piston Return Spring

Fig. 11

brake) is activated due to the driver's door being open and the parking brake not applied; and one mounted separately from the control module, which comes on when the light "R" output (brake system pressure) is activated.

See Table 2 for information on when the input terminals are activated.

General Description and Principles of Operation

Terminal Number	Function	Circuit Number	Activated if
7	Ignition Input	388	The ignition is on.
8	Parking Brake Input	309	Parking brake is applied.
9	Relay Input	389	The ignition is on or brake pedal is depressed.
10	Door Open Input	397	Driver's door open, and parking brake not applied.
11	Pressure Differential Switch Input	36F	Pressure difference between front and rear systems becomes more than 483 kPa (70 psi).
12	Brake Pedal Input	500	Brake pedal depressed.
13	Pump Motor Input	398	Electrical resistance of backup pump motor too high.
14	Fluid Level Input	395	Fluid level of master cylinder below 25 percent capacity.
15	Flow Switch Input	393	No hydraulic flow through power booster.

Table 2

Safety Precautions

Because many brake linings contain asbestos, you should know the potential hazards of asbestos and the precautions to be taken. Because medical experts believe that long-term exposure to some non-asbestos fibers could also be a health hazard, also observe the following precautions if servicing non-asbestos brake linings.

NOTE: The vehicle is originally equipped with non-asbestos brake linings.

Exposure to airborne brake lining dust can cause serious and possibly fatal diseases such as asbestosis (a chronic lung disease) and cancer.

During brake servicing, wear an air purifying respirator with high-efficiency filters. The respirator and filter must be approved by NIOSH or MSHA, and worn during all procedures.

OSHA recommends that enclosed cylinders equipped with vacuums and high-efficiency particulate air (HEPA) filters be used during brake repairs. Under this system, the entire brake assembly is placed within the cylinder and the mechanic works on the brake through sleeves attached to the cylinder. Compressed air is blown into the cylinder to clean the assembly, and the dirty air is then removed from the cylinder by the vacuum.

If such an enclosed system is not available, or can't be used, clean the brake assembly in the open air. During disassembly, carefully place all parts on the floor to minimize creating airborne dust. Using an industrial vacuum cleaner with an HEPA filter system, remove dust from the brake rotors, caliper assemblies, dust shields, and brake pads. After vacuuming, remove any remaining dust using a rag soaked in water and wrung until nearly dry.

⚠ WARNING

WARNING: Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by NIOSH or MSHA. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

Hydraulic brake fluid is hazardous, and can cause blindness if it gets in your eyes. Always wear safety glasses when handling brake fluid or bleeding brake components. Brake fluid may also be a skin irritant. If you get it on your skin, wash it off as soon as possible.

Special care must be taken when disposing of used brake fluid. Put the fluid in a sealed plastic container and label it "Used Brake Fluid." Then dispose of it in an approved manner. Check with local and state regulations as to the correct disposal procedure.

Hydraulic System Bleeding

⚠ WARNING

WARNING: Before doing any of the work below, read the information under "Safety Precautions, 100". Failure to read the safety precautions, and to be aware of the dangers of brake fluid, could result in injury.

Whenever any hydraulic system fitting is loosened or disconnected, the entire system must be bled to remove any air that may have entered it.

⚠ CAUTION

CAUTION: Power steering fluid and brake fluid are incompatible. Never mix these two fluids, or serious damage to both hydraulic systems will result. Use only brake fluid for the master cylinder and brake lines. Use only power steering fluid for the power booster.

Always use new, clean brake fluid that meets DOT 3 specifications when bleeding the master cylinder and service brake system. Never reuse brake fluid, and don't use brake fluid containers for any other purpose. Keep brake fluid containers tightly closed to keep new brake fluid clean and dry.

IMPORTANT: Don't let brake fluid touch any painted surfaces, as it will remove the paint. Brake fluid may also damage certain non-metal surfaces. Don't let it get on brake pads or rotors.

PRESSURE BLEEDING, SERVICE BRAKE SYSTEM

Pressure bleeding is the preferred method for bleeding the service brake system. It requires the use of a special pressure bleeder kit, consisting of a tank, pressure pump and valve, gauge, tubing, and adapter. These are available from a number of manufacturers, and include instructions for use. **See Fig.1 .**

1. Apply the parking brake, chock the tires, and tilt the hood.
2. Connect the pressure bleeder to the brake master cylinder reservoir, following the manufacturer's instructions.
   - 2.1 Fill the pressure bleeder with new DOT 3 approved brake fluid, then pressurize it according to the manufacturer's instructions.

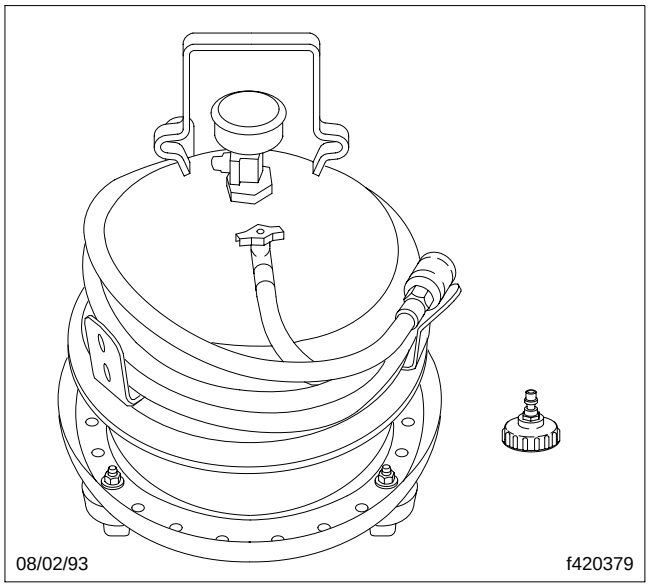


Fig. 1

   - 2.2 Using the supplied adapter, connect the pressure bleeder to the rear compartment of the master cylinder reservoir.
3. Bleed the hydraulic connections at the rear wheel calipers, starting on the right side.
   - 3.1 Put a wrench on the bleeder fitting at the caliper, then attach a length of clear tubing to the bleeder fitting. Make sure the tube fits snugly. Submerge the tubing in a container of clean brake fluid. **See Fig.2.**
   - 3.2 Loosen the bleeder fitting about 3/4 turn, and let the brake fluid flow out of the fitting until it is free of air bubbles. **See Fig.2and Fig. 3.** Then tighten the fitting firmly.
   - 3.3 Move to the left rear caliper, and repeat steps for bleeding the caliper.

Hydraulic System Bleeding

4. Disconnect the pressure bleeder from the rear compartment of the master cylinder reservoir, then connect it to the front compartment of the reservoir.
5. Bleed the front wheel brake calipers, starting at the right side.

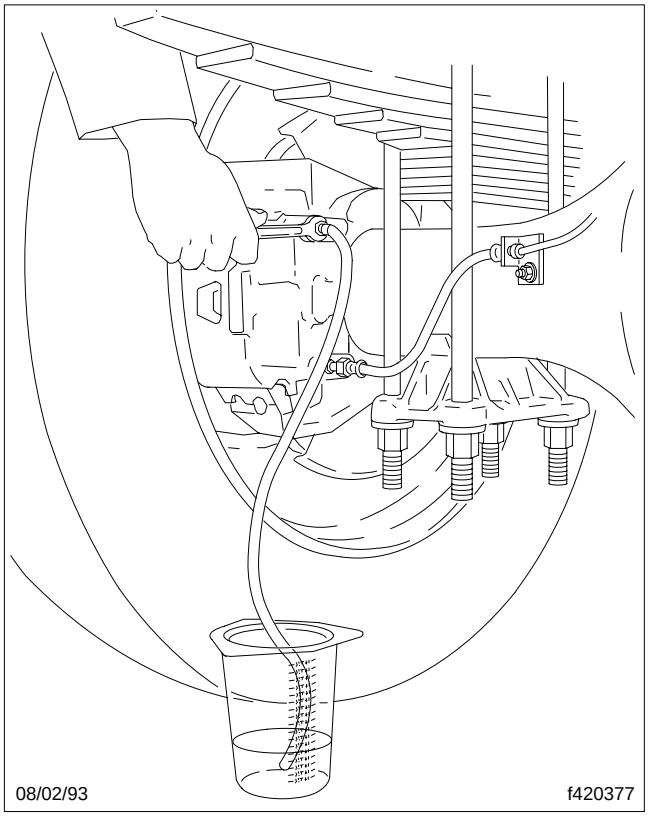


Fig. 2

5.1 Put a wrench on the bleeder fitting at the caliper, then attach a length of clear tubing to the bleeder fitting. Make sure the tube fits snugly. Submerge the tubing in a container of clean brake fluid. **See Fig.2 .**

5.2 Loosen the bleeder fitting about 3/4 turn, and let the brake fluid flow out of the fitting until it is free of air bubbles. **See Fig.2and Fig. 3.** Then tighten the fitting firmly.

5.3 Move to the left front wheel caliper, and repeat steps for bleeding the caliper.

6. Check the brake fluid level in both compartments of the reservoir. Add new DOT 3 approved brake fluid if needed.
7. Check the operation of the brakes by depressing the brake pedal several times, until if feels firm. The brake pedal should not go all the way down to the floor. If it does, go to **"Troubleshooting, 300"** and find the problem.

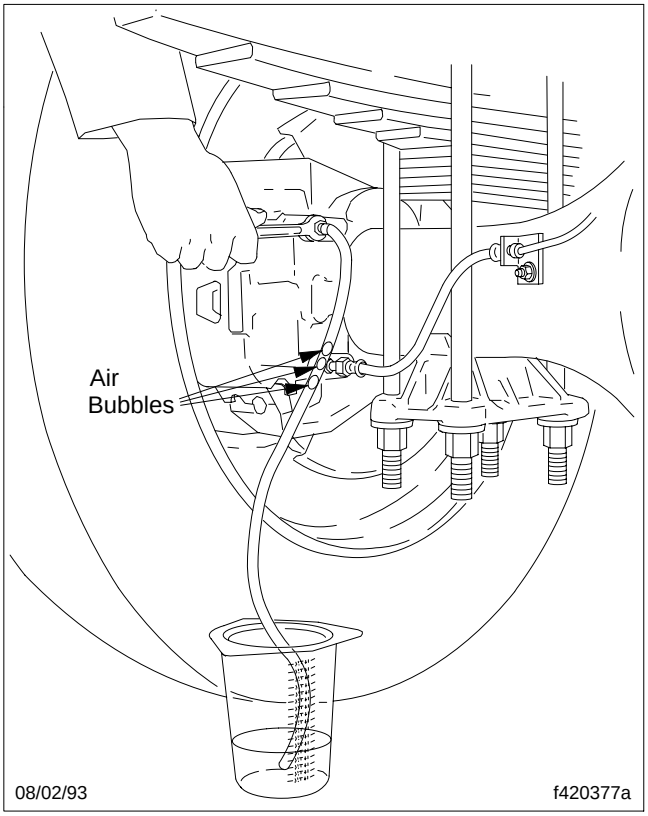


Fig. 3

8. Lower the hood and remove the chocks.

MANUAL BLEEDING, SERVICE BRAKE SYSTEM

If you don't have pressure bleeding equipment, you can use the manual bleeding procedure.

⚠ WARNING

WARNING: Read over the information under "Safety Precautions, 100" before starting the procedure below. Failure to do so may result in

either serious injury to yourself, or damage to the brake system, resulting in an accident causing serious personal injury or property damage.

IMPORTANT: Don't let the brake master cylinder run dry during manual bleeding operations. Keep the master cylinder reservoir filled with new, DOT 3 approved brake fluid. Failure to keep the brake reservoir filled could result in more air entering the system, making it impossible to effectively bleed the system.

1. Apply the parking brake, chock the tires, and tilt the hood.
2. Bleed the master cylinder.
   - 2.1 Using a wrench (and a rag to absorb leaking brake fluid), loosen the fitting at the rear outlet port on the master cylinder. **See Fig. 4 .** Loosen the fitting about one turn.
   - 2.2 Have someone push the brake pedal down slowly— by hand— to the floor. Brake fluid, and any air in the master cylinder, will squirt from the fitting.
   - 2.3 *With the brake pedal held down,* tighten the rear hydraulic line fitting firmly.

   IMPORTANT: Don't release the brake pedal until the fitting is tightened, or more air will get into the system.
   - 2.4 Release the brake pedal.
   - 2.5 Loosen the fitting again, and repeat steps for bleeding as required until no air escapes from the fitting, and the brake pedal feels firm.
   - 2.6 Check the level of the rear compartment of the reservoir, then add new DOT 3 approved brake fluid if needed.
   - 2.7 Using a wrench (and a rag to absorb leaking brake fluid), loosen the fitting at the front outlet port on the master cylinder. **See Fig. 5 .** Loosen the fitting about one turn.
   - 2.8 Repeat steps as required for the front outlet port.
   - 2.9 Check the brake fluid level in the front compartment of the reservoir. Add new DOT 3 approved brake fluid if needed.
3. Bleed the hydraulic connections at the wheel calipers, starting at the right rear wheel caliper.
   - 3.1 Put a wrench on the bleeder fitting at the caliper, then attach a length of clear tubing to the bleeder fitting. Make sure the tube fits snugly. Submerge the tubing in a container of clean brake fluid. **See Fig. 2 .**
   - 3.2 Loosen the bleeder fitting about 3/4 turn.

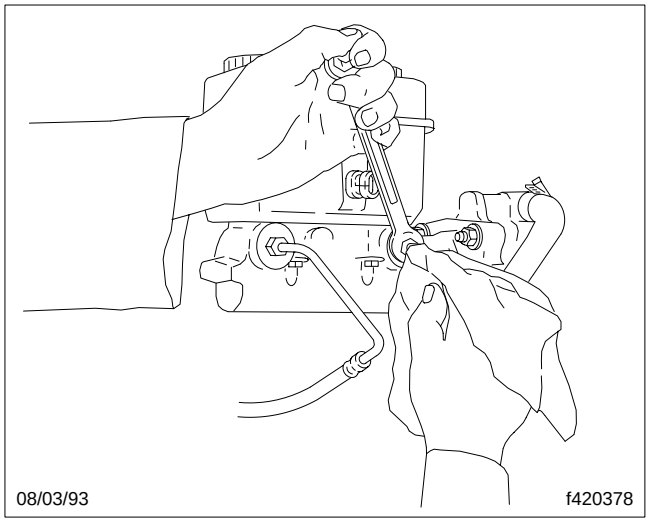


Fig. 4

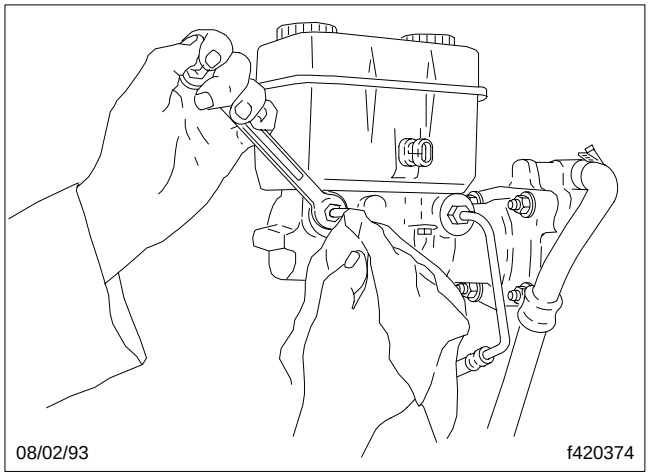


Fig. 5

Hydraulic System Bleeding

3.3 Have someone slowly push the brake pedal to the floor, then *with the brake pedal depressed,* tighten the bleeder fitting.

IMPORTANT: Make sure the brake pedal stays depressed while you tighten the fitting. If it's released before you tighten the fitting, more air will get into the system.

3.4 Release the brake pedal. Check the fluid in the tube. If there are air bubbles present **(Fig.3),** repeat steps as required until the fluid in the tube is completely free of air bubbles, **as shown in Fig.2.**

3.5 Check the brake fluid level in the reservoir. Add new DOT 3 approved brake fluid if needed.

3.6 Repeat steps for bleeding the connections for the left rear caliper, then the right front caliper, and finally for the left front caliper.

4. Lower the hood and remove the chocks.

Booster Bleeding

⚠ WARNING

WARNING: Use only clean, approved power steering fluid for the procedure below. Do not use brake fluid. Mixing brake fluid with power steering fluid will damage the seals and O-rings in the power booster, the power steering pump, and the power steering gear, resulting in possible loss of steering.

1. Apply the parking brake, chock the tires, and tilt the hood.
2. Check the level of fluid in the power steering reservoir. **See Fig. 1 .** If needed, fill it with approved power steering fluid. **See "Specifications, 400"** for approved power steering fluid.
3. Crank the starter several times, but don't start the engine.
4. Check the fluid level in the power steering reservoir. Fill it if needed.
5. Crank the starter and check the fluid level again.
6. Check the operation of the brakes.
   - 6.1 With the engine off, depress the brake pedal. The dash warning light and buzzer should come on, and the electric motor assist should come on.
   - 6.2 Start the engine. Depress the brake pedal. The dash warning light and buzzer should not come on; neither should the electric motor. If they do, go to **"Troubleshooting, 300"** and find the problem; otherwise, stop the engine. Check the fluid level in the power steering reservoir. Fill it if needed.
7. Lower the hood, then remove the chocks.

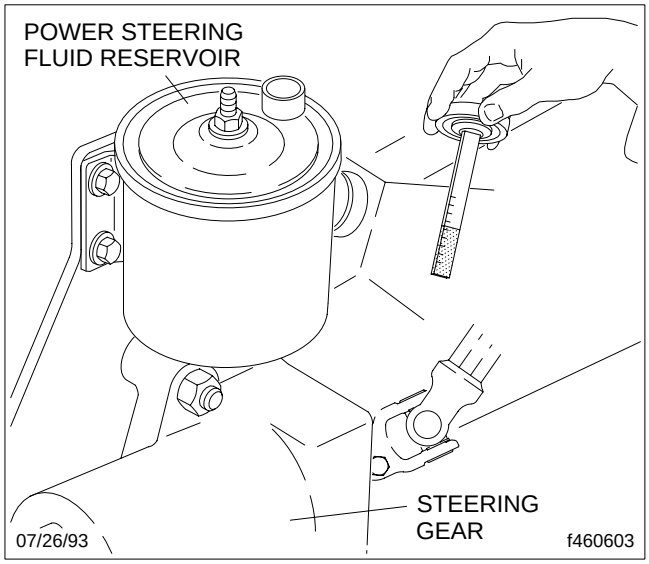


Fig. 1

Replacing Hydraulic Lines

POWER BOOSTER SYSTEM

The power booster is plumbed into the power steering system, and uses the same type of high pressure rubber hoses as that system.

The power booster has two hoses connected to it: one from the steering gear to the booster supply port, and one from the booster return port to the power steering reservoir. See **Fig. 1**.

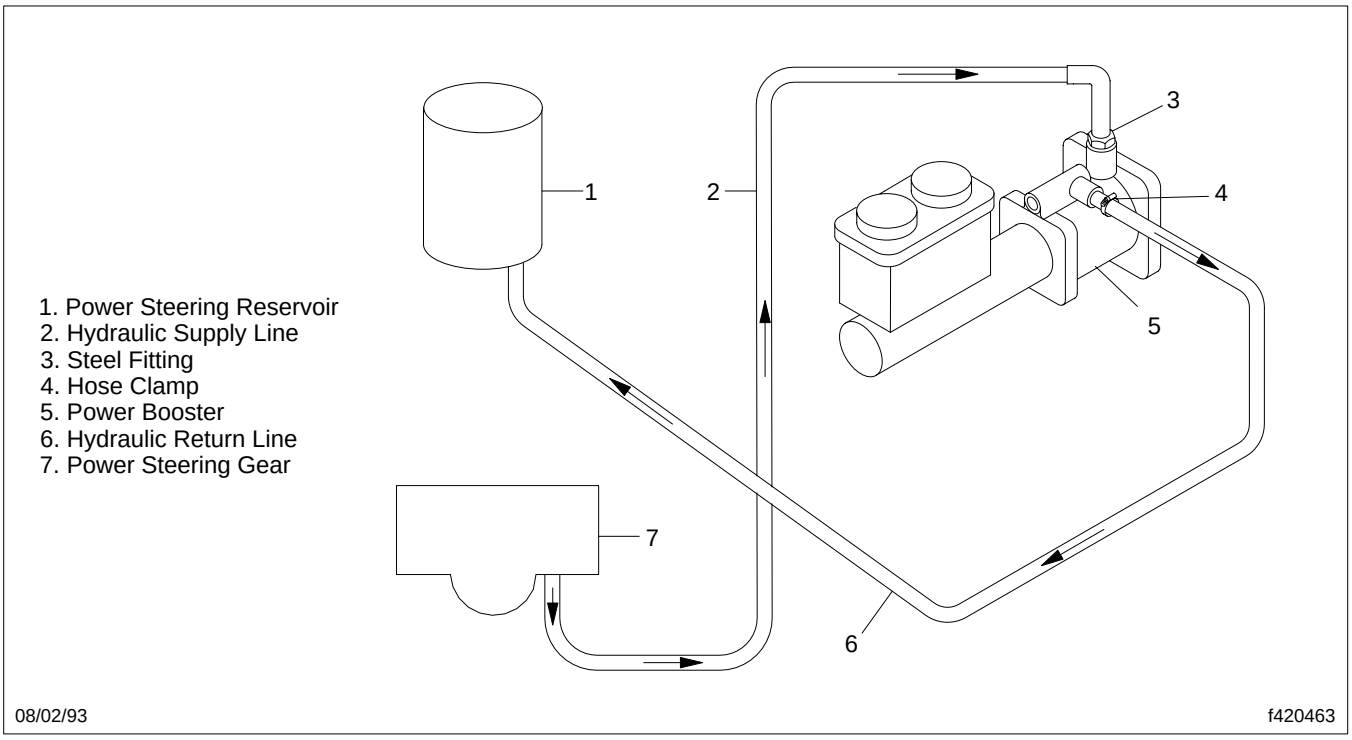


Fig. 1

1. Apply the parking brake, chock the tires, and tilt the hood.
2. Replace the power booster hoses if they are leaking or show signs of cracking, softening, or bulging. Replace the entire hose if there are problems; don't repair it.

   2.1 Remove all hose clamps and tie straps used for routing the hose.

   2.2 Using a shop towel over the fittings to catch any power steering fluid, disconnect both ends of the hose being replaced.

   2.3 Install the new hose.

   If replacing the booster supply hose, tighten the supply port connection 22 lbf·ft (30 N·m), and the outlet connection on the power steering gear 41 lbf·ft (56 N·m).

   If replacing the booster return hose, tighten the hose clamps at the booster return fitting and the power steering reservoir firmly.

   2.4 Install the hose clamps and replace any tie straps removed above.

   Check the routing of the hose. Make sure it's away from heat sources and moving parts, such as the steering driveline.
3. Bleed the power booster system, following instructions in **Subject 115**.
4. Lower the hood, then remove the chocks.

Replacing Hydraulic Lines

SERVICE BRAKE SYSTEM

The service brake system has two types of hydraulic brake lines: rigid steel tubing and flexible rubber hose. See **Fig. 2**.

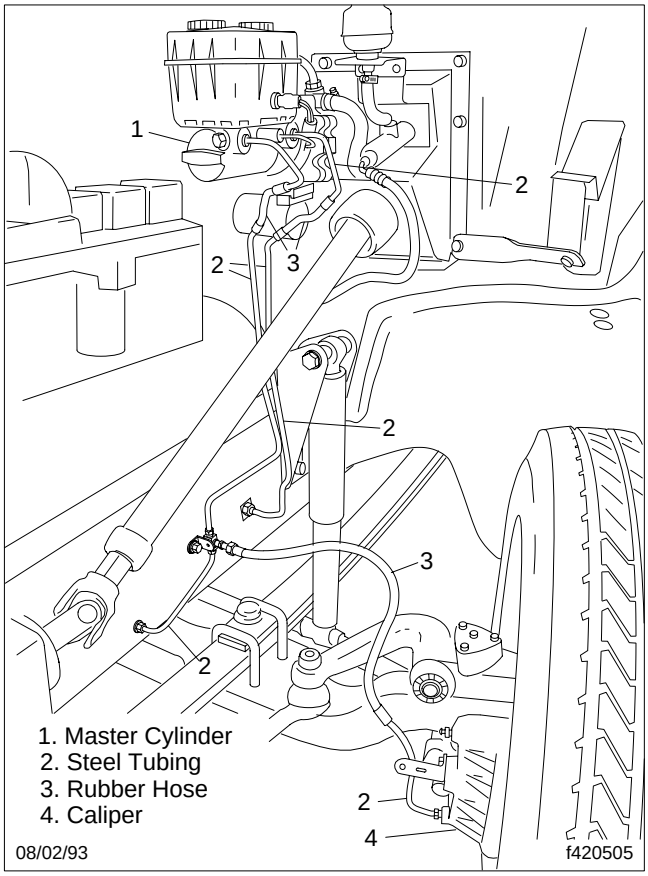


Fig. 2

The steel brake lines are 1/4-inch o.d. double-walled tubing, and run from the master cylinder to points on the chassis near each wheel. The rubber brake hoses are 1/8-inch i.d. low-expansion rubber; they connect the end of each rigid line to the caliper assembly at each wheel.

If a brake line is leaking, replace the whole section of line. Replace flexible brake hoses if they show signs of cracking, softening, or bulging.

1. Apply the parking brake and chock the tires.
2. Locate the leak in the brake line, then determine the length and configuration (if a steel line) of the section involved.
3. If necessary, loosen and remove any brackets holding the brake line to the frame or axle, so that you can remove the damaged section.
4. Put a container under the connection on one side of the leak, then disconnect the line. Plug both ends of the connection.

   Repeat at the connection on the other side of the leak.
5. Remove the plugs installed earlier, then install the new section of brake line, and tighten the connections 15 lbf·ft (20 N·m).
6. Install any brackets that were removed above.
7. Bleed the brake system, following the procedure in **Subject 110**.

Replacement

WARNING

WARNING: Before starting the procedure below, read the information in "Safety Precautions, 100." Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

IMPORTANT: When replacing brake pads, always replace them on both wheels of the axle (right and left side). If the brake pad linings are worn down to the minimum thickness of 1.6 mm (1/16 inch), you must also rebuild the calipers, as dirt has probably gotten into the caliper cylinders. Refer to **"Brake Caliper Removal and Installation, 140"** and **"Brake Caliper Rebuild, 142"** for instructions.

1. Apply the parking brake and chock the tires of the axle you will not be working on.
2. Remove the brake caliper from the wheel. Refer to **"Brake Caliper Removal and Installation, 140"** for instructions.
3. Remove the brake pads.
   - 3.1 Remove the outboard brake pad from the caliper assembly.
   - 3.2 Pull the inboard pad away from the rotor and the anchor plate. **See Fig. 1 .**
4. Using a wet rag that is wrung out until nearly dry, clean the caliper housing (especially around the piston boots), and the dust shield.
5. Check the rotor.
   - 5.1 Check the rotor surface for discoloration, cracks, scoring, and heat checking. **See Fig. 2 .**

     If the rotor is cracked, has a bluish color, or has severe heat checking, replace it. If it has minor heat checking or is scored **(refer to Fig. 2),** have it resurfaced.

     IMPORTANT: If the rotor will be 33.5 mm (1.32 inches) or less after it's resurfaced, replace it.
   - 5.2 Using a vernier caliper, check the thickness of the rotor. If it is less than 33.5 mm (1.32 inches) thick, replace it.

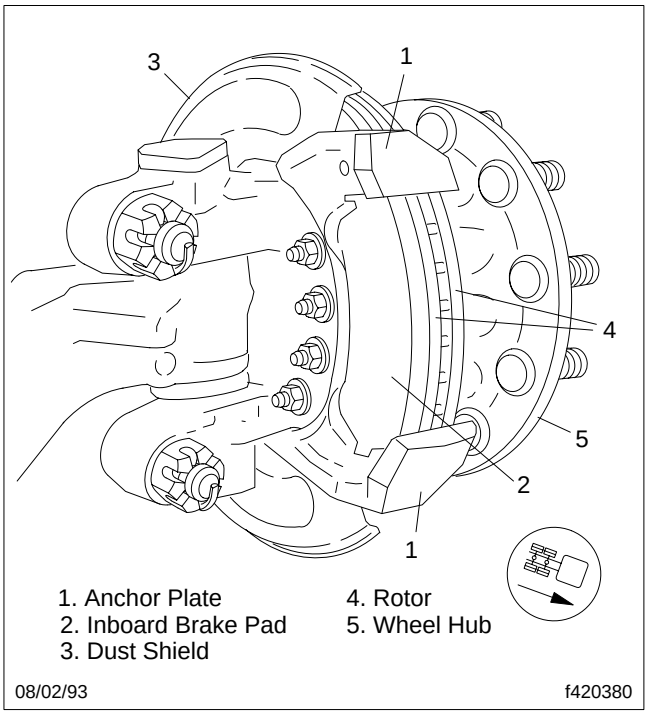


Fig. 1, Left Front Wheel Shown; Caliper Removed

   - 5.3 Check for runout and parallelism. Refer to **"Brake Rotor Runout and Parallelism Checking, 152"** for instructions.
6. Check the caliper.
   - 6.1 Check the piston dust boots for cracks or leaks. **See Fig. 3 .** Also check the piston heat shields for damage. If a problem is found, disconnect the brake hose from the caliper, plug the hose, then rebuild the caliper, following the instructions under **"Brake Caliper Rebuild, 142."**
   - 6.2 Check the supply port and bleeder fitting **(Fig. 4)** on the caliper housing for damage or leaks. If a problem is found, replace the fitting, following the instructions under **"Brake Caliper Rebuild, 142."**
7. Clean and lubricate the sliding surfaces (V-ways) of the caliper housing and the anchor plate rails with anti-corrosion grease. **See Fig. 5 .**

Brake Pad Replacement

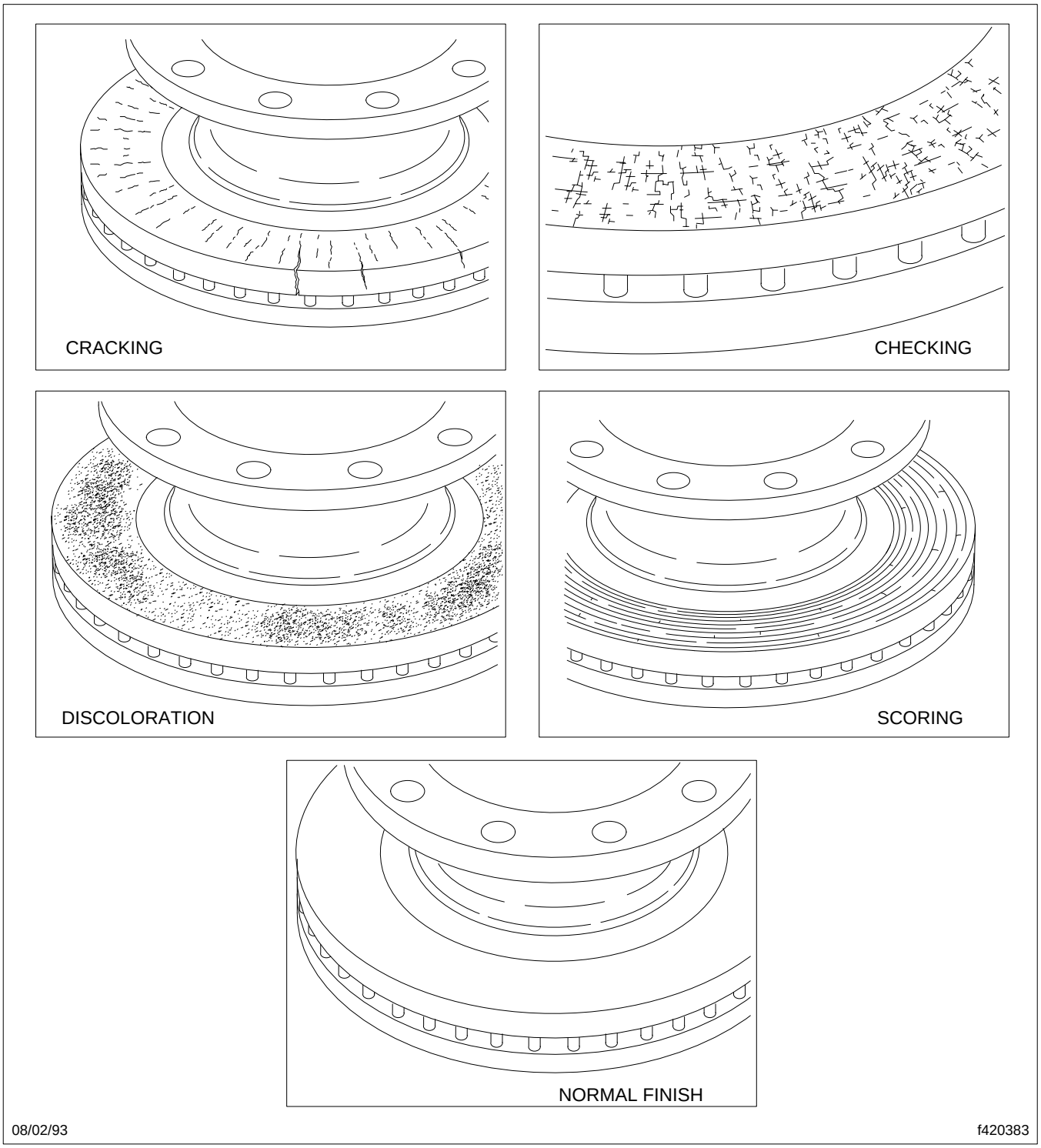
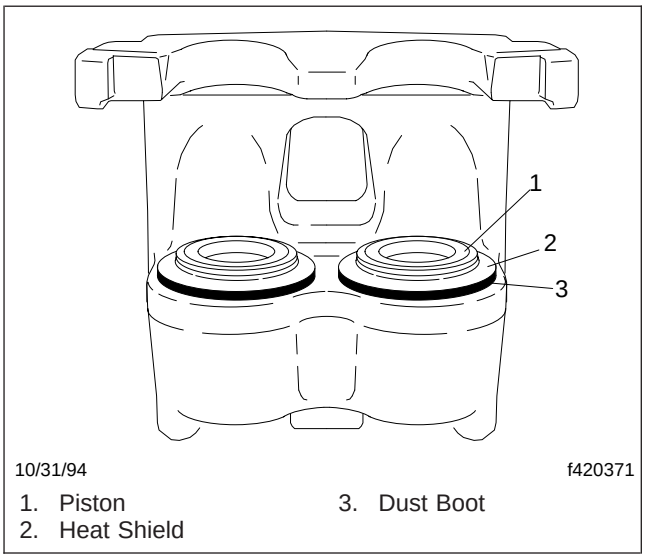
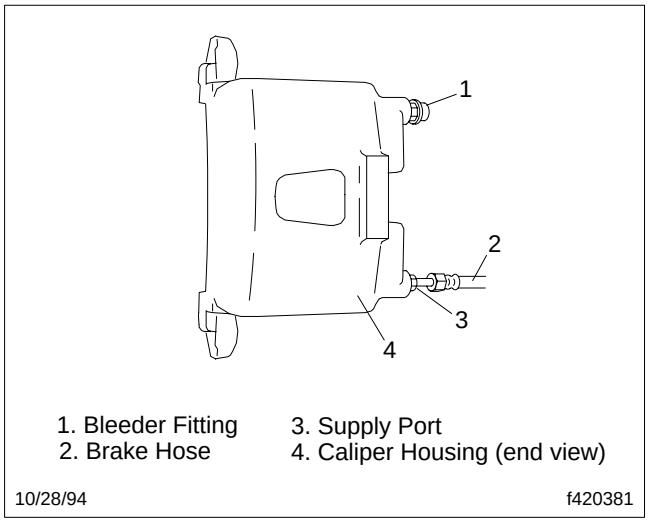


Fig. 2



1. Piston
2. Heat Shield
3. Dust Boot

Fig. 3



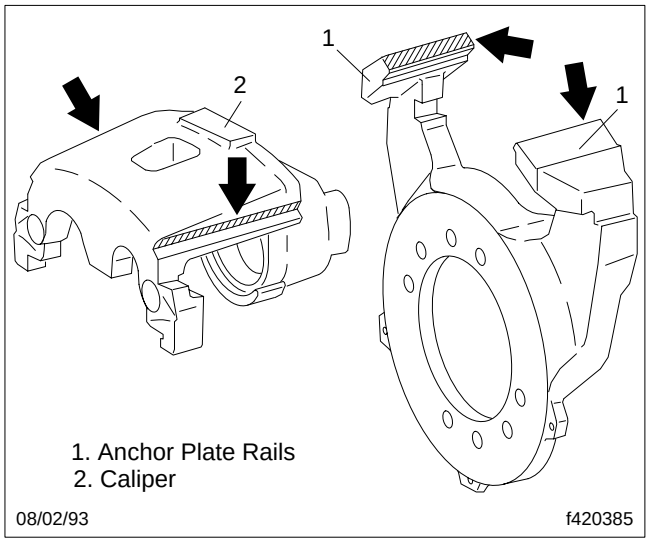
1. Bleeder Fitting
2. Brake Hose
3. Supply Port
4. Caliper Housing (end view)

Fig. 4

7.1 Using a fine file or emery cloth, clean the sliding surfaces (V-ways) of the caliper housing, and the corresponding surfaces of the anchor plate.

7.2 Grease the surfaces lightly with anti-corrosion grease.

8. Install the new brake pads.



1. Anchor Plate Rails
2. Caliper

Fig. 5

⚠ WARNING

WARNING: Don't get any dirt, oil, grease, or brake fluid on the brake lining material or the rotor surfaces. To do so could cause loss of brake control, which could result in an accident causing personal injury or property damage.

8.1 Install the inboard (smaller) brake pad into the mating notches of the anchor plate, **as shown in Fig. 1 .** Make sure the pad lining is facing the rotor.

8.2 Using a piece of wood and a C-clamp, push the pistons all the way into the caliper housing. **See Fig. 6 .** Be careful not to damage the piston heat shields. Remove the C-clamp and block of wood.

8.3 Install the outboard (larger) brake pad in the housing, with the pad lining facing the piston, **as shown in Fig. 7 .**

9. Install the caliper, following the instructions under **"Brake Caliper Removal and Installation, 140."**

10. Install the tires, then remove the jackstands and lower the vehicle. Remove the chocks.

11. Pump the brake pedal until it feels firm. If it doesn't get firm, check for leaks or air in the brake system. Repair any leaks, if needed, then

Brake Pad Replacement

bleed the system, following the instructions under **"Hydraulic System Bleeding, 110."**

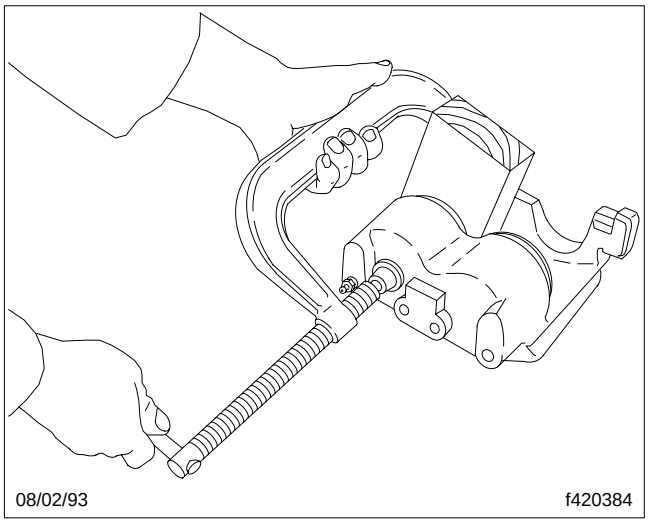
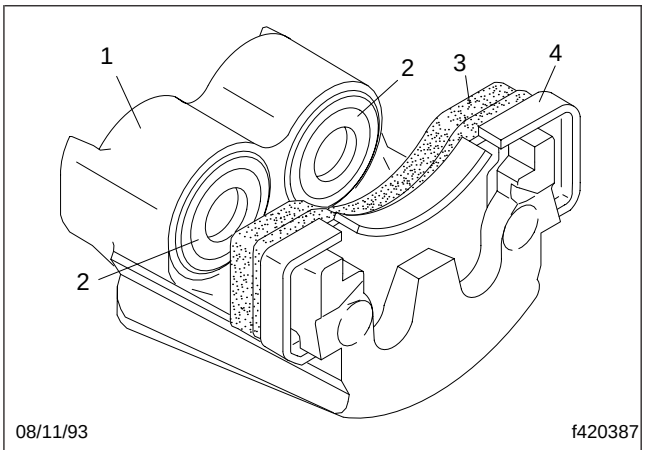


Fig. 6



1. Caliper Housing
2. Piston
3. Brake Pad Lining
4. Outboard Brake Pad

Fig. 7

⚠ WARNING

WARNING: Do not move the vehicle until the brake pedal feels firm. To do otherwise could result in loss of vehicle control, causing an accident resulting in personal injury or property damage.

12. Road test the vehicle, and seat the brake pads.

Accelerate the vehicle to 30 mph (48 km/h), then brake to a stop, using medium brake pedal pressure. *Do not slam on the brakes.*

Repeat this step between 20 and 30 times, allowing a one-minute interval between brake applications.

Brake Caliper Removal and Installation

Removal

⚠ WARNING

WARNING: Before starting the procedure below, read the information in "Safety Precautions, 100." Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

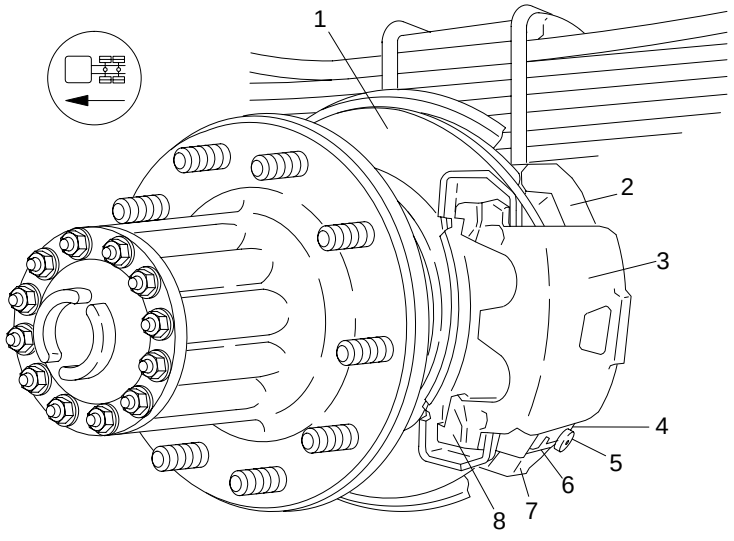
1. Apply the parking brake, chock the tires, and tilt the hood.
2. If you are removing the rear wheel caliper(s), remove half the fluid from the rear section of the master cylinder reservoir. If you are removing the front wheel caliper(s), remove half the fluid from the front section.
3. Chock the front or rear tires, depending on which axle you are working on. Then jack up the axle, and support it with jackstands.
4. Remove the tires.
5. Remove the brake caliper.
   - 5.1 If you are going to do work on the caliper, disconnect and plug the brake supply hose; otherwise, leave it attached.
   - 5.2 Remove the allen-head bolt that holds the key and spring assembly in place (on the upper anchor plate rail for the front wheel; on the lower rail for the rear wheel). **See Fig.1.**
   - 5.3 Using a punch, drive out the key and spring from between the caliper and the anchor plate rail, **as shown in Fig.2.** Save the parts.
   - 5.4 Tilt the caliper up so the outboard brake pad clears the rotor, then slide the caliper off the anchor plate rails. **See Fig.3.** Be careful not to stretch the brake hose.

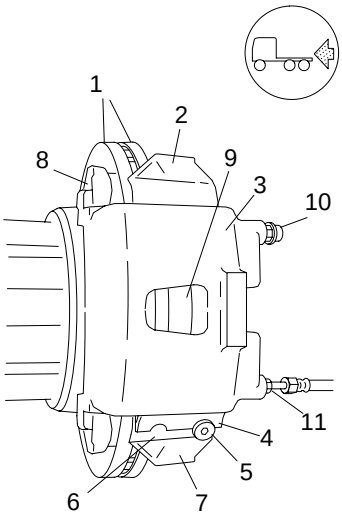
     The inboard brake pad will stay in place between the upper and lower rails of the anchor plate.
   - 5.5 If the brake supply hose is attached, support the caliper with a wire, or rest it on the axle suspension. *Don't let the caliper hang by its brake hose.*
6. Remove the outboard brake pad from the caliper housing.
7. Remove the inboard brake pad from the anchor plate. **See Fig.4.**

Installation

1. Check the brake pad linings for wear and damage.
   - 1.1 Check the linings for wear. If they are 1.6 mm (1/16 inch) or less thick, replace the brake pads, following the instructions under **Subject 130.**
   - 1.2 Check the linings for pits, cracks (**see Fig.5**), separation of the material (delaminating), or other damage. Replace the brake pads if they are damaged.
   - 1.3 Check the linings for glazing. If they are glazed but not otherwise damaged, deglaze the linings, using deglazing compound. Follow the manufacturer's directions.
2. Check the caliper.
   - 2.1 Check the piston dust boots for damage or leaks. **See Fig.6.** If a problem is found, rebuild the caliper, following the instructions under **Subject 142.**
   - 2.2 Check the bleeder fitting for leaks or damage. If there are signs of leakage, check the tightness of the fitting. If the fitting is damaged, replace it. Refer to **Subject 142** for instructions.
3. Check the rotor, following the instructions under **Subject 130.**
4. Clean and lightly lubricate the sliding surfaces (V-ways) of the caliper housing and the anchor plate rails with Aeroshell Grade 5 (ES-1246) grease (don't use any type of anti-seize compound, such as Never-Seeze). **See Fig.7.**
   - 4.1 Using a fine file or emery cloth, clean the sliding surfaces (V-ways) of the caliper housing, and the corresponding surfaces of the anchor plate rails.
   - 4.2 Grease the surfaces lightly with Aeroshell Grade 5 (ES-1246) grease (don't use any

Brake Caliper Removal and Installation

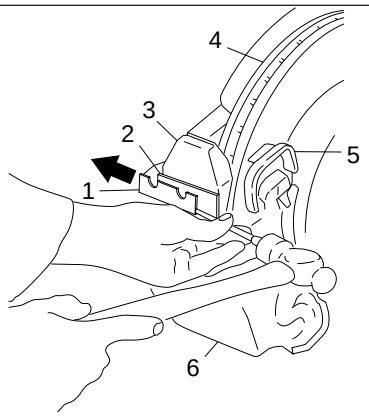




08/11/93 f420478

1. Rotor
2. Upper Anchor Plate Rail
3. Caliper Housing
4. Key
5. Allen-Head Bolt
6. Spring
7. Lower Anchor Plate Rail
8. Outboard Brake Pad
9. Inspection Hole
10. Bleeder Fitting
11. Supply Port

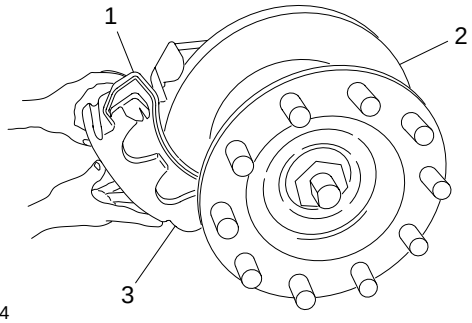
Fig. 1, Rear Caliper Shown



08/11/93 f420546

1. Key
2. Spring
3. Upper Rail of Anchor Plate
4. Rotor
5. Outboard Brake Pad
6. Caliper Housing

Fig. 2, Front Caliper Shown

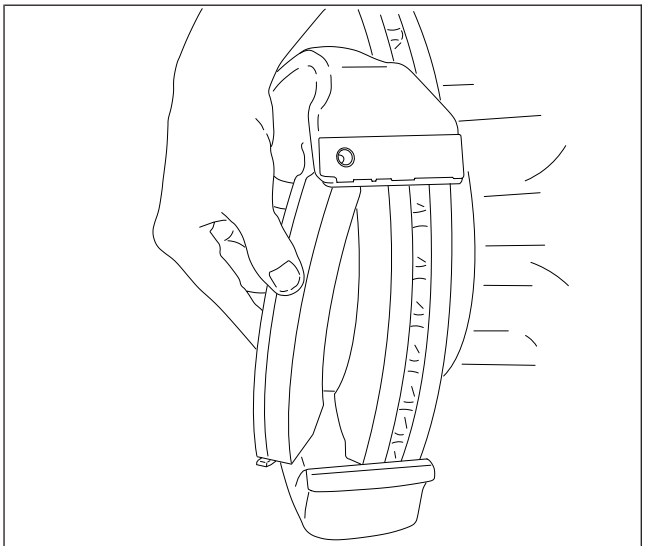


10/28/94 f420538

1. Outboard Brake Pad
2. Rotor
3. Caliper

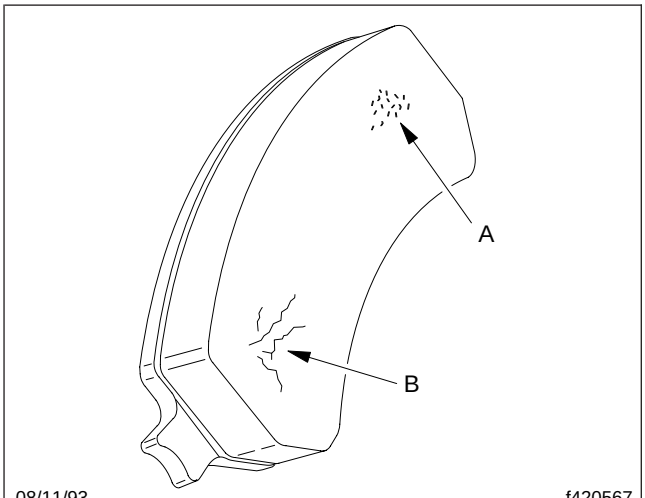
Fig. 3

type of anti-seize compound, such as Never-Seeze).



08/11/93 f420594

Fig. 4

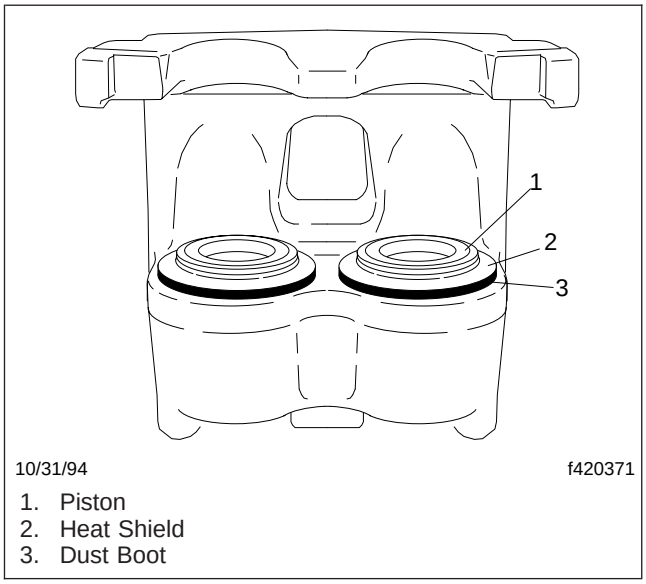


08/11/93 f420567

A. Pits
B. Cracks

Fig. 5

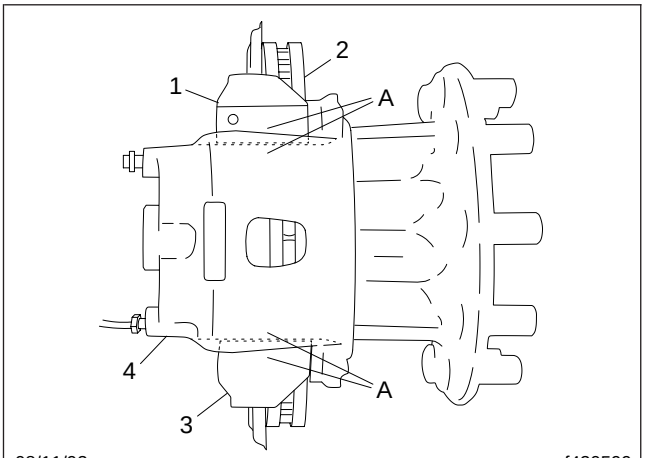
5. Install the inboard (smaller) brake pad between the upper and lower rails of the anchor plate. Make sure the lining material is facing the rotor.
6. Install the caliper.
   6.1 Using a piece of wood and a C-clamp, push the pistons all the way into the caliper housing. **See Fig.8.** Be careful not to damage the piston heat shields (**Fig. 6**, Ref. 2).
   6.2 Install the outboard (larger) brake pad in the housing, with the pad lining facing the piston, **as shown in Fig.9.**



10/31/94 f420371

1. Piston
2. Heat Shield
3. Dust Boot

Fig. 6



08/11/93 f420599

A. V-ways
1. Upper Rail of Anchor Plate
2. Rotor
3. Lower Rail of Anchor Plate
4. Caliper Housing

Fig. 7

Brake Caliper Removal and Installation

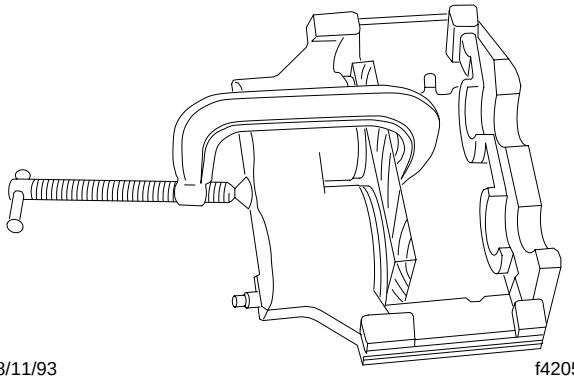
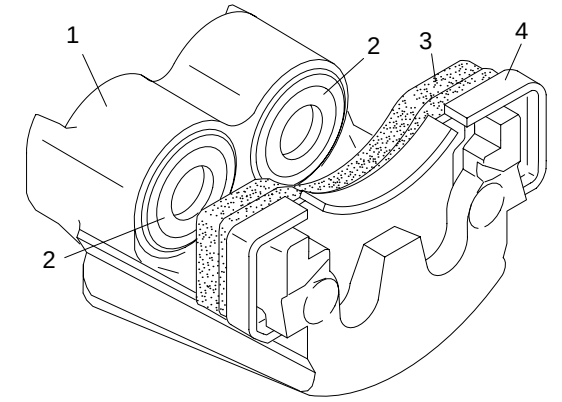


Fig. 8



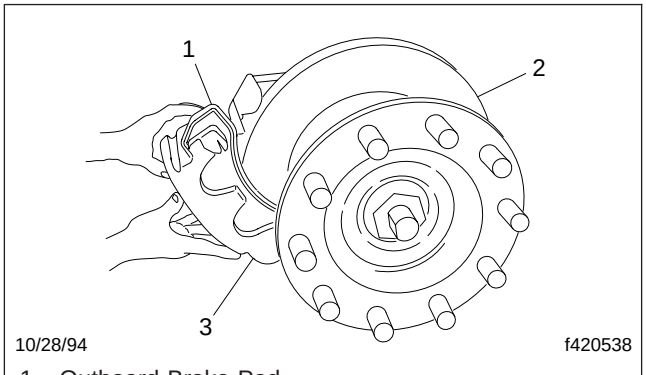
1. Caliper Housing
2. Pistons
3. Brake Pad Lining
4. Outboard Brake Pad

Fig. 9

6.3 Tilt the caliper housing so that the outboard brake pad will fit over the rotor, then push the caliper down onto the anchor plate rails. **See Fig.10.**

IMPORTANT: 2.88-inch calipers have pads that are chamfered on one end. Depending on mounting location (steer axle or rear axle), make sure that the 2.88-inch calipers are installed **as shown in Fig.11.**

6.4 Assemble the spring and key **as shown in Fig.12**, then install them between the caliper housing and the anchor plate rail (the upper rail for front wheel calipers, or the lower rail for rear wheel calipers).



1. Outboard Brake Pad
2. Rotor
3. Caliper

Fig. 10

6.5 Drive the key and spring into place, using a punch and mallet. **See Fig.13.** Make sure the notch in the key lines up with the hole in the anchor plate rail.

6.6 Install the allen-head bolt, and tighten it 20 N·m (15 lbf·ft).

7. If the brake supply hose was disconnected, connect it; otherwise go to the next step and check the fluid level.

   7.1 Tighten the brake supply hose fitting 20 N·m (15 lbf·ft).

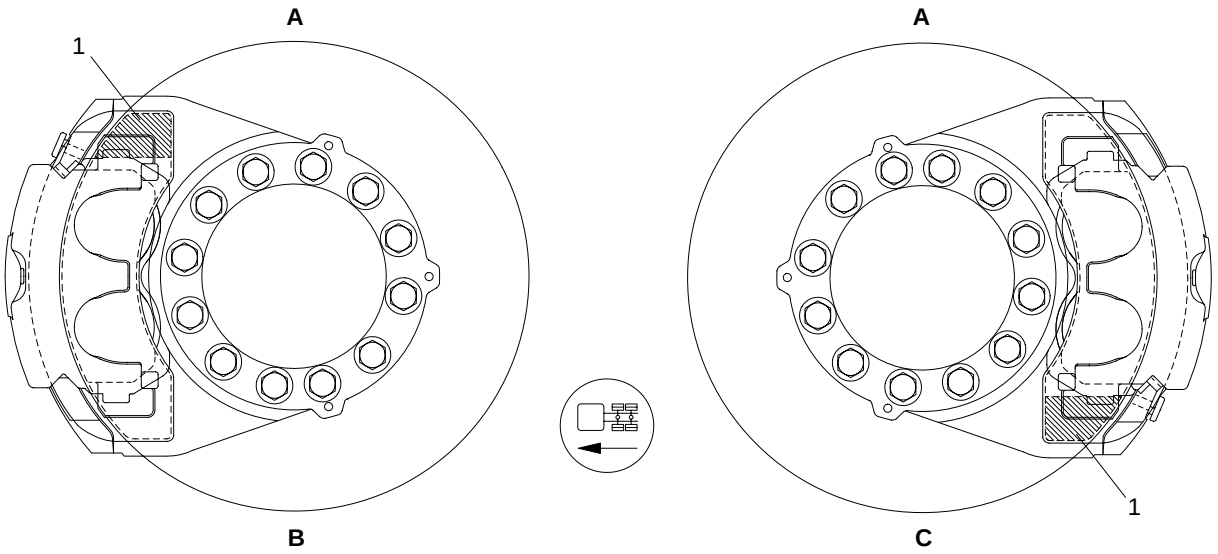
   7.2 Bleed the brake supply line to the caliper, following the instructions under **Subject 110.** If you have removed more than one brake caliper, bleed the entire brake system.

8. Check the fluid level in the master cylinder reservoir, and add the necessary amount of new DOT 3 approved brake fluid.

9. Seat the brake pads by pressing firmly on the brake pedal several times.

   If new brake pads were installed, seat them following the instructions under **Subject 130.**

10. Lower the hood, then remove the chocks.



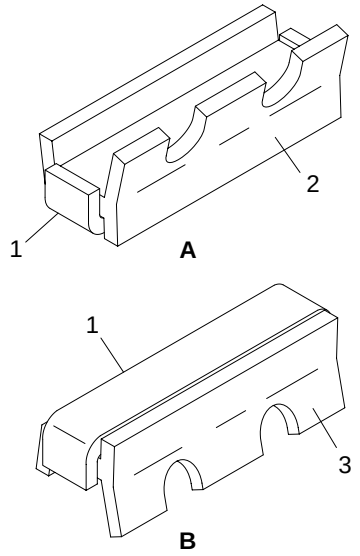
08/11/93 f420946

NOTE: Left-side mountings shown.

A. Top
B. Front Steer Axle Installation
C. Rear Axle Installation
1. Chamfer

Fig. 11

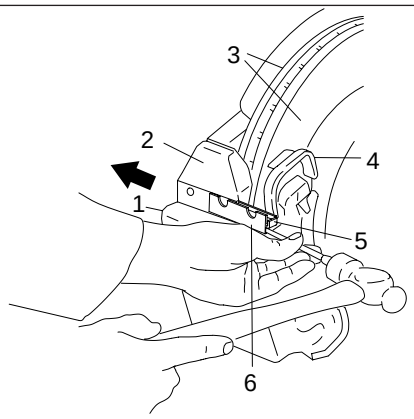
Brake Caliper Removal and Installation



08/11/93 f420551

A. Front Caliper
B. Rear Caliper
1. Spring
2. Key (notches up)
3. Key (notches down)

Fig. 12



08/11/93 f420564

1. Caliper
2. Upper Rail of the Mounting Bracket
3. Rotor
4. Outboard Brake Pad
5. Spring
6. Key

Fig. 13

Rebuild

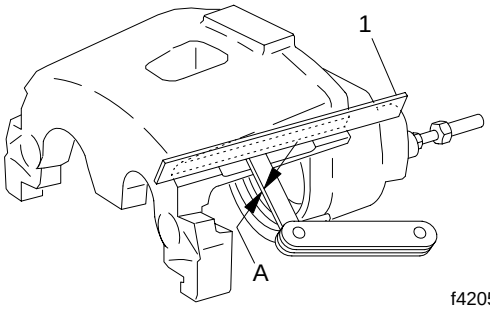
WARNING

WARNING: Before starting the procedure below, read the information in Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

1. Apply the parking brake, then chock the tires of the axle(s) you are not working on.
2. Remove the tire.
3. Clean the outside of the caliper housing, using a damp rag.
4. Remove the caliper from the wheel, following the instructions under **Subject 140.**
5. Drain any remaining brake fluid from the caliper housing. Discard the fluid.
6. Measure the wear depth of both caliper V-ways.

   6.1 Using a wire brush, clean the V-way surfaces of the caliper housing. File smooth any deep nicks or gouges.

   6.2 Lay the caliper housing on a bench, then put a straight edge on a V-way surface, as shown in **Fig. 1 .**



10/28/94 f420598a

A. 1.27 mm (0.05 in)
1. Straightedge

Fig. 1

   6.3 Using a feeler gauge, measure the gap between the V-way surface and the straight edge. **See Fig. 1.** Record the measurement.

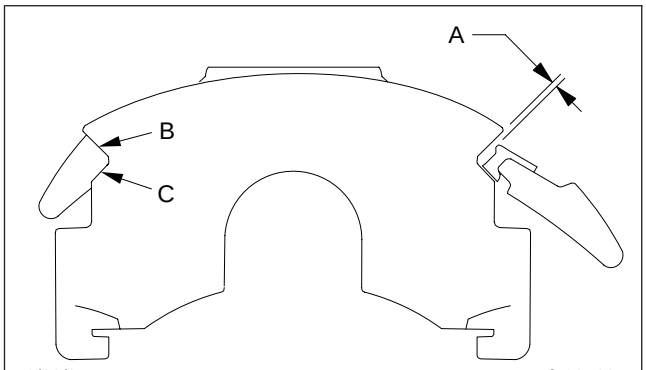
   Repeat this measurement for all the V-way surfaces. If any measurement is 1.27 mm (0.05 inch) or more, replace the caliper housing; otherwise, go to the step for checking caliper-to-anchor plate looseness.

7. Check for caliper-to-anchor plate looseness.

   7.1 Install the caliper on the rotor.

   7.2 Install a new key and the existing allen head bolt, but don't install the spring.

   7.3 Put a screwdriver in the gap (bumper gap) between the key and the V-way of the caliper. Pry up to seat the caliper against the sliding surfaces B and C, as shown in **Fig. 2.**



10/28/94 f420568a

A. 3.68 mm (0.145 inch)

Fig. 2

   7.4 Using a feeler gauge, measure the bumper gap (the distance between the key and the caliper V-way). **See Fig. 2.**

   7.5 If the bumper gap is more than 3.68 mm (0.145 inch), replace the caliper, and repeat steps checking caliper-to-anchor plate looseness. If the bumper gap is more than 3.68 mm (0.145 inch) with the new caliper installed, replace the anchor plate.

   If the bumper gap is 3.68 mm (0.145 inch) or less, check **Table 1** for the correct size wear shim to install on the anchor plate. Then remove the caliper from the rotor, and go to the step for removing the pistons from the caliper housing.

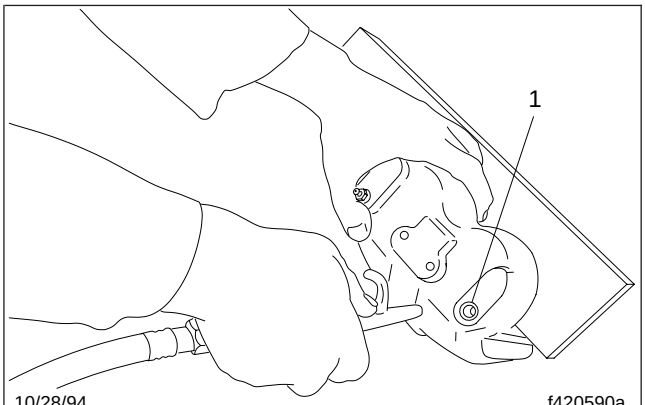
Brake Caliper Rebuild

Bumper Gap mm (inch)		Shim Thickness
More than	But Not Over	
0	1.47 (0.058)	None needed
1.47 (0.058)	2.57 (0.101)	0.025
2.57 (0.101)	3.68 (0.145)	0.045
3.68 (0.145)	—	Replace the caliper

Table 1, Bumper Gap Sizes

8. Remove the pistons from the caliper housing.

8.1 Connect a compressed air line with a control nozzle to the supply port of the caliper housing. **See Fig. 3.**



1. Supply Port

Fig. 3

8.2 Put a padded block of wood up against the outboard legs of the caliper, opposite the pistons, as shown in **Fig. 4.**

⚠ WARNING

WARNING: Be careful when using compressed air to remove the caliper pistons from their cylinders. Keep your hands away from the front of the pistons. Use only enough air pressure to ease out the pistons, or they may fly out forcibly, which could cause personal injury, or damage the pistons.

8.3 Slowly release compressed air, and ease the pistons out of the cylinders until they

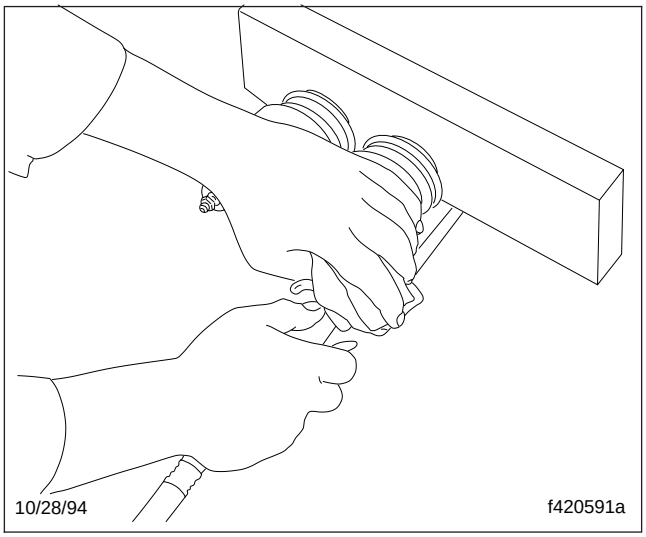
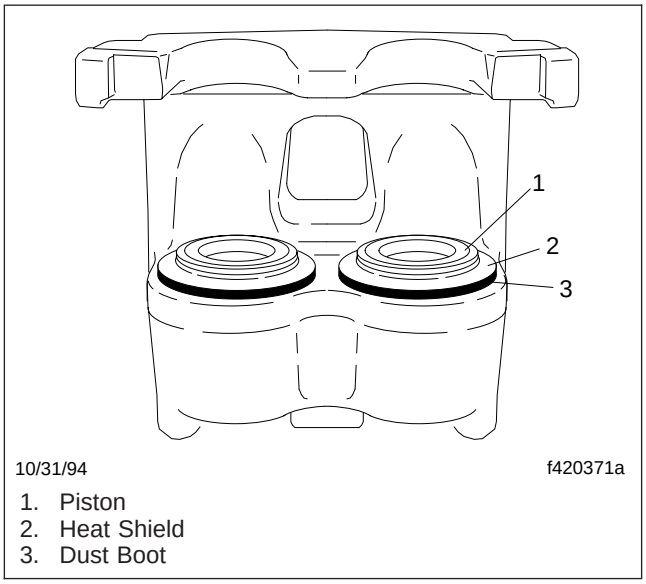


Fig. 4

are up against the wooden block. Don't pop the pistons out.

8.4 Using tin snips, cut both piston heat shields **(Fig. 5),** then remove them from the pistons.

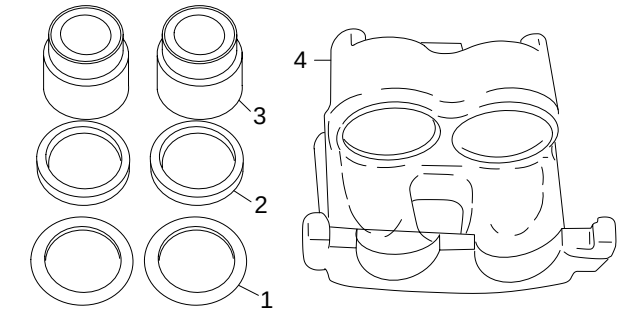


1. Piston
2. Heat Shield
3. Dust Boot

Fig. 5

8.5 Pry the dust boot of one of the pistons from its seat in the cylinder, then do the same for the other dust boot. Remove and discard both dust boots.

8.6 Remove both pistons from their cylinders. **See Fig. 6.**



1. Heat Shield
2. Dust Boot
3. Piston
4. Caliper Housing

Fig. 6

8.7 Remove the piston seal **(Fig. 7)** from inside each cylinder.

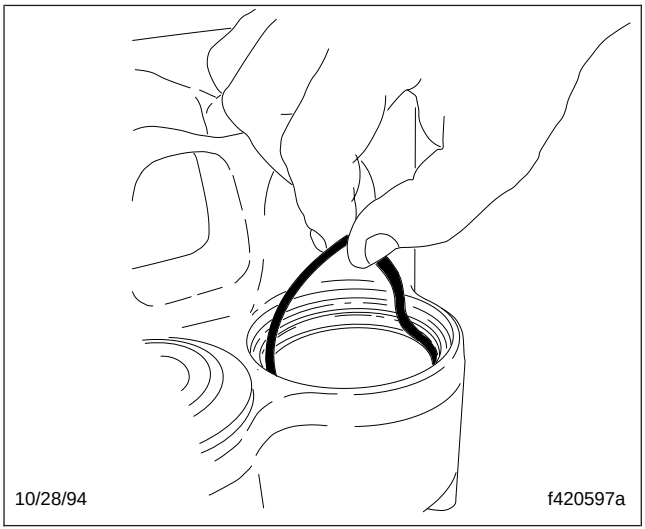


Fig. 7

9. Using denatured alcohol, clean the pistons and the caliper housing. Clean both the outside of the caliper and the piston cylinders. Blow dry all the parts with compressed air.
10. Check the outside of the pistons for pitting, scoring, corrosion, or damage. If any problem is found, replace the piston.
11. Check the caliper seal grooves and dust boot seats for pitting. **See Fig. 8.** If pitting is found, replace the caliper housing. Clean any corrosion from the area between the seal groove and dust boot seat.

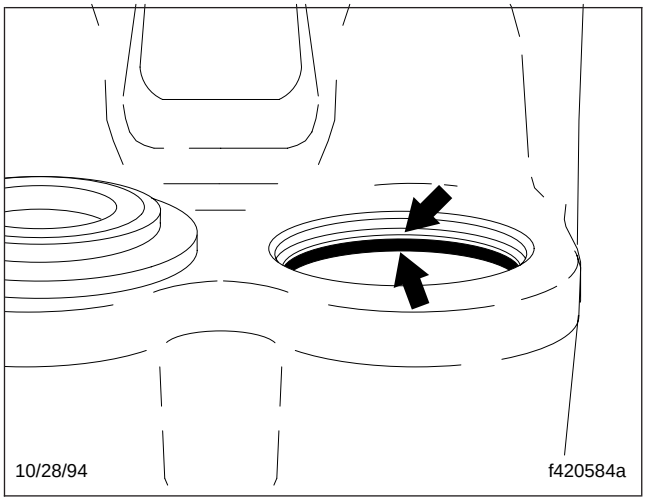
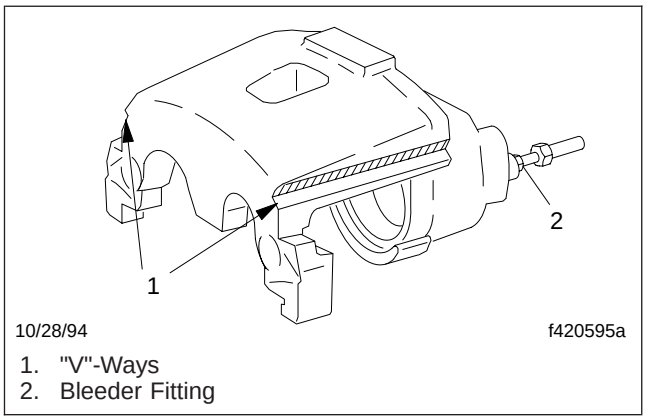


Fig. 8

12. Check the bleeder fitting **(Fig. 9)** for damage or wear. If a problem is found, replace the fitting.



1. "V"-Ways
2. Bleeder Fitting

Fig. 9

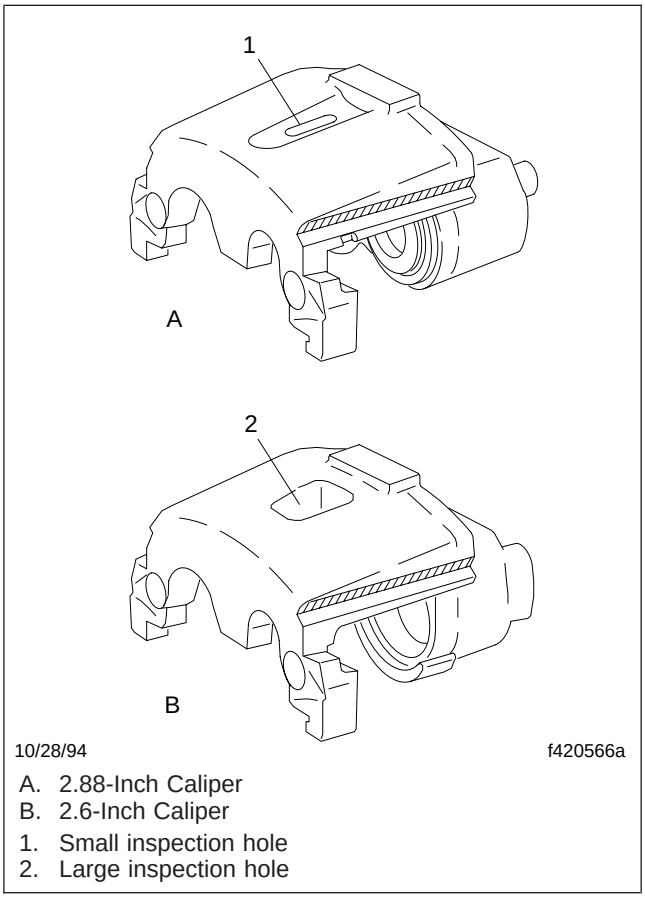
13. Install new piston seals.

IMPORTANT: Two different types of brake calipers are used on Freightliner vehicles: calipers with 2.6 inch-diameter pistons, and those with 2.88 inch-diameter pistons. Make sure you use the right seals, dust boots, and heat shields, for the type of caliper you are rebuilding.

Brake Caliper Rebuild

To determine the type of caliper, check the inspection hole on the rear of the caliper housing. If it's large, the pistons are 2.6 inches in diameter; if the hole is small, they are 2.88 inches. **See Fig. 10.**

13.1 Coat a new piston seal with new, clean brake fluid **See Fig. 11.**



A. 2.88-Inch Caliper
B. 2.6-Inch Caliper
1. Small inspection hole
2. Large inspection hole

Fig. 10

13.2 Install a new piston seal in each of the cylinders. Make sure the seal is not twisted.

14. Install new dust boots on the pistons, as shown in **Fig. 12 .**

15. Install the pistons.

15.1 Coat the bottom half (closed end) of one of the pistons with new brake fluid. *Don't get any brake fluid on the dust boot.*

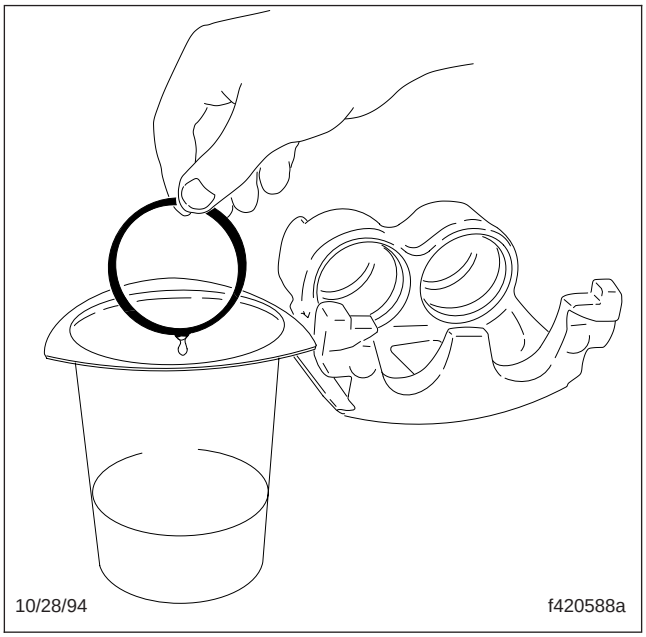


Fig. 11

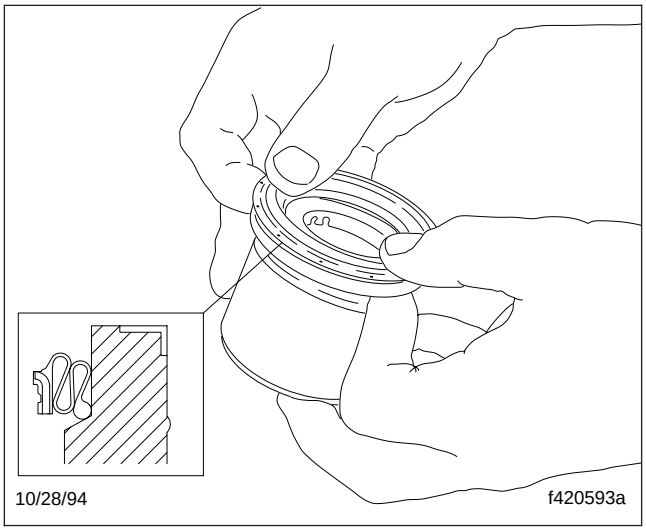


Fig. 12

15.2 Place the bottom (closed end) of the piston into its cylinder, making sure it is perfectly straight. **See Fig. 13.**

IMPORTANT: Make sure the piston is lined up in the cylinder perfectly straight before you install it; otherwise it will bind. If the piston binds in the cylinder, it will be impossible to install, and very difficult to remove.

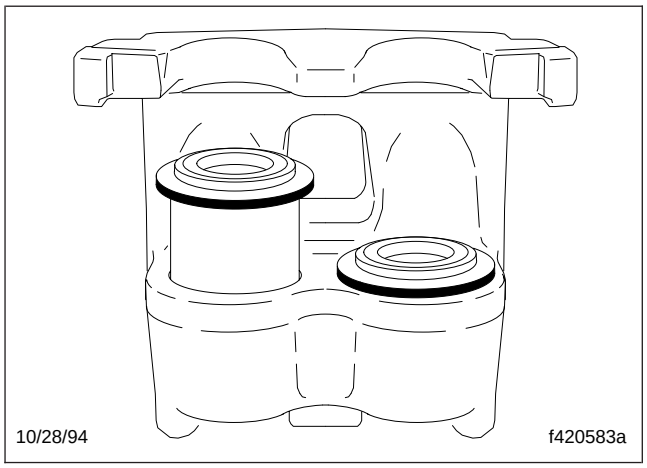


Fig. 13

15.3 Put a piece of thick metal or a block of wood over the top (open end) of the piston. Then, using a C-clamp, push the piston all the way into the cylinder until it bottoms out. **See Fig. 14.** Be careful not to damage the dust boot. If you feel resistance, the piston is in crooked. Remove it and start over.

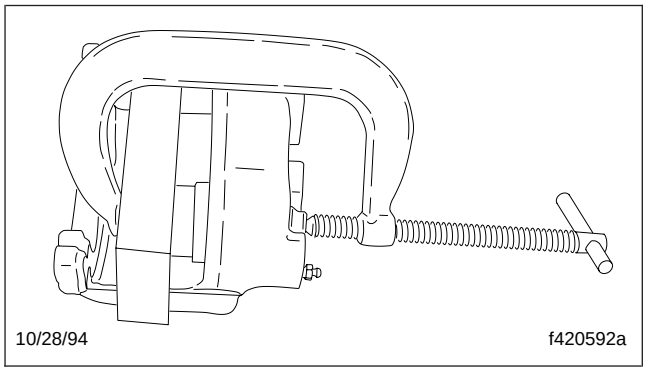


Fig. 14

15.4 Take the Kent-Moore special tool (KMS/ZTSE4275 for 2.88-inch pistons, or KMS/ZTSE4343 for 2.60-inch pistons), and put the side of the tool marked "Boot" against the dust boot. Then using the C-clamp, seat the dust boot into its groove in the cylinder.

15.5 Repeat the previous steps as needed for installing the other piston.

16. Install the heat shields on the pistons.

16.1 Put a new heat shield over the top of one piston as shown in **Fig. 15.** Make sure the heat shield is positioned correctly.

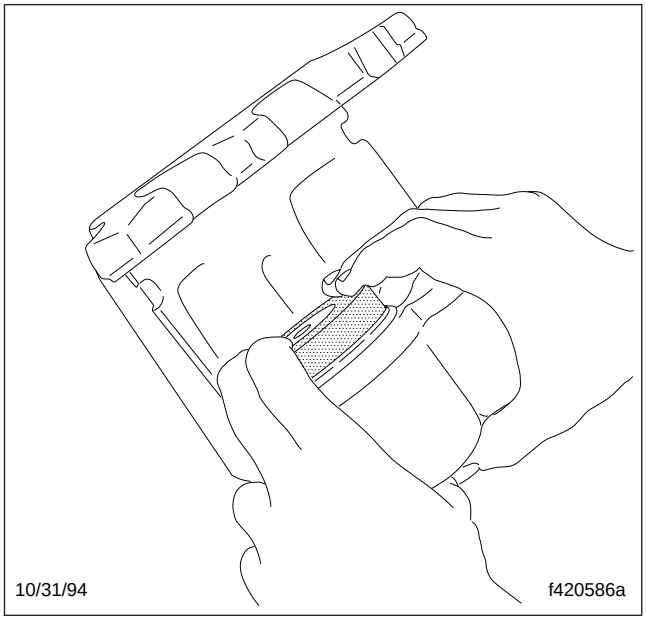


Fig. 15

16.2 Put the side of the Kent-Moore special tool (KMS/ZTSE4275 for 2.88-inch pistons, or KMS/ZTSE4343 for 2.6-inch pistons) marked "Heat Shield" against the heat shield. **See Fig. 16.** Using the C-clamp, seat the new heat shield onto the piston.

17. If a wear shim is required, install the applicable wear shim (chosen according to **Table 1**) on the opposite anchor plate V-way from which the key and spring are installed. **See Fig. 17.**

18. Install the caliper on the rotor following the instructions under **Subject 140.**

19. Install the tire. Remove the chocks.

Brake Caliper Rebuild

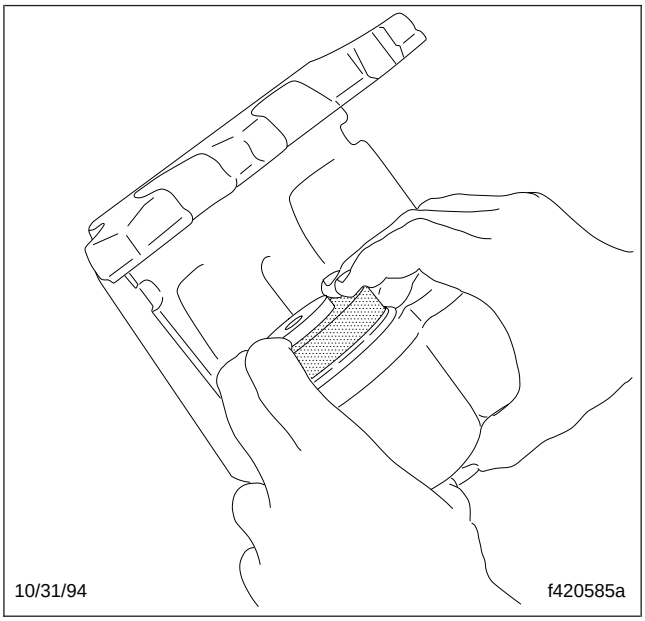
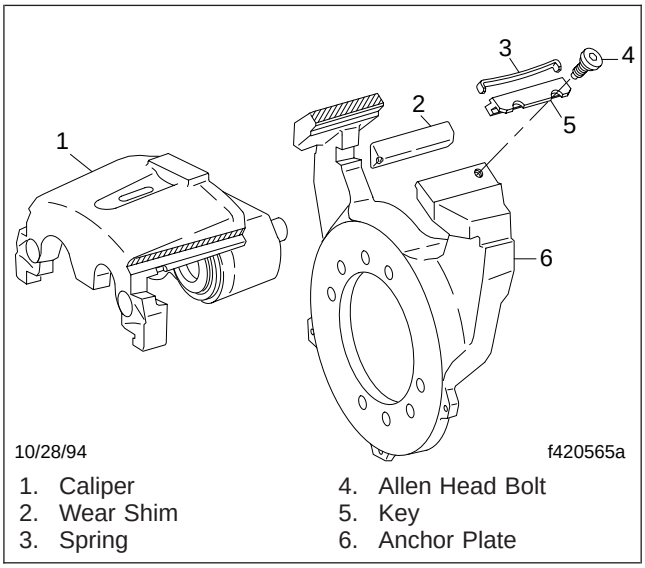


Fig. 16



1. Caliper
2. Wear Shim
3. Spring
4. Allen Head Bolt
5. Key
6. Anchor Plate

Fig. 17

Brake Rotor Removal and Installation

⚠ WARNING

Before starting the procedure below, read the information in Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

Removal

1. Apply the parking brake, chock the tires, and tilt the hood.
2. Remove about half the brake fluid from the front section (if removing a front-axle rotor) or the rear section (rear-axle rotor) of the master cylinder reservoir. See **Fig. 1**.

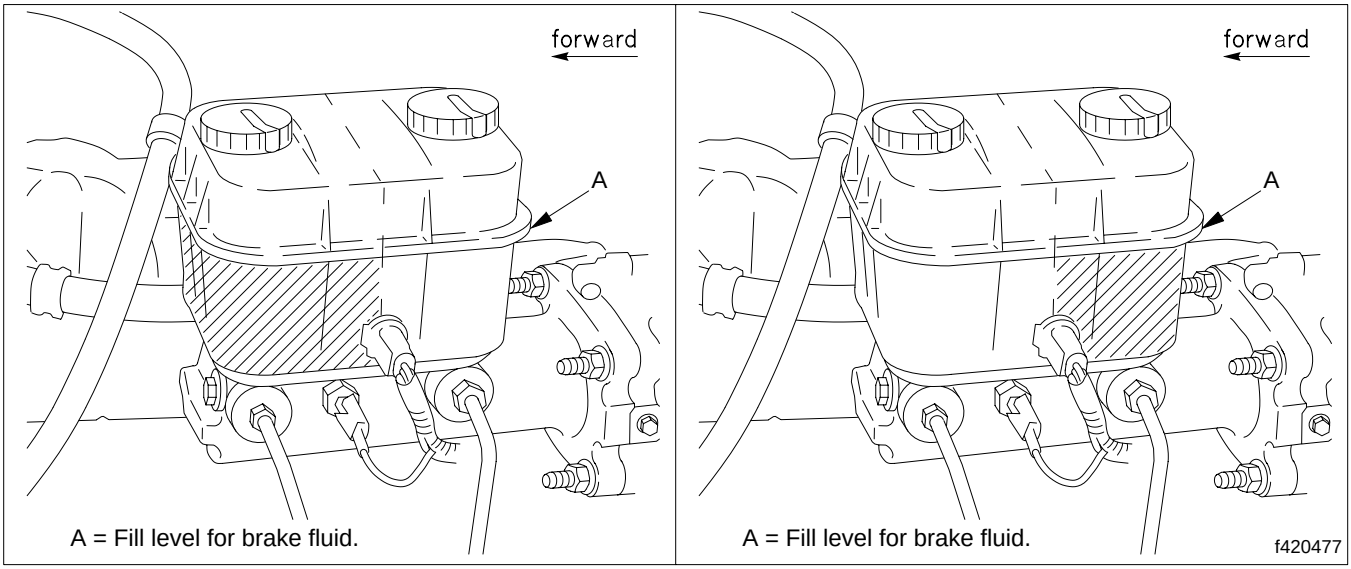


Fig. 1

3. Chock the front or rear tires, as required.
4. Jack up the vehicle, then support the axle with jackstands.
5. Remove the tire.
6. Remove the brake caliper from the rotor, following the instructions in **Subject 140**.
7. Remove the hub and rotor assembly from the axle, following the instructions in **Group 33** or **Group 35**. Put the hub on the floor so the rotor is facing up.
8. Remove the brake rotor from the wheel hub.
   - 8.1 Remove the hexbolts and washers that attach the rotor to the hub. See **Fig. 2**.
   - 8.2 Lift the brake rotor off the hub.

Installation

1. Install the rotor on the wheel hub.
   - 1.1 Position the rotor on the hub as shown in **Fig. 3**. Make sure the holes in the rotor are lined up with those of the hub.
   - 1.2 Install the mounting hexbolts and washers. Using a star pattern, tighten the hexbolts 175 N·m (130 lbf·ft). See **Fig. 4**.
2. Install the hub and rotor assembly on the axle, following the instructions in **Group 33** or **Group 35**.
3. Install the brake caliper on the rotor, following the instructions in **Subject 140**.
4. Install the tire.
5. Remove the jackstands, then lower the vehicle.
6. Fill the applicable section of the master cylinder reservoir with new DOT 3 approved brake fluid. The brake fluid level should be even with the

Brake Rotor Removal and Installation

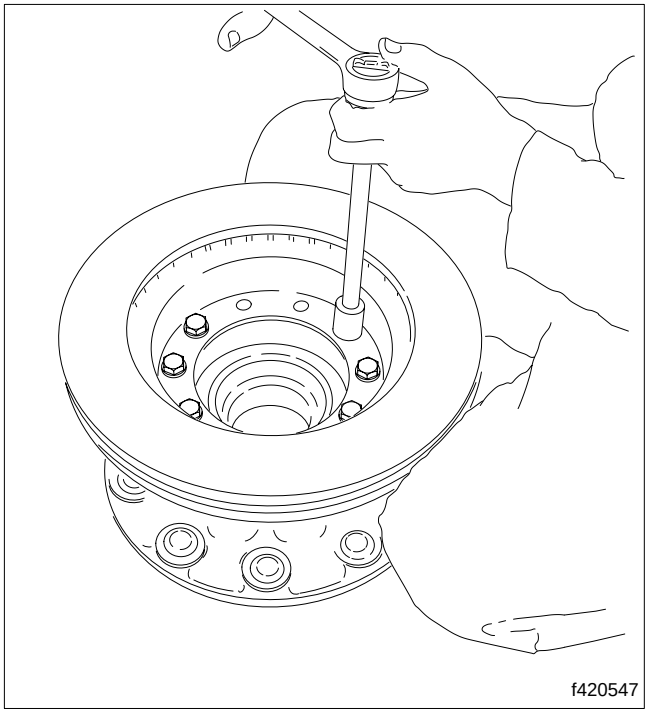


Fig. 2

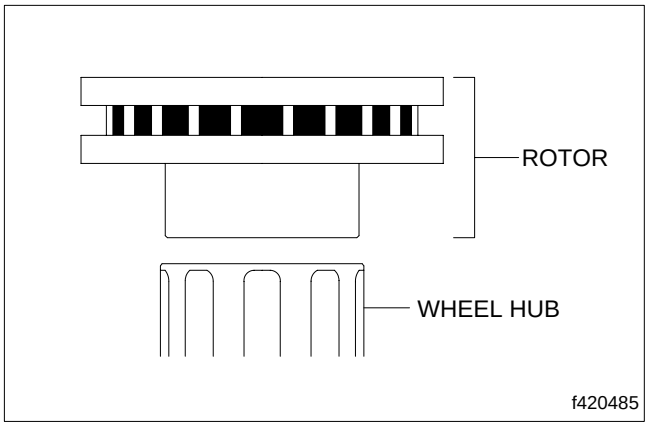


Fig. 3

raised seam on the outside circumference of the reservoir. See **Fig. 1**, Ref. A.

7. Lower the hood, then remove the chocks.

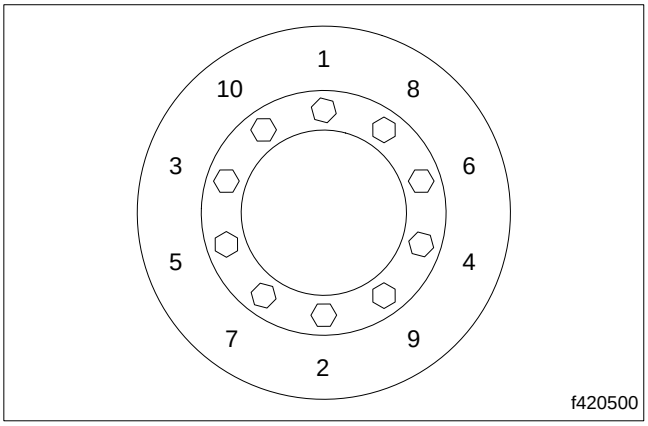


Fig. 4

Brake Rotor Runout and Parallelism Checking

Runout Checking

Brake rotor runout refers to the amount of lateral wobble the rotor has when it is turning, with the wheel bearings correctly adjusted. **See Fig. 1 .** Check the rotor runout whenever you replace the brake pads.

1. If not already done, chock the tires, jack up the axle you are working on and support it with jackstands. Then remove the wheels and tires.
2. If working on the rear axle, put the transmission in neutral.
3. Using a dial indicator, measure the amount of runout while spinning the rotor, **as shown in Fig. 2 .** Make sure the indicator is centered on the rotor face (between the outer and inner edges).
4. If the runout is more than 0.38 mm (0.015 inch), check that the rotor is securely mounted to the hub. Also check the wheel bearing end-play, following the instructions **in the front axle group** or **the rear axle group.**
5. Repeat the runout measurement. If the runout is still more than 0.38 mm (0.015 inch), replace the rotor.

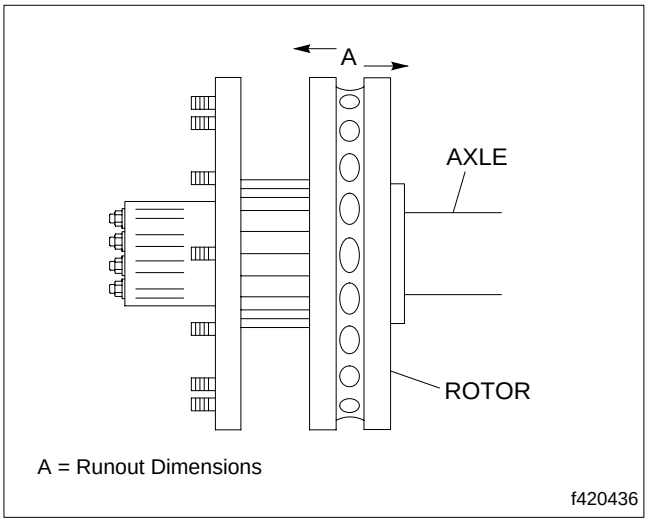


Fig. 1

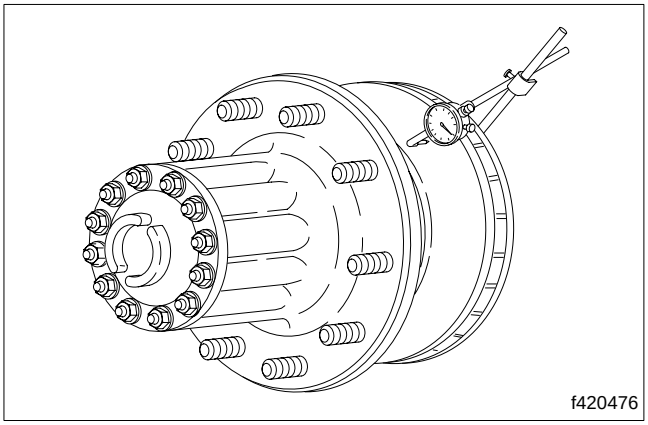


Fig. 2

Parallelism Checking

Parallelism is the difference in rotor thickness at different points around the rotor. It should be checked whenever the brake pads are replaced.

1. Using a vernier caliper or a micrometer, measure the thickness of the rotor (between the inboard and outboard faces) at four or more equally spaced points around the rotor. **See Fig. 3 .**
2. If there is a difference of more than 0.13 mm (0.005 inch) between any two measurements, have the rotor resurfaced. If resurfacing will decrease the overall thickness of the rotor to 33.5 mm (1.32 inches) or less, replace the rotor.

Brake Rotor Runout and Parallelism Checking

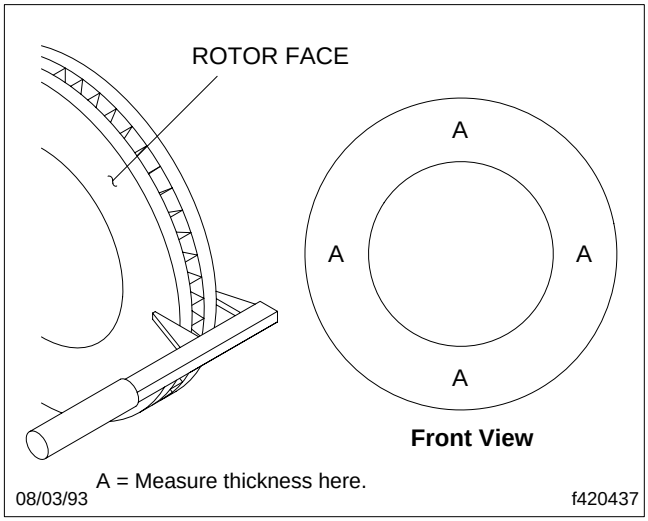


Fig. 3

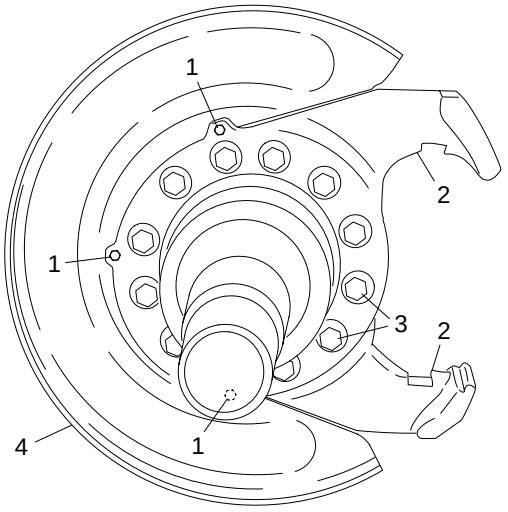
Anchor Plate Removal and Installation

Removal

1. Chock the rear or front tires, as required.
2. Jack up the vehicle, then support the axle with jackstands.
3. Remove the tire.
4. Remove the brake caliper from the anchor plate, following the instructions under **"Brake Caliper Removal and Installation, 140."**
5. Remove the wheel hub and rotor assembly from the axle, following the instructions in **the front axle group** or **the rear axle group.**
6. Remove the anchor plate from the axle.
   - 6.1 Remove the three screws holding the dust shield to the anchor plate, then remove the dust shield.
   - 6.2 Remove the hexbolts, washers, and nuts that hold the anchor plate to the axle. **See Fig. 1 .**
   - 6.3 Remove the anchor plate from the axle.

Installation

1. Install the anchor plate on the axle.
   - 1.1 Position the anchor plate in place against the outboard side of the axle flange, making sure the holes in both are lined up.
   - 1.2 From the outboard side of the anchor plate, install the hexbolts and washers, then install the nuts and remaining washers. **See Fig. 1 .** Using a star pattern, tighten the hexnuts as follows:
     - Rear Axle; 142 N·m (105 lbf·ft)
     - Front Axle Type FC; 102 N·m (75 lbf·ft)
     - Front Axle Type FD/FF; 197 N·m (145 lbf·ft)
2. Install the dust shield on the anchor plate. **See Fig. 1 .**
3. Install the wheel hub and rotor assembly onto the axle, following the instructions in **the front axle group** or **the rear axle group.**



1. Dust Shield Screws (3 qty.)
2. Anchor Plate
3. Mounting Hexbolts (12 qty.)
4. Dust Shield

08/03/93 f420554

Fig. 1

4. Install the brake caliper on the anchor plate, following the instructions under **"Brake Caliper Removal and Installation, 140."**
5. Install the tire.
6. Remove the jackstands, then lower the vehicle.
7. Remove the chocks.

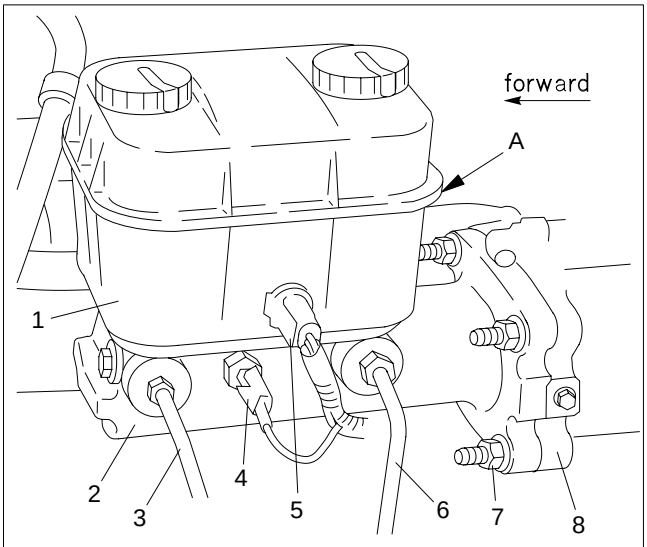
Master Cylinder Removal and Installation

Removal

WARNING

WARNING: Before starting the procedure below, read the information in "Safety Precautions, 100." Failure to be aware of the dangers of brake fluid exposure could result in serious and permanent health damage.

1. Apply the parking brake, chock the tires, and tilt the hood.
2. Disconnect the wires from the pressure differential switch (**Fig. 1** , Ref. 4) on the master cylinder, and the fluid level sensor (Ref. 5) on the reservoir.
3. Remove the accelerator cable clamp (**Fig. 2** , Ref. 2) from the L-bracket (Ref. 1) attached to the front inboard side of the master cylinder.



1. Reservoir
2. Master Cylinder
3. Front (Secondary) Circuit Brake Line
4. Pressure Differential Switch
5. Fluid Level Sensor
6. Rear (Primary) Ciruit Brake Line
7. Flanged Hexnut
8. Power Booster

A = Fill reservoir sections to this level.

08/03/93 f420479

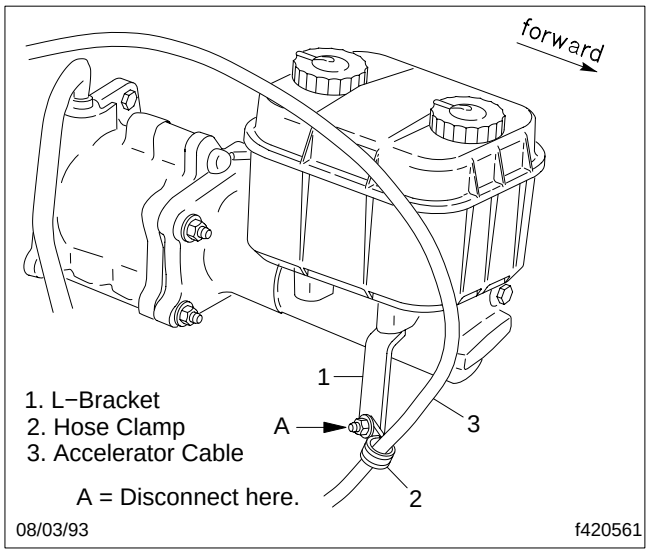
Fig. 1

CAUTION

CAUTION: Do not let the brake fluid get on any painted surface, as it will dissolve the paint. Use a rag around fittings, or put a container underneath it to catch any fluid.

4. Disconnect the brake lines from the front and rear outlet ports of the master cylinder. **See Fig. 3 .** Plug the brake lines.
5. Remove the four flanged hexnuts that attach the master cylinder to the power booster unit. **See Fig. 4 .**

   Remove the master cylinder and reservoir assembly from the vehicle. **See Fig. 5 .** Keep it upright so you don't spill any brake fluid from the reservoir.



1. L−Bracket
2. Hose Clamp
3. Accelerator Cable

A = Disconnect here.

08/03/93 f420561

Fig. 2

6. Remove the caps from the master cylinder reservoir, then carefully invert the master cylinder and reservoir assembly, and dump the brake fluid into a container. Dispose of the brake fluid in an approved manner.

Installation

1. Bench bleed the master cylinder.
   1.1 Put the master cylinder and reservoir assembly in a vise.

Master Cylinder Removal and Installation

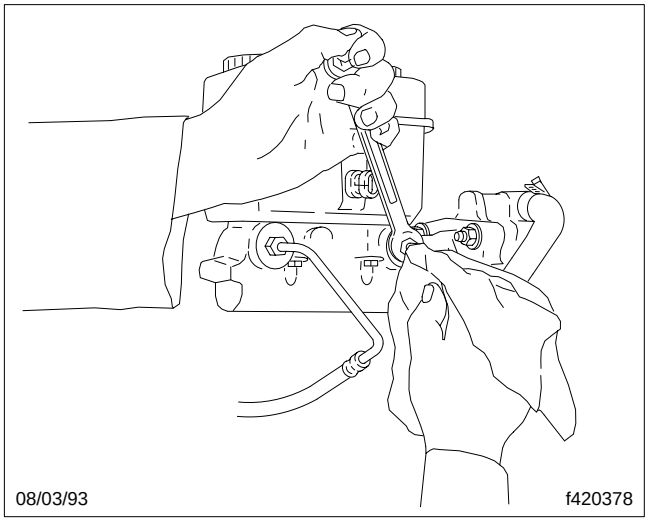


Fig. 3

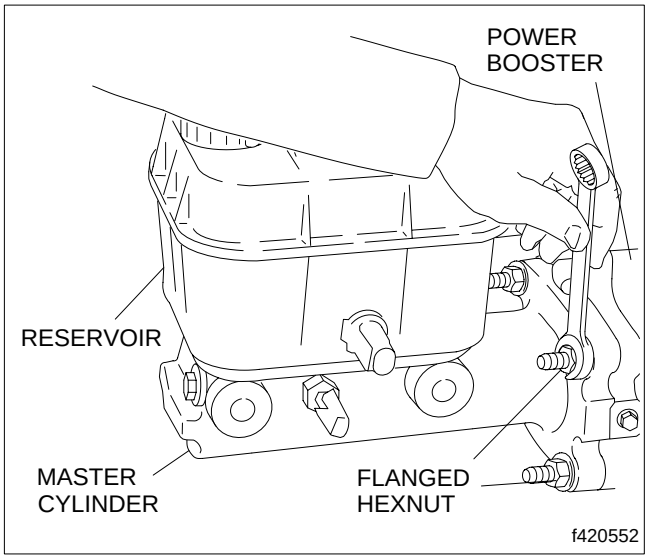


Fig. 4

1.2 Install a plastic adapter and clear rubber hose on the primary and secondary outlet ports, **as shown in Fig. 6 .**

1.3 Put the other end of each tube into its section of the reservoir, **as shown in Fig. 6 .**

1.4 Fill the reservoir sections about half-full with new DOT 3 approved brake fluid.

1.5 Using a metal rod with a rounded end, depress and release the primary piston several times.

1.6 Reposition the master cylinder in the vise, with the front (closed) end tilted slightly up. Depress and release the primary piston again until you feel increased resistance.

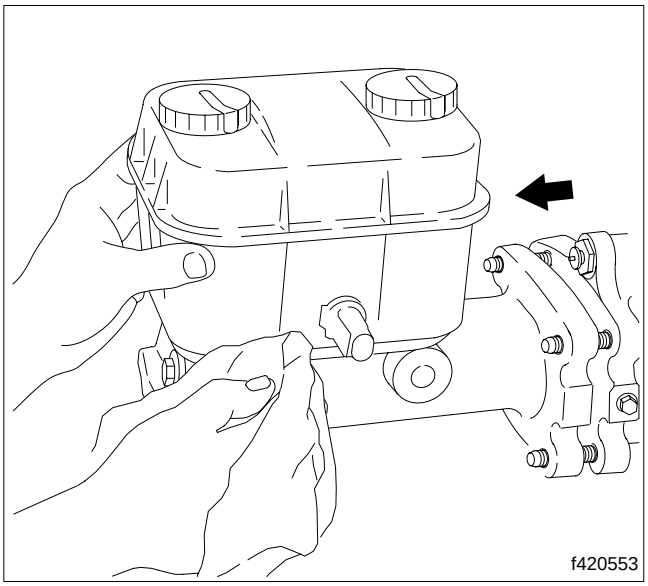


Fig. 5

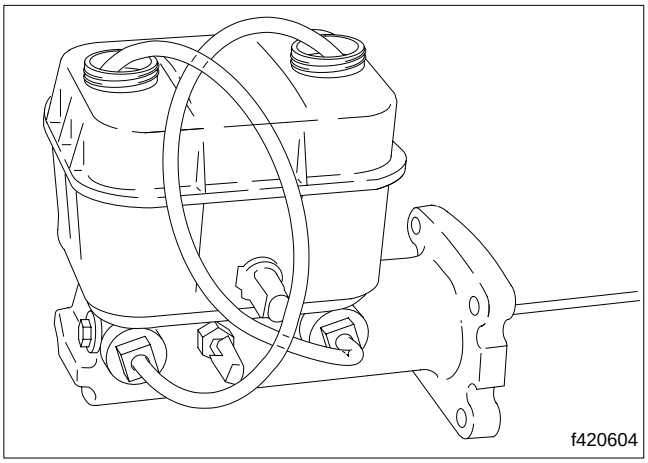


Fig. 6

2. Position the master cylinder on the front of the power booster.

3. Install the four flanged nuts on the studs of the power booster, then tighten them 34 N·m (25 lbf·ft).
4. Connect the rear brake (primary circuit) line to the rear outlet port on the master cylinder, then the front brake (secondary circuit) line to the front outlet port. Tighten the fittings 20 N·m (15 lbf·ft).
5. Connect the accelerator cable clamp (**Fig. 2** , Ref. 2) to the L-bracket (Ref. 1) on the front inboard side of the master cylinder.
6. Connect the wires to the pressure differential switch and the fluid level sensor. **See Fig. 1** , Refs. 4 and 5.
7. Fill both sections of the reservoir with new DOT 3 approved brake fluid. Fill to the raised seam on the outside of the reservoir. **See Fig. 1** , Ref. A.
8. Bleed the entire brake system, following the instructions under **"Hydraulic System Bleeding, 110."**
9. Lower the hood, then remove the chocks.

Master Cylinder Disassembly, Inspection, and Assembly

⚠ WARNING

WARNING: Before starting the procedure below, read the information in "Safety Precautions, 100." Failure to be aware of the dangers of brake fluid exposure could result in serious and permanent health damage.

Disassembly (Refer to Fig. 1)

1. Apply the parking brake, chock the tires, and tilt the hood.
2. Remove the master cylinder and reservoir assembly from the vehicle, following the instructions under **"Master Cylinder Removal and Installation, 170."**
3. Remove the reservoir from the master cylinder.
   - 3.1 Remove the four flanged hexbolts that attach the reservoir to the top of the master cylinder. **See Fig. 2 .** Note that one of the bolts has an L-bracket on it.
   - 3.2 Lift the reservoir off the master cylinder. Turn the reservoir over, then remove the two compensating valve seals from the bottom of it. **See Fig. 3 .**
4. Remove the small O-ring, then the two compensating valves and their springs from the top of the master cylinder housing. **See Fig. 4 and Fig. 5.**

⚠ CAUTION

CAUTION: Don't remove the piston stop at this time, or you may damage it and the piston bore in the master cylinder housing.

5. Remove the differential pressure indicator assembly from the front of the housing.
   - 5.1 Unscrew the aluminum plug at the front end of the housing. **See Fig. 6 .**
   - 5.2 Using an allen wrench, remove the nylon insert underneath the aluminum plug. **See Fig. 7 .**
   - 5.3 Remove the differential pressure switch from the side of the housing. **See Fig. 8 .**
   - 5.4 Put a compressed air hose into the port on top of the housing where the primary compensating valve was. Put a shop towel over the hole at the front end of the housing, then place the housing so that the front end is facing down toward a padded surface; keep your hands away from the front of the master cylinder housing.

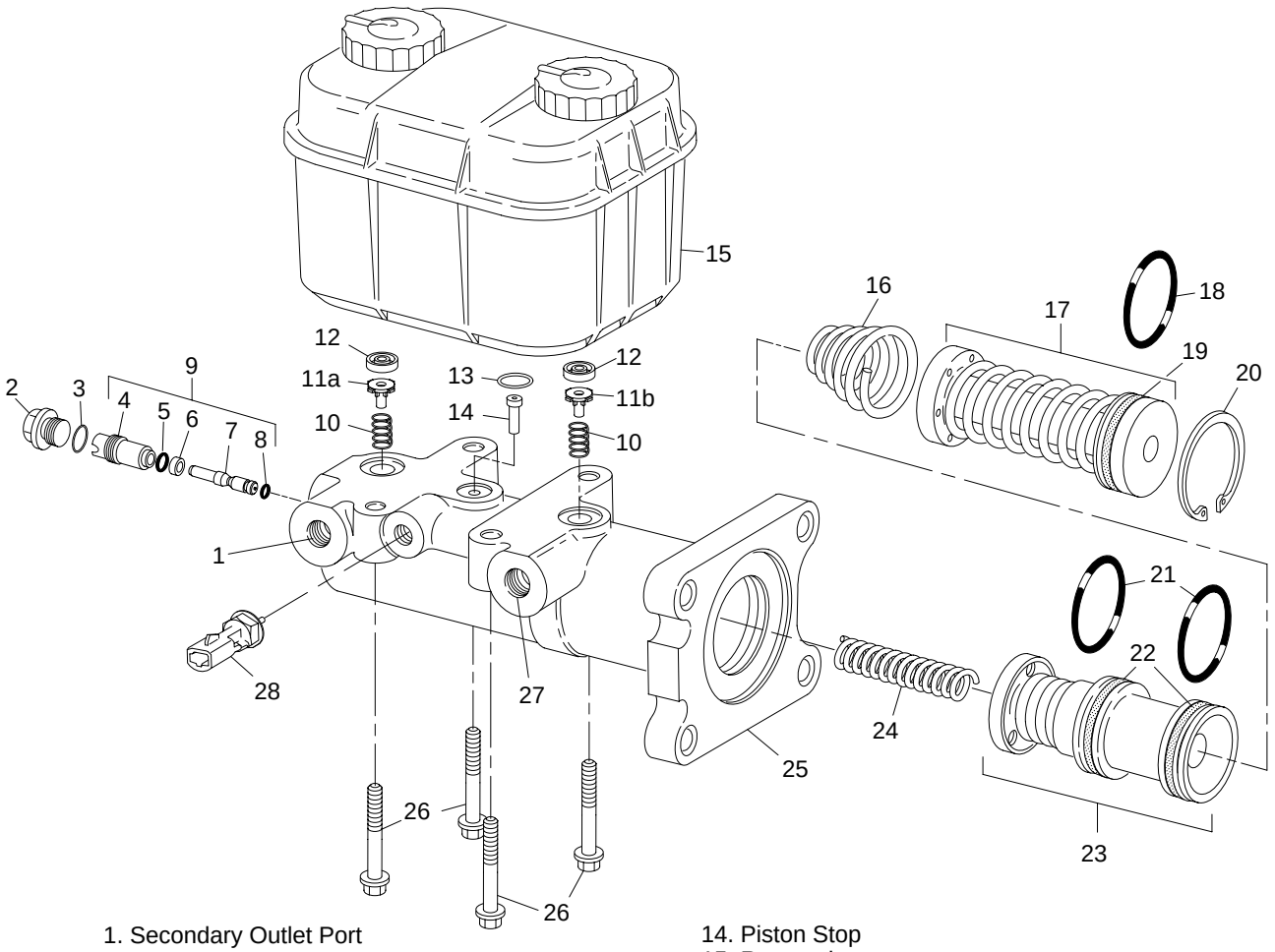
⚠ WARNING

WARNING: Be careful when using compressed air to remove the differential pressure indicator assembly from the master cylinder housing. It may come out of the housing with considerable force, which could cause personal injury or damage to the part.

   - 5.5 Plug the primary circuit outlet (**Fig. 1** , Ref. 27), then release just enough air pressure to force out the brass spool, O-ring, and collar (Refs. 5, 6, and 7). Discard the O-ring.

     Remove and discard the small O-ring (Ref. 8) from the brass spool.
6. Remove the primary piston assembly from the master cylinder bore.
   - 6.1 Put the master cylinder in a vise.
   - 6.2 Using a crossbar puller, a C-clamp, or other suitable tool, push the primary piston about 13 mm (1/2 inch) into the bore. **See Fig. 9 .**
   - 6.3 With the primary piston pushed in, remove the lock ring from the open end of the bore. **See Fig. 9 .** Then remove the small piston stop from the top of the master cylinder housing. **See Fig. 10 .**
   - 6.4 Carefully release the tension on the primary piston, and ease it and its return spring out of the bore. **See Fig. 11 .**
   - 6.5 Remove and discard the pressure seal and back-up ring (**Fig. 1** , Refs. 18 and 19) from the primary piston.

Master Cylinder Disassembly, Inspection, and Assembly



1. Secondary Outlet Port
2. Aluminum Plug
3. O−Ring
4. Nylon Insert
5. Large O−Ring
6. Brass Collar
7. Brass Spool
8. Small O−Ring
9. Pressure Differential Indicator Assembly
10. Compensating Valve Spring (2 qty.)
11a. Secondary Compensating Valve
11b. Primary Compensating Valve
12. Compensating Valve Seal (2 qty.)
13. O−Ring
14. Piston Stop
15. Reservoir
16. Primary Piston Return Spring
17. Primary Piston Assembly
18. Primary Pressure Seal
19. Primary Back−Up Ring
20. Lock Ring
21. Secondary Pressure Seal (2 qty.)
22. Secondary Back−Up Ring (2 qty.)
23. Secondary Piston Assembly
24. Secondary Return Spring
25. Master Cylinder Housing
26. Flanged Hexbolts (4 qty.)
27. Primary Outlet Port
28. Pressure Differential Switch

08/04/93 f420501

Fig. 1

Master Cylinder Disassembly, Inspection, and Assembly

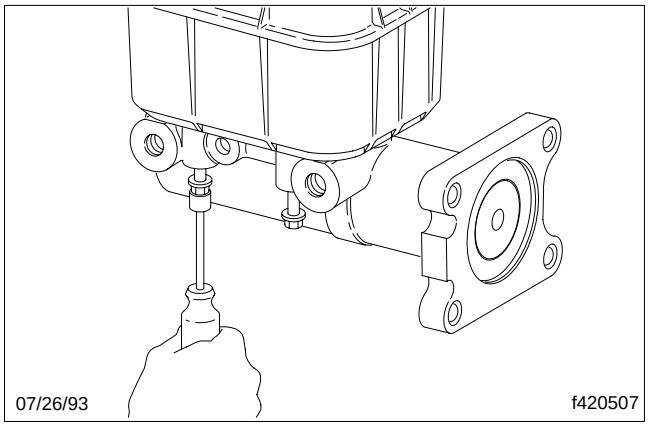


Fig. 2

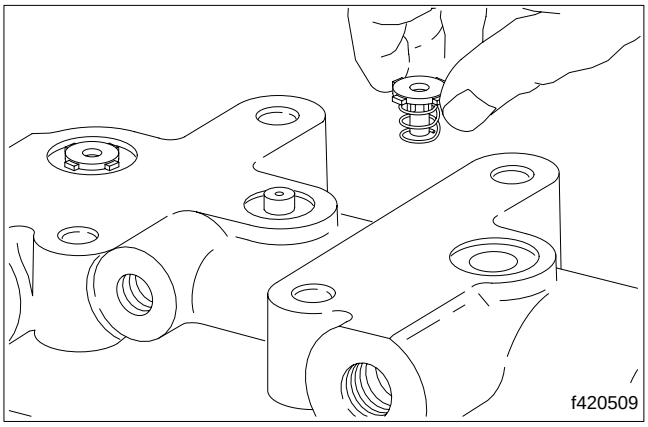


Fig. 5

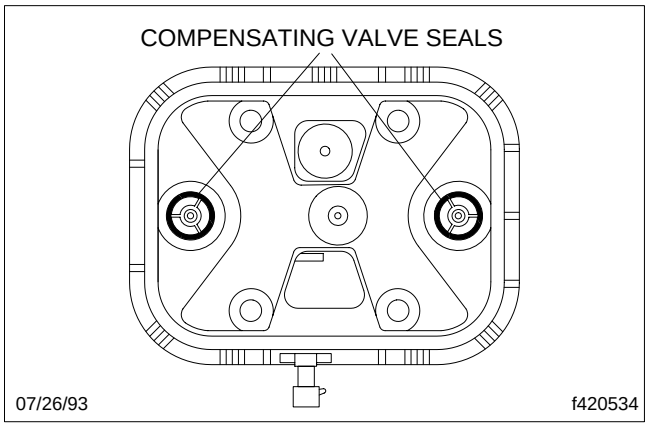


Fig. 3

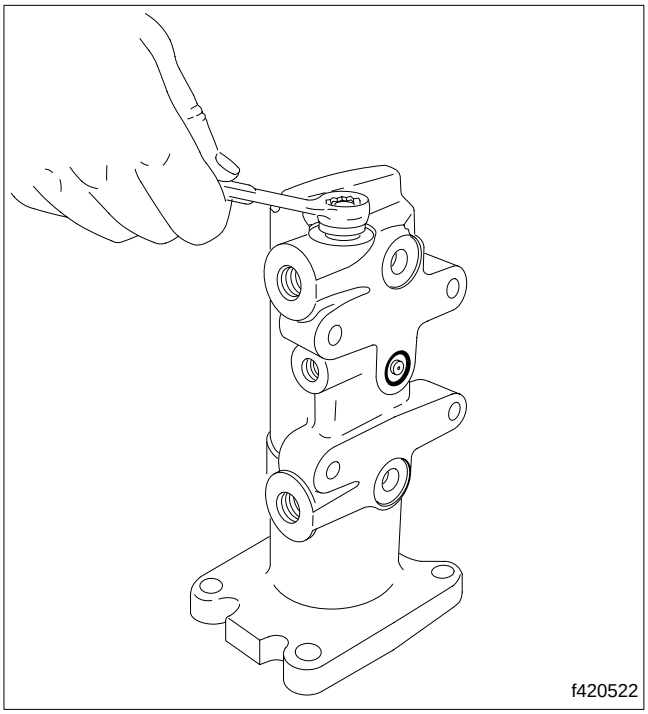


Fig. 6

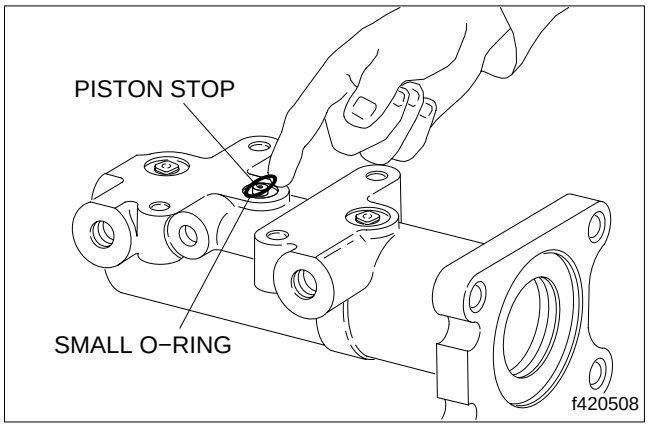


Fig. 4

⚠ WARNING

WARNING: Be careful when using compressed air to remove the secondary piston and actuator assembly from the master cylinder bore. Make sure the open end of the bore is pointed down toward a padded surface. Keep your hands away from the open end of the bore to prevent injury.

Master Cylinder Disassembly, Inspection, and Assembly

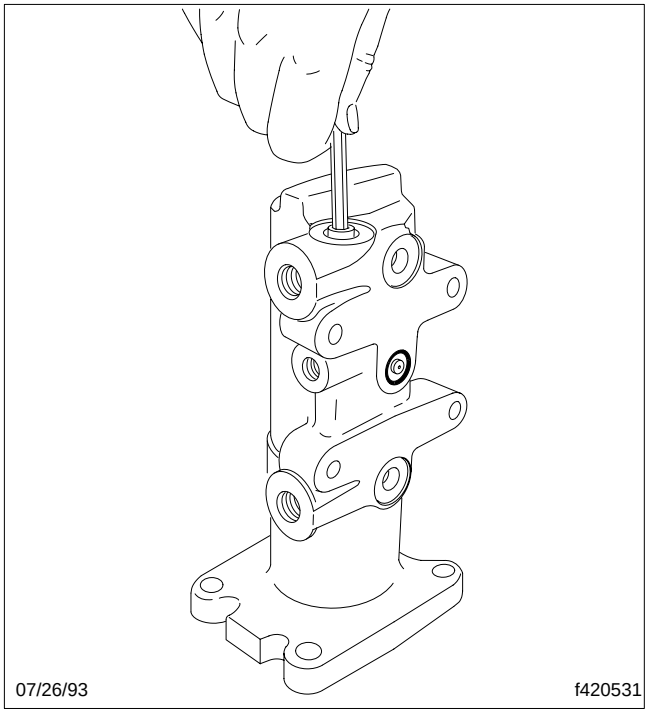


Fig. 7

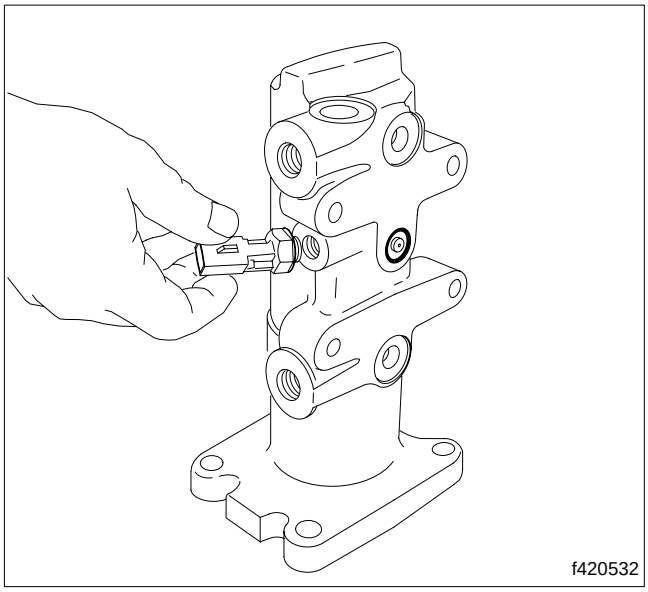


Fig. 8

7. Using compressed air, remove the secondary piston assembly from the master cylinder bore.

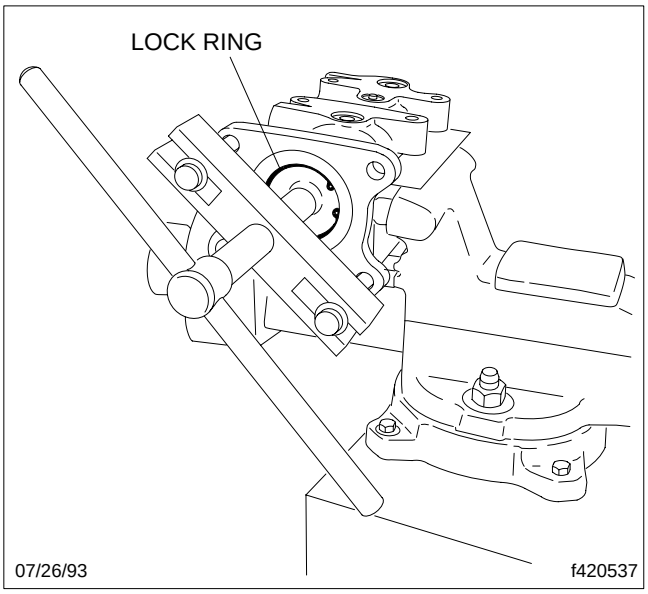


Fig. 9

7.1 Connect a compressed air hose to the front compensating valve port **(Fig. 12)** on top of the housing.

7.2 Plug the secondary outlet port (**Fig. 1** , Ref. 1) and the hole where the pressure differential indicator (Ref. 9) was on the housing.

7.3 With the open end of the housing bore facing down, and about an inch away from a padded surface, carefully apply just enough air pressure to remove the secondary piston assembly and its return spring from the bore **(see Fig. 13);** don't pop it out.

7.4 Remove and discard the pressure seal and back-up ring from the secondary piston.

Inspection

1. Check the master cylinder bore for scoring or corrosion. If the master cylinder housing is pitted, rough, or corroded, replace the entire master cylinder assembly.
2. If needed, polish any discolored or stained areas in the bore with a crocus cloth. *Don't use emery*

Master Cylinder Disassembly, Inspection, and Assembly

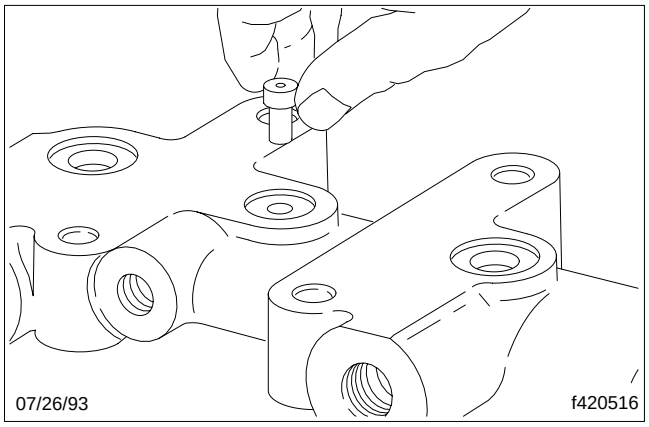


Fig. 10

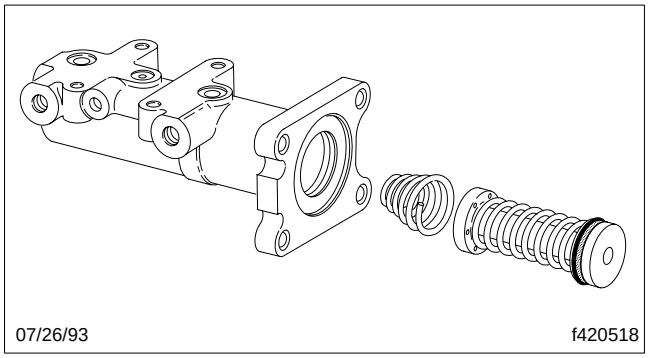


Fig. 11

cloth or sandpaper; they could scratch the bore, which could cause leakage.

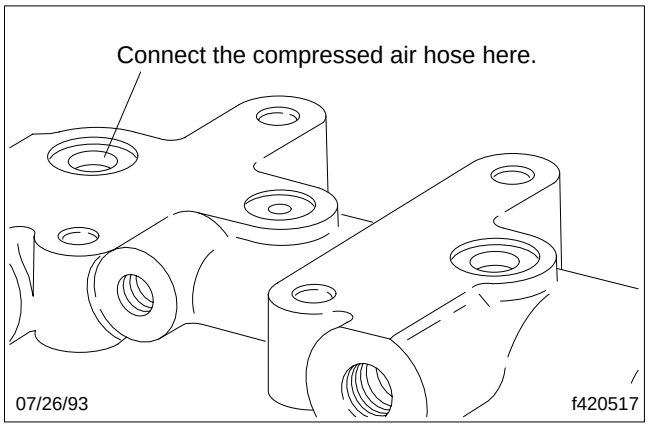


Fig. 12

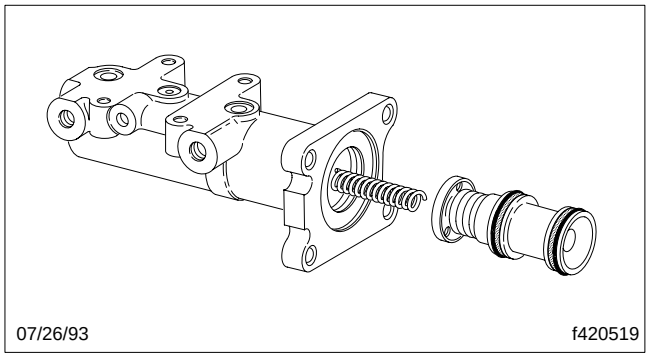


Fig. 13

Assembly (Refer to Fig. 1)

IMPORTANT: When assembling the master cylinder, use new seals and rings. Don't reuse old ones.

1. Wash all the parts and the cylinder bore in clean, new DOT 3 approved brake fluid. Discard the brake fluid afterward.
2. Install the secondary piston assembly in the master cylinder bore.
   - 2.1 Install two new pressure seals and back-up rings (**Fig. 1** , Refs. 21 and 22) on the secondary piston.
   - 2.2 Lubricate the piston assembly, the seals, and the cylinder bore **(see Fig. 14)** with clean DOT 3 approved brake fluid.
   - 2.3 Put the secondary return spring (**Fig. 1** , Ref. 24) on the actuator (flanged) end of the secondary piston assembly, then insert the piston assembly, spring end first, into the cylinder bore. **See Fig. 15 .** Push it all the way to the bottom of the bore.
3. Install the primary piston assembly in the master cylinder bore.
   - 3.1 Install a new pressure seal and back-up ring (**Fig. 1** , Refs. 18 and 19) on the primary cylinder.
   - 3.2 Lubricate the piston assembly and the seal with new DOT 3 approved brake fluid.

Master Cylinder Disassembly, Inspection, and Assembly

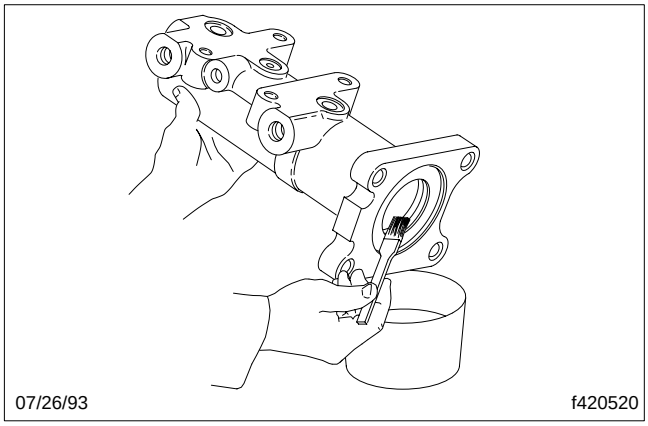


Fig. 14

3.3 Insert the small end of the primary return spring (**Fig. 1** , Ref. 16) into the master cylinder bore.

3.4 Insert the primary piston assembly into the master cylinder bore, actuator (flanged) end first. **See Fig. 16 .**

4. Put the master cylinder housing into a vise, then using a crossbar puller or a C-clamp, push the pistons far enough into the master cylinder bore to install the lock ring in its groove. **See Fig. 17 .**

5. Install the compensating valve seals on the bottom of the reservoir. **See Fig. 18 .** Make sure the seals are completely seated.

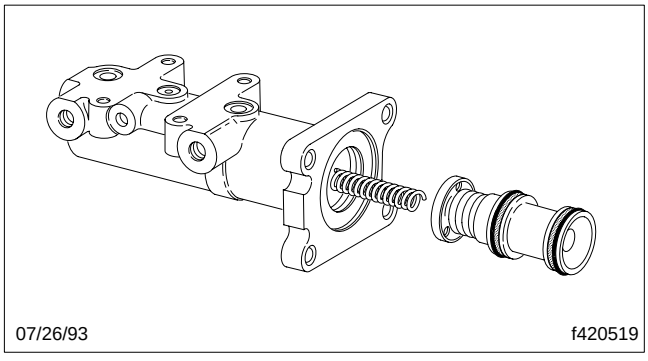


Fig. 15

6. Using a crossbar puller or a C-clamp, push the primary piston 25 mm (1 inch) into the bore. **See Fig. 19 .**

7. Install the compensating valve poppets and their springs in the top of the master cylinder housing.

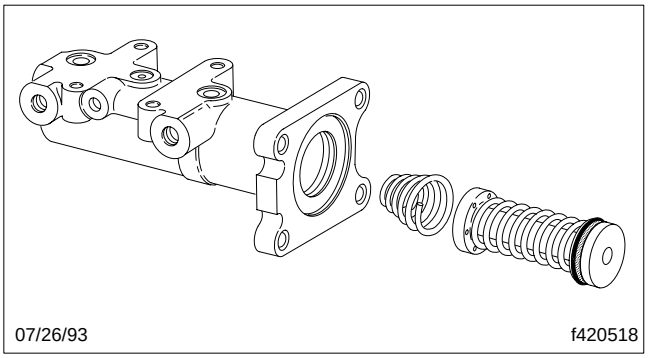


Fig. 16

Also install the piston stop and the O-ring. **See Fig. 20 .**

8. With the primary piston still pushed in, install the reservoir onto the top of the master cylinder, using the four mounting hexbolts. **See Fig. 21 .** Make sure the L-bracket goes on the front inboard (when the master

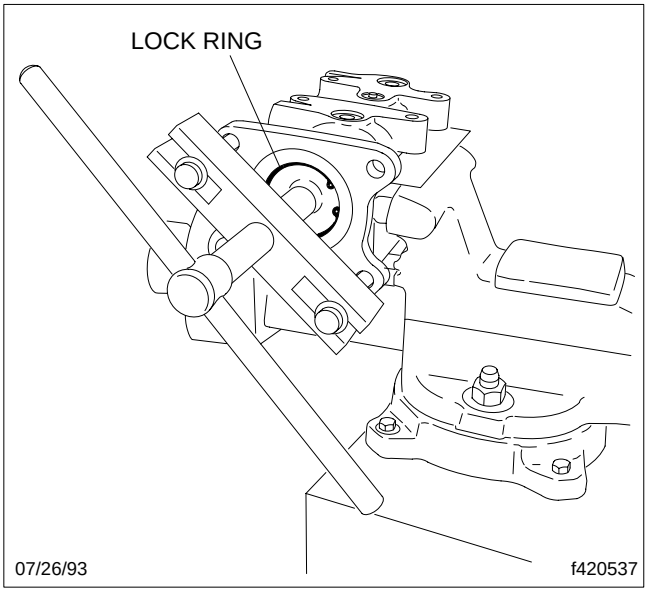


Fig. 17

9. cylinder is installed on the vehicle) mounting hexbolt. Tighten the bolts 20 N·m (15 lbf·ft).

10. Assemble the pressure differential indicator **(refer to Fig. 22).**

Master Cylinder Disassembly, Inspection, and Assembly

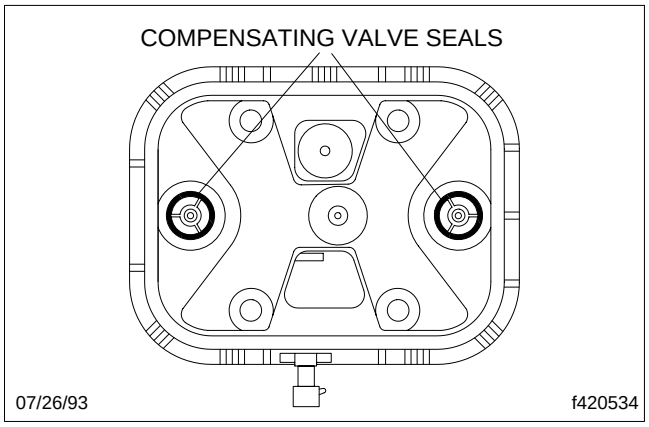


Fig. 18

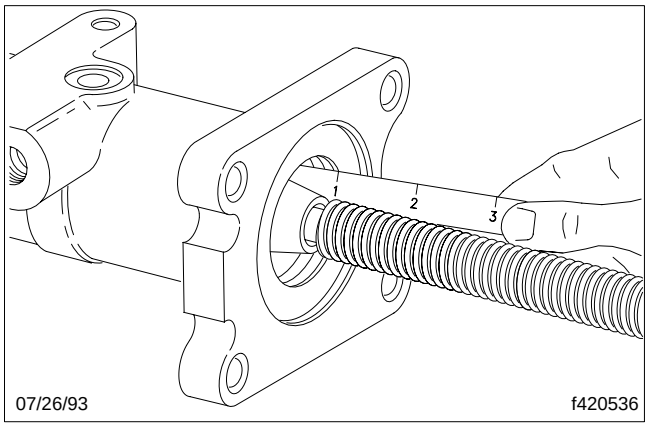


Fig. 19

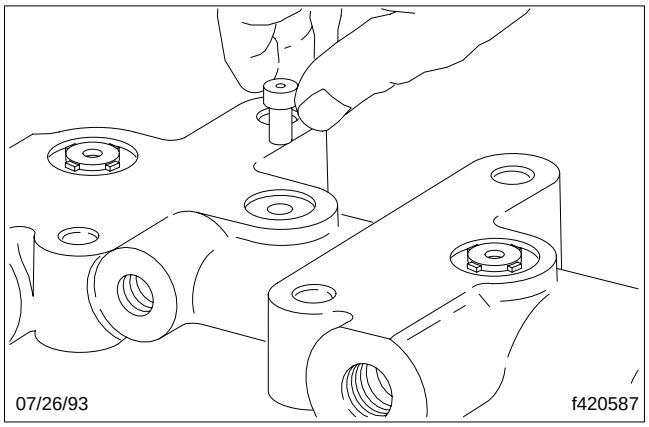


Fig. 20

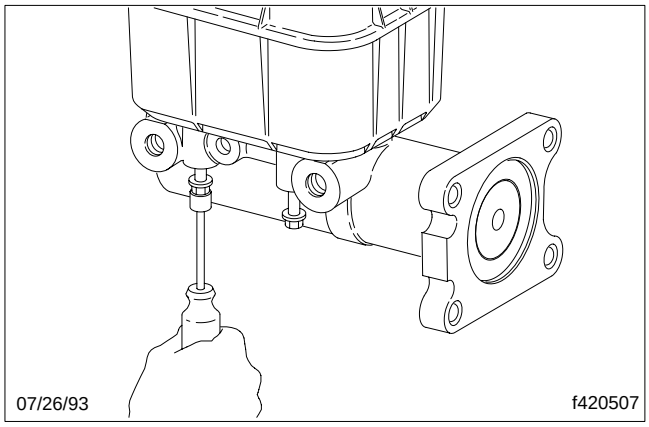


Fig. 21

10.1 Install a new small O-ring (Ref. 3) in the groove on the end of the brass spool (Ref. 4).

10.2 Install the collar (Ref. 2) on the brass spool.

10.3 Install a new large O-ring (Ref. 1) onto other end of the brass spool, and push it down onto the collar, **as shown in Fig. 22 .**

11. Install the spool and collar assembly— with the collar end up— into the hole at the front of the master cylinder housing, **as shown in Fig. 23 .** Using a small piece of wood, seat the assembly at the bottom of its hole.

12. Using an allen wrench, install the nylon insert on top of the brass spool. **See Fig. 24 .**

13. Install a new O-ring on the aluminum plug (**Fig. 1** , Refs. 3 and 2), then install the plug into the hole at the front of the master cylinder housing. Tighten the plug firmly.

14. Install the pressure differential switch in the side of the master cylinder housing, **as shown in Fig. 25 .** Tighten it finger-tight.

15. Check the operation of the compensating valves by poking a wire through the hole in the bottom of each reservoir section. The compensating valves should depress easily, about 1.5 mm (1/16 inch), then spring back. If not, remove the reservoir and install it again. Check the valves again.

Master Cylinder Disassembly, Inspection, and Assembly

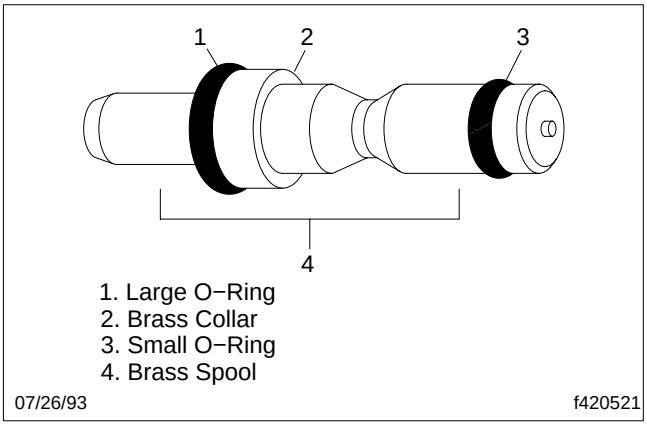


Fig. 22

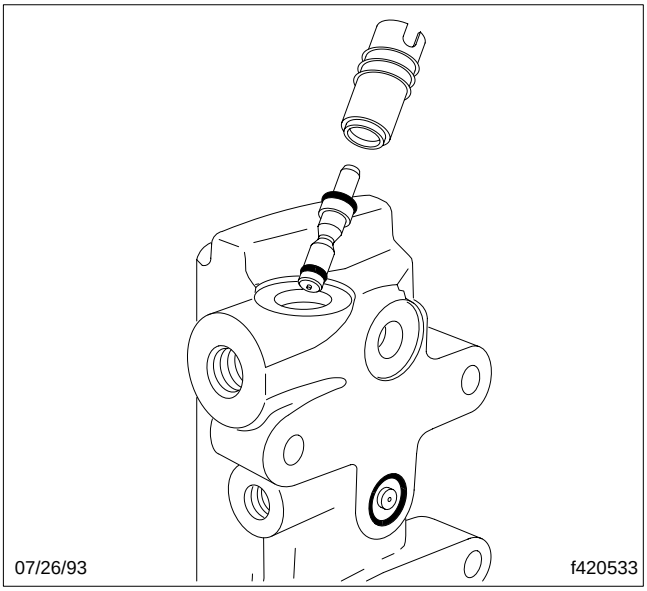


Fig. 23

16. Remove the cross-bar puller or C-clamp installed to push the primary piston into the bore.
17. Bench bleed, then install the master cylinder on the booster, following the instructions under **"Master Cylinder Removal and Installation, 170."**
18. Lower the hood, then remove the chocks.

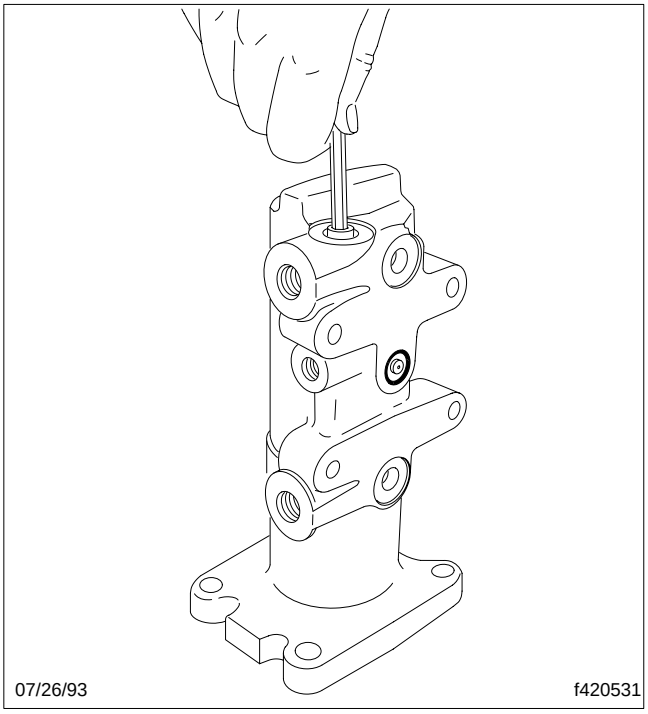


Fig. 24

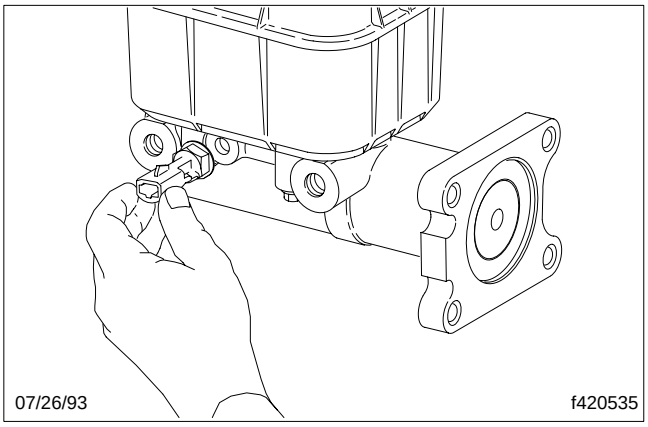


Fig. 25

Hydro-Max II® Power Booster Removal and Installation

Removal

1. Apply the parking brake, chock the tires, and tilt the hood.
2. Disconnect the batteries at the negative cable.
3. If not already done, disconnect the master cylinder from the power booster, following the instructions **in Subject 170.**
4. From inside the cab, disconnect the push rod from the brake pedal.
   - 4.1 Below the dash, find the clevis pin, washer, and cotter key that hold the power booster push rod to the brake pedal. **See Fig. 1 .**
   - 4.2 Remove the cotter key, washer and clevis pin.
5. Disconnect the wiring from the auxiliary electric pump assembly. **See Fig. 2 .**
6. Disconnect the wiring from the flow switch at the front of the power booster. **See Fig. 2 .**

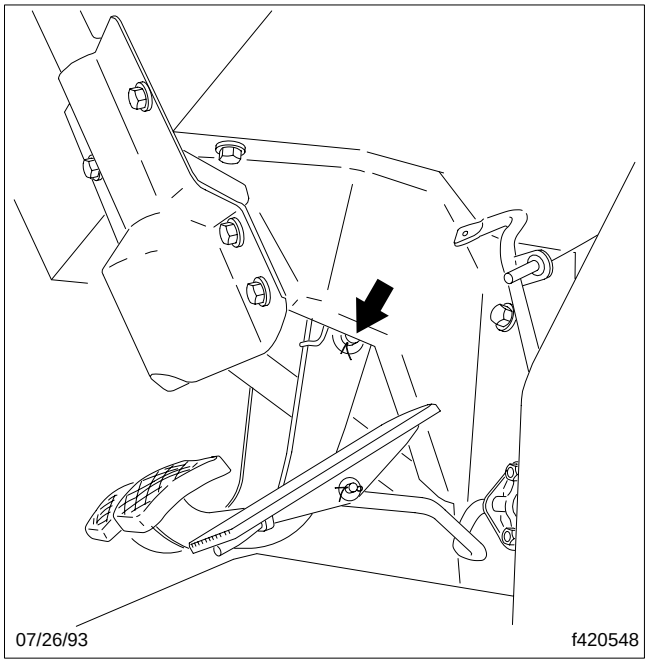
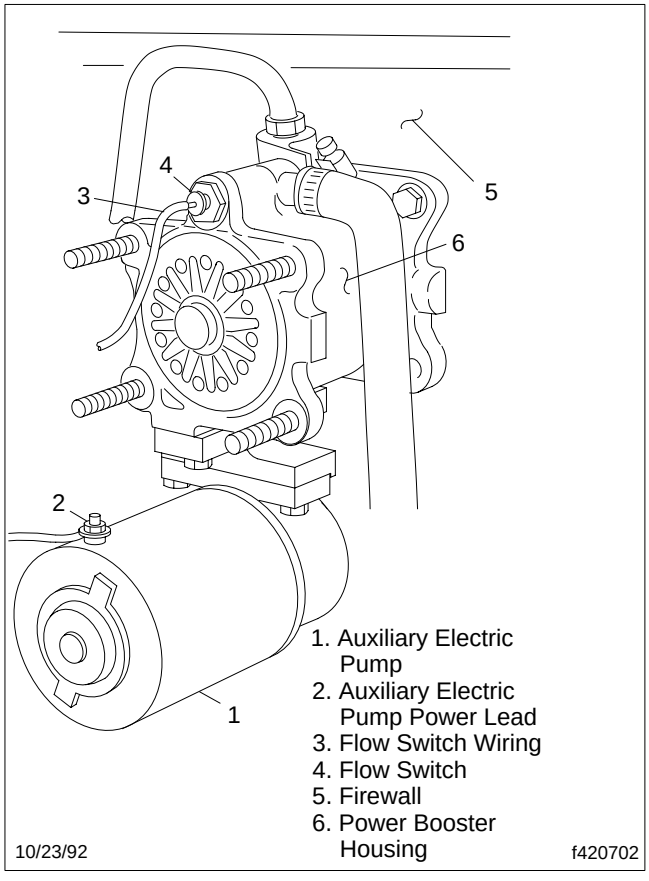


Fig. 1

7. Using a shop towel or a container to catch any power steering fluid, disconnect the hydraulic supply and return lines from the power booster. **See Fig. 3 .** Plug the lines.
8. Remove the four hexbolts and washers **(Fig. 4)** holding the power booster to the firewall, then pull the power booster straight out from the firewall, **as shown in Fig. 5 .**

Installation

1. Position the power booster on the firewall so the push rod fits through the large hole and into the cab, and the four holes in the power booster line up with those on the firewall. **See Fig. 5 .**
2. Install the four mounting hexbolts and washers. **See Fig. 4 .** Tighten them 27 N·m (15 lbf·ft).



1. Auxiliary Electric Pump
2. Auxiliary Electric Pump Power Lead
3. Flow Switch Wiring
4. Flow Switch
5. Firewall
6. Power Booster Housing

Fig. 2

3. Install the master cylinder on the power booster, following the instructions **in Subject 170.**

Hydro-Max II® Power Booster Removal and Installation

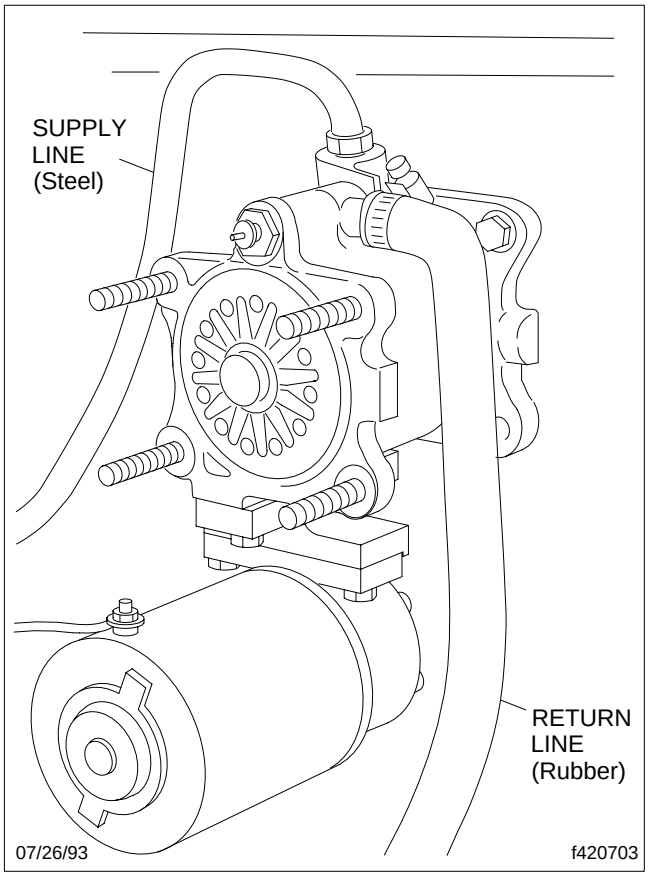


Fig. 3

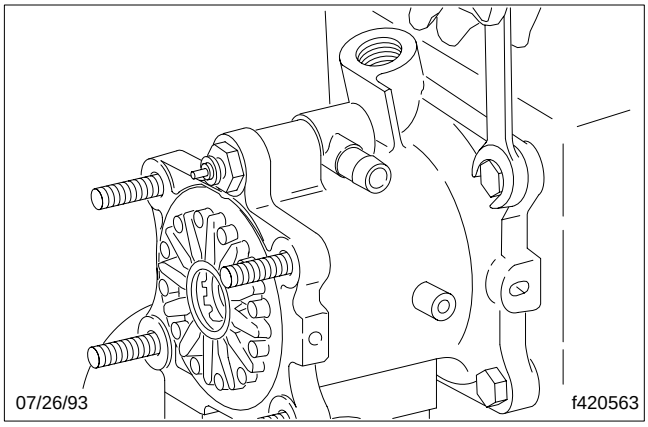


Fig. 4

4. Connect the hydraulic supply and return lines **(Fig. 3).** Tighten the supply line 20 N·m (20 lbf·ft). Tighten the hose clamp on the return line firmly.

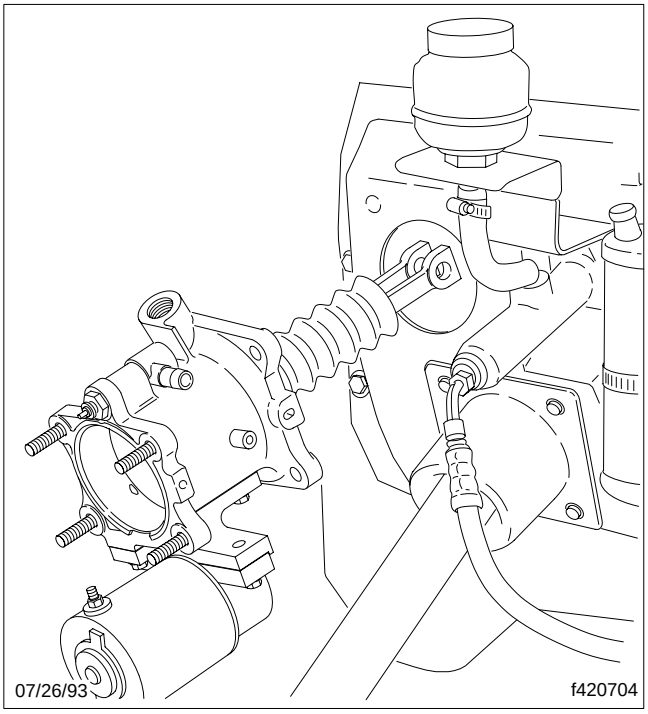


Fig. 5

5. Connect the wiring to the auxiliary electric pump assembly, and to the flow switch assembly. **See Fig. 2 .**
6. Check the fluid level in the power steering reservoir **(Fig. 6).** Add approved power steering fluid if needed. **Refer to "Specifications, 400"** for the approved power steering fluid.
7. Connect the batteries.
8. Lower the hood, then remove the chocks.
9. Bleed the power booster, following the instructions **in Subject 115.**

Hydro-Max II® Power Booster Removal and Installation

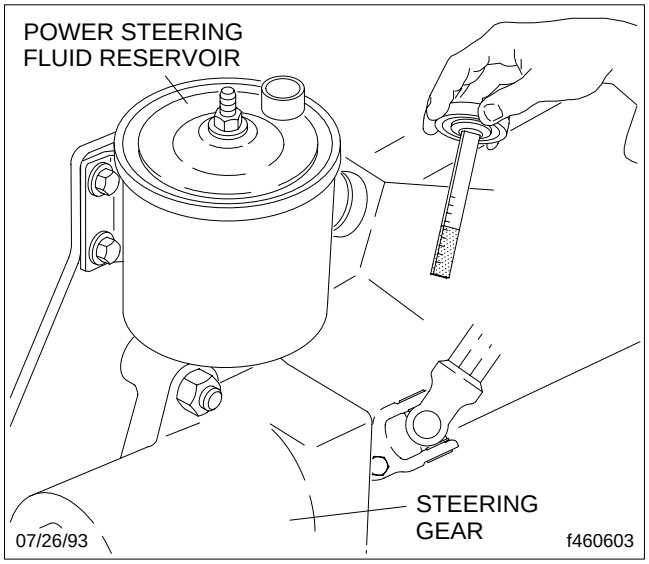


Fig. 6

Hydro-Max II® Power Booster Disassembly Inspection, and Assembly

Disassembly (Fig. 1)

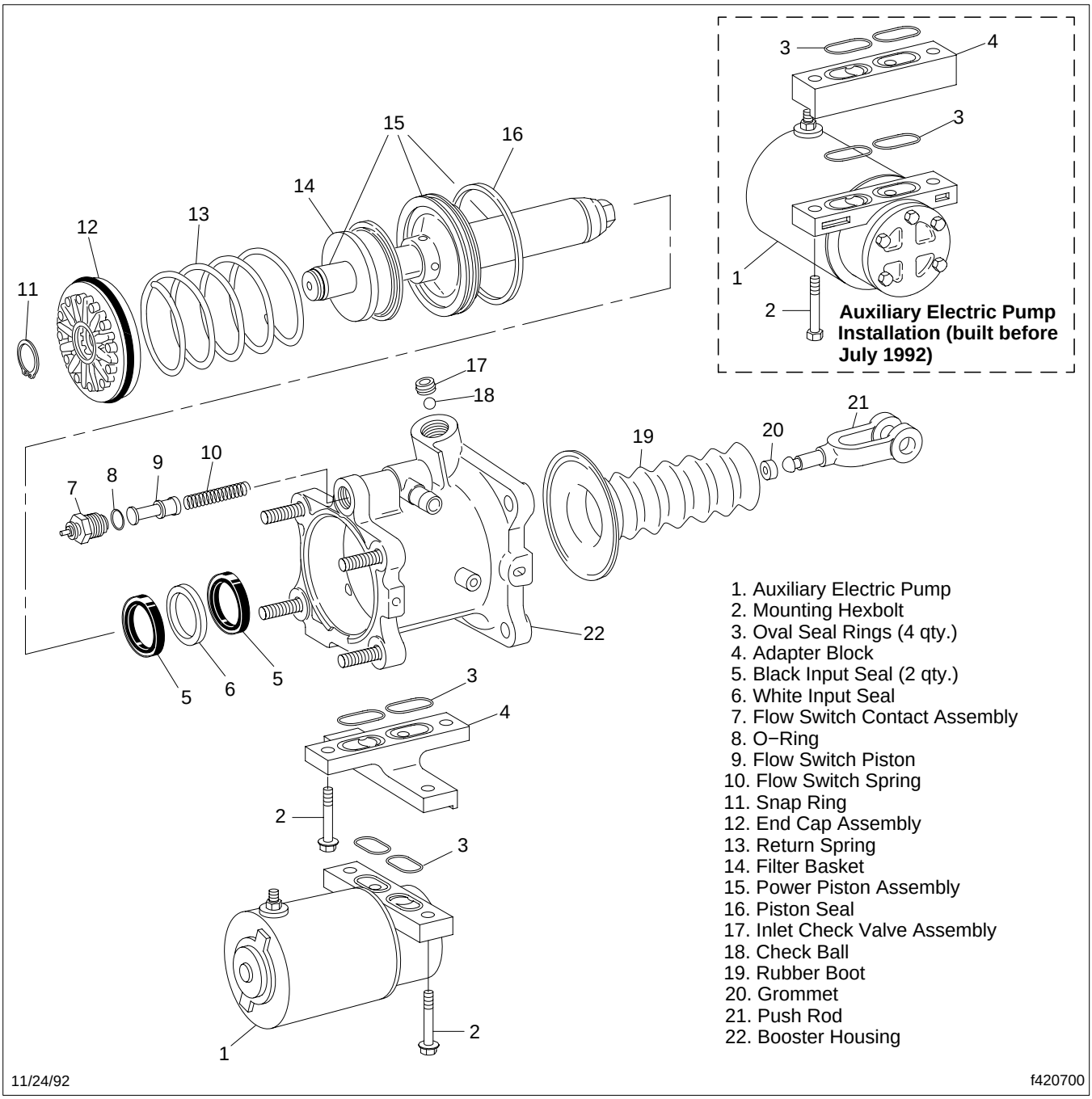


Fig. 1

Hydro-Max II® Power Booster Disassembly Inspection, and Assembly

⚠ WARNING

WARNING: Always wear safety goggles or glasses when working on the power booster. Some power booster parts are under compression (such as springs, snap-rings, and the like), and they could release with some force, possibly causing injury.

1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Remove the power booster from the vehicle, following instructions in **Subject 180**.
3. Remove the auxiliary electric pump (**Fig. 1** , Ref. 1) from the power booster housing.
   - 3.1 Hold the booster and pump assembly over a container. There are about 3 cups of fluid in the assembly.
   - 3.2 Remove the two screws that hold the pump and the adapter block to the bottom of the booster. See **Fig. 2**.

     Remove the two screws that attach the pump to the adapter (if applicable).
   - 3.3 After the power steering fluid has been drained, remove and discard the oval seal rings (**Fig. 1**, Ref. 3) from the electric pump and the adapter block.
4. Remove and discard the rubber boot (**Fig. 1** , Ref. 19) from the push rod.
5. Remove push rod (**Fig. 1**, Ref. 21) from the end of the power piston (Ref. 15).
   - 5.1 Put the booster unit in a padded vise so the wrench flats at the end of the power piston are in the vise jaws, as shown in **Fig. 3**.
   - 5.2 Put a round pry bar through the eyes of the push rod clevis, then pry the push rod out of the end of the power piston. See **Fig. 3**.
   - 5.3 Remove all the plastic grommet pieces from inside the power piston end and the push rod.
6. Remove the power piston assembly and the end cap from the booster housing.

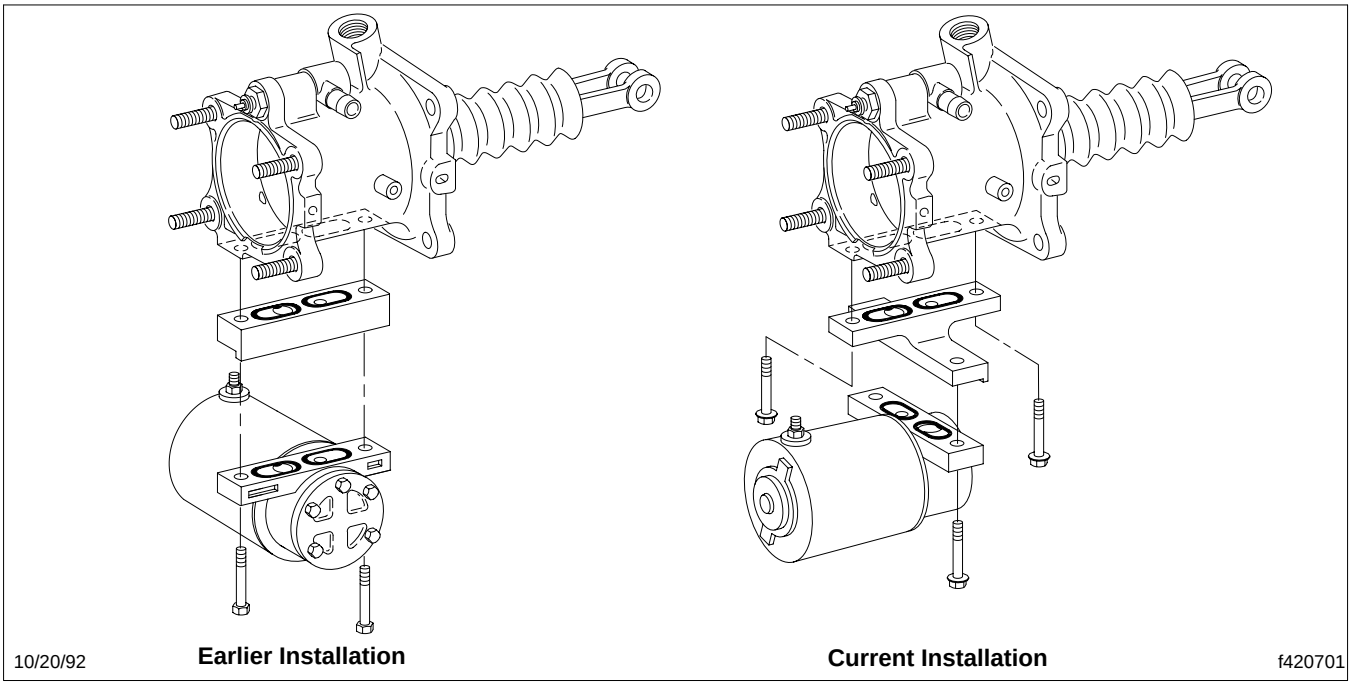


Fig. 2

Hydro-Max II® Power Booster Disassembly Inspection, and Assembly

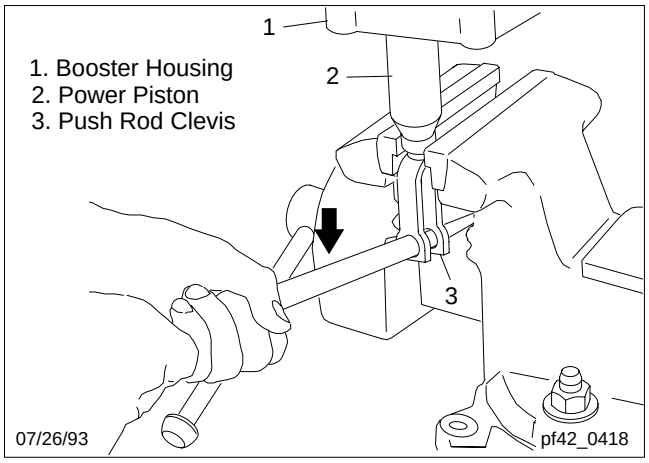


Fig. 3

6.1 Place the booster housing on a padded surface, with the end cap facing down.

6.2 Push down on the end of the power piston until the end cap and power piston come out of the front of the housing.

6.3 Pull the power piston and end cap straight out of the booster housing (see **Fig. 4**); be careful not to scratch the piston or the housing bore.

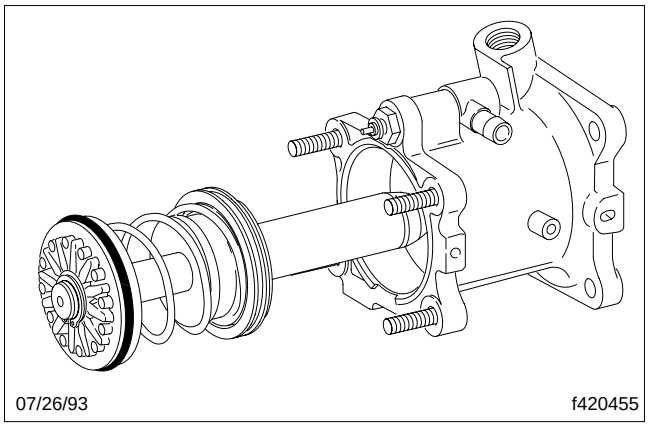


Fig. 4

7. Remove and discard the three input seals from the small bore at rear of the booster housing. See **Fig. 1**, Refs. 5 and 6.

8. Remove and discard the piston seal (Ref. 16) from the power piston.

9. Remove the end cap and the filter basket from the power piston.

9.1 Put the end cap and power piston on a padded surface.

9.2 Push down on the end cap to release the pressure on the snap ring, as shown in **Fig. 5**.

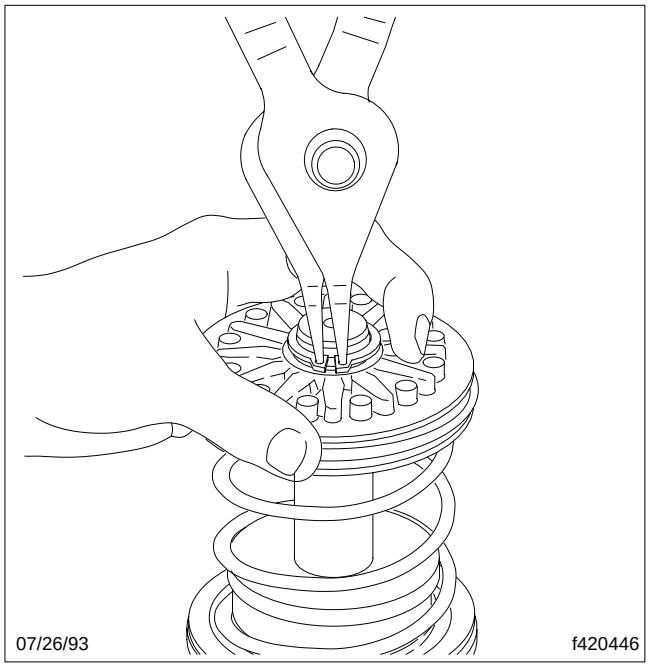


Fig. 5

9.3 Remove and discard the snap ring from the output shaft of the power piston. See **Fig. 6**.

9.4 Remove and discard the end cap and the return spring. See **Fig. 6**.

9.5 Remove the filter basket.

10. Remove the flow switch assembly from the front of the booster housing.

10.1 Unscrew the nylon flow switch contact assembly from the housing. See **Fig. 7**.

10.2 Using a small magnet, remove the flow switch piston and spring (**Fig. 8**) from the booster housing.

10.3 Remove and discard the O-ring from the nylon contact assembly.

Hydro-Max II® Power Booster Disassembly Inspection, and Assembly

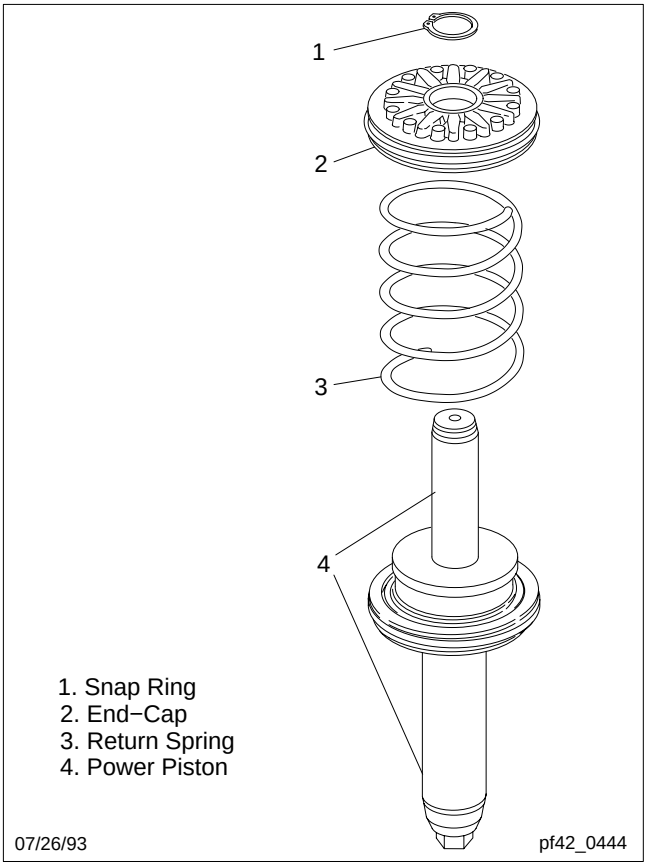


Fig. 6

11. Using a hooked piece of wire, remove the inlet check valve from the inlet port on the booster housing. Then remove the check ball. Discard both parts. See **Fig. 9**, **Fig. 10**, and **Fig. 11**.

Inspection

1. Check the power piston surface for nicks or scratches. Pay special attention to the sealing surface and the input and output shafts. See **Fig. 12**. If there is any damage, replace the power piston assembly.
2. Check the bore in the booster housing. If it is grooved, nicked, or otherwise damaged, replace the entire power booster assembly.

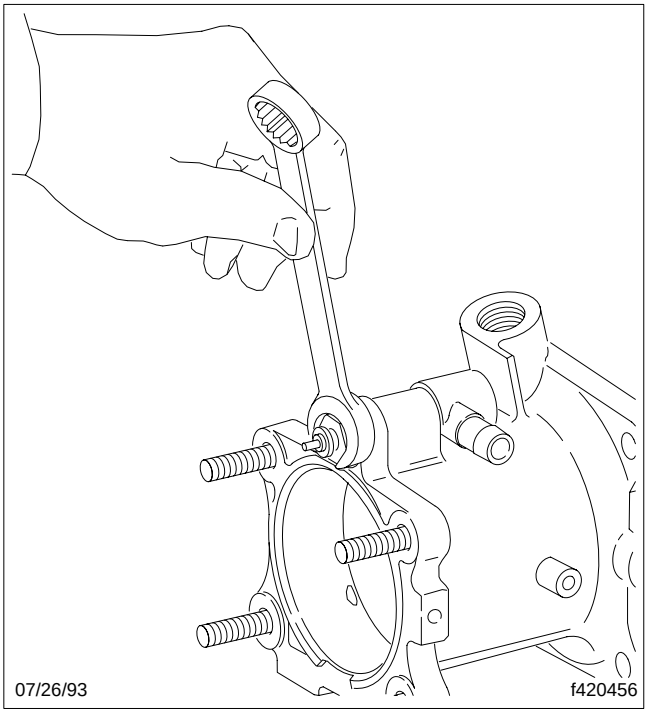


Fig. 7

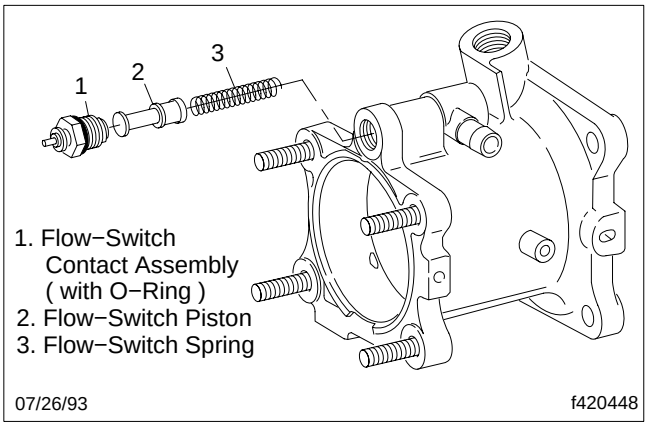


Fig. 8

Assembly (Fig. 1)

⚠ WARNING

WARNING: Use only clean Dexron II® ATF for cleaning or lubricating power booster parts. Don't use brake fluid. Using other types of fluids

Hydro-Max II® Power Booster Disassembly Inspection, and Assembly

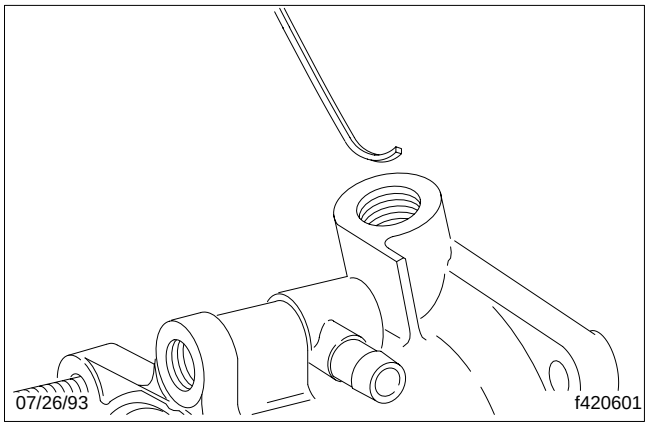


Fig. 9

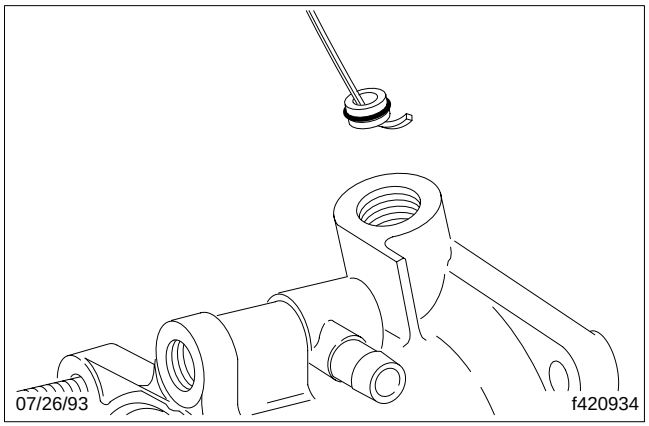


Fig. 10

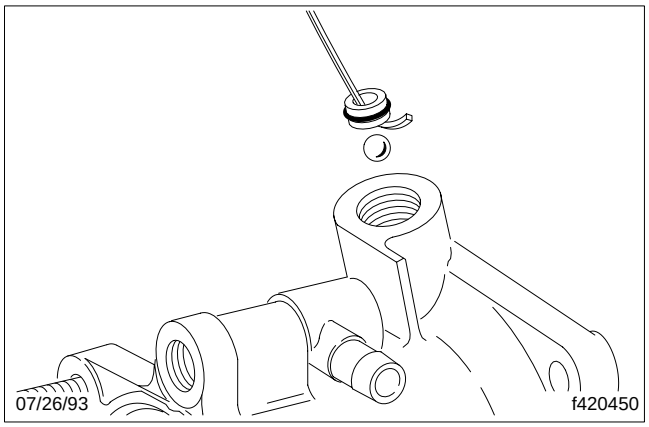


Fig. 11

may destroy seals and O-rings, which could cause the eventual loss of brake control.

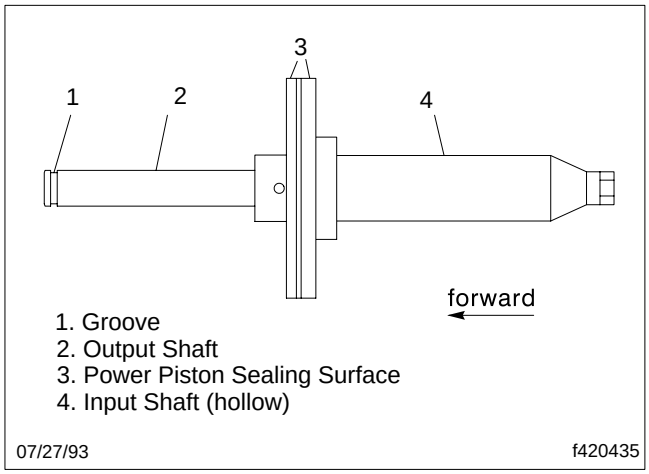


Fig. 12, Power Piston Assembly

1. Using clean power steering fluid, clean and lightly lubricate all the power booster parts.
2. Install new input seals in the small bore of the booster housing. Install the white seal between the two black ones, as shown in **Fig. 13**.

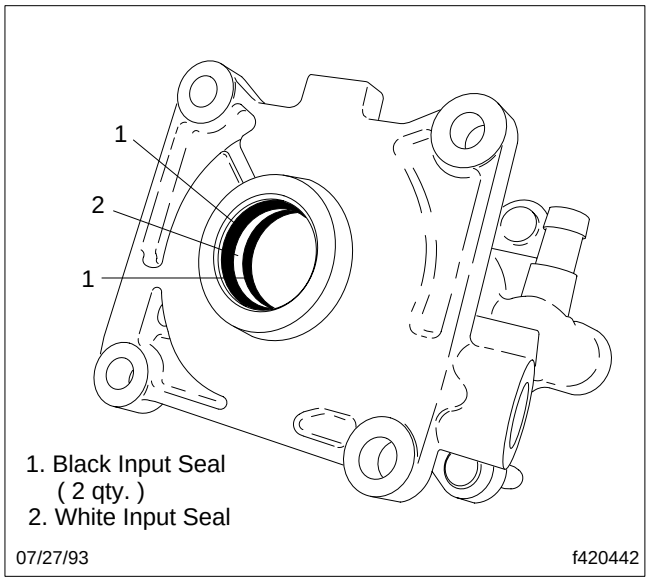


Fig. 13

3. Install a new check ball in the inlet port on top of the booster housing, then install a new inlet check valve assembly. Make sure it's seated firmly.
4. Install the flow switch assembly in the front of the booster housing. See **Fig. 14**.

Hydro-Max II® Power Booster Disassembly Inspection, and Assembly

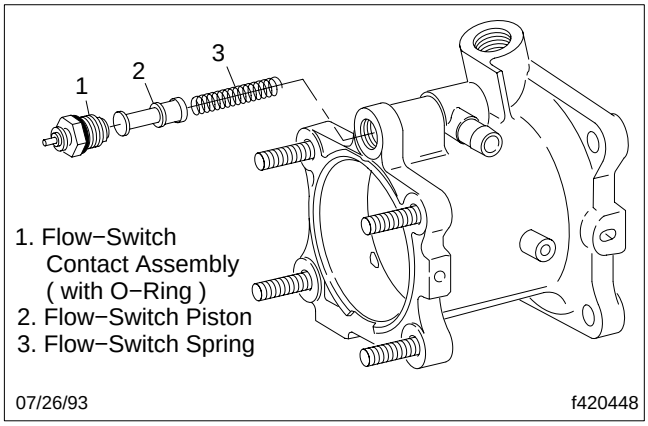


Fig. 14

4.1 Install the flow switch spring in its hole at the front of the booster housing.

4.2 Install the flow switch piston.

4.3 Install a new O-ring on the flow-switch contact assembly, then install the assembly in the hole at the front of the booster housing. Tighten it finger-tight.

5. Install a new filter basket— open end first— over the power piston output shaft, and push it up against the power piston.

6. Install the return spring on the power piston output shaft.

7. Install a new end-cap assembly on the power piston output shaft.

7.1 Install a new square cut seal on the outside diameter of the new end cap, then install a new O-ring inside the small bore of the end cap.

7.2 Lubricate the O-ring and lip seal in the end-cap hole with power steering fluid.

7.3 Carefully install the end-cap assembly (ribbed side up) on the power piston output shaft.

7.4 Keeping the end cap pushed down, install the snap ring in the groove of the power piston output shaft. See **Fig. 15**.

8. Install the power piston assembly in the booster housing.

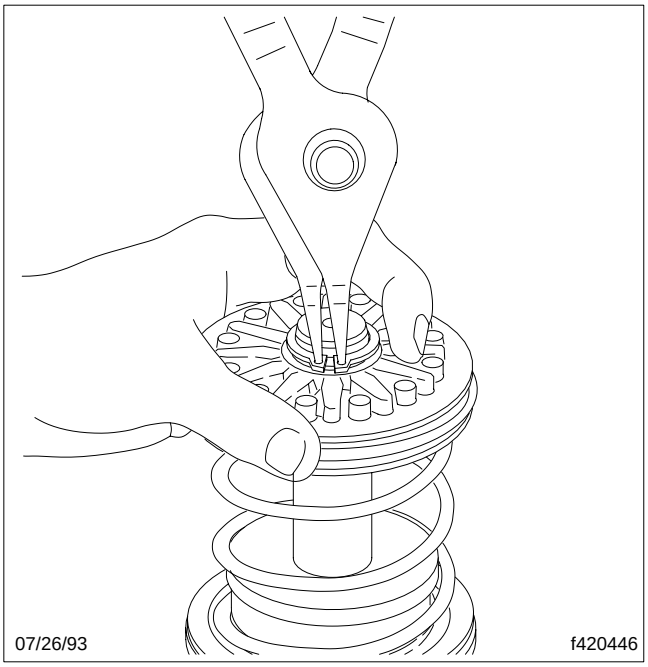


Fig. 15

8.1 Install the power piston, larger shaft first, into the large bore at the front of the booster housing.

⚠ WARNING

WARNING: Be careful not to damage the input seals in the small bore of the booster housing when you install the power piston shaft through the small bore. If these seals are damaged, the booster assembly will leak, causing loss of braking power.

8.2 Carefully work the end of the power piston shaft through the small bore of the booster housing. Use a gentle twisting motion to work the shaft past the two seals (**Fig. 13**) in the bore.

IMPORTANT: If the seals are damaged by the power piston shaft, replace them. Then repeat steps for installation of the power piston.

8.3 Seat the end cap in the large bore of the housing.

9. Install a new boot on the push rod.

Hydro-Max II® Power Booster Disassembly Inspection, and Assembly

10. Install the push rod on the end of the power piston.
    - 10.1 Install a new grommet on the push rod.
    - 10.2 Put the flats of the power piston end into a padded vise, then install the push rod and the grommet firmly into the end of the power piston.

⚠ WARNING

WARNING: Be sure the push rod is seated all the way into the power piston end. If it's not, it could become disconnected later, which could result in the loss of braking control.

11. Install new oval face seals on the mating surface of the auxiliary electric pump. See **Fig. 16**.

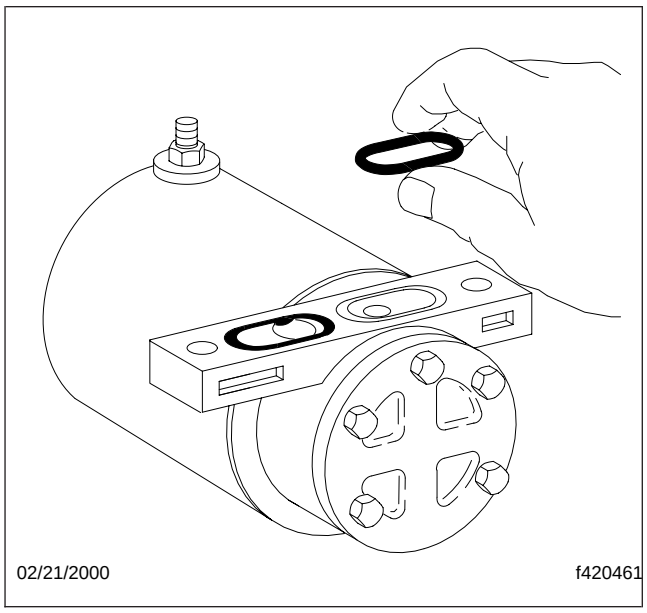


Fig. 16

12. Install the adapter block on the electric pump, with the machined lip on the block down, and hanging over the front edge of the electric pump. See **Fig. 17**. Tighten the mounting bolts 30 N·m (22 lbf·ft).
13. Install new oval face seals on the top of the adapter block, then install the adapter block and electric pump assembly on the bottom of the booster housing, as shown in **Fig. 18**. Tighten the two mounting bolts 30 N·m (22 lbf·ft).

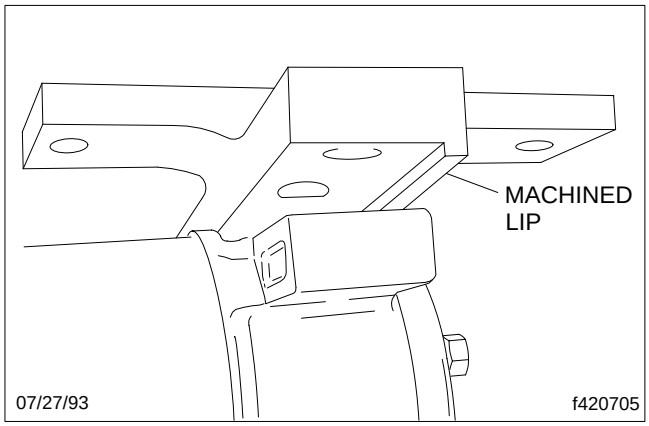


Fig. 17

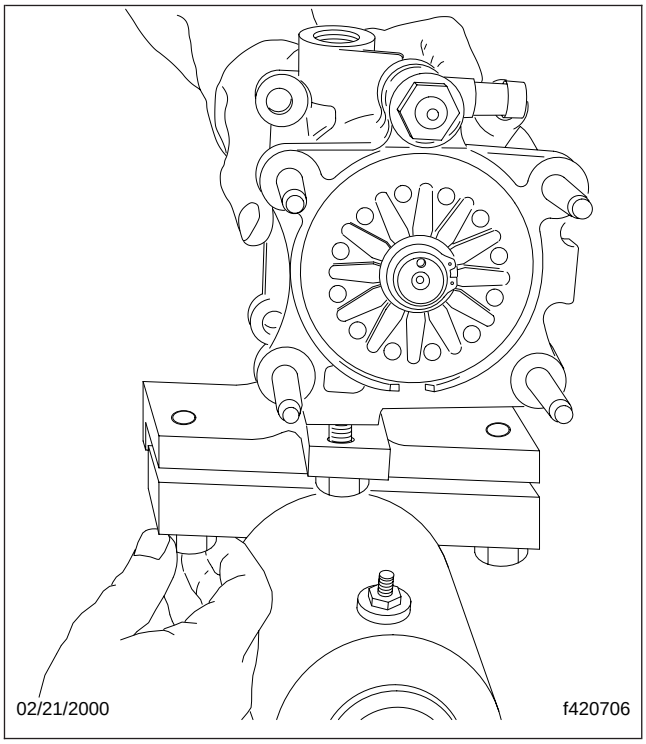


Fig. 18

14. Install the power booster assembly on the vehicle, following instructions in **Subject 180**.

Hydraulic Brake Control Module Removal and Installation

Removal

1. Disconnect the batteries at the negative terminals.
2. Access the control module.
   2.1 Remove the extruded rubber strip from the top of the dashboard. **See Fig. 1**.

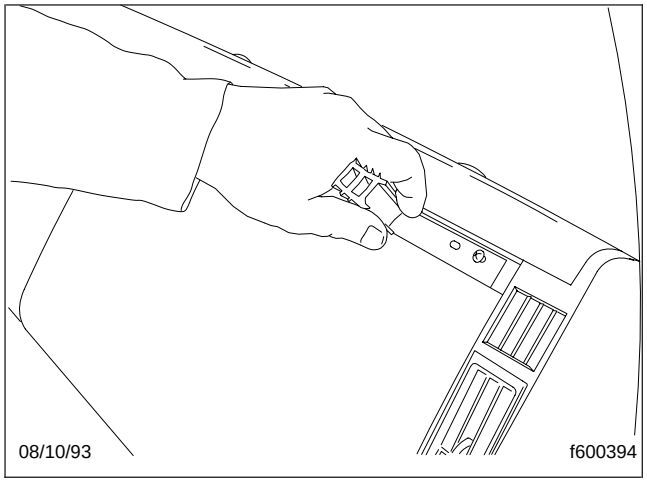
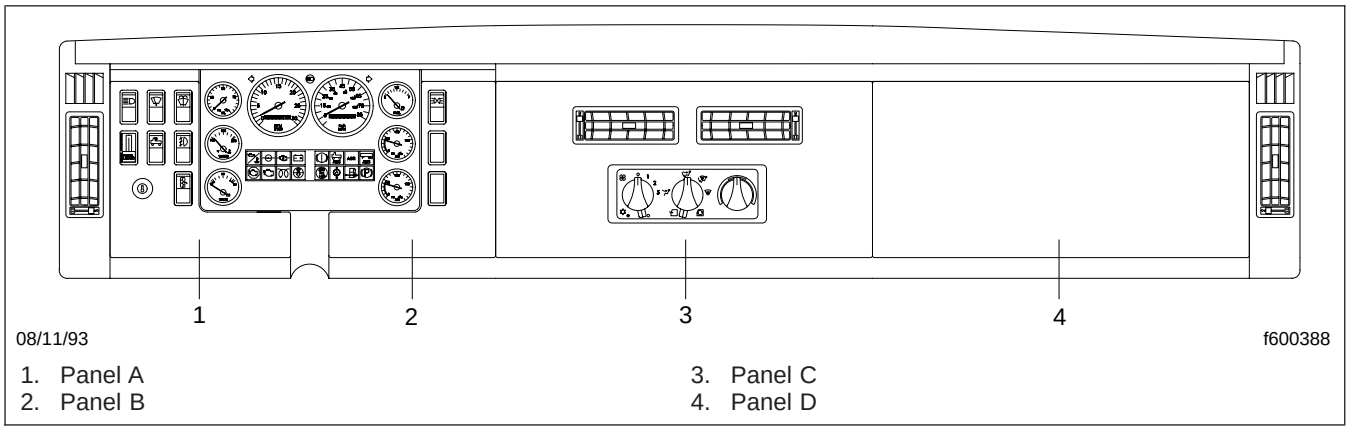


Fig. 1

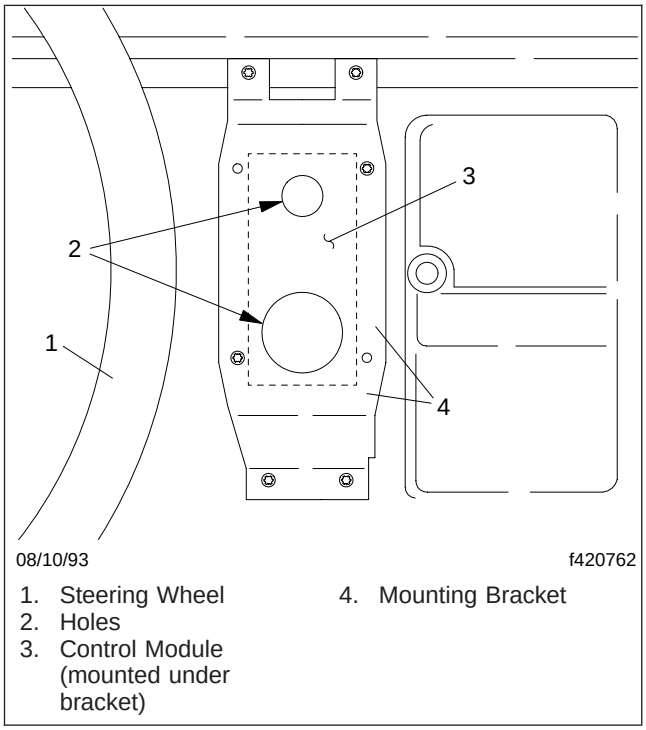
   2.2 Remove dash panels B and D. **See Fig. 2**. Mark and disconnect any electrical wires from the back of panel B.



1. Panel A
2. Panel B
3. Panel C
4. Panel D

Fig. 2

   2.3 Remove the screws from panel C, then swing it down.
3. Find the control module (**see Fig. 3**). Remove the four Torx® head screws holding the module and bracket assembly to the dash, then pull out the module and bracket assembly.

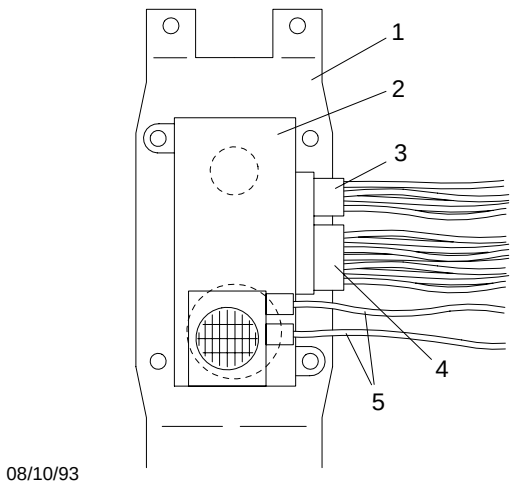


1. Steering Wheel
2. Holes
3. Control Module (mounted under bracket)
4. Mounting Bracket

Fig. 3

4. Disconnect the 9-pin connector, the 4-pin connector, and the two buzzer wires from the back of the module. **See Fig. 4**.

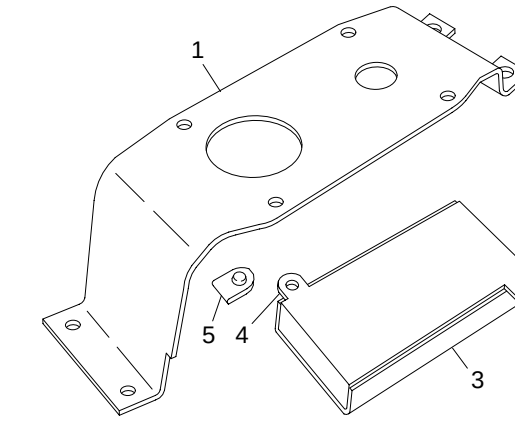
Hydraulic Brake Control Module Removal and Installation



1. Mounting Bracket
2. Control Module
3. 4-Pin Connector
4. 9-Pin Connector
5. Buzzer Wires

Fig. 4

5. Remove the two Torx head screws that attach the module to the mounting bracket, then remove the mounting bracket.
6. Remove and save the two clips from the ears of the module. **Refer to Fig. 5**.



1. Mounting Bracket
2. Clip (installed)
3. Control Module
4. Ear
5. Clip (removed)

Fig. 5

Installation

1. Install the two clips on the ears of the control module, then install the control module on the mounting bracket.
2. Connect the two buzzer wires to the posts on the back of the control module (it doesn't matter which wire goes to which post), then connect the 9-pin and the 4-pin connectors to the back of the control module. **See Fig. 4**.
3. Install the control module and mounting bracket assembly in the dash, using the four Torx head screws.
4. Connect any electrical wires (if present) to the back of dash panel B.
5. Swing dash panel C into place, and then install its mounting screws.
6. Install dash panels B and D.
7. Install the extruded rubber strip in the top of the dashboard.
8. Connect the batteries.

Troubleshooting Tables

Pedal

Problem—The Power Booster Works Sluggishly or Not at All

Problem—The Power Booster Works Sluggishly or Not at All	
Possible Cause	**Remedy**
Binding power booster push rod	Check the linkage between the brake pedal and the power booster push rod. Check the hole in the cab front wall through which the push rod fits. Repair or replace parts as needed.

Problem—The Auxiliary Electric Pump Runs Continuously When the Ignition Is Off and the Brake Pedal Is Not Depressed

Problem—The Auxiliary Electric Pump Runs Continuously When the Ignition Is Off and the Brake Pedal Is Not Depressed	
Possible Cause	**Remedy**
Brake pedal linkage	Check the brake pedal linkage. Repair or replace as needed.

Problem—Pedal Does Not Return, The Brakes are Dragging, Grabbing, or the Brake Action is Uneven

Problem—Pedal Does Not Return, The Brakes are Dragging, Grabbing, or the Brake Action is Uneven	
Possible Cause	**Remedy**
Brake pedal binding or restricted from returning	Check the brake pedal for a restriction. Repair as needed.

Problem—The Brake Pedal Is Hard to Depress With the Engine Running

Problem—The Brake Pedal Is Hard to Depress With the Engine Running	
Possible Cause	**Remedy**
Binding brake pedal	Check the brake pedal linkage. Repair or replace as needed.
Pedal misalignment (side-to-side)	

Wheel-End Components

Problem—Fluid Level Indicator Light Illuminated

Problem—Fluid Level Indicator Light Illuminated	
Possible Cause	**Remedy**
Brake pads worn out	Inspect the brake pads and replace as necessary in axle sets. Add fluid as required.

Troubleshooting

Problem—The Brakes Grab

Problem—The Brakes Grab	
Possible Cause	**Remedy**
Incorrect pads or loose pads on plate	Replace with the correct pads in axle sets.
Grease or brake fluid on pads	Repair grease seal or caliper as required. Replace pads in axle sets.

Problem—The Brakes Pull To the Left or Right

Problem—The Brakes Pull To the Left or Right	
Possible Cause	**Remedy**
Low tire pressure	Inflate the tires to the correct pressure.
Front wheels out of alignment	Align the front wheels. See **Section 33.00**.
Mismatched tires	Check the tire sizes and correct as needed.
Kinked brake lines	Check the routing of the brake lines and hoses. Repair or replace as needed.
Loose or not working caliper	Repair the caliper.
Oily brake pads	Replace the brake pads in axle sets.
Rear brakes not working	Check the rear brakes and repair or replace parts as needed.
Loose suspension parts	Check the front and rear suspension, and repair as needed.
Mismatched or worn brake pads	Replace the brake pads in axle sets. Repair or replace the rotor(s) as needed.
Grease on pads or rotor	Clean the parts as needed.
Caliper piston sticking	Replace caliper as required.
Caliper or anchor plate V-ways sticking	Clean V-ways and anchor plate rails thoroughly and lubricate with approved grease.

Problem—Brake Noises With the Brakes Not Applied

Problem—Brake Noises With the Brakes Not Applied	
Possible Cause	**Remedy**
Worn out front pads	Replace the pads in axle sets.
Dust or oil on rotors	Clean the rotors. Check for and repair an oil leak.

Problem—Brake Noises With the Brakes Applied

Problem—Brake Noises With the Brakes Applied	
Possible Cause	**Remedy**
Bent, damaged or incorrect brake pads installed	Install the correct brake pads in axle sets.
Loose caliper	Install wear shims, or replace worn parts as needed.

Problem—Roughness, Chattering, or Pulsating Is Felt When the Brakes are Applied

Problem—Roughness, Chattering, or Pulsating Is Felt When the Brakes are Applied	
Possible Cause	**Remedy**
Too much rotor lateral runout	Check the lateral runout on the rotors. Repair or replace as needed.
Rotor parallelism not to specifications	Check the parallelism of the rotors. Repair or replace as needed.
Incorrectly adjusted wheel bearings	Check the end play of the front and rear wheel bearings. Adjust as needed. See **Group 33** for front axles and **Group 35** for rear axles.
Brake pad installed backwards (steel side toward the rotor face)	Install the brake pad correctly.
Foreign material imbedded in pads	Replace pads in axle sets.

Problem—Too Much Effort Is Needed to Apply the Brakes (Hard Pedal)

Problem—Too Much Effort Is Needed to Apply the Brakes (Hard Pedal)	
Possible Cause	**Remedy**
Worn brake pads	Replace the brake pads in axle sets.
Stuck or binding caliper piston	Check the caliper pistons. Rebuild the caliper(s) as needed.
Fading brakes due to incorrect pads	Install the correct brake pads in axle sets.
Glazed rotors or brake pads	Replace the glazed rotors or brake pads in axle sets.
Grease or oil on brake pads or rotors	Clean the brake pads or rotors.
Overloaded vehicle	Do not exceed rated vehicle loads.

Problem—The Brakes are Dragging

Problem—The Brakes are Dragging	
Possible Cause	**Remedy**
Kinked or pinched brake lines or hoses	Check the brake lines and hoses. Repair or replace as needed.
Incorrectly installed inboard brake pad	Check the inboard brake pads. Install them correctly as needed.
Brake caliper pistons not returning	Repair or replace the caliper(s) as needed. Check the brake fluid for water. Drain, flush and fill the system if water is found.
Stuck or bound caliper pins or rails	Repair or replace the caliper(s) as needed.
Soft or swollen rubber parts caused by incorrect or contaminated brake fluid	Replace all rubber parts including calipers (which have internal rubber seals). Flush the hydraulic system and fill with approved fluid.

Problem—Excessive Pedal Travel (Low Pedal)

Problem—Excessive Pedal Travel (Low Pedal)	
Possible Cause	**Remedy**
Worn brake pads	Replace the brake pads in axle sets.
Pad and piston knockback caused by loose wheel bearings	Adjust, tighten or replace parts as necessary.

Troubleshooting

Problem—One Brake Drags

Problem—One Brake Drags	
Possible Cause	**Remedy**
Loose or worn front wheel bearings	Adjust to specifications or replace.
Worn or damaged brake hose or hydraulic tube preventing return of brake fluid	Replace worn or damaged hose or tube as necessary.
Sticking caliper piston	Repair or replace the caliper.
Swollen caliper piston seal	Replace the caliper. Flush hydraulic brake system and fill with clean, approved brake fluid.
Sticking caliper V-ways	Clean the V-ways and anchor plate rails and thoroughly lubricate with approved grease.

Hydro-Max II® Power Booster and Master Cylinder

Problem—The Auxiliary Electric Pump Does Not Work With the Engine Off and the Brake Pedal Depressed

Problem—The Auxiliary Electric Pump Does Not Work With the Engine Off and the Brake Pedal Depressed	
Possible Cause	**Remedy**
Loose, broken or disconnected wiring to flow switch on power booster	Check the wiring and repair or replace as needed.
Power booster flow switch not working	Replace the flow switch.

Problem—Fluid Level Indicator Light Illuminated

Problem—Fluid Level Indicator Light Illuminated	
Possible Cause	**Remedy**
Low fluid level	Inspect brake pads, replace as necessary in axle sets. Add fluid as required.
Fluid level indicator switch not working	Replace the master cylinder.

Problem—Silicon Floating in Master Cylinder

Problem—Silicon Floating in Master Cylinder	
Possible Cause	**Remedy**
None	This material is an assembly lubricant and is harmless.

Problem—Noise or Whistle

Problem—Noise or Whistle	
Possible Cause	**Remedy**
None	This noise is inherent in some power boosters (whistle).

Problem—Brakes Self-Apply

Problem—Brakes Self-Apply	
Possible Cause	**Remedy**
Constricted master cylinder reservoir vent	Clean the vent passage in the reservoir cap.

Problem—Pedal Does Not Return

Problem—Pedal Does Not Return	
Possible Cause	**Remedy**
Fluid contamination	Drain the system and fill with the correct type of fluid. Bleed the air from the system. Replace the power booster or master cylinder as needed. Replace the power steering reservoir filter as needed.
Master cylinder not working	Replace the master cylinder.
Binding power booster	Replace the power booster.

Problem—Soft, Spongy Brakes

Problem—Soft, Springy or Spongy Brakes	
Possible Cause	**Remedy**
Air in the hydraulic system	Bleed the brake hydraulic system and the power steering system as needed.
Poor quality brake fluid (low boiling point)	Drain the system, flush and refill with the recommended fluid.
Weak brake hoses that expand under pressure	Replace the hoses as needed.

Problem—Too Much Effort Is Needed to Apply the Brakes (Hard Pedal)

Problem—Too Much Effort Is Needed to Apply the Brakes (Hard Pedal)	
Possible Cause	**Remedy**
Overloaded vehicle	Do not exceed rated vehicle loads.
Power booster not working	Go to "System Pressure Test," under "Pressure Tests" in this subject.
Master cylinder not working	Replace the master cylinder.
Tube and hose passages blocked shut	Replace the parts containing blocked passages.

Problem—Too Much Brake Pedal Travel (Low Pedal)

Problem—Too Much Brake Pedal Travel (Low Pedal)	
Possible Cause	**Remedy**
Leak in hydraulic system	Check for and repair any leaks found in either the power booster (power steering) hydraulic system or the brake hydraulic system.
Low fluid level or leak in master cylinder	Find the cause of the low fluid level and remedy the problem. Fill the master cylinder compartments to the correct level.
Air in the hydraulic system	Bleed the brake hydraulic system and the power steering system as needed.
Plugged master cylinder cap	Clean or replace the master cylinder cap.

Troubleshooting

Problem—Too Much Brake Pedal Travel (Low Pedal)	
Possible Cause	**Remedy**
Wrong type of brake fluid in system	Drain the system and fill with the correct type of brake fluid. Bleed the air from the system.
Master cylinder not working	Replace the master cylinder.
Weak brake hoses that expand under pressure	Replace the hoses.

Problem—The Brake Pedal Travel is Decreasing

Problem—The Brake Pedal Travel is Decreasing	
Possible Cause	**Remedy**
Plugged compensating port in master cylinder	Check the compensating ports in the master cylinder through the openings at the bottom of each reservoir compartment. Unplug them if needed. If the compensating valves are stuck, remove the reservoir. Install the compensating valves correctly.
Master cylinder pistons not returning	Repair or replace the master cylinder.

Problem—The Brakes are Dragging

Problem—The Brakes are Dragging	
Possible Cause	**Remedy**
Master cylinder pistons not returning	Repair or replace the master cylinder.
Kinked or pinched brake lines or hoses	Check the brake lines and hoses. Repair or replace as needed.
Power piston in power booster not returning	Repair or replace the power booster.
Restriction or blockage inside a brake line or hose	Go to "Residual Pressure Test," under "Pressure Tests" in this subject.
Soft or swollen master cylinder seals due to brake fluid contamination	Flush out the old brake fluid and replace the master cylinder. Fill the system with new brake fluid.
Soft or swollen rubber parts caused by incorrect or contaminated brake fluid	Replace all rubber parts including calipers (which have internal rubber seals). Flush the hydraulic system and fill with approved fluid.
Trapped pressure in brake lines caused by master cylinder or power booster not fully releasing	Repair or replace the master cylinder or power booster as necessary.

Problem—The Brakes are Grabbing or the Brake Action is Uneven

Problem—The Brakes are Grabbing or the Brake Action is Uneven	
Possible Cause	**Remedy**
Power booster not working	Repair or replace the power booster.

Problem—Fluid Is Leaking Between the Power Booster and the Master Cylinder (a slight amount of moisture between the power booster and master cylinder is normal)

Problem—Fluid Is Leaking Between the Power Booster and the Master Cylinder (a slight amount of moisture between the power booster and master cylinder is normal)	
Possible Cause	**Remedy**
Worn or damaged master cylinder primary pressure seal or backup ring	Repair or replace the master cylinder.
Worn or damaged seals or O-rings in the power booster end-cap assembly	Repair or replace the power booster.

Problem—Fluid Is Leaking at the Power Booster or the Power Steering Pump

Problem—Fluid Is Leaking at the Power Booster or the Power Steering Pump	
Possible Cause	**Remedy**
Worn or damaged seals between the auxiliary electric pump and the power booster	Replace the seals.
Loose hexbolts attaching the auxiliary electric pump to the power booster	Tighten the hexbolts 22 lbf·ft (30 N·m).
Worn or damaged power booster housing	Replace the power booster.
Worn or damaged power booster flow switch seals	Repair the power booster.
Leaking master cylinder reservoir vent caps	Replace the diaphragms and the caps.
Fluid contamination	Drain the system and fill with the correct type of fluid. Bleed the air from the system. Replace the power booster or master cylinder as needed. Replace the power steering reservoir filter as necessary.
Leaking flow switch seal	Replace the O-ring.
Leaking hydraulic fittings and connections	Check the fittings and connections. Tighten and replace as necessary.

Problem—The Power Booster Works Sluggishly or Not at All

Problem—The Power Booster Works Sluggishly or Not at All	
Possible Cause	**Remedy**
Binding power booster push rod	Check the linkage between the brake pedal and the power booster push rod. Check the hole in the cab front wall through which the push rod fits. Repair or replace parts as needed.
Worn or damaged power booster	Replace or rebuild the power booster.

Auxiliary Electric Pump

Troubleshooting

Problem—Fluid is Leaking at the Power Booster or the Power Steering Pump

Problem—Fluid is Leaking at the Power Booster or the Power Steering Pump	
Possible Cause	**Remedy**
Worn or damaged seals between the auxiliary electric pump and the power booster	Replace the seals.
Worn or damaged auxiliary electric pump	Replace the auxiliary electric pump.
Loose hexbolts attaching the auxiliary electric pump to the power booster	Tighten the hexbolts 22 lbf·ft (30 N·m).
Leaking auxiliary electric pump mounting seals	Replace the seals.

Problem—The Power Booster Works Sluggishly or Not at All

Problem—The Power Booster Works Sluggishly or Not at All	
Possible Cause	**Remedy**
Leakage around the check ball in the auxiliary electric pump	Install a flow gauge on the power booster inlet port. Check the pressure with the engine on, and the brakes fully applied. If the pressure is less than 800 psi (5515 kPa), replace the auxiliary electric pump.

Problem—The Auxiliary Electric Pump Does Not Work With the Engine Off and the Brake Pedal Depressed

Problem—The Auxiliary Electric Pump Does Not Work With the Engine Off and the Brake Pedal Depressed	
Possible Cause	**Remedy**
Disconnected or damaged wiring to auxiliary electric pump	Check the wiring. Repair or replace as needed.
Dead batteries	Check the batteries. Recharge them as needed.
Out of adjustment brake switch	Check the brake switch and adjust it as needed.
Worn or damaged brake switch	Replace the brake switch.
Relay to the auxiliary electric pump not working	Check the relay. Replace it if needed.
Auxiliary electric pump not working	Check the operation of the auxiliary electric pump and replace as needed.
Open circuit	Repair the circuit.

Problem—The Auxiliary Electric Pump Runs Continuously When the Ignition Is Off and the Brake Pedal Is Not Depressed

Problem—The Auxiliary Electric Pump Runs Continuously When the Ignition Is Off and the Brake Pedal Is Not Depressed	
Possible Cause	**Remedy**
Brake light switch not working or incorrectly adjusted	Check the brake light switch and repair or replace as needed.
Relay to the auxiliary electric pump not working	Check the relay. Replace if needed.

Problem—The Auxiliary Electric Pump Runs Continuously When the Ignition Is Off and the Brake Pedal Is Not Depressed	
Possible Cause	**Remedy**
Flow switch not working	Remove the switch components, clean and inspect them for damage or contamination. Repair or replace as necessary.

Problem—The Auxiliary Electric Pump Is Working, But There Is No Boost Power to the Brakes

Problem—The Auxiliary Electric Pump Is Working, But There Is No Boost Power to the Brakes	
Possible Cause	**Remedy**
Low battery voltage	Check the batteries and recharge them as needed.
Low auxiliary electric pump voltage	Disconnect the wiring from the auxiliary electric pump. Check the voltage at the wire. If the voltage is 10 volts or less, replace the wire. If it is more than 10 volts, replace the auxiliary electric pump.

Power Steering Pump

Problem—The Brakes Are Dragging, Brakes Self-Apply or Pedal Does Not Return

Problem—The Brakes Are Dragging, Brakes Self-Apply or Pedal Does Not Return	
Possible Cause	**Remedy**
Self-applied booster (fluid flow too high)	Repair or replace the power steering pump.

Problem—Too Much Effort Is Needed to Apply the Brakes (Hard Pedal)

Problem—Too Much Effort Is Needed to Apply the Brakes (Hard Pedal)	
Possible Cause	**Remedy**
Overloaded vehicle	Do not exceed rated vehicle loads.
Low power booster supply flow	Repair or replace the power steering pump. Check the belt for tightness.
Power steering pump flow control valve not working	Repair or replace the power steering pump. Check the belt for tightness.
Power steering pump relief valve setting too low	Replace the power steering pump.
Tube and hose passages blocked shut	Replace the parts containing blocked passages.

Problem—Fluid Is Leaking at the Power Booster or the Power Steering Pump

Problem—Fluid Is Leaking at the Power Booster or the Power Steering Pump	
Possible Cause	**Remedy**
Worn or damaged power steering pump	Replace the power steering pump.
Fluid contamination	Drain the system and fill with the correct type of fluid. Bleed the air from the system. Replace the power booster or master cylinder as needed. Replace the power steering reservoir filter as necessary.
Leaking hydraulic fittings and connections	Check the fittings and connections. Tighten and replace as necessary.

Troubleshooting

Problem—The Power Steering Pump Is Noisy

Problem—The Power Steering Pump Is Noisy	
Possible Cause	**Remedy**
Hydraulic supply and return lines touching chassis	Reroute the power booster supply and return lines.
Low fluid level in power steering reservoir	Fill the power steering reservoir to the correct level.
Air in power steering fluid	Bleed the power steering system.
Contaminated power steering fluid	Change the power steering fluid or replace the power steering pump.

Problem—The Power Booster Works Sluggishly or Not at All

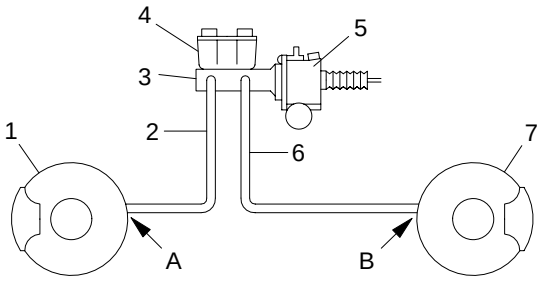
Problem—The Power Booster Works Sluggishly or Not at All	
Possible Cause	**Remedy**
Low fluid level in power steering reservoir	Fill the power steering reservoir to the correct level.
Restriction in power steering hydraulic lines	Check all the power steering system hydraulic lines. Replace as needed.
Air in power steering hydraulic system	Bleed the power steering hydraulic system.
Worn or damaged power steering pump	Repair or replace the power steering pump.

Pressure Tests

Residual Pressure Test

1. Install two pressure gauges with a range of 0 to 50 psi (345 kPa)—one in the primary circuit (at the rear wheel), and one in the secondary circuit (at the front wheel). See **Fig. 1**.
2. Bleed the two circuits following the procedure in **Subject 110**.
3. With the ignition off, lightly apply the brakes several times. Do not apply full pressure to the brake pedal or you may damage the pressure gauges.
4. Release the brakes. Read the residual pressure on the two gauges. Record the information.
5. If the residual pressure on one or both gauges is less than 2 psi (14 kPa), go to "System Pressure Test" in this subject.

   If the residual pressure on one or both gauges is more than 2 psi (14 kPa), check the linkage between the brake pedal and the booster. Adjust or repair the linkage as needed. Repeat steps 3 and 4. If the problem is solved, go to "System Pressure Test" in this subject. If the problem is not solved, continue with the procedure.



08/10/93 f420765

A. Install gauge #2 here.
B. Install gauge #1 here.
1. Front Brake
2. Secondary Circuit
3. Master Cylinder
4. Reservoir
5. Power Booster
6. Primary Circuit
7. Rear Brake

Fig. 1, Gauge Installation

6. If the check ports of the master cylinder have check valves, replace the master cylinder. Repeat steps 2 and 3. If the problem is solved, go to "System Pressure Test" in this subject. If the problem is not solved, continue with the procedure.

If the check ports of the master cylinder do not have check valves, check the hydraulic lines for internal blockage. Repair or replace lines as needed. Repeat steps 3 and 4. If the problem is solved, go to "System Pressure Test" in this subject. If the problem is not solved, continue with the procedure.

7. Check the master cylinder function. Repair or replace as needed. Go to "System Pressure Test" in this subject.

System Pressure Test

1. Install two pressure gauges with a range of 0 to 2500 psi (17 237 kPa)—one in the primary circuit (at the rear wheel), and one in the secondary circuit (at the front wheel). See **Fig. 1**.

   If you have previously done the residual pressure test, remove the two low-pressure gauges installed for that test, and replace them with the two high-pressure gauges.

2. Bleed the primary and secondary brake circuits following the procedure under **Subject 110**.

3. Make a copy of **Table 1**. Use this copy to record the results from the next step.

Test Results				
Pressure Test	**Gauge 1 (installed at rear wheel)**		**Gauge 1 (installed at front wheel)**	
Rapid Pressure Rise	Yes	No	Yes	No
Slow Pressure Rise	Yes	No	Yes	No
Highest Reading (psi)		psi		psi
Pressure Constant	Yes	No	Yes	No

Table 1, Test Results

4. Start the engine. Quickly apply the brakes using full pedal force. Hold the pedal down for 15 to 20 seconds. Record the speed of the pressure rise, the highest pressure registered on each gauge and whether the pressure stayed constant while the pedal was depressed. See **Table 1**.

5. If the pressure reading on both gauges is not within 10 percent, repair or replace the master cylinder as needed. Remove the pressure gauges. Bleed the system following the instructions in **Subject 110**.

6. If the pressure reading on both gauges is within 10 percent, but the gauges show less than 1170 psi (8067 kPa), turn off the engine; ignition on. Apply the brakes hard, hold the pedal down 15 to 20 seconds.

   If both gauges show at least 860 psi (5930 kPa), repair or replace the power booster. Remove the pressure gauges. Bleed the system following the instructions in **Subject 110**.

   If both gauges do not show at least 860 psi (5930 kPa), repair or replace the power steering pump. Bleed the system following the instructions in **Subject 110**.

7. If the pressure reading on both gauges is within 10 percent and the gauges show at least 1170 psi (8067 kPa), but the pressure came up slowly on both gauges, turn off the engine; ignition on. Apply the brakes hard, hold down the pedal 15 to 20 seconds. If there was an instant pressure rise on both gauges, repair or replace the power steering pump. Remove the pressure gauges. Bleed the system following the instructions in **Subject 110**.

   If there was not an instant pressure rise on both gauges, repair or replace the power booster. Remove the pressure gauges. Bleed the system following the instructions in **Subject 110**.

8. If the pressure reading on both gauges is within 10 percent and the gauges show at least 1170 psi (8067 kPa), but the pressure came up fast on one gauge and slowly on the other gauge, locate the restriction in the circuit having the slow gauge. Remove and install the gauge closer to the master cylinder until the pressure rises quickly. The restriction is between that point and the point of previous installation. Repair or replace the brake line as needed. Remove the pressure gauges. Bleed the system following the instructions in **Subject 110**.

9. If the pressure reading on both gauges is within 10 percent, the gauges show at least 1170 psi (8067 kPa) and the pressure came up instantly on both gauges, but there was not constant gauge pressure while the pedal was depressed, turn off the engine; ignition on. Apply the brakes hard, hold down the pedal for 15 to 20 seconds. If there is constant pressure on both gauges while the pedal is down, repair or replace the

Troubleshooting

power steering pump. Bleed the system following the instructions in **Subject 110**.

If there is not constant pressure on both gauges while the pedal is down, repair or replace the power booster. Bleed the system following the instructions in **Subject 110**.

10. If the pressure reading on both gauges is within 10 percent, the gauges show at least 1170 psi (8067 kPa), the pressure came up instantly on both gauges and there was constant gauge pressure while the pedal was depressed, but the brake pedal did not stay firm, repair or replace the master cylinder as needed. Bleed the system following the instructions in **Subject 110**.
11. If the pressure reading on both gauges is within 10 percent, the gauges show at least 1170 psi (8067 kPa), the pressure came up instantly on both gauges, there was constant gauge pressure while the pedal was depressed and the brake pedal stayed firm, remove the pressure gauges. Bleed the system following the instructions in **Subject 110**. If the problem still exists, check the foundation brakes.

Specifications

See Fig. 1 for the hydraulic brake system plumbing diagram. **See Fig. 2** for the brake control module wiring diagram.

Kent-Moore Part Number	Tool
KMS/ZTSE4276	Seating Tool for 2.88-Inch Caliper Pistons
KMS/ZTSE4343	Seating Tool for 2.6-Inch Caliper Pistons

Table 1, Kent-Moore Tools, Kent-Moore Tool Division, 29784 Little Mack, Roseville, MI 48066

Description	Bolt or Nut Size	Grade	Torque N·m (lbf·ft)
Power Booster Mounting Bolts	—	—	27 (20)
Master Cylinder Mounting Nuts	—	—	38 (28)
Brake Line Tube Nuts	7/16–24	—	20 (15)
Caliper Supply Fitting	7/16–24	—	20 (15)
Allen-Head Key Retainer Bolts	—	—	24 (18)
Reservoir Mounting Hexbolts	—	—	20 (15)
Anchor Plate Mounting Hexbolts	1/2–13	8	95 (70)
Rotor Mounting Hexbolts	9/16–12	8	175 (130)
Dust Shield Mounting Bolts	—	—	20 (15)
Master Cylinder Outlet Fittings	7/16–24	—	20 (15)
Power Booster Supply Line Fitting	—	—	27 (20)

Table 2, Fastener Torques

Fluid Type	Recommended Fluid
Automatic Transmission Fluid	Dexron II®

Table 3, Approved Power Steering Fluid for Power Booster

Fluid Type	Recommended Fluid
DOT 3	Wagner-Premium Plus Super HD Delco Supreme II Dow HD 50-4

Table 4, Approved Brake Fluid for Brake System

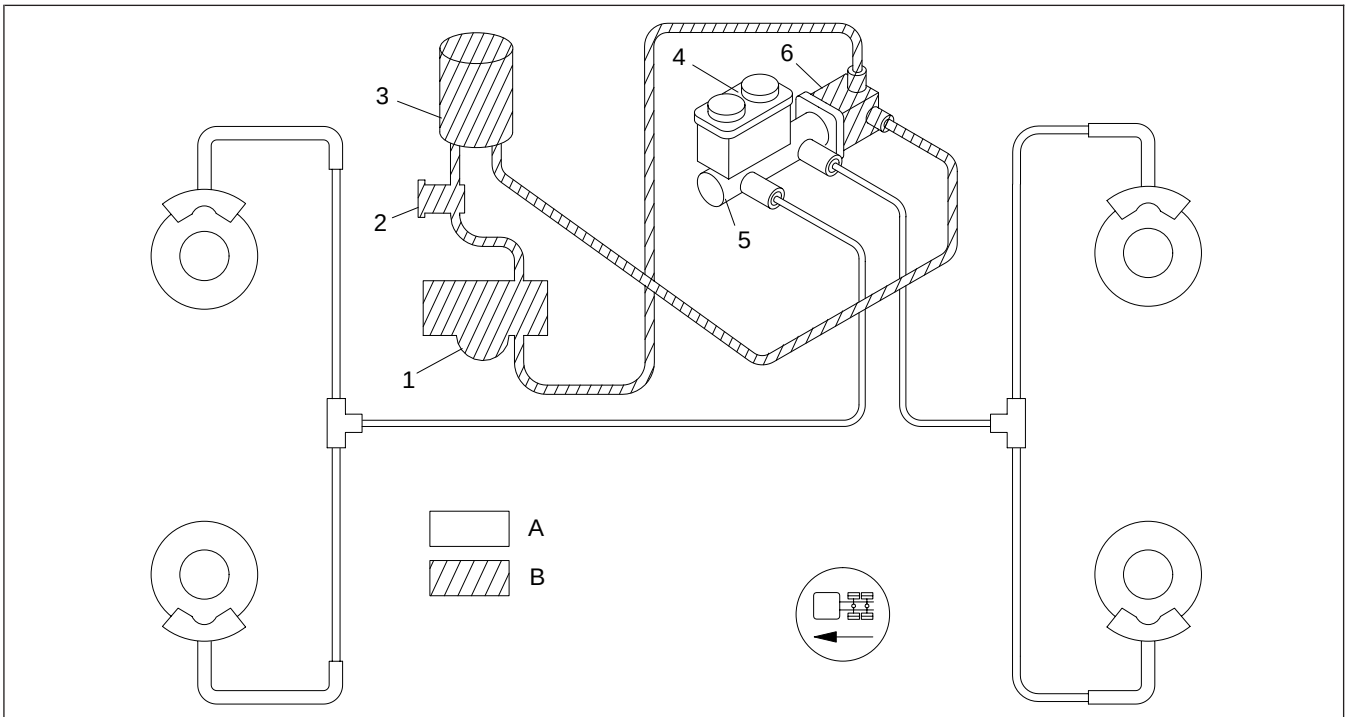
Specifications

Maximum Allowable Lateral Runout mm (inch)	Minimum Allowable Thickness mm (inch)	Maximum Difference in Parallelism mm (inch)
0.38 (0.015)	33.5 (1.32)	0.13 (0.005)

Table 5, Rotor Specifications

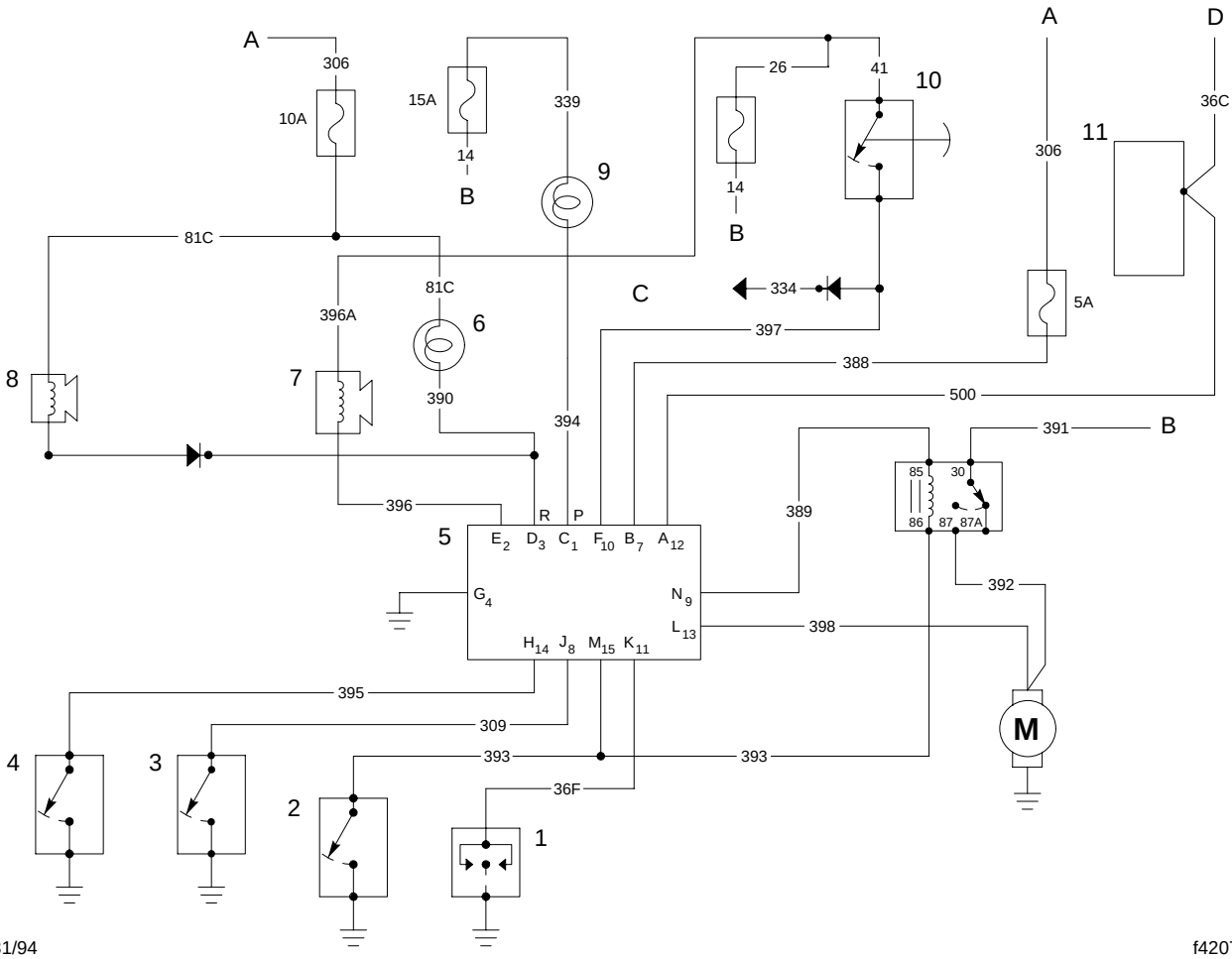
Component	Recommended Grease
Brake Caliper V-Ways and Anchor Plate Rails	Aeroshell Grade 5 (ES-1246)

Table 6, Approved Brake System Grease



A. Brake System (Brake Fluid)
B. Brake Booster and Power Steering System (Power Steering Fluid)
1. Power Steering Gear
2. Power Steering Pump
3. Power Steering Reservoir
4. Brake Master Cylinder Reservoir
5. Brake Master Cylinder
6. Power Booster

Fig. 1, Hydraulic Brake System Plumbing Diagram



NOTE: Key off, door closed.

A. To ignition switch.
B. To positive battery post.
C. To right-side door switch and dome lamp.
D. To stoplight switch relay.

1. Pressure Differential Switch
2. Flow Switch
3. Parking Brake Switch (Hydraulic)
4. Fluid Indicator Switch
5. Brake Control Module
6. Brake Pressure Indicator
7. Control Module Buzzer
8. Dash Buzzer
9. Parking Brake Indicator
10. Left-Side Door Switch
11. Turn Signal Switch

Fig. 2, Brake Control Module Wiring

General Description

The pressure relief valve **(Fig. 1)** protects the air brake system against excessive air pressure build-up. The valve has a spring-loaded cap and O-ring assembly which will exhaust air from the reservoir, if pressure rises above the valve's pressure setting. This setting is determined by the force of the spring.

Principles of Operation

To illustrate the operation of the pressure relief valve, note that the governor cut-out pressure on all Freightliner vehicles is set at a maximum 125 psi (862 kPa). A pressure relief valve with a setting of 150 psi (1034 kPa) is then used. Should system pressure rise to approximately 150 psi (1034 kPa), air pressure will force the cap and O-ring assembly off its seat, and allow the reservoir pressure to vent to the atmosphere. **See Fig. 2 .**

When the reservoir pressure decreases sufficiently, the spring force will seat the cap and O-ring assembly, sealing off reservoir pressure. This will occur at approximately 135 psi (931 kPa) for the 150 psi (1034 kPa) valve. Note that the desired pressure setting of the pressure relief valve is determined by the governor cut-out pressure. The opening and closing pressures of the pressure relief valve should always be higher than the governor cut-out pressure setting.

Normally, the pressure relief valve remains inoperative and only functions if, for any reason, the reservoir pressure rises above the setting of the valve. Constant exhausting of the pressure relief valve can be caused by a faulty pressure relief valve, faulty governor, faulty compressor unloading mechanism, or a combination of any of the preceding.

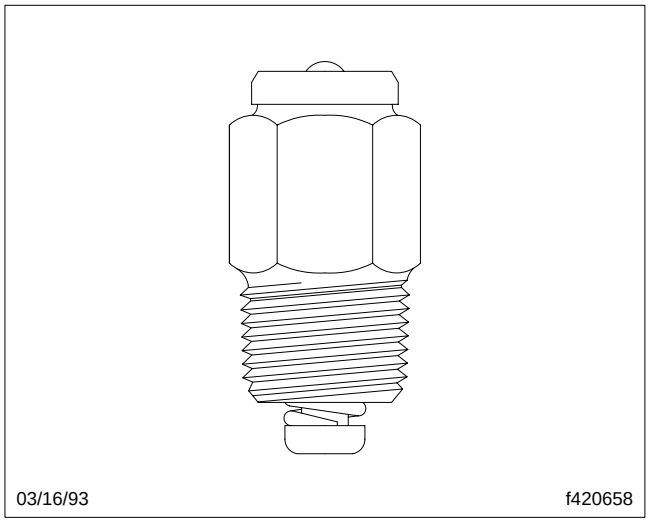


Fig. 1

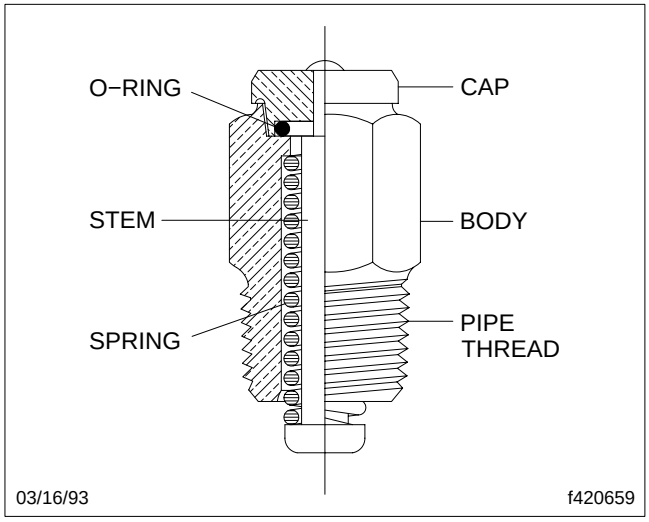


Fig. 2

Operating Check (Refer to Fig. 1)

With air pressure built up in the system, proceed as follows:

⚠ WARNING

WARNING: Wear safety goggles when exhausting the air system because debris could fly out at high speed. Failure to take all necessary precautions could result in personal injury.

1. With your index finger and thumb, pull the cap of the valve, removing the spring load from the O-ring. Air should exhaust from the valve.
2. Release the cap; the airflow should stop.

   Failure of a valve to pass the operating test indicates the valve should be replaced, using the instructions in this section.

Leakage Check

Coat the exhaust port with a soap solution. Leakage resulting in a 1-inch (2.5-cm) bubble in 5 seconds is permitted. Excessive leakage indicates dirt in the valve or a faulty O-ring or seat. The valve should be replaced, using the instructions in this section.

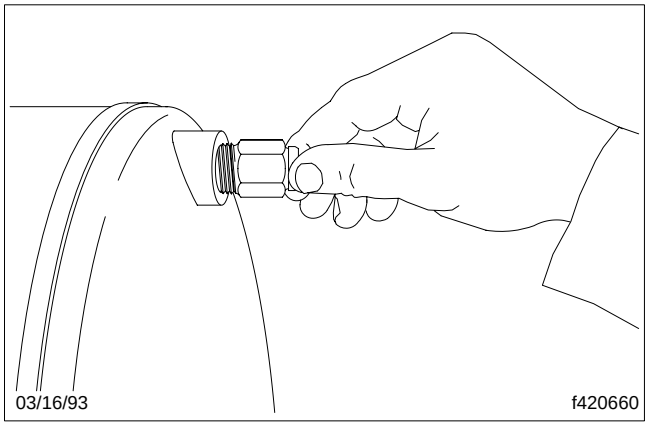


Fig. 1

Removal

1. Chock the tires, and drain the air reservoirs.
2. Using a wrench, unscrew the valve from the reservoir. **See Fig. 1 .**

Installation

1. Apply a small quantity of Loctite® 242, or an equivalent sealant, to the valve threads.

⚠ WARNING

WARNING: Make sure that excess sealant does not get inside either the male or female fittings. This would allow loose foreign material inside the plumbing, and may clog a valve. This could result in an unexpected loss of brake control, which could cause property damage or personal injury.

2. Install the valve and tighten it finger-tight. With a wrench, tighten it 1-1/2 additional turns past finger-tight.
3. Perform the operating and leakage checks on the valve and the valve fitting. For instructions, **refer to Subject 100.**

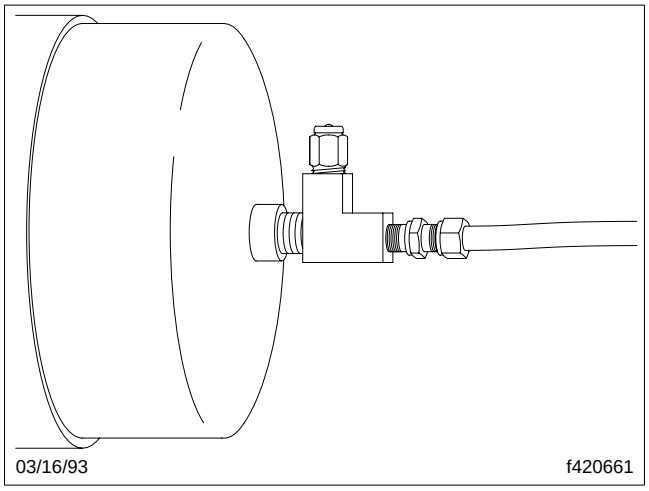


Fig. 1

General Description

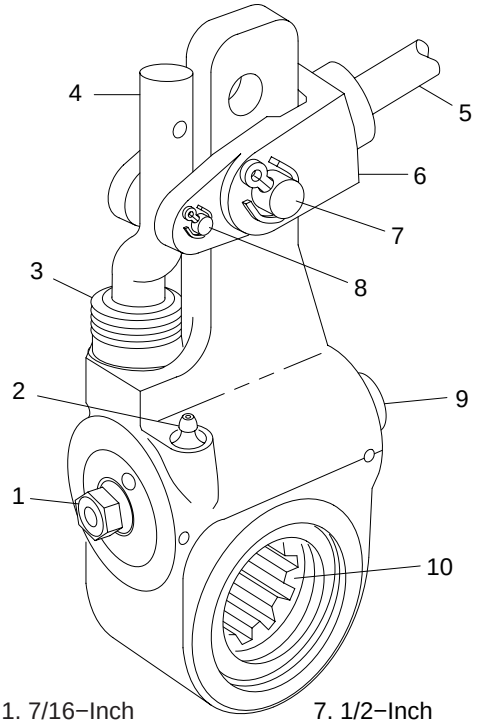
(Refer to Fig. 1)

The Gunite [1] automatic slack adjuster has two main functions:

- As a lever it converts the straight-line force of the brake chamber push rod to torque on the brake camshaft. Rotation of the camshaft forces the brake shoes against the drum.
- As an automatic adjuster, it maintains the lining-to-drum clearance needed for proper brake chamber push rod stroke.

The slack adjuster is installed between the brake chamber push rod and the brake camshaft. A clevis connects the brake chamber push rod to the top of the slack adjuster. The bottom of the slack adjuster is splined to the brake camshaft. The splines hold the slack adjuster internal gear to the camshaft, so the camshaft turns when the slack adjuster moves. When the brakes are applied, the brake chamber push rod moves outward forcing the slack adjuster and camshaft to rotate. This movement forces the brake shoes against the drum.

The brakes are adjusted when the slack adjuster senses an increase in the lining-to-drum clearance. The slack adjuster's internal worm shaft and ratchet shorten excessive lining-to-drum clearance. This provides maximum leverage for the brake chamber push rod. The automatic slack adjuster adjusts the brakes at the beginning of the brake application.



1. 7/16−Inch Adjusting Hexnut
2. Grease Fitting
3. Boot
4. Link
5. Brake Chamber Push Rod
6. Clevis
7. 1/2−Inch Clevis Pin
8. 1/4−Inch Clevis Pin
9. Grease Relief Opening
10. Slack Adjuster Spline

07/27/93 f420653

Fig. 1

[1] Formerly Kelsey-Hayes

IMPORTANT: This automatic slack adjuster cannot be rebuilt. If it is damaged or inoperative, replace the unit. Also, when installing or replacing a Gunite automatic slack adjuster, a new clevis must be installed.

Removal (Refer to Fig. 1)

1. Park the vehicle on a level surface, and chock the tires. If you are removing a rear slack adjuster, release the parking brake, then cage the parking brake power spring. For instructions, refer to the brake chamber section in this manual.
2. Back off the clevis jam nut.
3. Remove the cotter pins, clevis pins, and link.
4. Rotate the adjusting hexnut counterclockwise until the slack adjuster clears the clevis.
5. Remove the snap ring from the brake camshaft, then slide the slack adjuster off the camshaft.
6. Remove the clevis from the brake chamber push rod.

Installation (Refer to Fig. 2)

1. Coat the end of the brake chamber push rod, the camshaft splines, and the splines of the slack adjuster gear with an anticorrosive grease.
2. Make sure that the jam nut is on the brake chamber push rod. Tighten a new snap nut (Ref. 4) until the push rod is flush with the end of the snap nut. Do not tighten the jam nut.
3. Using the cotter pins and clevis pins, install a new clevis on the slack adjuster.
4. Using the old snap ring, install the automatic slack adjuster on the brake camshaft.
5. Turn the adjusting hexnut (Ref. 1) clockwise to rotate the slack adjuster toward the brake chamber until the clevis (Ref. 3) contacts the snap nut. Then, push the clevis and snap nut together.

⚠ WARNING

WARNING: Make sure that the snap nut contacts the clevis and that there is proper engagement. If the snap nut and clevis are not installed correctly, the brakes may not work properly. This could result in an accident causing personal injury and property damage.

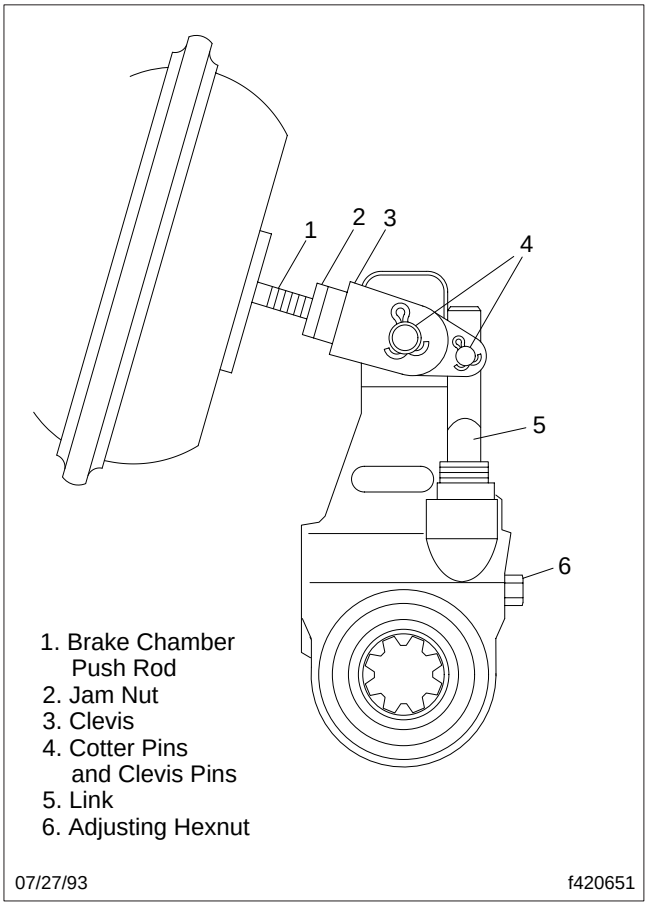


Fig. 1

⚠ CAUTION

CAUTION: Once attached to the clevis, the snap nut cannot be removed from the clevis. If the snap nut is removed, the clevis and/or snap nut will be damaged.

6. Pull on the clevis to make sure that it and the snap nut are properly engaged.
7. Using the gauge supplied with the new slack adjuster, adjust the clevis. **See Fig. 3 .**
   - 7.1 Position the 1/2-inch hole in the gauge over the end of the 1/2-inch clevis pin.

Removal and Installation

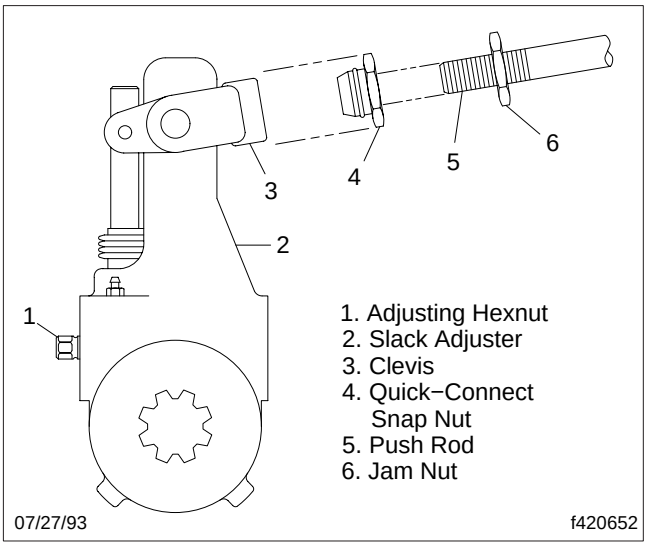


Fig. 2

7.2 Align the applicable 1/4-inch hole in the bottom of the gauge over the center hole of the camshaft.

7.3 Turn the snap nut and adjust the clevis so all of the 1/4-inch pin is visible in the notched area of the gauge. Make sure the push rod doesn't extend into the clevis opening more than 1.5 mm (1/16 inch) past the snap nut.

7.4 Tighten the jam nut.

⚠ CAUTION

CAUTION: Be sure to tighten the jam nut. Failure to do so may allow the snap nut to turn, which could prevent the automatic slack adjuster from working correctly.

NOTE: Make sure there is clearance between the slack adjuster and other vehicle components when the brakes are applied and the push rod travels its maximum stroke.

8. Set the initial free-stroke.

8.1 Turn the adjusting hexnut clockwise until the brake linings contact the drum.

8.2 Turn the adjusting hexnut counterclockwise one-half turn. There should be about 41 N·m (30 lbf·ft) resistance, and a ratcheting sound will be heard.

9. Measure the brake chamber stroke.

9.1 With the brakes fully released, use a ruler to measure the distance from the bottom of the brake chamber to the center of the large clevis pin. **See Fig. 4 ,** Ref. *A* .

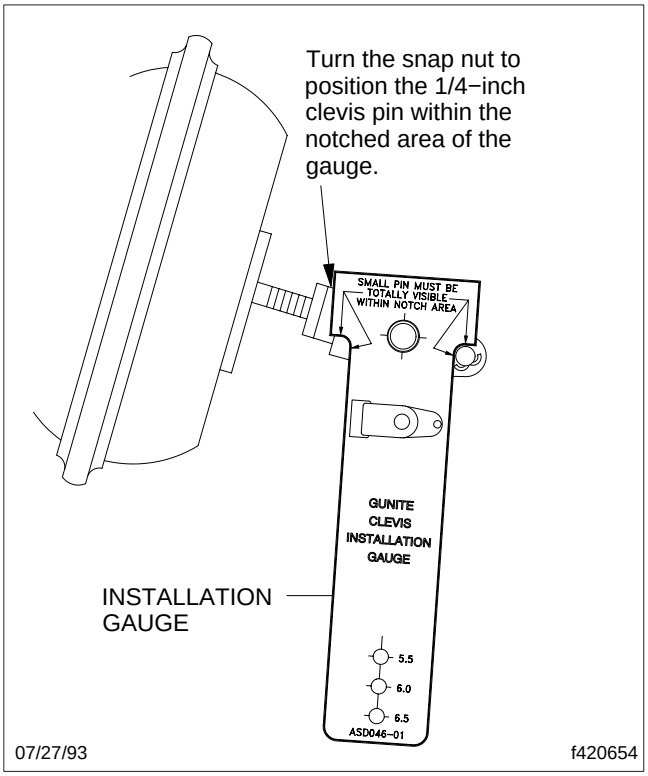


Fig. 3

9.2 Build air pressure to at least 586 kPa (85 psi). Apply the brakes, then measure the distance from the bottom of the brake chamber to the center of the large clevis pin. **See Fig. 4** , Ref. *B* . The difference between the measurements is the brake chamber stroke.

9.3 The brake chamber stroke must be less than the measurements shown in the applicable table in **"Specifications, 400."** If it isn't, check the foundation brakes for problems such as worn cams, bushings, pins and rollers, or broken springs. Repair or replace as needed. For instructions,

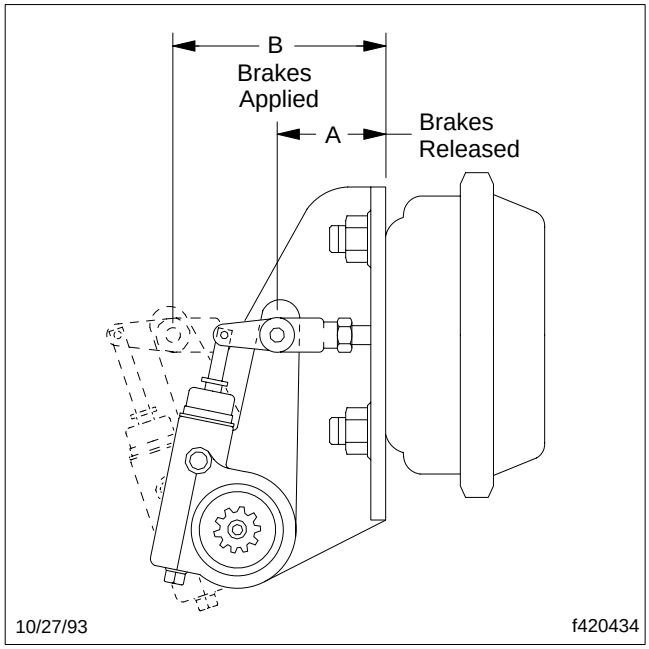


Fig. 4

refer to the foundation brake section in this manual. Then, repeat steps for setting the initial free-stroke, and measuring the brake chamber stroke.

10. If a rear axle slack adjuster was installed, manually uncage the parking brake. For instructions, refer to the brake chamber section in this manual.
11. Apply the parking brakes. Remove the chocks from the tires.

Specifications

Lubricant Type	Temperature
Lubriplate Aero	Above -40°C (-40°F)
Texaco Multifak EP-2 Mobil Grease 77	Above -29°C (-20°F)

Table 1, Approved Lubricants

Chamber Size	Maximum Chamber Stroke
16 20 24	Less than 44 mm (1-3/4 inches)
24 * 30	Less than 51 mm (2 inches)

* Long stroke.

Table 2, Maximum Adjusted Brake Chamber Strokes

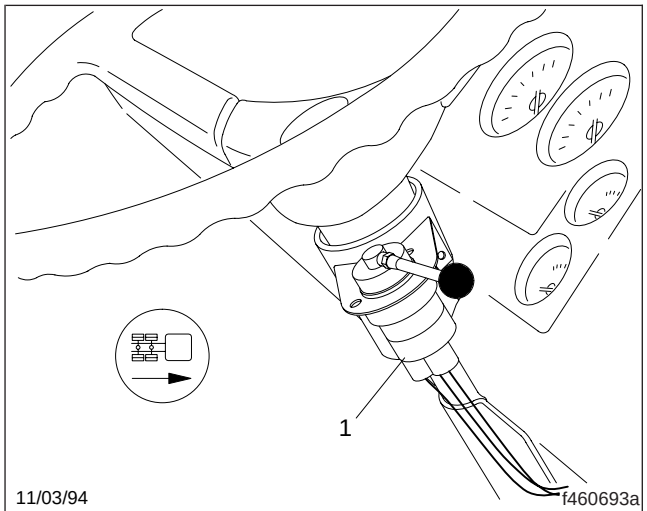
General Information

A hand-operated brake valve is included in some air brake systems for tractor units pulling trailers, in addition to the standard foot brake valve and related equipment. This valve allows the driver independent control of the trailer brakes, which can be useful when checking trailer brakes, or changing adjustable fifth wheel locations.

The brake valve is mounted on the right side of the steering column. See **Fig. 1.**

Principles of Operation (See Fig. 2)

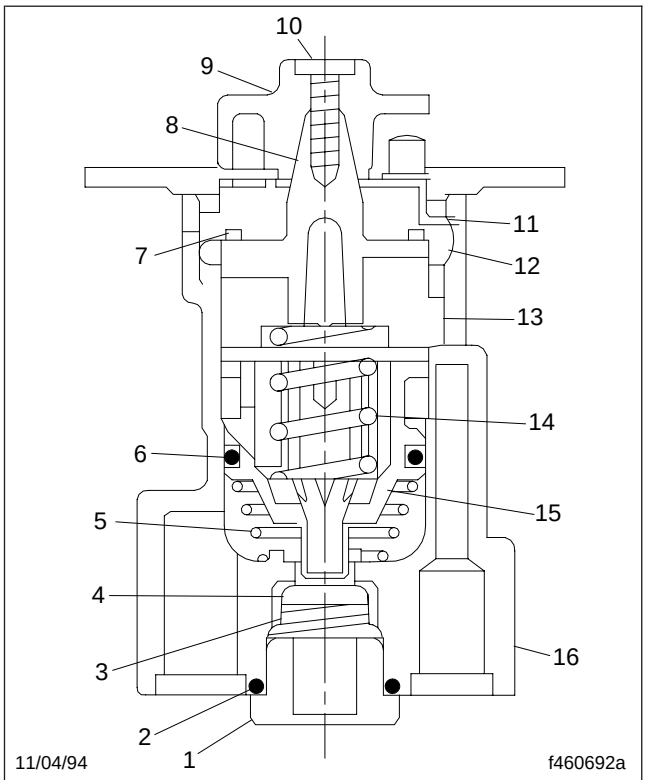
When the valve's control handle is moved in a clockwise direction, the cam (Ref. 13) compresses the graduating spring (Ref. 14), which in turn forces the piston (Ref. 15) to move down. As the piston moves down, compressed air from the supply port flows to the delivery port, applying the trailer brakes through the trailer service line.



1. Trailer Break Control Valve

Fig. 1, Trailer Brake Control Valve Installed on the Steering Column

As air pressure builds in the trailer air system, the pressure under the piston will match the pressure of the compressed graduating spring. This moves the piston up enough to stop air flow through the valve, allowing air pressure in the trailer service brake system to remain constant.



1. End Cap
2. O-Ring
3. Valve Spring
4. Valve Disc Assembly
5. Piston Return Spring
6. Piston O-Ring
7. Bushing
8. Camshaft
9. Cover
10. Screw, Handle
11. Lock
12. Bearing
13. Cam
14. Graduating Spring
15. Piston
16. Body

Fig. 2, Trailer Brake Control Valve (sectional view)

When the control handle is moved counterclockwise, the cam moves up, releasing tension on the graduating spring. This allows the pressure below the piston to increase. The air pressure will then move the piston up and allow air in the service line to flow out of the exhaust port, releasing the trailer brakes.

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Chock the tires and stop the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing compressed air— it may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released. Even when compressed air has been released at the reservoirs, residual air may still be trapped in the air lines.
3. Never exceed recommended air pressure, and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood the recommended procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to the use of those tools.

⚠ WARNING

WARNING: Don't use the hand brake valve to apply the trailer brakes for parking. It is not designed for this purpose. The air could bleed out of the trailer air tank allowing the vehicle to roll, which could cause personal injury, property damage, or damage to the vehicle.

Test

1. Park the vehicle on a level surface and chock the tires.
2. Connect an accurate test gauge to the delivery port of the valve, or connect the gauge to the service hose coupling located behind the cab. When the gauge is connected to the service hose coupling, install a dummy hose coupling on the supply (emergency) hose coupling, and place the dash valve in the trailer charge position. When the valve control handle is moved to the fully applied position, the gauge should register full reservoir pressure.

NOTE: Midland valves are set to deliver full reservoir pressure. Intermediate positions should deliver proportional intermediate pressures. Upon manual release, the gauge should immediately register zero.

3. Locate the exhaust port or exhaust line and apply a soap solution.
4. With the valve in the released position, exhaust leakage should not exceed a 2.5-cm (1-inch) bubble in 5 seconds.

   With the valve fully applied, exhaust leakage should not exceed a 2.5-cm (1-inch) bubble in 5 seconds.
5. If the valve does not function properly or if leakage is excessive, replace the valve following the instructions **in Subject 120.**
6. Remove the chocks from the tires.

WARNING

WARNING: Before starting the procedure below, read the information in "Safety Precautions, 100." Failure to be aware of the safety precautions could result in personal injury.

Replacement (Refer to Fig. 1)

1. Chock the tires or hold the vehicle on a level surface by means other than the air brakes.
2. Drain the air system by opening both the primary and secondary reservoir drain cocks.
3. For later assembly reference, mark the three air lines connected to the valve. Disconnect the air lines from the valve.
4. Remove the two screws which hold the valve and the valve mounting bracket to the steering column. Remove the valve and the mounting bracket from the steering column.
5. Remove the three screws that attach the valve to the mounting bracket.
6. Install the mounting bracket on the new valve. Tighten the three screws firmly.
7. Position the mounting bracket and the valve on the steering column. Install and tighten the two mounting screws firmly.
8. Attach the air lines to the valve. Using two wrenches, tighten the lines firmly.
9. Do the operating and leakage test in **Subject 110.**

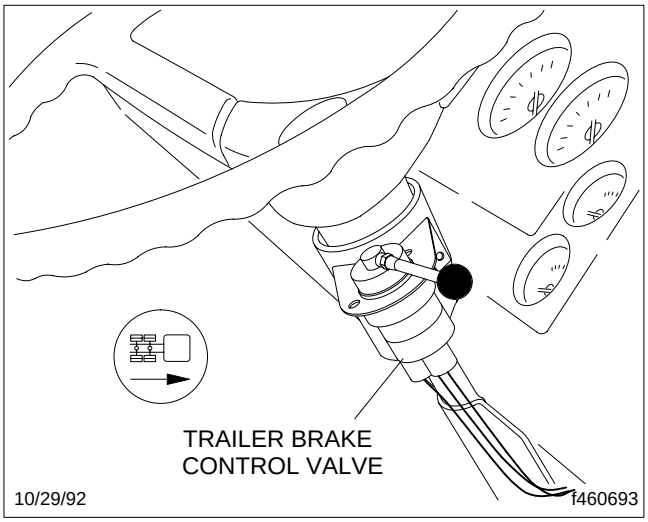
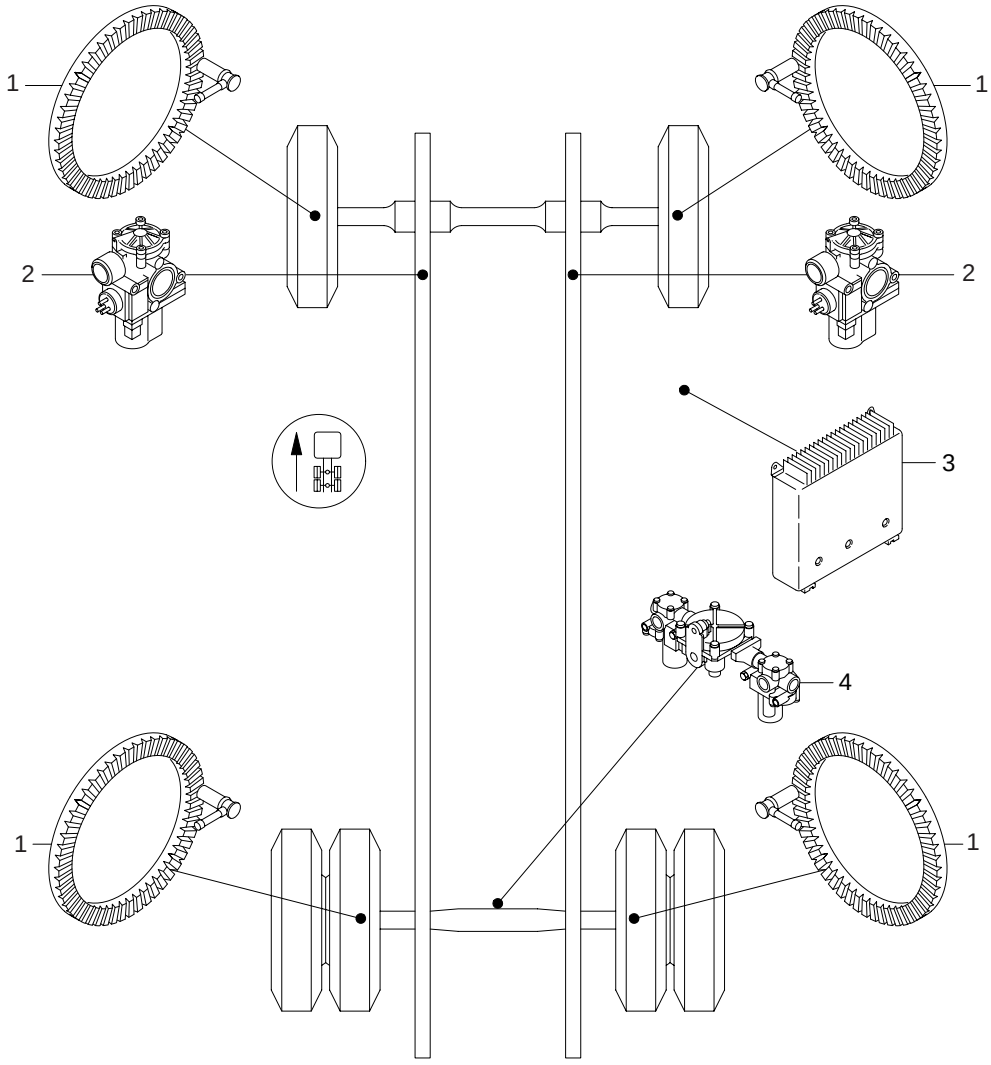


Fig. 1

General Description (See Fig. 1)



04/30/96 f421364

1. Tone Wheel and Sensor
2. Solenoid Control Valve
3. Electronic Control Unit
4. Combination Solenoid Control Valve

Fig. 1, Location of ABS Components, Four-Channel System

The WABCO Antilock Braking System (ABS) is an electronic wheel speed monitoring and control system that works with the air brake system. ABS passively monitors vehicle wheel speed at all times, and controls wheel speed during emergency stops. If equipped with Traction Control or Automatic Traction Control, wheel spin is controlled during reduced-traction situations. In normal braking applications, the air brake system is in effect.

ABS includes signal-generating tone wheels and sensors located in the wheel hubs of each sensed wheel. The sensors transmit vehicle wheel speed information to an electronic control unit. According to programmed specifications, the control unit signals

General Description and Principles of Operation

the appropriate solenoid control valve to increase, reduce, or maintain air pressure supply in the brake chamber. This prevents front and rear wheel lockup, and enhances steering control during emergency braking situations. If equipped with Traction Control or Automatic Traction Control (ATC), two additional solenoid valves are installed. During reduced-traction situations, these valves increase or reduce air pressure supply in the brake chamber to provide better traction whenever wheel spin occurs.

Principles of Operation

The ABS electronic control unit (**Fig. 2**) is a digital microcomputer that serves as the information processing and command center for the antilock braking system. The control unit receives and processes vehicle wheel speed information from the sensors. During emergency brake applications, the control unit regulates the braking force applied to each wheel by sending control signals to the solenoid control valves (**Fig. 3**).

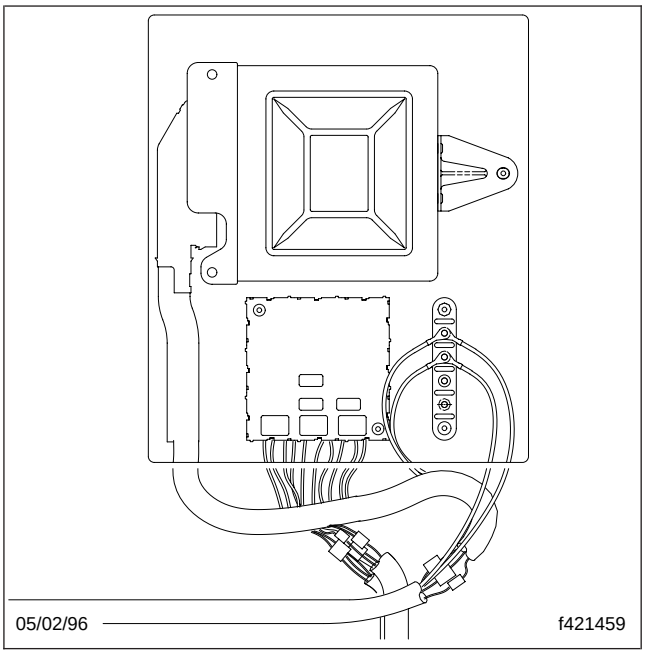


Fig. 2, Electronic Control Unit

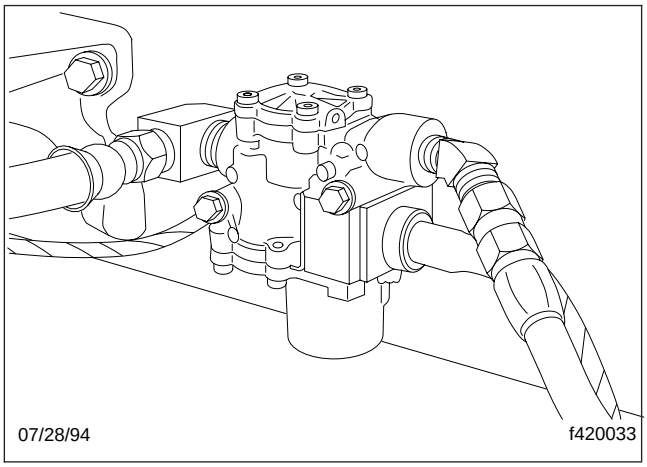


Fig. 3, Solenoid Control Valve

ABS MAJOR COMPONENTS

Wheel Speed Sensor

The wheel speed sensors use pulse feedback from 100-tooth tone wheels located in the front and rear axle wheel hubs. When the vehicle is moving, the teeth of the tone wheel cause interruptions in a magnetic field created by the sensor. The interruptions created in the magnetic field in turn create electrical pulses that are sent by the sensor to the electronic control unit.

Electronic Control Unit

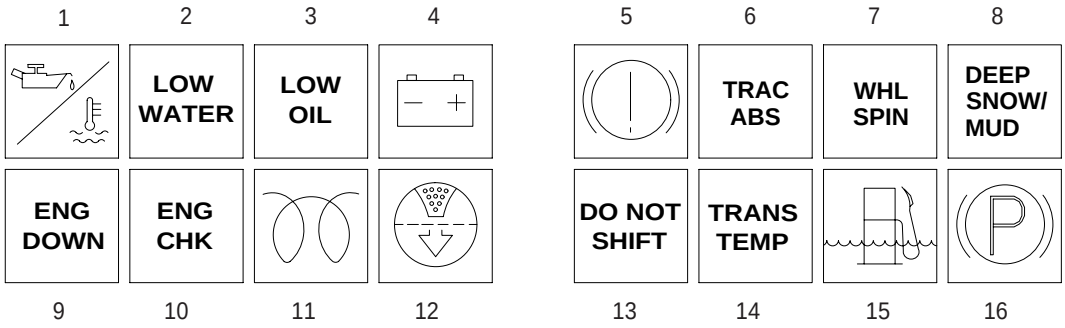
The WABCO ABS system combines one front-axle control channel with one rear axle to form a control circuit. For example, the sensor and solenoid control valve on the left-front axle form a control circuit with the sensor and solenoid control valve on the right-rear axle.

The electronic control unit (ECU), located behind the passenger seat, contains microcomputers to monitor both control circuits. The ECU receives speed sensor pulses and interprets these signals to calculate wheel speed and a vehicle reference speed. If the calculations indicate wheel spin or lockup, the appropriate control circuit signals the solenoid control valve(s) to increase or decrease braking pressure.

The ECU contains another microcomputer that provides a safety circuit to constantly monitor the wheel sensors, traction control valves (if equipped), solenoid control valves, and the electrical circuitry. After the engine is started, the tractor warning light (TRAC

ABS) comes on. See **Fig. 4**. Once the vehicle moves faster than about 4 mph (6 km/h), the warning light goes out if all of the tractor's ABS components are working properly.

if a solenoid control valve (or combination solenoid control valve) is damaged and inoperative. As these components are an integral part of the air brake system, normal braking may be impaired or inoperative.



09/20/93 f600365a

1. Low Oil Pressure/High Water Temperature Warning
2. Low Water Level Warning
3. Low Oil Level Warning
4. Alternator Warning Light
5. Brake System Warning
6. Tractor ABS Warning Light
7. Wheel Spin Indicator Light
8. Deep Snow/Mud
9. Stop Engine Indicator
10. Engine Check Indicator
11. Cold-Start Manifold Heater Indicator
12. Air Cleaner Restriction Indicator
13. Do-Not-Shift Indicator
14. High Oil Temperature Warning (Automatic Transmission)
15. Water in Fuel/Water Separator Warning
16. Parking Brake Indicator

Fig. 4, Dash Warning and Indicator Lights

A wheel spin (WHL SPIN) indicator light (if equipped) will come on if one of the drive wheels spins during reduced-traction situations. See **Fig. 4**. Refer to the vehicle driver's manual for operating instructions.

If equipped with an electronic engine, an automatic traction control (ATC) system may be installed. On these vehicles, the ATC system automatically reduces wheel spin during reduced-traction situations.

An "ATC Function" switch (if equipped), may be used under more adverse conditions. Turning on this switch illuminates the DEEP SNOW/MUD indicator light (**Fig. 4**). The ATC system now allows some wheel spin (for example, to help burn through a thin layer of ice) during reduced-traction situations.

If, during vehicle operation, the safety circuit senses a failure in any part of the ABS system (a sensor, solenoid control valve, wiring connection, short circuit, etc.), the tractor warning light (TRAC ABS) comes on, and the control circuit where the failure occurred is switched to normal braking action. The remaining control circuit will retain the ABS effect. Even if the ABS system is completely inoperative, normal braking is maintained. An exception would be

IMPORTANT: If the TRAC ABS warning light does not work as described above, repair the ABS system. See **"Troubleshooting, 300"** for fault diagnosis.

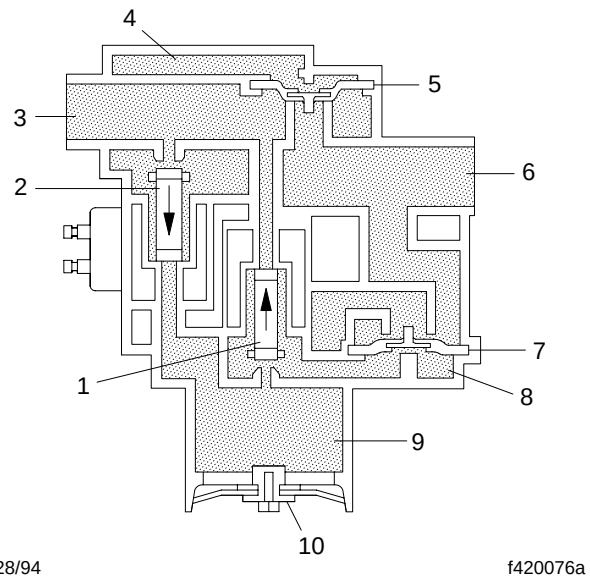
Solenoid Control Valve and Combination Valve

The solenoid control valves are attached to the frame crossmember near the brake chambers. The combination solenoid control valve (for vehicles without traction control manufactured November, 1995 or later), which includes a relay valve, is also attached to the frame crossmember near the rear brake chambers. Depending on the signal received from the electronic control unit, the control valve prevents wheel lockup by reducing, maintaining, or increasing brake chamber air pressure. During normal braking applications, compressed air flows freely to the brake chamber through the control valve.

If the electronic control unit signals indicate wheel lockup, air pressure is reduced in the brake chamber.

General Description and Principles of Operation

Solenoid valve 1 opens allowing compressed air to enter the inlet chamber and pilot chamber 1. See **Fig. 5**.



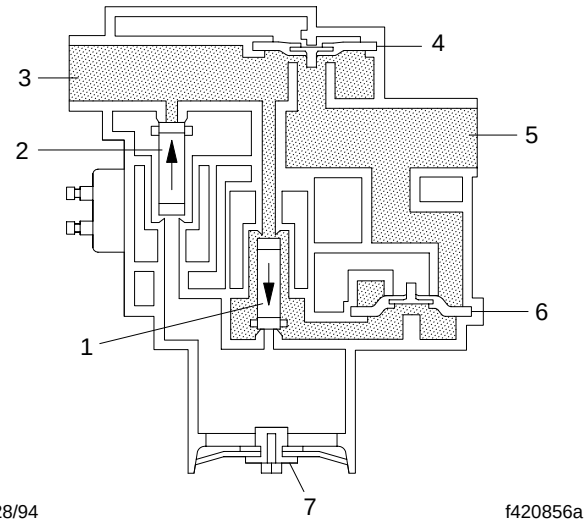
1. Solenoid Valve No. 2
2. Solenoid Valve No. 1
3. Inlet Chamber
4. Pilot Chamber No. 1
5. Diaphragm Valve No. 1
6. Delivery Chamber
7. Diaphragm Valve No. 2
8. Pilot Chamber No. 2
9. Exhaust Chamber
10. Exhaust Port

Fig. 5, Wheel Lockup Cycle

At the same time, solenoid valve 1 closes off the exhaust chamber preventing the escape of air from the inlet chamber to atmosphere. Compressed air in the inlet chamber is forced into pilot chamber 1, closing diaphragm valve 1; this prevents air passage to the delivery chamber. Solenoid valve 2 also opens allowing air to vent from pilot chamber 2 through the exhaust port. Complete venting of all air in the delivery chamber occurs as diaphragm valve 2 opens.

As wheel speed increases, the control valve alternately increases, then maintains brake pressure until the proper wheel speed is obtained, or until wheel lockup occurs and the control cycle starts again.

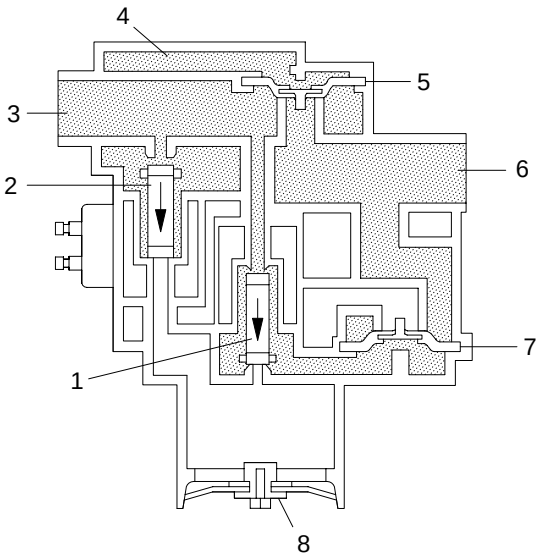
During the pressure increase cycle (**Fig. 6**), both solenoid valves are closed. Compressed air entering through the inlet chamber forces diaphragm valve 1 open, allowing air to pass through the delivery chamber into the brake chamber. At the same time, pressure within the control valve keeps diaphragm valve 2 closed, preventing air from releasing through the exhaust port.



1. Solenoid Valve No. 2
2. Solenoid Valve No. 1
3. Inlet Chamber
4. Diaphragm Valve No. 1
5. Delivery Chamber
6. Diaphragm Valve No. 2
7. Exhaust Port

Fig. 6, Pressure Increase Cycle

If maintaining brake air pressure (**Fig. 7**), solenoid valve 1 opens and compressed air passes from the inlet chamber into pilot chamber 1. Both of the diaphragm valves are forced closed, sealing the delivery chamber and maintaining brake air pressure.



1. Solenoid Valve No. 2
2. Solenoid Valve No. 1
3. Inlet Chamber
4. Pilot Chamber No. 1
5. Diaphragm Valve No. 1
6. Delivery Chamber
7. Diaphragm Valve No. 2
8. Exhaust Port

Fig. 7, Maintaining Brake Air Pressure Cycle

Wheel Speed Sensor Replacement

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. Refer to the electrical section (wiring) in this manual for information on special terminals and connectors, and on ordering tools for them.

Front Axle

1. Chock the rear tires to prevent vehicle movement. Apply the parking brakes.
2. Gently twist and pull the sensor, to remove it from the steering knuckle (**Fig. 1**).

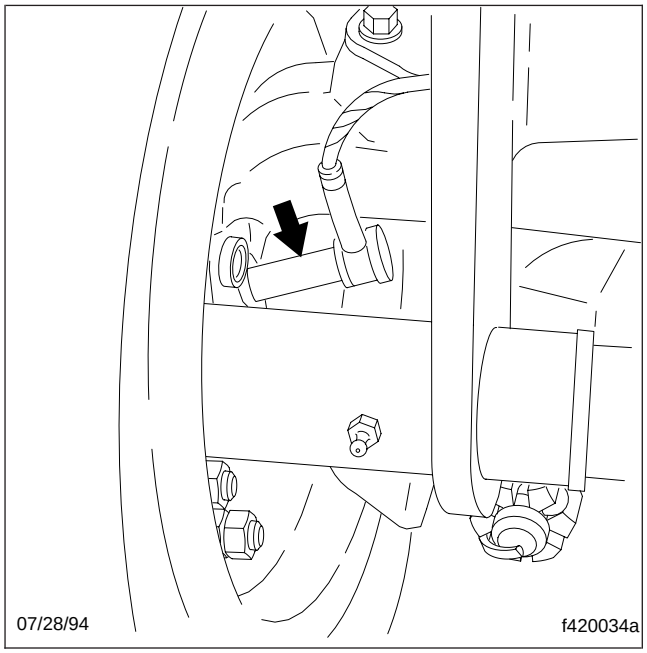


Fig. 1

3. Remove the sensor cable from the steering knuckle top cap.
4. Disconnect the sensor cable from the chassis harness.
5. Remove the clamping bushing from the steering knuckle.
6. Connect the sensor cable to the chassis harness.
7. Attach the sensor cable to the steering knuckle top cap.
8. Press the clamping bushing into the brake spider hole until it stops.
9. Coat the sensor with Mobil HP, Valvoline EP 633, Penzoil 707L, or an equivalent. Press the sensor into the clamping bushing until it is stopped by the tone wheel.
10. Remove the chocks from the rear tires.

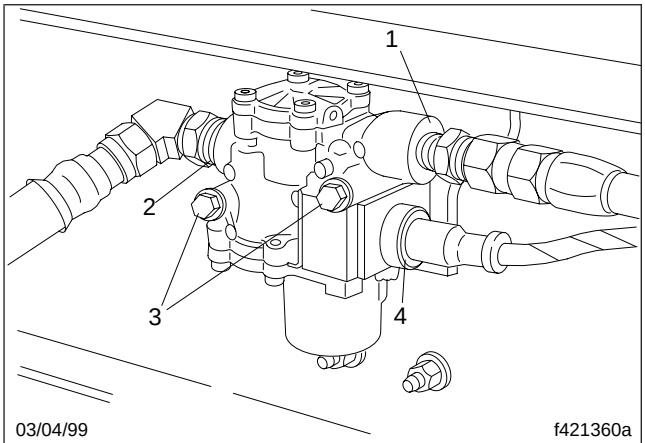
Rear Axle

1. Chock the front tires to prevent vehicle movement. Apply the parking brakes.
2. Raise the rear of the vehicle until the tires clear the ground. Place safety stands under the axle.
3. Back off the slack adjuster to release the rear axle brake shoes.
4. Remove the wheel and tire assembly from the rear axle. For instructions, refer to the wheels and tires section in this manual.
5. Remove the brake drum. For instructions, refer to the rear axle section in this manual.
6. Gently twist and pull the sensor, to remove it from the mounting block in the axle housing.
7. Remove the clamping bushing.
8. Remove the capscrew that attaches the sensor cable and the hose clamp to the axle tube.
9. Disconnect the sensor cable from the chassis harness.
10. Connect the sensor cable to the chassis harness.
11. Attach the hose clamp and sensor cable to the axle tube located between the backing plate and the spring plate.
12. Press the clamping bushing into the mounting block until it stops.
13. Coat the sensor with Mobil HP, Valvoline EP633, Penzoil 707L, or an equivalent. Push the sensor into the clamping bushing until it is stopped by the tone wheel.
14. Install the brake drum on the wheel hub.

Wheel Speed Sensor Replacement

15. Adjust the rear axle brakes. For instructions, refer to the brake section in the vehicle maintenance manual.
16. Install the wheel and tire assembly, and tighten the wheel nuts. Use the tightening sequence and torque values listed in the wheels and tires section in this manual.
17. Remove the safety stands, lower the vehicle, and remove the chocks from the front tires.

Removal (See Fig.1or Fig.2)



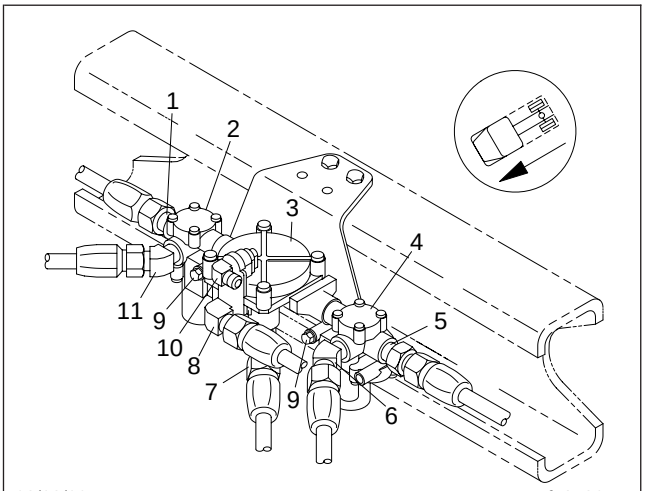
1. Supply Port 1 (from steer axle quick release)
2. Delivery Port 2 (to brake chamber)
3. Mounting Fasteners
4. Electrical Connection

Fig. 1, Solenoid Control Valve

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. See **Group 54** in this manual for information on special terminals and connectors, and on ordering tools for them.

1. Chock the front and rear tires.
2. Release the pressure from the air reservoirs.
3. Disconnect the wiring from the solenoid control valves or combination solenoid control valve.
4. Mark the air lines for ease of installation. Disconnect the air lines.
5. Remove the two mounting capscrews, washers, and nuts.
6. Remove the solenoid control valves or combination solenoid control valve.

NOTE: The combination solenoid control valve can be disassembled if replacement of the relay valve or one of the solenoid control valves is needed. For disassembly and assembly instructions, see **Subject 140**.



1. Delivery Port (to right rear brake chamber)
2. Right Modulator Valve
3. Relay Valve
4. Left Modulator Valve
5. Delivery Port (to left rear brake chamber)
6. Delivery Port (to left forward brake chamber)
7. Delivery Port (to park brake quick release valve)
8. Relay Supply Port (from primary air tank)
9. Mounting Fasteners
10. Relay Control Port (from foot valve)
11. Delivery Port (to right forward brake chamber)

Fig. 2, Combination Solenoid Control Valve

Installation

IMPORTANT: It is possible for the solenoid valves to be installed backward. See **Fig.1** to be sure the valves are installed correctly.

1. Install the solenoid valves or the combination solenoid control valve.
2. Install the two mounting capscrews, washers, and nuts. Tighten the mounting nuts 15 lbf·ft (20 N·m).
3. Connect the air lines.
4. Connect the wiring to the solenoid control valves, or combination solenoid control valve.
5. Start the engine and allow the air reservoirs to fill.
6. Remove the chocks from the front and rear tires.

Replacement

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. Refer to the electrical section (wiring) in this manual for information on special terminals and connectors, and on ordering tools for them.

1. Chock the front and rear tires.
2. Disconnect the wiring from the traction control valve.
3. Disconnect the air supply and air discharge lines.
4. Remove the two mounting capscrews, washers, and nuts.
5. Remove the traction control valve.
6. Install the traction control valve using the above instructions in reverse order. Tighten the mounting nuts 24 N·m (18 lbf·ft).

Adjustment

NOTE: The following adjustment procedure requires the use of special tool T11–17556–000. Use of this tool, available through the PDCs, eliminates the time-consuming task of removing the wheel and tire assembly, and the brake drum. **See Fig. 1.**

1. Park the vehicle on level ground, set the parking brake, and shut down the engine.

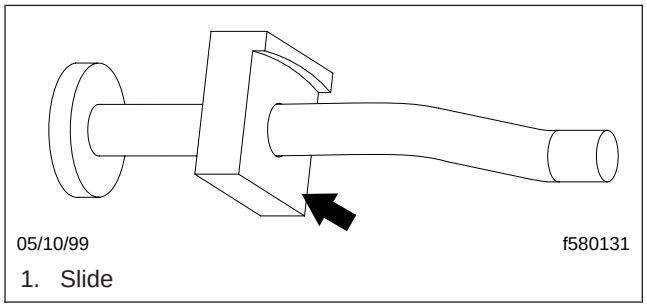


Fig. 1, ABS sensor Adjustment Tool

2. Chock the front tires.
3. Find the sensor access hole in the rear axle flange.
   - 3.1 View the brake drum and axle from the rear. The ABS sensor wiring harness should be visible passing through a hole in the 12 o'clock position.
   - 3.2 Find the S cam at either the 3 o'clock or 9 o'clock position.
   - 3.3 Just opposite the S cam is the sensor access hole, approximately 19 mm (3/4 inch) diameter.
4. Insert the service tool T11–17556–000 into this hole.
5. Position the slide of the tool on the axle flange to align the tool. **See Fig. 2.**
6. Tap the tool lightly with the palm of your hand. This will ensure the sensor is touching the tone wheel.
7. Remove the tool from the wheel and repeat the procedure on the other rear axle speed sensor.
8. Remove the chocks from the tires.

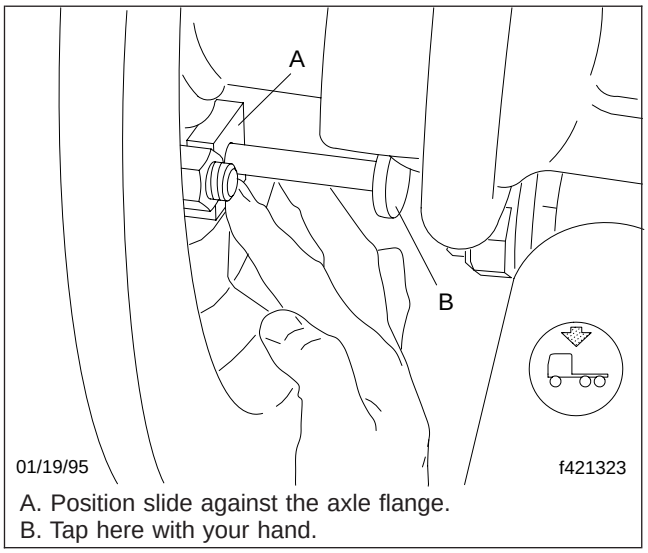
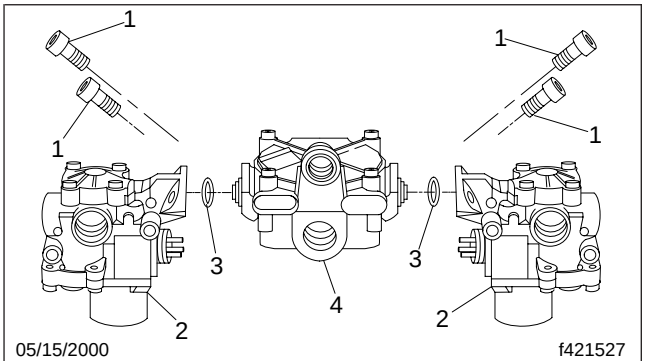


Fig. 2, Position the Tool

Combination Solenoid Control Valve Disassembly and Assembly

Disassembly (See Fig. 1)



1. Allen-Head Bolt
2. ABS Control Valve
3. O-Ring
4. Relay Valve

Fig. 1, Combination Solenoid Control Valve

1. Using a 6 mm allen-head wrench, remove the allen-head bolts.
2. Carefully separate the ABS control valve(s) from the relay valve.
3. Remove and discard the old O-rings.

Assembly (See Fig. 1)

1. Lubricate the replacement O-rings with grease.
2. Plug any unused ports on the replacement valve(s).
3. Attach the ABS control valve(s) to the relay valve. Tighten the allen-head bolts 13 to 15 lbf·ft (18 to 20 N·m).

ABS Tone Ring Installation on Service Hubs

Installation

IMPORTANT: Some ABS service hubs do not have a tone ring installed on the hub. The tone ring must be ordered separately and installed on the hub before installation of the hub onto the axle. Tone rings are made of a special material and require a specific installation procedure for proper installation.

⚠ WARNING

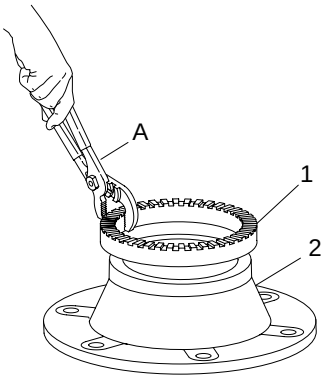
When installing an ABS system, special ABS hubs must be ordered. Machining of older hubs to accommodate the installation of tone rings can cause problems due to insufficient hub bore wall thickness. Machining an older hub with insufficient hub bore wall thickness could result in cracking, causing bearing damage and wheel loss. This could cause an accident resulting in personal injury and property damage.

1. Submerge the tone ring in boiling water or place it in an oven at 250°F (121°C) for approximately 15 minutes.

⚠ CAUTION

Do not attempt to heat the tone ring with a torch as this can damage the ring.

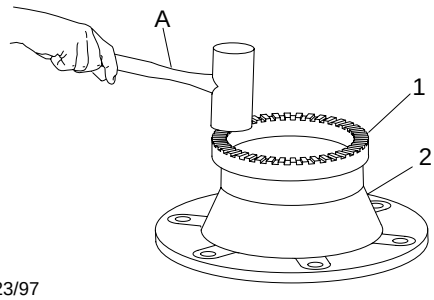
2. Using pliers, remove the tone ring from the boiling water or oven and center it on the machined area of the hub bore. See **Fig. 1**.
3. While the tone ring is still hot, make sure that it is properly centered on the machined surface. Using a rubber mallet, tap the tone ring until it bottoms out around the machined surface on the hub. See **Fig. 2**.
4. Install the hub on the axle. Position a dial indicator with a magnetic base so the dial indicator is against the tone ring teeth. See **Fig. 3**.
5. Rotate the hub and check the ring for runout. The runout should be less than 0.005 inch (0.13 mm). See **Fig. 4**.
6. Install the wheel. For instructions, see **Group 40** of this manual.



12/23/97 f421664

A. Use pliers to apply the ring.
1. Tone Ring 2. Hub

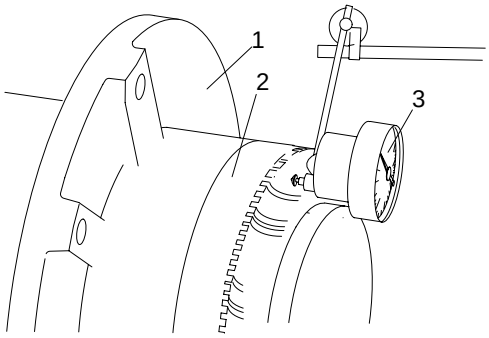
Fig. 1, Install the Ring on the Hub



12/23/97 f421665

A. Use a rubber mallet.
1. Tone Ring 2. Hub

Fig. 2, Tap the Tone Ring

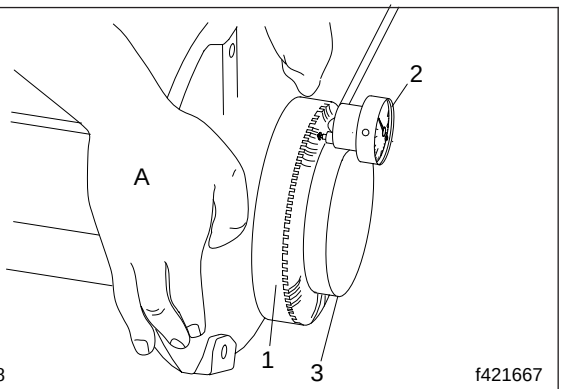


02/27/98 f421666

1. Hub 3. Dial Indicator
2. Tone Ring

Fig. 3, Position the Dial Indicator

ABS Tone Ring Installation on Service Hubs



A. Rotate the hub.
1. Tone Ring
2. Dial Indicator
3. Axle

Fig. 4, Check Tone Ring Runout

Using the Instrument Panel Blink Codes

This system has built-in diagnostics to ensure that all components are operating properly. Under normal conditions, the tractor warning light (TRAC ABS) comes on after the engine is started. Once the vehicle moves faster than about 4 mph (6 km/h) the warning light should go out if all of the tractor's ABS components are working. If the light stays on, or comes back on later, a problem within the ABS system has occurred. The vehicle can continue to be driven, but the ABS system could be partially or completely inoperative. However, normal braking ability is maintained.

To check the type of fault code recorded, stop the vehicle and turn off the engine. Then, turn on the ignition switch, but don't start the engine. If the warning light is still on, there is an "existing" system fault that must be repaired to ensure proper system operation. If the warning light is not on, an "intermittent" fault (indicating a loose connector or broken wire) has been recorded in the ECU memory.

Fault codes can be erased one at a time from the ECU memory. Erase a fault code by turning off the "ABS CHK" switch. After the WHL SPIN light stops flashing, turn off the ignition switch, then turn it back on.

NOTE: An "existing" fault code cannot be erased from ECU memory until the fault is corrected. An "intermittent" fault can be erased from ECU memory without being repaired. However, make sure that an "intermittent" fault code is recorded because it should be repaired as soon as possible if the code occurs again.

IMPORTANT: If the vehicle is equipped with an electronic engine and automatic traction control, don't turn on the "ABS CHK" switch while driving the vehicle. Activating the switch will reduce the engine speed to idle. Always park the vehicle before using the "ABS CHK" switch to read the instrument panel blink codes.

Before troubleshooting with the instrument panel blink codes, check all fuses in the control unit panel, and replace if necessary. Check the wiring to the "ABS CHK" switch and the warning lamps. See **Table 1**, and repair or replace the wiring as needed. Make sure that a charged 12-volt battery is available (the ABS system needs at least 11 volts to work).

NOTE: If troubleshooting the system with the Pro-Link 9000, use the instruction booklet that is supplied with the data cartridge.

Use the "ABS CHK" switch (**Fig. 1**) and the WHL SPIN light to display system faults. Turn on the ignition switch, then move the "ABS CHK" switch up (on position). After a five second pause, the WHL SPIN light will come on for two and one-half seconds (this is the start flash), then the diagnostic code cycle begins. After a two and one-half second pause, the three digit fault code will be displayed.

For example (**Fig. 2**), after the start flash, fault code 271 is shown by two flashes (each lasting one-half second and separated by a one-half second pause), a pause of two and one-half seconds, followed by seven flashes (each lasting one-half second and separated by a one-half second pause), another pause, followed by one flash for one-half second. After a seven and one-half second pause, the same fault code will continue to repeat beginning with the two and one-half second "start" flash and ending with a seven and one-half second pause.

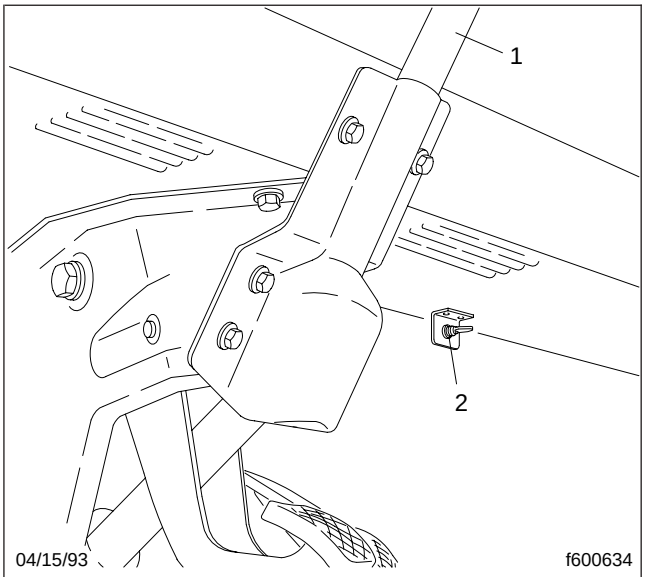
Wiring Tested	Test These Pins	Volt/Ohmmeter Reading	Possible Cause	Remedy
Tractor Warning (TRAC ABS) Light	9 and 26	2 to 50 ohms (depends on bulb wattage)	Wiring light is shorted or open; or the bulb needs replacing.	Repair the wiring, or replace the bulb.
Blink Code (Whl Spin) Light	3 and 9	2 to 50 ohms (depends on bulb wattage)	Wiring light is shorted or open; or the bulb needs replacing.	Repair the wiring, or replace the bulb.

Troubleshooting

Wiring Tested	Test These Pins	Volt/Ohmmeter Reading	Possible Cause	Remedy
ABS CHK Switch	14 and 27 (also, turn the ABS CHK switch on).	0 to 2 ohms	Wiring light is shorted or open; or the switch needs replacing.	Repair the wiring, or replace the switch.

Table 1

IMPORTANT: The key switch must be off when doing the tests in **Table 1**.



1. Steering Column
2. ABS Check Switch

Fig. 1

See **Fig. 3** for another example of a fault code reading.

NOTE: When there are no fault codes in the ECU memory, blink code 2–0–0 is displayed.

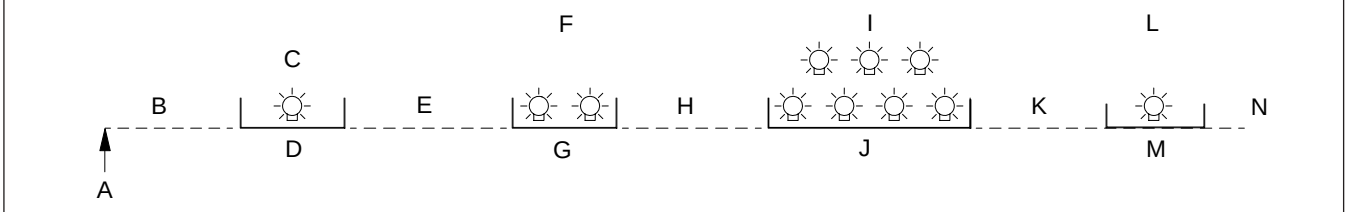
Once a fault code has been identified, use a volt/ohmmeter to check the electrical harness at the ECU's 35-pin connector (**Fig. 4**). Connect the ohmmeter leads to the applicable pins on the connector. A Rockwell WABCO test adaptor (part number 446 300 314 0) is also available and connects to the 35-pin connector.

IMPORTANT: The ignition switch must be off when connecting or disconnecting the ECU.

After attaching the adaptor (**Fig. 5**) to the 35-pin connector, insert the leads from an ohmmeter into the numbered holes on the adaptor.

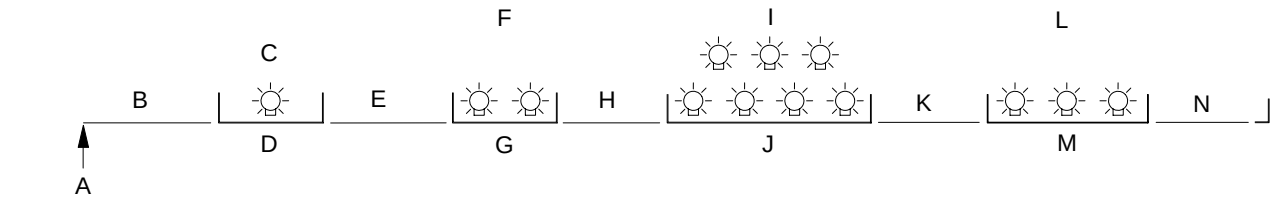
NOTE: Regardless of the ECU model installed (B3, C1, or C2), the test adaptor can be used to troubleshoot all 4-channel ABS systems.

See **Table 2** for a listing of all fault codes, pins to be tested, and the correct volt/ohmmeter readings. Repair or replace the components and/or wiring if the readings are not correct.



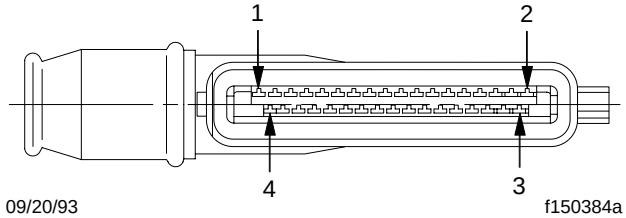
A. Switch Activated Here
B. 5 Sec. Pause
C. 2.5 Sec.
D. Start Pulse
E. 2.5 Sec. Pause
F. 2 Flashes
G. 1st Digit
H. 2.5 Sec. Pause
I. 7 Flashes
J. 2nd Digit
K. 2.5 Sec. Pause
L. 1 Flash
M. 3rd Digit
N. 7.5 Sec. Pause

Fig. 2



A. Switch Activated Here
B. 5 Sec. Pause
C. 2.5 Sec.
D. Start Pulse
E. 2.5 Sec. Pause
F. 2 Flashes
G. 1st Digit
H. 2.5 Sec. Pause
I. 7 Flashes
J. 2nd Digit
K. 2.5 Sec. Pause
L. 3 Flashes
M. 3rd Digit
N. 7.5 Sec. Pause

Fig. 3



1. Pin 1
2. Pin 18
3. Pin 35
4. Pin 19

Fig. 4

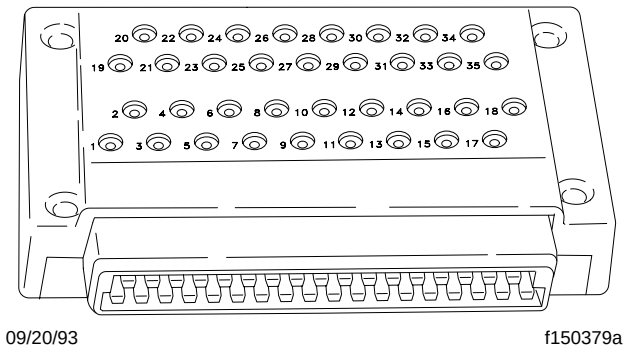


Fig. 5

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals.

See the electrical section (wiring) of this manual for information on special terminals and connectors, and ordering tools for them.

See the wiring diagram in **Subject 400**, when troubleshooting the ABS system equipped with the instrument panel blink codes. The key switch must be turned on (engine off) to activate the blink codes. However, if using the test adaptor 446 300 314 0, the key switch must be off, unless otherwise noted.

If a blink code is displayed that is not in **Table 2**, try to erase the code from ECU memory. If a fault can't be repaired, or erased from ECU memory, test the operation of the solenoid control valves and the traction control valves. For instructions, see **Table 3**. If a fault still can't be repaired, or erased from ECU memory, contact your Rockwell District Service Manager.

If necessary, start the engine and build system air pressure to at least 100 psi (689 kPa). Shut down the engine, but leave the ignition switch on.

⚠ CAUTION

CAUTION: When doing the tests in Table 3, don't leave the positive volt/ohmmeter test lead connected to pin 9 for more than 10 seconds. Momentarily touch the positive test lead to pin 9 only when you are ready to observe the reading. Leaving the test lead connected to pin 9 for more than 10 seconds could damage the solenoid or traction control valve, or the volt/ ohmmeter.

When testing the solenoid control valves or the traction control valves in **Table 3**, always connect the *positive* volt/ohmmeter test lead to pin 9. Connect the *negative* test lead to the other pin referenced in **Table 3**. Set the volt/ohmmeter to 10 amps.

NOTE: If a 10-amp capacity meter is not available, a jumper wire can be used.

Troubleshooting

IMPORTANT: The key switch must be on when doing the tests in **Table 3**.

WABCO ABS Fault Codes/Tests					
Key Switch On to Determine Fault Code			Key Switch Off to Test System		
Fault Code		Problem	Test These Pins	Volt/Ohmmeter Reading	Remedy
2–0–0	No faults.	—	—	—	
2–6–6 (VR1)	2–6–7 (VR2)	Battery voltage to the relay is low, or the relay is not working properly.	+1 and –27 (VR1) * +19 and –27 (VR2) *	0.0 volt	Problem found with key switch on. Repair or replace as needed.
2–6–8 Right Front (RF)	2–6–9 Left Front (LF)	Wheel speed signal is erratic.	15 and 32 (LF) † 17 and 34 (RF) †	Above 0.2 volt AC	A damaged tone wheel, a sensor needs adjustment, or there is excessive hub runout. Repair or replace as needed.
2–6–10 Right Front (RF)	2–6–11 Left Front (LF)	Sensor circuit damage.	15 and 27 (LF) 15 and 32 (LF) 17 and 27 (RF) 17 and 34 (RF)	Above 30.0 kilo ohms 1.0 to 1.99 kilo ohms Above 30.0 kilo ohms 1.0 to 1.99 kilo ohms	On the steer axle, there is damage to the wheel sensor and/or sensor wiring to the ECU. Repair or replace as needed.
2–6–12 Right Front (RF)	2–6–13 Left Front (LF)	Sensor out of adjustment.	15 and 32 (LF) † 17 and 34 (RF) †	Above 0.2 volt AC	On the steer axle, adjust the wheel sensor.
2–7–0 Left Rear (LR)	2–7–1 Right Rear (RR)	Wheel speed signal is erratic.	18 and 35 (LR) † 16 and 33 (RR) †	Above 0.2 volt AC	On the drive axle, a damaged tone wheel, a sensor needs adjustment, or there is excessive hub runout. Repair or replace as needed.
2–7–2 Left Rear (LR)	2–7–3 Right Rear (RR)	Sensor circuit damage.	18 and 27 (LR) 18 and 35 (LR) 16 and 27 (RR) 16 and 33 (RR)	Above 30.0 kilo ohms 1.0 to 1.99 kilo ohms Above 30.0 kilo ohms 1.0 to 1.99 kilo ohms	On the drive axle, damage to the wheel sensor and/or sensor wiring to the ECU. Repair or replace as needed.
2–7–4 Left Rear (LR)	2–7–5 Right Rear (RR)	Sensor out of adjustment.	18 and 35 (LR) † 16 and 33 (RR) †	Above 0.2 volt AC	On the drive axle, adjust the wheel sensor.
2–8–3 2–8–5	2–8–7 2–8–9	J1922 electronic engine data link is not working properly.	Idle the engine at about 1500 rpm. Short 14 to 27, or turn on the ABS CHK switch. The rpm should decrease.	Damage to the data link and/or data link wiring connections. Repair or replace as needed.	

WABCO ABS Fault Codes/Tests					
Key Switch On to Determine Fault Code			**Key Switch Off to Test System**		
Fault Code		**Problem**	**Test These Pins**	**Volt/Ohmmeter Reading**	**Remedy**
2–8–10 Right Front (RF)	2–8–11 Left Front (LF)	On the steer axle, there is a short circuit in the ABS solenoid control valve to ground connection.	23 and 27 (LF) 24 and 27 (LF) 6 and 27 (RF) 7 and 27 (RF)	4 to 8 ohms	Check the ABS solenoid valve and cab wiring connections. Repair or replace as needed.
2–8–12 Right Front (RF)	2–8–13 Left Front (LF)	On the steer axle, there is an open circuit in the ABS solenoid control valve and/or wiring to the ground connection.			
2–8–14 Right Front (RF)	2–8–15 Left Front (LF)	On the steer axle, there is a short circuit in the ABS solenoid control valve and/or wiring to the ground connection.			
2–9–0 Right Front (RF)	2–9–1 Left Front (LF)	On the steer axle, there is an open circuit in the ABS solenoid control valve and/or wiring.			
2–9–2 Left Rear (LR)	2–9–3 Right Rear (RR)	On the drive axle, there is a short circuit in the ABS solenoid control valve and/or wiring to the ground connection.	21 and 27 (LR) 22 and 27 (LR) 4 and 27 (RR) 5 and 27 (RR)	4 to 8 ohms	Check the ABS solenoid valve and cab wiring connections. Repair or replace as needed.
2–9–4 Left Rear (LR)	2–9–5 Right Rear (RR)	On the drive axle, there is an open circuit in the ABS solenoid control valve and/or wiring.			
2–9–6 Left Rear (LR)	2–9–7 Right Rear (RR)	On the drive axle, there is a short circuit in the ABS solenoid control valve and/or wiring to the ground connection.			
2–9–8 Left Rear (LR)	2–9–9 Right Rear (RR)	On the drive axle, there is an open circuit in the ABS solenoid control valve and/or wiring.	21 and 27 (LR) 22 and 27 (LR) 4 and 27 (RR) 5 and 27 (RR)	4 to 8 ohms	Check the ABS solenoid valve and cab wiring connections. Repair or replace as needed.
2–10–2 Left Rear (LR)	2–10–3 Right Rear (RR)	Short circuit in the traction control valve and/or wiring to the ground connection.	2 and 27 (LR) 20 and 27 (RR)	8 to 14 ohms	Check the traction control valve and cab wiring connections. Repair or replace as needed.
2–10–4 Left Rear (LR)	2–10–5 Right Rear (RR)	Open circuit in the traction control valve and/or wiring.			

Troubleshooting

WABCO ABS Fault Codes/Tests					
Key Switch On to Determine Fault Code			Key Switch Off to Test System		
Fault Code		Problem	Test These Pins	Volt/Ohmmeter Reading	Remedy
2–10–7		Short circuit in the wiring or the relay that controls the engine brake.	With key switch on, short 11 to 27 and 9 to 19 at the same time. The relay contacts should open, disabling the engine brake.		Check the engine brake relay and wiring. Repair or replace as needed.
2–10–8 Left Rear (LR)	2–10–9 Right Rear (RR)	Excessive wheel spin caused by driver or dynamometer. Erase the fault.	—	—	—
2–11–12 Right Front (RF)	2–11–13 Left Front (LF)	On the steer axle, there is a short circuit in the ABS solenoid control valve and/or wiring to the power supply connection.	23 and 27 (LF) 24 and 27 (LF) 6 and 27 (RF) 7 and 27 (RF)	4 to 8 ohms	Check the ABS solenoid valve, wiring, and cab wiring connections. Repair or replace as needed.
2–11–14 Left Rear (LR)	2–11–15 Right Rear (RR)	On the drive axle, there is a short circuit in the ABS solenoid control valve and/or wiring to the power supply connection.	21 and 27 (LR) 22 and 27 (LR) 4 and 27 (RR) 5 and 27 (RR)		
2–12–2 Left Rear (LR)	2–12–3 Right Rear (RR)	Short circuit in the traction control valve and/or wiring to the power supply connection.	2 and 27 (LR) 20 and 27 (RR)	8 to 14 ohms	
2–12–7	Short circuit in the engine brake relay and/or wiring to the ground connection.	—	—	Check the engine brake relay and wiring. Repair or replace as needed.	

WABCO ABS Fault Codes/Tests					
Key Switch On to Determine Fault Code			**Key Switch Off to Test System**		
Fault Code		**Problem**	**Test These Pins**	**Volt/Ohmmeter Reading**	**Remedy**
2–12–8 Right Front (RF)	2–12–9 Left Front (LF)	On the steer axle, there is a short circuit in the ABS solenoid control valve and/or wiring to the battery.	23 and 27 (LF) 24 and 27 (LF) 6 and 27 (RF) 7 and 27 (RF)	4 to 8 ohms	Check the ABS solenoid valve, wiring, and cab wiring connections. Repair or replace as needed.
2–12–10 Left Rear (LR)	2–12–11 Right Rear (RR)	On the drive axle, there is a short circuit in the ABS solenoid control valve and/or wiring to the battery.	21 and 27 (LR) 22 and 27 (LR) 4 and 27 (RR) 5 and 27 (RR)		
2–12–14 Left Rear (LR)	2–12–15 Right Rear (RR)	Short circuit in the traction control valve and/or wiring to the battery.	2 and 27 (LR) 20 and 27 (RR)	8 to 14 ohms	
2–13–4 (VR1)	2–13–5 (VR2)	The valve relay is not operating properly.	VR1) – With the key on, short 8 to 27. Vehicle voltage should read 11.0 to 15.4 volts DC between pins 1 and 27.(VR2) – With the key on, short 25 to 27. Vehicle voltage should read 11.0 to 15.4 volts DC between pins 19 and 27.	Replace the valve relay.	
2–13–8 (VR1)	2–13–9 (VR2)	Vehicle power supply is too high.		Check the vehicle power supply system. Repair as needed.	

* Connect the positive volt/ohmmeter test lead to pins 1 and 19. Connect the negative test lead to pin 27.

† After connecting the volt/ohmmeter test leads, rotate the applicable tire at about 30 rpm (1 revolution every 2 seconds).

Table 2

Troubleshooting

Valve Tested	What to Do	Desired Result	Problem	Remedy
Left Front Solenoid Control Valve	Depress the brake pedal; connect pins 9 and 24. Release the brake pedal.	Left front brake chamber exhausts.	The electrical lines of the two control valves are crossed; the air supply and discharge lines are crossed; the electrical connector at the valve is not correctly plugged in; or, the control valve needs replacing.	Repair or replace as needed.
	Connect pins 9 and 23; depress the brake pedal.	No pressure build up in left front brake chamber.		
Right Front Solenoid Control Valve	Depress the brake pedal; connect pins 9 and 7. Release the brake pedal.	Right front brake chamber exhausts.		
	Connect pins 9 and 6; depress the brake pedal.	No pressure build up in right front brake chamber.		
Left Rear Solenoid Control Valve	Depress the brake pedal; connect pins 9 and 22. Release the brake pedal.	Left rear brake chamber exhausts.		
	Connect pins 9 and 21; depress the brake pedal.	No pressure build up in left rear brake chamber.		
Right Rear Solenoid Control Valve	Depress the brake pedal; connect pins 9 and 5. Release the brake pedal.	Right rear brake chamber exhausts.		
	Connect pins 9 and 4; depress the brake pedal.	No pressure build up in right rear brake chamber.		
Left Rear Traction Control Valve	Connect pins 9 and 2.	Pressure build up in left rear brake chamber(s).	The air supply and discharge lines are crossed or, the air supply and discharge lines are blocked.	
Right Rear Traction Control Valve	Connect pins 9 and 20.	Pressure build up in right rear brake chamber(s).		

Table 3

Refer to Fig. 1 for a full view of the WABCO ABS wiring diagram. **Refer to Fig. 2**, **Fig. 3** , **Fig. 4**, or **Fig. 5** for sectional views as shown in the full view of the WABCO ABS wiring diagram.

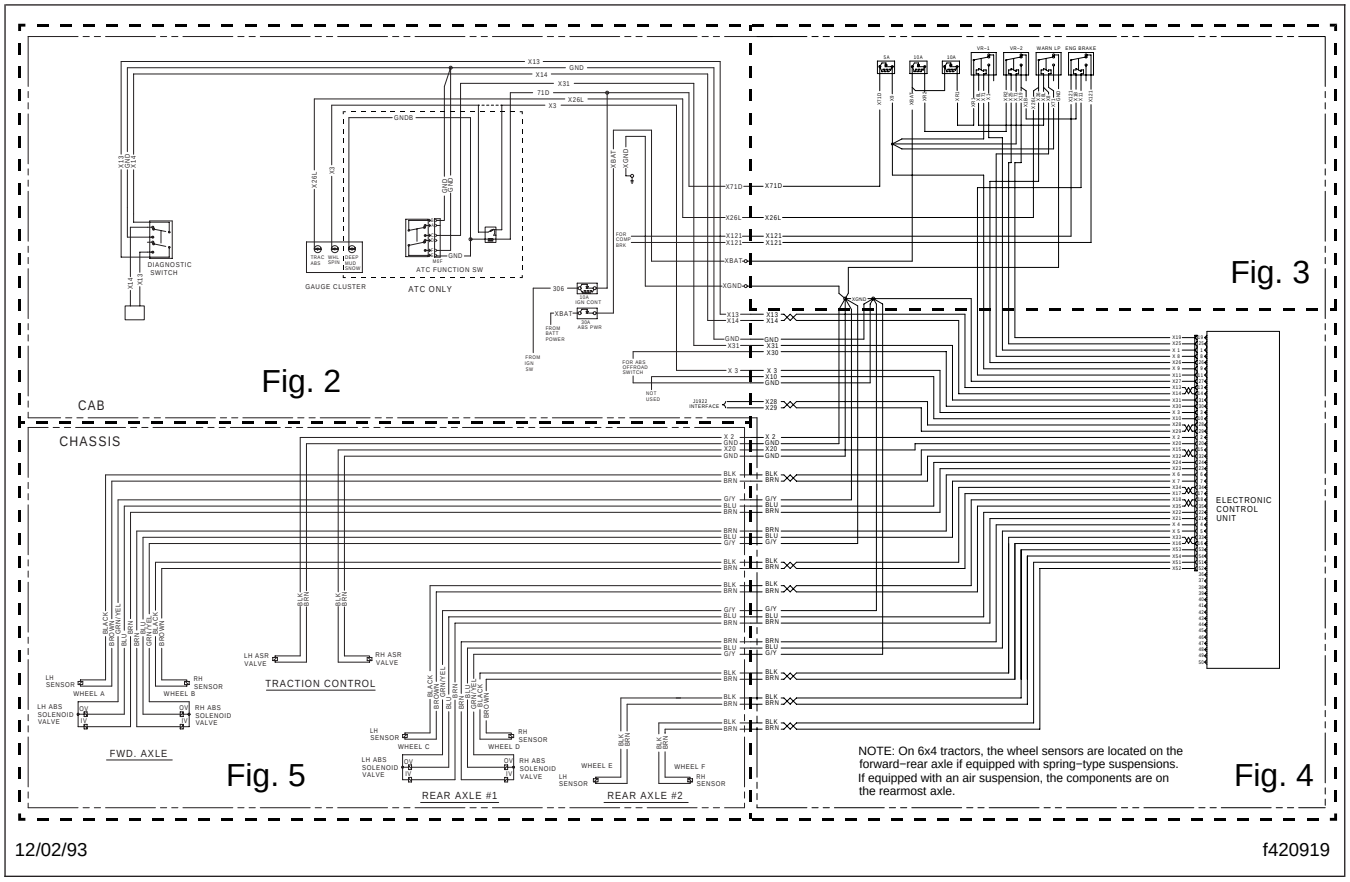


Fig. 1, Wiring Diagram for Troubleshooting ABS Systems Using Instrument Panel Blink Codes

Specifications

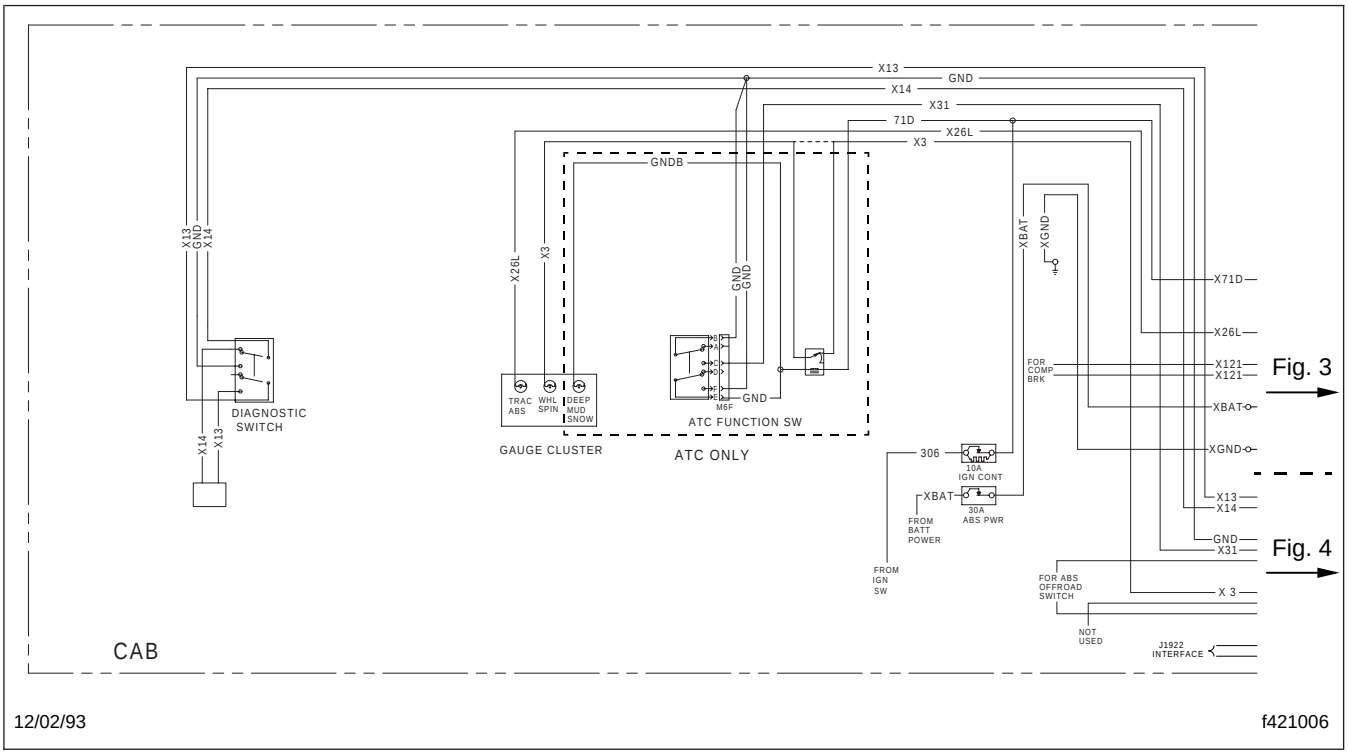


Fig. 2

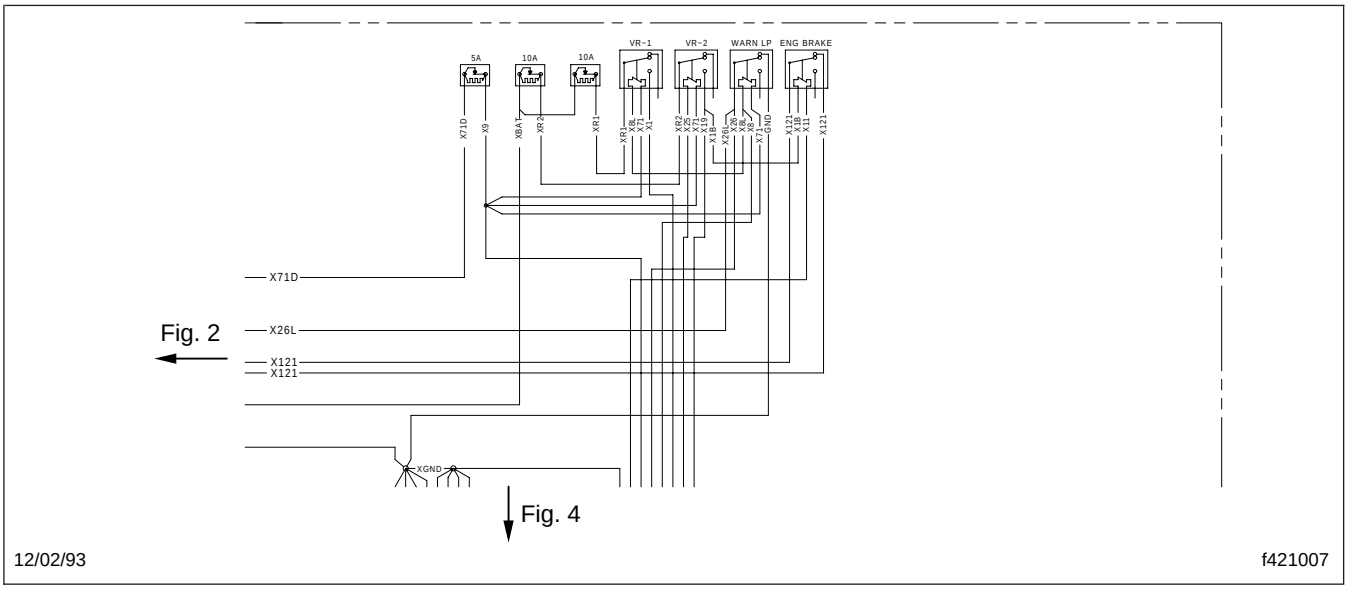


Fig. 3

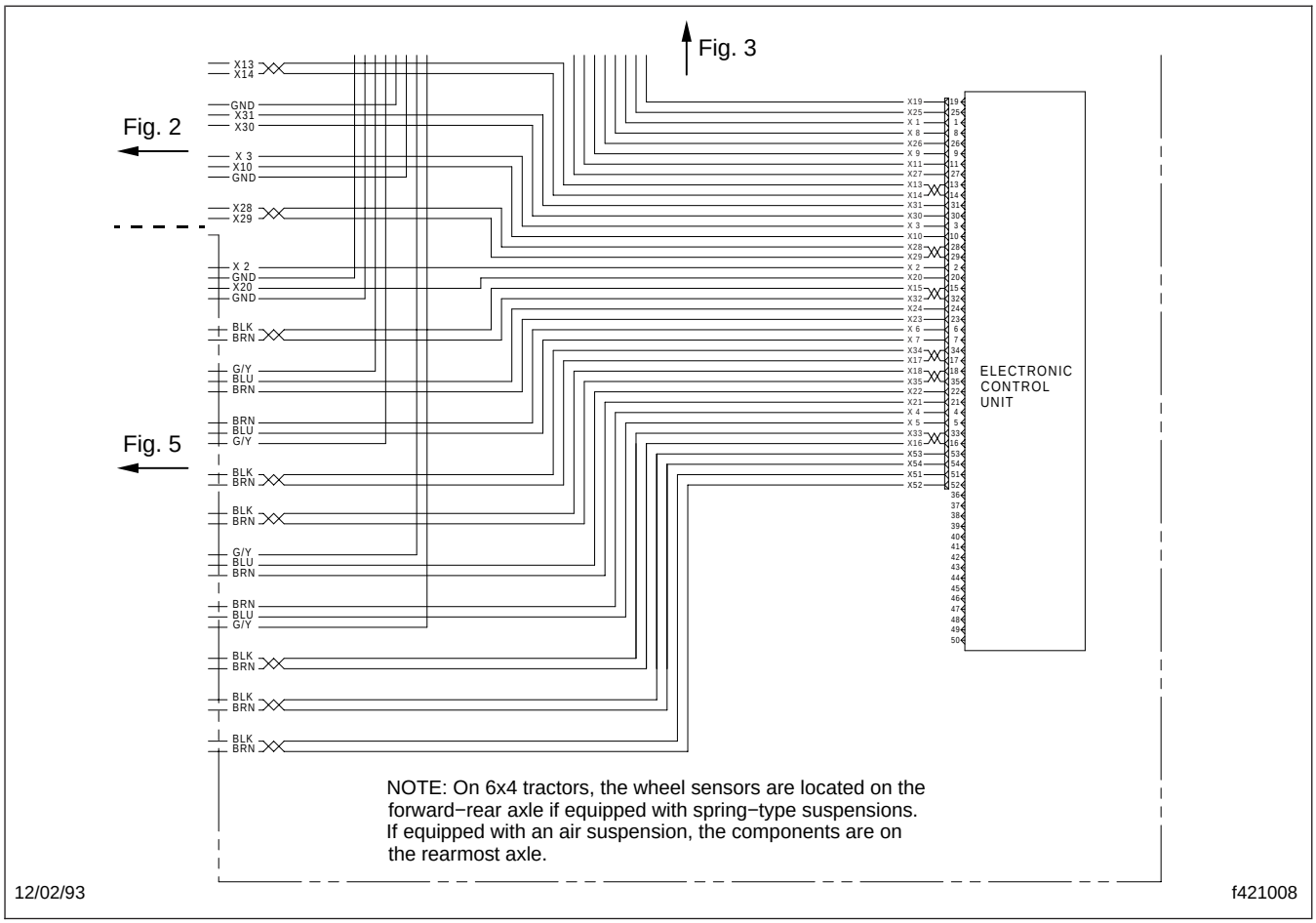

Fig. 3
Fig. 2
Fig. 5
X13
X14
GND
X31
X30
X 3
X10
GND
X28
X29
X 2
GND
X20
GND
BLK
BRN
G/Y
BLU
BRN
BRN
BLU
G/Y
BLK
BRN
BLK
BRN
G/Y
BLU
BRN
BRN
BLU
G/Y
BLK
BRN
BLK
BRN
BLK
BRN
ELECTRONIC
CONTROL
UNIT
NOTE: On 6x4 tractors, the wheel sensors are located on the forward−rear axle if equipped with spring−type suspensions. If equipped with an air suspension, the components are on the rearmost axle.
12/02/93
f421008

Fig. 4

Specifications

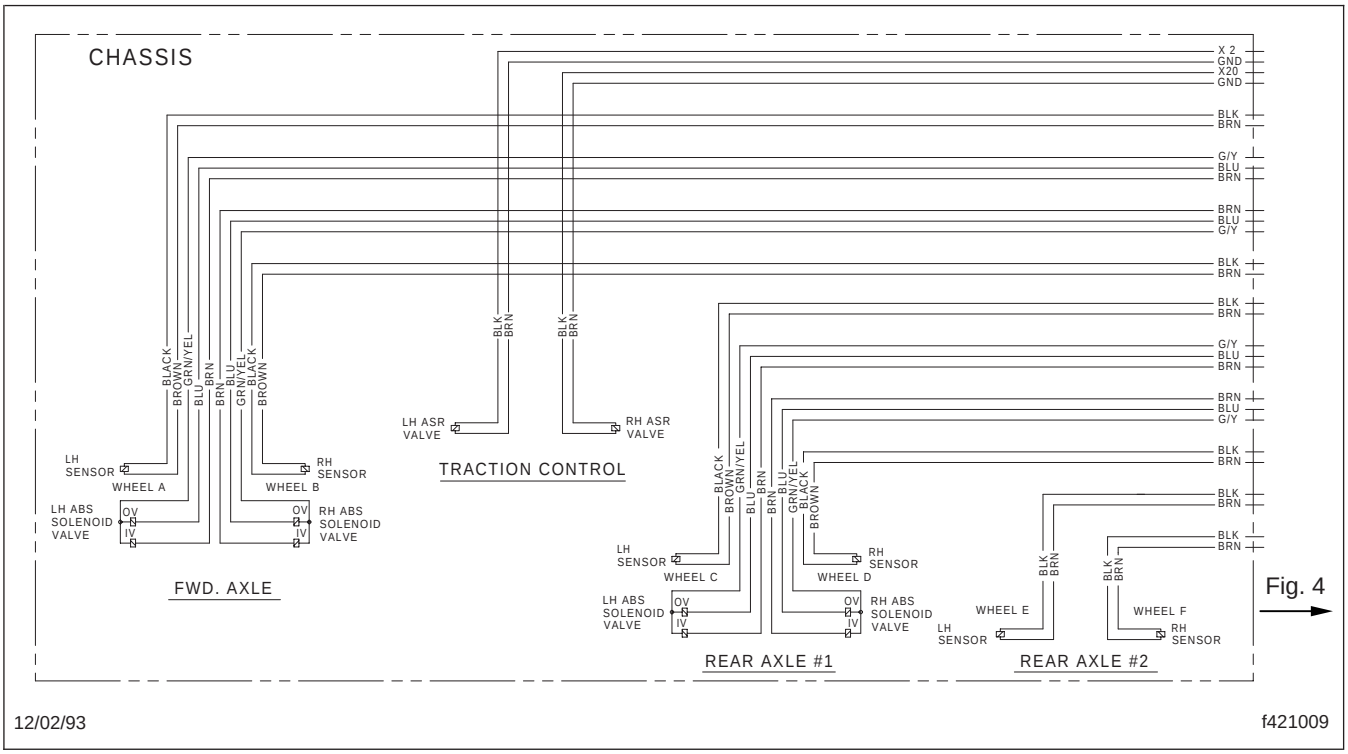
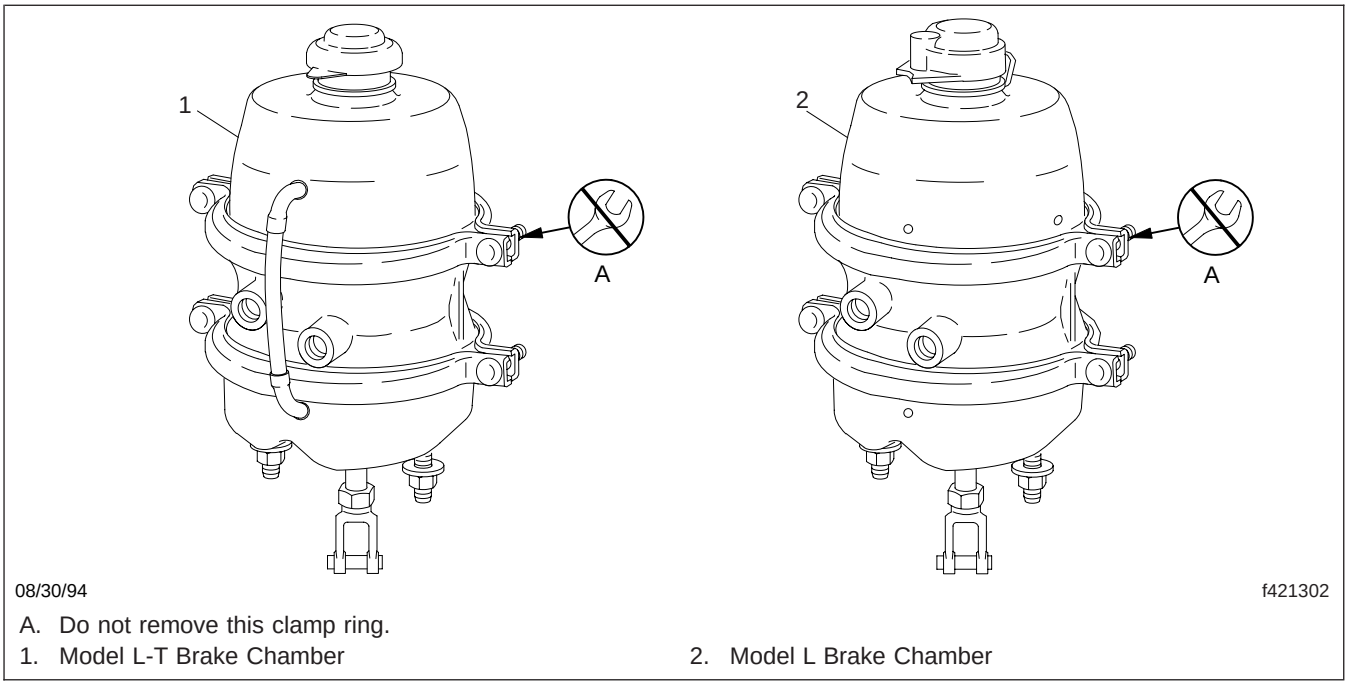


Fig. 5

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.



A. Do not remove this clamp ring.
1. Model L-T Brake Chamber
2. Model L Brake Chamber

Fig. 1, L Series Brake Chambers

General Information

MGM "L" series tandem cam brake chambers consist of a service brake section and a parking/emergency spring brake section. **See Fig. 2.** The service brake chamber is in the smaller section near the clevis assembly. Some installations include the service brake chamber only. **See Fig. 3.**

In the service brake section, the flange case (or pressure cap for service-only chambers) and non-pressure chamber contain a service return spring, piston rod assembly, and service brake diaphragm.

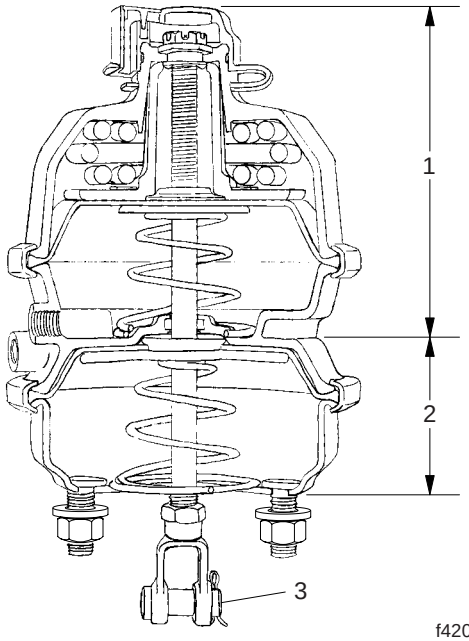
In the parking/emergency brake section, the flange case and the head assembly contain a return spring, a push rod assembly, a parking (spring) brake diaphragm, a piston, a power spring, and an integral (contained inside the chamber) release bolt and nut.

All MGM brake chambers are mounted to the frame using prevailing torque locknuts and hardened flat-washers.

To protect internal components from contaminants, MGM Model "L-T" brake chambers are equipped with an external breather tube. Model "L" employs a filtered breather cap. **See Fig. 2.**

Periodic maintenance of the brake chamber is required. Also, whenever the service brake chamber is disassembled (*do not attempt to disassemble the parking brake chamber*), the parts should be inspected for damage. For maintenance schedules and procedures, and for inspection of brake chamber parts, refer to the vehicle maintenance manual.

General Information and Principles of Operation



1. Parking (Spring) Brake
2. Service Brake
3. Clevis Assembly

Fig. 2, L Series Cam Brake Chambers (sectional view)

Principles of Operation

SERVICE BRAKES

As the brake pedal is depressed, compressed air enters the service brake chamber through a port. Air pressure acts upon a diaphragm, which forces the piston rod toward the non-pressure chamber, applying a straight-line force to the slack adjuster, which converts it to a rotational force. This in turn rotates the camshaft and applies the brakes.

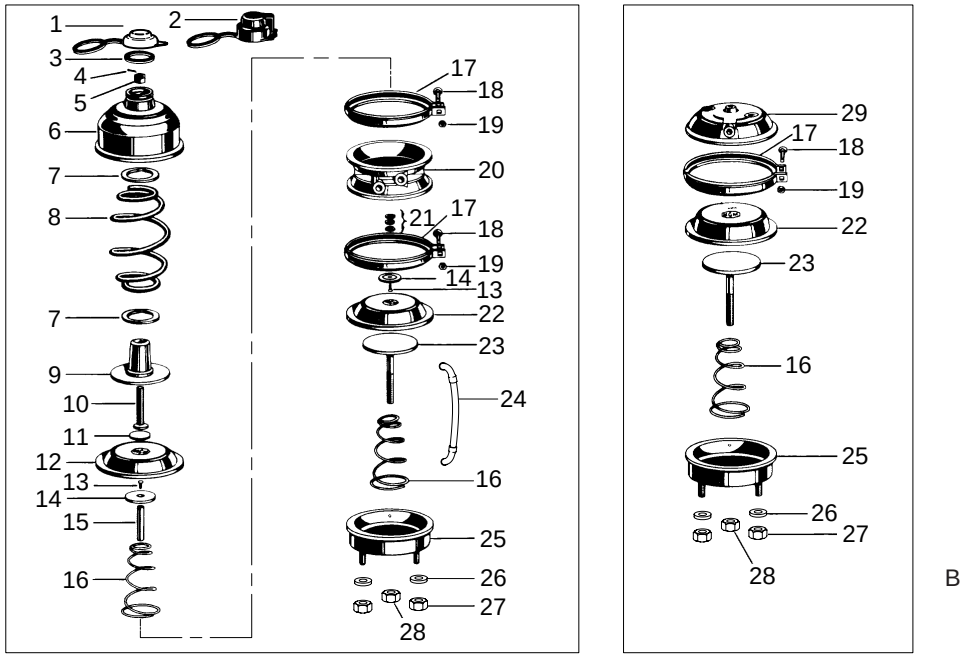
Then, when the brake pedal is released, air is exhausted from the service brake chamber. The return spring allows the diaphragm, piston rod, and slack adjuster to return to their normal positions, releasing the brakes.

PARKING/EMERGENCY BRAKES

During parking brake release, compressed air enters the parking brake chamber and acts upon the diaphragm and piston, fully compressing the power spring. When the power spring is compressed, the parking brakes are released; the service brakes can then be operated at the brake pedal.

During parking brake application, air is exhausted from the parking brake chamber. The power spring releases, forcing the piston and parking brake diaphragm toward the flange case. The resulting motion on the push rod forces the service brake diaphragm and the piston rod outward, applying the brakes.

Emergency brake application automatically begins when the air pressure in the brake system drops below approximately 550 kPa (80 psi). Full emergency brake application occurs when the air pressure drops below aproximately 275 kPa (40 psi).



A. Combined Service Brake and Parking/Emergency Brake Chamber

B. Service Brake Chamber

1. End Cap and Retainer (on Model L-T only)
2. Breather Cap (on Model L only)
3. Filter (on Model L only)
4. Lockpin
5. Release Nut
6. Head Assembly
7. Thrustwasher
8. Power Spring
9. Piston
10. Integral Release Bolt
11. Piston Plug
12. Parking (Spring) Brake Diaphragm
13. Screw
14. Push Rod Plate
15. Push Rod
16. Return Spring
17. Clamp Ring
18. Clamp Ring Bolt
19. Clamp Ring Nut
20. Flange Case
21. Seal and Guide
22. Service Brake Diaphragm
23. Piston Rod
24. Breather Tube and Elbows (on Model L-T only)
25. Non-Pressure Chamber
26. Hardened Flatwasher
27. Prevailing Torque Locknut
28. Piston Rod Jam Nut
29. Pressure Cap

Fig. 3, L Series Cam Brake Chambers (exploded view)

DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

Manual Compression (Parking Brake Release)

1. Chock the tires.
2. Remove the end cap (breather cap if so equipped). See **Fig. 2**.

DANGER

Do not attempt to cage the power spring if the parking brake chamber is damaged severely enough to lose its structural integrity. If the power spring were to break loose, it could result in death, severe personal injury, or property damage.

A DAMAGED PARKING BRAKE CHAMBER IS EXTREMELY DANGEROUS! Only qualified service personnel should attempt to remove and disarm a damaged chamber. Using a torch, burn off the piston rod in the space between the clevis and the base of the service chamber.

Remove the chamber carefully from its bracket, and disarm it inside a suitable container. For disarming procedures, consult the MGM service manual.

3. Manually release the parking brake (cage the power spring).
   3.1 Apply at least 620 kPa (90 psi) air pressure to the parking brake inlet port (set parking brake in the "release" position).

CAUTION

Don't exceed 68 N·m (50 lbf·ft) torque on the release bolt; and don't use an impact wrench on this bolt. Too much torque could distort the head of the chamber and prevent manual release of the parking brake.

   3.2 Using a hand wrench, (*don't use an impact wrench*), turn the release bolt *counterclockwise* until the bolt is fully extended, or about 57 to 64 mm (2-1/4 to 2-1/2 inches). See **Fig. 3**, dimension A.
4. Once the power spring has been caged, exhaust the compressed air from the parking brake.

Manual Reset (Parking Brake Reset)

1. If the threads of the release bolt are dry, coat them with a light film of low-temperature molybdenum (moly) grease.
2. Uncage the power spring.
   2.1 Apply at least 620 kPa (90 psi) air pressure to the parking brake inlet port (set parking brake in the "release" position).

CAUTION

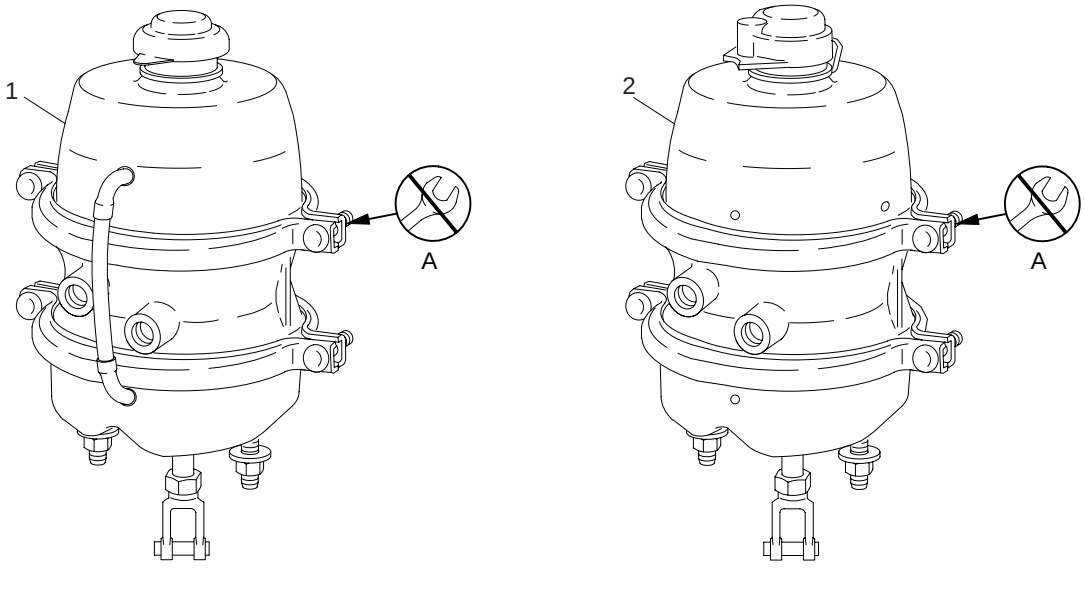
Don't exceed 68 N·m (50 lbf·ft) torque on the release bolt; and don't use an impact wrench on this bolt. Too much torque could distort the head of the chamber and prevent manual release of the parking brake.

   2.2 Using a hand wrench (*don't use an impact wrench*), turn the release bolt *clockwise* until the bolt is fully engaged into the unit and the slotted nut bottoms out onto the head insert.
   2.3 Tighten the release bolt 61 to 68 N·m (45 to 50 lbf·ft). See **Fig. 4**.
3. Snap the end cap tightly into place. On chambers equipped with a breather cap, make sure the drain tab is pointing to the ground. Regardless of the position in which the brake chamber is installed, the arrow on the drain tab must be pointed downwards. See **Fig. 5**, Reference A.

CAUTION

If the external breather tube or breather cap is missing or incorrectly installed, road dirt and debris can adversely affect the operation of the brake chamber. Once inside the chamber, dirt and debris cause the internal parts to deteriorate

Power Spring Manual Compression and Reset



A. Do not remove this clamp ring.
1. Model L-T Brake Chamber
2. Model L Brake Chamber

Fig. 1, L Series Brake Chambers

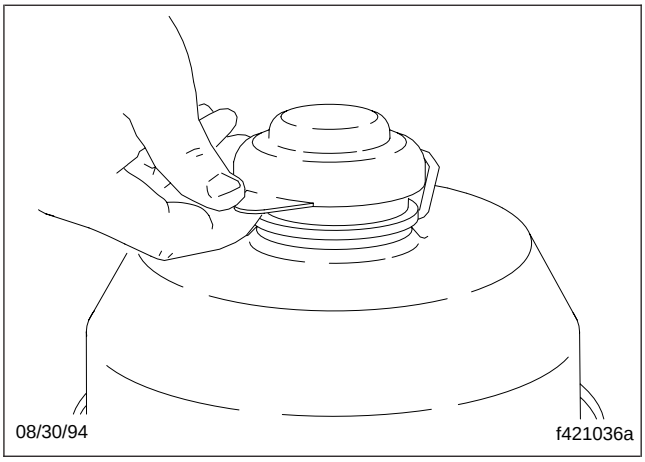
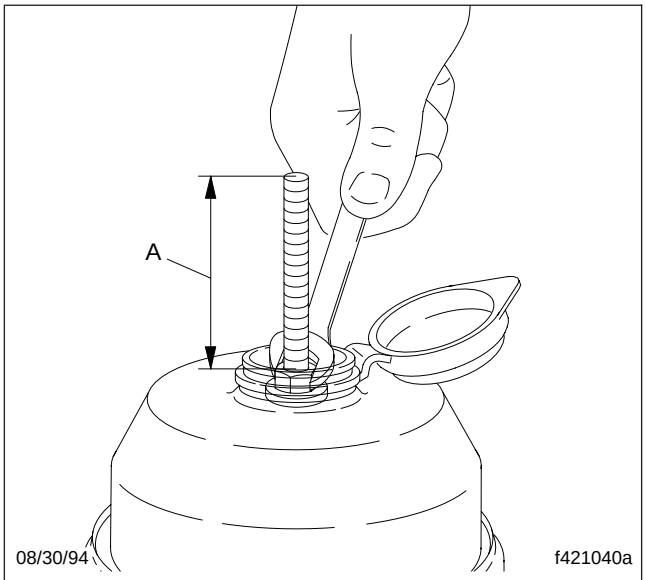


Fig. 2

and shorten their lives. Operating the unit without the external breather tube or breather cap in place voids the MGM warranty.

4. Check the breather tube or cap periodically, and replace it with a new one at once if damaged or missing. Also replace the breather cap if the foam filter is contaminated with dirt or debris. For intervals, see the vehicle maintenance manual.



Make sure the bolt extends at least 57 mm (2-1/4 inches) above the lip on the chamber head.
A. Measure this distance.

Fig. 3

5. Remove the chocks from the tires.

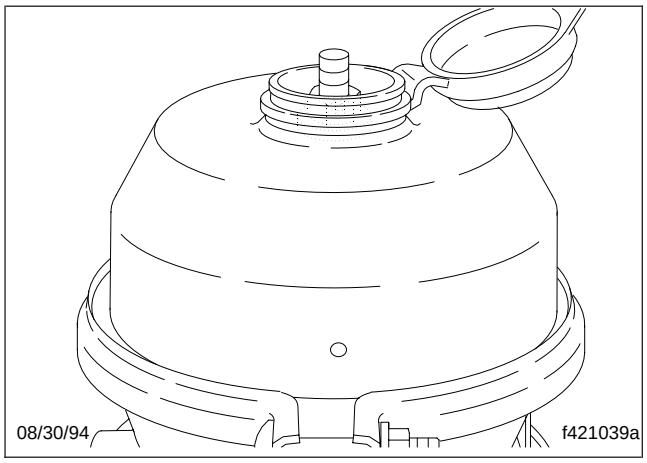


Fig. 4

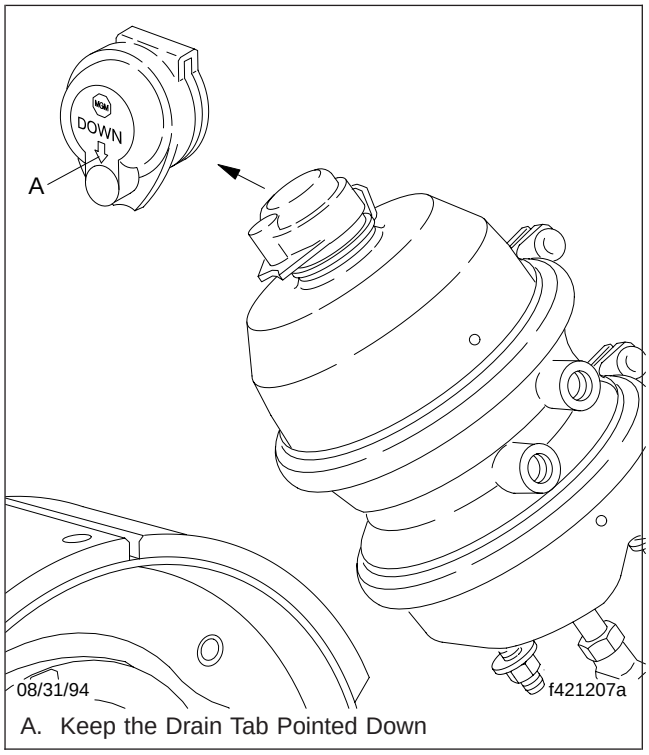


Fig. 5, Breather Cap Installation (on Model L only)

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

Removal

1. To make removal and installation of the parking brake section easier (without removing the service brake chamber), lock off the service chamber piston rod.

   1.1 Apply the service brakes by actuating the driver's foot brake treadle valve.

   1.2 With the brakes applied, clamp a pair of locking-jaw pliers on the piston rod to lock the rod in place when the air pressure is released (see Fig. 2).

⚠ WARNING

Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section (see Subject 100). When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.

2. Manually release the parking brake (cage the power spring). For instructions, see Subject 100.
3. Mark the air lines for later reference. Then carefully disconnect them from the brake chamber.

   On chambers equipped with an external breather tube, disconnect the tube and elbow from the service brake chamber.

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

4. Remove the parking brake section from the service brake section.

   4.1 Using a hand wrench (*don't use an impact wrench*), remove the clamp nuts on the *service* clamp ring (*do not disassemble the parking brake section*).

   4.2 While holding the parking brake section securely in place, remove the service clamp ring. Then remove the parking brake section from the service brake non-pressure chamber (see Fig. 3).

5. Remove the service brake diaphragm from the bottom of the parking brake section.

Installation

IMPORTANT: At this time, take the opportunity to inspect the parking/emergency brake section, and replace it if it shows signs of damage, corrosion, or rust. Follow the detailed inspection instructions in the vehicle maintenance manual.

1. Inspect all parts in the service (non-pressure) chamber. Replace any damaged or worn parts with genuine MGM-engineered replacement parts.
2. Place the new service brake diaphragm in the bottom recess of the parking brake section (see Fig. 4).
3. Install the (new, if needed) parking/emergency brake section.

   3.1 If installing a new parking brake section, be sure it is the same size and make as the old one.

   3.2 Check that the release bolt is fully extended outward. For instructions, refer to Subject 100.

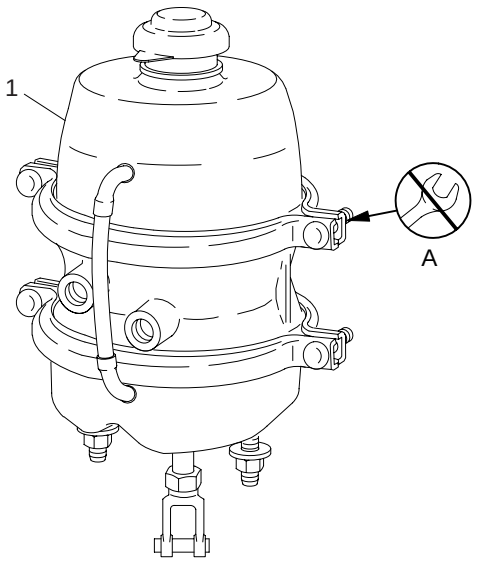
   3.3 Install the parking brake section on the service chamber so that all mating parts are aligned straight and the air lines are positioned to mate with the vehicle air supply lines.

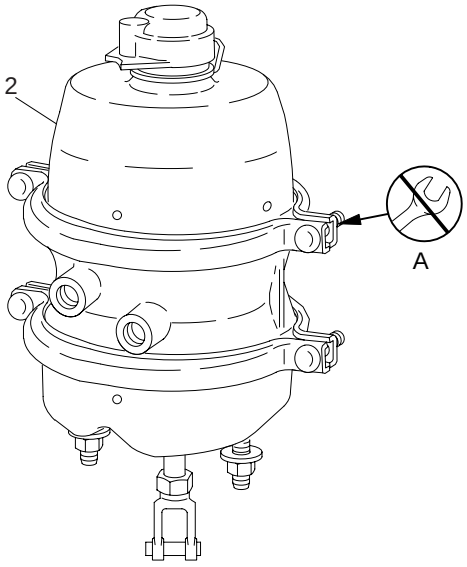
4. Install the service brake clamp ring.

   4.1 With the service brake clamp ring in place, install the clamp bolts and nuts.

   4.2 Using a hand wrench (*don't use an impact wrench*), alternately tighten each clamp nut in increments of 680 to 1360

Service Brake Diaphragm Replacement

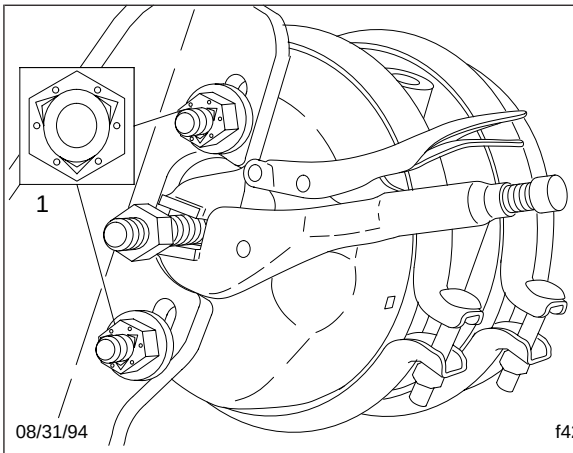




08/30/94 f421302

A. Do not remove this clamp ring.
1. Model L-T Brake Chamber
2. Model L Brake Chamber

Fig. 1



08/31/94 f421204a

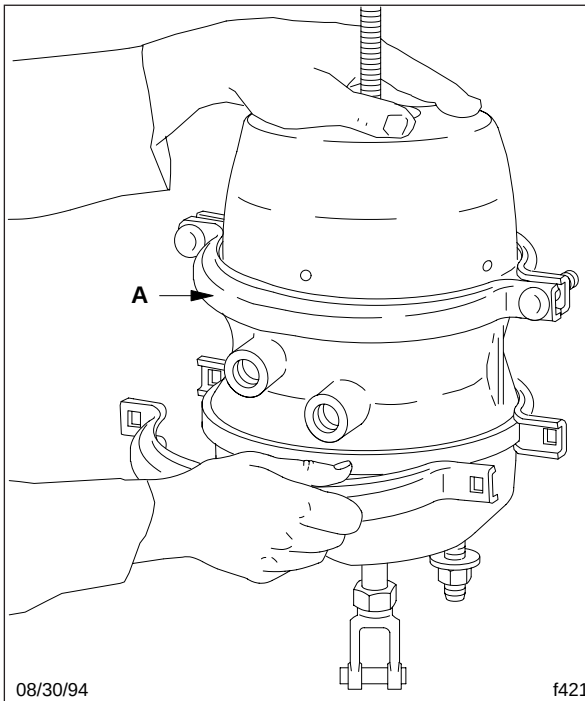
1. Prevailing Torque Locknut

Fig. 2

N·cm (60 to 120 lbf·in) while constantly rechecking the alignment of mating parts.

If realignment is needed, loosen the nuts again, and repeat this substep.

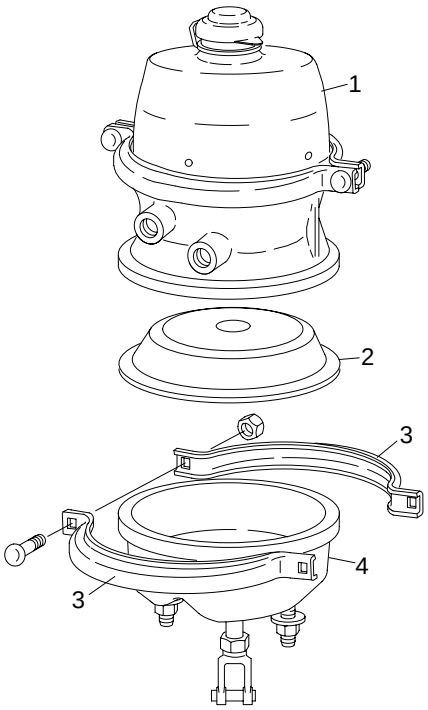
4.3 Firmly tap around the circumference of the service clamp ring with a rubber mallet to ensure full seating of the clamp. Tighten



08/30/94 f421205a

A. Do not remove this clamp ring.

Fig. 3



1. Parking/Emergency Brake Section
2. Service Brake Diaphragm
3. Service Brake Clamp Ring
4. Service Brake (Non-Pressure) Chamber

Fig. 4

the nuts to a final torque of 34 to 41 N·m (25 to 30 lbf·ft).

5. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench (*don't use an impact wrench*), tighten the fittings 34 N·m (25 lbf·ft).

6. Using the vehicle system air, charge the parking brake with full line pressure—at least 690 kPa (100 psi). Using only soapy water (*never any type of oil,* which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If bubbles or leaks appear, tighten the fittings slightly, but not over 34 N·m (25 lbf·ft).

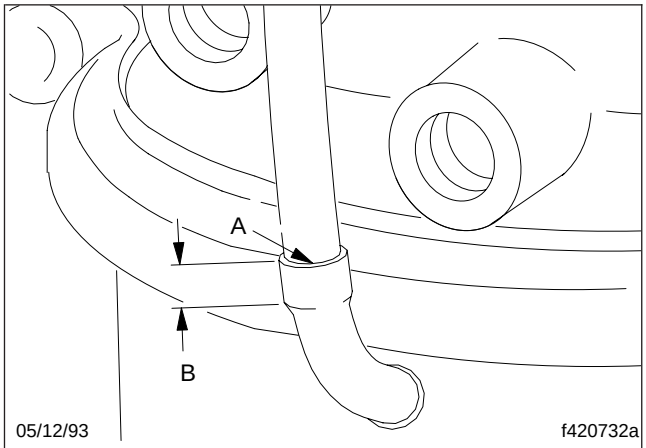
7. With the parking brake still charged with full line pressure, apply and hold the foot brake treadle valve down to charge the service brake chamber. Remove the locking-jaw pliers from the service piston rod so that the piston returns to a normal position in the chamber.

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

8. Test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, firmly tap the circumference of the clamp ring with a rubber mallet, and retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). MGM recommends 34 to 41 N·m (25 to 30 lbf·ft) torque on the clamp hexnuts.

9. On chambers equipped with an external breather tube, make sure that the open end of the tube is free of grease, dirt, and other debris. Then, apply a high-quality rubber cement to the tube and insert it into the elbow at least 13 mm (1/2 inch). See **Fig. 5**. Insert the tube into the service brake chamber.



A. Apply adhesive here.
B. Check for 1/2" (13 mm) minimum engagement.

Fig. 5

10. With air pressure now exhausted from the service brake chamber, but held on the parking brake, reset the parking brakes by uncaging the power spring, and snap the end cover cap in place. For instructions, see **Subject 100**.

Service Brake Diaphragm Replacement

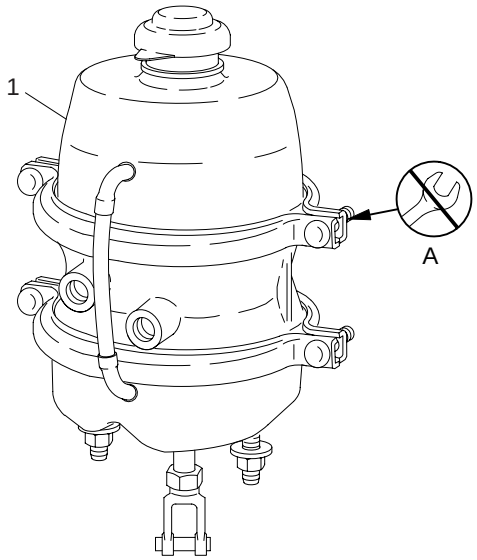
11. Snap the end cap into place. On chambers equipped with a breather cap, snap the breather cap into place, taking care to point the drain tab downwards. Replace the breather cap if the foam filter is contaminated with dirt or debris.
12. Adjust the brakes at the slack adjuster.

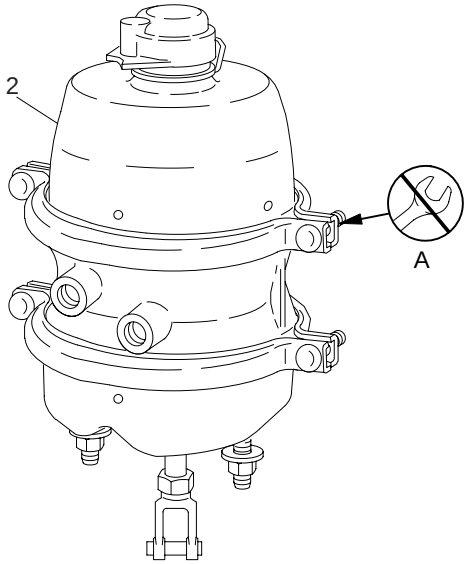
IMPORTANT: After replacing any brake chamber components, check the piston rod stroke and actuating alignment to ensure correct installation and foundation brake adjustment. No foundation brake adjustments, parking brake or service brake, can be made at the chamber and all "stroke" adjustments must be made at the slack adjuster. For instructions, see the applicable slack adjuster section in **Group 42**.

Replacement

DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.





08/30/94 f421302

A. Do not remove this clamp ring.
1. Model L-T Brake Chamber
2. Model L Brake Chamber

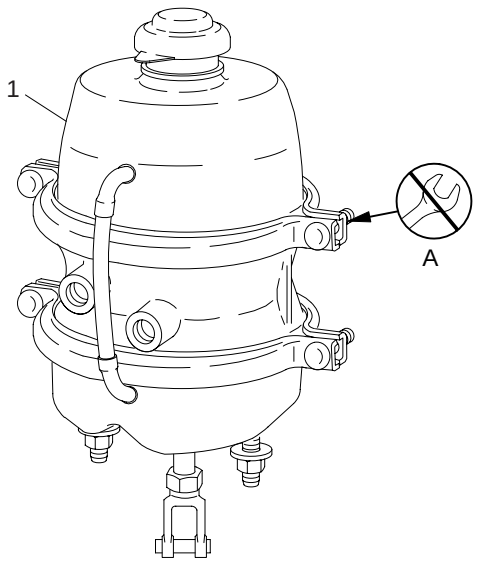
Fig. 1, L Series Brake Chambers

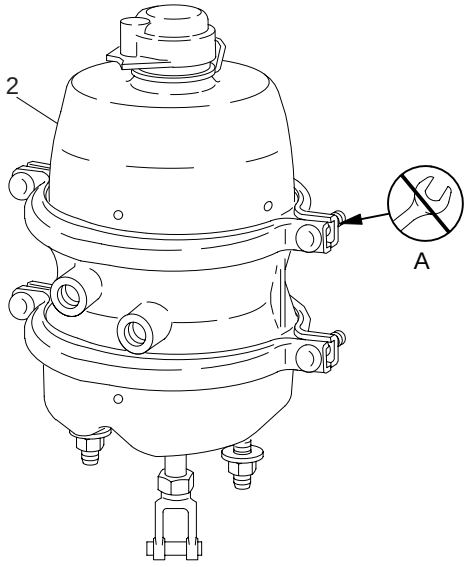
IMPORTANT: The parking/emergency brake section can be replaced as a unit. For instructions, refer to **Subject 110**.

Combination Service and Parking Brake Chamber Removal and Installation

DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.





08/30/94 f421302

A. Do not remove this clamp ring.
1. Model L-T Brake Chamber
2. Model L Brake Chamber

Fig. 1, L Series Brake Chambers

Removal (See Fig. 2 or Fig. 3)

WARNING

WARNING: Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section (see Subject 100). When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.

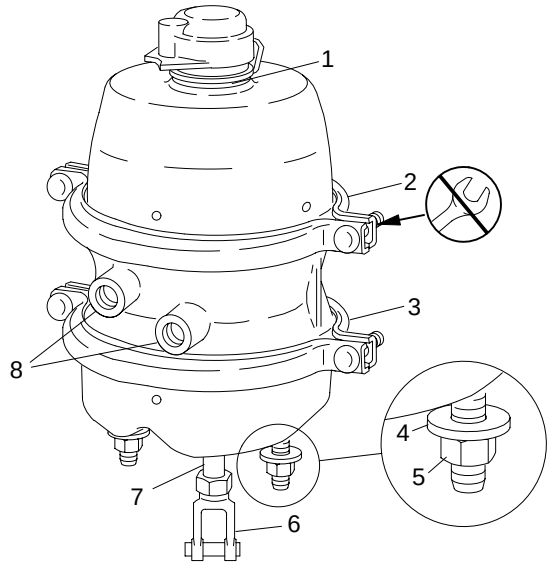
1. Manually release the parking brake (cage the power spring). For instructions, refer to **Subject 100**.
2. Mark the air lines for later reference. Then carefully disconnect them from the brake chamber.
3. Remove the brake chamber from the vehicle.

   3.1 Remove the cotter pin(s) from the clevis pin(s), then remove the clevis pin(s) from the clevis. Disconnect the clevis from the slack adjuster.

   NOTE: Gunite and Rockwell automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

   3.2 Make sure the parking brake has been released manually (the power spring has been caged). For instructions, refer to **Subject 100**. Also, make sure that the service brake piston is fully retracted (in the brakes "OFF" position). Then, record both of the following dimensions in either mm or inches, measuring outward from

Combination Service and Parking Brake Chamber Removal and Installation

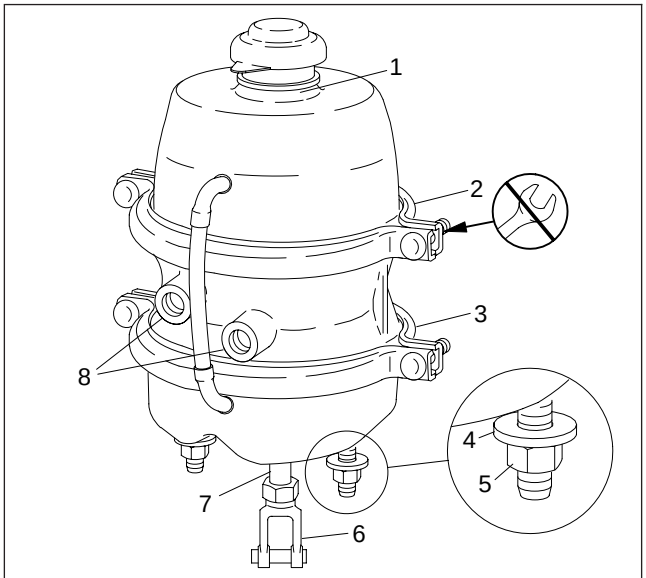


08/31/94 f421031a

Do not remove the parking brake clamp ring.

1. Breather Cap
2. Parking Brake Clamp Ring
3. Service Brake Clamp Ring
4. Hardened Flatwasher
5. Prevailing Torque Locknut
6. Clevis Assembly
7. Piston Rod
8. Air Inlet Ports

Fig. 2, Model L Brake Chamber



08/31/94 f421303

Do not remove the parking brake clamp ring.

1. End Cap
2. Parking Brake Clamp Ring
3. Service Brake Clamp Ring
4. Hardened Flatwasher
5. Prevailing Torque Locknut
6. Clevis Assembly
7. Piston Rod
8. Air Inlet Ports
9. External Breather Tube

Fig. 3, Model L-T Brake Chamber

the base of the service brake chamber (**see Fig. 4**):

X dimension: to end of threaded piston rod

Y dimension: to centerline of (large) clevis pin

IMPORTANT: If new chambers are to be attached to manual slack adjusters, the Y dimension is the most critical measurement. When installing the new assembly, cut its service piston rod (**see Fig. 5**) to exactly duplicate this "rod-plus-clevis" length *after* the clevis assembly is installed on the piston rod.

If new chambers are to be attached to automatic slack adjusters, the X dimension is the most critical measurement. When installing the new assembly, cut its service piston rod (**see Fig. 5**) to exactly duplicate the "rod only" length *before* the clevis assembly is installed on the piston rod.

3.3 From each mounting stud, remove any installed nuts and washers. Then, cautiously remove the brake chamber from the mounting bracket.

Installation (See Fig. 2 or Fig. 3)

1. If installing a new brake chamber unit, do the following steps:

   1.1 First, make sure the power spring is caged (release bolt fully extended outward). If not, **go to Subject 100** and do the applicable steps.

   1.2 Make sure that the piston rod is the same length as the rod on the old unit (measure the rods when *both* chambers are caged).

Combination Service and Parking Brake Chamber Removal and Installation

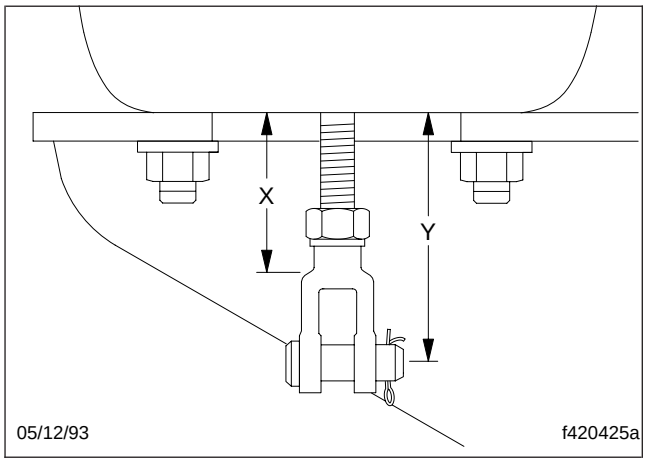


Fig. 4

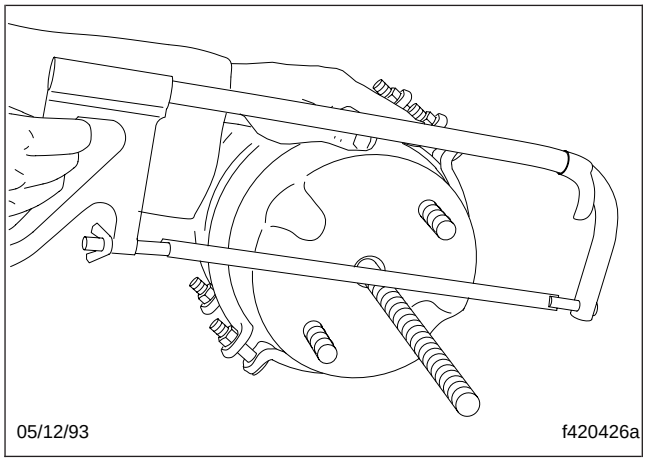


Fig. 5

1.3 Be sure the new chamber is the same size and make as the brake chamber installed on the other side of the axle.

1.4 Remove the prevailing torque locknut and hardened flatwasher from each of the mounting studs on the chamber.

2. Clean the face of the mounting bracket, and position the chamber on the bracket. Pay close attention to positioning the chamber air inlet ports for correct alignment to the vehicle air lines.

⚠ WARNING

WARNING: Tighten the mounting nuts with a hand wrench, not an impact wrench. An impact wrench could damage the mounting fasteners, reducing the force of the brakes. This could result in personal injury or property damage.

3. Install one hardened flatwasher and prevailing torque locknut on each mounting stud. Using a hand wrench (*don't use an impact wrench*), tighten the nuts 136 to 156 N·m (100 to 115 lbf·ft). Make sure that the hardened flatwasher is installed between the locknut and the mounting bracket.

   On chambers equipped with an external breather tube, make sure that the tube is installed in the side of the chamber that faces away from the road surface. An improperly installed breather tube voids the MGM warranty.

4. Check mating and alignment with the vehicle air lines.

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

4.1 Using a hand wrench (*don't use an impact wrench*), loosen the clamp nuts on the *service* clamp ring (*do not disassemble the parking brake section*).

4.2 Reposition the air inlet ports, as needed, to mate with vehicle air supply lines.

Alternately tighten each clamp nut in increments of 680 to 1360 N·cm (60 to 120 lbf·in) while constantly rechecking the alignment of mating parts.

If realignment is needed, loosen the nuts again, and repeat this substep.

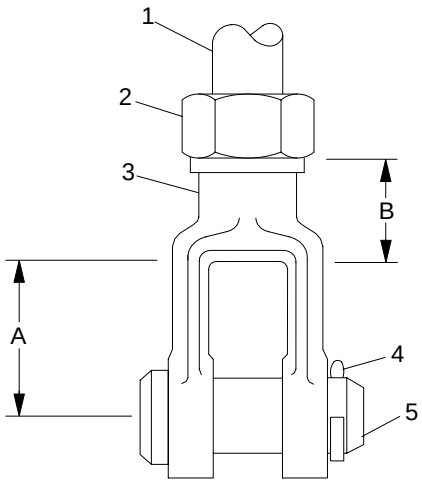
4.3 Firmly tap around the circumference of the service clamp ring with a rubber mallet to ensure full seating of the clamp. Tighten the nuts to a final torque of 34 to 41 N·m (25 to 30 lbf·ft).

5. With manual slack adjusters, connect the slack adjuster to the clevis, then install the clevis pin. Insert the cotter pin in the clevis pin, and lock it in place. Check the piston-rod engagement with the clevis. At least seven threads of engagement

Combination Service and Parking Brake Chamber Removal and Installation

are required; there should be 25-mm (1-inch) clearance from the centerline of the clevis pin hole to the end of the piston rod. **See Fig. 6.** Adjust as needed.

With automatic slack adjusters, refer to the applicable slack adjuster section in **Group 42** in this manual for installation instructions.



A. Minimum clearance of 25 mm (1 inch) between centerline of clevis pin hole and piston rod end.
B. Minimum of 7 threads engagement.

1. Piston Rod
2. Piston Rod Nut
3. Clevis
4. Cotter Pin
5. Clevis Pin

Fig. 6, Piston Rod Engagement With the Clevis

6. Inspect the piston rod to be sure it is working free, not binding, and is square with the chamber bottom within ±3° from zero to full stroke. If there is misalignment, make corrections by loosening the locknuts and repositioning the chamber on the mounting bracket, or by shimming the slack adjuster to the right or left on the camshaft.
7. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench (*don't use an impact wrench*), tighten the fittings 34 N·m (25 lbf·ft).
8. Using the vehicle system air, charge the parking brake with full line pressure, at least 690 kPa (100 psi). Using only soapy water (*never any type of oil,* which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If bubbles or leaks appear, tighten the fittings slightly, but not over 34 N·m (25 lbf·ft).

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

IMPORTANT: If the service brake clamp ring was loosened to reposition the air inlet ports, apply air to the parking brake, and then apply and hold the foot brake treadle valve down to charge the service brake chamber. Now test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, firmly tap the circumference of the clamp ring with a rubber mallet, and retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). MGM recommends 34 to 41 N·m (25 to 30 lbf·ft) torque on the clamp hexnuts.

9. With air pressure now exhausted from the service brake chamber, but held on the parking brake, reset the parking brakes by uncaging the power spring. For instructions, refer to **Subject 100**.
10. Snap the end cap into place. On chambers equipped with a breather cap, snap the breather cap into place, taking care to point the drain tab downwards. Replace the breather cap if the foam filter is contaminated with dirt or debris.
11. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable slack adjuster section in this manual.

IMPORTANT: After replacing any brake chamber, check the piston rod stroke and actuating alignment to ensure correct installation and foundation brake adjustment. No foundation brake adjustments, parking brake or service brake, can be made at the chamber and all "stroke" adjustments must be made at the slack

adjuster. For instructions, refer to the applicable slack adjuster section in **Group 42** in this manual.

Specifications

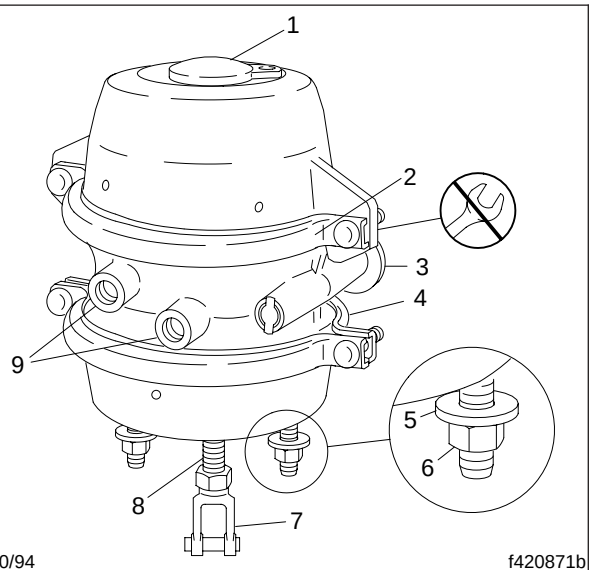
Description	Torque N·m (lbf·ft)
Parking Brake Release Bolt Nut	68 (50)
Service Brake Clamp Ring Nut	34-41 (25-30)
Brake Chamber Mounting Stud Locknut	136-156 (100-115)
Air Hose Fitting-to-Chamber	34 (25)

Table 1, Torque Values

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

NOTE: On some Anchorlok models, the parking/emergency brake section is factory sealed (no clamp ring) and is a *non-serviceable* unit. On other models, the parking/emergency brake section is attached with a clamp ring. *Do not ever perform any service on this clamp ring.*



08/30/94 f420871b

NOTE: On some models, the parking brake clamp ring is permanently sealed.

1. Dust Plug
2. Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Air Inlet Ports

Fig. 1

General Information

Anchorlok brake chambers consist of a service brake section and a parking/emergency spring brake section. **See Fig. 1**. The service brake section is the smaller section near the clevis assembly.

In the service brake section, the service brake chamber contains a service return spring, piston rod assembly, and service brake diaphragm.

In the parking/emergency brake section, the adaptor and the chamber contain a return spring, a push rod assembly, a parking (spring) brake diaphragm, a pressure plate, a power spring, and a detachable release bolt.

All Anchorlok brake chambers are mounted to the frame using prevailing torque locknuts and hardened flatwashers.

Periodic maintenance of the brake chambers is required. Also, whenever the service brake chamber is disassembled (*do not attempt to disassemble the parking brake chamber*), the parts should be inspected for damage. For maintenance schedules and procedures, and for inspection of brake chamber parts, refer to the vehicle maintenance manual.

Principles of Operation

SERVICE BRAKES

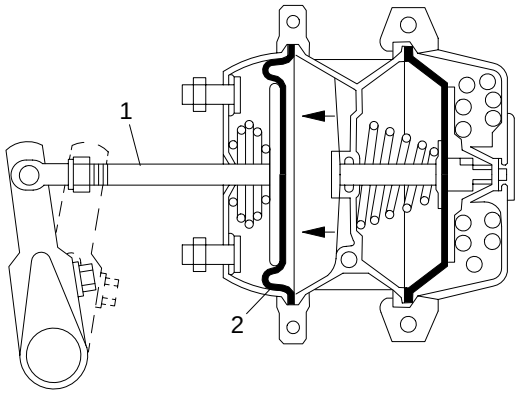
As the brake pedal is depressed, compressed air enters the service brake chamber through a port. Air pressure acts upon a diaphragm, which forces the piston rod toward the non-pressure chamber, applying a straight-line force to the slack adjuster, which converts it to a rotational force. This in turn rotates the camshaft and applies the brakes. **See Fig. 2.**

Then, when the brake pedal is released (**Fig. 3**), air is exhausted from the service brake chamber, and the return spring allows the diaphragm, piston rod assembly, and slack adjuster to return to their normal positions, releasing the brakes.

PARKING/EMERGENCY BRAKES

During parking brake release, compressed air enters the parking/emergency brake chamber below the diaphragm, forcing the diaphragm against the pressure plate to compress the power spring and release the parking/emergency brake. **See Fig. 4**. During parking brake application, a control valve in the cab exhausts air from the parking/emergency brake chamber. This

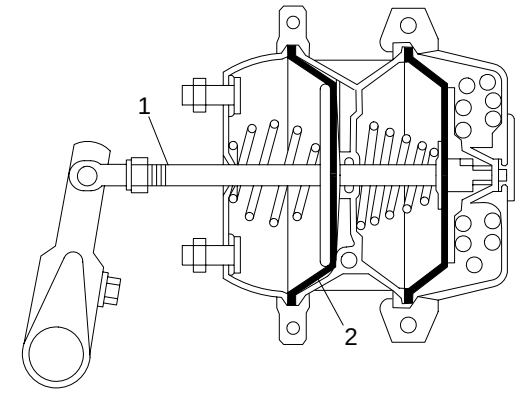
General Information and Principles of Operation



05/20/93 f420889

1. Piston Rod Assembly
2. Service Brake Diaphragm

Fig. 2, Service Brake Applied



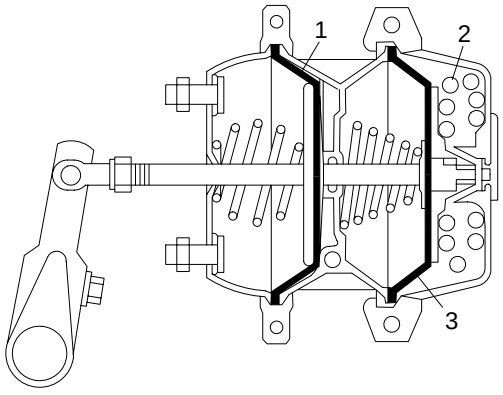
05/20/93 f420885

1. Piston Rod Assembly
2. Service Brake Diaphragm

Fig. 3, Service Brakes Applied

allows the power spring to extend and apply the brakes. **See Fig. 5**.

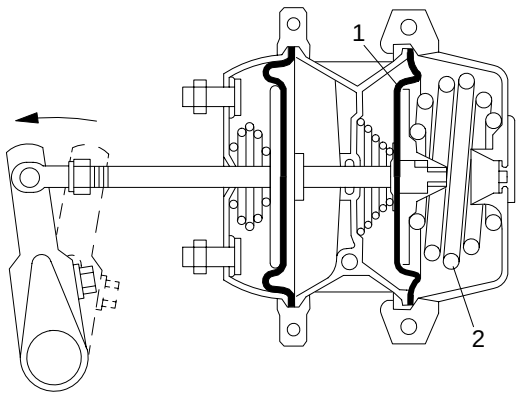
Emergency brake application begins when air pressure in the service brake reservoir drops below about 550 to 585 kPa (80 to 85 psi). Maximum spring brake force is applied when air is entirely exhausted from the parking/emergency brake chamber.



07/02/93 f420888

1. Service Brake Diaphragm
2. Power Spring
3. Parking/Emergency Brake Diaphragm

Fig. 4, Parking/Emergency Brakes Released



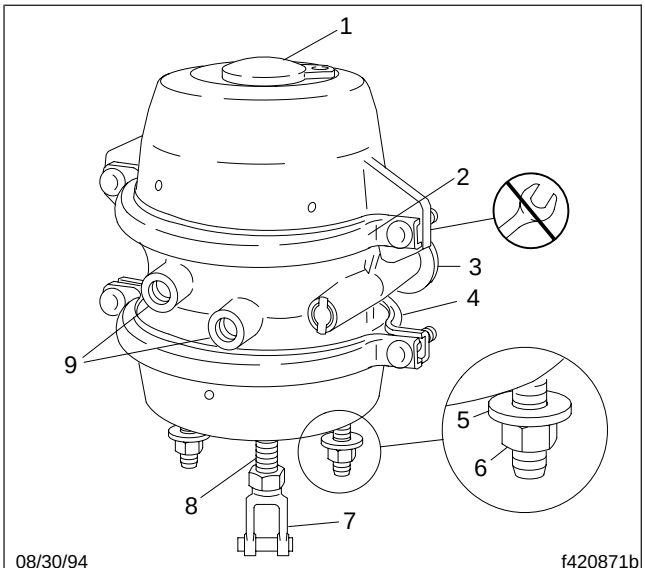
09/11/98 f420924

1. Parking/Emergency Brake Diaphragm
2. Power Spring

Fig. 5, Parking/Emergency Brakes Applied

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.



NOTE: On some models, the parking brake clamp ring is permanently sealed.

1. Dust Plug
2. Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Air Inlet Ports

Fig. 1

Manual Compression (Parking Brake Release)

1. Chock the tires.
2. Remove the dust plug from the center-hole in the head of the chamber. **See Fig. 2.**

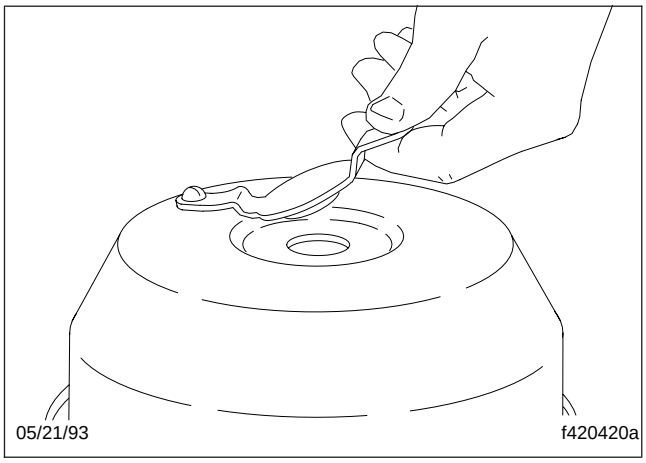


Fig. 2

⚠ DANGER

Do not attempt to cage the power spring if the safety hooks have been removed, or if the parking brake chamber is damaged severely enough to lose its structural integrity. If the power spring were to break loose, it could result in death, severe personal injury, or property damage.

A DAMAGED PARKING BRAKE CHAMBER IS EXTREMELY DANGEROUS! Only qualified service personnel should attempt to remove and disarm a damaged chamber. Using a torch, burn off the piston rod in the space between the clevis and the base of the service chamber.

Remove the chamber carefully from its bracket, and disarm it inside a suitable container. For disarming procedures, consult the Anchorlok installation instructions.

3. Manually release the parking brake (cage the power spring).

⚠ CAUTION

CAUTION: Don't use an impact wrench on this nut. Too much torque could damage the pressure plate and prevent manual release of the parking brake.

3.1 Using a hand wrench, (*don't use an impact wrench*), unscrew the release nut, and remove the nut, flatwasher, and release bolt from the storage pocket on the side of the chamber. **See Fig. 3.**

Power Spring Manual Compression and Reset

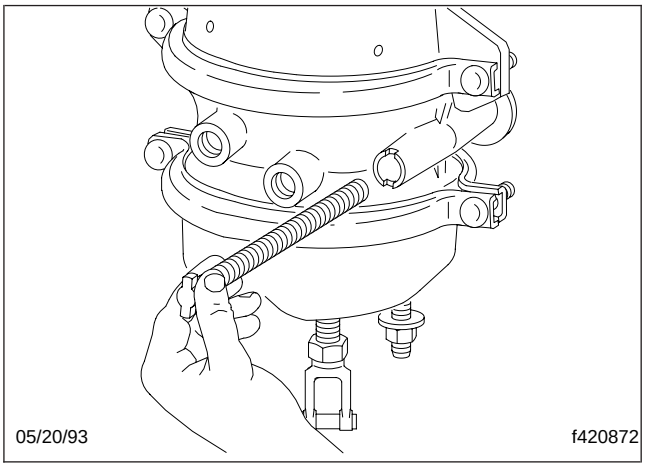


Fig. 3

IMPORTANT: If these parts are not stored on the chamber, they must be otherwise obtained or purchased; the parking brake cannot be manually released without them.

3.2 Insert the release bolt into the center-hole in the chamber head (**see Fig. 4**). Continue to insert the bolt until it bottoms out into the hole in the pressure plate inside the chamber.

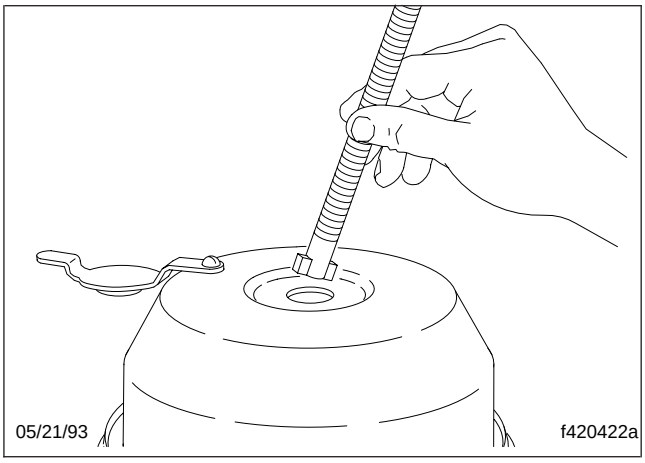


Fig. 4

IMPORTANT: If you are not absolutely sure that the formed end of the bolt has engaged the pressure plate correctly, repeat this step. Repeat it until you are absolutely sure.

3.3 Turn the release bolt one-quarter turn clockwise. Pull to seat the formed end of the release bolt in the recess of the pressure plate.

3.4 Holding the release bolt locked into the pressure plate, install the flatwasher and release nut on the end of the bolt, and turn down the nut against the flatwasher until it is finger-tight. **See Fig. 5**.

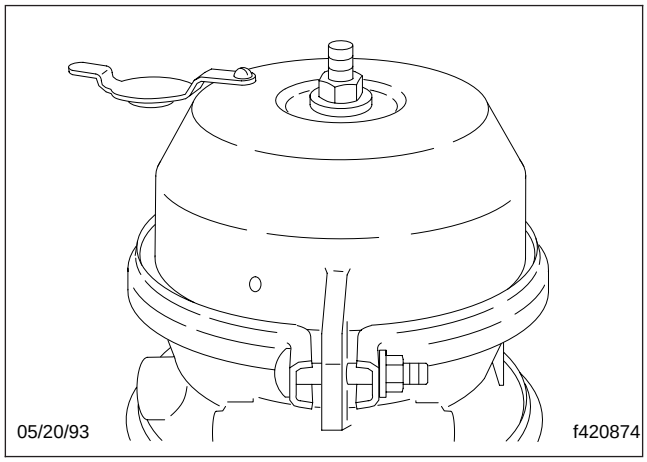


Fig. 5

⚠ DANGER

Exhaust all air pressure before tightening the release nut more than finger-tight. Tightening this nut under pressure can damage the pressure plate and result in sudden release of the power spring, causing death or severe personal injury.

⚠ CAUTION

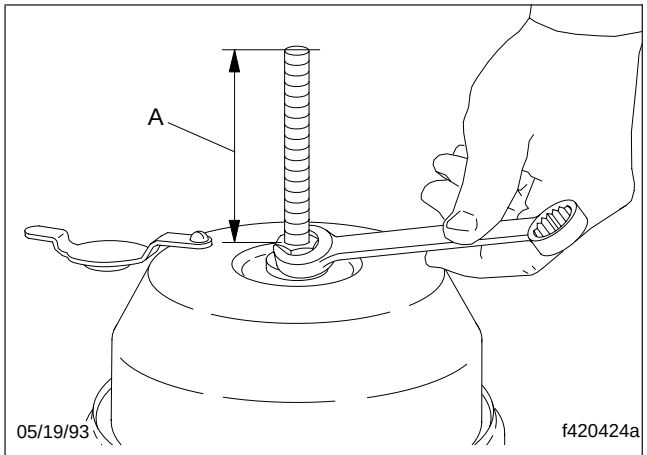
CAUTION: If equipped with S-cam or disc brakes, don't exceed 47 N·m (35 lbf·ft) torque on the release nut; if equipped with wedge brakes, don't exceed 27 N·m (20 lbf·ft) torque on the release nut.

3.5 Using a hand wrench (*don't use an impact wrench*), turn the release nut clockwise until the power spring is caged (**see Fig. 6**):

On parking/emergency brake chambers that are permanently sealed (no clamp ring), the bolt should extend above the nut

at least 74 mm (2.9 inches) on 24-inch chambers, or 73 mm (2.875 inches) on 30-inch chambers.

On parking/emergency brake chambers that are sealed with a clamp ring, the bolt should extend above the nut at least 71 mm (2.8 inches) on 24-inch chambers, or 69 mm (2.7 inches) on 30-inch chambers.



A. Measure this distance.

Fig. 6

IMPORTANT: Don't exceed these bolt lengths. If the bolt lengths can't be obtained without exceeding the recommended maximum torque values, replace the tandem brake chamber.

Manual Reset (Parking Brake Reset)

1. Uncage the power spring.

CAUTION

CAUTION: Don't use an impact wrench on this nut. Too much torque could damage the pressure plate and prevent manual release of the parking brake.

1.1 With air applied to the parking brake section (the parking brake control valve is in the "release" position), use a hand wrench and turn the release nut *counterclockwise* until the power spring extends back into the parking/emergency brake chamber.

NOTE: When the power spring is fully extended, force will no longer be felt on the release nut.

1.2 Remove the nut and flatwasher.

1.3 Turn the release bolt one-quarter turn counterclockwise and unlock the bolt from the receptacle in the pressure plate. Remove the release bolt from the center-hole of the chamber.

2. Install the release bolt, flatwasher, and release nut in the storage pocket. Tighten the nut 680 to 1080 N·cm (60 to 96 lbf·in). **See Fig. 7.**

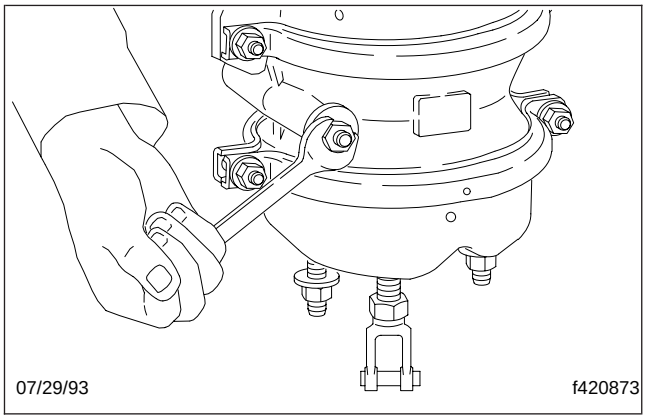


Fig. 7

3. Snap the dust plug in place over the center-hole in the chamber head. **See Fig. 8.**

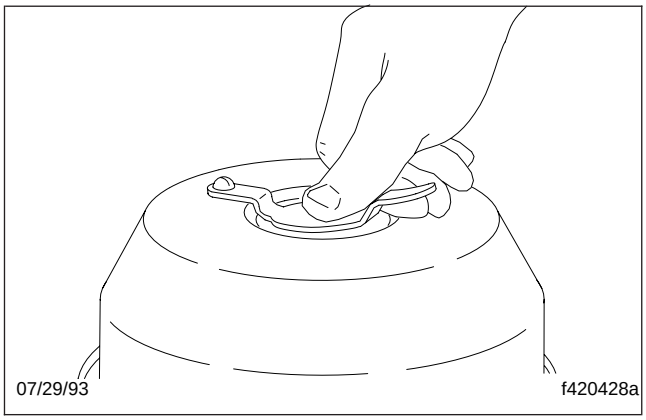


Fig. 8

Power Spring Manual Compression and Reset

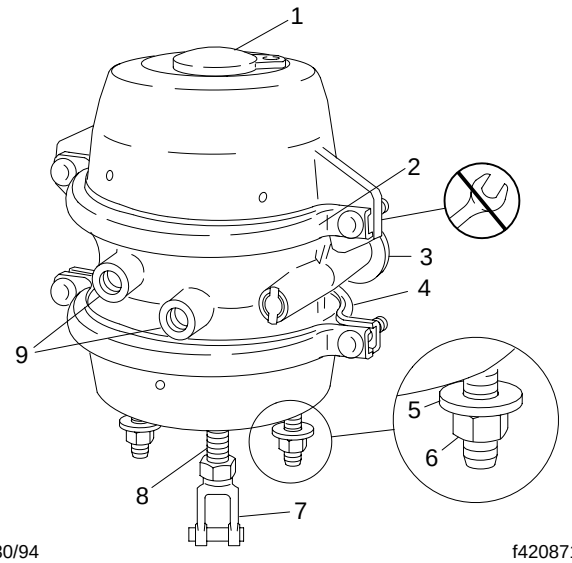
⚠ CAUTION

CAUTION: If a dust plug is missing or incorrectly installed, road dirt and debris can adversely affect the operation of the brake chambers. Once inside the chambers, dirt and debris cause the internal parts to deteriorate and shorten their lives.

4. Check the plastic dust plug periodically, and replace it with a new one at once if damaged or missing. For intervals, refer to the vehicle maintenance manual.
5. Remove the chocks from the tires.

DANGER

Don't loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.



NOTE: On some models, the parking brake clamp ring is permanently sealed.

1. Dust Plug
2. Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Air Inlet Ports

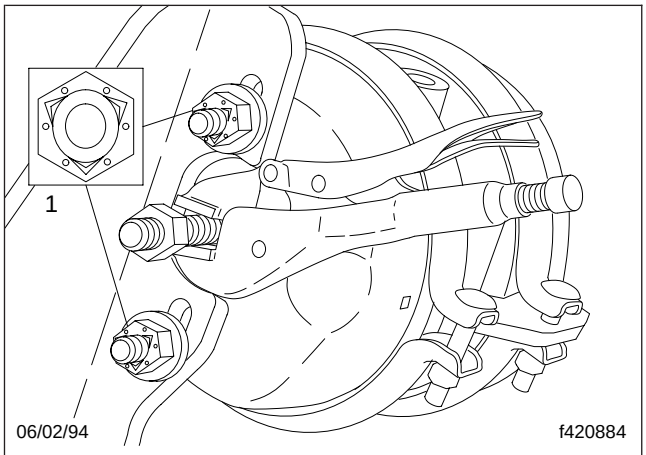
Fig. 1

Removal

1. To make removal and installation of the parking brake section easier (without removing the service brake chamber), lock off the service chamber piston rod.

   1.1 Apply the service brakes by actuating the driver's foot brake treadle valve.

   1.2 With the brakes applied, clamp a pair of locking-jaw pliers on the piston rod to lock the rod in place when the air pressure is released (see Fig. 2).



1. Prevailing Torque Locknut

Fig. 2

WARNING

WARNING: Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section (see Subject 100). When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.

2. Manually release the parking brake (cage the power spring). For instructions, refer to **Subject 100**.

3. Mark the air lines for later reference. Then carefully disconnect them from the brake chamber.

DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

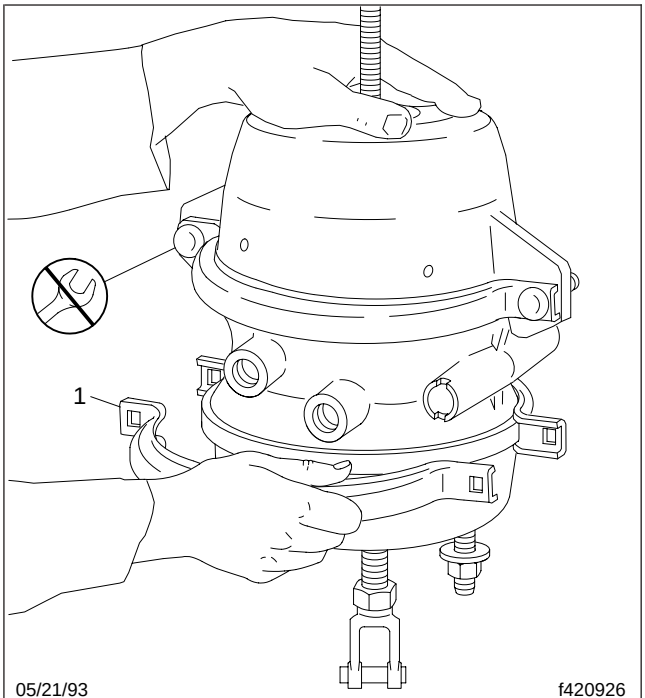
4. Remove the parking brake and adaptor from the service brake section.

   4.1 Using a hand wrench (*don't use an impact wrench*), remove the clamp nuts on

Service Brake Diaphragm Replacement

the *service* brake clamp ring (*do not disassemble the parking brake section*).

4.2 While holding the parking brake section securely in place, remove the service clamp ring. Then remove the parking brake section from the service brake non-pressure chamber (**see Fig. 3**).



1. Service Brake Clamp Ring

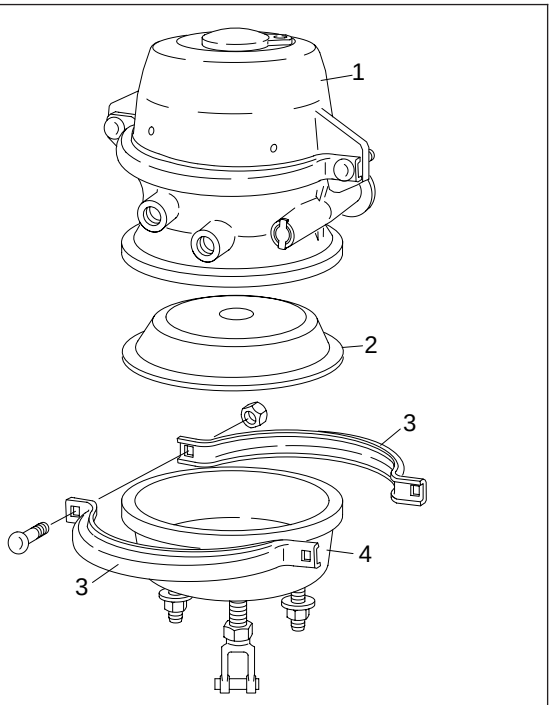
Fig. 3

5. Remove the service brake diaphragm from the bottom of the parking brake section.

Installation

IMPORTANT: At this time, take the opportunity to inspect the parking/emergency brake section, and replace it if it shows signs of damage, corrosion, or rust. Follow the detailed inspection instructions in the vehicle maintenance manual.

1. Inspect all parts in the service (non-pressure) chamber. Replace any damaged or worn parts.
2. Place the new service brake diaphragm in the bottom recess of the adaptor (**see Fig. 4**).



1. Parking/Emergency Brake and Adaptor
2. Service Brake Diaphragm
3. Service Brake Clamp Ring
4. Service Brake (Non-Pressure) Chamber

Fig. 4

3. Install the (new, if needed) parking/emergency brake section.

   3.1 If installing a new parking brake section, be sure it is the same size and make as the old one.

   3.2 Check that the release bolt is fully extended outward. For instructions, refer to **Subject 100**.

   3.3 Install the parking brake section on the service chamber so that all mating parts are aligned straight and the air lines are positioned to mate with the vehicle air supply lines.

4. Install the service brake clamp ring.

   4.1 With the service brake clamp ring in place, install the clamp bolts and nuts.

   4.2 Using a hand wrench (*don't use an impact wrench*), alternately tighten each

clamp nut in increments of 680 to 1360 N·cm (60 to 120 lbf·in) while constantly rechecking the alignment of mating parts.

If realignment is needed, loosen the nuts again, and repeat this substep.

4.3 Lightly tap around the circumference of the service clamp ring with a rubber mallet to ensure full seating of the clamp. Tighten the nuts to a final torque of 24 to 34 N·m (18 to 25 lbf·ft).

5. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench (*don't use an impact wrench*), tighten the fittings 34 N·m (25 lbf·ft).

6. Using the vehicle system air, charge the parking brake with full line pressure—at least 690 kPa (100 psi). Using only soapy water (*never any type of oil,* which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If bubbles or leaks appear, tighten the fittings slightly, but not over 34 N·m (25 lbf·ft).

7. With the parking brake still charged with full line pressure, apply and hold the foot brake treadle valve down to charge the service brake chamber. Remove the locking-jaw pliers from the service piston rod so that the piston returns to a normal position in the chamber.

⚠ DANGER

Don't loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

8. Test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, release all air pressure from the chamber, then retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). Anchorlok recommends 24 to 34 N·m (18 to 25 lbf·ft) torque on the clamp hexnuts.

9. With air pressure now exhausted from the service brake chamber, but held on the parking brake, reset the parking brakes by uncaging the power spring, and snap the dust plug in place. For instructions, refer to **Subject 100**.

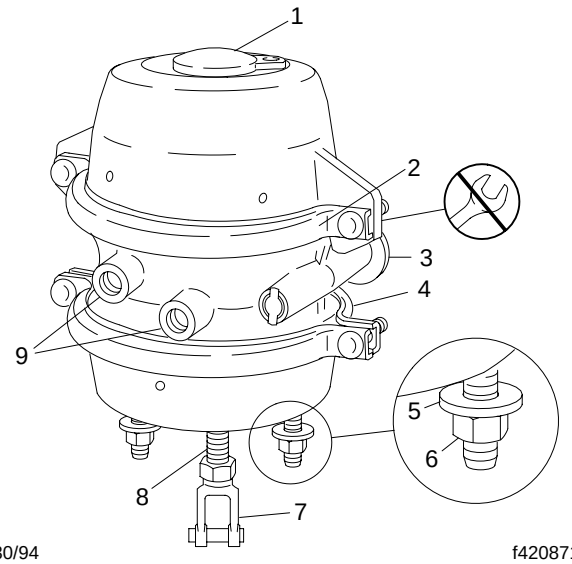
10. Adjust the brakes at the slack adjuster.

IMPORTANT: After replacing any brake chamber components, check the piston rod stroke and actuating alignment to ensure correct installation and foundation brake adjustment. No foundation brake adjustments, parking brake or service brake, can be made at the chamber and all "stroke" adjustments must be made at the slack adjuster. For instructions, refer to the applicable slack adjuster section in **Group 42** in this manual.

Replacement

DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the compression spring.



NOTE: On some models, the parking brake clamp ring is permanently sealed.

1. Dust Plug
2. Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Air Inlet Ports

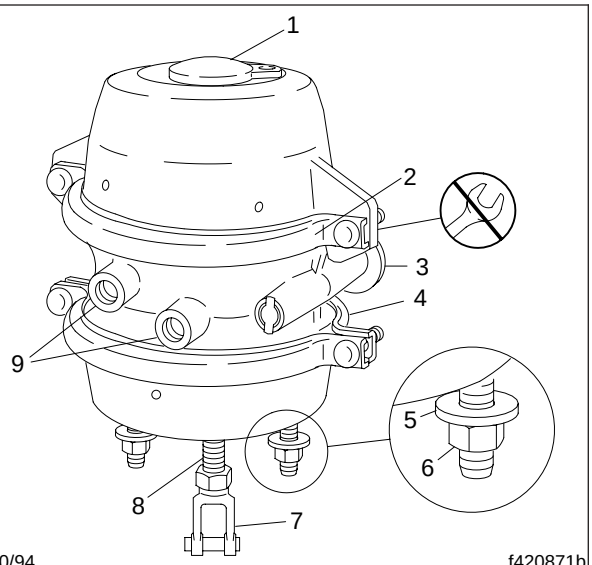
Fig. 1

IMPORTANT: The parking/emergency brake section can be replaced as a unit. For instructions, refer to **Subject 110**.

Combination Service and Parking Brake Chamber Removal and Installation

DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.



NOTE: On some models, the parking brake clamp ring is permanently sealed.

1. Dust Plug
2. Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Air Inlet Ports

Fig. 1

Removal

WARNING

WARNING: Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section (see Subject 100). When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.

1. Manually release the parking brake (cage the power spring). For instructions, refer to **Subject 100**.
2. Mark the air lines for later reference. Then carefully disconnect them from the brake chambers.
3. Remove the brake chamber from the vehicle.

   3.1 Remove the cotter pin(s) from the clevis pin(s), then remove the clevis pin(s) from the clevis. Disconnect the clevis from the slack adjuster.

   NOTE: Gunite and Rockwell automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

   3.2 From each mounting stud, remove any installed nuts and washers. Then, cautiously remove the brake chamber from the mounting bracket.

Installation

1. If installing a new brake chamber unit, do the following steps:

   1.1 First, make sure the power spring is caged (release bolt fully extended outward). If not, **go to Subject 100** and do the applicable steps.

   1.2 Make sure that the piston rod is the same length as the rod on the old unit (measure the rods when *both* chambers are caged).

   1.3 Be sure the new chamber is the same size and make as the brake chamber installed on the other side of the axle.

   1.4 Remove the prevailing torque locknut and hardened flatwasher from each of the mounting studs on the chamber.

2. Clean the face of the mounting bracket, and position the chamber on the bracket. Pay close attention to positioning the chamber air inlet ports for correct alignment to the vehicle air lines.

WARNING

WARNING: Tighten the mounting nuts with a hand wrench, not an impact wrench. An impact wrench could damage the mounting fasteners,

Combination Service and Parking Brake Chamber Removal and Installation

reducing the force of the brakes. This could result in personal injury or property damage.

3. Install one hardened flatwasher and prevailing torque locknut on each mounting stud. Using a hand wrench (*don't use an impact wrench*), tighten the nuts 149 to 203 N·m (110 to 150 lbf·ft). Make sure that the hardened flatwasher is installed between the locknut and the mounting bracket.
4. Check proper mating and alignment with the vehicle air lines.

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

4.1 Using a hand wrench (*don't use an impact wrench*), loosen the clamp nuts on the *service* clamp ring (*do not disassemble the parking brake section*).

4.2 Reposition the air inlet ports, as needed, to mate with vehicle air supply lines.

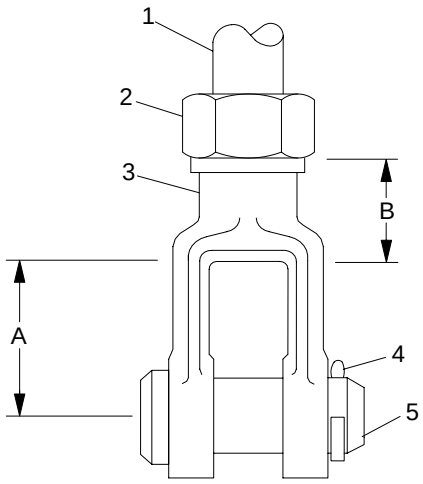
Alternately tighten each clamp nut in increments of 680 to 1360 N·cm (60 to 120 lbf·in) while constantly rechecking the alignment of mating parts.

If realignment is needed, loosen the nuts again, and repeat this substep.

4.3 Lightly tap around the circumference of the service clamp ring to ensure full seating of the clamp. Tighten the nuts to a final torque of 24 to 34 N·m (18 to 25 lbf·ft).

5. With manual slack adjusters, connect the slack adjuster to the clevis, then install the clevis pin. Insert the cotter pin in the clevis pin, and lock it in place. Check the piston-rod engagement with the clevis. At least seven threads of engagement are required; there should be 25-mm (1-inch) clearance from the centerline of the clevis pin hole to the end of the piston rod. **See Fig. 2.** Adjust as needed.

With automatic slack adjusters, refer to the applicable slack adjuster section in **Group 42** for installation instructions.



08/20/93 f420225a

A. Minimum clearance of 25 mm (1 inch) between centerline of clevis pin hole and piston rod end.
B. Minimum of 7 threads engagement.

1. Piston Rod
2. Piston Rod Nut
3. Clevis
4. Cotter Pin
5. Clevis Pin

Fig. 2, Piston Rod Engagement With the Clevis

6. Inspect the piston rod to be sure it is working free, not binding, and is square with the chamber bottom from zero to full stroke. If there is misalignment, make corrections by loosening the locknuts and repositioning the chamber on the mounting bracket, or by shimming the slack adjuster to the right or left on the camshaft. If loosened, tighten the clamp nuts 24 to 34 N·m (18 to 25 lbf·ft).
7. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench (*don't use an impact wrench*), tighten the fittings 34 N·m (25 lbf·ft).
8. Using the vehicle system air, charge the parking brake with full line pressure, at least 690 kPa (100 psi). Using only soapy water (*never any type of oil,* which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If

bubbles or leaks appear, tighten the fittings slightly, but not over 34 N·m (25 lbf·ft).

⚠ DANGER

Do not loosen or remove the parking brake clamp ring (see Fig. 1) for any purpose, at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

IMPORTANT: If the service brake clamp ring was loosened to reposition the air inlet ports, apply air to the parking brake, and then apply and hold the foot brake treadle valve down to charge the service brake chamber. Now test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, release all air pressure from the chamber, then retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). Anchorlok recommends 24 to 34 N·m (18 to 25 lbf·ft) torque on the clamp hexnuts.

9. With air pressure now exhausted from the service brake chamber, but held on the parking brake, reset the parking brakes by uncaging the power spring, and snap the dust plug in place. For instructions, refer to **Subject 100**.
10. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable slack adjuster section in this manual.

IMPORTANT: After replacing any brake chamber, check the piston rod stroke and actuating alignment to ensure correct installation and foundation brake adjustment. No foundation brake adjustments, parking brake or service brake, can be made at the chamber and all "stroke" adjustments must be made at the slack adjuster. For instructions, refer to the applicable slack adjuster section in **Group 42** in this manual.

Specifications

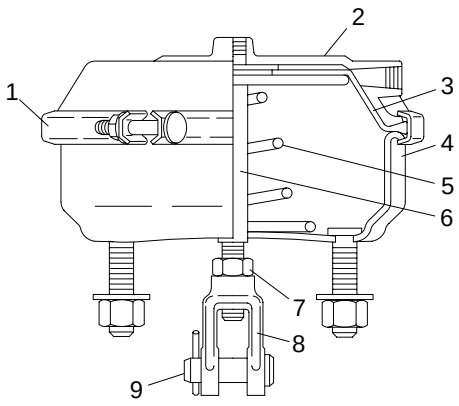
Description	Torque	
	N·m (lbf·ft)	N·cm (lbf·in)
Parking Brake Release Bolt Nut (in storage pocket)	—	680 to 1080 (60 to 96)
(caged—on S-cam or disc brakes)	47 (35)	—
(caged—on wedge brakes)	27 (20)	—
Service Brake Clamp Ring Nut	24 to 34 (18 to 25)	—
Brake Chamber Mounting Stud Locknut	149 to 203 (110 to 150)	—
Air Hose Fitting-to-Chamber	34 (25)	—

Table 1, Torque Values

General Description

Brake chambers convert the energy of compressed air into the mechanical force and motion needed to apply the brakes. Two chambers operate the brakes, one on each side of the axle.

Each brake chamber consists of two dished metal sections: the pressure cap and the chamber, which are separated by a nylon-reinforced diaphragm. A metal two-segment clamp ring holds the assemblies together. **See Fig. 1.**



02/28/95 f421326

1. Clamp Ring
2. Pressure Cap
3. Diaphragm
4. Chamber Assembly
5. Piston Rod Spring
6. Piston Rod Assembly
7. Clevis Jam Nut
8. Clevis
9. Clevis Pin

Fig. 1, Sectional View

In front of the diaphragm are the piston rod assembly, and a piston rod spring. The threaded piston rod assembly extends through the bottom of the chamber and connects to the clevis. **See Fig. 1.**

Different sized brake chambers are identified by numbers, which specify the effective area of the diaphragm. For example, a type 16 brake chamber has 16 square inches of effective area.

Principles of Operation

The greater the air pressure admitted to the brake chamber, the greater the force applied by the piston rod. Piston rod force is determined by multiplying the delivered air pressure by the effective diaphragm area. For example, if 415 kPa (60 psi) is admitted to a type 16 brake chamber, the force on the end of the piston rod is about 4270 N (960 lb).

When the brake pedal is depressed, air pressure from the brake valve passes through the port in the brake chamber pressure cap to move the diaphragm and piston rod assembly forward. This compresses the spring, and applies a straight-line force to the slack adjuster, which converts it to a rotational force. This in turn rotates the camshaft and applies the brakes.

When the brake pedal is released, compressed air behind the diaphragm exhausts through the quick release valve. The spring then allows the piston rod assembly and diaphragm to return to their previous positions.

NOTE: For both of these tests, the air system must be pressurized to at least 550 kPa (80 psi).

Operating Test

1. Chock the tires.
2. Apply the brakes. Check that each piston rod moves out promptly, without binding.
3. Release the brakes. Check that each piston rod returns to the released position promptly, without binding.
4. Check the brake chamber stroke. It should be as short as possible without causing the brakes to drag. If needed, adjust the travel of the piston rod at the slack adjuster. For instructions, refer to the applicable slack adjuster section in this group.

Leakage Test

1. Apply the brakes and hold them on full line pressure of at least 550 kPa (80 psi).
2. Using a soap solution, coat the clamp ring. Leakage is excessive if it produces a 25-mm (1-inch) bubble within five seconds.

⚠ CAUTION

CAUTION: Don't overtighten the clamp ring. This can distort the flange sealing surface, or the clamp ring itself.

3. If the leakage is excessive, tighten the clamp ring flange nuts evenly until the leakage is reduced. Do not tighten more than 34 to 41 N·m (25 to 30 lbf·ft).
4. Using a soap solution, coat the area around the piston-rod hole. No leakage is permitted. If there is leakage, replace the diaphragm. For instructions, refer to **Subject 110.**

Service Brake Chamber Diaphragm Replacement

NOTE: This procedure is for service of a leaking brake chamber *diaphragm only*. If there are any other problems, refer to the applicable subjects elsewhere in this section.

Replacement

1. Chock the tires.

⚠ WARNING

WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at anyone. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.

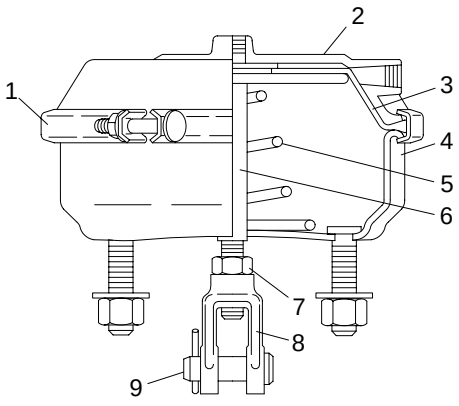
Follow the manufacturer's recommendations when working on any air device so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or compressed-air propulsion.

2. Drain the air reservoirs and lines.
3. Back off the slack adjuster; for instructions, refer to the applicable slack adjuster section in this group. Pull out the piston rod. **See Fig. 1.** Clamp the rod at the chamber body to protect it from damage.
4. Before disassembly, mark a reference line along the chamber to allow the parts to be reassembled later in their old positions. **See Fig. 2.**
5. Replace the diaphragm.
   - 5.1 Remove one clamp ring bolt and flange nut completely and loosen the other bolt and flange nut enough to remove the clamp ring.
   - 5.2 Remove the pressure cap, and replace the diaphragm.

⚠ CAUTION

CAUTION: Don't overtighten the clamp ring. This can distort the flange sealing surface, or the clamp ring itself.

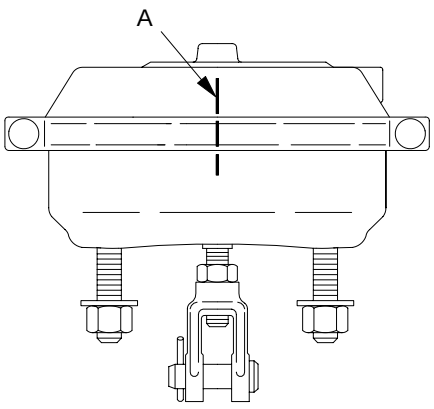
   - 5.3 Position the pressure cap and clamp ring (aligning the reference marks), and install the clamp ring bolt and flange nut. Tighten the flange nuts evenly 34 to 41 N·m (25 to 30 lbf·ft) to eliminate leakage.
6. Release the clamp on the piston rod.
7. Do both of the tests **in Subject 100.**
8. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable brake section in this group.
9. Remove the chocks from the tires.



02/28/95 f421326

1. Clamp Ring
2. Pressure Cap
3. Diaphragm
4. Chamber Assembly
5. Piston Rod Spring
6. Piston Rod Assembly
7. Clevis Jam Nut
8. Clevis
9. Clevis Pin

Fig. 1, Sectional View

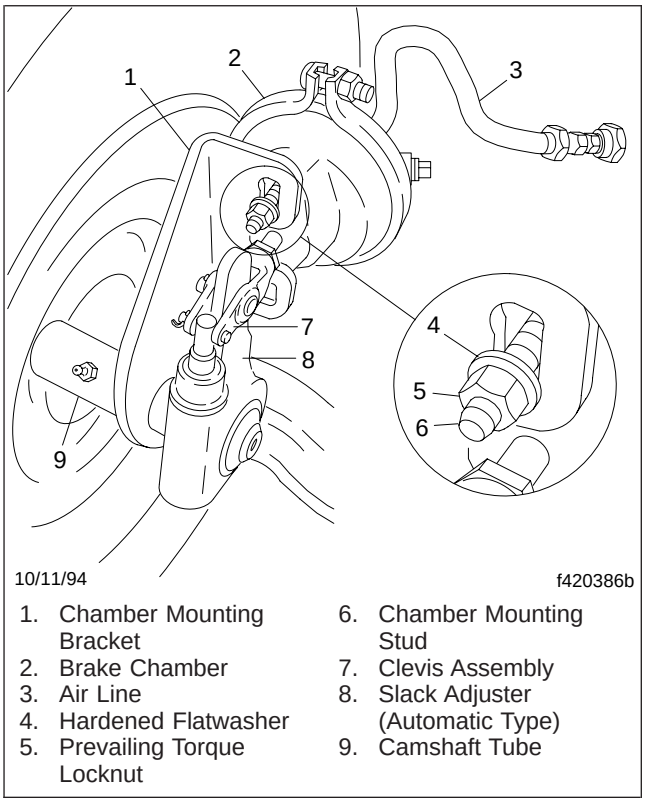


02/28/95 f421327

A. Reference Line

Fig. 2

Removal (See Fig. 1)



1. Chamber Mounting Bracket
2. Brake Chamber
3. Air Line
4. Hardened Flatwasher
5. Prevailing Torque Locknut
6. Chamber Mounting Stud
7. Clevis Assembly
8. Slack Adjuster (Automatic Type)
9. Camshaft Tube

Fig. 1

1. Chock the tires.

⚠ WARNING

WARNING: Wear safety goggles when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Don't direct the airstreams at other people. Don't disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in severe personal injury.

Follow the manufacturer's recommendations when working on any air device so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or compressed-air propulsion.

2. Drain the air reservoirs and lines.
3. Carefully disconnect the air line from the brake chamber.
4. Remove the brake chamber.

   4.1 Remove the cotter pin(s) from the clevis pin(s).

   NOTE: Gunite and Rockwell automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

   4.2 Remove the clevis pin(s) from the slack adjuster.

   4.3 From each mounting stud, remove any installed nuts and washers. Remove the brake chamber from the vehicle.

Installation (See Fig. 1)

1. Before installing a new chamber, be sure the new chamber is the same size and make as the brake chamber on the other side of the axle.
2. Install the brake chamber.

   2.1 Attach the brake chamber to the mounting bracket using a hardened flatwasher and prevailing torque locknut. Install the flatwasher between the locknut and the mounting bracket.

   2.2 Tighten the locknuts. **See Table 1** for the correct torque value.

Description	Chamber Size (in ²)	Torque N·m (lbf·ft)
Brake Chamber Mounting-Stud Locknuts	16	47–54 (35–40)
	20	136–156 (100–115)
	24	136–156 (100–115)

Table 1, Mounting Stud Locknut Torque Values

   2.3 Connect the clevis pins to the slack adjuster.

   2.4 Install and lock the cotter pin(s) to secure the clevis pin(s).

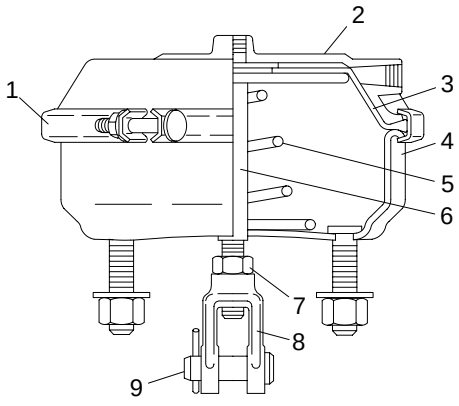
   NOTE: Gunite and Rockwell automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

Service Brake Chamber Removal and Installation

3. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable brake section in this group.
4. Connect the air line to the brake chamber.
   - 4.1 Check that the hoses are properly supported and, if needed, clamped to provide good clearance.
   - 4.2 Before connecting the air line, make sure the fittings are clean and free of debris.
   - 4.3 Connect the air line as follows: tighten the nut finger-tight. Using a wrench, further tighten the nut until there is resistance, then tighten one-sixth turn more.
5. Do both of the tests **in Subject 100.**
6. Remove the chocks from the tires.

Service Brake Chamber Disassembly, Inspection and Cleaning, and Assembly

Disassembly (See Fig. 1)



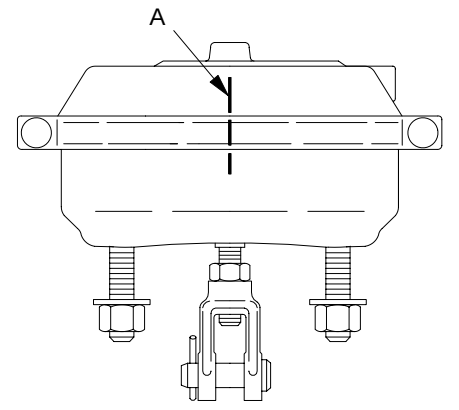
02/28/95 f421326

1. Clamp Ring
2. Pressure Cap
3. Diaphragm
4. Chamber Assembly
5. Piston Rod Spring
6. Piston Rod Assembly
7. Clevis Jam Nut
8. Clevis
9. Clevis Pin

Fig. 1, Sectional View

NOTE: If the brake chamber is to be disassembled without removing the body assembly from the vehicle, first back off the slack adjuster. For instructions, refer to the applicable slack adjuster section in this manual.

1. Before disassembly, mark a reference line along the chamber to allow the parts to be reassembled later in their old positions. **See Fig. 2.**



02/28/95 f421327

A. Reference Line

Fig. 2

2. Pull out the piston rod. Clamp the rod at the chamber body to protect it from damage.
3. Disassemble the brake chamber.
   - 3.1 Remove one clamp ring bolt and flange nut completely and loosen the other bolt and flange nut enough to remove the clamp ring.
   - 3.2 Remove the pressure cap and the diaphragm.
   - 3.3 Remove the clevis locknut and clevis from the piston rod, and release the clamp on the piston rod, being careful to contain the piston rod assembly and body until the return spring is relaxed.
   - 3.4 Remove the piston rod assembly and spring.

Inspection and Cleaning

1. Clean all metal parts with cleaning solvent.
2. Inspect all parts for wear or damage; replace as needed.
   - 2.1 Check the pressure cap and the chamber for dents. If any are too deep to be pounded out, replace as needed.
   - 2.2 Check the diaphragm for wear or deterioration and replace it if needed.
   - 2.3 Inspect all other parts not considered serviceable. Replace if needed.

Assembly (See Fig. 1)

1. Stand the piston rod assembly upright on a flat surface (if the chamber was removed from the vehicle).
2. Assemble the brake chamber.
   - 2.1 Place the return spring on the piston rod.
   - 2.2 Place the chamber on the piston rod assembly, and press the chamber down, working against the tension of the spring, until the chamber bottoms out on the flat surface. Clamp the rod at the chamber, making sure to protect the rod from damage. Insert the piston rod assembly

Service Brake Chamber Disassembly, Inspection and Cleaning, and Assembly

through the chamber and clamp the rod (if the chamber wasn't removed from the vehicle).

2.3 Place the diaphragm in the chamber.

CAUTION

CAUTION: Don't overtighten the clamp ring. This can distort the flange sealing surface, or the clamp ring itself.

2.4 Position the pressure cap and clamp ring (aligning the reference marks), and install the clamp ring bolt and flange nut. Tighten the flange nuts evenly 34 to 41 N·m (25 to 30 lbf·ft) to eliminate leakage.

3. Install the clevis locknut and clevis, and release the clamp on the piston rod.
4. If the brake chamber was removed from the vehicle, install it. For instructions, refer to **Subject 120.**
5. Do both of the tests found **in Subject 100.**

Specifications

Mounting-Stud Locknut Torque Values		
Description	**Chamber Size (in ^{2})**	**Torque lbf·ft (N·m)**
Brake Chamber Mounting-Stud Locknuts	16	35 to 40 (47 to 54)
	20	100 to 115 (136 to 156)
	24	100 to 115 (136 to 156)

Table 1, Mounting-Stud Locknut Torque Values

General Information

The automatic slack adjuster has two main functions:

- As a lever it converts the straight-line force of the brake chamber push rod to torque on the brake camshaft. Rotation of the camshaft forces the brake shoes against the drum.
- As an automatic slack adjuster, it maintains the lining-to-drum clearance needed for proper brake chamber push rod stroke.

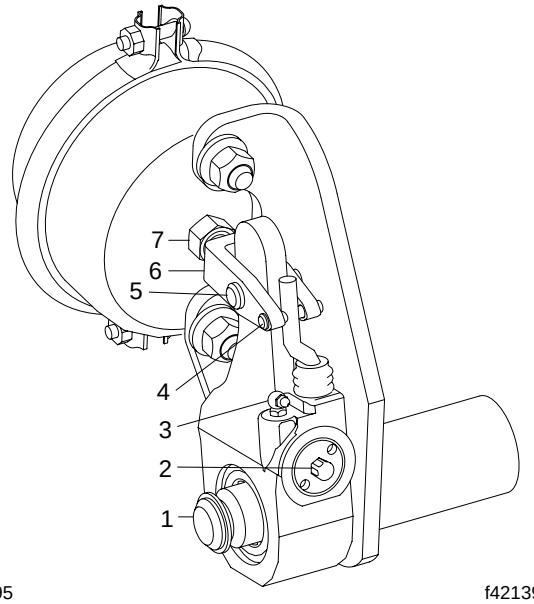
The slack adjuster is installed between the brake chamber push rod and the brake camshaft. A clevis connects the brake chamber push rod to the top of the slack adjuster. The bottom of the slack adjuster is splined to the brake camshaft. The splines hold the slack adjuster internal gear to the camshaft, so the camshaft turns when the slack adjuster moves.

When the brakes are applied, the brake chamber push rod moves outward forcing the slack adjuster and camshaft to rotate. This movement forces the brake shoes against the drum.

Whenever the brakes are released, the slack adjuster detects any increase in the lining-to-drum clearance. Excessive brake clearance is eliminated internally by the adjuster's one-way clutch and worm shaft, thus ensuring optimum leverage for the brake chamber push rod.

IMPORTANT: This automatic slack adjuster cannot be rebuilt. If it is damaged or inoperative, replace the unit. Also, when installing or replacing the automatic slack adjuster, a new clevis must be installed.

Removal (See Fig. 1)

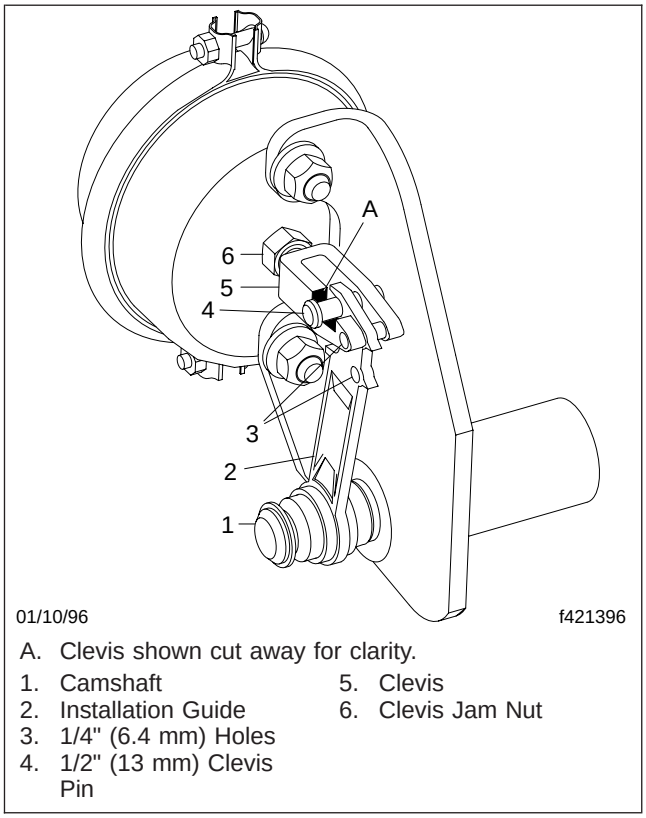


1. Camshaft
2. Manual Adjuster Shaft
3. Grease Fitting
4. 1/4" (6.4 mm) Clevis Pin
5. 1/2" (13 mm) Clevis Pin
6. Clevis
7. Clevis Jam Nut

Fig. 1, Slack Adjuster Mounting

1. Park the vehicle on a level surface, and chock the tires. If you are removing a rear slack adjuster, release the parking brake, then cage the parking brake power spring. For instructions, see the applicable brake chamber section in this group.
2. Back off the clevis jam nut.
3. Remove the cotter pins and clevis pins.
4. Rotate the manual adjuster shaft counterclockwise until the slack adjuster clears the clevis.
5. Remove the snap ring from the brake camshaft, then slide the slack adjuster off the camshaft.
6. Remove the clevis from the brake chamber push rod.

Installation (See Fig. 2)



A. Clevis shown cut away for clarity.

1. Camshaft
2. Installation Guide
3. 1/4" (6.4 mm) Holes
4. 1/2" (13 mm) Clevis Pin
5. Clevis
6. Clevis Jam Nut

Fig. 2, Slack Adjuster Installation Guide Use

1. Coat the end of the brake chamber push rod, the camshaft splines, and the splines of the slack adjuster gear with an anticorrosive grease.
2. Install the new clevis (with the 1/2-inch [13-mm] clevis pin) on the brake chamber push rod. Thread the clevis up to the jam nut. Do not tighten the jam nut.
3. Fit the installation guide over the camshaft splines so the 1/2-inch (13-mm) clevis-pin slot on the guide faces the brake chamber.
4. Swing the installation guide into the clevis until the slot (top or bottom) engages the 1/2-inch (13-mm) pin.
5. Check the alignment of the 1/4-inch (6.4-mm) holes in the guide and the clevis. Screw the cle-

Slack Adjuster Removal and Installation

vis on or off the push rod until the 1/4-inch (6.4-mm) clevis pin can be inserted through the clevis and the guide. Tighten the jam nut against the clevis 50 lbf·ft (68 N·m).

Remove the installation guide from the camshaft.

IMPORTANT: If the push rod extends through the clevis more than 1/16 inch (1.6 mm), remove the clevis and cut the rod to length. If the push rod does not engage a minimum 1/2 inch (13 mm) in the clevis body, cut a new push rod to length and install it. For instructions, see the applicable brake chamber section in this group.

6. Using the original snap ring, install the automatic slack adjuster on the brake camshaft.
7. Turn the manual adjuster shaft clockwise until the clevis pin holes align with the clevis. Install the 1/2-inch (13-mm) and 1/4-inch (6.4-mm) clevis pins and secure with new cotter pins.

NOTE: Make sure there is clearance between the slack adjuster and other vehicle components when the brakes are applied and the push rod travels its maximum stroke.

8. Set the initial free-stroke.
   - 8.1 Turn the adjusting hexnut clockwise until the brake linings contact the drum.
   - 8.2 Turn the adjusting hexnut counterclockwise one-half turn.
9. If a rear axle slack adjuster was installed, manually uncage the parking brake. For instructions, see the applicable brake chamber section in this group.
10. Measure the brake chamber stroke.
    - 10.1 With the brakes fully released, use a ruler to measure the distance from the bottom of the brake chamber to the centerline of the 1/2-inch (13-mm) clevis pin. See **Fig. 3**, Ref. A.
    - 10.2 Build air pressure to at least 85 psi (586 kPa). Apply the brakes, then measure the distance from the bottom of the brake chamber to the centerline of the 1/2-inch (13-mm) clevis pin. See **Fig. 3**, Ref. B. The difference between the measurements is the brake chamber stroke.

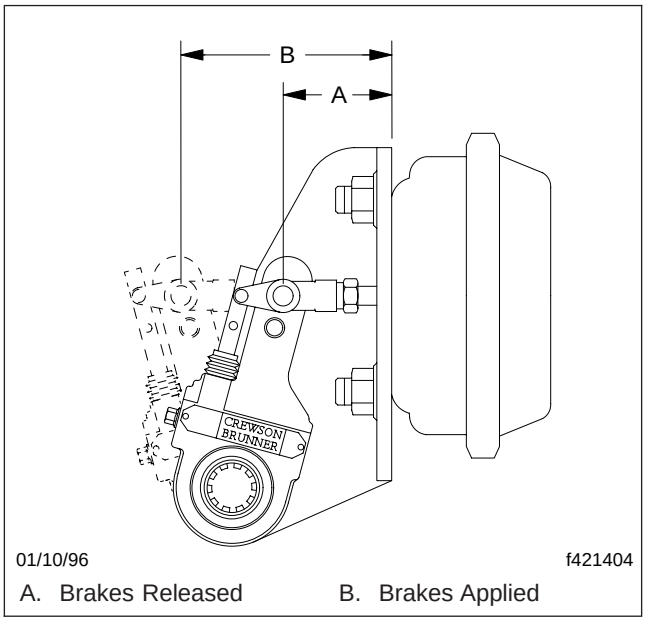


Fig. 3, Brake Stroke Check

- 10.3 The brake chamber stroke must be less than the measurements shown in **Table 1**. If it isn't, check the foundation brakes for problems such as worn cams, bushings, pins and rollers, or broken springs. Repair or replace as needed. For instructions, see the applicable brake section in this group. Then, repeat the previous steps as needed.

Chamber Size	Maximum Chamber Stroke
16	Less than 1-1/2 inches (38 mm)
20 24	Less than 1-3/4 inches (44 mm)
30	Less than 2 inches (51 mm)
36	Less than 2-1/2 inches (64 mm)

Table 1, Maximum Adjusted Brake Chamber Strokes

11. Apply the parking brakes. Remove the chocks from the tires.

General Description

The Bendix PP–DC parking brake air valve is installed on trucks with air brakes, and is used to control the rear axle parking brakes. It is a push-pull type of valve, and is mounted on the right side of the dash.

Principles of Operation

When the valve knob is pulled out, air is exhausted from the parking brake chambers, releasing the springs, and applying the parking brakes. When the knob is pushed in, air flows into the parking brake chambers from one of the reservoirs, and compresses the springs, releasing the parking brakes.

The PP–DC has a double check valve feature. The valve uses air pressure from the air system (primary or secondary) with the higher pressure for the parking brakes. If the pressure drops below 20 to 30 psi (138 to 207 kPa) in both air systems, the brakes will automatically apply. The parking brakes will not apply automatically unless pressure is lost from both systems.

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

- Chock the tires and stop the engine before working under a vehicle. Keep hands away from brake chamber push rods and slack adjusters; the brakes may apply as air system pressure drops.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
- Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
- Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.

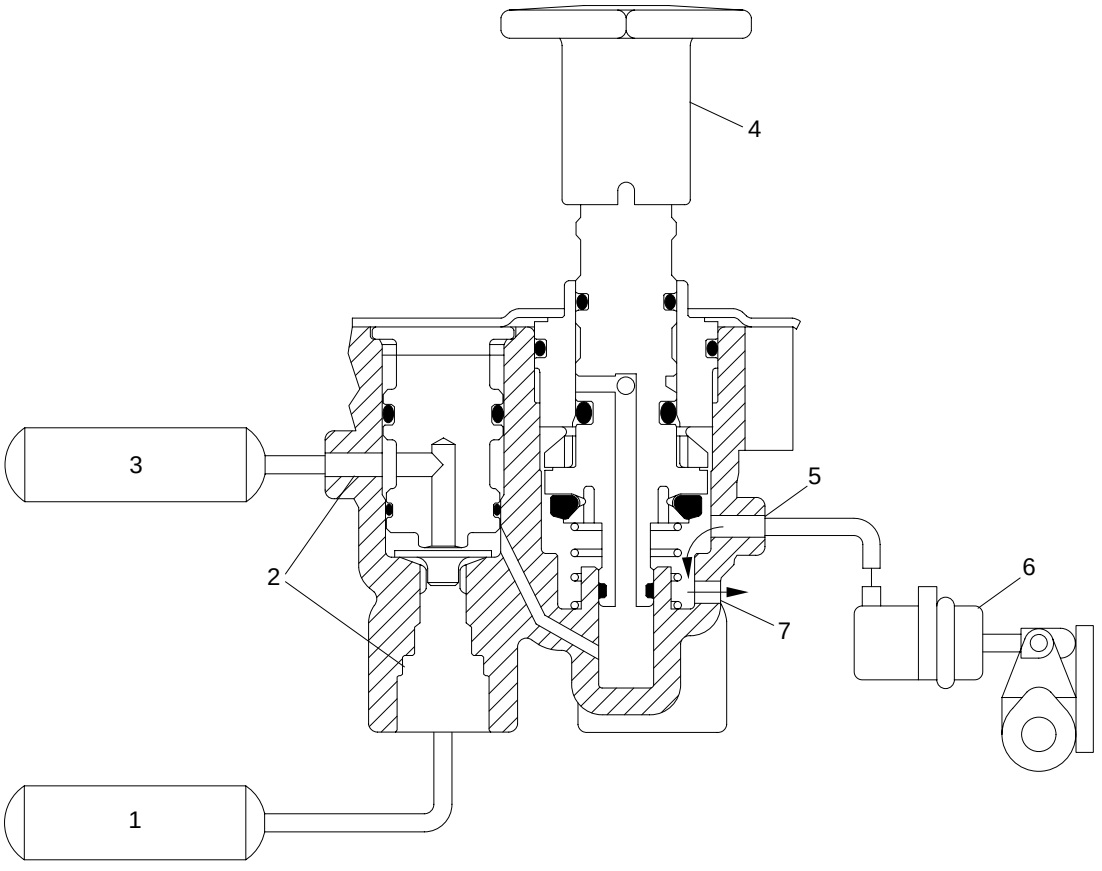
Parking Brake Hand Valve Tests

IMPORTANT: To do the following tests, connect two separate 120 psi (827 kPa) air sources to the PP–DC supply ports. See **Fig. 1.** Tee an accurate test gauge into the supply lines, and provide for a means to control supply line pressure. Connect a small volume air source with a gauge to the delivery port.

Operating Test

1. Chock the tires.
2. Start the engine and build up the air pressure to the normal operating level.
3. With the valve knob pulled out, supply either supply port with 120 psi (827 kPa) of pressure. Push the valve knob in. Air pressure should rise in the delivery line and equal supply line pressure.

   Pull the valve knob out. Delivery pressure should exhaust to zero.
4. Build air pressure to each supply source to 120 psi (827 kPa). Decrease supply pressure at the secondary service reservoir supply port at a rate of 10 psi (69 kPa) per second.



1. Primary Service Reservoir
2. Supply Port
3. Secondary Service Reservoir
4. Valve Knob
5. Delivery Port
6. Brake Chamber
7. Exhaust Port

Fig. 1, Parking Brake Hand Valve (sectional view)

Parking Brake Hand Valve Tests

Primary supply pressure and delivery pressure should not drop below 100 psi (689 kPa). Repeat this step for decreasing primary service reservoir pressure.

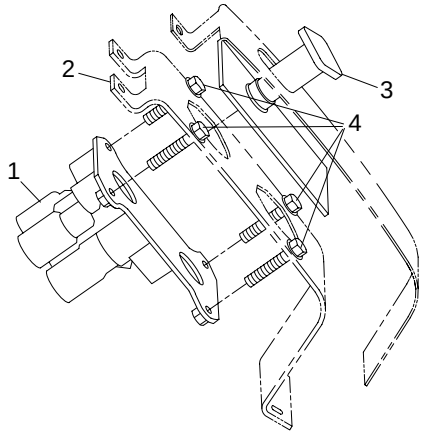
5. Build air pressure to each supply source to 120 psi (827 kPa). Then, decrease both supply pressures to below 20 to 30 psi (138 to 207 kPa). The valve knob should automatically pop out when the pressure is within that range.
6. If the valve does not work as described, repair the valve or replace it following instructions under **Subject 130.**

Leak Testing

1. Chock the tires.
2. Supply the valve with 120 psi (827 kPa) from the primary reservoir supply port.
3. With the valve knob pulled out, coat the exhaust port and the plunger stem with a soapy solution. Leakage at either fitting should not exceed a 1-inch (2.5-cm) bubble every five seconds.There should be no leakage from the secondary reservoir supply port.
4. Supply the valve with 120 psi (827 kPa) from the secondary reservoir supply port. There should be no leakage from the primary reservoir supply port.
5. With the valve knob pushed in, coat the exhaust port and the plunger stem with a soapy solution. Leakage at the fittings should not exceed a 1-inch (2.5-cm) bubble every three seconds. If it does, replace or repair the valve, following instructions in **Subject 130.**

Parking Brake Hand Valve Removal and Installation

Removal (See Fig. 1)



1. Parking Brake Valve
2. Bracket
3. Knob
4. Mounting Screws

Fig. 1, Parking Brake Hand Valve Mounting

WARNING

WARNING: Review the precautions under Safety Precautions, 100 before doing any work on the parking brake valve. Failure to do so could result in personal injury.

1. Park the vehicle on a level surface, apply the parking brakes, chock the tires, and drain the air tanks.
2. Turn the valve knob (Ref. 3) counterclockwise and remove it from the valve stem.
3. Mark the air lines for later reference, then disconnect them from the valve assembly.

NOTE: The primary supply line is green; the secondary supply line is red; the exhaust line is black and 1/2-inch (13-mm) in diameter; the delivery line is black and 3/8-inch (9.6-mm) in diameter.

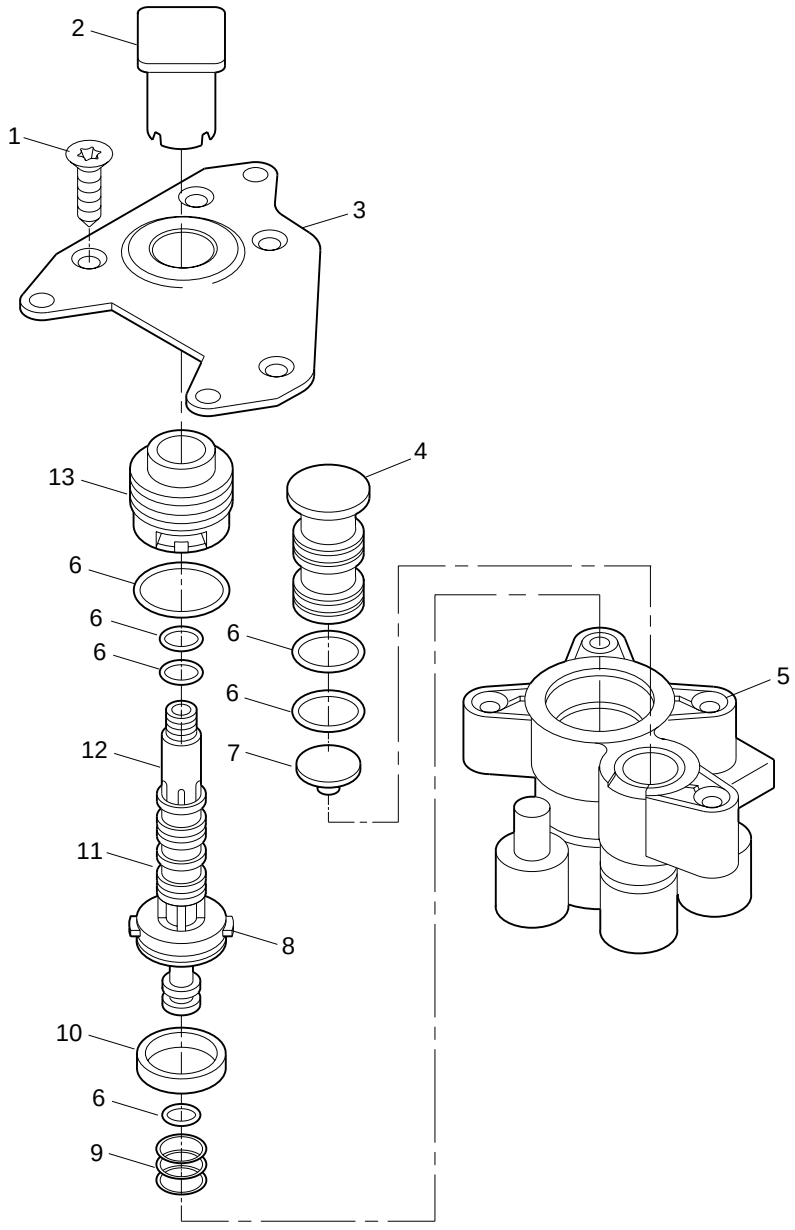
4. Remove the four screws (Ref. 4) that attach the valve (Ref. 1) to the bracket (Ref. 2). Remove the valve.

Installation

1. Position the valve assembly in the bracket. Install the four mounting screws.
2. Connect the air lines to the applicable fittings.
   - 2.1 Tighten the fittings hand tight.
   - 2.2 Using a wrench, tighten the fittings until the connections feel firm.
   - 2.3 Tighten the fittings an additional one-sixth turn.
3. Screw the valve knob onto the valve stem.
4. Leak test the fittings, following the instructions in **Subject 110.**

Parking Brake Hand Valve Disassembly and Assembly

Disassembly (See Fig. 1)



1. Screw
2. Valve Knob
3. Cover
4. Check Valve Seat
5. Valve Body
6. O-Ring
7. Check Valve
8. Index Tab
9. Plunger Spring
10. Exhaust Seal
11. Plunger
12. Plunger Stem
13. Guide Spool

Fig. 1, Exploded View

Parking Brake Hand Valve Disassembly and Assembly

1. Remove the valve assembly from the dash, following the instructions in **Subject 120.**
2. Put the valve assembly in a soft-jawed or padded vise.
3. Remove the screws that attach the cover to the body. Remove the cover.
4. Pull the plunger stem and remove the plunger and guide spool from the body.
5. Remove and discard the plunger spring.
6. Using a screwdriver (if needed), carefully remove the check valve seat from the body. Use care not to damage either the check valve seat or the valve body.
7. Remove and discard the check valve seat O-rings.
8. Turn the body upside down and gently tap it on a flat surface to remove the check valve. Discard the check valve.
9. Remove the guide spool from the plunger. Remove and discard the O-ring.
10. Remove and discard the O-rings from the plunger. Also, remove and discard the exhaust seal.

Assembly (See Fig. 1)

1. Clean and dry all the parts.
2. Check all the parts. Replace a part if any wear or damage is found.
3. Lightly grease all the parts—including the new parts from the maintenance kit—with Dow Corning 55 silicone pneumatic grease or equivalent.
4. Position the check valve in its seat in the body with the flat surface of the valve facing up. If needed, reach into the body to make sure that the valve is seated evenly in the bore.
5. Install the O-rings on the check valve seat and install the assembly into the body. Make sure that the check valve seat is even with the valve body surface.
6. Install the plunger spring into the body. Make sure that the spring is upright and seated properly in the body bore.

NOTE: The plunger spring should surround the protrusion or "lip" at the bottom of the body bore.

7. Install the O-rings onto the plunger, then install the plunger into the body.

   For ease of installation, line up the plunger's index tabs with the spaces in the body bore.
8. Install the O-ring on the guide spool. Install the spool over the plunger and into the body. Firmly press the guide spool into position.
9. Install the screws that attach the cover to the body. Tighten the screws 35 lbf·in (400 N·cm).
10. Install the valve in the dash, then leak test it. Follow the instructions in **Subject 120** for installation and **Subject 110** for leak testing.

General Description

The WABCO Antilock Braking System (ABS) is an electronic wheel speed monitoring and control system that works with the hydraulic brake system. See **Fig. 1**. ABS passively monitors vehicle wheel speed at all times, and controls wheel speed during emergency stops. In normal braking applications, the hydraulic brake system is in effect.

ABS includes signal-generating tone wheels and sensors located in the rotor assembly of each sensed wheel. The sensors transmit vehicle wheel speed information to an electronic control unit. During emergency braking, the control unit signals the brake pressure modulator to reduce, maintain, or increase hydraulic fluid pressure to the brake caliper housing. This prevents front and rear wheel lockup, and enhances steering control during emergency braking situations.

Principles of Operation

The ABS electronic control unit (**Fig. 2**) is a digital microcomputer that serves as the information processing and command center for the antilock braking system. The control unit receives and processes vehicle wheel speed information from the sensors. During emergency brake applications, the control unit regulates the braking force applied to each wheel by sending control signals to the brake pressure modulator (**Fig. 3**).

ABS Major Components

Wheel Speed Sensor

The wheel speed sensors use pulse feedback from tone wheels located in the front and rear axle wheel hubs. When the vehicle is moving, the teeth of the tone wheel cause changes in the magnetic field created by the sensor. The changes create an AC volatage signal that is sent by the sensor to the electronic control unit.

Electronic Control Unit (ECU)

The electronic control unit (ECU), located just behind the passenger's seat, contains microcomputers to monitor the front and rear control channels. The ECU receives wheel speed signals and interprets these signals to calculate wheel speed and a vehicle reference speed. If the calculations indicate a high degree of wheel slip the ECU signals the brake pressure modulator to adjust braking pressure.

The ECU contains another microcomputer that provides a safety circuit to constantly monitor the wheel sensors, the brake pressure modulator, and the electrical circuitry.

IMPORTANT: After the ignition switch is turned on, the tractor warning light (ABS) comes on for about three seconds. See **Fig. 4**. After about three seconds, the light goes out only if all of the tractor's ABS components are working correctly.

If, during vehicle operation, the safety circuit senses a failure in any part of the ABS system (a sensor, brake pressure modulator, wiring connection, short circuit, etc.), the tractor warning light (ABS) comes on, and the control circuit where the failure occurred is switched to normal braking action. Even if the ABS system is completely inoperative, normal braking is maintained. Refer to the vehicle driver's manual for complete operating instructions.

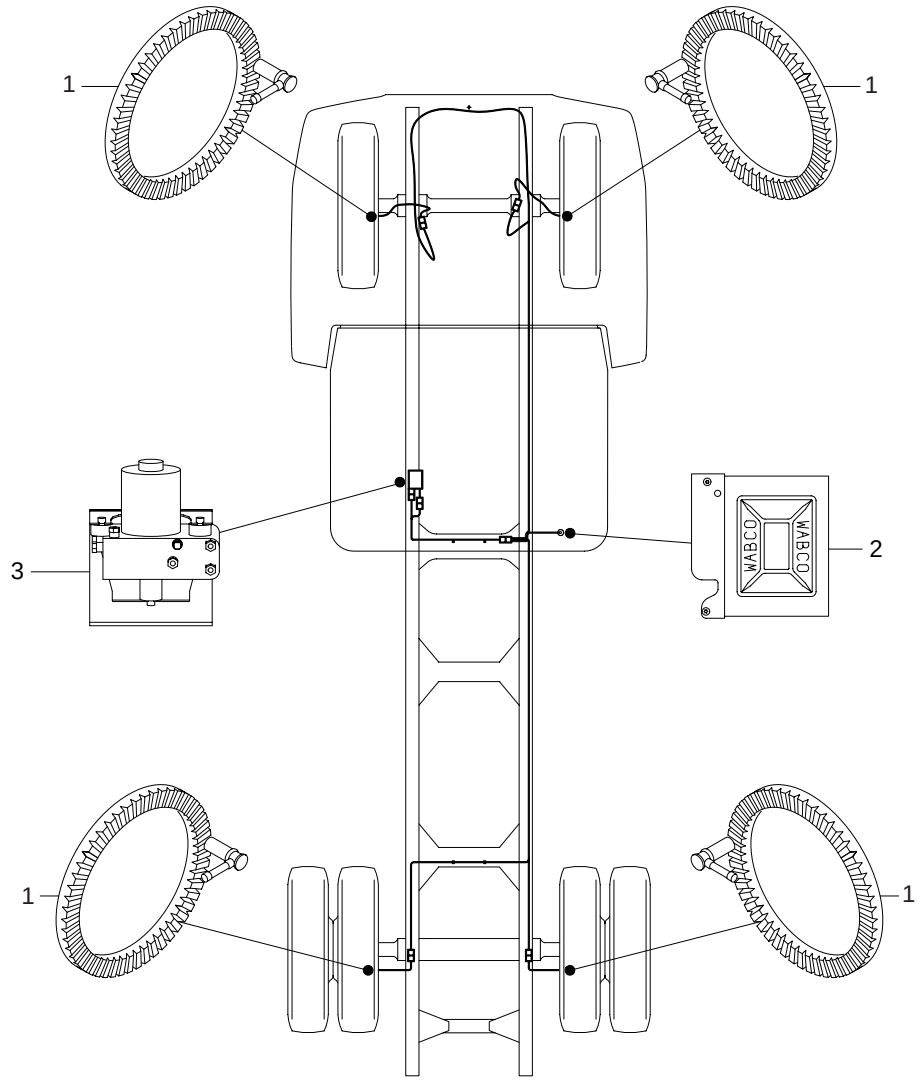
Brake Pressure Modulator

The brake pressure modulator is attached to the left frame rail just ahead of the center or forward rear-suspension crossmember. Depending on the signal received from the electronic control unit, the modulator prevents wheel lockup by adjusting the hydraulic fluid pressure. During normal braking applications, hydraulic fluid flows freely to the brake caliper housing through the modulator.

Within the modulator are an inlet and outlet control valve for each sensed wheel. If the electronic control unit signals indicate wheel lockup is close to occurring, fluid pressure to the brake caliper of the sensed wheel is reduced. The inlet valve of the sensed wheel closes, preventing fluid delivery to the brake caliper. At the same time, the outlet valve opens, allowing fluid to flow to an accumulator within the module. From the accumulator, a recirculation pump within the module delivers brake fluid back to the master cylinder.

As wheel speed increases, the brake pressure modulator allows increases (inlet valve opens and outlet valve closes), or maintains brake pressure until the proper wheel speed is obtained, or until wheel lockup occurs and the control cycle starts again.

General Information



06/09/97 f422013a

1. Tone Wheel and Sensor
2. Electronic Control Unit
3. Brake Pressure Modulator

Fig. 1, Location of ABS Components, Four-Channel System

If maintaining brake pressure, both valves are closed, preventing fluid delivery and maintaining fluid pressure.

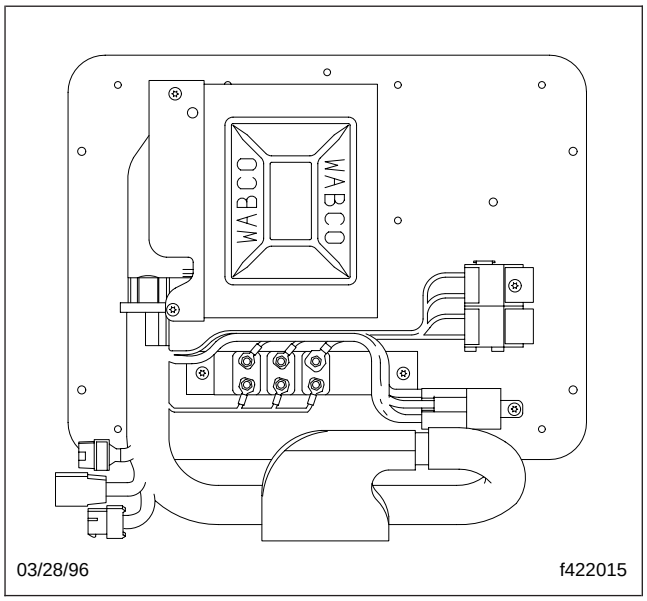


Fig. 2, Electronic Control Unit

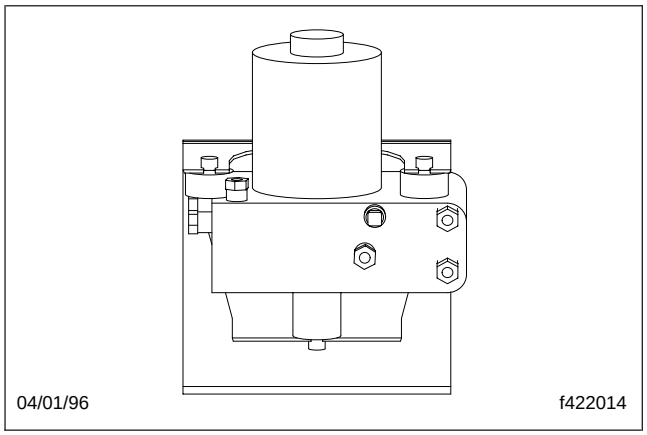
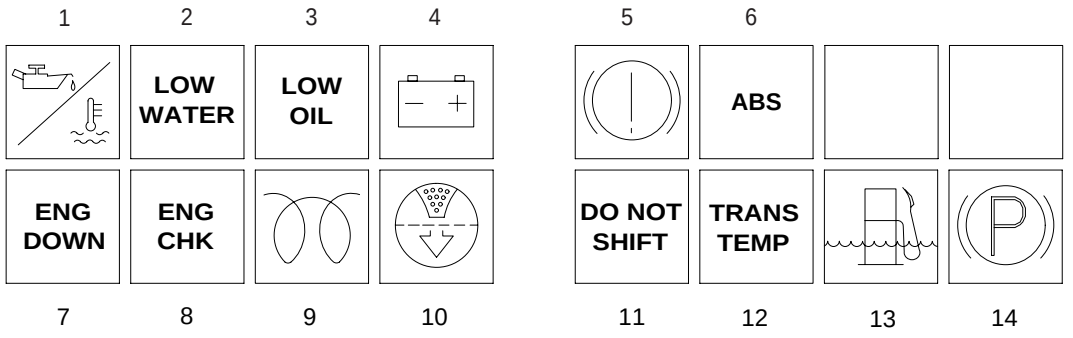


Fig. 3, Brake Pressure Modulator

General Information



06/09/97 f601245a

1. Low Oil Pressure/High Water Temperature Warning
2. Low Water Level Warning
3. Low Oil Level Warning
4. Alternator Warning Light
5. Brake System Warning
6. Tractor ABS Warning Light
7. Stop Engine Indicator
8. Engine Check Indicator
9. Cold-Start Manifold Heater Indicator
10. Air Cleaner Restriction Indicator
11. Do-Not-Shift Indicator
12. High Oil Temperature Warning (Automatic Transmission)
13. Water in Fuel/Water Separator Warning
14. Parking Brake Indicator

Fig. 4, Dash Warning and Indicator Lights

Wheel Speed Sensor Replacement

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. Refer to **Group 54** (wiring) in this manual for information on special terminals and connectors, and on ordering tools for them.

Front Axle

1. Apply the parking brakes. Chock the rear tires to prevent vehicle movement.
2. Twist and pull the sensor to remove it from the sensor bracket (**Fig. 1**).

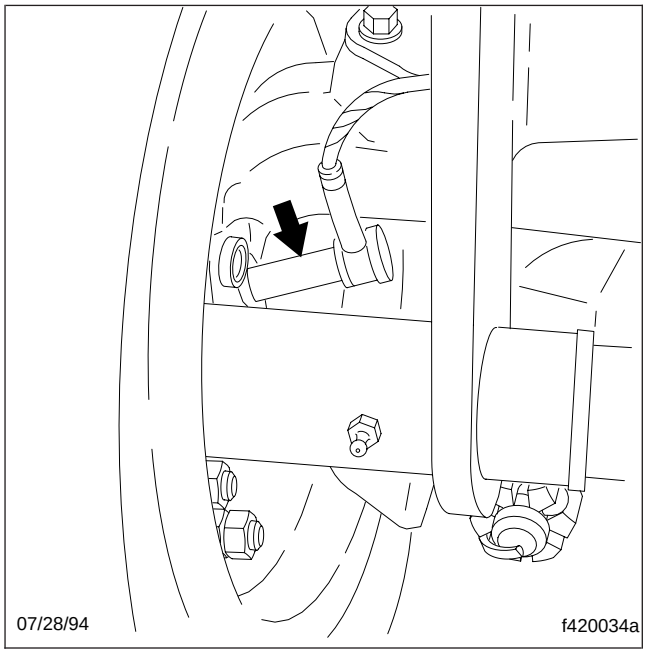


Fig. 1, Remove the Wheel Speed Sensor

3. Remove the sensor cable clip from the top cap.
4. Disconnect the sensor cable from the chassis harness.
5. Remove the clamping bushing from the sensor bracket.
6. Connect the sensor cable to the chassis harness.
7. Attach the sensor cable to the steering knuckle top cap.
8. Press the clamping bushing into the sensor bracket at the brake spider hole until it stops.
9. Coat the sensor with Mobil HP, Valvoline EP 633, Penzoil 707L, or an equivalent. Press the sensor into the clamping bushing until it is stopped by the tone wheel.
10. Remove the chocks from the rear tires.

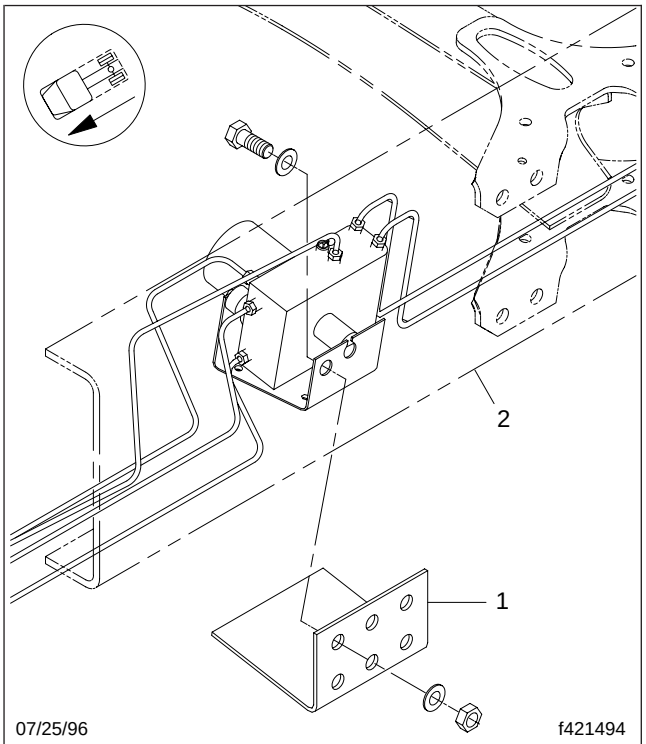
Rear Axle

1. Apply the parking brakes. Chock the front tires to prevent vehicle movement.
2. Raise the rear of the vehicle until the tires clear the ground. Place safety stands under the axle.
3. Twist and pull the sensor to remove it from the mounting block in the axle housing.
4. Remove the clamping bushing.
5. Remove the capscrew that attaches the sensor cable and the hose clamp to the axle tube.
6. Disconnect the sensor cable from the chassis harness.
7. Connect the new sensor cable to the chassis harness.
8. Attach the hose clamp and sensor cable to the axle tube located between the backing plate and the spring plate.
9. Press the clamping bushing into the mounting block until it stops.
10. Coat the sensor with Mobil HP, Valvoline EP633, Penzoil 707L, or an equivalent. Using your hand, push the sensor into the clamping bushing until it is stopped by the tone wheel.
11. Remove the safety stands, lower the vehicle, and remove the chocks from the front tires.

Replacement

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. Refer to **Group 54** in this manual for information on special terminals and connectors, and on ordering tools for them.

1. Chock the front and rear tires.
2. Put a container under the modulator to catch leaking brake fluid.
3. Disconnect the wiring from the modulator.
4. Mark the brake lines for ease of installation. Disconnect the lines.
5. Remove the mounting capscrews, washers, and nuts that attach the modulator and bracket assembly to the bracket on the frame rail. See **Fig. 1**.



1. Modulator Mounting Bracket
2. Left Frame Rail

Fig. 1, Brake Pressure Modulator Mounting

6. Remove the modulator and bracket assembly.

IMPORTANT: When replacing the modulator, make sure the new modulator is pre-charged.

7. Install the new modulator using the above instructions in reverse order. Tighten the modulator and bracket assembly mounting nuts 132 lbf·in (1500 N·cm). Tighten the brake line connections 108 lbf·in (1220 N·cm).
8. Bleed the brake system following the instructions in **Subject 120**.

Hydraulic System Bleeding

Whenever any hydraulic system fitting is loosened or disconnected, the entire system must be bled to remove any air that may have entered it.

⚠ CAUTION

Power steering fluid and brake fluid are incompatible. Never mix these two fluids, or serious damage to both hydraulic systems will result. Use only brake fluid for the master cylinder and brake lines. Use only power steering fluid for the power booster.

Always use new, clean brake fluid that meets DOT 3 specifications when bleeding the master cylinder and service brake system. Never reuse brake fluid, and don't use brake fluid containers for any other purpose. Keep brake fluid containers tightly closed to keep new brake fluid clean and dry.

IMPORTANT: Don't let brake fluid touch any painted surfaces, as it will remove the paint. Brake fluid may also damage certain non-metal surfaces. Don't let it get on brake pads or rotors.

Pressure Bleeding, Service Brake System

Pressure bleeding is the preferred method for bleeding the service brake system. It requires the use of a special pressure bleeder kit, consisting of a tank, pressure pump and valve, gauge, tubing, and adapter. These are available from a number of manufacturers, and include instructions for use. See **Fig. 1**.

1. Apply the parking brake, chock the tires, and tilt the hood.
2. Connect the pressure bleeder to the brake master cylinder reservoir, following the manufacturer's instructions.
   - 2.1 Fill the pressure bleeder with new DOT 3 approved brake fluid, then pressurize it according to the manufacturer's instructions.
   - 2.2 Using the supplied adapter, connect the pressure bleeder to the rear compartment of the master cylinder reservoir.

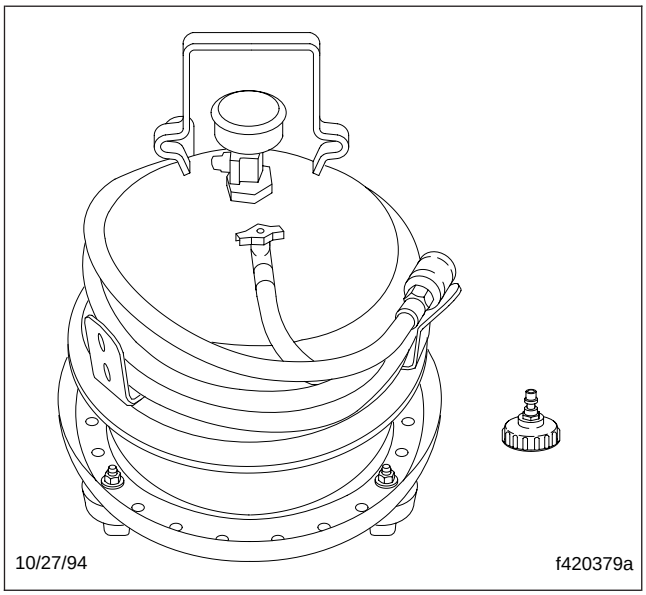


Fig. 1, Pressure Bleeder Kit

3. Bleed the hydraulic connections at the rear wheel calipers, starting on the right side.
   - 3.1 Put a wrench on the bleeder fitting at the caliper, then attach a length of clear tubing to the bleeder fitting. Make sure the tube fits snugly. Submerge the tubing in a container of clean brake fluid. See **Fig. 2**.
   - 3.2 Loosen the bleeder fitting about 3/4 turn, and let the brake fluid flow out of the fitting until it is free of air bubbles. See **Fig. 2** and **Fig. 3**. Then tighten the fitting firmly.
   - 3.3 Move to the left rear caliper, and repeat steps for bleeding the caliper.
4. Disconnect the pressure bleeder from the rear compartment of the master cylinder reservoir, then connect it to the front compartment of the reservoir.
5. Bleed the front wheel brake calipers, starting at the right side.
   - 5.1 Put a wrench on the bleeder fitting at the caliper, then attach a length of clear tubing to the bleeder fitting. Make sure the tube fits snugly. Submerge the tubing in a container of clean brake fluid. See **Fig. 2**.

Hydraulic System Bleeding

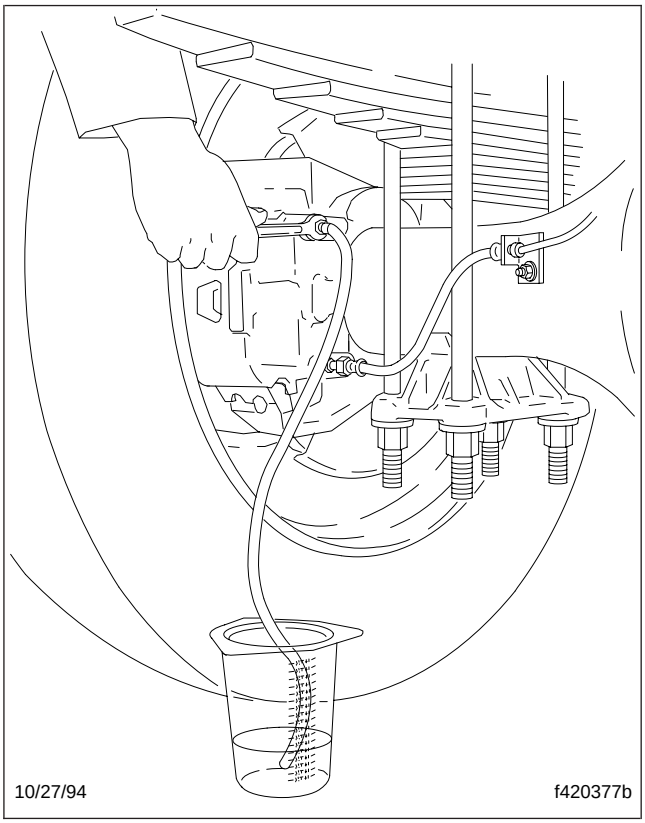
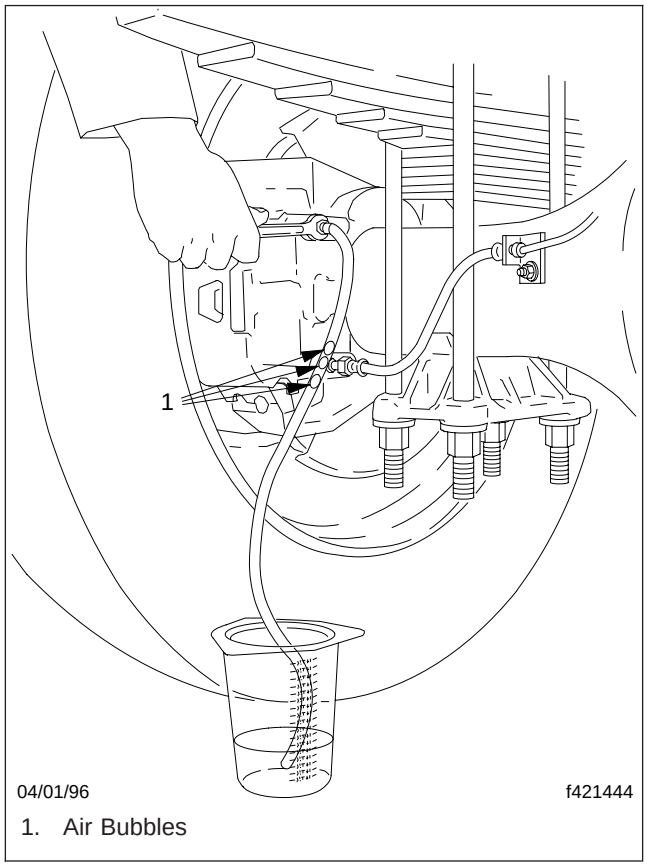


Fig. 2, Bleed the Connections at the Rear Wheel Calipers

5.2 Loosen the bleeder fitting about 3/4 turn, and let the brake fluid flow out of the fitting until it is free of air bubbles. See **Fig. 2** and **Fig. 3**. Then tighten the fitting firmly.

5.3 Move to the left front wheel caliper, and repeat steps for bleeding the caliper.

6. Check the brake fluid level in both compartments of the reservoir. Add new DOT 3 approved brake fluid if needed.
7. Check the operation of the brakes by depressing the brake pedal several times, until if feels firm. The brake pedal should not go all the way down to the floor. If it does, go to the troubleshooting subject in **Section 42.26** and find the problem.
8. Lower the hood and remove the chocks.



1. Air Bubbles

Fig. 3, Loosen the Bleeder Fitting

Manual Bleeding, Service Brake System

If you don't have pressure bleeding equipment, you can use the manual bleeding procedure.

IMPORTANT: Don't let the brake master cylinder fluid level get too low during manual bleeding operations. Keep the master cylinder reservoir filled with new, DOT 3 approved brake fluid. Failure to keep the brake reservoir filled could result in more air entering the system, making it impossible to effectively bleed the system.

1. Apply the parking brake, chock the tires, and tilt the hood.
2. Bleed the master cylinder.

2.1 Using a wrench (and a rag to absorb leaking brake fluid), loosen the fitting at the

rear outlet port on the master cylinder. See **Fig. 4**. Loosen the fitting about one turn.

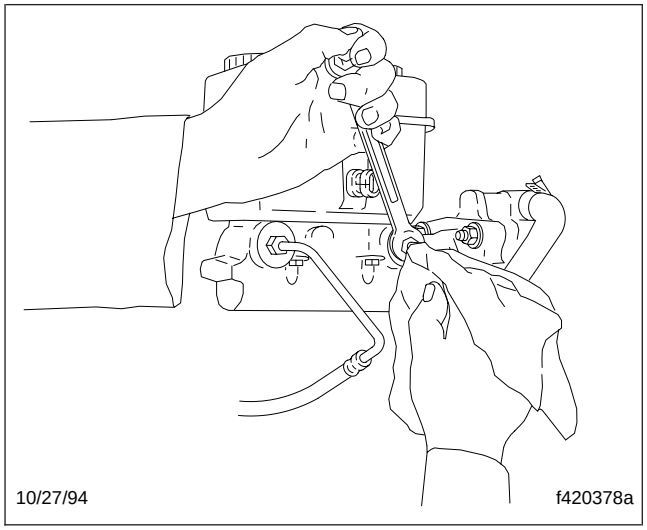


Fig. 4, Loosen the Fitting at the Rear Outlet Port

2.2 Have someone push the brake pedal down slowly—by hand—to the floor. Brake fluid, and any air in the master cylinder, will squirt from the fitting.

2.3 *With the brake pedal held down,* tighten the rear hydraulic line fitting firmly.

IMPORTANT: Don't release the brake pedal until the fitting is tightened, or more air will get into the system.

2.4 Release the brake pedal.

2.5 Loosen the fitting again, and repeat steps for bleeding as required until no air escapes from the fitting, and the brake pedal feels firm.

2.6 Check the level of the rear compartment of the reservoir, then add new DOT 3 approved brake fluid if needed.

2.7 Using a wrench (and a rag to absorb leaking brake fluid), loosen the fitting at the front outlet port on the master cylinder. See **Fig. 5**. Loosen the fitting about one turn.

2.8 Repeat steps as required for the front outlet port.

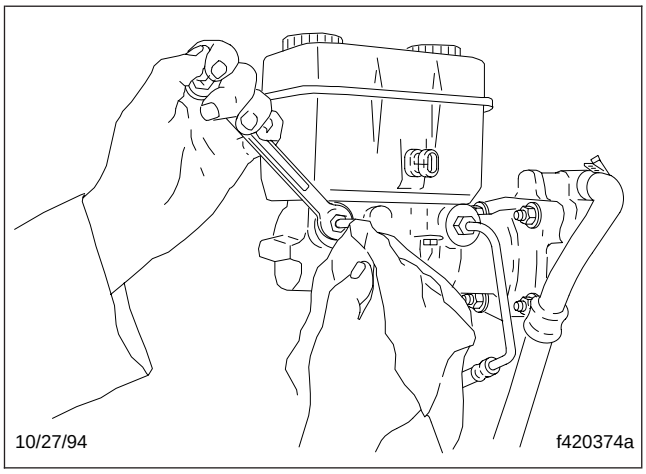


Fig. 5, Loosen the Fitting at the Front Outlet Port

2.9 Check the brake fluid level in the front compartment of the reservoir. Add new DOT 3 approved brake fluid if needed.

3. Bleed the hydraulic connections at the wheel calipers, starting at the right rear wheel caliper.

3.1 Put a wrench on the bleeder fitting at the caliper, then attach a length of clear tubing to the bleeder fitting. Make sure the tube fits snugly. Submerge the tubing in a container of clean brake fluid. See **Fig. 2**.

3.2 Loosen the bleeder fitting about 3/4 turn.

3.3 Have someone slowly push the brake pedal to the floor, then *with the brake pedal depressed,* tighten the bleeder fitting.

IMPORTANT: Make sure the brake pedal stays depressed while you tighten the fitting. If it's released before you tighten the fitting, more air will get into the system.

3.4 Release the brake pedal. Check the fluid in the tube. If there are air bubbles present (**Fig. 3**), repeat steps as required until the fluid in the tube is completely free of air bubbles, as shown in **Fig. 2**.

3.5 Check the brake fluid level in the reservoir. Add new DOT 3 approved brake fluid if needed.

3.6 Repeat steps for bleeding the connections for the left rear caliper, then the right front caliper, and finally for the left front caliper.

Hydraulic System Bleeding

4. Lower the hood and remove the chocks.

Troubleshooting Using the Instrument Panel Blink Codes

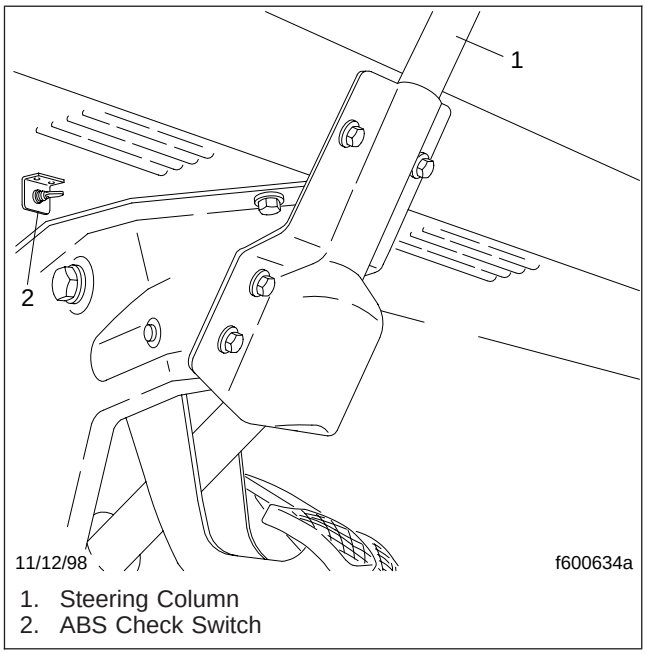
Using the Instrument Panel Blink Codes

This system has built-in diagnostics to ensure that all components are operating properly. Under normal conditions, the tractor warning light (ABS) comes on when the ignition is turned on. After about three seconds the light should go out if all of the tractor's ABS components are working. If the light stays on, or comes back on later, a problem within the ABS system has occurred. The vehicle can continue to be driven, but the ABS system could be partially or completely inoperative. To check the fault code recorded, stop the vehicle and turn off the engine. Then, turn on the ignition switch, but don't start the engine. If the light is still on, there is an "active" system fault that must be repaired to ensure proper system operation.

IMPORTANT: Remove the ABS light relay from the power distribution module (PDM). See **Group 54**. It is necessary to remove the relay in order to display multiple fault codes.

Use the ABS CHECK switch (see **Fig. 1**), located under the driver's left-side dash, and the ABS light to display system faults. With the ignition switch on, turn on the ABS CHK switch. The ABS light should go out. After a one-second pause, the ABS light will blink the first digit of the two-digit configuration code. This code is indicated by one long flash, a two-second pause, then one short flash (1–1). Any active fault codes will be displayed following this configuration code. There will be a two-second pause between the last configuration code flash and the first set of flashes of the fault code. The fault code will be indicated by two sets of flashes. The number of blinks displaying the first digit will be a number between one and six. After another two and one-half second pause, the second digit will be displayed. The number of blinks displaying the second digit will be a number between one and fifteen. After a two and one-half second pause, the diagnostic code cycle continues to repeat the configuration code and fault code until the fault is repaired.

For example (**Fig. 2**), after the ABS CHECK switch has been turned on, the configuration code (1–1) will blink followed by fault code 5–4, shown by five flashes, a pause of two and one-half seconds, followed by four flashes. After a two and one-half second pause, the same configuration and fault code will continue to repeat, always ending with a two and one-half second pause.



1. Steering Column
2. ABS Check Switch

Fig. 1, ABS Check Switch Location

Once a fault code has been identified, use a volt/ohmmeter to check the electrical harness at the ECU's 35-pin connector, which is located just behind the passenger's seat. Connect the ohmmeter leads to the applicable pins on each connector. See **Fig. 3** and **Table 1**, for a description of the circuit wire numbers and their location within the pin connectors.

Make the necessary repairs and clear the fault code from the ECU memory as outlined at the end of this section. If more than one fault exists, it will be displayed after the first one has been cleared from memory.

To make testing easier, use the Meritor WABCO test adaptor. See **Fig. 4**.

The Meritor WABCO test adaptor is used to service and troubleshoot the Meritor WABCO ABS system. *It can not be used with a vehicle frame-mounted ECU.* A volt ohmmeter (VOM) can determine the condition of the ABS valves, wheel end sensors and associated wiring. When used with the procedures and blink codes in *Meritor WABCO Maintenance Manual No. 38, Rev. 6/98*, it allows you to measure voltages and resistances of components in the system.

Troubleshooting Using the Instrument Panel Blink Codes

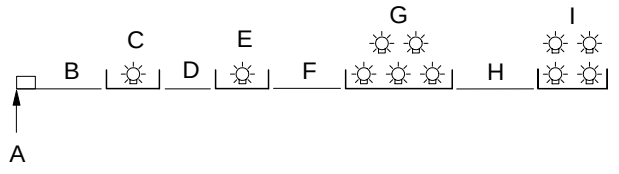
Circuit Wire Numbers and Descriptions		
Pin Number	**Freightliner Wire Number**	**WABCO Circuit Description**
1	X1	ECU Supply/Battery
2	—	—
3	—	—
4	X4	Right Rear Inlet Valve
5	X5	Right Rear Outlet Valve
6	X6	Right Front Inlet Valve
7	X7	Right Front Outlet Valve
8	X8	Valve Relay
9	X9	ECU Ignition Supply
10	X10	Brake Light Input
11	X11	Recirculation Pump Relay
12	—	—
13	X13	Diagnostic Interface
14	X14	Diagnostic Interface/Blink Code Activation
15	X15	Left Front Sensor
16	X16	Right Rear Sensor
17	X17	Right Front Sensor
18	X18	Left Rear Sensor
19	X19	ECU Supply
20	—	—
21	X21	Left Rear Inlet Valve
22	X22	Left Rear Outlet Valve
23	X23	Left Front Inlet Valve
24	X24	Left Front Outlet Valve
25	X25	Brake Light Input
26	X26	ABS Warning Light
27	X27	ECU Ground
28	—	—
29	—	—
30	X30	Recirculation Pump Control
31	X31	Modulator Ground
32	X32	Left Front Sensor
33	X33	Right Rear Sensor
34	X34	Right Front Sensor

Troubleshooting Using the Instrument Panel Blink Codes

Circuit Wire Numbers and Descriptions		
Pin Number	**Freightliner Wire Number**	**WABCO Circuit Description**
35	X35	Left Rear Sensor

Table 1, Circuit Wire Numbers and Descriptions

The receptacles of the Meritor WABCO test adaptor

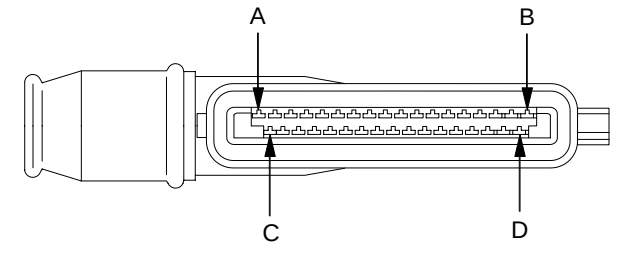


11/12/98 f150542a

NOTE: This sequence will repeat until the fault is repaired or cleared.

A. ABS CHECK Switch Activated Here
B. 1 Second Pause
C. 1 Long Flash
D. 2 Second Pause
E. 1 Short Flash
F. 2 Second Pause
G. 5 Flashes
H. 2.5 Second Pause
I. 4 Flashes

Fig. 2, Fault Code 5-4 shown



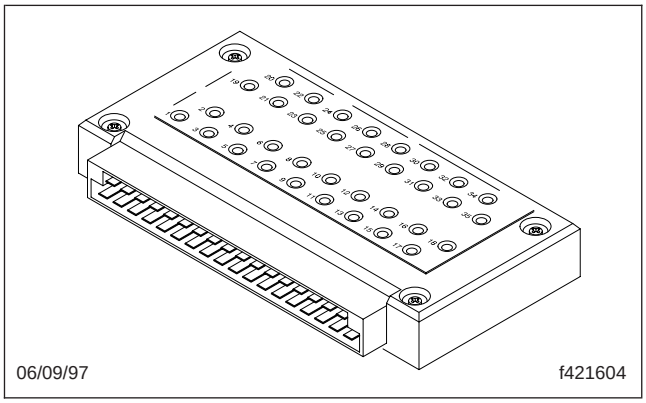
06/09/97 f150384b

A. Pin 1
B. Pin 18
C. Pin 19
D. Pin 35

Fig. 3, ECU 35-Pin Connector

accept the tips of standard VOM cables. These tips are about 0.080 inch diameter (2 mm). Any good quality digital or analog VOM can be used. A meter with automatic polarity sensing is recommended so you do not have to worry about correct polarity of the meter leads during voltage measurements.

The test adaptor lets you access the 35-pins in the connector that attaches to the Meritor WABCO Electronic Control Unit (ECU). By inserting the probes of



06/09/97 f421604

Fig. 4, Test Adaptor

a VOM into the proper holes of the adaptor, sensor resistances, solenoid resistances, power, and grounds can be measured and compared to acceptable values. Sensor adjustment and tone ring runout can also be checked using the adaptor.

IMPORTANT: The ignition switch must be off when connecting or disconnecting the ECU.

NOTE: The blink codes are erased from ECU memory as repairs are made. Once a repair has been made, cycle the ignition to ensure the blink code does not reappear. If there are any other outstanding faults, the next blink code will be displayed.

If the ABS light does not operate correctly after the ignition is turned on (the light doesn't come on at all or it doesn't go out after about three seconds), check all circuit breakers in the control unit panel, and replace if necessary. Check the wiring to the ABS CHECK switch and the warning lamp, and repair or replace the wiring as needed. When checking the warning lamp, do the following:

- Replace the bulb.
- Check voltage potential at the socket.
- Check continuity of the wires to the socket.

When checking the switch, do the following:

Troubleshooting Using the Instrument Panel Blink Codes

- Check the resistance between the terminals while cycling the switch.
- Check the continuity of the wires to the switch.

Make sure that a charged 12-volt battery is available (the ABS system needs at least 11 volts to work).

See **Table 2** for a listing of all fault codes, pins to be tested, and the correct volt/ohmmeter readings. Repair or replace the components and/or wiring if the readings are not correct.

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals.

Refer to **Group 54** in this manual for information on special terminals and connectors, and ordering tools for them.

WABCO ABS Fault Codes and Tests

Key Switch On to Determine ABS Blink Fault Code		Key Switch Off to Test System		
WABCO Fault Code	**Problem**	**Begin by Testing These Pins**	**Volt, Amp, and Ohmmeter Reading**	**Remedy**
2–0	Internal electronic control unit fault.	—	—	Replace the electronic control unit.
2–1	Internal electronic control unit fault.	—	—	Replace the electronic control unit.
2–2	Recirculation pump operates continuously.	—	—	Check the recirculation pump wiring (circuits 11 & 30), the pump relay, and the wiring connections. Repair or replace as needed.
2–3	Recirculation pump does not work.	—	—	Jump pins 9 and 11, and you should hear the pump motor run. Check the recirculation pump wiring, the relay circuit, and the pump connections.
2–4	Recirculation pump motor locked.	—	0.30 A	Jump pins 9 and 11, and you should hear the pump motor run. Check the recirculation pump wiring, the relay circuit, and the pump connections.
2–6	Stop light switch has failed.	10 and 25	—	Repair the wiring if needed (circuits 10 & 25). Also, make sure that the 35-pin connector is secure at the ECU.
2–7	Continuous power supply to the ECU with ignition off.	9 and 27	0 DCV	With the ignition off, check the valve relay and wiring connections. Repair or replace as needed.
2–8	No voltage to the inlet or outlet valve.	1, 9 and 27	12 V	Check the valve relay, the wiring (circuits 1 & 8), and the wiring connections. Repair or replace as needed.
2–9	Inlet valve supervision time exceeded.	—	—	Check the valves for normal operation. If okay, clear the faults.
2–10	Modulator reference ground interrupted.	31	—	Repair or replace wiring (circuit 31) as needed. Check the chassis ground circuit.

Troubleshooting Using the Instrument Panel Blink Codes

WABCO ABS Fault Codes and Tests				
Key Switch On to Determine ABS Blink Fault Code		**Key Switch Off to Test System**		
WABCO Fault Code	**Problem**	**Begin by Testing These Pins**	**Volt, Amp, and Ohmmeter Reading**	**Remedy**
2–11	Recirculation pump cycle time is excessive.	—	—	Check the recirculation pump operation. If okay, clear the fault.
2–12 Right Front (RF) 2–14 Left Front (LF)	Wheel speed signal is erratic.	(RF), pins 17 and 34 * (LF), pins 15 and 32 *	above 0.20 volt AC	A damaged tone wheel, a sensor needs adjustment, or there is excessive hub runout. Repair or replace as needed.
2–13 Left Rear (LR) 2–15 Right Rear (RR)	Wheel speed signal is erratic.	(LR), pins 18 and 35 * (RR), pins 16 and 33 *	above 0.20 volt AC	A damaged tone wheel, a sensor needs adjustment, or there is excessive hub runout. Repair or replace as needed.
3–0 Right Front (RF)	On the steer axle, there is an open circuit in the RF inlet control valve and/or wiring to the modulator connection.	6 and 27	5 to 7.5 ohms 1.6 amps †	Check the inlet control valve wiring (circuit 6). Repair or replace wiring as needed.
3–1 Right Front (RF)	On the steer axle, there is an open circuit in the RF outlet control valve and/or wiring to the modulator connection.	7 and 27	3 to 5 ohms 2.5 amps †	Check the outlet control valve wiring (circuit 7). Repair or replace wiring as needed.
3–2 Left Front (LF)	On the steer axle, there is an open circuit in the LF inlet control valve and/or wiring to the modulator connection.	23 and 27	5 to 7.5 ohms 1.6 amps †	Check the inlet control valve wiring (circuit 23). Repair or replace the wiring as needed.
3–3 Left Front (LF)	On the steer axle, there is an open circuit in the LF outlet control valve and/or wiring to the modulator connection.	24 and 27	3 to 5 ohms 2.5 amps †	Check the outlet control valve wiring (circuit 24). Repair or replace the wiring as needed.
3–4 Right Rear (RR)	On the rear axle, there is an open circuit in the RR inlet control valve and/or wiring to the modulator connection.	4 and 27	5 to 7.5 ohms 1.6 amps †	Check the inlet control valve wiring (circuit 4). Repair or replace the wiring as needed.
3–5 Right Rear (RR)	On the rear axle, there is an open circuit in the RR outlet control valve and/or wiring to the modulator connection.	5 and 27	3 to 5 ohms 2.5 amps †	Check the outlet control valve wiring (circuit 5). Repair or replace the wiring as needed.

Troubleshooting Using the Instrument Panel Blink Codes

WABCO ABS Fault Codes and Tests				
Key Switch On to Determine ABS Blink Fault Code		Key Switch Off to Test System		
WABCO Fault Code	Problem	Begin by Testing These Pins	Volt, Amp, and Ohmmeter Reading	Remedy
3–6 Left Rear (LR)	On the rear axle, there is an open circuit in the inlet control valve and/or wiring to the modulator connection.	21 and 27	5 to 7.5 ohms 1.6 amps †	Check the inlet control valve wiring (circuit 21). Repair or replace the wiring as needed.
3–7 Left Rear (LR)	On the rear axle, there is an open circuit in the outlet control valve and/or wiring to the connection.	22 and 31	3 to 5 ohms 2.5 amps †	Check the outlet control valve wiring (circuit 22). Repair or replace the wiring as needed.
3–8	Open circuit between the ECU and the recirculation pump relays.	22 and 31	—	Jump pins 9 & 11, and if the pump doesn't run, check circuit 11 and the recirculation pump relay.
4–0 Right Front (RF)	On the steer axle, there is a short circuit to ground between the ECU and the RF inlet control valve.	6 and 27	5 to 7.5 ohms 1.6 amps †	Check the inlet control valve wiring (circuit 6). Repair or replace the wiring as needed.
4–1 Right Front (RF)	On the steer axle, there is a short circuit to ground between the ECU and the RF outlet control valve.	7 and 27	3 to 5 ohms 2.5 amps †	Check the outlet control valve wiring (circuit 7). Repair or replace the wiring as needed.
4–2 Left Front (LF)	On the steer axle, there is a short circuit to ground between the ECU and the LF inlet control valve.	23 and 27	5 to 7.5 ohms 1.6 amps †	Check the inlet control valve wiring (circuit 23). Repair or replace the wiring as needed.
4–3 Left Front (LF)	On the steer axle, there is a short circuit to ground between the ECU and the LF outlet control valve.	24 and 27	3 to 5 ohms 2.5 amps †	Check the outlet control valve wiring (circuit 24). Repair or replace the wiring as needed.
4–4 Right Rear (RR)	On the rear axle, there is a short circuit to ground between the ECU and the RR inlet control valve.	4 and 27	5 to 7.5 ohms 1.6 amps †	Check the inlet control valve wiring (circuit 4). Repair or replace the wiring as needed.
4–5 Right Rear (RR)	On the rear axle, there is a short circuit to ground between the ECU and the RR outlet control valve.	5 and 27	3 to 5 ohms 2.5 amps †	Check the outlet control valve wiring (circuit 5). Repair or replace the wiring as needed.
4–6 Left Rear (LR)	On the rear axle, there is a short circuit to ground between the ECU and the LR inlet control valve.	21 and 27	5 to 7.5 ohms 1.6 amps †	Check the inlet control valve wiring (circuit 21). Repair or replace the wiring as needed.
4–7 Left Rear (LR)	On the rear axle, there is a short circuit to ground between the ECU and the LR outlet control valve.	22 and 27	3 to 5 ohms 2.5 amps †	Check the outlet control valve wiring (circuit 22). Repair or replace the wiring as needed.

Troubleshooting Using the Instrument Panel Blink Codes

WABCO ABS Fault Codes and Tests				
Key Switch On to Determine ABS Blink Fault Code		**Key Switch Off to Test System**		
WABCO Fault Code	**Problem**	**Begin by Testing These Pins**	**Volt, Amp, and Ohmmeter Reading**	**Remedy**
4–8	Short circuit to ground between the ECU and the recirculation pump relay.	11, 30 and 27	Open Circuit	Check continuity through the pump to ground. Check the pump connector. Repair or replace wiring as needed.
4–12 Right Front (RF) 4–14 Left Front (LF)	Sensor open circuit.	(RF), pins 17 and 34 * (LF), pins 15 and 32 *	above 0.20 volt AC	Check the sensor wiring. Repair or replace as needed.
4–13 Left Rear (LR) 4–15 Right Rear (RR)	Sensor open circuit.	(LR), pins 18 and 35 * (RR), pins 16 and 33 *	above 0.20 volt AC	Check the sensor wiring. Repair or replace as needed.
5–0 Right Front (RF)	On the steer axle, there is a short circuit to the battery between the ECU and the RF inlet control valve.	6 and 9	5 to 7.5 ohms 1.6 amps †	Check the inlet control valve wiring (circuit 6). Repair or replace the wiring as needed
5–1 Right Front (RF)	On the steer axle, there is a short circuit to the battery between the ECU and the RF outlet control valve.	7 and 9	3 to 5 ohms 2.5 amps †	Check the outlet control valve wiring (circuit 7). Repair or replace the wiring as needed.
5–2 Left Front (LF)	On the steer axle, there is a short circuit to the battery between the ECU and the LF inlet control valve.	23 and 9	5 to 7.5 ohms 1.6 amps †	Check the inlet control valve wiring (circuit 23). Repair or replace the wiring as needed.
5–3 Left Front (LF)	On the steer axle, there is a short circuit to the battery between the ECU and the LF outlet control valve.	24 and 9	3 to 5 ohms 2.5 amps †	Check the outlet control valve wiring (circuit 24). Repair or replace the wiring as needed.
5–4 Right Rear (RR)	On the rear axle, there is a short circuit to the battery between the ECU and the RR inlet control valve.	4 and 9	5 to 7.5 ohms 1.6 amps †	Check the inlet control valve wiring (circuit 4). Repair or replace the wiring as needed.
5–5 Right Rear (RR)	On the rear axle, there is a short circuit to the battery between the ECU and the RR outlet control valve.	5 and 9	3 to 5 ohms 2.5 amps †	Check the outlet control valve wiring (circuit 5). Repair or replace the wiring as needed.

Troubleshooting Using the Instrument Panel Blink Codes

WABCO ABS Fault Codes and Tests				
Key Switch On to Determine ABS Blink Fault Code		Key Switch Off to Test System		
WABCO Fault Code	**Problem**	**Begin by Testing These Pins**	**Volt, Amp, and Ohmmeter Reading**	**Remedy**
5–6 Left Rear (LR)	On the rear axle, there is a short circuit to the battery between the ECU and the LR inlet control valve.	21 and 9	5 to 7.5 ohms 1.6 amps †	Check the inlet control valve wiring (circuit 21). Repair or replace the wiring as needed.
5–7 Left Rear (LR)	On the rear axle, there is a short circuit to the battery between the ECU and the LR outlet control valve.	22 and 9	3 to 5 ohms 2.5 amps †	Check the outlet control valve wiring (circuit 22). Repair or replace the wiring as needed.
5–8	Short circuit to battery between the ECU and the recirculation pump relay.	30 and 11	Open Circuit	Repair or replace wiring as needed. Check the pump ground connection.
5–12 Right Front (RF) 5–14 Left Front (LF)	Wheel speed signal is erratic.	pins 17 and 34 pins 15 and 32	Above 0.2 volts AC	An incorrect or damaged tone wheel. Replace the tone wheel and rotor if needed. Also, check the tire sizes for possible mismatch, and check for correct wheel bearing adjustment.
5–13 Left Rear (LR) 5–15 Right Rear (RR)	Wheel speed signal is erratic.	pins 18 and 35 pins 16 and 33	Above 0.2 volts AC	An incorrect or damaged tone wheel. Replace the tone wheel and rotor if needed. Also, check the tire sizes for possible mismatch, and check for correct wheel bearing adjustment.
6–0 Right Front (RF)	On the steer axle, there is a short circuit in the RF inlet control valve wiring to other wiring.	4, 5, 6, 7, 21, 23, and 24	Open circuit	Repair or replace the wiring if continuity exists between circuit 6 and the other control valve circuits. Replace the modulator if the short is located within the valve.
6–1 Right Front (RF)	On the steer axle, there is a short circuit in the RF outlet control valve wiring to other wiring.	4, 5, 6, 7, 21, 22, 23, and 24	Open circuit	Repair or replace the wiring if continuity exists between circuit 7 and the other control valve circuits. Replace the modulator if the short is located within the valve.
6–2 Left Front (LF)	On the steer axle, there is a short circuit in the LF inlet control valve wiring to other valve wiring.	4, 5, 6, 7, 21, 22, 23, and 24	Open circuit	Repair or replace the wiring if continuity exists between circuit 23 and the other control valve circuits. Replace the modulator if the short is located within the valve.

Troubleshooting Using the Instrument Panel Blink Codes

WABCO ABS Fault Codes and Tests				
Key Switch On to Determine ABS Blink Fault Code		Key Switch Off to Test System		
WABCO Fault Code	**Problem**	**Begin by Testing These Pins**	**Volt, Amp, and Ohmmeter Reading**	**Remedy**
6–3 Left Front (LF)	On the steer axle, there is a short circuit in the LF outlet control valve wiring to other valve wiring.	4, 5, 6, 7, 21, 22, 23, and 24	Open circuit	Repair or replace the wiring if continuity exists between circuit 24 and the other control valve circuits. Replace the modulator if the short is located within the valve.
6–4 Right Rear (RR)	On the rear axle, there is a short circuit in the RR inlet control valve wiring to other valve wiring.	4, 5, 6, 7, 21, 22, 23, and 24	Open circuit	Repair or replace the wiring if continuity exists between circuit 4 and the other control valve circuits. Replace the modulator if the short is located within the valve.
6–5 Right Rear (RR)	On the rear axle, there is a short circuit in the RR outlet control valve wiring to other valve wiring.	4, 5, 6, 7, 21, 22, 23, and 24	Open circuit	Repair or replace the wiring if continuity exists between circuit 5 and the other control valve circuits. Replace the modulator if the short is located within the valve.
6–6 Left Rear (LR)	On the rear axle, there is a short circuit in the LR inlet control valve wiring to other valve wiring.	4, 5, 6, 7, 21, 22, 23, and 24	Open circuit	Repair or replace the wiring if continuity exists between circuit 21 and the other control valve circuits. Replace the modulator if the short is located within the valve.
6–7 Left Rear (LR)	On the rear axle, there is a short circuit in the LR outlet control valve wiring to other valve wiring.	4, 5, 6, 7, 21, 22, 23, and 24	Open circuit	Repair or replace the wiring if continuity exists between circuit 22 and the other control valve circuits. Replace the modulator if the short is located within the valve.
6–8	Short circuit to the battery between a solenoid valve and recirculation pump relay.	11 and 27	—	Check the 35-pin connector and the ECU.
6–12 Right Front (RF) 6–14 Left Front (LF)	Wheel speed signal is missing.	pins 17 and 34 pins 15 and 32	Above 0.2 volts AC	The gap is too large, adjust the sensor.

Troubleshooting Using the Instrument Panel Blink Codes

WABCO ABS Fault Codes and Tests				
Key Switch On to Determine ABS Blink Fault Code		Key Switch Off to Test System		
WABCO Fault Code	**Problem**	**Begin by Testing These Pins**	**Volt, Amp, and Ohmmeter Reading**	**Remedy**
6–13 Left Rear (LR) 6–15 Right Rear (RR)	Wheel speed signal is missing.	pins 18 and 35 pins 16 and 33	Above 0.2 volts AC	The gap is too large, adjust the sensor.

* After connecting the volt/ohmmeter test leads, rotate the applicable tire at about 30 rpm (1 revolution every 2 seconds).
† Desired readings are with the battery potential at approximately 12.5 volts.

Table 2, WABCO ABS Fault Codes and Tests

Refer to the wiring diagram in **Specifications 400** when troubleshooting the ABS system. The key switch must be turned on (engine off) to activate the blink codes.

If a fault still can't be repaired, or erased from ECU memory, contact your Meritor District Service Manager, or call Meritor WABCO at 1-800-535-5560.

ERASING A FAULT FROM THE ECU MEMORY

NOTE: An existing fault cannot be erased until it has been corrected.

Meritor WABCO recommends that you erase all faults from the ECU memory after they have been noted and corrected.

Faults can only be erased one at a time. A fault is erased from the ECU memory by doing the following:

1. Turn the ignition switch on.
2. Turn the blink code switch on.
3. Wait until the blink code begins to flash.
4. Turn the blink code switch off.
5. Wait for the ABS lamp to stop flashing.
6. Turn the ignition switch off, then back on.
7. Turn the blink code switch off, then back on.
8. Check for additional faults. If they are present, repair and clear them.

When all faults are repaired and cleared, only the configuration code (1–1) will be displayed.

See **Fig. 1** for a full view of the wiring diagram for troubleshooting 4S/4M ABS systems using instrument panel blink codes. See **Fig. 2**, or **Fig. 3** for partial (detailed) views of the wiring diagram. See **Fig. 4** for a plumbing diagram of the hydraulic ABS system.

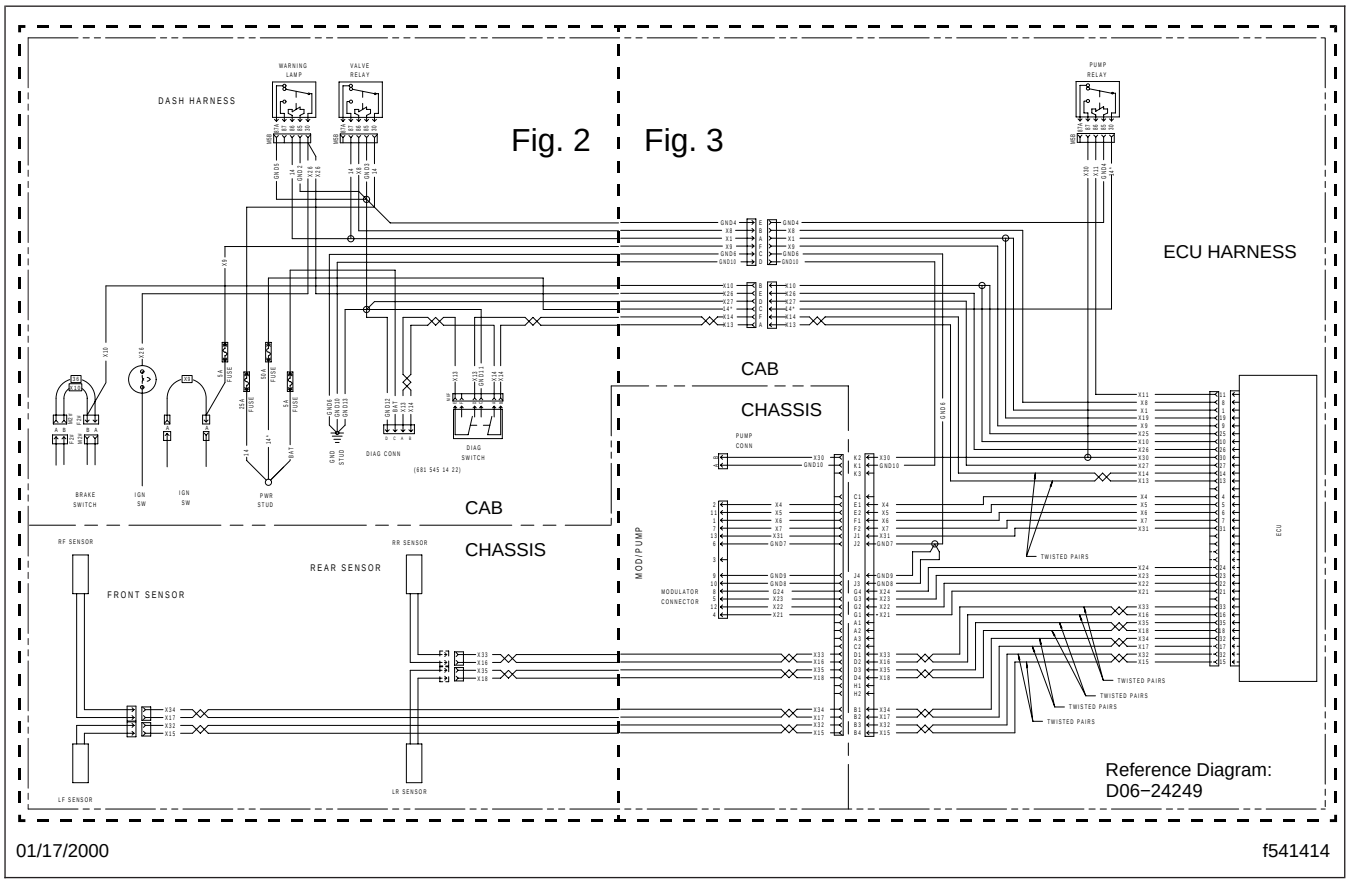


Fig. 1, Full View of the Cab and Chassis Wiring Diagram

Specifications

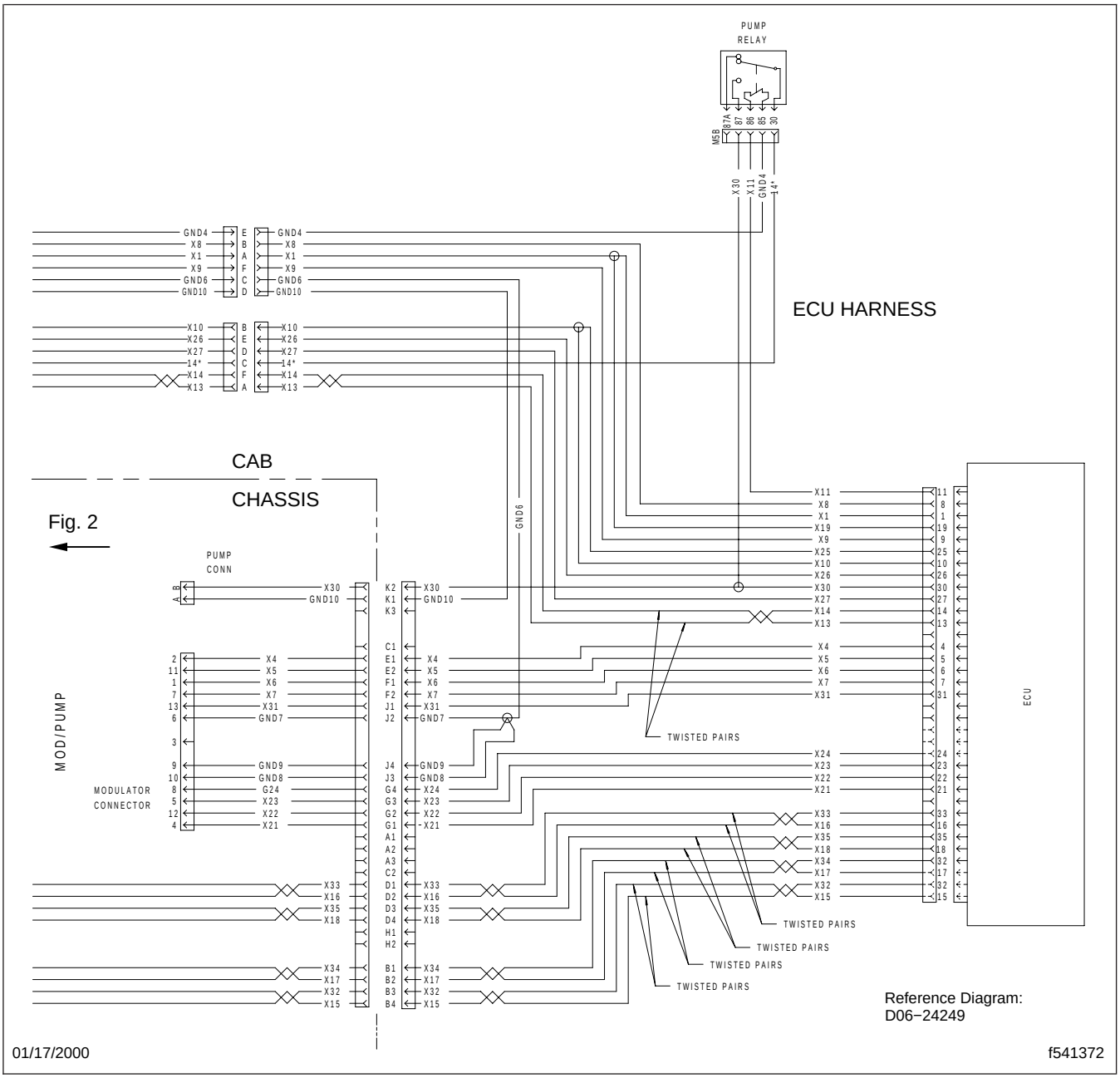


Fig. 2, Partial View of the Cab and Chassis Wiring Diagram

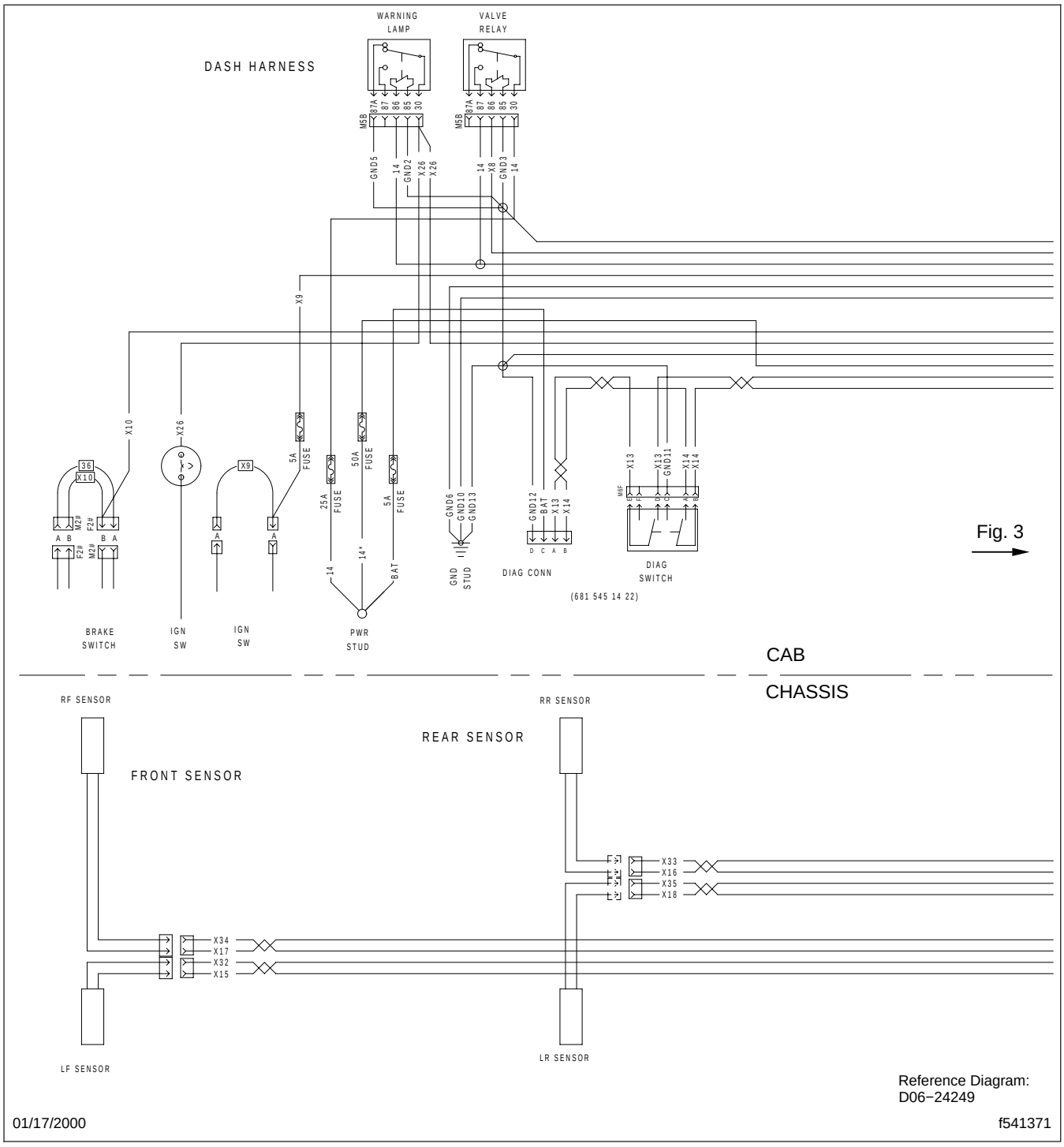
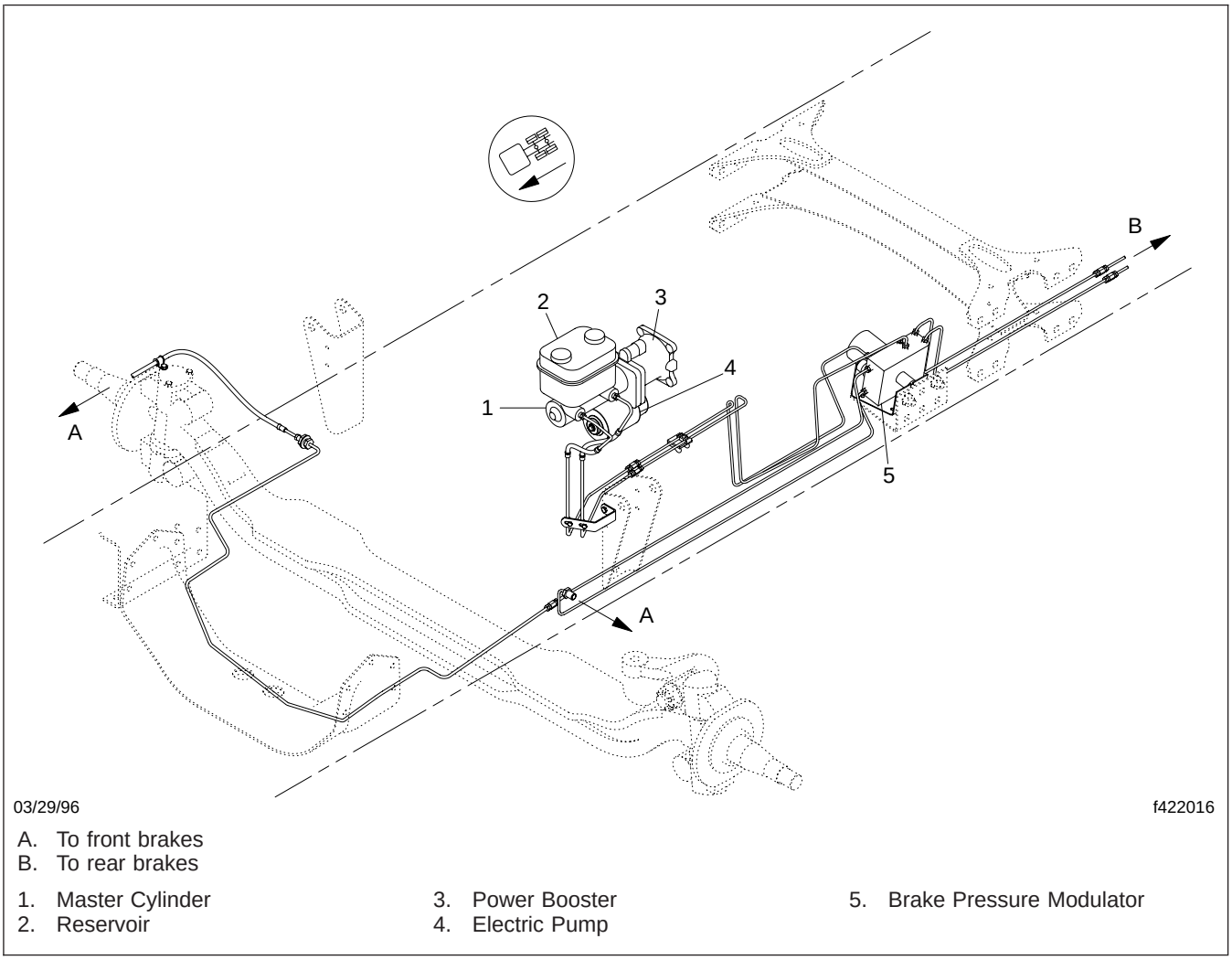


Fig. 3, Partial View of the Cab and Chassis Wiring Diagram

Specifications



A. To front brakes
B. To rear brakes

1. Master Cylinder
2. Reservoir
3. Power Booster
4. Electric Pump
5. Brake Pressure Modulator

Fig. 4, Hydraulic ABS Plumbing

Cab and Chassis Plumbing Diagram

See **Fig. 1** for a full view of the cab and chassis plumbing diagram. See **Fig. 2**, **Fig. 3**, and **Fig. 4** for partial (detailed) views of the plumbing diagram.

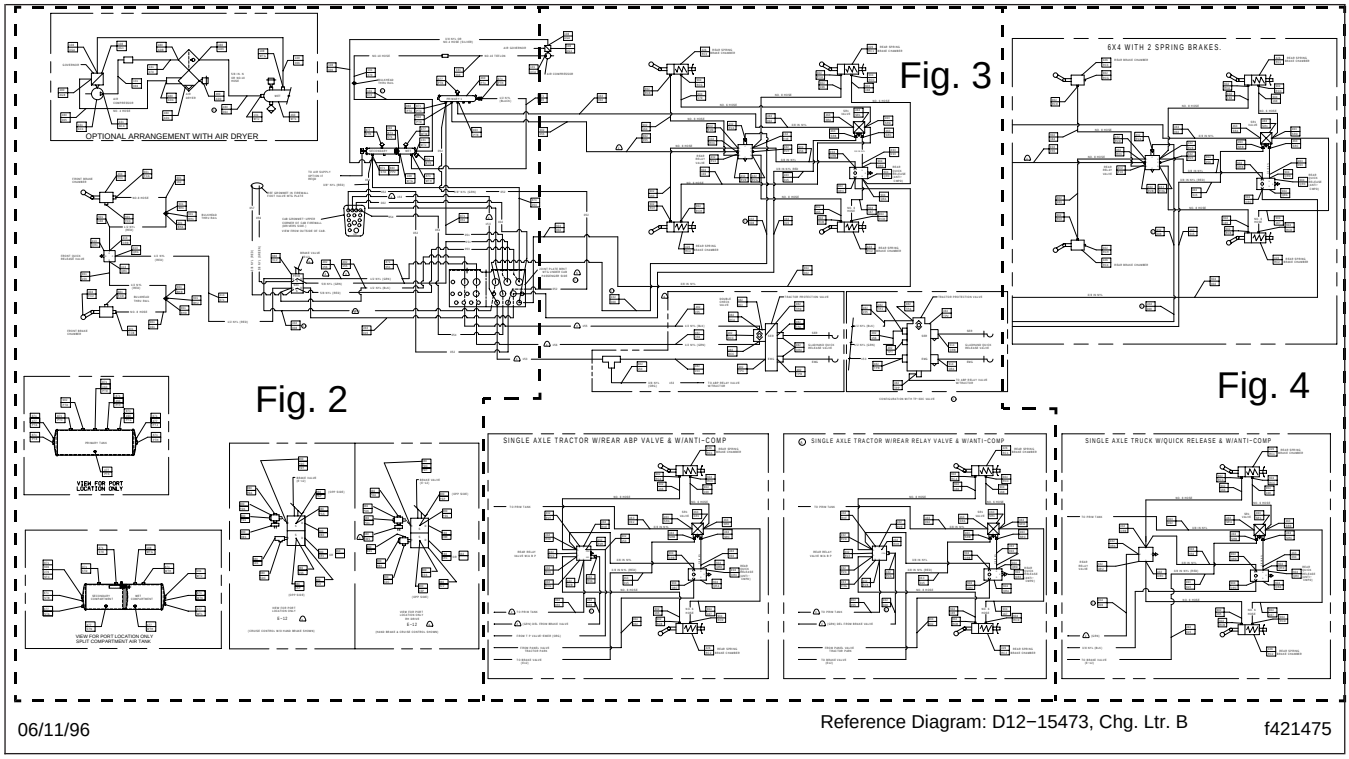


Fig. 1, Cab and Chassis Plumbing Diagram, Right-Hand-Drive Vehicles

Cab and Chassis Plumbing Diagram

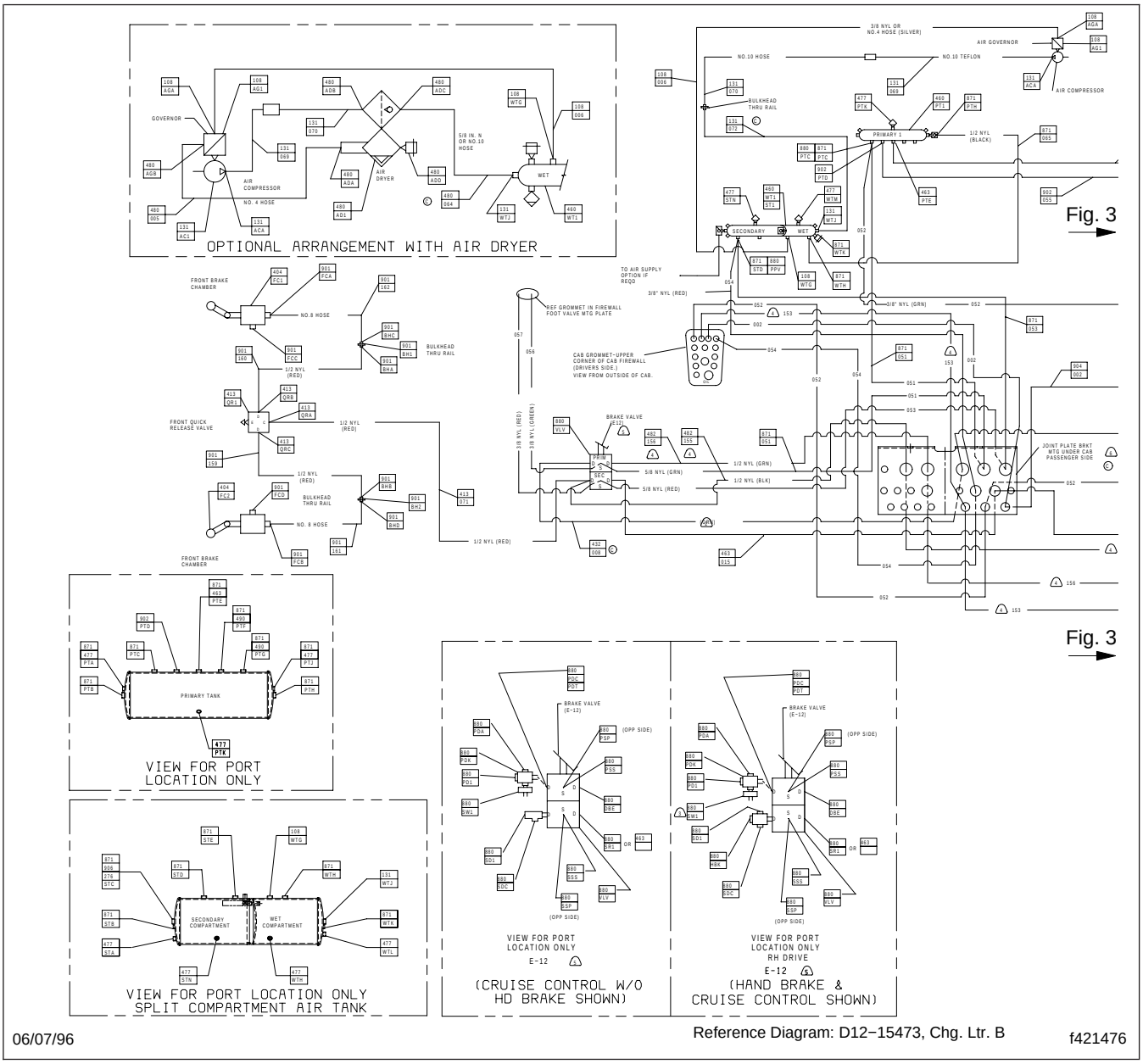


Fig. 2, Partial View of the Cab and Chassis Plumbing Diagram, Right-Hand-Drive Vehicles

Cab and Chassis Plumbing Diagram

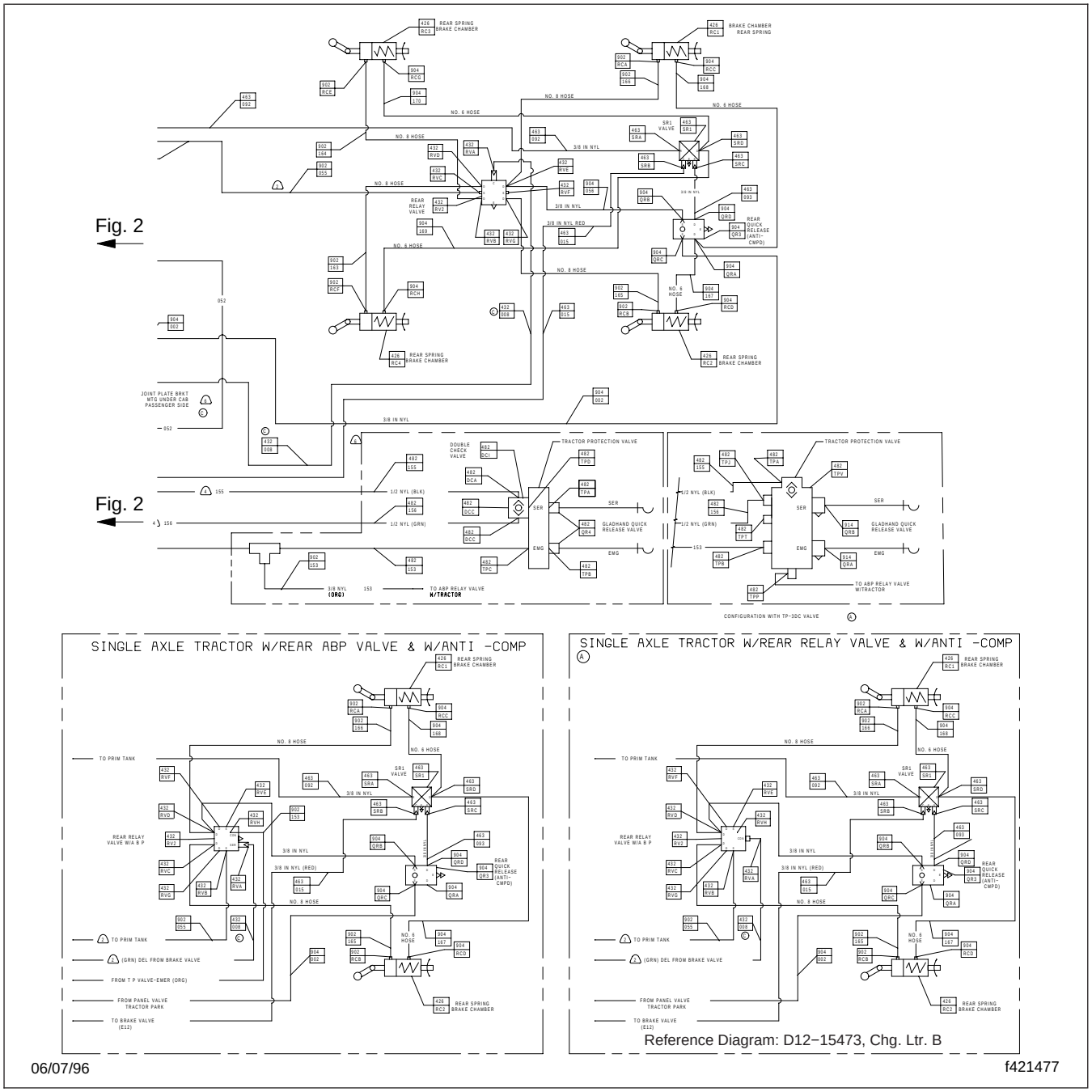
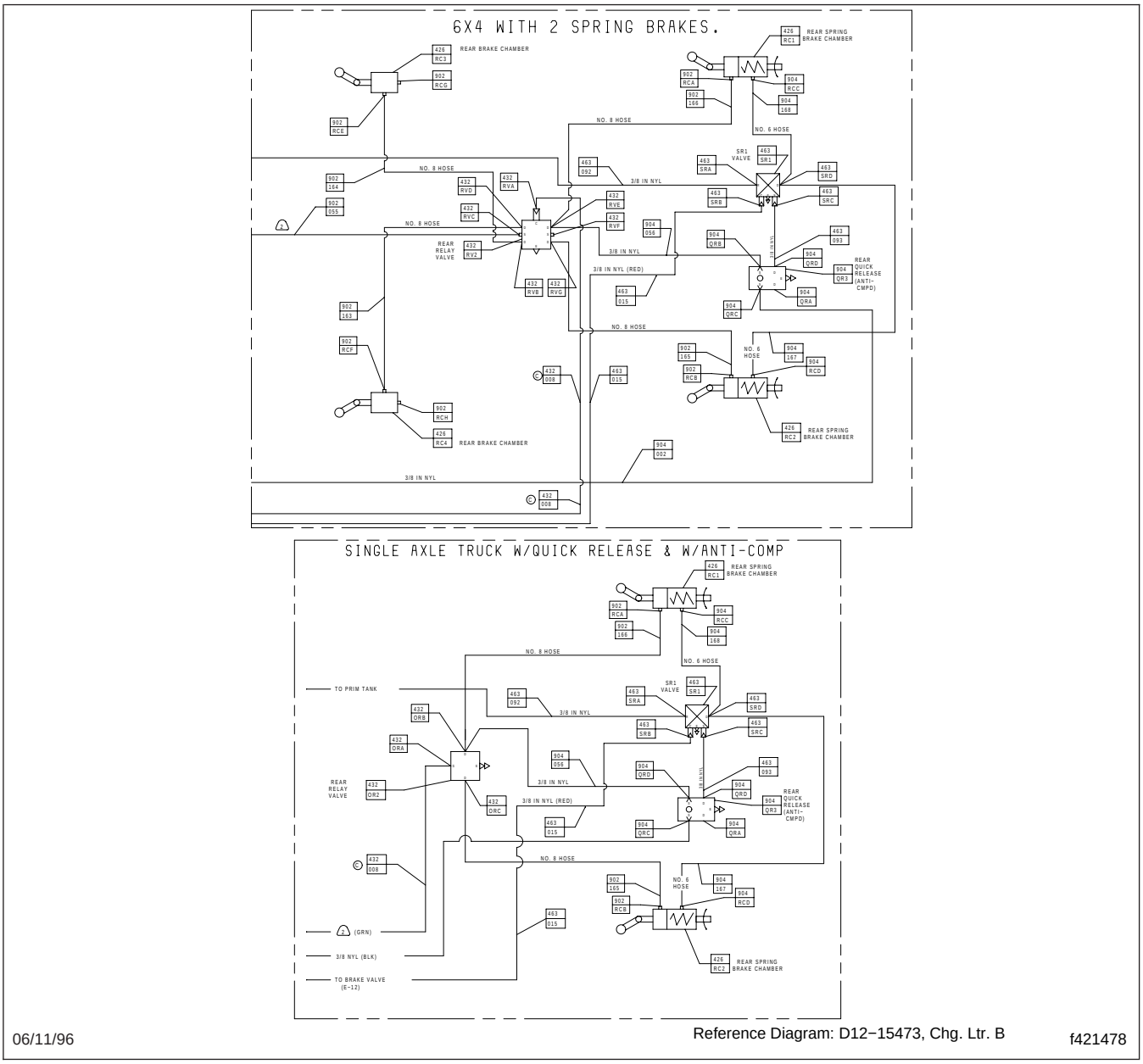


Fig. 3, Partial View of the Cab and Chassis Plumbing Diagram, Right-Hand-Drive Vehicles

Cab and Chassis Plumbing Diagram



06/11/96 Reference Diagram: D12−15473, Chg. Ltr. B f421478

Fig. 4, Partial View of the Cab and Chassis Plumbing Diagram, Right-Hand-Drive Vehicles

General Information

The Allied Signal/Bendix TP–3DC is a tractor protection valve which includes an integral double check valve. The TP–3DC serves two purposes. First, as required by Federal law, the valve protects the tractor brakes in the event of trailer breakaway or a severe air system leak. Second, when used with a dash-mounted trailer supply control valve, the TP–3DC valve can be used to shut off the trailer control line before the trailer is disconnected.

The TP–3DC also includes an integral single check valve which prevents air from getting trapped in the trailer control line. Trapped air in this line could cause service/spring brake compounding and, if the trailer is parked with air applied, a trailer roll-away situation.

On Business Class vehicles, the TP–3DC tractor protection valve is mounted under the left rear cab corner (see **Fig. 1**).

TP–3DC valve port designations and internal components are shown in **Fig. 2**.

Principles of Operation

INITIAL CHARGE **(See Fig. 3)**

Pushing in the red trailer air supply knob (Ref. 1) on the instrument panel causes air to flow into the TP–3DC valve at the tractor supply port (Ref. 2). Air flows through the valve housing, exiting via the auxiliary supply port (if used) and the trailer supply port (Ref. 4), to pressurize the trailer brake system and release the trailer parking brakes.

As air pressure builds in the trailer supply circuit, the single check valve (Ref. 5) seats, and the valve plunger (Ref. 16) begins to move (against spring pressure) toward the guide (Ref. 8). When pressure reaches about 45 psi (310 kPa), the plunger bottoms against the guide and the inlet valve is open.

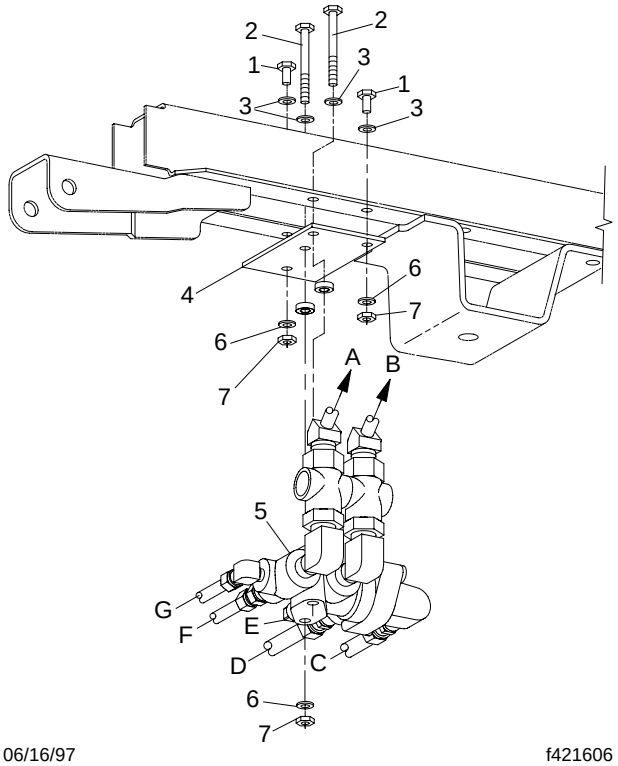
The TP–3DC valve is in the "run" mode, and ready to receive and deliver a service brake application from either the foot valve or the hand valve.

SERVICE BRAKE APPLICATION

(See Fig. 4)

When the foot pedal is pressed, air flows to the TP–3DC valve tractor control primary (Ref. 10) and secondary (Ref. 13) ports. If the trailer control valve (Ref. 14) is also used, the external double check (Ref. 12) delivers the higher pressure (trailer control or foot valve secondary) to the TP–3DC Tractor Control secondary port.

Inside the TP–3DC valve, the higher pressure (primary or secondary) moves the diaphragm (Ref. 9) to seal off the port at the lower pressure.

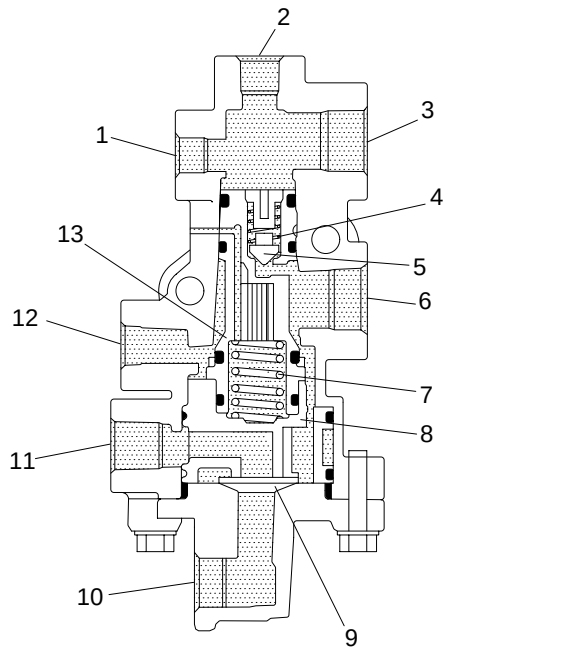


06/16/97 f421606

A. To trailer emergency port
B. To trailer service port
C. From service brake foot valve, primary circuit
D. From service brake foot valve, secondary circuit
E. Pipe Plug
F. From trailer supply valve
G. To proportioning relay (if installed)
1. 5/16–18 x .75" Capscrew
2. 5/16–18 x 3" Capscrew
3. Flatwasher
4. Mounting Plate
5. TP–3DC Tractor Protection Valve
6. 5/16" Lockwasher
7. 5/16" Locknut

Fig. 1, TP–3DC Mounting Location and Connections

General Information and Principles of Operation



02/22/2000 f421487

1. Tractor Supply
2. Auxiliary Supply
3. Trailer Supply
4. Tee Plug and Spring
5. Single Check Valve
6. Trailer Control
7. Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control (Primary)
11. Tractor Control (Secondary)
12. Stop Lamp Switch
13. Plunger

Fig. 2, TP–3DC, Sectional View

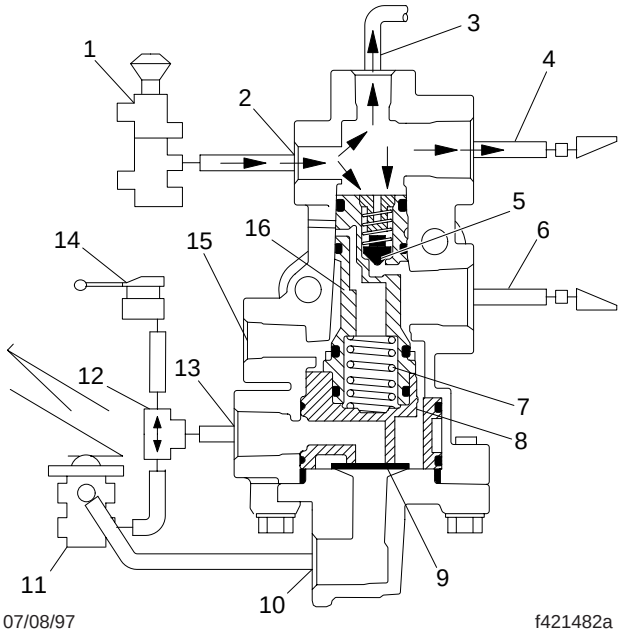
With the plunger bottomed against the guide and the inlet valve open (as described earlier), the higher pressure air flows through the valve to the trailer control port (Ref. 6) and the stop lamp switch, applying the brakes and activating the stop lamps.

NOTE: While air pressure also reaches the TP–3DC single check valve, the valve stays closed because supply pressure is acting on the other side.

SERVICE BRAKE RELEASE

(See Fig. 5)

When the foot pedal is released, air stops flowing into the TP–3DC valve at the tractor control primary (Ref. 10) or secondary (Ref. 13) port. At the same time, air in the trailer control line (Ref. 6) returns to the valve, flowing back through the open inlet valve.



07/08/97 f421482a

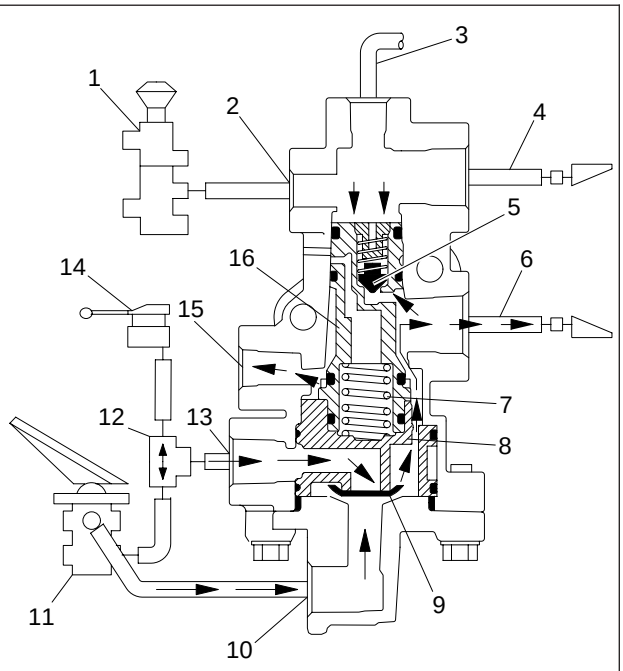
1. Trailer Air Supply Valve
2. Tractor Supply Port
3. Auxiliary Supply Port
4. Trailer Supply Port
5. Single Check Valve
6. Trailer Control Port
7. Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Foot Valve
12. Double Check Valve
13. Tractor Control Port (Secondary)
14. Hand Valve
15. Stop Lamp Switch Port
16. Plunger

Fig. 3, Initial Charge

The air forces the diaphragm (Ref. 9) to seat, sealing off the tractor control primary port. The air then exits the valve at the tractor control (secondary) port (Ref. 13) and flows to the foot valve or hand valve where it is exhausted.

TRACTOR PROTECTION **(See Fig. 6)**

If the red trailer air supply knob on the instrument panel is pulled out (or if a large leak develops in the trailer supply circuit), pressure in the trailer supply circuit (and the auxiliary supply circuit, if used) is vented. When pressure drops to about 20 to 30 psi (138 to 207 kPa), the pressure can no longer over-



1. Trailer Air Supply Valve
2. Tractor Supply Port
3. Auxiliary Supply Port
4. Trailer Supply Port
5. Single Check Valve
6. Trailer Control Port
7. Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Foot Valve
12. Double Check Valve
13. Tractor Control Port (Secondary)
14. Hand Valve
15. Stop Lamp Switch Port
16. Plunger

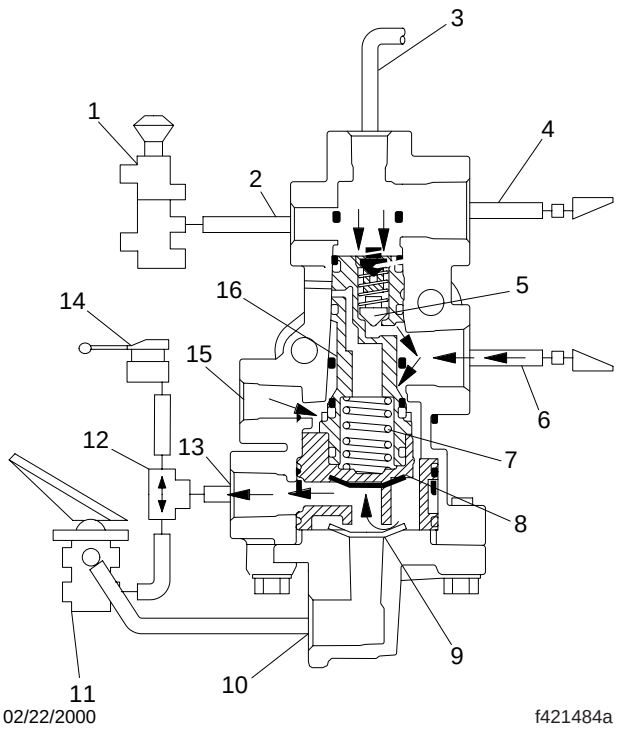
Fig. 4, Service Brake Application

come the spring force inside the TP–3DC valve and the inlet valve closes.

With the inlet valve closed, air pressure from the brake foot or hand control valves will not reach the trailer control circuit when the brakes are applied.

ANTI-COMPOUNDING **(See Fig. 7)**

If the red trailer air supply knob on the instrument panel is pulled out while the service brakes are applied, the single check valve (Ref. 5) in the TP–3DC prevents simultaneous spring and service brake application. As pressure in the trailer supply circuit drops, the spring (Ref. 7) in the TP–3DC valve forces the inlet valve closed (as described above in "Tractor Protection." Any pressure in the trailer control circuit



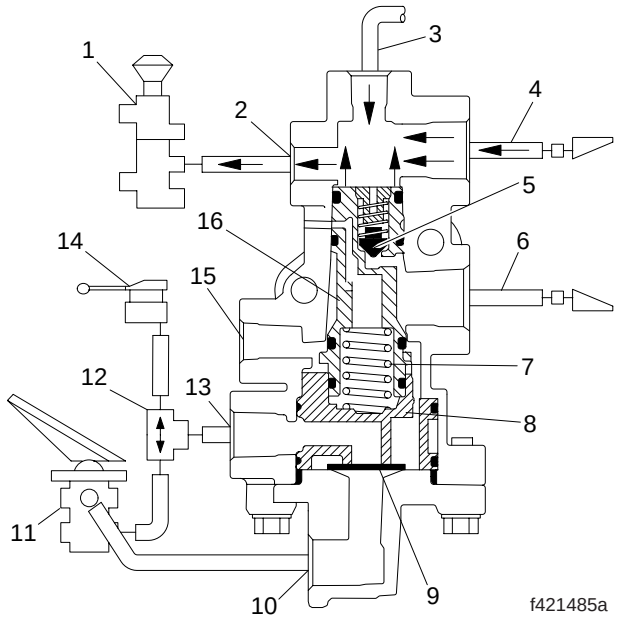
1. Trailer Air Supply Valve
2. Tractor Supply Port
3. Auxiliary Supply Port
4. Trailer Supply Port
5. Single Check Valve
6. Trailer Control Port
7. Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Foot Valve
12. Double Check Valve
13. Tractor Control Port (Secondary)
14. Hand Valve
15. Stop Lamp Switch Port
16. Plunger

Fig. 5, Service Brake Release

(Ref. 6) is relieved by passing first through the single check valve and then exhausting at the trailer supply valve.

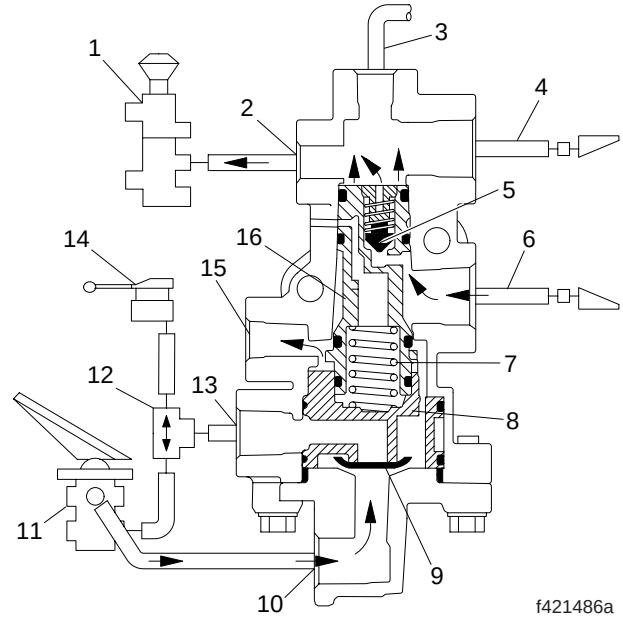
If the service brakes (hand or foot) are released and applied again, the closed inlet valve prevents air pressure from reaching the trailer control circuit.

General Information and Principles of Operation



1. Trailer Air Supply Valve
2. Tractor Supply Port
3. Auxiliary Supply Port
4. Trailer Supply Port
5. Single Check Valve
6. Trailer Control Port
7. Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Foot Valve
12. Double Check Valve
13. Tractor Control Port (Secondary)
14. Hand Valve
15. Stop Lamp Switch Port
16. Plunger

Fig. 6, Tractor Protection



1. Trailer Air Supply Valve
2. Tractor Supply Port
3. Auxiliary Supply Port
4. Trailer Supply Port
5. Single Check Valve
6. Trailer Control Port
7. Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Foot Valve
12. Double Check Valve
13. Tractor Control Port (Secondary)
14. Hand Valve
15. Stop Lamp Switch Port
16. Plunger

Fig. 7, Anti-Compounding

Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

1. Chock the tires and stop the engine before working under the vehicle. Releasing air from the system may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they will apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if not correctly disassembled. Use only correct tools and observe all precautions regarding use of those tools.

Leakage Test

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100.**

1. Chock the tires, start the engine, and run it until the air system is fully charged.
2. Shut down the engine and place the trailer air supply valve in the emergency position.
3. Disconnect the trailer control line hose coupling and apply a soap-water solution to the coupling.
4. With tractor reservoirs charged to at least 100 psi (689 kPa) make and hold a full service brake application using either the foot valve or the trailer control valve. Leakage at the hose coupling should not exceed a 1-inch (2.5-cm) bubble in five seconds.
5. Release the service brake application and place the trailer supply valve in the "run" position. Connect the trailer control valve to a test gauge.
6. Make a service brake application and note that service air pressure is present at the trailer control line hose coupling.
7. Disconnect the air line at the TP–3DC tractor control port (primary), plug the line, and apply a soap-water solution to the valve.
8. Make a service brake application and check for leakage at the open tractor control port. Leakage should not exceed a 1-inch (2.5-cm) bubble in five seconds.
9. Reconnect the air line to the tractor control port (primary) and disconnect the air line at the tractor control port (secondary). Then, plug the disconnected line and apply a soap-water solution to the valve.
10. Make and service brake application and check for leakage at the open tractor control port. Leakage should not exceed a 1-inch (2.5-cm) bubble in five seconds.

IMPORTANT: If the valve does not function as described, or if leakage is excessive, repair or replace the valve.

Removal

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

1. Chock the tires, and open the air reservoir drain cocks to bleed the air from the system.
2. Remove the trailer hose assemblies from the TP–3DC valve. Disconnect the tractor service and supply lines. Mark the lines for later assembly reference. Cap the air lines tightly to keep out contaminants.
3. Remove the fasteners attaching the TP–3DC valve to the vehicle, and remove the valve.

Installation

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

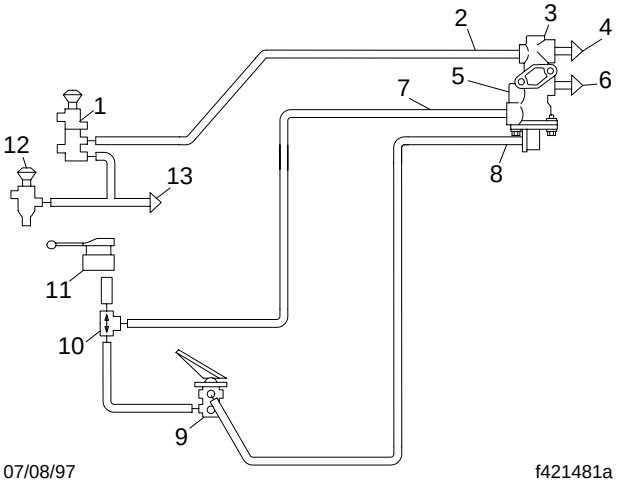
1. Place the TP–3DC valve on the vehicle, and attach it with bolts, washers, and nuts. Tighten the nuts 11 to 15 lbf·ft (15 to 20 N·m).

NOTE: The delivery line from the trailer air supply valve is connected to the tractor emergency port of the TP–3DC valve. See **Fig. 1**. The delivery line from the brake valve (double check valve) is connected to the tractor service port of the TP–3DC valve. Trailer hose assemblies are installed in the trailer emergency and trailer service ports of the TP–3DC valve.

2. Remove the caps from the air lines, and depending on the type of air hose, use the following instructions to connect the air hoses to the TP–3DC valve:

   If equipped with nylon tube air hoses, connect the hose fittings to the valve ports, and tighten the nuts finger-tight. Then, using a wrench, tighten the nuts at least two turns, or until no threads show on the fitting.

   If equipped with wire braid hoses, connect the hose fittings to the valve ports, and hand-tighten the nuts. Using a wrench, tighten the nuts until there is resistance. Tighten one-sixth turn more. Do not overtighten.

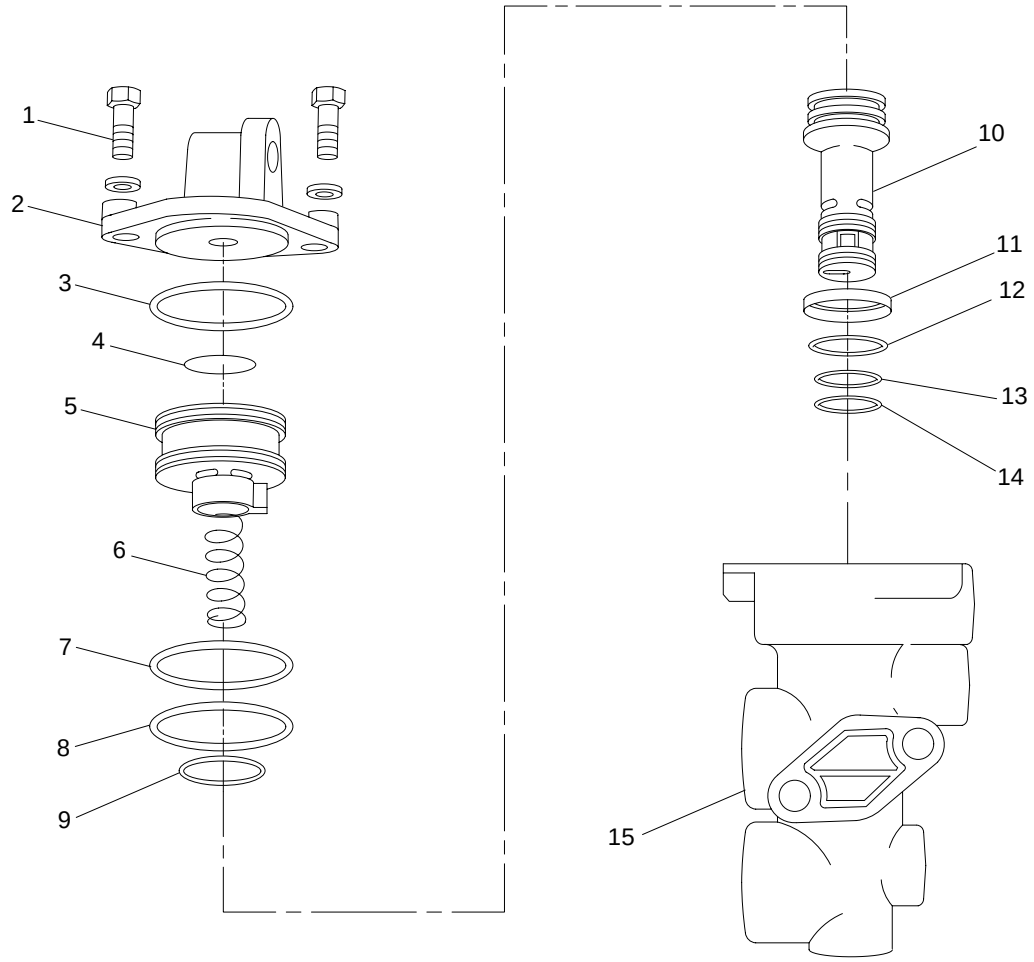


1. Trailer Air Supply Valve
2. Tractor Supply
3. Auxiliary Supply Port
4. Trailer Supply
5. Stop Lamp Switch Port
6. Trailer Control
7. Tractor Control (Secondary)
8. Tractor Control (Primary)
9. Foot Brake Valve
10. Double Check Valve
11. Trailer Control Valve
12. Parking Brake Valve
13. To Tractor Spring Brakes

Fig. 1, Partial Plumbing Diagram, With TP–3DC

3. Close the drain cocks to the air reservoirs. Start the vehicle engine to pressurize the air system.
4. Leak test the TP–3DC valve following the instructions in **Subject 110**.

Disassembly (See Fig. 1)



1. 1/4" Hex/Torx Screw
2. Valve Cover
3. Cover O-Ring
4. Diaphragm
5. Guide
6. Valve Spring
7. Guide O-Ring
8. Guide O-Ring
9. Plunger O-Ring
10. Plunger
11. Collar
12. O-Ring
13. Plunger O-Ring
14. Plunger O-Ring
15. Valve Body

Fig. 1, Exploded View of TP–3DC Valve

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

1. Remove the valve from the vehicle, retaining the mounting hardware. For instructions, see **Subject 120**.
2. Scribe a line across the valve cover (Ref. 2) and valve body (Ref. 15) to ensure proper alignment during assembly.
3. Remove the two 1/4-inch screws (Ref. 1) which secure the valve cover to the valve body and

Disassembly, Cleaning and Inspection, and Assembly

allow the valve spring to expand until the valve cover can be removed.

4. Remove the cover O-ring (Ref. 3) and discard it.
5. Remove the diaphragm (Ref. 4) from the valve body and discard it.
6. Remove the guide (Ref. 5) from the valve body.
7. Remove the O-rings (Refs. 7 and 8) from the guide and discard them.
8. Remove the valve spring from the plunger, then the plunger from the valve body.
9. Remove the O-rings (Refs. 9, 13, and 14) from the plunger and discard them.
10. Remove the collar (Ref. 11) and the O-ring (Ref. 12) from the plunger. Discard the O-ring, but keep the collar.

Cleaning and Inspection

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

1. Wash all metal parts of the TP–3DC valve in cleaning solvent, then dry them using compressed air.
2. Examine the cover, body, guide, and plunger for corrosion, excessive wear, cracks, or other damage. If any of these conditions are found on a part, replace the part with a new one.
3. Check the spring for distortion and corrosion. If the spring is distorted or corroded, replace it.
4. Check the valve body bores for deep scratches or gouging

Assembly

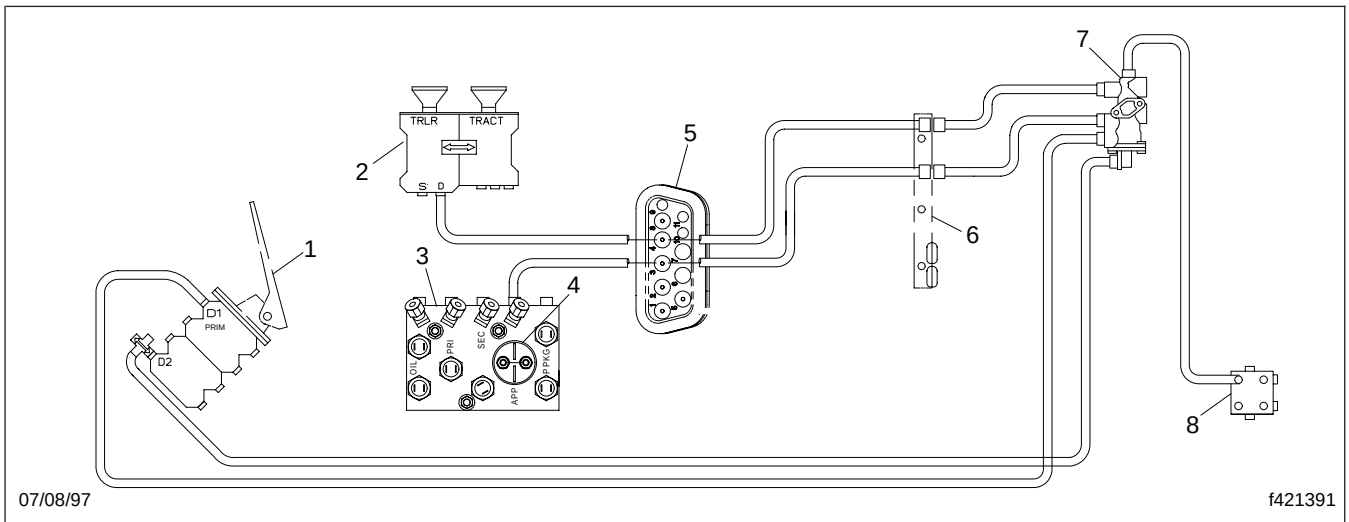
IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions, 100**.

1. Lubricate the O-rings, O-ring grooves, body bores, and all sliding parts with the lubricant provided in the overhaul kit (Bendix silicone lubricant #291126 or equivalent).
2. Install the O-rings (Refs. 9, 13, and 14) on the plunger.
3. Install the O-ring (Ref. 12) on the plunger and then the collar (Ref. 11) over the O-ring. Make sure that the collar is fully seated and firmly in place over the O-ring.
4. Install the plunger into the valve body and the spring (Ref. 6) into the plunger.
5. Install the O-rings (Refs. 7 and 8) in their grooves on the guide.
6. Align the indexing tab on the guide with the notch in the valve body and install the guide in the valve body.
7. Place the diaphragm (Ref. 4) in its recess on the guide.
8. Place the O-ring (Ref. 3) on the cover.
9. Place the cover on the guide and press them down, against spring pressure, until the cover is seated against the valve body.
10. Install the two 1/4-inch screws and tighten them 30 to 60 lbf·in (340 to 675 N·cm).
11. Install the TP–3DC valve on the vehicle following the instructions in **Subject 120**.

See **Fig. 1** for a TP–3DC plumbing diagram.

Torque Values		
Description	**Torque lbf·in (N·cm)**	**Torque lbf·ft (N·m)**
Valve Cover Capscrews	30–60 (340–675)	—
Valve Mounting Capscrews	—	11–15 (15–20)

Table 1, Torque Values

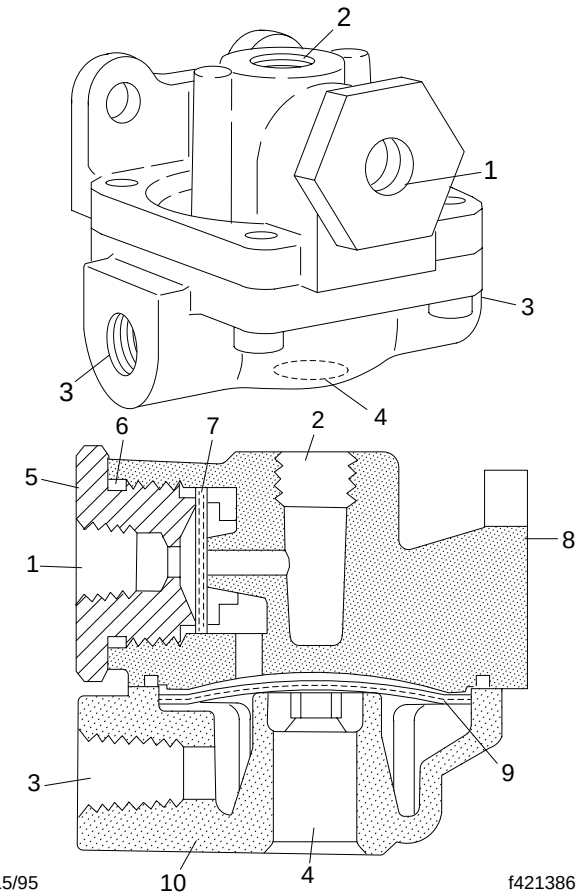


1. Foot Valve
2. Dash Valves
3. Air Manifold
4. Stop Lamp Switch
5. Pass-Thru Grommet
6. Junction Plate
7. TP–3DC Valve
8. Relay Valve

Fig. 1, TP–3DC Plumbing Diagram

General Information

The QR–1C quick release valve **(Fig. 1)** is a dual function valve. Its primary function is to speed up the release of air pressure from the service brake chambers. Additionally, the valve works as an anti-compound device. The double check valve feature prevents a service and parking brake application from occuring at the same time.



1. Supply Port
2. Balance Port
3. Delivery Port
4. Exhaust
5. Cap Nut
6. Sealing Ring
7. Double Check Diaphragm
8. Body
9. Quick Release Diaphragm
10. Cover

Fig. 1, QR-1C Valve and Cross Section

The QR–1C valve is generally mounted near the rear axle. A balance line from the relay valve delivery port (port 2 on the WABCO combination valve) is connected to the balance port on top of the QR–1C quick release valve; the two side ports are for brake chamber connections; the supply port is connected to the delivery port of the parking brake control valve, and the exhaust port is located at the bottom of the valve.

Principles of Operation **(See Fig. 1)**

Parking Brakes Released

When the parking brakes are released, air from the parking brake control valve flows through the QR–1C valve. This forces the double check diaphragm and the quick release diaphragm to flex and seal the balance and exhaust ports. Air flows into the inlet ports of the parking brake chambers from the QR–1C valve delivery ports.

Parking Brakes Applied

When the parking brakes are applied, supply line air pressure to the QR–1C valve is exhausted through the parking brake control valve. As air pressure is exhausted from one side of the double check diaphragm and the quick release diaphragm, both diaphragms flex in the opposite direction to open the balance and exhaust ports. Parking brake pressure is released at the exhaust port of the QR–1C valve while a small amount of air trapped between the two diaphragms is released through a relay valve or the foot valve exhaust port.

Anti-Compounding

When a service brake application is made with the parking brakes applied, service air enters the balance port and flows through the QR–1C valve into the inlet ports of the parking brake chambers. This prevents application of the service and parking brakes at the same time. Service air passing through the QR–1C valve flexes the double check and quick release diaphragms, sealing the supply and exhaust ports. When the service brake application is released, air is exhausted from the parking brakes.

Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

1. Chock the tires and stop the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.

QR–1C Quick Release Valve Operating and Leakage Tests

Operating and Leakage Tests

⚠ WARNING

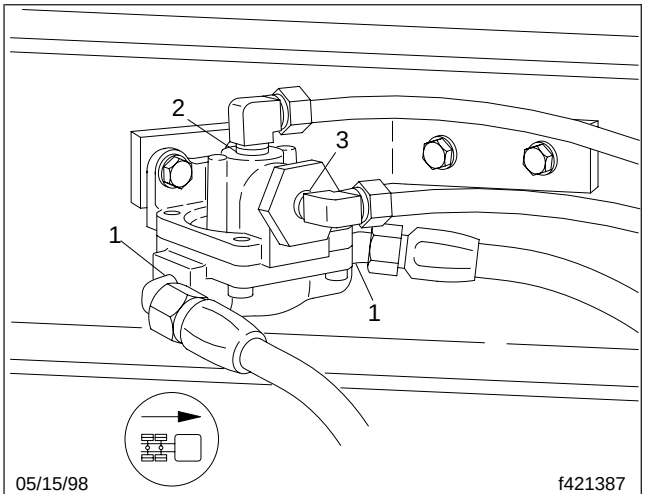
Before working on or around air brake systems and components, review the safety precautions in Subject 100. Failure to do so could result in personal injury.

The following tests should also be performed after repairing or replacing the QR–1C valve to ensure that it is functioning properly.

1. Chock the tires.
2. Drain the air system.
3. Release the parking brakes.
4. Remove the air line from the valve balance port. Build system air pressure to 120 psi (827 kPa). Coat the exhaust and balance ports with a soap solution; leakage of a one-inch bubble in five seconds at either port is allowable. Install the air line at the balance port.
5. Apply the parking brakes. Step on the foot brake; the QR–1C valve should exhaust air at the exhaust port.
6. Drain the air system.
7. Remove the air line from the valve supply port. Build system air pressure to 120 psi (827 kPa). With the foot valve depressed, coat the supply port and the seam between the body and cover with a soap solution; leakage of a one-inch bubble in five seconds at the supply port is allowable. No leakage between the body and cover is permitted. Install the air line at the supply port.
8. If the valve does not function properly, or if leakage is excessive, repair or replace it following the instructions in this section.

QR–1C Quick Release Valve Removal and Installation

Removal (See Fig. 1)



NOTE: Valve mounting inside the left frame rail shown.

1. Delivery Port
2. Balance Port
3. Supply Port

Fig. 1, QR-1C Valve Mounting (plumbing and location will vary depending on vehicle configuration)

WARNING

Before working on or around air brake systems and components, review the safety precautions in Subject 100. Failure to do so could result in personal injury.

1. Chock the tires or hold the vehicle by means other than air brakes.
2. Drain the air brake system.
3. Mark and disconnect the air lines from the quick release valve.
4. Remove the mounting bolts and the valve.

Installation (See Fig. 1)

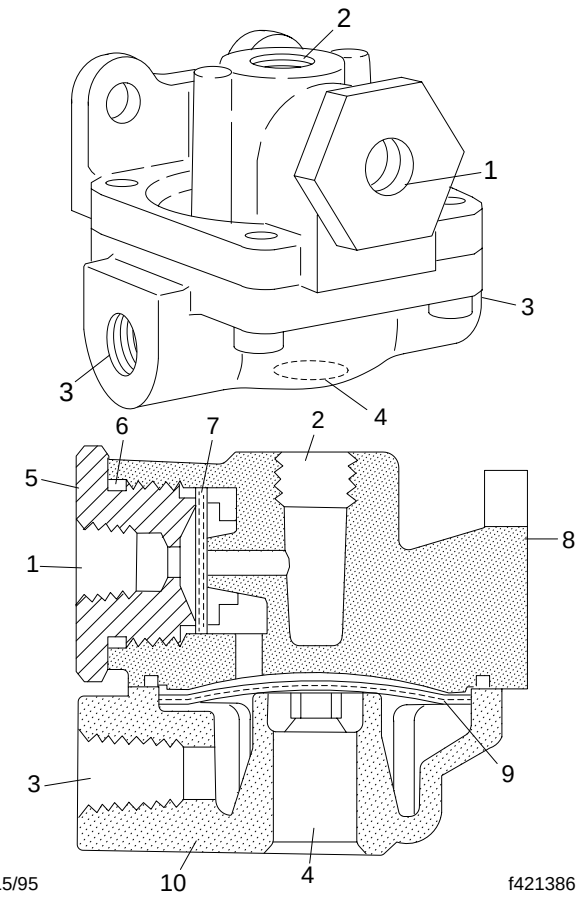
WARNING

Before working on or around air brake systems and components, review the safety precautions in Subject 100. Failure to do so could result in personal injury.

1. Install the quick release valve with the exhaust port facing down. Securely tighten the mounting bolts.
2. Connect the air lines to the quick release valve in the locations previously marked.
3. Perform the operating and leakage tests in **Subject 110.**

QR–1C Quick Release Valve Disassembly, Cleaning and Inspection, and Assembly

Disassembly (See Fig. 1)



1. Supply Port
2. Balance Port
3. Delivery Port
4. Exhaust
5. Cap Nut
6. Sealing Ring
7. Double Check Diaphragm
8. Body
9. Quick Release Diaphragm
10. Cover

Fig. 1, QR-1C Valve and Cross Section

1. Remove the quick release valve from the vehicle following the instructions in **Subject 120.**
2. Mark the valve body and cover for ease of installation.
3. Remove the cap nut at the supply port. Remove the sealing ring from the cap nut.
4. Remove the double check diaphragm.
5. Remove the four screws holding the valve cover on the valve body.
6. Separate the cover from the body and remove the sealing ring and the quick release diaphragm.

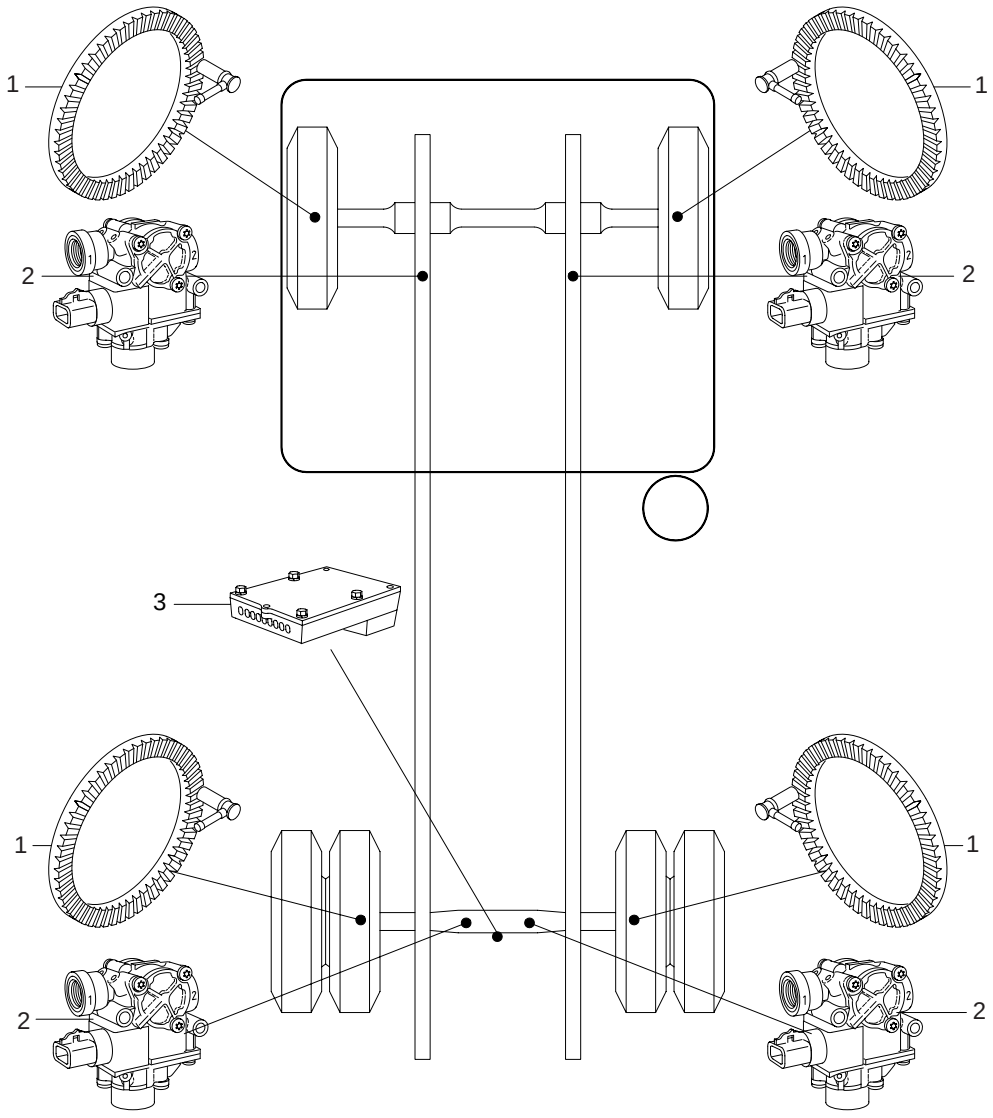
Cleaning and Inspection

1. Clean all metal parts in mineral spirits. Wipe all rubber parts clean.
2. It is recommended that all rubber parts and any other part showing signs of wear or deterioration be replaced with genuine Bendix parts.

Assembly

1. Install the sealing ring on the cap nut.
2. Install the double check diaphragm in the valve body.
3. Install the cap nut. Tighten the nut 150 to 400 lbf·in (1700 to 4520 N·cm).
4. Install the quick release diaphragm in the cover.
5. Install the valve cover on the body. Tighten the screws 30 to 60 lbf·in (340 to 680 N·cm) evenly and securely.
6. Install the quick release valve, following the instructions in **Subject 120.**
7. Do the operating and leakage test as instructed in **Subject 110.**

General Information (See Fig. 1)



07/02/97 f421526

1. Tone Wheel and Sensor
2. Modulator Assembly
3. Electronic Control Unit (ECU)

Fig. 1, Location of ABS Components, Four-Channel System

The Bendix® antilock braking system (ABS) is an electronic wheel-speed monitoring and control system that works with the standard air brake system. ABS passively monitors vehicle wheel speed at all times, and controls wheel speed during emergency

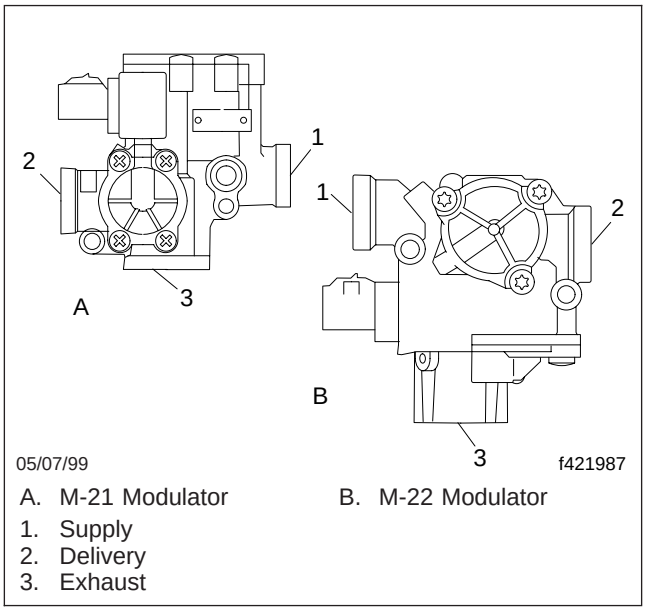
General Information

stops. In normal braking applications, the standard air brake system is in effect.

ABS includes signal-generating tone wheels and sensors located in the wheel hubs of each sensed wheel. The sensors transmit vehicle wheel speed information to an electronic control unit (ECU). According to programmed specifications, the ECU signals the appropriate modulator assembly to increase, reduce, or maintain air pressure supply in the brake chamber. This prevents front and rear wheel lockup, and enhances steering control during emergency braking situations.

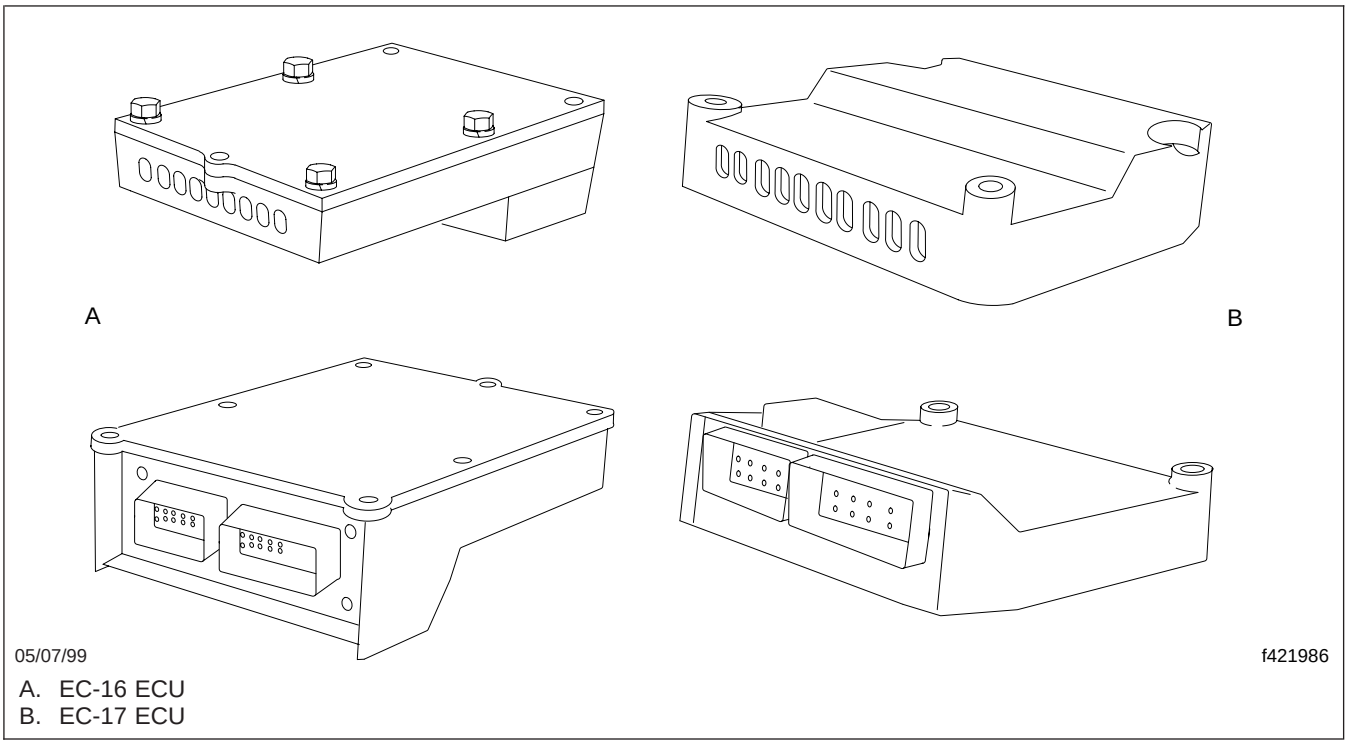
Principles of Operation

The ABS electronic control unit (ECU) (**Fig. 2**) is a digital microcomputer that serves as the information processing and command center for the ABS. The ECU receives and processes vehicle wheel speed information from the sensors. During emergency brake applications, the ECU regulates the braking force applied to each wheel by sending control signals to the modulator assembly (**Fig. 3**).



A. M-21 Modulator
B. M-22 Modulator
1. Supply
2. Delivery
3. Exhaust

Fig. 3, M-21 and M-22 Modulator Assemblies



A. EC-16 ECU
B. EC-17 ECU

Fig. 2, EC-16 and EC-17 ABS Electronic Control Units

ABS MAJOR COMPONENTS

Wheel Speed Sensor

The wheel speed sensors use pulse feedback from 100-tooth tone wheels located in the front and rear axle wheel hubs. When the vehicle is moving, the teeth of the tone wheel cause interruptions in a magnetic field created by the sensor. The interruptions created in the magnetic field in turn create electrical pulses that are sent by the sensor to the ECU.

Electronic Control Unit (ECU)

The ECU receives speed sensor pulses and interprets these signals to calculate wheel speed and a vehicle reference speed. If the calculations indicate wheel slip or lockup, the appropriate control circuit signals the modulator assembly to increase or decrease braking pressure.

There are three versions of the ECU. The older versions (EC-15 and EC-16) are factory programmed with vehicle particulars, such as the number of speed sensors, if the traction control feature was enabled and the type of traction control (torque limiting, differential braking, or both).

The current, self-configuring ECU (EC-17) can be most easily identified while installed on the vehicle. Identification can be made by observing the reaction of the diagnostic display when the ignition is turned on and power is applied to the ECU. The current configuration of the ECU is displayed via the troubleshooting LEDs and occurs during the normal self-test sequence. Only the LEDs that correspond to the sensors identified during the self-configuration will illuminate. If all antilock components are working properly, the red LEDs will turn off and the single, green, VLT LED will be illuminated. This configuration review is repeated each time the ignition is turned on.

IMPORTANT: The LED display is optional on the EC-17. The EC-17N control unit does not have an LED display and the AlliedSignal Bendix Diagnostic Communication Interface (DCI) must be used for diagnostics or reconfiguration.

On the older versions of the ECU, *all* diagnostic LEDs will illuminate and then go out if all antilock components are working properly. During normal operation, all the red LEDs will be off and the single, green, VLT LED will be illuminated. See **Troubleshooting, 300** for more information on the LED display.

The ECU contains a safety circuit to constantly monitor the wheel sensors, modulator assemblies, and the electrical circuitry. After the ignition is switched on, the tractor warning light (TRAC ABS) comes on. See **Fig. 4**. On vehicles with newer ECUs, the TRAC ABS light will go out shortly after the ignition is turned on. On vehicles with the older ECUs, the TRAC ABS light will stay lit until the vehicle reaches 7 mph (11 km/h). The TRAC ABS light will stay on if the tractor's ABS components are not working properly.

When vehicle power is supplied to the EC-17, a modulator "chuff" test is performed. When the brake pedal is depressed while the ECU is powered up, the modulator "chuff" test can be heard. This test will verify if the modulator is connected correctly and is functional. The modulators will exhaust air in the sequence of right front, left front, right rear and left rear. If they do not follow this sequence, proceed with modulator troubleshooting. See **Troubleshooting, 300**.

If, during vehicle operation, the safety circuit senses a failure in any part of the ABS system (a sensor, modulator assembly, wiring connection, short circuit, etc.), the TRAC ABS light comes on, and the control circuit where the failure occurred is switched to normal braking action. Remaining control circuits will retain the ABS effect. Even if the ABS system is completely inoperative, normal braking is maintained. The vehicle is not disabled.

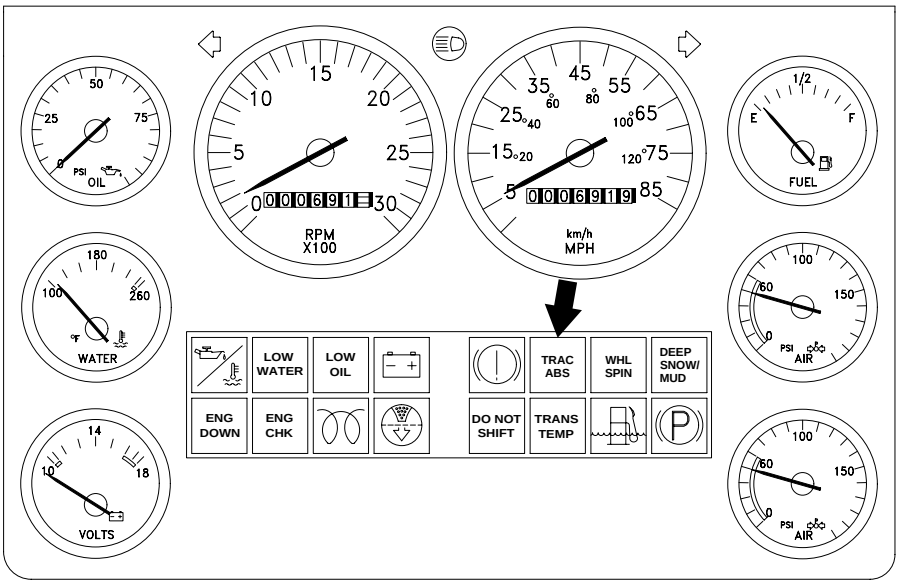
IMPORTANT: If the ABS warning lights do not work as described above, there is a possible system malfunction. If this occurs, the vehicle will continue to have normal braking ability, but without ABS. Service the ABS as soon as possible. See **Troubleshooting, 300** for fault diagnosis.

Modulator Assembly

To ensure proper operation, ABS solenoid/modulator valves must be plumbed properly. If the valve plumbing is removed during service, care must be taken to ensure the air lines are plumbed to the correct valve ports when reinstalled.

Depending on the signal received from the ECU, the modulator assembly prevents wheel lockup by reducing, maintaining, or increasing brake chamber air pressure. During normal braking applications, com-

General Information



05/10/99 f601812

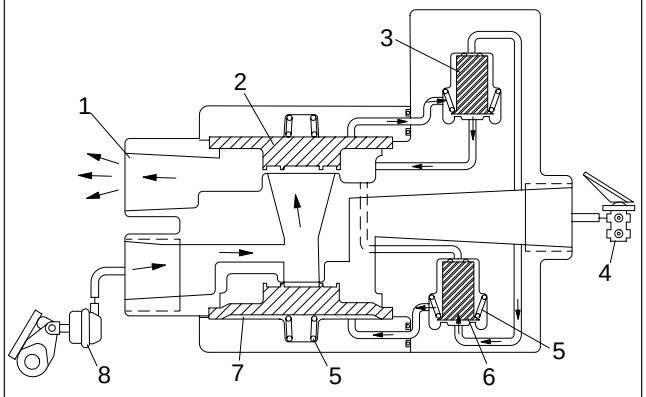
Fig. 4, TRAC ABS Indicator Light

pressed air flows freely to the brake chamber through the modulator assembly.

If the ECU receives signals indicating wheel lockup during a brake application, the ECU energizes both the supply and exhaust solenoids in the modulator assembly. See **Fig. 5**. Energizing the supply solenoid causes its exhaust to close and its inlet to open. With the inlet of the supply solenoid open, application air is permitted to flow to the control side of the supply diaphragm. Air pressure acting on the supply diaphragm causes it to close the supply diaphragm and prevent further delivery of air to the brake chamber.

Energizing the exhaust solenoid closes its inlet and opens its exhaust. By closing the exhaust solenoid inlet, application air is prevented from flowing to the control side of the exhaust diaphragm. Air pressure, which was present on the control side of the exhaust diaphragm flows out the exhaust port of the modulator assembly. With control air pressure removed from the exhaust diaphragm, brake application air forces the exhaust diaphragm to unseat which allows it to flow out the modulator exhaust port.

As wheel speed increases, the modulator assembly alternately increases, then maintains brake pressure until the proper wheel speed is obtained, or until wheel lockup occurs and the control cycle starts again.



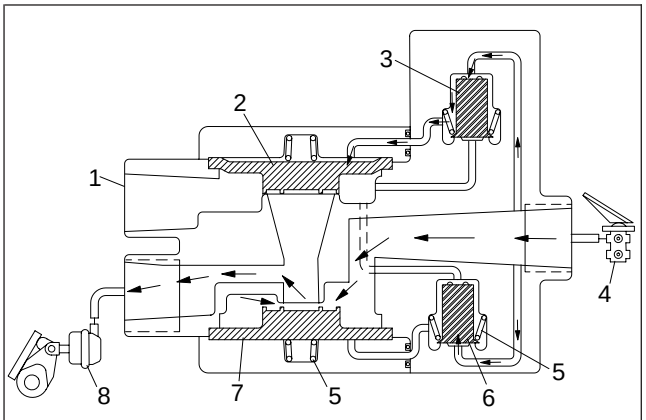
04/09/96 f421450

1. Exhaust Port
2. Exhaust Diaphragm
3. Exhaust Solenoid Energized
4. Brake Valve
5. Spring
6. Supply Solenoid Energized
7. Supply Diaphragm
8. Brake Chamber

Fig. 5, Wheel Lockup

During the pressure increase cycle (**Fig. 6**), brake application air enters the supply port of the modulator assembly and flows to, and through, the open ex-

haust solenoid, then to the exhaust diaphragm. Air pressure, along with spring force, seats the exhaust diaphragm on the exhaust passage thus preventing the escape of service air. At the same time, application air flows to the supply diaphragm and forces it away from its seat. Air flows past the open supply and out the modulator assembly delivery port to the service brake chambers.

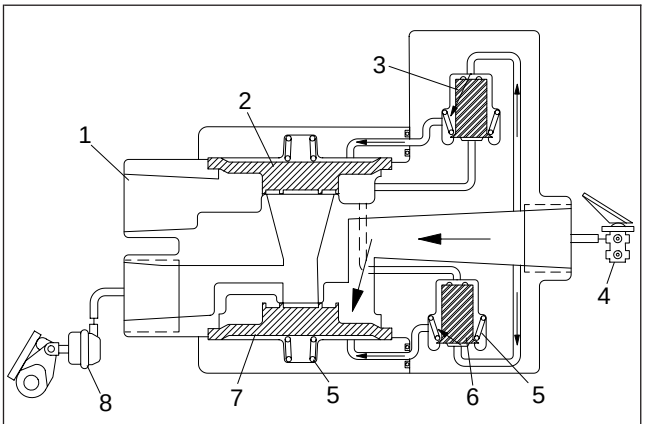


04/09/96 f421449

1. Exhaust Port
2. Exhaust Diaphragm
3. Exhaust Solenoid
4. Brake Valve
5. Spring
6. Supply Solenoid
7. Supply Diaphragm
8. Brake Chamber

Fig. 6, Pressure Increase

If maintaining brake air pressure (**Fig. 7**), the ECU energizes the supply solenoid and de-energizes the exhaust solenoid. This seats both diaphragms and prevents further exhaust of brake chamber air pressure and prevents the application air from flowing out of the delivery port to the brake chamber.



06/29/98 f421451

1. Exhaust Port
2. Exhaust Diaphragm
3. Exhaust Solenoid
4. Brake Valve
5. Spring
6. Supply Solenoid
7. Supply Diaphragm
8. Brake Chamber

Fig. 7, Maintaining Pressure

Replacement

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. See **Group 54** of this manual for information on special terminals and connectors, and on ordering tools for them.

FRONT AXLE

1. Chock the rear tires to prevent vehicle movement. Apply the parking brakes.
2. Twist and pull the sensor to remove it from the steering knuckle (see **Fig. 1**).

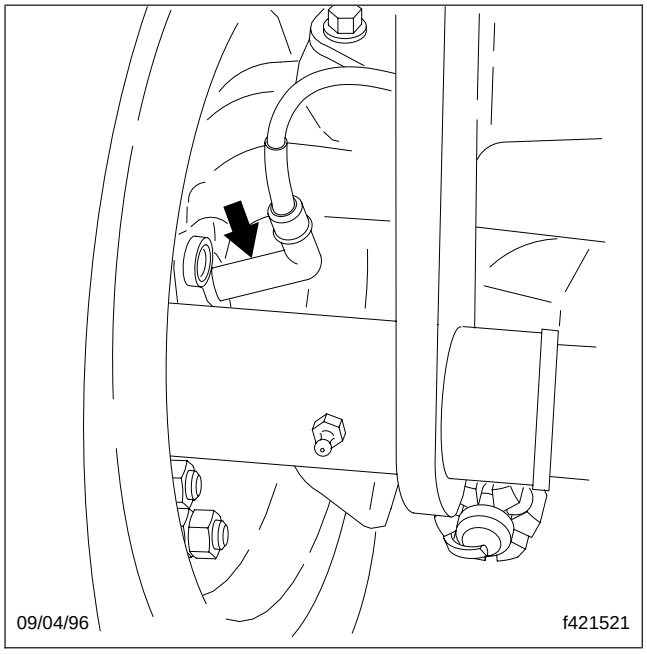


Fig. 1, Wheel Speed Sensor

3. Remove the sensor cable from the steering knuckle top cap.
4. Disconnect the sensor cable from the chassis harness.
5. Remove the clamping bushing from the brake spider hole.
6. Connect the sensor cable to the chassis harness.
7. Attach the sensor cable to the steering knuckle top cap.
8. Push the clamping bushing into the brake spider hole until it stops.
9. Coat the sensor with Mobil HP, Valvoline EP 633, Penzoil 707L, or an equivalent grease. Push the sensor into the clamping bushing until it is stopped by the tone wheel.
10. Remove the chocks from the rear tires.

REAR AXLE

1. Chock the front tires to prevent vehicle movement. Apply the parking brakes.
2. Raise the rear of the vehicle until the tires clear the ground. Place safety stands under the axle.
3. Back off the slack adjuster to release the rear axle brake shoes.
4. Remove the wheel and tire assembly from the rear axle. For instructions, see **Group 40** of this manual.
5. Remove the brake drum. For instructions, see **Group 35** of this manual.
6. Twist and pull the sensor to remove it from the mounting block in the axle housing.
7. Remove the clamping bushing.
8. Remove the capscrew that attaches the sensor cable and the hose clamp to the axle tube.
9. Disconnect the sensor cable from the chassis harness.
10. Connect the sensor cable to the chassis harness.
11. Attach the hose clamp and sensor cable to the axle tube located between the backing plate and the spring plate.
12. Push the clamping bushing into the mounting block until it stops.
13. Coat the sensor with Mobil HP, Valvoline EP633, Penzoil 707L, or an equivalent grease. Push the sensor into the clamping bushing until it is stopped by the tone wheel.
14. Install the brake drum on the wheel hub.
15. Adjust the rear axle brakes. For instructions, see **Group 42** of this manual.

Wheel Speed Sensor Replacement

16. Install the wheel and tire assembly, and tighten the wheel nuts. Use the tightening sequence and torque values listed in **Group 40** of this manual.
17. Remove the safety stands, lower the vehicle, and remove the chocks from the front tires.

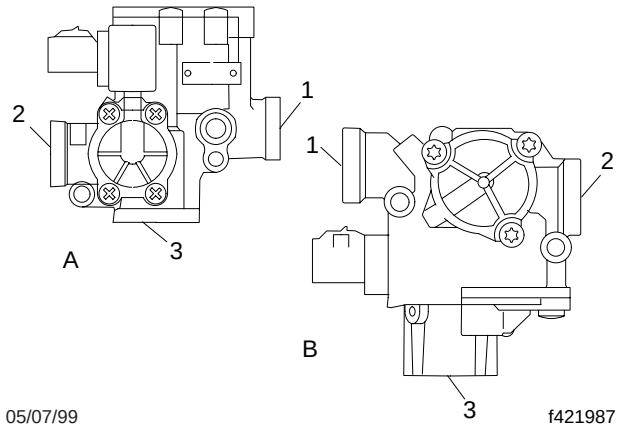
Replacement

WARNING

Reversal of supply and delivery air lines plumbed to the modulator could cause the vehicle brakes to lock up, and remain locked, during a hard brake application. Locked brakes may cause the vehicle to slide or cause loss of steering and/or stability, possibly resulting in vehicle damage or personal injury.

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. See **Group 54** of this manual for information on special terminals and connectors, and on ordering tools for them.

1. Chock the front and rear tires.
2. Release the pressure from the air reservoirs.
3. Disconnect the wiring from the modulator assembly.
4. Disconnect the air supply line (**Fig. 1**) and the air discharge line.



A. M-21 Modulator
B. M-22 Modulator
1. Supply
2. Delivery
3. Exhaust

Fig. 1, M-21 and M-22 Modulator Assemblies

IMPORTANT: Modulator porting is reversed on the M-21 modulator.

5. Remove the two mounting capscrews and nuts.
6. Remove the modulator assembly.
7. Position the modulator assembly and install the two mounting capscrews and nuts. Tighten the mounting nuts 18 lbf·ft (24 N·m).
8. Connect the air supply line (**Fig. 1**) and the air discharge line.

IMPORTANT: Modulator porting is reversed on the M-21 modulator.

9. Connect the wiring to the modulator assembly.
10. Remove the chocks from the front and rear tires.

Adjustment

NOTE: The following adjustment procedure requires the use of special tool T11–17556–000. Use of this tool, available through the PDCs, eliminates the time-consuming task of removing the wheel and tire assembly, and the brake drum. See **Fig. 1**.

1. Park the vehicle on level ground, set the parking brake, and shut down the engine.

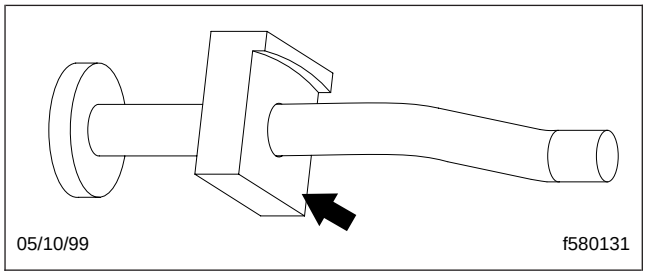
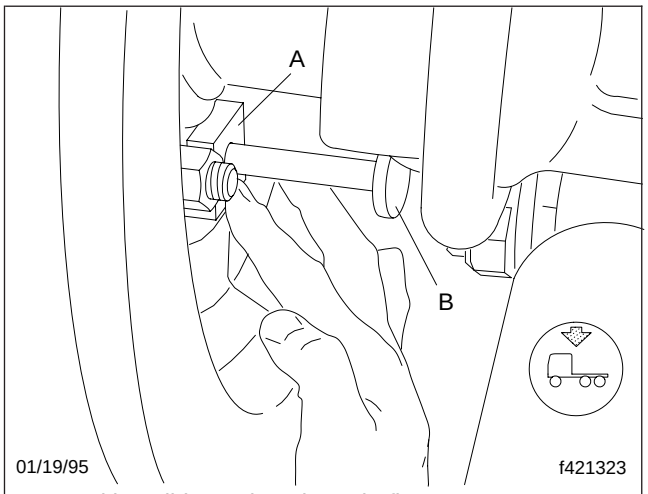


Fig. 1, ABS Sensor Adjustment Tool Slide

2. Chock the front tires.
3. Find the sensor access hole in the rear axle flange.
   - 3.1 View the brake drum and axle from the rear. The ABS sensor wiring harness should be visible passing through a hole in the 12 o'clock position.
   - 3.2 Find the S-cam at either the 3 o'clock or 9 o'clock position.
   - 3.3 Just opposite the S-cam is the sensor access hole, approximately 3/4 inch (19 mm) diameter.
4. Insert the service tool T11–17556–000 into this hole.
5. Position the slide of the tool on the axle flange to align the tool. See **Fig. 2**.
6. Tap the tool lightly with the palm of your hand. This will ensure the sensor is touching the tone wheel.
7. Remove the tool from the wheel and repeat the procedure on the other rear axle speed sensor.
8. Remove the chocks from the tires.



A. Position slide against the axle flange.
B. Tap here with your hand.

Fig. 2, Position the Tool

Using the Electronic Control Unit (ECU) Panel Lights (LEDs)

This system has built-in diagnostics to ensure that all components are operating properly. After the ignition is turned on, the tractor warning light (TRAC ABS) comes on. On vehicles with newer ECUs, the TRAC ABS light will go out shortly after the ignition is turned on. On vehicles with the older ECUs, the TRAC ABS light will stay lit until the vehicle reaches 7 mph (11 km/h). The TRAC ABS light will go out if the tractor's ABS components are working properly. See "Electronic Control Unit (ECU)" in **Subject 050** for more information. If the light stays on, or comes back on later, a problem within the ABS system has occurred. The vehicle can continue to be driven, but the ABS system could be partially or completely inoperative. However, normal braking ability is maintained. To check the type of fault code recorded, stop the vehicle and turn off the engine. Then, turn on the ignition switch, but do not start the engine. If the warning light is still on, there is a system fault that must be repaired to ensure proper system operation. Faults are displayed by the ECU panel lights. See **Fig. 1**. If the warning light is not on, an "intermittent" fault has occurred. An intermittent fault could involve a power surge, taking the system out of voltage range for a moment. In such cases, the problem basically corrects itself; the ECU memory is cleared and the system is restored to full ABS capability.

NOTE: LED lamps are not serviceable.

Following is a list of the faults displayed by the ECU panel lights (**Fig. 1**). Once a fault has been recorded, turn on the ignition switch, but do not start the engine.

- FRT (front): This red lighted display indicates the location of a malfunctioning component or its wiring. This light will always come on with either the right (RHT) or left (LFT) display light, and the modulator (MOD) or sensor (SEN) display light.
- MID (middle or forward sensed rear axle on 6S/4M systems only): This red lighted display indicates the location of a malfunctioning sensor or its wiring. This light will always come on with either the RHT or LFT display light, and the SEN display light.

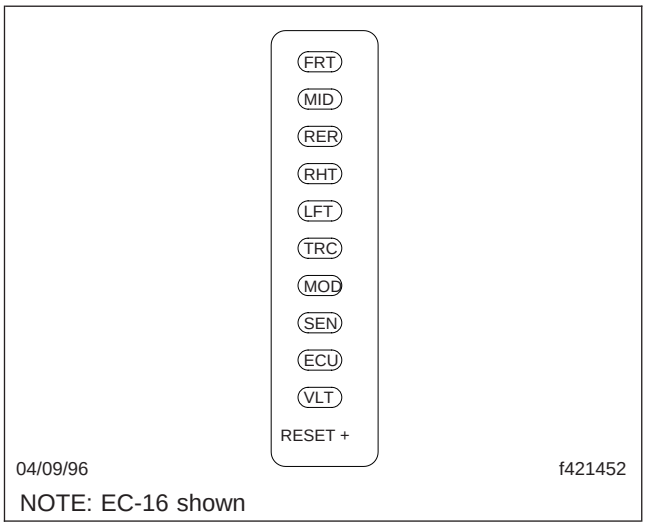


Fig. 1, ECU Panel Lights (LEDs)

- RER (rear): This red lighted display indicates the location of a malfunctioning component or its wiring. This light will always come on with either the RHT or LFT display light, and the MOD or SEN display light.
- RHT (right): This red lighted display indicates the location of a malfunctioning component or its wiring. This light will always come on with either the FRT or RER display light, and the MOD or SEN display light.
- LFT (left): This red lighted display indicates the location of a malfunctioning component or its wiring. This light will always come on with either the FRT or RER display light, and the MOD or SEN display light.
- TRC (traction control, if equipped): This red lighted display indicates a problem within the traction control system. This light may come on by itself, or with the MOD display light (indicating a problem within the automatic traction control relay valve).
- MOD (modulator): This red lighted display indicates an open or short circuit in the solenoid(s) of one of the modulators. This light will always come on with two positioning display lights RHT or LFT plus FRT or RER. The light may also come on with the TRC display light which would indicate a problem within the automatic traction control relay valve or its wiring. Also, the red MOD light will come on if:

Troubleshooting

- The traction enable/disable switch is in the wrong position;
- Traction engine serial communication is lost;
- The traction solenoid is not connected or not operating properly.

- SEN (sensor): This red lighted display indicates an open or short circuit in the sensor circuit. This light will always come on with two positioning display lights RHT or LFT plus FRT, MID, or RER.
- ECU (electronic control unit): This red lighted display indicates that the ECU is inoperative.
- VLT (voltage): This green lighted display is always on during vehicle operation. The light indicates proper system voltage. If vehicle power is out of range (below 11 or above 17 volts), the light will flash until the power problem is corrected.
- RESET: Beneath the reset display is a magnetically sensitive switch used to clear fault codes and reset the ABS diagnostic system. This switch is also used to self-configure the ECU.

A system fault cannot be cleared from ECU memory until the fault is corrected. Once corrected, faults can be cleared one at a time from ECU memory. To clear a fault, pass a small magnet (capable of lifting a three ounce weight) over the RESET display on the ECU (**Fig. 1**). Once all of the lights on the ECU come on, remove the magnet. Holding the magnet against the RESET display for longer than 10 to 20 seconds could cause the ECU to go into a self-configuration mode.

Before troubleshooting, check all fuses in the control unit panel, and replace if necessary. Check the wiring to the warning lights. Refer to **Table 1**, and repair or replace the wiring as needed. Make sure that a charged 12-volt battery is available (the ABS system needs at least 11 volts to work).

IMPORTANT: The key switch must be on when doing the tests in **Table 1.**

Once a fault code has been identified, use a volt/ohmmeter to check the electrical harness at the ECU's 30-pin or 18-pin connector. See **Fig. 2** and **Fig. 3**. Touch the ohmmeter leads to the applicable terminals on the connector, not the ECU.

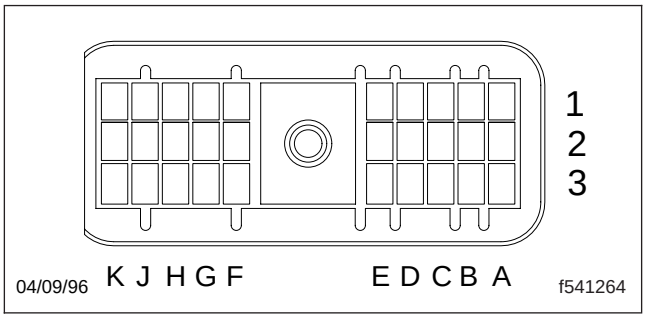


Fig. 2, 30-Pin Connector, Terminal View

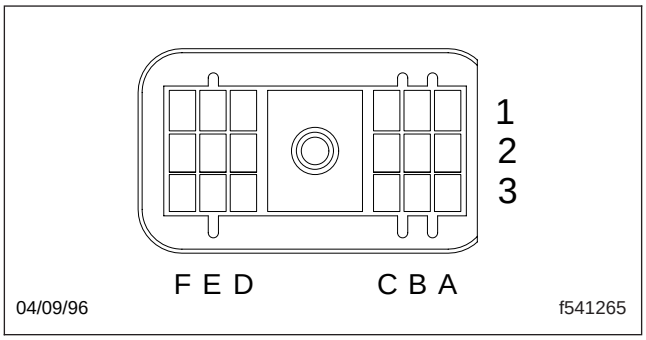


Fig. 3, 18-Pin Connector, Terminal View

IMPORTANT: The ignition switch must be off when connecting or disconnecting the ECU.

Refer to the problem charts for a listing of all diagnostic panel displays (system faults), terminals to be tested, and the correct volt/ohmmeter readings. Repair or replace the components and/or wiring if the readings are not correct.

NOTE: If a dealer has Freightliner Service Link, fault code information can be read from Service Link. For more information, see Service Bulletin 00-20.

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals.

See **Group 54** of this manual for information on special terminals and connectors, and for information on ordering tools for them.

See the appropriate wiring diagram in **Specifications, 400** when troubleshooting the ABS system.

Warning Lamp Wiring Check				
Wiring Tested	**Test These Pins**	**Volt/Ohmmeter Reading**	**Possible Cause**	**Remedy**
Tractor Warning (TRAC ABS) Light	On the 30-pin connector, pins E3 and A1, E3 and A2, and E3 and A3.	Voltage should be the same as battery voltage.	Wiring to the light is shorted or open; or the bulb needs replacing.	Repair the wiring, or replace the bulb.
WHL SPIN Light (if equipped with ATC)	On the 30-pin connector, pin C2.			

Table 1, Warning Lamp Wiring Check

Problem—Battery Voltage is Too Low or Too High (Green VLT LED is Flashing)

Problem—Battery Voltage is Too Low or Too High (Green VLT LED is Flashing)	
Possible Cause	**Remedy**
Damaged ECU or unsatisfactory battery voltage and wiring continuity	If VLT or ECU is displayed, test the voltage on the 30-pin connector between battery terminals B1, K2, K3, and ground terminals A1, A2, and A3. Voltage between the terminals should be 11 to 17 volts. If the voltage readings are okay, replace the ECU. If the voltage readings are incorrect, check the battery voltage and wiring continuity. Repair or replace as needed.

Problem—Sensor Out of Adjustment, Wheel Speed Erratic, or Sensor Circuit Damage (Red SEN LED is On)

Problem—Sensor Out of Adjustment, Wheel Speed Erratic, or Sensor Circuit Damage (Red SEN LED is On)	
Possible Cause	**Remedy**
Damage to the tone wheel, wheel sensor, and/or sensor wiring to the ECU on the axle	If RHT or LFT and FRT plus SEN is displayed, measure the resistance on the 30-pin connector between terminals J1 and J2 (left front), and H2 and H3 (right front). If the readings are not 1500 to 2500 ohms, measure the resistance between the terminals at the sensor. Repair or replace as needed. If RHT or LFT and RER plus SEN is displayed, measure the resistance on the 18-pin connector between terminals F2 and F3 (left rearmost), and E2 and E3 (right rearmost). If the readings are not 1500 to 2500 ohms, measure the resistance between the terminals at the sensor. Repair or replace as needed. If RHT or LFT and MID plus SEN is displayed on the 18-pin connector, measure the resistance between terminals C2 and C3 (left rear), and B2 and B3 (right rear). If the readings are not 1500 to 2500 ohms, measure the resistance between the terminals at the sensor. Repair or replace as needed.
A sensor may be out of adjustment, or there is excessive hub runout	
Tire size is mismatched	Repair or replace as needed.

Troubleshooting

Problem—Open or Short Circuit in the Modulator, and/or Wiring to the Ground Connection (Red MOD LED is On)

Problem—Open or Short Circuit in the Modulator, and/or Wiring to the Ground Connection (Red MOD LED is On)	
Possible Cause	**Remedy**
Damage to the modulator valve and cab wiring connections on the axle	If RHT or LFT and FRT plus MOD is displayed, measure the resistance on the 30-pin connector between terminals G1 and H1 (left front), C1 and D1 (right front), F1 and H1 (left front), and C1 and E1 (right front). The resistance between the terminals should read 3.5 to 5.0 ohms. Measure the resistance between terminals G1 and F1 (left front), and D1 and E1 (right front). Resistance between the terminals should read 7 to 10 ohms. Also, there should be no continuity between any of the previously referenced terminals, and ground terminals A1, A2, A3, and J3. If the above readings are not correct, check the resistance between the pins at the modulator valve (see **Fig. 4**). Resistance between pins A and B, and B and C should be 3.5 to 5.0 ohms. Resistance between pins A and C should be 7 to 10 ohms. There should be no continuity between any of these pins and ground. Repair or replace as needed. If RHT or LFT and RER plus MOD is displayed, measure the resistance on the 18-pin connector between terminals E1 and F1 (left rear), A1 and B1 (right rear), D1 and F1 (left rear), and A1 and C1 (right rear). Resistance should read 3.5 to 5.0 ohms. Measure the resistance between terminals D1 and E1 (left rear), and B1 and C1 (right rear). Resistance between the terminals should read 7 to 10 ohms. Also, there should be no continuity between any of the previously referenced terminals, and ground terminals A1, A2, A3, and J3. If the above readings are not correct, check the resistance between the pins at the modulator valve (see **Fig. 4**). Resistance between pins A and B, and B and C should be 3.5 to 5.0 ohms. Resistance between pins A and C should be 7 to 10 ohms. There should be no continuity between any of these pins and ground. Repair or replace as needed.

Problem—Open or Short Circuit in the Traction Control Relay Valve and/or Wiring to the Ground Connection (Red

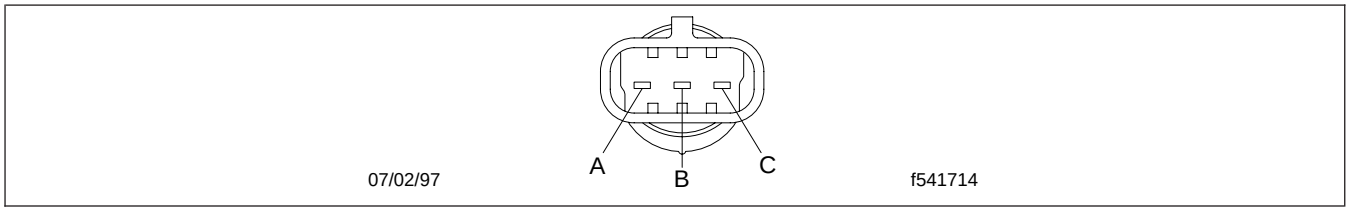


Fig. 4, Modulator Valve Connector Pin Identification

TRC LED and Red MOD LED are On)

Problem—Open or Short Circuit in the Traction Control Relay Valve and/or Wiring to the Ground Connection (Red TRC LED and Red MOD LED are On)	
Possible Cause	**Remedy**
Open or shorted circuit in the traction control relay valve and/or cab wiring connections	If TRC and MOD is displayed, measure the resistance on the 18-pin connector between terminals D2 and D3. Resistance between the terminals should be 10 to 12 ohms. Check continuity at the 30-pin connector between terminals A1, A2, A3, and terminals D2 and D3. There should be no continuity between these terminals. If the above readings are not correct, check the resistance between the pins at the connector at the relay valve. Resistance between the pins should be 10 to 12 ohms. There should be no continuity between ground pins A1, A2, and A3 (on the 30-pin connector), and the pins D2 and D3 at the valve connector. Repair or replace as needed.

Problem—J 1922 Electronic Engine Data Link is Not Working Properly (Red TRC LED is On)

Problem—J 1922 Electronic Engine Data Link is Not Working Properly (Red TRC LED is On)	
Possible Cause	**Remedy**
Damage to the data link and/or data link wiring	If TRC is displayed, check for continuity between terminals B2 and B3 on the 30-pin connector, and the two corresponding terminals on the engine's electronic control module. Repair or replace as needed.

See **Fig. 1** for a full view of the wiring diagram for the Bendix ABS system. See **Fig. 2** and **Fig. 3** for partial (detailed) views of **Fig. 1**.

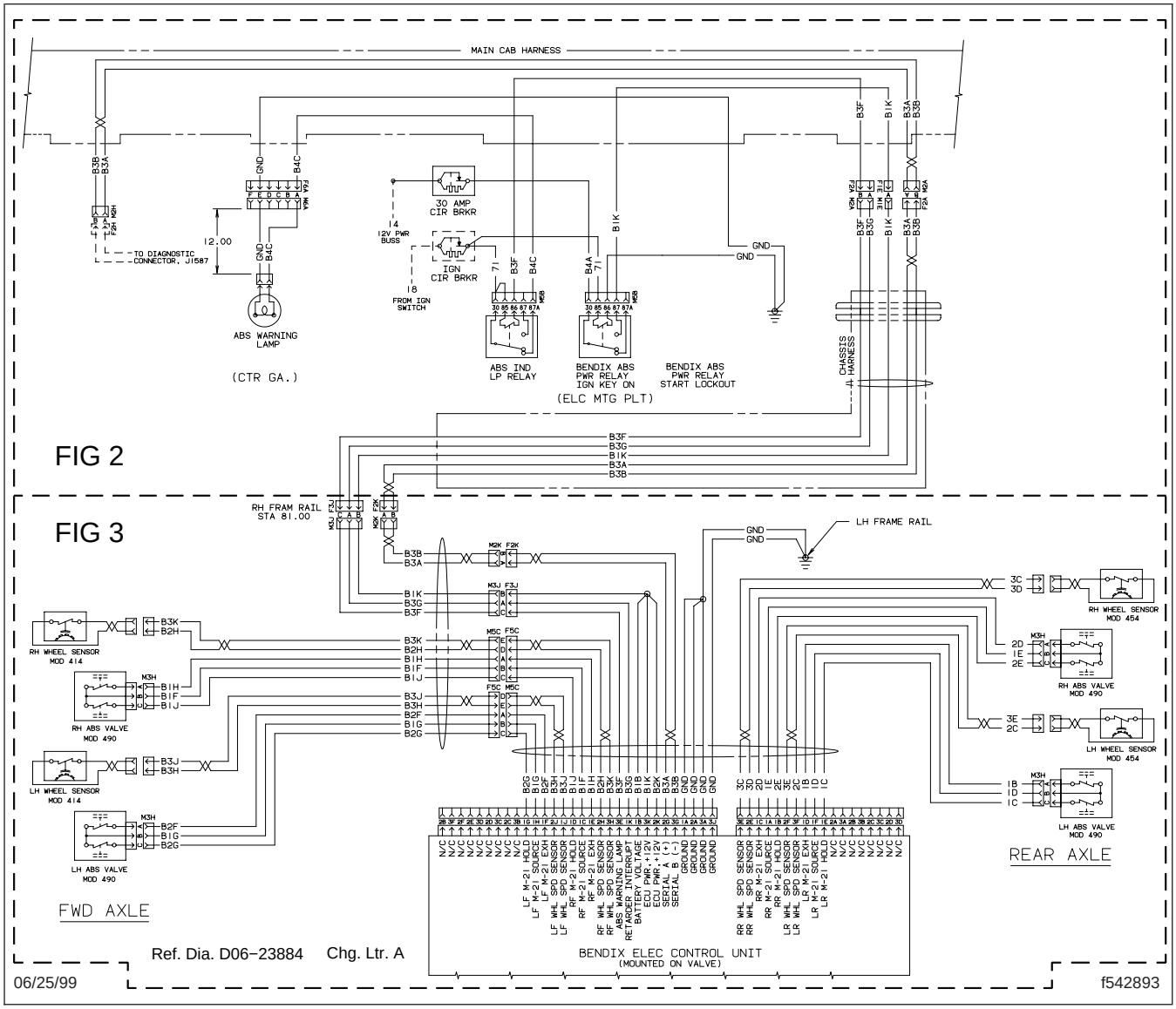


Fig. 1, Wiring Diagram for the Bendix ABS System

Specifications

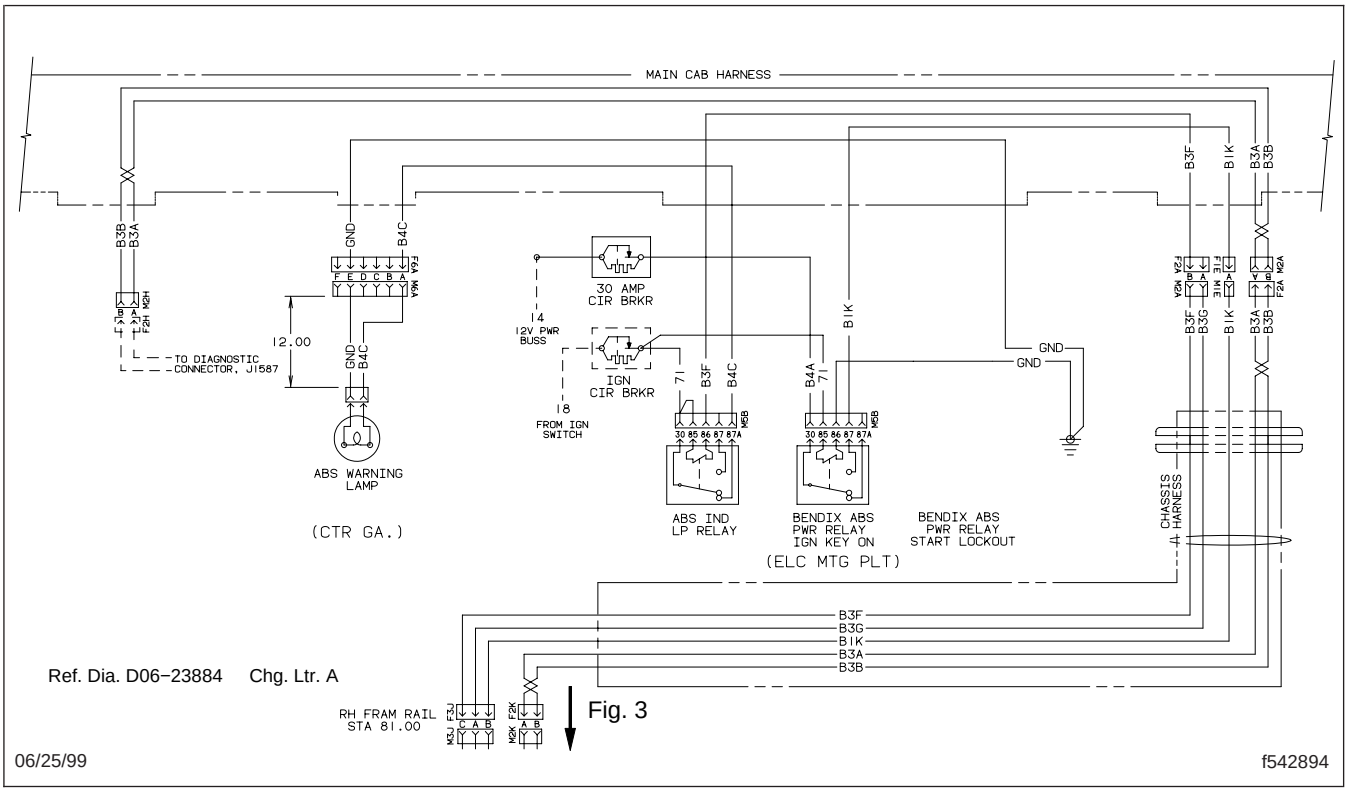


Fig. 2, Partial View of the Bendix ABS System Wiring Diagram

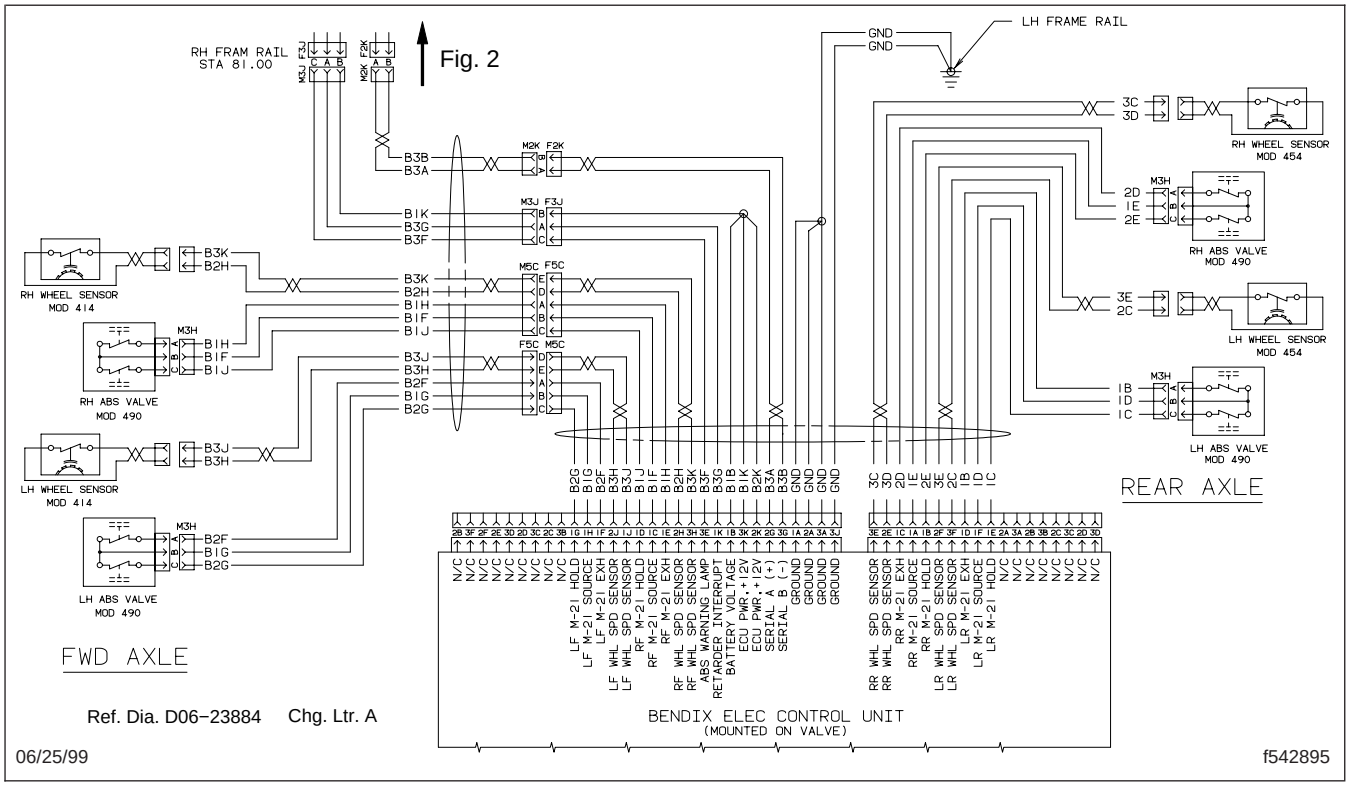
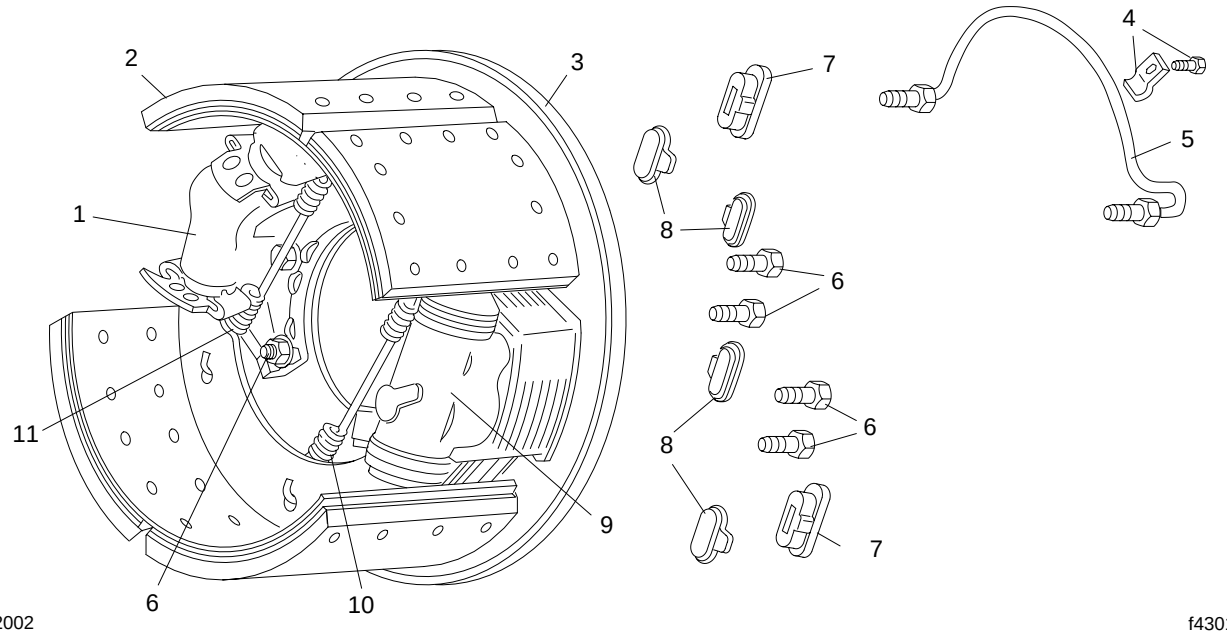


Fig. 3, Partial View of the Bendix ABS System Wiring Diagram

General Description

DURAPARK® rear hydraulic drum brakes are self-adjusting and include a parking brake function as an integral part of the brake assembly. Each DURAPARK brake consists of a backing plate, two brake shoes and lining assemblies, an adjuster cylinder, and a park cylinder. See **Fig. 1**.

- Two lining inspection holes allow for inspection and measurement of the shoe-to-drum clearance.
- Two adjuster slots provide access to the manual override wheel of the adjuster cylinder to increase or decrease the shoe-to-drum clearance. This should only be needed to set a specific shoe-to-drum clearance during initial installation or for backing the shoes off to enable a lipped drum to be removed.
- Two adjuster sight holes are used to make sure the adjusting tool is inserted in the adjusting slot correctly without damaging the dust boot on the cylinder.



NOTE: Brake configuration for spring suspensions shown.

1. Adjuster Cylinder Assembly
2. Brake Shoe and Lining
3. Backing Plate
4. Retaining Clip and Screw
5. Bridge Pipe
6. Cylinder Mounting Bolts, 7/32-inch
7. Manual Override Access Plug
8. Inspection Plugs
9. Park Cylinder Assembly
10. Return Spring, Orange or White
11. Return Spring, Green or Yellow

Fig. 1, DURAPARK Rear Hydraulic Drum Brake Assembly

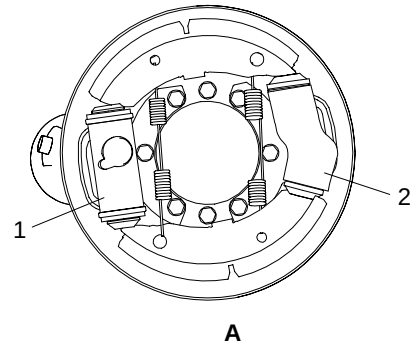
IMPORTANT: The figures in this subject illustrate installation of brakes on vehicles with spring suspensions. On vehicles with Freightliner AirLiner suspensions, the park cylinder and adjuster cylinder positions are reversed. See **Fig. 2**.

The two cylinders are conventional wheel cylinders with special functions. The adjuster cylinder contains automatic adjusters that maintain the shoe-to-drum clearance within a specified range. The park cylinder applies and releases the brake shoes for parking.

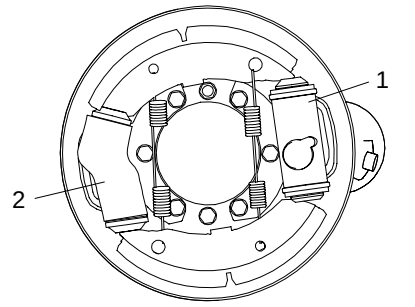
The backing plate has six mounting holes:

NOTE: There are more than six total holes in the backing plate. Additional holes are used for mounting the ABS sensor on some applications.

General Information



A



B

04/17/2002 f430299

A. Standard Brake Configuration
B. AirLiner Suspension Configuration
1. Park Cylinder
2. Adjuster Cylinder

Fig. 2, DURAPARK Brake Configurations

Principles of Operation

Service Brake Operation

The adjuster and park cylinders are connected to each other through a bridge pipe. As a result, increasing the hydraulic pressure in one also increases the pressure in the other.

When the brake pedal is applied, increased hydraulic pressure in the adjuster cylinder forces two pistons outward, moving one end of each shoe toward the drum. At the same time, increased pressure in the park cylinder forces its pistons outward, moving the other end of each shoe toward the drum.

When the shoes contact the drum, they are forced around in whichever direction the drum is moving until the pistons stop against the cylinder body. Thus, regardless of forward or reverse rotation, the brake is always a two leading-shoe brake.

In the forward direction the torque load is taken by one adjuster cylinder piston bottoming in its bore, and by the park cylinder abutment piston head resting against the cylinder body. In the reverse direction, the torque is taken by the other adjuster cylinder piston bottoming and the expander piston head resting against the park cylinder body.

Parking Brake Operation

When the parking brakes are applied, the hydraulic pressure in the spring chamber is released. A spring in the parking brake chamber then forces a wedge and roller assembly into the park cylinder and forces the pistons outward, pressing the shoes against the drums.

Automatic Adjustment

In the DURAPARK brake, automatic adjustment is carried out by the adjuster cylinder. The adjuster cylinder contains two adjuster units, each unit individually adjusting the appropriate shoe. The clearance between the shoe and the drum is governed by the axial clearance (backlash) built into each adjuster mechanism.

Automatic brake shoe adjustment as the lining material wears has important advantages:

- An optimum shoe-to-drum clearance is maintained.
- Response time of the brake is kept to a minimum.
- Hydraulic brake fluid movement is kept to a minimum.
- Excessive taper wear of the lining along the shoe is avoided and lining life maximized.
- Vehicle downtime for adjustment is eliminated.

Although DURAPARK brakes adjust automatically and maintain the shoe-to-drum clearance within a specified range, correct and full adjustment occurs only when the drum is rotating. Pumping the brake pedal with the vehicle stationary will not achieve the proper adjustment.

⚠ WARNING

Wear a respirator at all times when servicing the brakes, starting with the removal of the wheels and continuing through assembly. Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH.

⚠ WARNING

Hydraulic brake fluid is hazardous, and can cause blindness if it gets in your eyes. Always wear safety glasses when handling brake fluid or bleeding brake components. Brake fluid may also be a skin irritant. If you get it on your skin, wash it off as soon as possible.

Safety Precautions

Medical experts believe that long-term exposure to some brake lining fibers could be a health hazard, so the following precautions should be observed when servicing all brake linings.

Areas where brake work is done should be separate from other operations, if possible. As required by regulations, the entrance to the areas should have a sign displayed indicating the health hazard.

During brake servicing, an air purifying respirator with high-efficiency filters must be worn. The respirator and filter must be approved by MSHA or NIOSH, and worn during all procedures.

OSHA recommends that enclosed cylinders equipped with vacuums and high-efficiency (HEPA) filters be used during brake repairs. Under this system, the entire brake assembly is placed within the cylinder and the mechanic works on the brake through sleeves attached to the cylinder. Compressed air is blown into the cylinder to clean the assembly, and the dirty air is then removed from the cylinder by the vacuum.

If such an enclosed system is not available, the brake assembly must be cleaned in the open air. During disassembly, carefully place all parts on the floor to minimize creating airborne dust. Using an industrial vacuum cleaner with a HEPA filter system, remove dust from the brake drums, brake backing plates, and brake parts. After vacuuming, any remaining dust should be removed using a rag soaked in water and wrung until nearly dry. Do not use compressed air or dry brushing to clean the brake assembly.

Work areas should be cleaned by industrial vacuums with HEPA filters or by wet wiping. Compressed air or dry sweeping should never be used for cleaning. Respirators should be used when emptying vacuum cleaners and handling asbestos waste products.

Special care must be taken when disposing of used brake fluid. Put the fluid in a sealed plastic container and label it "Used Brake Fluid." Then dispose of it in an approved manner. Check with local and state regulations as to the correct disposal procedure.

Removal

WARNING

Before doing this procedure, read the information in Safety Precautions 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

1. Park the vehicle on a level surface and chock the front tires.
2. Make sure the parking brakes are released. Releasing the parking brakes pressurizes the spring chambers and compresses the parking brake springs. The engine must be running while the parking brakes are released.

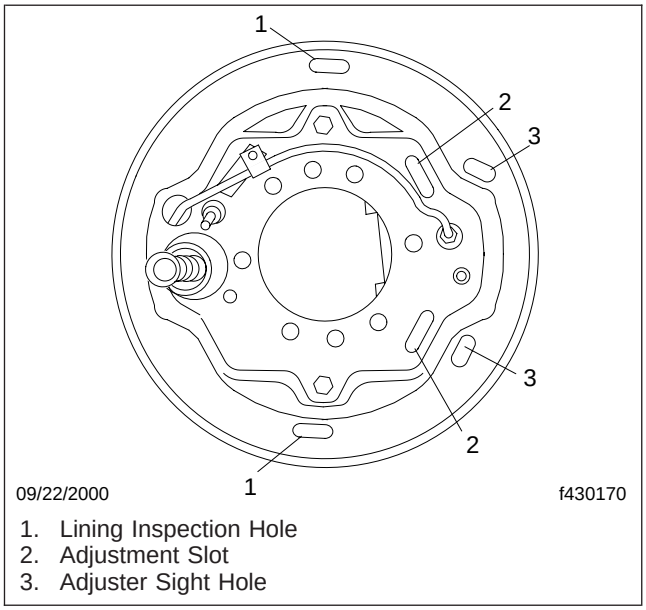
WARNING

When work is being done on the spring chamber, carefully follow the service instructions of the chamber manufacturer. The sudden release of a compressed spring can cause serious personal injury.

3. Carefully cage and lock the springs so that the springs cannot actuate during disassembly.
4. Set the parking brakes to release the parking brake system pressure, then shut down the engine.
5. Raise the rear axle and place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
6. Remove the wheels. For instructions, see **Section 40.00**, Subject 100.
7. Remove six rubber plugs from the backing plate. See **Fig. 1**.
   - two lining inspection hole plugs
   - two adjustment slot plugs
   - two adjuster sight hole plugs

CAUTION

When backing off the brake shoes, brake fluid will be displaced from the adjuster cylinder bore. Make sure this action does not displace other pistons on the axle.



1. Lining Inspection Hole
2. Adjustment Slot
3. Adjuster Sight Hole

Fig. 1, Backing Plate Access Holes

IMPORTANT: The adjustment procedures in this subject are for vehicles with spring suspensions. On vehicles with Freightliner AirLiner suspensions, the park cylinder and adjuster cylinder positions are reversed. Therefore, the adjustment procedure should be adjusted accordingly when working on a vehicle with AirLiner suspensions.

8. Back off the brake shoes.

CAUTION

Take care not to damage the dust boot with the adjusting tool.

8.1 Insert the adjusting tool (OTC part number D90T-2588-AR) in the upper adjustment slot in the backing plate. See **Fig. 3**.

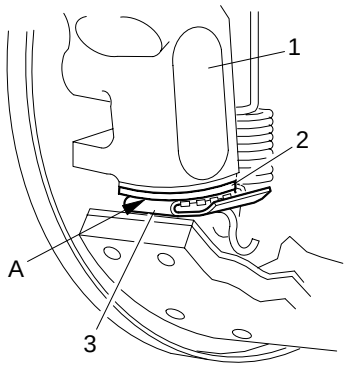
IMPORTANT: A 1/16-inch gap must exist between the override wheel assembly and the dust boot. See **Fig. 2**. The 1/16-inch gap is necessary to ensure that the internal adjuster does not bottom-out in the piston, as this will prevent the adjust from operating.

8.2 With the brake shoes and return springs in place, manually back off (de-adjust) the

Brake Shoe Removal and Installation

upper brake shoe by pushing the adjusting tool to the right.

Back off the shoe enough to ensure that any drum lip will clear the brake shoes during drum removal. View the clearance through the lining inspection holes.



06/26/2001 f430267

A. 1/16-inch gap between override wheel assembly and dust boot.
1. Adjuster Cylinder
2. Dust Boot
3. Override Wheel Assembly

Fig. 2, Gap Measurement at Cylinder

8.3 Move the adjusting tool to the lower adjustment slot.

8.4 Back off the lower brake shoe by pushing the adjustment tool to the left.

9. Remove the brake drums. For instructions, see **Section 35.01**, Subject 100.

CAUTION

Do not apply service or parking brakes after the brake drums are removed. The unrestricted brake shoe movement may damage the cylinders.

IMPORTANT: Additional de-adjustment can be done at this time before the brake shoes are removed. Once the shoes are removed, the previous procedure cannot be used to de-adjust the adjuster cylinder.

CAUTION

When removing the brake shoes, do not allow the brake shoe assembly to contact the dust boots on the adjuster or park cylinder. To do so could damage the boots.

10. Remove the brake shoes. Vehicles with rotated brakes are those equipped with AirLiner suspensions.

10.1 Place a durable load plate (at least 4 x 1 x 1/8-inch) against the brake lining on the adjuster cylinder end of the upper shoe (lower shoes on rotated brake). See **Fig. 4**.

10.2 Using a 12-inch (or larger) adjustable wrench to grip the shoe and load plate, lift the upper shoe (lower shoe for rotated brake) out of the slot on the top of the adjuster cylinder.

10.3 Rotate the shoe slightly outboard, then lower it with the shoe web resting as far down on the protective shield (next to the slot) as possible. This reduces the tension on the spring for the next step. Remove the wrench and load plate.

10.4 Insert the spring tool, OTC part number 7462 or equivalent (**Fig. 5**), in the loop on the lower end of the adjuster cylinder return spring. See **Fig. 6**. Unhook the spring from the lower shoe.

10.5 Place the load plate against the brake lining on the park cylinder end of the lower shoe (upper shoe for rotated brake).

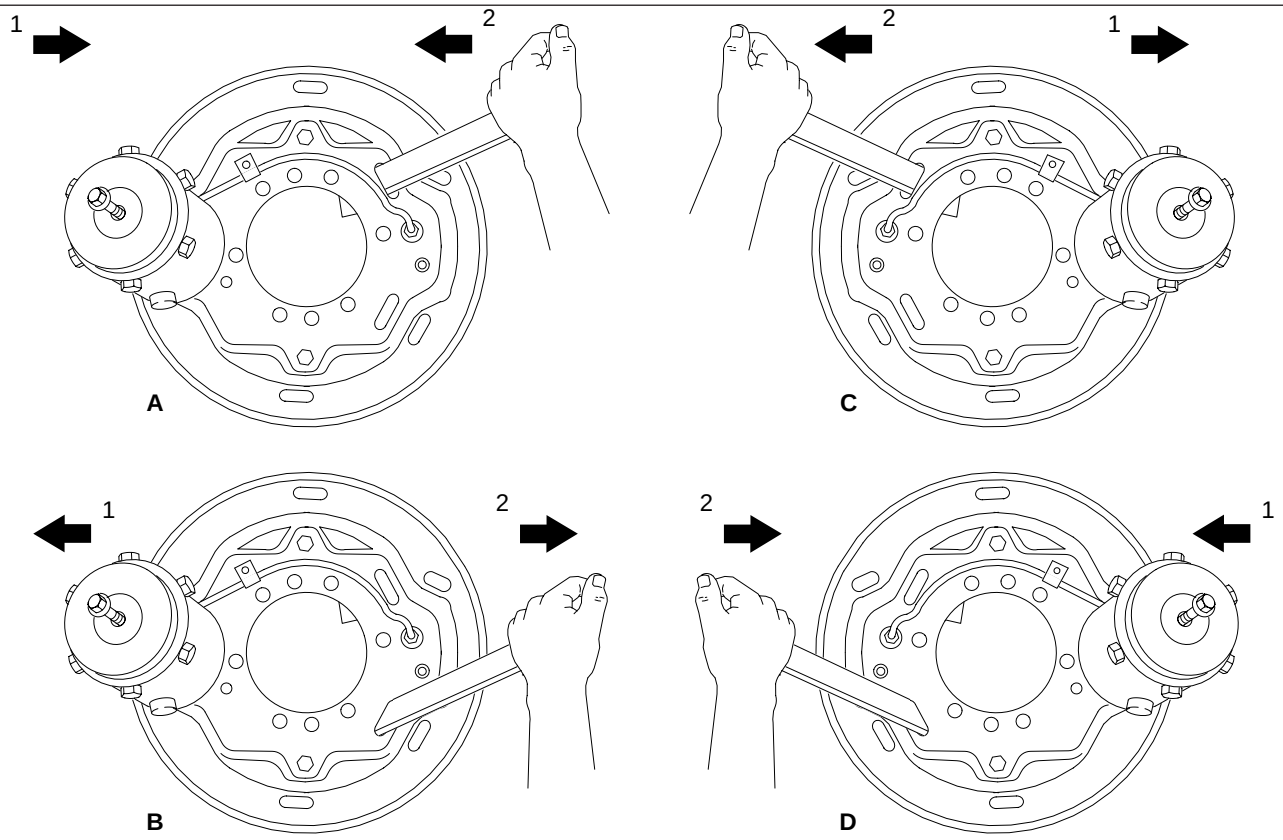
CAUTION

Do not allow the brake shoe or web to contact the dust boot on the park cylinder. To do so could damage the boot.

10.6 Using the adjustable wrench to grip the lower shoe (upper shoe for rotated brake) and load plate, lower the shoe out of the slot on the bottom of the park cylinder.

10.7 Rotate the shoe outboard, then place the shoe on the end of the park cylinder. Remove the wrench and load plate.

10.8 While supporting the lower shoe (upper shoe for rotated brake), unhook the lower end of the park cylinder return spring. Re-



NOTE: Arrows on the back plate indicate the adjustment direction.

A. Left wheel, upper shoe
B. Left wheel, lower shoe
C. Right wheel, upper shoe
D. Right wheel, lower shoe

1. Increase Lining-to-Drum Clearance
2. Decrease Lining-to-Drum Clearance

Fig. 3, Brake Shoe Adjustment (vehicles with spring suspensions)

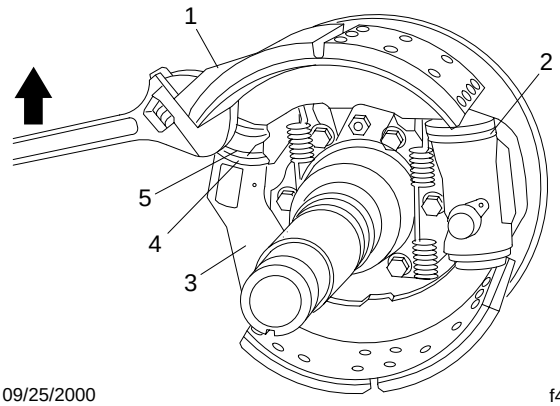
move the lower shoe (upper shoe for rotated brake).

10.9 Remove the upper shoe (lower shoe for rotated brake).

IMPORTANT: Do not de-adjust the adjuster cylinder with the shoes removed. If further de-adjustment is required, contact your district service manager for technical support.

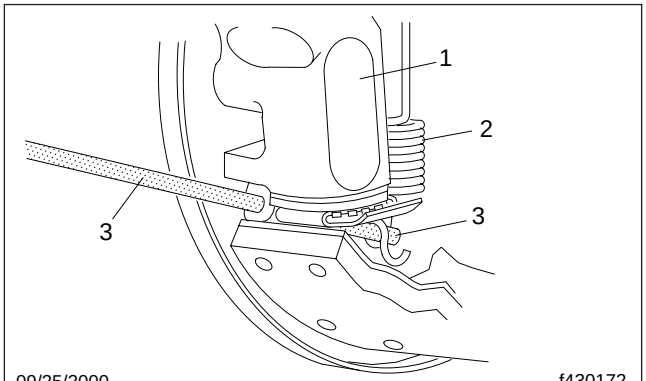
11. Remove and discard the return springs.
12. Secure both lower pistons to pervent them from falling out of the housing.
13. Inspect the dust boots for damage; replace as needed. The dust boots can be replaced without removing either cylinder from the backing plate.
    - To replace a dust boot on the park cylinder, remove and replace the dust boot on the top (expander) piston or bottom (abutment) piston. No disassembly is required.
    - To replace a dust boot on the adjuster cylinder, remove the slotted cap (manual override wheel assembly) from the applicable end of the adjuster cylinder. See **Fig. 7**.

Brake Shoe Removal and Installation



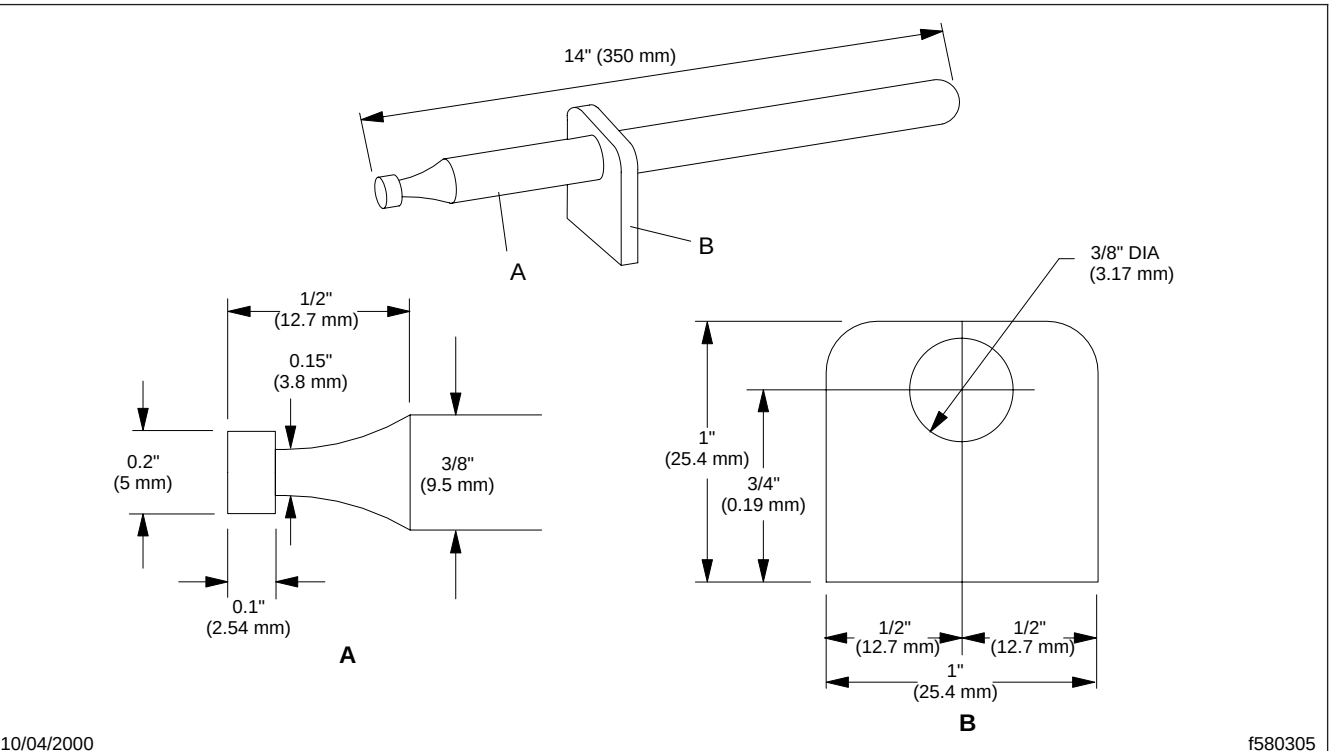
1. Load Plate
2. Park Cylinder
3. Adjuster Cylinder
4. Dust Boot
5. Protective Shield

Fig. 4, Lift Upper Brake Shoe



1. Adjuster Cylinder
2. Return Spring
3. Spring Tool
4. Return Spring Loop

Fig. 6, Unhook the Return Spring

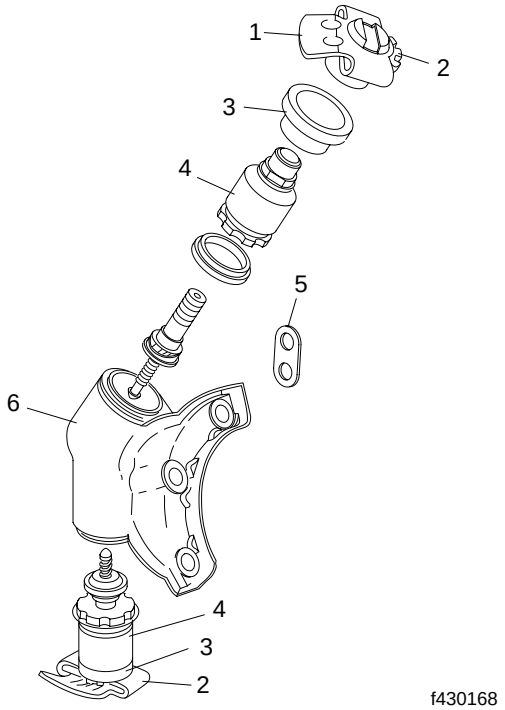


NOTE: OTC part number 7462. The tool can be made from 3/8-inch (9.5-mm) tool steel.

A. Tool head, 3/8-inch (10 mm) diameter tool steel.
B. Tool guide, 1 x 1 x 1/8-inch (25 x 25 x 3-mm) tool steel.

Fig. 5, Spring Tool

The manual override wheels are snapped onto the pistons. Pull to remove, being careful not to remove the piston. Install a new dust boot and snap the cap back on the housing.



1. Protective Shield
2. Slotted Cap (Manual Override Wheel Assembly)
3. Dust Boot
4. Piston
5. Gasket
6. Housing

Fig. 7, Adjuster Cylinder

14. Inspect the brake shoes and linings for wear or damage. For instructions, see **Subject 120**.

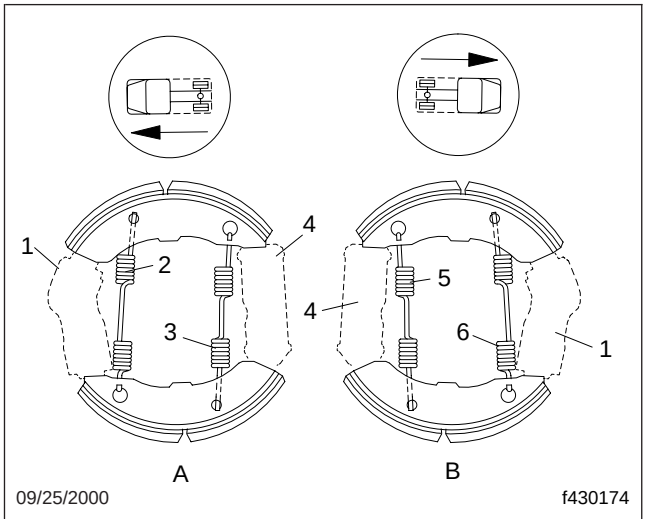
Installation

⚠ WARNING

When installing new brake shoes, always install new return springs. Also, turn or replace the drums according to the manufacturer's recommendations.

IMPORTANT: Use the same brake series on both ends of the axle.

1. Arrange the brake shoe assemblies on the floor in the positions you will view them on the vehicle. See **Fig. 8**. Although all four shoes are identical, they are not symmetrical and must be correctly oriented to the adjuster and park cylinders.



NOTE: If the springs cannot be identified by color, the springs with a loop at the bottom are next to the adjuster cylinders and the straight center section of the spring is closest to the front of the vehicle. When the top J-hook on a park cylinder spring is installed, the opening in the lower hook faces forward.

A. Left-side brake.
B. Right-side brake.
1. Adjuster Cylinder
2. Green Return Spring
3. Orange Return Spring
4. Park Cylinder
5. White Return Spring
6. Yellow Return Spring

Fig. 8, Brake Shoe Assembly Orientation (spring suspensions)

2. Hook the return springs in the upper shoe from the underside of the web. Leave the bottom of the springs free.
3. Install the brake shoes.
   3.1 Lift the upper shoe and springs. Place the shoe webs in the slots on the top of the adjuster and park cylinders.

Brake Shoe Removal and Installation

NOTE: The following is a seesaw procedure to provide anchor points for installing the return springs.

3.2 Hold the lower shoe near (not under) the park cylinder and install the free end of the return spring in the lower shoe web.

3.3 Place the other end of the lower shoe web in the slot on the bottom of the adjuster cylinder.

3.4 Place the load plate against the brake lining on the park cylinder end of the lower shoe.

3.5 Using the adjustable wrench to grip the lower shoe and load plate, press the shoe down far enough to place the web in the slot on the bottom of the park cylinder.

3.6 Move the load plate to the adjuster cylinder end of the lower shoe.

3.7 Using the adjustable wrench, press the shoe down just far enough to remove the web from the slot on the bottom of the adjuster cylinder. Allow the web to rest against the protective shield at the base of the adjuster cylinder.

3.8 Insert the spring tool in the loop at the bottom of the return spring. See **Fig. 6**. Hook the return spring in the lower shoe web.

3.9 Using the load plate and adjustable wrench, press the shoe down and place the web in the slot on the bottom of the adjuster cylinder again.

4. Install the brake drums. For instructions, see **Section 35.01**, Subject 100.

⚠ WARNING

Always wear safety glasses when handling brake fluid or bleeding brake components. Hydraulic brake fluid is hazardous and can cause blindness if it gets in your eyes. Brake fluid may also be a skin irritant. If you get it on your skin, wash it off as soon as possible.

IMPORTANT: Use only new brake fluid.

5. Fill the master cylinder reservoir, if needed, with new brake fluid that meets DOT 3 specifications. Cover the reservoir.
6. Make two slow, hard applications of the brake foot pedal to center the shoes. Repeat before each evaluation of the shoe-to-drum clearance.
7. Manually adjust the upper and lower shoes. See **Subject 160** for instructions.
8. Start the engine and check the brake pedal travel. If the pedal travel is excessive, shut down the engine and bleed the hydraulic system. For instructions, see **Subject 170**.
9. Install the six rubber plugs in the backing plate.
10. Start the engine and run it long enough to pressurize the parking brake system. The parking brake should still be in the released position. Shut down the engine.
11. Manually uncage the power spring in the parking brake chamber. For instructions, refer to the applicable brake chamber section in this manual.
12. Install the wheels. For instructions, see **Section 40.00**, Subject 100.
13. Rotate each wheel by hand to verify that the parking brakes are fully released.
14. Apply the parking brake and check that the wheels cannot be rotated by hand.
15. Remove the safety stands, lower the vehicle, and remove the chocks from the tires.

⚠ WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

16. Before you put the vehicle in service, check for proper brake operation in a safe area.

16.1 Start the engine and release the parking brake.

16.2 Apply and release the brakes several times to check for leaks and proper operation.

16.3 Perform several low-speed stops to ensure correct parts replacement and full vehicle control.

Inspection

WARNING

Before starting this procedure, read the information in Safety Precautions 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

1. Remove the rear brake shoes. Refer to **Subject 110** for instructions.
2. Inspect the rear brake shoe linings. If the linings are grease- or oil-soaked, cracked, or worn to the lining wear groove, replace them.

NOTE: The lining wear groove is approx. 3/8-inch (9.5 mm) thick.

3. Check the shoes for bent or cracked webs or tables, broken welds, loose rivets, or out-of-round rivet holes. Replace the shoes if any of these conditions exist.

Replacement

WARNING

Before starting this procedure, read the information in Safety Precautions 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

IMPORTANT: Vehicle brake systems require the correct lining material to perform as originally designed. The type of lining material that is specified for the vehicle is based on several technical considerations and Department of Transportation (DOT) braking performance regulations. To ensure fewer relines and greater compatibility with the vehicle's brake system, use the same quality of friction lining material that was installed at the factory.

Always reline both wheels of a single axle and all wheels of a tandem axle at the same time.

Always install the same linings and drums on both wheels of a single axle and all four wheels of a tandem axle. It is not necessary for the steering axle brakes to have the same linings as the rear drive axle brakes.

When the minimum thickness is reached for any of the brake linings on an axle, reline both brakes on that axle at the same time.

NOTE: Replace the return springs each time the brakes are relined.

1. Remove the brake shoes. For instructions, see **Subject 110**.

CAUTION

Drilling out rivets or cutting off rivet heads with a chisel can cause the rivet hole to become out-of-round. This could damage the brake shoe.

2. Using a suitable riveting mandrel, push out (do not drill out) the old rivets.
3. Clean the shoe table. For instructions, see **Subject 150**, "Cleaning."

CAUTION

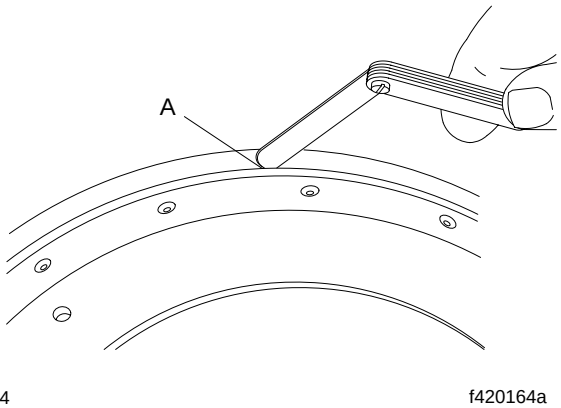
Make sure that the replacement lining material conforms to FMSI 1308, a standard for lining size and shape only. Use of an improper FMSI lining specification or friction material type may cause brake dragging or grabbing, or improper brake performance.

4. Align the brake shoe and lining rivet holes. Using a C-clamp, clamp the lining to the brake shoe.

IMPORTANT: Use rivets supplied with Meritor lining kits.

5. Insert the rivets into all the holes in the new block. Temporarily hold them in place with masking tape.
6. Secure the rivets in the correct sequence. Start with two of the middle holes and work toward the ends in a crisscross pattern.
7. Check for a close fit between the lining and shoe table.

   Try to insert a 0.010-inch (0.254-mm) feeler gauge between the lining and shoe table along the edges. See **Fig. 1**. It should not be possible to insert the gauge anywhere along the edge, except at each end beyond the last row of rivets. A larger clearance may exist in these areas.



A. The clearance between the brake lining and shoe table must be less than 00.010-inch (0.254-mm).

Fig. 1, Check Fit Between Lining and Shoe Table

8. Remove the C-clamp and masking tape.

Brake Shoe Lining Replacement

IMPORTANT: Always adjust the brakes after replacing the linings. For instructions, see **Subject 160**.

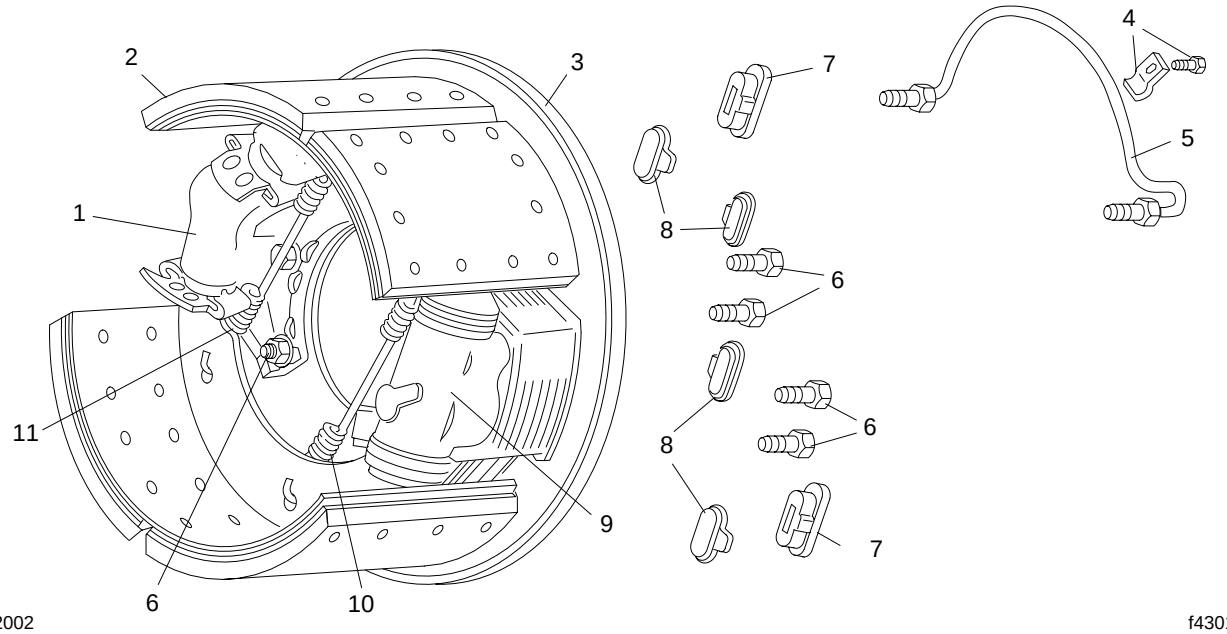
Adjuster and Park Cylinder Removal and Installation

⚠ WARNING

Before starting this procedure, read the information in Safety Precautions 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

Clyinder Removal

1. Remove the brake shoes. For instructions, see **Subject 110**.
2. Remove the bridge pipe retaining clip and screw from the backing plate. See **Fig. 1**.
   - 3.2 Remove the parking brake spring chamber. See **Section 42.25** for instructions.
   - 3.3 Remove three 9/16–18 bolts, hexnuts, and washers securing the park cylinder to the backing plate and axle flange.
   - 3.4 Remove the two 7/32-inch Allen-head bolts (if installed) securing the park cylinder to the backing plate. Discard the Allen-head bolts; they were originally installed for shipping.
   - 3.5 Remove the park cylinder and gasket from the backing plate. Discard the gasket.



1. Adjuster Cylinder Assembly
2. Brake Shoe and Lining
3. Backing Plate
4. Retaining Clips and Screw
5. Bridge Pipe
6. Cylinder Mounting Bolts
7. Manual Override Access Plug
8. Inspection Plugs
9. Park Cylinder Assembly
10. Return Spring, Orange (LH brake) or White (RH brake)
11. Return Spring, Green (LH brake) or Yellow (RH brake)

Fig. 1, DURAPARK Rear Hydraulic Drum Brake Assembly

3. Remove the park cylinder.
   - 3.1 Clean the bridge pipe and disconnect it from the cylinder.
4. Remove the adjuster cylinder.
   - 4.1 Clean the bridge pipe and disconnect it from the cylinder.

Adjuster and Park Cylinder Removal and Installation

4.2 Remove three 9/16–18 bolts, hexnuts, and washers securing the adjuster cylinder to the backing plate and axle flange.

4.3 Remove the two 7/32-inch Allen-head bolts (if installed) securing the park cylinder to the backing plate. Discard the Allen-head bolts; they were originally installed for shipping.

4.4 Remove the adjuster cylinder and gasket from the backing plate. Discard the gasket.

Clyinder Installation

1. Install the adjuster cylinder.
   1.1 Using a new gasket, install the adjuster cylinder on the backing plate. Insert three 9/16–18 x 1-1/2 inch bolts through the axle flange, backing plate, and cylinder housing.
   1.2 Secure the bolts with hardened washers and 9/16–18 hexnuts. Torque the nuts 135 to 160 lbf·ft (185 to 215 N·m).
   1.3 Connect the bridge pipe to the cylinder. Torque the capscrew 10 to 15 lbf·ft (14 to 20 N·m).
2. Install the park cylinder.
   2.1 Using a new gasket, install the park cylinder on the backing plate. Insert three 9/16–18 x 1-1/2 inch bolts through the axle flange, backing plate, and cylinder housing.
   2.2 Secure the bolts with hardened washers and 9/16–18 hexnuts. Torque the nuts 135 to 160 lbf·ft (185 to 215 N·m).
   2.3 Connect the bridge pipe to the cylinder. Torque the capscrew 10 to 15 lbf·ft (14 to 20 N·m).
   2.4 Install the parking brake spring chamber. See **Section 42.25** for instructions.
3. Install the bridge pipe retainer and screw on the backing plate.
4. Install the brake shoes, drums, and wheels. For instructions, see **Subject 110**.

WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.

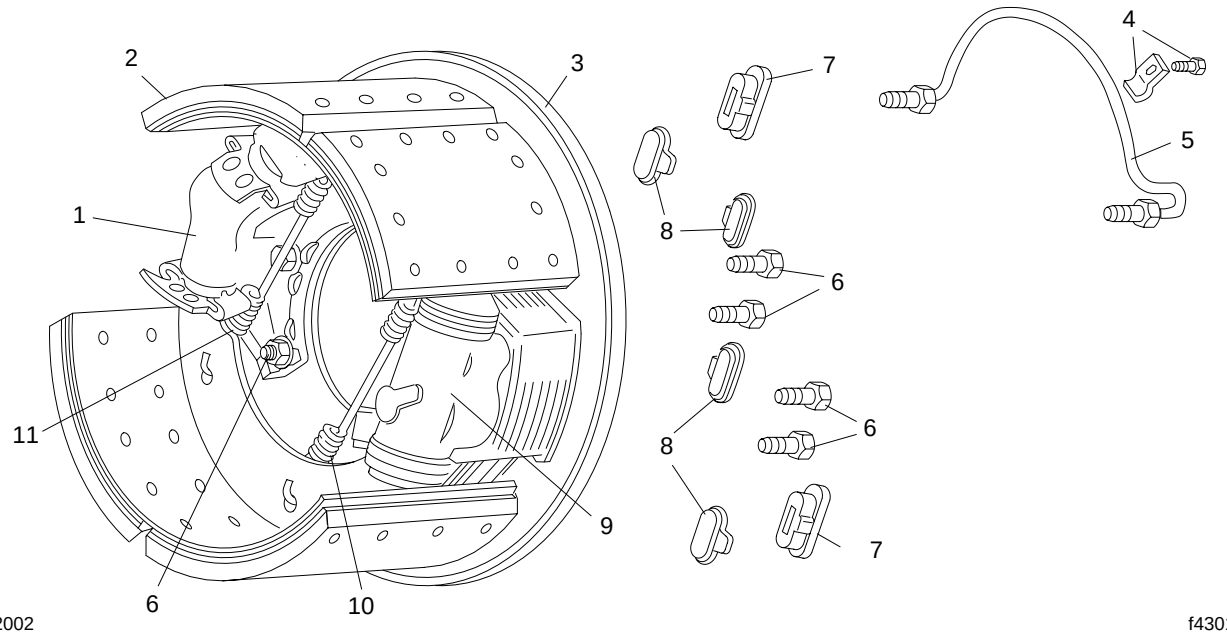
5. Bleed the hydraulic brake system. For instructions, see **Subject 170**.

Brake Components Disassembly and Inspection, Cleaning, and Assembly

⚠ WARNING

Before starting this procedure, read the information in Safety Precautions 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

Figure 1 shows a DURAPARK® rear hydraulic drum brake.



1. Adjuster Cylinder Assembly
2. Brake Shoe and Lining
3. Backing Plate
4. Retaining Clips and Screw
5. Bridge Pipe
6. Cylinder Mounting Bolts
7. Manual Override Access Plug
8. Inspection Plugs
9. Park Cylinder Assembly
10. Return Spring, Orange (LH brake) or White (RH brake)
11. Return Spring, Green (LH brake) or Yellow (RH brake)

Fig. 1, DURAPARK Rear Hydraulic Drum Brake Assembly

IMPORTANT: The figures and instructions in this subject illustrate installation of brakes on vehicles with spring suspensions. On vehicles with Freightliner AirLiner suspensions, the park cylinder and adjuster cylinder positions are reversed. See **Fig. 2**.

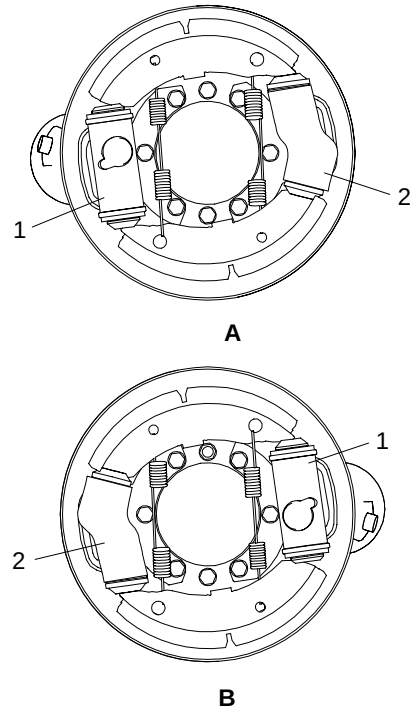
Disassembly

Adjuster Cylinder

Refer to **Fig. 3** while performing the following procedures.

1. Park the vehicle on a level surface, shut down the engine, and chock the tires.
2. Remove the adjuster cylinder. See **Subject 140**.

Brake Components Disassembly and Inspection, Cleaning, and Assembly



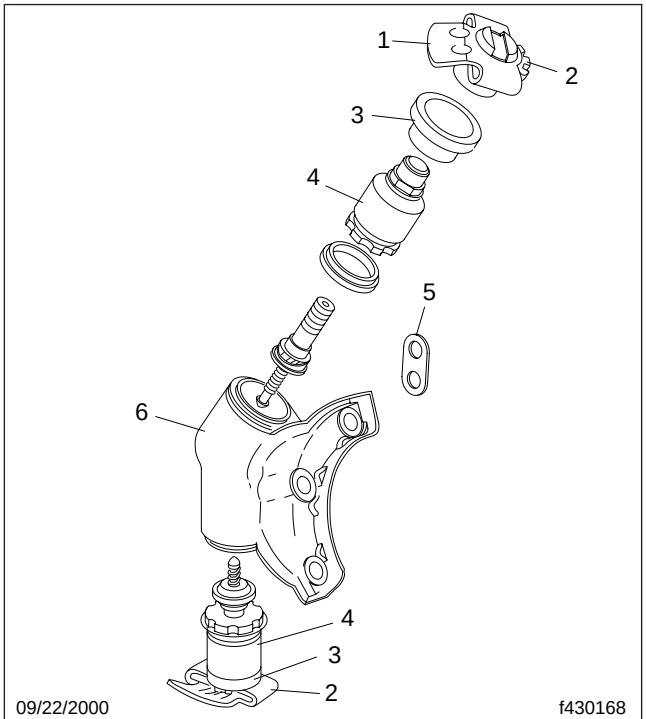
A. Standard Brake Configuration
B. AirLiner Suspension Configuration
1. Park Cylinder
2. Adjuster Cylinder

Fig. 2, DURAPARK Brake Configurations

3. Remove and inspect the manual override wheels. Clean the manual override wheels by soaking them in clean DOT 3 heavy duty brake fluid. Remove the dust boots from the housing. Discard the boots.
4. Remove the pistons and adjuster assemblies from housing, being careful not to cock them and scratch the housing bore. Inspect the pistons. Replaced if any pitting, peeling, or scoring is found. Some discoloration of the piston diameter may be apparent. This is the natural result of brake actuation over a period of operation.
5. Remove the adjuster shaft from the piston. Keep the adjuster shafts and pistons together as sets.

IMPORTANT: Do not remove the drive ring from the adjuster shaft.

6. Remove the seals from the pistons. Use care not to score the seal groove. Discard the seal.



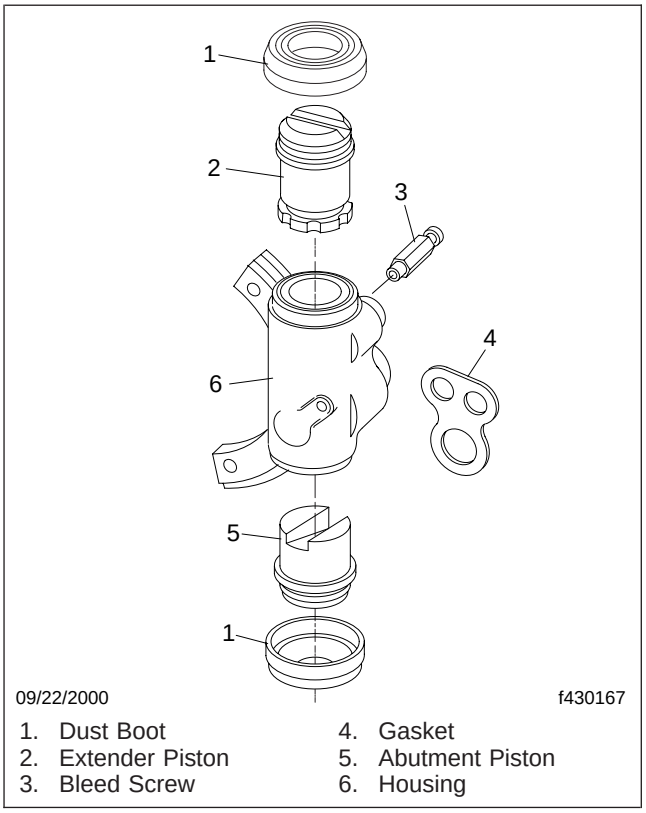
1. Protective Shield
2. Slotted Cap (Manual Override Wheel Assembly)
3. Dust Boot
4. Piston
5. Gasket
6. Housing

Fig. 3, Adjuster Cylinder

Park Cylinder

Refer to **Fig. 4** while performing the following procedures.

1. Park the vehicle on a level surface, shut down the engine, and chock the tires.
2. Remove the park cylinder. See **Subject 140**.
3. Place the cylinder in a soft jawed vise.
4. Remove the bleed screw
5. Remove the dust boots from the housing and discard the boots.
6. Remove the abutment piston.
7. Remove the Allen-head 5/32-inch stop pin from the housing.



1. Dust Boot
2. Extender Piston
3. Bleed Screw
4. Gasket
5. Abutment Piston
6. Housing

Fig. 4, Park Cylinder

8. Push the expander piston and the handbrake piston out of the housing.
9. Remove and discard the seals and O-ring from the pistons.
10. Press down on the wedge assembly sleeve and return spring to remove the pin from the shaft. Slowly release the wedge return spring and remove the sleeve and return spring from the shaft.
11. Remove the snap ring that retains the shaft, retainer and washer in the housing. Remove the wedge and roller assembly.

Inspection and Cleaning

After removing the brake parts being serviced, do the following:

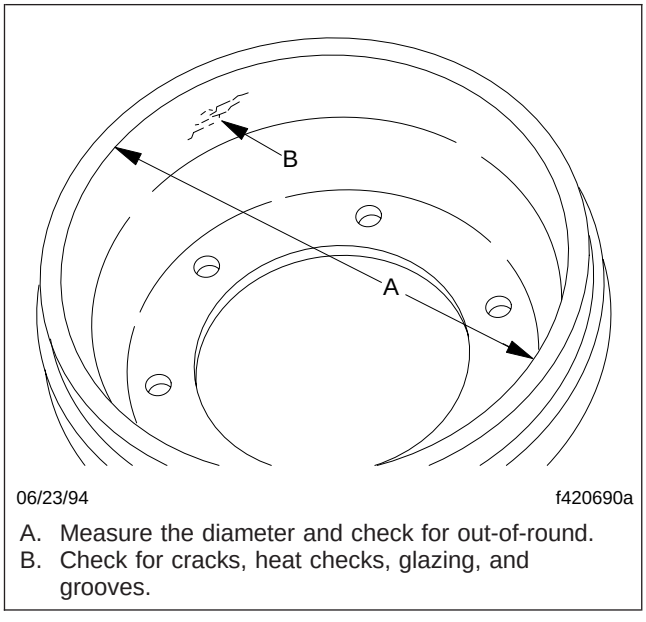
Brake Drums and Chambers

CAUTION

Do not clean ground or polished metal parts in a hot solution tank or with water, steam, or alkaline solutions. These solutions will cause parts to corrode.

IMPORTANT: Do not apply brake grease or corrosion-preventive materials to the brake linings or the brake drum.

1. Inspect the drum.
   - 1.1 Check the drum for cracks. Replace any cracked drum.
   - 1.2 Using a drum caliper or other measuring device, measure the inside diameter of the drum in several places. Replace the drum if it exceeds the maximum diameter stamped on it.
   - 1.3 Check the drum for heat checks, glazing, grooving, run-out, and out-of-round. See **Fig. 5**. Some drums that are glazed, grooved, or out-of-round can be repaired. For detailed instructions, see **Section 35.01**.



A. Measure the diameter and check for out-of-round.
B. Check for cracks, heat checks, glazing, and grooves.

Fig. 5, Check the Drum

Brake Components Disassembly and Inspection, Cleaning, and Assembly

2. Check the brake chamber for a cracked housing, loose fittings, and leakage. Repair or replace parts as needed.
3. Wire brush all parts that have been exposed to mud, road dirt, and salt, including the exterior of the drum.

   If relining the shoes, thoroughly wire-brush the shoe tables and paint them with a rust-inhibitive coating.

⚠ CAUTION

A thick layer of oxidation and dirt on the outside of a brake drum acts as an insulator and may hinder normal heat dissipation. Make sure oxidation and dirt are removed by wire brushing, or damage to brake components could occur.

4. Using a wire brush, remove any rust or corrosion from the backing plate.
5. Using an industrial vacuum cleaner with a HEPA filter system, remove any dust accumulation from the brake parts.
6. Wipe the inside of the drums with a damp rag to remove lining dust.
7. Prepare the brake parts for assembly.

   7.1 Thoroughly clean all the brake parts.

   For ground or polished metal parts, use a cleaning solvent to clean the parts and surfaces.

   For rough metal parts, use a cleaning solvent or a weak alkaline solution in a hot solution tank to clean the parts. If a hot solution tank is used, leave the rough parts in the hot solution tank until they are completely cleaned and heated. Remove the rough parts from the hot solution tank and wash them with water until the alkaline solution is removed.

   7.2 Thoroughly dry all the brake parts with a clean, lint-free cloth or paper towel, or use low-pressure filtered and compressed air.

⚠ WARNING

All worn or damaged brake parts must be replaced. If the brakes are assembled with worn or damaged parts, they may not perform to their capacity and a brake failure could occur, which could cause personal injury and property damage.

   7.3 Inspect all the brake parts for wear or damage. It is very important that all the parts be carefully inspected before they are assembled. Repair or replace any worn or damaged parts.

   7.4 For parts that will be assembled, apply a thin layer of brake grease to the parts after they have been cleaned, dried, and inspected to protect them from corrosion.

   If the parts will be stored, apply a special material that prevents corrosion and rust on all surfaces. The parts should be stored in special paper (or other material) that prevents corrosion and rust.

Adjuster Cylinder

Refer to **Fig. 3** while performing the following procedures.

1. Wash all parts with clean DOT 3 heavy duty brake fluid. Placed the cleaned parts on a clean sheet of paper.
2. Clean the adjust shaft hole in the piston.

   2.1 Fill the threaded hole half-full with new brake fluid.

   2.2 Cover the hole and shake the piston vigorously.

   2.3 Rapidly turn the piston upside down and drain the brake fluid.

   IMPORTANT: Do not use a cleaning brush on any of the parts.

NOTE: Some discoloration of the bore surface near the mouth of the cylinder may be apparent. This is the natural result of brake actuation over a period of operation.

3. Inspect the cylinder bore and pistons for evidence of corrosion, ridges or scoring. If

scratches or scoring are present in the bore, hosing is allowed. However, the bore diameter must not be larger than 1.75 inches (44.5 mm) after honing. If larger than specified, replace the cylinder housing. Hone the cylinder bore using a 220 spring loaded wheel cylinder stone that gives a smooth finish. If any defects are present after honing the cylinder housing much be replaced.

Clean the cylinder bore with isopropyl alcohol to remove all honing residue.

Park Cylinder

Refer to **Fig. 4** while performing the following procedures.

1. Inspect all three pistons. Replace the pistons if any pitting, peeling, or scoring is found. Some discoloration of the piston diameter may be apparent. This is the natural result of the brake actuation over a period of operation.
2. Inspect the wedge components for any signs of wear, replace as needed.
3. Wash all parts in clean DOT 3 heavy duty brake fluid.

NOTE: Some discoloration of the bore surface near the mouth of the cylinder may be apparent. This is the natural result of brake actuation over a period of operation.

4. Inspect the cylinder bore and pistons for evidence of corrosion, ridges or scoring. If scratches or scoring are present in the bore, honing is allowed. However, the bore diameter must not be larger than 1.75 inches (44.5 mm) after honing. If larger than specified, replace the cylinder housing. Hone the cylinder bore using a 220 spring loaded wheel cylinder stone that gives a smooth finish. If any scoring is present after honing, the housing must be replaced.

IMPORTANT: Clean the cylinder bore with the isopropyl alcohol to remove all honing residue.

Assembly

Adjuster Cylinder

Refer to **Fig. 3** while performing the following procedures.

⚠ WARNING

The use any mineral based grease will cause contamination of the seals and may result in brake failure. Use only the specified lubricants.

1. Coat the adjuster shaft threads with new brake fluid.
2. Assemble piston and adjuster shaft, adjuster shaft must turn freely and smoothly without roughness or drag over its full length. Turn the adjuster shaft all the way in then back out one full turn. This will insure the shaft is not locked in the piston.

NOTE: It is essential that the adjuster shaft rotates freely in the piston to allow for the initial self-adjuster movement to take place. If the shaft binds or does not rotate freely in the piston, replace the piston and adjuster assembly.

3. Coat the new seal with the clean DOT 3 heavy duty brake fluid. Install the new seal in the groove on the piston so that the lip seal faces toward the adjuster shaft.
4. Lubricate the pistons and seals with clean DOT 3 heavy duty brake fluid. Install the piston assemblies into the cylinder bores.
5. Lubricate the inside of the dust boot with synthetic lube provided with the adjuster cylinder parts kit available from Meritor.

⚠ WARNING

The use of any mineral based grease will cause contamination of the seals and may result in brake failure. Use only the specified lubricants.

6. Install the dust boot onto the housing.
7. Install the manual override wheel.

NOTE: Be sure the tappet head ears are properly located in the corresponding flats in the piston.

8. Install the adjuster cylinder. See **Subject 140**.

Park Cylinder

Refer to **Fig. 4** while performing the following procedures.

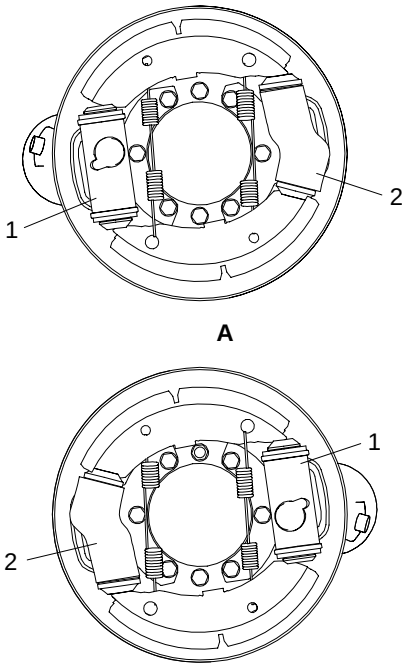
Brake Components Disassembly and Inspection, Cleaning, and Assembly

WARNING

The use any mineral based grease will cause contamination of the seals and may result in brake failure. Use only the specified lubricants.

1. Assemble and install the wedge assembly into the housing.
2. Coat the outside diameter and the ramp of the abutment piston with synthetic grease included in the seal kit. Install the abutment piston into the bore the ramp engages the wedge and roller assembly. Install a new dust boot over the abutment piston and onto the housing.
3. Coat the handbrake piston ramp and O-ring with grease and install the O-ring onto the piston.
4. Coat the seals with clean DOT 3 heavy duty brake fluid. Install the seal on the handbrake piston so that the seal lip faces away from the wedge and roller slot. Install the seal on the expander piston so the seal lip faces away from the shoe web slot.
5. Install the handbrake piston into the bore, aligning the slot on the side of the piston with the stop pin hole.
6. Install the stop pin. Tighten to 16 lbf·ft (21.5 N·m).
7. Install the expander piston into the bore. Install a new dust boot over the expander piston onto the housing.
8. Install the park brake cylinder. See **Subject 140**.

IMPORTANT: The figures and instructions in this subject illustrate installation of brakes on vehicles with spring suspensions. On vehicles with Freightliner AirLiner suspensions, the park cylinder and adjuster cylinder positions are reversed. See **Fig. 1**.



A. Standard Brake Configuration
B. AirLiner Suspension Configuration
1. Park Cylinder
2. Adjuster Cylinder

Fig. 1, DURAPARK Brake Configurations

Pre-Adjustment Checks

1. Park the vehicle on a level surface and chock the front tires.
2. Make sure the parking brakes are released. Releasing the parking brakes pressurizes the spring chambers and compresses the parking brake springs. The engine must be running while the parking brakes are released.

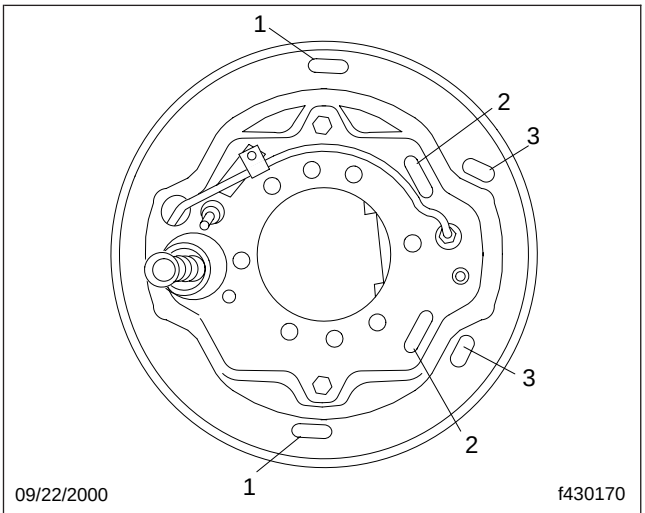
⚠ WARNING

When work is being done on the spring chamber, carefully follow the service instructions of the chamber manufacturer. The sudden release of a compressed spring can cause serious personal injury.

3. Carefully cage and lock the springs so that the springs cannot actuate during disassembly.
4. Set the parking brakes to release the parking brake system pressure, then shut down the engine.
5. Raise the rear axle and place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.

Shoe-to-Drum Clearance Measurement

1. Center the shoes in the drum by making two slow, hard applications and releases of the service brakes.
2. Remove the rubber plugs from the inspection holes in the backing plate. See **Fig. 2**.



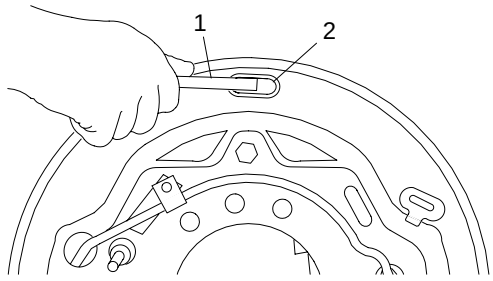
1. Lining Inspection Hole
2. Adjustment Slot
3. Adjuster Sight Hole

Fig. 2, Backing Plate Access Holes

Manual Brake Adjustment

NOTE: Make sure the feeler gauge is on the lining surface, not in the area between the two lining blocks.

3. Insert feeler gauges between the lining and the drum, about half way across the width of the lining. See **Fig. 3**.



1. Feeler Gauge
2. Lining Inspection Hole

Fig. 3, Clearance Measurement

NOTE: The clearance between the drum and brake lining may vary from top to bottom, and from the left side of the vehicle to the right. This is normal and does not indicate that service is required.

4. If the shoe-to-drum clearance meets either of the following criteria, do not adjust the brake.
   - The shoe-to-drum clearance should be 0.020 to 0.050 inch (0.508 to 1.27 mm).
   - If it is not, add the clearance for the top and bottom shoes. The sum should be 0.040 to 0.100 inch (1.016 to 2.54 mm).
5. If the shoe-to-drum clearance does not meet the criteria above, manually adjust the brakes. Otherwise, skip to "Assembly and Test."

Manual Adjustment

IMPORTANT: The adjustment procedures in this subject are for vehicles with spring suspensions. On vehicles with Freightliner AirLiner suspensions, the park cylinder and adjuster cylinder positions are reversed. Therefore, the adjustment procedure should be adjusted accordingly when working on a vehicle with AirLiner suspensions.

⚠ CAUTION

Take care not to damage the dust boot with the adjusting tool.

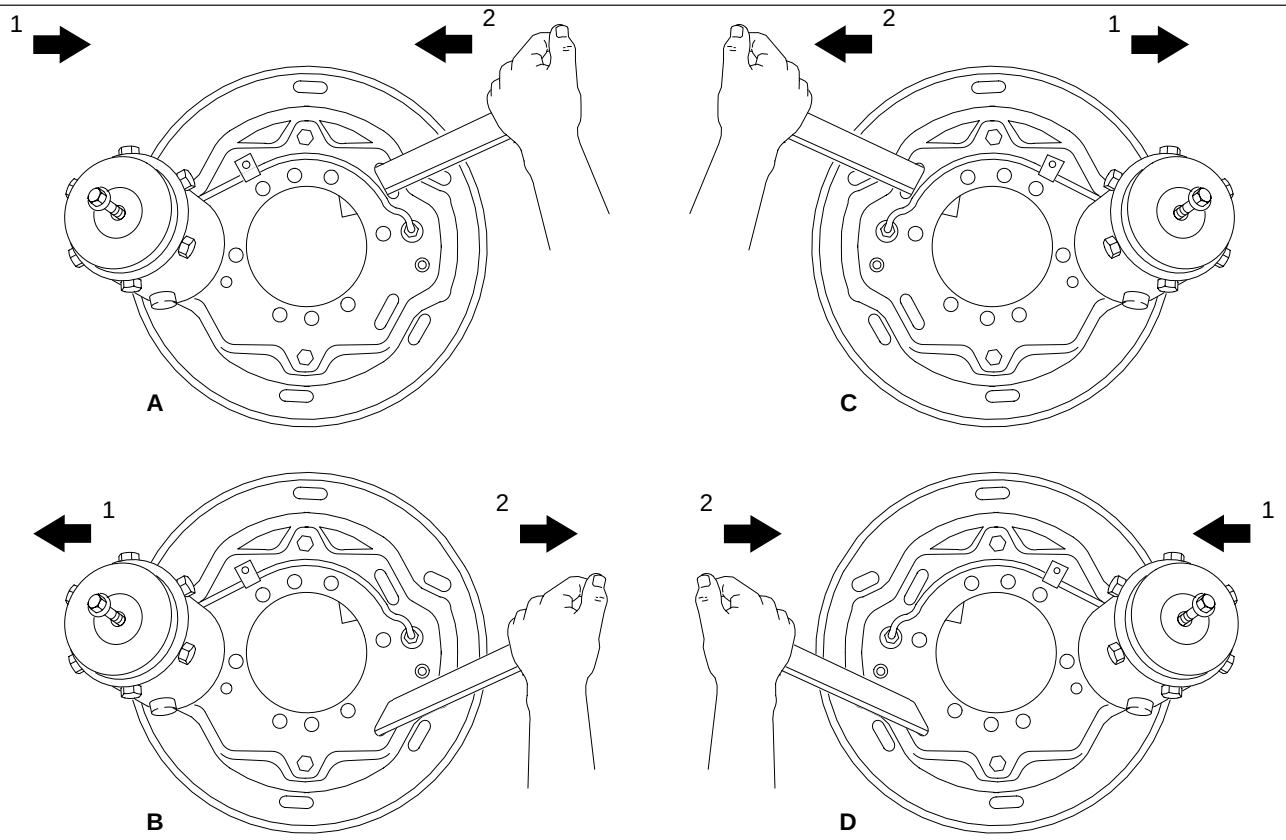
1. Insert the adjusting tool (OTC part number D90T-2588-AR) in the upper adjustment slot on the back side of the backing plate. See **Fig. 4**.
2. Manually adjust the upper shoe by pushing or pulling the adjusting tool (OTC part number D90T-2588-AR) in the direction shown in **Fig. 4**.
   - Adjust burnished shoes to 0.020 inch (0.508 mm) clearance.
   - Adjust new shoes to 0.030 inch (0.732 mm) clearance.
3. Insert the adjusting tool in the lower adjustment slot on the backing plate. Repeat the previous procedure to adjust the lower shoe.

Assembly and Test

1. With the parking brake still in the released position, start the engine to pressurize the parking brake system.
2. Manually uncage the power spring of the parking brake chamber. For instructions, refer to the applicable brake chamber section in this manual.
3. Rotate each wheel by hand to make sure the hydraulic system has fully released the parking brakes.
4. Apply the parking brakes and verify that the wheels cannot be rotated by hand.
5. Remove the safety stands, lower the vehicle, and remove the chocks from the tires.
6. With the engine running, release the parking brakes.

⚠ WARNING

Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking



NOTE: Arrows on the back plate indicate the adjustment direction.

A. Left wheel, upper shoe
B. Left wheel, lower shoe
C. Right wheel, upper shoe
D. Right wheel, lower shoe

1. Increase Lining-to-Drum Clearance
2. Decrease Lining-to-Drum Clearance

Fig. 4, Brake Shoe Adjustment (vehicles with spring suspensions)

ability, which could cause personal injury or death, and property damage.

7. Before you put the vehicle in service, check for proper brake operation in a safe area.

   7.1 Drive the vehicle slowly and check the service and parking brakes.

   7.2 Apply and release the brakes several times to check for air leaks and proper operation.

   7.3 Perform several low-speed stops to ensure correct parts replacement and full vehicle control.

System Bleeding

NOTE: The following manual bleed procedure has been proven to be more effective than using pressure bleed equipment when working with Durapark brakes. Please use only the following manual pressure bleed procedure.

IMPORTANT: The ignition must remain off for the entire bleed procedure.

1. Fill the reservoir with DOT 3 hydraulic fluid.

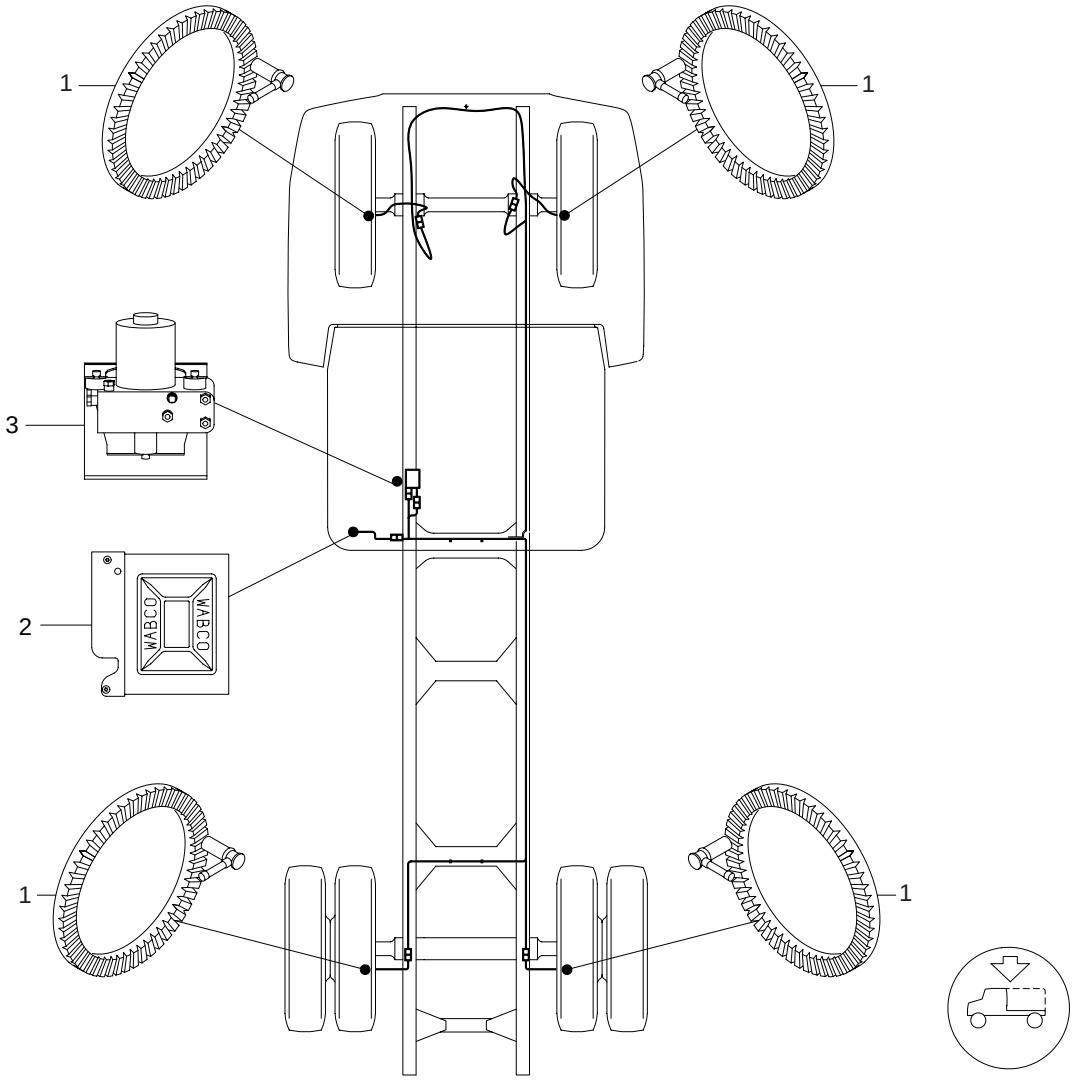
IMPORTANT: Do not allow the brake master cylinder fluid to fall below the minimum level during the bleeding operation. Keep the master cylinder reservoir filled with new DOT-3 approved brake fluid as specified by the original equipment manufacturer. Failure to keep the brake reservoir level above minimum could result in more air entering the system, making it impossible to effectively bleed the system.

2. Place a wrench on the right rear bleeder fitting. Attach a length of clear plastic tubing to the bleeder fitting. The tube must fit tight over the fitting.
3. Submerge the opposite end of the tubing in a container of clean brake fluid.

NOTE: Both the tubing and container must be able to withstand the effects of brake fluid.

4. Press the brake pedal. Loosen the bleeder fitting until the fluid begins to flow (about 3/4 turn) while pressing the brake pedal through its maximum available stroke. Continue to press on the brake pedal for 5 to 8 seconds after the brake fluid stops flowing from the bleeder fitting.
5. Tighten the bleeder fitting firmly, then release the brake pedal. The bleeder fitting must be tightened prior to releasing the brake pedal. Failure to perform the operations in this sequence will result in the discharged fluid and air being drawn back into the system.
6. Repeat steps 4 and 5 several times until the discharged fluid is clear and free of bubbles.
7. Repeat steps 2 through 6 for the left rear brake, right front brake, and then left front brake in this sequence.
8. Check the fluid level in the reservoir and fill if required. Replace reservoir cap and dispose of used brake fluid.
9. Remove the chocks from the tires.

General Information



04/05/2001 f422013b

1. Tone Wheel and Sensor
2. Electronic Control Unit
3. Brake Pressure Modulator

Fig. 1, Location of ABS Components, Four-Channel System

The Meritor WABCO Antilock Braking System (ABS) is an electronic wheel speed monitoring and control system that works with the hydraulic brake system. See **Fig. 1**. ABS passively monitors vehicle wheel speed at all times, and controls wheel speed during emergency stops.

D-version hydraulic ABS is used on vehicles built since February 19, 1999. To determine the hydraulic

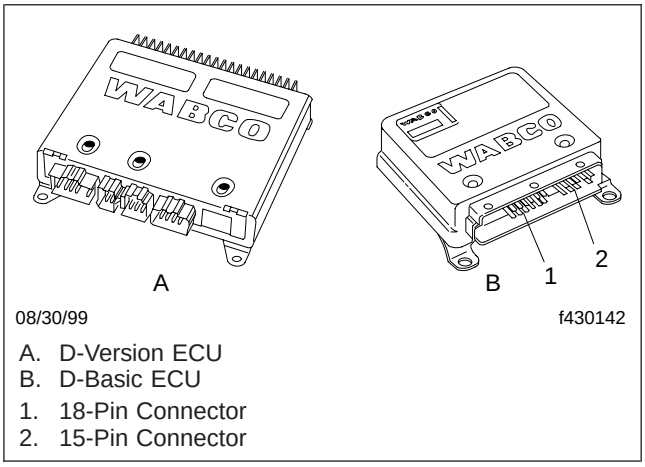
General Information

ABS version installed on the vehicle, look at the ABS electronic control unit (ECU). D-version ECUs have three connectors. See **Fig. 2**. The ECU version can also be determined by the letter designation printed on part number identification tag. See **Fig. 3**.

ABS includes signal-generating tone wheels and sensors located in the rotor assembly of each sensed wheel. The sensors transmit vehicle wheel speed information to the electronic control unit. During emergency braking, the control unit signals the brake pressure modulator to reduce, maintain, or increase hydraulic fluid pressure to the brake caliper housing. This prevents wheel lockup, and enhances steering control during emergency braking situations.

Principles of Operation

The ABS electronic control unit (**Fig. 2**) is a digital microcomputer that serves as the information processing and command center for the antilock braking system. The control unit receives and processes vehicle wheel speed information from the sensors. During emergency brake applications, the control unit regulates the braking force applied to each wheel by sending control signals to the brake pressure modulator. See **Fig. 4**.



08/30/99 f430142

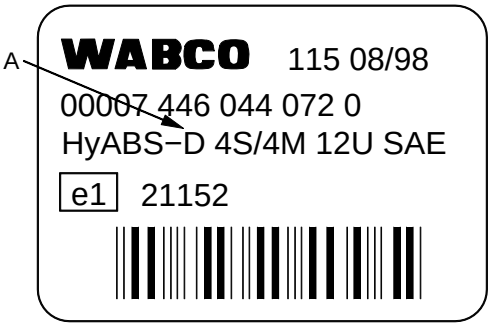
A. D-Version ECU
B. D-Basic ECU
1. 18-Pin Connector
2. 15-Pin Connector

Fig. 2, Electronic Control Unit

ABS Major Components

Wheel Speed Sensor

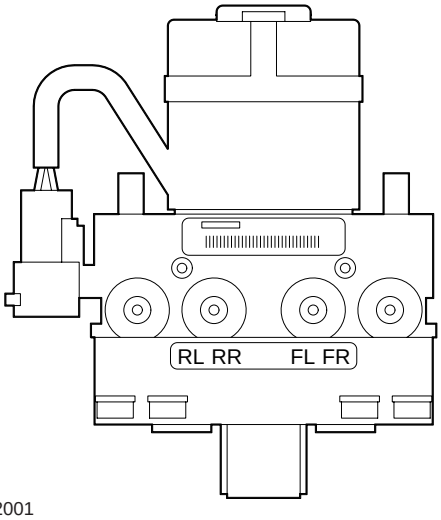
The wheel speed sensors use pulse feedback from tone wheels located in the front and rear axle wheel hubs. When the vehicle is moving, the teeth of the tone wheel cause changes in the magnetic field created by the sensor. The changes create an AC voltage signal that is sent by the sensor to the electronic control unit.



04/27/2000 f080097

A. Version Designation

Fig. 3, ECU Identification Tag ("D" Version Shown)



04/03/2001 f543727

Fig. 4, Brake Pressure Modulator, "D" Basic Version

Electronic Control Unit (ECU)

The electronic control unit (ECU), located just behind the driver's seat, contains a microcomputer to monitor the front and rear control channels. The ECU receives wheel speed signals and interprets these signals to calculate wheel speed and a vehicle reference speed. If the calculations indicate a high degree of wheel slip the ECU signals the brake pressure modulator to adjust braking pressure.

The ECU contains another microcomputer that provides a safety circuit to constantly monitor the wheel sensors, the brake pressure modulator, and the electrical circuitry.

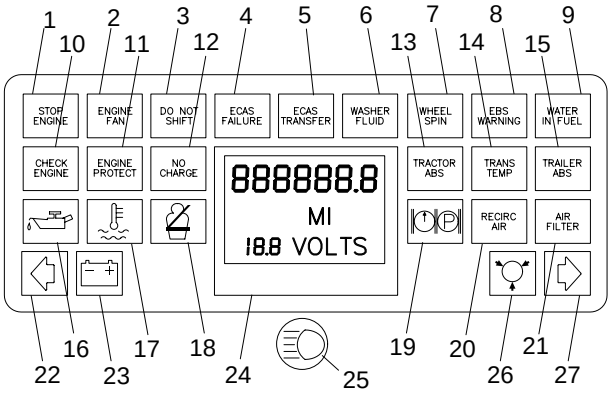
IMPORTANT: After the ignition switch is turned on, the tractor warning light (ABS) comes on for about 3 seconds. See **Fig. 5**. After about 3 seconds, the light goes out only if all of the tractor's ABS components are working correctly.

If, during vehicle operation, the safety circuit senses a failure in any part of the ABS system (a sensor, brake pressure modulator, wiring connection, short circuit, etc.), the tractor warning light (ABS) comes on, and the control circuit where the failure occurred is switched to normal braking action. Even if the ABS system is completely inoperative, normal braking is maintained. Refer to the vehicle driver's manual for complete operating instructions.

Brake Pressure Modulator

The brake pressure modulator is attached to the left frame rail just ahead of the center or forward rear-suspension crossmember. Depending on the signal received from the electronic control unit, the modulator prevents wheel lockup by adjusting the hydraulic fluid pressure. During normal braking applications, hydraulic fluid flows freely to the brake caliper housing through the modulator.

Within the modulator are an inlet and outlet control valve for each sensed wheel. If the electronic control unit signals indicate wheel lockup is close to occurring, fluid pressure to the brake caliper of the sensed wheel is reduced. The inlet valve of the sensed wheel closes, preventing fluid delivery to the brake caliper. At the same time, the outlet valve opens, allowing fluid to flow to an accumulator within the module. From the accumulator, a recirculation pump within the module delivers brake fluid back to the master cylinder.



08/02/2000 f610231a

Typical installation shown. Location of legends installed in the top row may vary, and other legends may be specified.

1. Stop Engine Warning (Cummins engine only)
2. Eng. Fan On Indicator, Optional
3. Do Not Shift Indicator, Optional
4. ECAS Failure Warning, Optional
5. ECAS Transfer Indicator, Optional
6. Low Washer Fluid Indicator, Optional
7. Wheel Spin Indicator, Optional
8. EBS Warning, Optional
9. Water In Fuel Indicator, Optional
10. Check Engine Indicator
11. Engine Protection Warning, Optional
12. No Charge Indicator, Optional
13. Tractor ABS Warning
14. Transmission Temperature Warning, Optional
15. Trailer ABS Warning, Optional
16. Low Oil Pressure Warning
17. High Coolant Temperature Warning
18. Fasten Seat Belt Warning
19. Parking Brake On Warning
20. Recirculated Air Indicator, Optional
21. Air Restriction Indicator, Optional
22. Left-Turn Signal
23. Low Battery Voltage Warning
24. Dash Driver Display Screen
25. High Beam Indicator
26. Low Air Pressure Warning
27. Right-Turn Signal

Fig. 5, Level I ICU Dash Message Center

General Information

As wheel speed increases, the brake pressure modulator allows increases (inlet valve opens and outlet valve closes), or maintains brake pressure until the proper wheel speed is obtained, or until wheel lockup occurs and the control cycle starts again.

If maintaining brake pressure, both valves are closed, preventing fluid delivery and maintaining fluid pressure.

Replacement

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals.

Front Axle

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires to prevent vehicle movement.
2. Twist and pull the sensor to remove it from the sensor bracket. See **Fig. 1**.

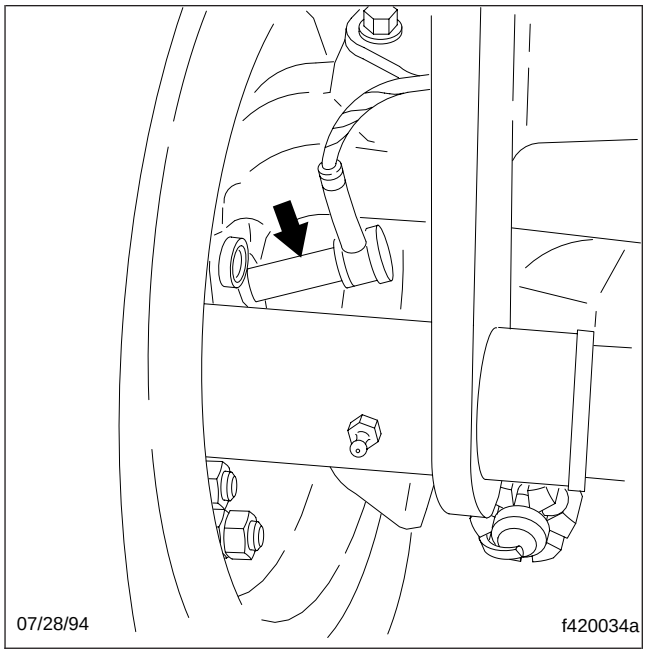


Fig. 1, Remove the Wheel Speed Sensor

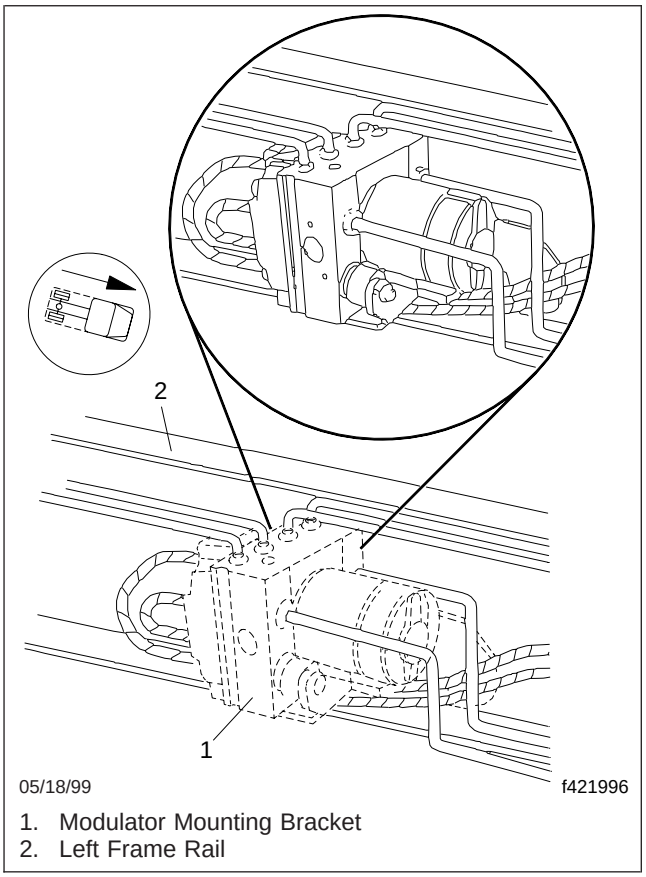
3. Remove the sensor cable clip from the top cap.
4. Disconnect the sensor cable from the chassis harness.
5. Remove the sensor spring clip from the sensor bracket.
6. Connect the sensor cable to the chassis harness.
7. Attach the sensor cable to the steering knuckle top cap.
8. Coat the sensor spring clip and the sensor with Mobil HP, Valvoline EP 633, Penzoil 707L or an equivalent.
9. Press the sensor spring clip into the sensor bracket at the brake spider hole until it stops. Make sure the spring clip tabs are on the inboard side of the vehicle.
10. Press the sensor into the sensor spring clip until it is stopped by the tone wheel.
11. Remove the chocks from the rear tires.

Rear Axle

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the front tires to prevent vehicle movement.
2. Twist and pull the sensor to remove it from the mounting block in the axle housing.
3. Remove the sensor spring clip.
4. Remove the capscrew that attaches the sensor cable and the hose clamp to the axle tube.
5. Disconnect the sensor cable from the chassis harness.
6. Connect the new sensor cable to the chassis harness.
7. Attach the hose clamp and sensor cable to the axle tube located between the backing plate and the spring plate.
8. Press the sensor spring clip into the mounting block until it stops.
9. Coat the sensor with Mobil HP, Valvoline EP633, Penzoil 707L or an equivalent. Using your hand, push the sensor into the sensor spring clip until it is stopped by the tone wheel.
10. Remove the chocks from the front tires.

Brake Pressure Modulator Removal and Installation

Removal



1. Modulator Mounting Bracket
2. Left Frame Rail

Fig. 1, Brake Pressure Modulator Mounting, "D" Basic Version

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. See **Group 54** for information on special terminals and connectors and on ordering tools for them.

See **Fig. 1** for the "D" basic version modulator.

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the front and rear tires.
2. Put a container under the modulator to catch leaking brake fluid.
3. Disconnect the wiring from the modulator.

⚠ CAUTION

The modulator assembly contains hydraulic brake fluid, a caustic substance. Remove the brake lines and modulator carefully so that fluid does not leak and cause skin irritation or damage to components.

4. Mark the brake lines for ease of installation. Disconnect the lines.
5. Remove the mounting capscrews, washers and nuts that attach the modulator and bracket assembly to the bracket on the frame rail.
6. Remove the modulator and bracket assembly.

Installation

1. Install the modulator and bracket assembly. Install the mounting capscrews, washers and nuts that attach the modulator and bracket assembly to the bracket on the frame rail. Tighten the modulator and bracket assembly mounting nuts 132 lbf·in (1500 N·cm).
2. Connect the brake lines. Tighten the two small adapters (M10XI) 108 lbf·in (1200 N·cm). Tighten the four large adapters (M12XI) 132 lbf·in (1500 N·cm).
3. Connect the wiring to the modulator.
4. Bleed the brake system following the instructions in **Subject 120**.
5. Remove the chocks from the tires.

Bleeding

⚠ WARNING

Failure to bleed the system whenever any hydraulic system fitting is loosened or disconnected will allow air to remain in the system. This will prevent the hydraulic pressure in the brake system from rising enough to apply the brakes properly. This will cause the stopping distance to increase and can result in serious personal injury.

Properly discard hydraulic brake fluid that is removed from the brake system. Hydraulic brake fluid that is removed can be contaminated and can cause damage, loss of braking and serious personal injury.

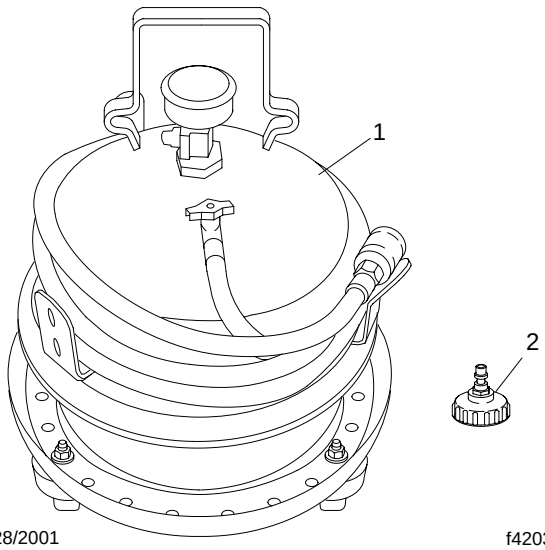
Power steering fluid and brake fluid are incompatible. Use only brake fluid for the master cylinder and brake lines. Use only power steering fluid for the power booster. Never mix these two fluids or serious damage to both hydraulic systems will result. The wrong hydraulic brake fluid will damage the rubber parts of the brake caliper and can cause damage, loss of braking and serious personal injury.

Always use new, clean brake fluid that meets DOT 3 specifications when bleeding the master cylinder and service brake system. Never reuse brake fluid, and don't use brake fluid containers for any other purpose. Keep brake fluid containers tightly closed to keep new brake fluid clean and dry.

IMPORTANT: Do not let brake fluid touch any painted surfaces, as it will remove the paint. Brake fluid may also damage certain non-metal surfaces. Do not let fluid get on brake pads or rotors.

Pressure Bleeding

Pressure bleeding is the preferred method for bleeding the service brake system. It requires the use of a special pressure bleeder kit, consisting of a tank, pressure pump and valve, gauge, tubing and adapter. These are available from a number of manufacturers and include instructions for use. See **Fig. 1**.



1. Pressure Bleeder
2. Adaptor

Fig. 1, Pressure Bleeder Kit

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Disconnect the batteries. The ignition must remain off for the entire bleed procedure.
3. Open the hood.
4. Connect the pressure bleeder to the brake master cylinder reservoir following the manufacturer's instructions.
   - 4.1 Fill the pressure bleeder with new DOT 3 approved brake fluid. Pressurize it according to the manufacturer's instructions.
   - 4.2 Using the supplied adapter, connect the pressure bleeder to the rear compartment of the master cylinder reservoir.
5. Bleed the hydraulic connections at the rear wheel calipers, starting on the right side.
   - 5.1 Put a wrench on the bleeder fitting at the caliper. Attach a length of clear tubing to the bleeder fitting. Make sure the tube fits snugly. Submerge the tubing in a container of clean brake fluid. See **Fig. 2**.
   - 5.2 Loosen the bleeder fitting by about a 3/4 turn and let the brake fluid flow out of the

Hydraulic System Bleeding

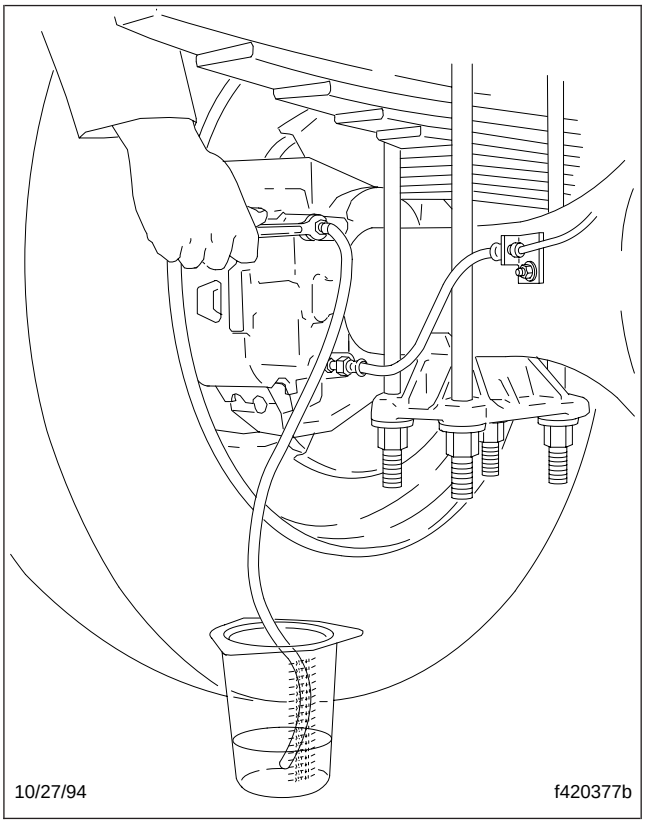


Fig. 2, Bleed the Connections at the Rear Wheel Calipers

fitting until it is free of air bubbles. Tighten the fitting firmly.

5.3 Move to the left rear caliper and repeat steps for bleeding the caliper.

6. Disconnect the pressure bleeder from the rear compartment of the master cylinder reservoir. Connect it to the front compartment of the reservoir.
7. Bleed the front wheel brake calipers, starting at the right side.

7.1 Put a wrench on the bleeder fitting at the caliper. Attach a length of clear tubing to the bleeder fitting. Make sure the tube fits snugly. Submerge the tubing in a container of clean brake fluid. See **Fig. 2**.

7.2 Loosen the bleeder fitting by about a 3/4 turn and let the brake fluid flow out of the fitting until it is free of air bubbles. Tighten the fitting firmly.

7.3 Move to the left front wheel caliper and repeat steps for bleeding the caliper.

8. Check the brake fluid level in both compartments of the reservoir. Add new DOT 3 approved brake fluid if needed.
9. Check the operation of the brakes by depressing the brake pedal several times until if feels firm. The brake pedal should not go all the way down to the floor. If it does, see "Troubleshooting" in **Section 42.26**, Subject 300 and find the problem.
10. Close and latch the hood.
11. Connect the batteries.
12. Remove the chocks from the rear tires.

Manual Bleeding

If you do not have pressure bleeding equipment, you can use the manual bleeding procedure.

IMPORTANT: Do not let the brake master cylinder fluid level get too low during manual bleeding operations. Keep the master cylinder reservoir filled with new, DOT 3 approved brake fluid. Failure to keep the brake reservoir filled could result in more air entering the system, making it impossible to effectively bleed the system.

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Disconnect the batteries. The ignition must remain off for the entire bleed procedure.
4. Bleed the master cylinder.

4.1 Using a wrench (and a rag to absorb leaking brake fluid), loosen the fitting at the rear outlet port on the master cylinder. See **Fig. 3**. Loosen the fitting about one turn.

4.2 Have someone push the brake pedal down slowly by hand to the floor. Brake fluid and any air in the master cylinder will squirt from the fitting.

4.3 *With the brake pedal held down*, tighten the rear hydraulic line fitting firmly.

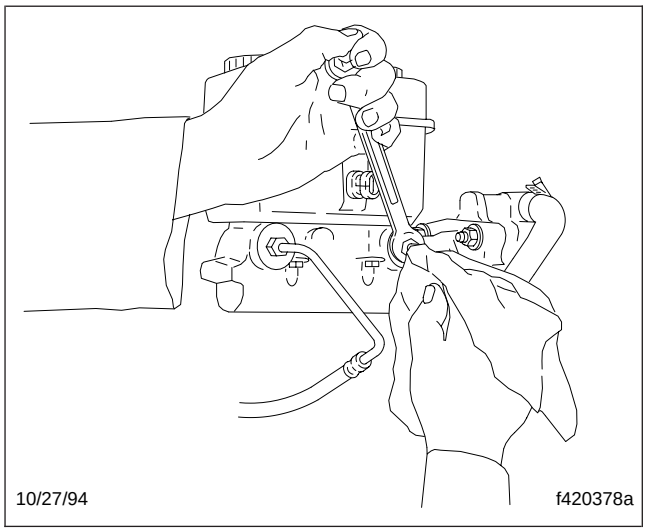


Fig. 3, Loosen the Fitting at the Rear Outlet Port

IMPORTANT: Do not release the brake pedal until the fitting is tightened or more air will get into the system.

4.4 Release the brake pedal.

4.5 Loosen the fitting again and repeat the steps for bleeding as required until no air escapes from the fitting and the brake pedal feels firm.

4.6 Check the fluid level of the rear compartment of the reservoir. Add new DOT 3 approved brake fluid if needed.

4.7 Using a wrench (and a rag to absorb leaking brake fluid), loosen the fitting at the front outlet port on the master cylinder. See **Fig. 4**. Loosen the fitting about one turn.

4.8 Repeat steps as required for the front outlet port.

4.9 Check the brake fluid level in the front compartment of the reservoir. Add new DOT 3 approved brake fluid if needed.

5. Bleed the hydraulic connections at the wheel calipers, starting at the right rear wheel caliper.

5.1 Put a wrench on the bleeder fitting at the caliper. Attach a length of clear tubing to the bleeder fitting. Make sure the tube fits snugly. Submerge the tubing in a container of clean brake fluid. See **Fig. 2**.

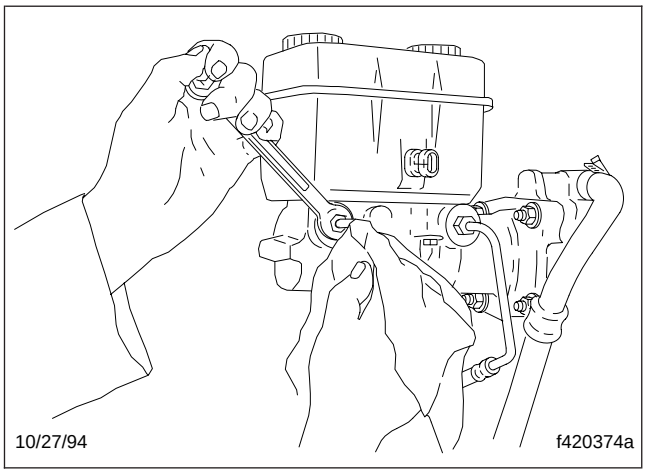


Fig. 4, Loosen the Fitting at the Front Outlet Port

5.2 Loosen the bleeder fitting by about a three-quarter turn.

5.3 Have an assistant slowly push the brake pedal to the floor. *With the brake pedal depressed*, tighten the bleeder fitting.

IMPORTANT: Make sure the brake pedal stays depressed while you tighten the fitting. If it is released before you tighten the fitting, more air will get into the system.

5.4 Release the brake pedal. Check the fluid in the tube. If there are air bubbles present, repeat steps as required until the fluid in the tube is completely free of air bubbles.

5.5 Check the brake fluid level in the reservoir. Add new DOT 3 approved brake fluid if needed.

5.6 Repeat the steps for bleeding the connections for the left rear caliper, the right front caliper and the left front caliper.

6. Close and latch the hood.

7. Connect the batteries.

8. Remove the chocks from the rear tires.

Voltage Check

NOTE: Along with the following, the voltage can also be checked using the Meritor WABCO PC Diagnostics-Toolbox Software.

IMPORTANT: Voltage must be between 9.5 and 14 volts for the 12-volt hydraulic ABS to function properly.

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires.
2. Turn the ignition on.
3. Check the voltage between 12 and 1, and pins 12 and 2, on the 18-pin connector.
4. If voltage is not between 9.5 and 14 volts, verify proper wiring connections. Make corrections as required.
5. Remove the chocks from the rear tires.

ABS Indicator Light

If the ABS indicator light does not come on after the ignition is turned on, check the bulb. Complete further diagnostics in **Troubleshooting 300**.

ABS Blink Code Switch

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires to prevent vehicle movement.
2. Check the resistance between the terminals while cycling the switch. There should be minimal resistance, if any, while the switch is in the momentary on position and infinite (high) resistance in its normal position, or off.
3. Remove the chocks from the rear tires.

Sensor Voltage Output Test

IMPORTANT: Sensor output voltage must be at least 0.2 volts AC at 30 rpm.

⚠ WARNING

Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury can result.

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the front and rear tires.
2. Turn the ignition off.
3. Release the parking brakes.
4. To measure voltage at the pins on the sensor connector, disconnect the sensor from the chassis harness.
5. Raise the vehicle off of the ground. Put safety stands under the axle.
6. Rotate the wheel by hand at 30 rpm (1/2 revolution per second).
7. Measure the voltage across the two pins at the sensor connector.
8. If the voltage is not greater than 0.2 volts AC, adjust the sensor and recheck. If the voltage is still not greater than 0.2 volts AC, replace the sensor.
9. Apply the parking brakes.
10. Remove the safety stands and lower the vehicle.
11. Remove the chocks from the rear tires.

Sensor Resistance

IMPORTANT: The sensor resistance must be between 900 and 2000 ohms. Measure resistance at the sensor connector or at the pins on the ECU connector.

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock the rear tires to prevent vehicle movement.
2. Turn the ignition off.
3. Measure resistance at the sensor connector. Disconnect the sensor from the chassis harness.
4. Measure the resistance across the two pins at the sensor connector.

Component Tests

5. If the measurement is not between 900 and 2000 ohms, replace the sensor.
6. Remove the chocks from the rear tires.

Troubleshooting

Meritor WABCO PC Diagnostics-Toolbox Software

The Meritor WABCO PC Diagnostics-Toolbox Software can be used to diagnose hydraulic antilock brake system (ABS) faults. This software is packaged with the CD ServiceLink and provides J1587 fault codes and on-screen information to assist in troubleshooting. Toolbox software must be used to reconfigure the ECU. The D version ECU does not allow reconfiguration through the blink code switch. See *Meritor WABCO Maintenance Manual No. 39, Rev. 1/00*.

Servicelink

ServiceLink can be used to troubleshoot the Meritor WABCO hydraulic ABS. J1587 fault codes can be read by connecting the vehicle to the ServiceLink computer.

J1587 Fault Codes

See **Table 1** for a listing of J1587 fault codes.

Instrument Panel Blink Codes

This system has built-in diagnostics to ensure that all components are operating properly. The ABS warning light in the instrument control unit comes on when the ignition is turned on. After about 3 seconds the light goes out if all of the ABS components are working correctly. If the light stays on, or comes back on later, a problem within the ABS has occurred. The vehicle can continue to be driven, but the ABS could be partially or completely inoperative. To check the fault code recorded, stop the vehicle and turn off the engine. Turn on the ignition switch, but do not start the engine. If the light stays on, there is an "active" system fault that must be repaired to ensure proper system operation. See **Table 2** for a listing of instrument panel blink codes.

J1587 Fault Code Cross Reference

J1587 Fault Code (MID-SID)	Description	Table
136s001	Left Front Wheel Sensor	**Table 4**
136s002	Right Front Wheel Sensor	**Table 5**
136s003	Left Rear Wheel Sensor	**Table 6**
136s004	Right Rear Wheel Sensor	**Table 7**
136s013	Retarder	**Table 8**
136s014	Power	**Table 9**
136s023	ABS Warning Light	**Table 10**
136s030	Recirculation Pump Relay	**Table 11**
136s042	Left Front Inlet Solenoid Valve	**Table 12**
136s043	Right Front Inlet Solenoid Valve	**Table 13**
136s044	Left Rear Inlet Solenoid Valve	**Table 14**
136s045	Right Rear Inlet Solenoid Valve	**Table 15**
136s048	Left Front Outlet Solenoid Valve	**Table 16**
136s049	Right Front Outlet Solenoid Valve	**Table 17**
136s050	Left Rear Outlet Solenoid Valve	**Table 18**
136s051	Right Rear Outlet Solenoid Valve	**Table 19**
136s054	Recirculation Pump	**Table 20**
136s055	ECU	**Table 21**

Troubleshooting

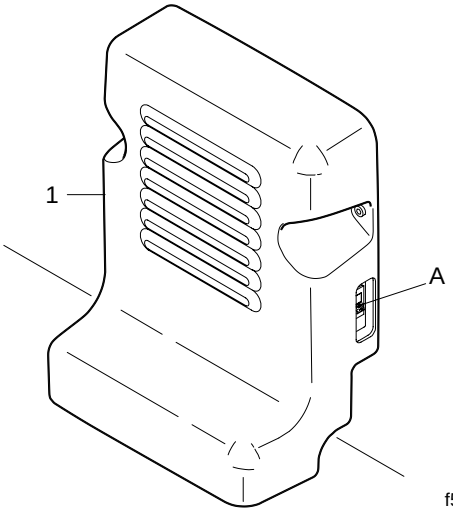
J1587 Fault Code Cross Reference		
J1587 Fault Code (MID-SID)	**Description**	**Table**
136-251	Low Voltage	**Table 22**
136-253	Internal Tire Parameter	**Table 23**
136-254	ECU Internal Fault	**Table 24**

Table 1, J1587 Fault Code Cross Reference

Blink Code Cross Reference	
Blink Code	**Reference**
2-1	**Table 13**, and **Table 17**
2-2	**Table 12**, and **Table 16**
2-3	**Table 15**, and **Table 19**
2-4	**Table 14**, and **Table 18**
2-7	**Table 21**
3-1	**Table 5**
2-3	**Table 4**
3-3	**Table 7**
3-4	**Table 6**
4-1	**Table 5**
4-2	**Table 4**
4-3	**Table 7**
4-4	**Table 6**
5-1	**Table 4**
5-2	**Table 4**
5-3	**Table 4**
5-4	**Table 4**
7-3	**Table 8**
7-4	**Table 10**
7-7	**Table 20**
7-8	**Table 11**
8-1	**Table 9**, and **Table 22**
8-2	**Table 9**, and **Table 22**
8-3	**Table 24**
8-4	**Table 23**

Table 2, Blink Code Cross Reference

Use the ABS CHECK switch (**Fig. 1**), located behind the driver's seat, and the ABS light to display system faults. With the ignition switch on, hold the ABS switch ON for 1 second. The ABS light should go out. After a 1-second pause, the ABS light will blink any active or stored fault codes. Each fault code will be indicated by two sets of flashes. The number of blinks displaying the first digit will be a number between one and eight. After a 1-1/2 second pause, the second digit will be displayed. The number of blinks displaying the second digit will be a number between one and eight. After a 4-second pause, the diagnostic code cycle continues to repeat the active fault code until the fault is repaired.



A. ABS Check Switch (access through opening in cover)
1. ABS ECU Cover

Fig. 1, ABS ECU Check Switch Location (behind driver's seat)

IMPORTANT: Active fault codes must be corrected before you can see stored faults.

For example, after the ABS CHECK switch has been turned on, the fault code 2–3 will blink, shown by two

flashes, a pause of 1-1/2 seconds, followed by three flashes. After a 4-second pause, the same fault code will continue to repeat, always ending with a 4-second pause.

- If it is an active fault, the same fault code will repeat until the ignition switch is turned off. See **Fig. 2**.
- If it is a stored fault, the next fault in the ECU memory will be displayed after the 4-second pause. See **Fig. 3**. The last fault stored in memory is displayed first; each stored fault is displayed only once.
- If there are no fault codes in the ECU memory, blink code 1–1 is displayed, meaning the system is clear. See **Fig. 4**.

Once a fault code has been identified, use a digital multimeter (DMM) to check the electrical harness at the electronic control unit (ECU) connectors or the modulator assembly connectors. Connect the meter leads to the applicable pins on each connector. See **Fig. 5** and **Table 3** for a description of the circuit wire numbers and their location within the pin connectors.

NOTE: In the harness connector, there is a jumper in Pin 15 that jumps Pin 12 to Pin 18 when the connector is disconnected from the ECU. This will cause the ABS lamp to illumincate if the connector is disconnected.

See **Fig. 6** for pin-out locations at the brake pressure modulator.

IMPORTANT: The ignition switch must be off when connecting or disconnecting the ECU.

NOTE: The active blink codes are erased from ECU memory as repairs are made. Once a repair has been made, cycle the ignition to ensure the blink code does not reappear. If there are any other outstanding faults, the next blink code will be displayed.

If the ABS light does not operate correctly after the ignition is turned on (the light does not come on at all or it does not go out after about 3 seconds), check all circuit breakers in the control unit panel and replace if necessary. Check the wiring to the ABS CHECK switch and the warning light and repair or replace the wiring as needed. When checking the warning light:

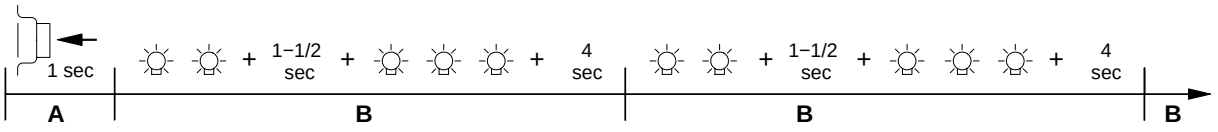
- Replace the bulb;
- Check for a fault in the warning lamp circuit, use a lamp test in Meritor PC-based diagnostics;

When checking the switch:

- Check the resistance between the terminals while cycling the switch;

The ABS system needs between 9.5 and 14 volts.

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. See **Group 54** for information on special terminals and connectors and ordering tools for them.



05/18/2000 f151013

NOTE: An active fault code repeats until the ignition switch is turned off.

A. Press the ABS CHECK switch for one second, then release. The ABS light goes out. After a 1-second pause, blink codes start.
B. Blink code 2–3: two blinks, a 1.5-second pause, three blinks, and a 4-second pause.

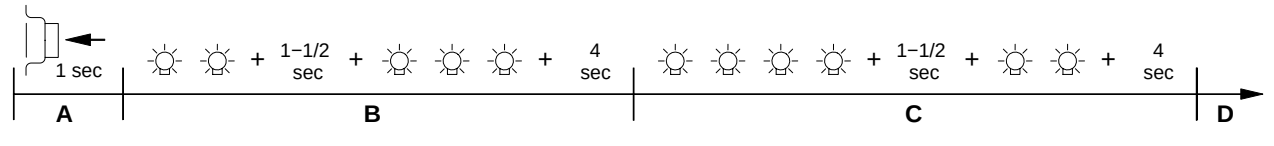
Fig. 2, Active Fault Codes Repeat (Blink Code 2-3 Shown)

Make the necessary repairs and clear the fault code from the ECU memory. If more than one active fault exists, it will be displayed after the first one has been cleared from memory.

A DMM can determine the condition of the ABS valves, wheel end sensors and associated wiring.

See the wiring diagrams in **Specifications 400** when troubleshooting the ABS system. If a fault cannot be repaired or erased from ECU memory, contact your

Troubleshooting

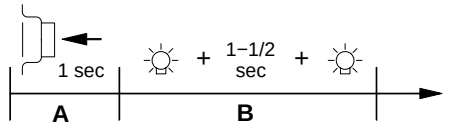


05/18/2000 f151014

NOTE: The last fault stored is displayed first; each stored fault is displayed only once.

A. Press the ABS CHECK switch for one second, then release. The ABS light goes out. After a 1.5-second pause, blink codes start.
B. The newest stored fault is displayed (blink code 2–3 is shown).
C. The second newest stored fault is displayed if one exists (blink code 4–2 is shown).
D. The third newest stored fault is displayed if one exists.

Fig. 3, Stored Fault Codes Display in Sequence



05/18/2000 f151012

A. Press the ABS CHECK switch for one second, then release. The ABS light goes out. After a 1-second pause, blink codes start.
B. Blink code 1–1: one blink, a 1-1/2 second pause, and 1 blink (system okay code).

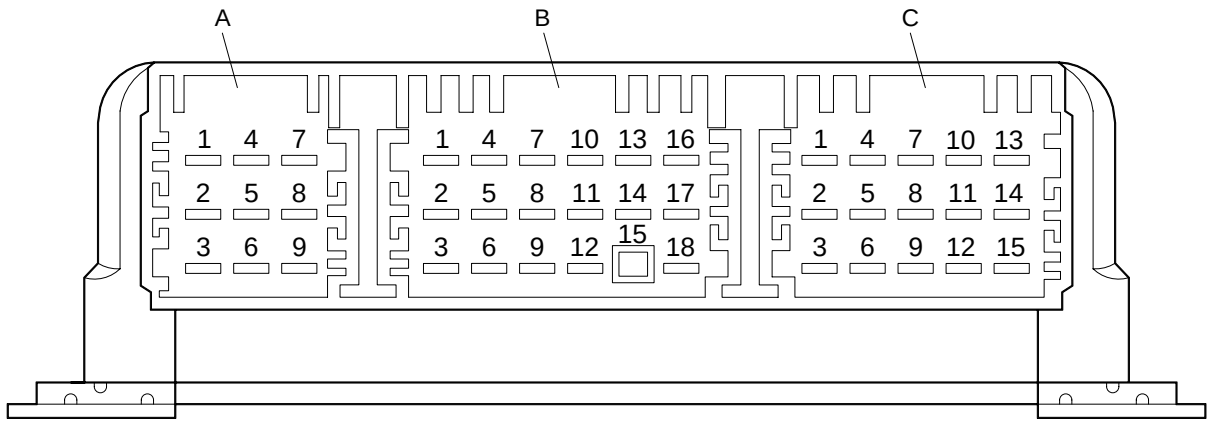
Fig. 4, No Faults, System OK

Erasing a Fault from the ECU Memory

NOTE: An active fault cannot be erased until it has been corrected.

Meritor WABCO recommends that you erase all faults from the ECU memory after they have been noted and corrected.

Stored faults are erased from the ECU memory by doing the following:



01/11/2000 f422100

A. 9-Pin ECU Connector
B. 18-Pin ECU Connector
C. 15-Pin ECU Connector

Fig. 5, "D" Basic ECU

District Service Manager or call Meritor WABCO at 1-800-535-5560.

1. Turn the ignition switch on.
2. Press the blink code switch on and hold for 3 seconds.

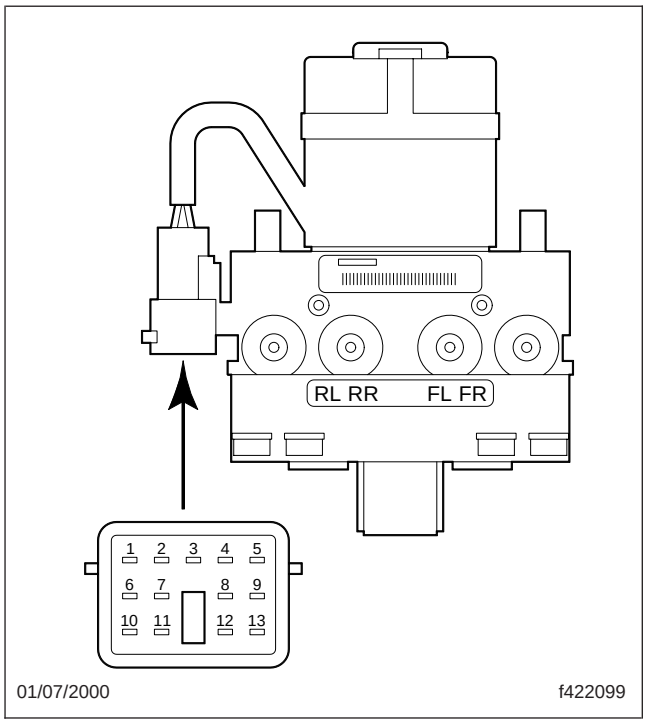


Fig. 6, Pin Locations at the Brake Pressure Modulator

3. Release the blink code switch.
4. If the ABS light flashes eight times and the system status code is repeated (Code 2), all stored faults have been successfully cleared. Turn the ignition OFF.

   Turn the ignition ON. The ABS light stays on because the system is looking for a wheel speed. Drive the vehicle above a speed of 4 mph (6 km/h). Once the ECU senses a wheel speed the light will go out. If the light remains on, there are still active faults.

   If the ABS light does not flash eight times, just flashing Code 2, active faults still exist. Repair the active fault and repeat the procedure to clear the fault codes.

Reset Memorized (Learned Components)

The ECU learns whether or not a retarder relay circuit is present. Once the ECU has detected a retarder circuit, it expects to see it every time the vehicle is powered up and will monitor the circuit for faults. If the ECU senses a resistance on the retarder circuit it will automatically learn that the retarder circuit exists. If an engine retarder circuit does not exist, but the ECU has detected one and is indicating faults, something may have been connected (a multimeter, etc.) to the retarder circuit during testing. Moisture, faulty circuit wiring, or moving an ECU from one vehicle to another can also cause the ECU to mistakenly detect a non-existent retarder circuit. If necessary, use the "Reset Memorized" command in the Meritor WABCO PC Diagnostics-Toolbox Software to clear the ECU memory of this component. For instructions, see *Meritor WABCO Maintenance Manual No. 39, Rev. 1/00*.

ECU Circuit Wire Numbers and Descriptions			
Pin Connector	**Pin Number**	**Freightliner Wire Number**	**WABCO Circuit Description**
9-Pin (EC3)	1	377LF+	Left Front Sensor
	2	377LF-	Left Front Sensor
	3	377RR+	Right Rear Sensor
	4	377RF+	Right Front Sensor
	5	377RF-	Right Front Sensor
	6	377RR-	Right Rear Sensor
	7	377LR+	Left Rear Sensor
	8	377LR-	Left Rear Sensor
	9	—	Not Used

Troubleshooting

ECU Circuit Wire Numbers and Descriptions			
Pin Connector	**Pin Number**	**Freightliner Wire Number**	**WABCO Circuit Description**
15-Pin (EC2)	1	378LFO	Left Front Outlet Valve
	2	378LFI	Left Front Inlet Valve
	3	GND7	Ground
	4	378RFO	Right Front Outlet Valve
	5	378RFI	Right Front Inlet Valve
	6	—	Not Used
	7	378LRO	Left Rear Outlet Valve
	8	378LRI	Left Rear Inlet Valve
	9	—	Not Used
	10	378RRO	Right Rear Outlet Valve
	11	378RRI	Right Rear Inlet Valve
	12	376R	Retarder Interrupt
	13	—	Not Used
	14	—	Not Used
	15	376H	Pump Relay Signal
18-Pin (EC1)	1	376B	ECU Supply/Battery +12V
	2	376C	ECU Ignition Supply +12V
	3	—	Not Used
	4	—	Not Used
	5	1587-A	SAE J1587 (-)
	6	1587+A	SAE J1587 (+)
	7	—	Not Used
	8	376A	Pump Motor Monitor
	9	—	Not Used
	10	—	Not Used
	11	—	Not Used
	12	GND6	Ground
	13	—	Not Used
	14	—	Not Used
	15	—	Jumper
	16	—	Not Used
	17	—	Not Used
	18	376L	ABS Indicator Lamp and Check Switch

Table 3, ECU Circuit Wire Numbers and Descriptions

Troubleshooting Tables

J1587 Fault 136s001 Left Front Wheel Sensor							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	001	01	Incorrect sensor air gap	1. Adjust the sensor. Check the AC voltage across the two pins at the sensor connector while rotating the left front wheel 30 rpm.	Voltage greater than 0.2 VAC	Sensor adjustment solved the problem. Clear the stored faults and drive the vehicle 4 mph (6 km/h).	3-2
					Voltage less than 0.2 VAC	Check for excessive wheel bearing end play. Repair as necessary.	
136	001	02	Intermittent open circuit or incorrect sensor resistance NOTE: This SAE J1587 fault code can also be caused by incorrect or mixed tire size (see information in TEST 4 below). The only way to determine the exact fault is to use blink code diagnostics. If blink code is 5-1, 5-2, 5-3 or 5-4, perform TEST 4 below.	2. Measure the resistance across Pins 1 and 2 of the 9-pin EC3 ECU connector (Circuits 377LF+ and 377LF–).	Resistance reading between 900 and 2000 ohms	Check for intermittent, loose or poor connections in Circuits 377LF+ and 377LF– and repair as necessary. If the problem persists, suspect the ECU is at fault.	4-2
					Resistance reading below 900 or above 2000 ohms	Go to TEST 3.	
				3. Disconnect the sensor at the sensor connector. Measure the resistance at the sensor connector (on the sensor side).	Resistance reading between 900 and 2000 ohms	Check the wiring between the ECU and the wheel sensor (Circuits 377LF+ and 377LF–). Repair as necessary. Go to TEST 4.	
					Resistance reading below 900 or above 2000 ohms	Replace the wheel sensor.	

Troubleshooting

J1587 Fault 136s001 Left Front Wheel Sensor							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	001	02	Incorrect or mixed tire size NOTE: This SAE J1587 fault code can also be caused by an intermittent open circuit or incorrect sensor resistance. The only way to determine the exact fault is to use blink code diagnostics. If blink code is 5-1, 5-2, 5-3 or 5-4, perform TEST 4. If blink code is 4-2, perform TESTS 2 and 3.	4. Check for tire size deviation in excess of 16 percent. Mixed tire sizes can cause this fault.	Tire size correct and size varies no more than 16 percent.	Check blink codes. If blink code 4-2 then perform TEST 2 and TEST 3 above if not already done. Verify fault and check ECU if problem cannot be verified	5-1 5-2 5-3 5-4
					The tire size varies more than 16 percent	Install the correct size tires.	
136	001	05	Open circuit	5. Measure the resistance across Pins 1 and 2 of the 9-pin EC3 ECU connector (Circuits 377LF+ and 377LF–).	Resistance reading between 900 and 2000 ohms	Check for intermittent, loose or poor connections in Circuits 377LF+ and 377LF– and repair as necessary. If the problem persists, suspect the ECU is at fault.	4-2
					Resistance reading below 900 or above 2000 ohms	Go to TEST 6.	
				6. Disconnect the sensor at the sensor connector. Measure the resistance at the sensor connector (on the sensor side).	Resistance reading between 900 and 2000 ohms	Check the wiring between the ECU and the wheel sensor (Circuits 377LF+ and 377LF–). Repair as necessary.	
					Resistance reading below 900 or above 2000 ohms	Replace the wheel sensor.	

Table 4, J1587 Fault 136s001 Left Front Wheel Sensor

J1587 Fault 136s002 Right Front Wheel Sensor							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	002	01	Incorrect sensor air gap	1. Adjust the sensor. Check the AC voltage across the two pins at the sensor connector while rotating the right front wheel 30 rpm.	Voltage greater than 0.2 VAC	Sensor adjustment solved the problem. Clear the stored faults and drive the vehicle 4 mph (6 km/h).	3-1
					Voltage less than 0.2 VAC	Check for excessive wheel bearing end play. Repair as necessary.	
136	002	02	Intermittent open circuit or incorrect sensor resistance	2. Measure the resistance across Pins 4 and 5 of the 9-pin EC3 ECU connector (Circuits 377RF+ and 377RF–).	Resistance reading between 900 and 2000 ohms	Check for intermittent, loose or poor connections in Circuits 377RF+ and 377RF– and repair as necessary. If the problem persists, suspect the ECU is at fault.	4-1
					Resistance reading below 900 or above 2000 ohms	Go to TEST 3.	
				3. Disconnect the sensor at the sensor connector. Measure the resistance at the sensor connector (on the sensor side).	Resistance reading between 900 and 2000 ohms	Check the wiring between the ECU and the wheel sensor (Circuits 377RF+ and 377RF–). Repair as necessary.	
					Resistance reading below 900 or above 2000 ohms	Replace the wheel sensor.	

Troubleshooting

J1587 Fault 136s002 Right Front Wheel Sensor							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	002	05	Open circuit	4. Measure the resistance across Pins 4 and 5 of the 9-pin EC3 ECU connector (Circuits 377RF+ and 377RF–).	Resistance reading between 900 and 2000 ohms	Check for intermittent, loose or poor connections in Circuits 377RF+ and 377RF– and repair as necessary. If the problem persists, suspect the ECU is at fault.	4-1
					Resistance reading below 900 or above 2000 ohms	Go to TEST 5.	
				5. Disconnect the sensor at the sensor connector. Measure the resistance at the sensor connector (on the sensor side).	Resistance reading between 900 and 2000 ohms	Check the wiring between the ECU and the wheel sensor (Circuits 377RF+ and 377RF–). Repair as necessary.	
					Resistance reading below 900 or above 2000 ohms	Replace the wheel sensor.	

Table 5, J1587 Fault 136s002 Right Front Wheel Sensor

J1587 Fault 136s003 Left Rear Wheel Sensor							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	003	01	Incorrect sensor air gap	1. Adjust the sensor. Check the AC voltage across the two pins at the sensor connector while rotating the left rear wheel 30 rpm.	Voltage greater than 0.2 VAC	Sensor adjustment solved the problem. Clear the stored faults and drive the vehicle 4 mph (6 km/h).	3-4
					Voltage less than 0.2 VAC	Check for excessive wheel bearing end play. Repair as necessary.	

J1587 Fault 136s003 Left Rear Wheel Sensor							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	003	02	Intermittent open circuit or incorrect sensor resistance	2. Measure the resistance across Pins 7 and 8 of the 9-pin EC3 ECU connector (Circuits 377RF+ and 377RF–).	Resistance reading between 900 and 2000 ohms	Check for intermittent, loose or poor connections in Circuits 377LR+ and 377LR– and repair as necessary. If the problem persists, suspect the ECU is at fault.	4-4
					Resistance reading below 900 or above 2000 ohms	Go to TEST 3.	
				3. Disconnect the sensor at the sensor connector. Measure the resistance at the sensor connector (on the sensor side).	Resistance reading between 900 and 2000 ohms	Check the wiring between the ECU and the wheel sensor (Circuits 377LR+ and 377LR–). Repair as necessary.	
					Resistance reading below 900 or above 2000 ohms	Replace the wheel sensor.	
136	003	05	Open circuit	4. Measure the resistance across Pins 7 and 8 of the 9-pin EC3 ECU connector (Circuits 377LR+ and 377LR–).	Resistance reading between 900 and 2000 ohms	Check for intermittent, loose or poor connections in Circuits 377LR+ and 377LR– and repair as necessary. If the problem persists, suspect the ECU is at fault.	4-4
					Resistance reading below 900 or above 2000 ohms	Go to TEST 5.	
				5. Disconnect the sensor at the sensor connector. Measure the resistance at the sensor connector (on the sensor side).	Resistance reading between 900 and 2000 ohms	Check the wiring between the ECU and the wheel sensor (Circuits 377LR+ and 377LR–). Repair as necessary.	
					Resistance reading below 900 or above 2000 ohms	Replace the wheel sensor.	

Table 6, J1587 Fault 136s003 Left Rear Wheel Sensor

Troubleshooting

J1587 Fault 136s004 Right Rear Wheel Sensor							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	004	01	Incorrect sensor air gap	1. Adjust the sensor. Check the AC voltage across the two pins at the sensor connector while rotating the right rear wheel 30 rpm.	Voltage greater than 0.2 VAC	Sensor adjustment solved the problem. Clear the stored faults and drive the vehicle 4 mph (6 km/h).	3-3
					Voltage less than 0.2 VAC	Check for excessive wheel bearing end play. Repair as necessary.	
136	004	02	Intermittent open circuit or incorrect sensor resistance	2. Measure the resistance across Pins 3 and 6 of the 9-pin EC3 ECU connector (Circuits 377RR+ and 377RR–).	Resistance reading between 900 and 2000 ohms	Check for intermittent, loose or poor connections in Circuits 377RR+ and 377RR– and repair as necessary. If the problem persists, suspect the ECU is at fault.	4-3
					Resistance reading below 900 or above 2000 ohms	Go to TEST 3.	
				3. Disconnect the sensor at the sensor connector. Measure the resistance at the sensor connector (on the sensor side).	Resistance reading between 900 and 2000 ohms	Check the wiring between the ECU and the wheel sensor (Circuits 377RR+ and 377RR–). Repair as necessary.	
					Resistance reading below 900 or above 2000 ohms	Replace the wheel sensor.	

J1587 Fault 136s004 Right Rear Wheel Sensor							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	004	05	Open circuit	4. Measure the resistance across Pins 3 and 6 of the 9-pin EC3 ECU connector (Circuits 377RR+ and 377RR–).	Resistance reading between 900 and 2000 ohms	Check for intermittent, loose or poor connections in Circuits 377RR+ and 377RR– and repair as necessary. If the problem persists, suspect the ECU is at fault.	4-3
					Resistance reading below 900 or above 2000 ohms	Go to TEST 5.	
				5. Disconnect the sensor at the sensor connector. Measure the resistance at the sensor connector (on the sensor side).	Resistance reading between 900 and 2000 ohms	Check the wiring between the ECU and the wheel sensor (Circuits 377RR+ and 377RR–). Repair as necessary.	
					Resistance reading below 900 or above 2000 ohms	Replace the wheel sensor.	

Table 7, J1587 Fault 136s004 Right Rear Wheel Sensor

Troubleshooting

J1587 Fault 136s013 Retarder							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	013	03	Short to power	1. Disconnect the 15-pin EC2 connector at the ECU. With the ignition ON, measure the voltage between Pin 12 of the 15-pin EC2 ECU connector and a good chassis ground.	Voltage is zero	Check for intermittent short to power in Circuit 376R. If the problem persists, suspect the ECU is at fault.	7-3
					Voltage not zero	Check for short to power in Circuit 376R. Repair as necessary.	
136	013	05	Open circuit	2. Disconnect the 15-pin EC2 connector at the ECU. With the ignition OFF, measure the resistance between Pin 12 of the 15-pin EC2 ECU connector and a good chassis ground.	Resistance is 59 to 71 ohms	If problem persists, suspect ECU is at fault	
					Resistance is 71 to 680 ohms	Check for poor or loose connections in circuit 376R and GND. If resistance is right at 680 Ohms, the retarder relay coil is open.	
					Resistance is greater than 680 ohms	If resistance is right at 680 Ohms then the retarder relay is open. If greater than 680 Ohms the retarder relay coil and its resistor are both open, or circuit 376R is open, or retarder relay coil ground circuit is open. repair as necessary. *	
136	013	06	Short to ground	3. Disconnect the 15-pin EC2 connector at the ECU. With the ignition OFF, measure the resistance between Pin 12 of the 15-pin EC2 ECU connector and a good chassis ground.	Resistance is 59 to 71 Ohms	If problem persists, suspect ECU is at fault	
					Resistance below 59 ohms	Check circuit 376R for short to ground, check for shorted retarder relay coil and resistor. Repair as necessary. *	

* NOTE: The retarder relay has a 680 Ohm resistor in parallel with the coil. Proper resistance across the coil terminals (85 and 86) should be approximately 59 to 71 Ohms (this is the combined resistance through both the coil and the resistor). If the resistor is open, the resistance across the coil terminals will be approximately 72 Ohms ±7 Ohms. If the relay coil is open, the resistance across the coil will be approximately 680 Ohms.

Table 8, J1587 Fault 136s013 Retarder

J1587 Fault 136s014 Power							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	014	03	Voltage supplied to ECU with ignition OFF This fault is caused by a malfunction to the internal relay to power the solenoid valves.	—	—	Replace ECU NOTE: If diagnosed by blink code 8-2, there may be another cause. See troubleshooting information under J1587 fault code 136 s251 before condemning the ECU.	8-2 *
136	014	04	No voltage supplied to ECU with ignition ON	2. Disconnect the 18-pin ECU connector. Measure the voltage between pin 8 (circuit 376A) and a good ground. Repeat test measuring the voltage between pin 1 (circuit 376B) and a good ground. NOTE: If the vehicle has a battery shut-off switch, make sure it is on. The above test assumes that the batteries are fully charged and have a nominal voltage reading of 12-volts at the batteries.	Voltage between 9.5 and 14 volts at both pins	Check for intermittent faults in circuits 376A and 376B. Check ECU ground circuit. If problem circuit fault can not be found and problem persists, replace the ECU.	8-1 *
					Voltage below 9.5 volts at either pin	Check the 25A and 40A ABS fuses. Check circuits 376A and 376B for open circuit or poor connection. Repair as necessary.	

* There is additional troubleshooting information for this blink code in Table 21.

Table 9, J1587 Fault 136s014 Power

Troubleshooting

J1587 Fault 136s023 ABS Warning Lamp							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	023	05	Open circuit or low current	1. Disconnect the 18-pin EC1 connector from the ECU. Turn the ignition ON.	ABS lamp illuminates	Check for intermittent wiring connections in Circuit 376L. If the wiring is OK, suspect the ECU is at fault.	7-4
					ABS lamp does not illuminate	Go to TEST 2.	
				2. Turn the ignition OFF and disconnect the 18-pin EC1 connector from the ECU. Measure the resistance between pin 18 of the EC1 connector and a good chassis ground.	Resistance is near zero Ohms	Go to TEST 3.	
					Resistance is above zero Ohms	Check the ground circuit (GRD6) between pin 12 of the 18-pin EC1 connector and ground splice S1. NOTE: There is a shorting bar in the 18-pin connector between pins 12 and 18. This bar should make contact between these pins when the connector is disconnected, thus providing the ground path to the ABS warning lamp.	
				3. Replace the ABS lamp in the ICU with a known good one. Leave the 18-pin EC1 connector disconnected. Turn the ignition ON.	ABS lamp illuminates	Replace the ABS lamp.	
					ABS lamp does not illuminate	Go to TEST 4.	
				4. Disconnect the B connector from the back of the ICU (leave the 18-pin EC1 connector disconnected). Measure the resistance between pin B11 of the ICU B connector and a good ground.	Resistance is near zero Ohms	Check the ICU, replace as necessary.	
					Resistance is above zero Ohms	Check circuit 376L between the ICU and the ABS ECU. Repair as necessary.	

Table 10, J1587 Fault 136s023 ABS Warning Lamp

J1587 Fault 136s030 Recirculation Pump Relay							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	030	03	Relay shorted to power	1. Disconnect the 15-pin EC2 connector. With the ignition ON, measure the voltage between pin 15 and a good chassis ground.	Voltage is zero	If the problem persists, suspect the ECU is at fault.	7-8
					Voltage is not zero	Circuit 376H is shorted to power. Repair as necessary.	
136	030	05	Relay open circuit	2. Disconnect the 15-pin EC2 connector. Measure the resistance between pin 15 and a good chassis ground.	Resistance is 59 to 71 Ohms	If the problem persists, suspect the ECU is at fault.	
					Resistance is 71 to 680 Ohms	Check for poor or loose connections in circuit 376H & GRND5. If the resistance is 680 Ohms, the relay coil is open.	
					Resistance is greater than 680 Ohms	If resistance is right at 680 Ohms then the relay coil is open, If greater than 680 Ohms either the relay coil and its resistor are both open, or circuit 376H is open, or relay coil ground circuit is open (GND5). Repair as necessary. *	
136	030	06	Relay short to ground	3. Disconnect the 15-pin EC2 connector. Measure the resistance between pin 15 and a good chassis ground.	Resistance between 59 and 71 ohms	If the problem persists, suspect the ECU is at fault.	
					Resistance below 50 or above 200 ohms	Check circuit 376H for short to ground, check for shorted relay coil and resistor. Repair as necessary. *	
136	030	07	Pump relay sticks, pump continues to run when ECU deactivates the relay NOTE: The problem may be intermittent and a new relay may be required to correct the fault.	4. If the fault is active, disconnect the 15-pin EC2 connector from the ECU. With the ignition ON, check to see if the recirculation pump is running.	Pump is OFF	ABS pump relay may be intermittently sticking. Try a new relay and verify that problem is solved.	
					Pump is ON	ABS pump relay is sticking. Replace relay.	

* The ABS pump relay (Siemens VF7-41F11) has a 680 Ohm resistor in parallel with the coil. Proper resistance across the coil terminals (85 and 86) should be approximately 59 to 71 Ohms (this is the combined resistance through both the coil and the resistor). If the resistor is open, the resistance across the coil terminals will be approximately 72 Ohms ±7 Ohms. If the relay coil is open, the resistance across the coil terminals will be approximately 680 Ohms.

Table 11, J1587 Fault 136s030 Recirculation Pump Relay

Troubleshooting

J1587 Fault 136s042 Left Front Inlet Solenoid Valve							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	042	03 05 06	Shorted to power Open circuit Shorted to ground NOTE: Check for an open circuit in the wiring between the ECU and the modulator valve. Check the ground circuit to the modulator valve.	1. Measure the resistance across pins 2 and 3 of the 15-pin EC2 connector (circuits 378LFI and GRD7).	Resistance is 6.5±0.5 Ohms.	Check for intermittent wiring connections. If the wiring is OK, suspect the ECU is at fault.	2-2
					Resistance is not 6.5±0.5 Ohms	Go to TEST 2.	
				2. Check the ground circuit by measuring the resistance between pin 3 of the 15-pin EC2 connector and a good chassis ground.	Resistance is near zero Ohms	Go to TEST 3.	
					Resistance is above zero Ohms	Check and repair the ground circuit.	
				3. Measure the resistance in circuit 378LFI between the modulator connector pin 12 and the 15-pin ECU2 connector pin 2.	Resistance is near zero Ohms	Go to TEST 4.	
					Resistance is above zero Ohms	Repair circuit 378LFI.	
				4. With the modulator valve connector removed, measure the resistance across pins 8 and 12 (on the modulator).	Resistance is 6.5±0.5 Ohms.	Repeat tests 1 - 4. Problem may be intermittent. If wiring is OK, suspect the ECU is at fault	
					Resistance is not 6.5±0.5 Ohms	Replace modulator valve	

Table 12, J1587 Fault 136s042 Left Front Inlet Solenoid Valve

J1587 Fault 136s043 Right Front Inlet Solenoid Valve							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	043	03 05 06	Shorted to power Open circuit Shorted to ground NOTE: Check for an open circuit in the wiring between the ECU and the modulator valve. Check the ground circuit to the modulator valve.	1. Measure the resistance across pins 5 and 3 of the 15-pin EC2 connector (circuits 378RFI and GRD7).	Resistance reading 6.5±0.5 ohms	Check for intermittent wiring connections. If the wiring is OK, suspect the ECU is at fault.	2-1
					Resistance reading not 6.5±0.5 ohms	Go to TEST 2.	
				2. Check the ground circuit by measuring the resistance between pin 3 of the 15-pin EC2 connector and a good chassis ground.	Resistance is near zero Ohms	Go to TEST 3.	
					Resistance is above zero Ohms	Check and repair the ground circuit.	
				3. Measure the resistance in circuit 378RFI between the modulator connector pin 4 and the 15-pin ECU2 connector pin 5.	Resistance is near zero Ohms	Go to TEST 4.	
					Resistance is above zero Ohms	Repair circuit 378LFI.	
				4. With the modulator valve connector removed, measure the resistance across pins 4 and 8 (on the modulator).	Resistance is 6.5±0.5 Ohms.	Repeat tests 1 - 4. Problem may be intermittent. If wiring is OK, suspect the ECU is at fault.	
					Resistance is not 6.5±0.5 Ohms	Replace modulator valve.	

Table 13, J1587 Fault 136s043 Right Front Inlet Solenoid Valve

Troubleshooting

J1587 Fault 136s044 Left Rear Inlet Solenoid Valve							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	044	03 05 06	Shorted to power Open circuit Shorted to ground NOTE: Check for an open circuit in the wiring between the ECU and the modulator valve. Check the ground circuit to the modulator valve.	1. Measure the resistance across pins 8 and 3 of the 15-pin EC2 connector (circuits 378LRI and GRD7).	Resistance reading 6.5±0.5 Ohms	Check for intermittent wiring connections. If the wiring is OK, suspect the ECU is at fault.	2-4
					Resistance reading not 6.5±0.5 Ohms	Go to TEST 2.	
				2. Check the ground circuit by measuring the resistance between pin 3 of the 15-pin EC2 connector and a good chassis ground.	Resistance is near zero Ohms	Go to TEST 3.	
					Resistance is above zero Ohms	Check and repair the ground circuit.	
				3. Measure the resistance in circuit 378LRI between the modulator connector pin 2 and the 15-pin EC2 connector pin 8.	Resistance is near zero Ohms	Go to TEST 4.	
					Resistance is above zero Ohms	Repair circuit 378LRI.	
				4. With the modulator valve connector removed, measure the resistance across pins 2 and 8 (on the modulator).	Resistance reading 6.5±0.5 Ohms	Repeat tests 1 - 4. Problem may be intermittent. If wiring is OK, suspect the ECU is at fault.	
					Resistance reading not 6.5±0.5 Ohms	Replace modulator valve	

Table 14, J1587 Fault 136s044 Left Rear Inlet Solenoid Valve

J1587 Fault 136s045 Right Rear Inlet Solenoid Valve							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	045	03 05 06	Shorted to power Open circuit Shorted to ground NOTE: Check for an open circuit in the wiring between the ECU and the modulator valve. Check the ground circuit to the modulator valve.	1. Measure the resistance across pins 11 and 3 of the 15-pin EC2 connector (circuits 378RRI and GRD7).	Resistance reading 6.5±0.5 ohms	Check for intermittent wiring connections. If the wiring is OK, suspect the ECU is at fault.	2-3
					Resistance reading not 6.5±0.5 ohms	Go to TEST 2.	
				2. Check the ground circuit by measuring the resistance between pin 3 of the 15-pin EC2 connector and a good chassis ground.	Resistance is near zero Ohms	Go to TEST 3.	
					Resistance is above zero Ohms	Check and repair the ground circuit.	
				3. Measure the resistance in circuit 378RRI between the modulator connector pin 11 and the 15-pin ECU2 connector pin 11.	Resistance is near zero Ohms	Go to TEST 4.	
					Resistance is above zero Ohms	Repair circuit 378RRI.	
				4. With the modulator valve connector removed, measure the resistance across pins 11 and 8 (on the modulator).	Resistance reading 6.5±0.5 ohms	Repeat tests 1 - 4. Problem may be intermittent. If wiring is OK, suspect the ECU is at fault.	
					Resistance reading not 6.5±0.5 ohms	Replace modulator valve.	

Table 15, J1587 Fault 136s045 Right Rear Inlet Solenoid Valve

Troubleshooting

J1587 Fault 136s048 Left Front Outlet Solenoid Valve							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	048	03 05 06	Shorted to power Open circuit Shorted to ground NOTE: Check for an open circuit in the wiring between the ECU and the modulator valve. Check the ground circuit to the modulator valve.	1. Measure the resistance across pins 1 and 3 of the 15-pin EC2 connector (circuits 378LFO and GRD7).	Resistance reading 3.5±0.5 ohms	Check for intermittent wiring connections. If the wiring is OK, suspect the ECU is at fault.	2-2
					Resistance reading not 3.5±0.5 ohms	Go to TEST 2.	
				2. Check the ground circuit by measuring the resistance between pin 3 of the 15-pin EC2 connector and a good chassis ground.	Resistance is near zero Ohms	Go to TEST 3.	
					Resistance is above zero Ohms	Check and repair the ground circuit.	
				3. Measure the resistance in circuit 378LFO between the modulator connector pin 13 and the 15-pin ECU2 connector pin 1.	Resistance is near zero Ohms	Go to TEST 4.	
					Resistance is above zero Ohms	Repair circuit 378LFO.	
				4. With the modulator valve connector removed, measure the resistance across pins 13 and 8 (on the modulator).	Resistance reading 3.5±0.5 ohms	Repeat tests 1 - 4. Problem may be intermittent. If wiring is OK, suspect the ECU is at fault.	
					Resistance reading not 3.5±0.5 ohms	Replace modulator valve.	

Table 16, J1587 Fault 136s048 Left Front Outlet Solenoid Valve

J1587 Fault 136s049 Right Front Outlet Solenoid Valve							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	049	03 05 06	Shorted to power Open circuit Shorted to ground NOTE: Check for an open circuit in the wiring between the ECU and the modulator valve. Check the ground circuit to the modulator valve.	1. Measure the resistance across pins 4 and 3 of the 15-pin EC2 connector (circuits 378RFO and GRD7).	Resistance reading 3.5±0.5 ohms	Check for intermittent wiring connections. If the wiring is OK, suspect the ECU is at fault.	2-1
					Resistance reading not 3.5±0.5 ohms	Go to TEST 2.	
				2. Check the ground circuit by measuring the resistance between pin 3 of the 15-pin EC2 connector and a good chassis ground.	Resistance is near zero Ohms	Go to TEST 3.	
					Resistance is above zero Ohms	Check and repair the ground circuit.	
				3. Measure the resistance in circuit 378RFO between the modulator connector pin 5 and the 15-pin ECU2 connector pin 4.	Resistance is near zero Ohms	Go to TEST 4.	
					Resistance is above zero Ohms	Repair circuit 378LFO.	
				4. With the modulator valve connector removed, measure the resistance across pins 5 and 8 (on the modulator).	Resistance reading 3.5±0.5 ohms	Repeat tests 1 - 4. Problem may be intermittent. If wiring is OK, suspect the ECU is at fault.	
					Resistance reading not 3.5±0.5 ohms	Replace modulator valve.	

Table 17, J1587 Fault 136s049 Right Front Outlet Solenoid Valve

Troubleshooting

J1587 Fault 136s050 Left Rear Outlet Solenoid Valve							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	050	03 05 06	Shorted to power Open circuit Shorted to ground NOTE: Check for an open circuit in the wiring between the ECU and the modulator valve. Check the ground circuit to the modulator valve.	1. Measure the resistance across pins 7 and 3 of the 15-pin EC2 connector (circuits 378LRO and GRD7).	Resistance reading 3.5±0.5 ohms	Check for intermittent wiring connections. If the wiring is OK, suspect the ECU is at fault.	2-4
					Resistance reading not 3.5±0.5 ohms	Go to TEST 2.	
				2. Check the ground circuit by measuring the resistance between pin 3 of the 15-pin EC2 connector and a good chassis ground.	Resistance is near zero Ohms	Go to TEST 3.	
					Resistance is above zero Ohms	Check and repair the ground circuit.	
				3. Measure the resistance in circuit 378LRO between the modulator connector pin 1 and the 15-pin ECU2 connector pin 7.	Resistance is near zero Ohms	Go to TEST 4.	
					Resistance is above zero Ohms	Repair circuit 378LRO.	
				4. With the modulator valve connector removed, measure the resistance across pins 1 and 8 (on the modulator).	Resistance reading 3.5±0.5 ohms	Repeat tests 1 - 4. Problem may be intermittent. If wiring is OK, suspect the ECU is at fault.	
					Resistance reading not 3.5±0.5 ohms	Replace modulator valve.	

Table 18, J1587 Fault 136s050 Left Rear Outlet Solenoid Valve

J1587 Fault 136s051 Right Rear Outlet Solenoid Valve							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	051	03 05 06	Shorted to power Open circuit Shorted to ground NOTE: Check for an open circuit in the wiring between the ECU and the modulator valve. Check the ground circuit to the modulator valve.	1. Measure the resistance across pins 10 and 3 of the 15-pin EC2 connector (circuits 378RRO and GRD7).	Resistance reading 3.5±0.5 ohms	Check for intermittent wiring connections. If the wiring is OK, suspect the ECU is at fault.	2-3
					Resistance reading not 3.5±0.5 ohms	Go to TEST 2.	
				2. Check the ground circuit by measuring the resistance between pin 3 of the 15-pin EC2 connector and a good chassis ground.	Resistance is near zero Ohms	Go to TEST 3.	
					Resistance is above zero Ohms	Check and repair the ground circuit.	
				3. Measure the resistance in circuit 378RRO between the modulator connector pin 10 and the 15-pin ECU2 connector pin 10.	Resistance is near zero Ohms	Go to TEST 4.	
					Resistance is above zero Ohms	Repair circuit 378RRO.	
				4. With the modulator valve connector removed, measure the resistance across pins 10 and 8 (on the modulator).	Resistance reading 3.5±0.5 ohms	Repeat tests 1 - 4. Problem may be intermittent. If wiring is OK, suspect the ECU is at fault.	
					Resistance reading not 3.5±0.5 ohms	Replace modulator valve.	

Table 19, J1587 Fault 136s051 Right Rear Outlet Solenoid Valve

Troubleshooting

J1587 Fault 136s054 Recirculation Pump							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	054	03	Recirculation pump on without being activated by ECU NOTE: In this case the ECU is sensing voltage on the pump monitor circuit (pin 8 of the 18-pin EC1 connector) when the pump relay was not activated by the ECU (pin 15 of the 15-pin EC2 connector).	1. Remove the 15-pin EC2 connector from the ECU. With the ignition ON, measure the voltage between pin 15 and a good chassis ground.	Voltage is zero.	Check the ECU and verify the fault.	7-7
					Voltage is not zero.	Go to TEST 2.	
				2. Remove the ABS pump relay and repeat TEST 1.	Voltage is zero.	Check pump relay; it may be sticking or shorted.	
					Voltage is not zero.	Check for a short to power in Circuit 376A causing the pump to run when it should not be. Repair as necessary.	
136	054	04	Recirculation pump does not switch on when activated by the ECU NOTE: In this case the ECU does not sense voltage on the pump monitor circuit (pin 8 of the 18-pin EC1 connector) when the pump relay was activated by the ECU (pin 15 of the 15-pin EC2 connector).	3. Remove both the 18-pin EC1 and 15-pin EC2 connectors from the ECU. With the ignition ON, Link pin 2 of the 18-pin EC1 connector to pin 15 of the 15-pin EC2 connector while measuring the voltage between pin 8 of the 18-pin EC1 connector and a good chassis ground. Note: the pump should run (do not hold for more than one minute).	Voltage is between 9.5 and 14 volts.	Check for intermittent connections in circuit 376A, check pump relay for intermittent operation. Repair as necessary.	
					Voltage is below 9.5 or above 14 volts.	Check circuit 376A, check the pump relay. Repair as necessary.	
136	054	07	Recirculation pump sticks or is locked NOTE: In this case, the ECU senses high current on the pump monitor circuit (pin 8 of the 18-pin EC1 connector) indicating the pump motor is locked.	4. Remove both the 18-pin EC1 and 15-pin EC2 connectors from the ECU. With the ignition ON, momentarily link pin 2 of the 18-pin EC1 connector to pin 15 of the 15-pin EC2 connector. Note: the pump should run (do not hold for more than one minute).	Pump runs	Repeat the test to verify. If the fault persists, suspect a problem with the ECU.	
					Pump does not run	Replace the recirculation pump.	

Table 20, J1587 Fault 136s054 Recirculation Pump

J1587 Fault 136s055 ECU							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	055	02	Reference to ground interrupted	1. With the ignition OFF, measure the voltage between pin 3 of the 15-pin EC2 connector (circuit GRD7) and a good chassis ground.	Voltage is zero	Go to TEST 2.	2-7
					Voltage is not zero	Check the ground circuit for a short to positive voltage.	
				2. Measure the resistance between pin 3 of the 15-pin EC2 connector and a good chassis ground.	Resistance near zero ohms	Check ECU ground circuit (GRD7) for intermittent or loose connection. Check pump and modulator ground circuits for intermittent or poor connections. If problem persists, suspect the ECU is at fault.	
					Resistance above zero ohms	Check ground circuit GRD7, pump ground, and modulator ground. Repair as necessary	

Table 21, J1587 Fault 136s055 ECU

J1587 Fault 136s251 Low Voltage							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	251	03	Voltage too high NOTE: Voltage to the ABS ECU must be between 9.5 and 14 volts to function properly.	1. Disconnect the 18-pin EC1 connector. Start the engine, run it at governed speed while measuring voltage between pins 2 and 12.	Voltage between 9.5 and 14 volts	Check the electrical system. If the problem persists, suspect the ECU is at fault.	8-2 *
					Voltage below 9.5 or above 14 volts	Check the batteries and charging system for malfunction. Repair as necessary.	

Troubleshooting

J1587 Fault 136s251 Low Voltage							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	251	04	Low voltage to ABS solenoid valves NOTE: Voltage to the ABS ECU must be between 9.5 and 14 volts to function properly.	2. Disconnect the 18-pin EC1 connector. Start the engine, run it at idle while measuring voltage between pins 2 and 12.	Voltage between 9.5 and 14 volts	Verify that the batteries were not drained or the charging system was not overloaded when the fault occurred. If the problem persists, suspect the ECU is at fault.	8-1 *
					Voltage below 9.5 or above 14 volts	Check the batteries and charging system for malfunction. Repair as necessary.	

* There is additional troubleshooting information under 136s014 for this blink code (**Table 8**).

Table 22, J1587 Fault 136s251 Low Voltage

J1587 Fault 136s253 Internal Tire Parameter							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	253	02	Incorrect internal tire parameter	—	—	Contact Meritor WABCO (1-800-535-5560).	8-4

Table 23, J1587 Fault 136s253 Internal Tire Parameter

J1587 Fault 136s254 ECU Internal Fault							
MID	**SID**	**FMI**	**Problem**	**Test**	**Test Result**	**Action**	**Blink Code**
136	254	12	Internal ECU Fault	—	—	Replace the ECU.	8-3

Table 24, J1587 Fault 136s254 ECU Internal Fault

Specifications

For a wiring diagram of the complete ABS system, see **Fig. 1**, **Fig. 2**, and **Fig. 3**.

For the "D" basic version hydraulic ABS system modulator valve and pump harness wiring diagram, see **Fig. 4**.

For the "D" basic version hydraulic ABS system front axle sensor harness wiring diagram, see **Fig. 5**.

For the "D" basic version hydraulic ABS system rear axle sensor harness wiring diagram, see **Fig. 6**.

For the "D" basic version hydraulic ABS system ECU harness wiring diagram, see **Fig. 7**.

For the "D" basic version hydraulic ABS system dash harness wiring diagram, see **Fig. 8**.

For the ECU and mounting plate assembly diagram, see **Fig. 9**.

For the chassis harness routing diagram of the "D" basic version hydraulic ABS system, see **Fig. 10**.

Specifications

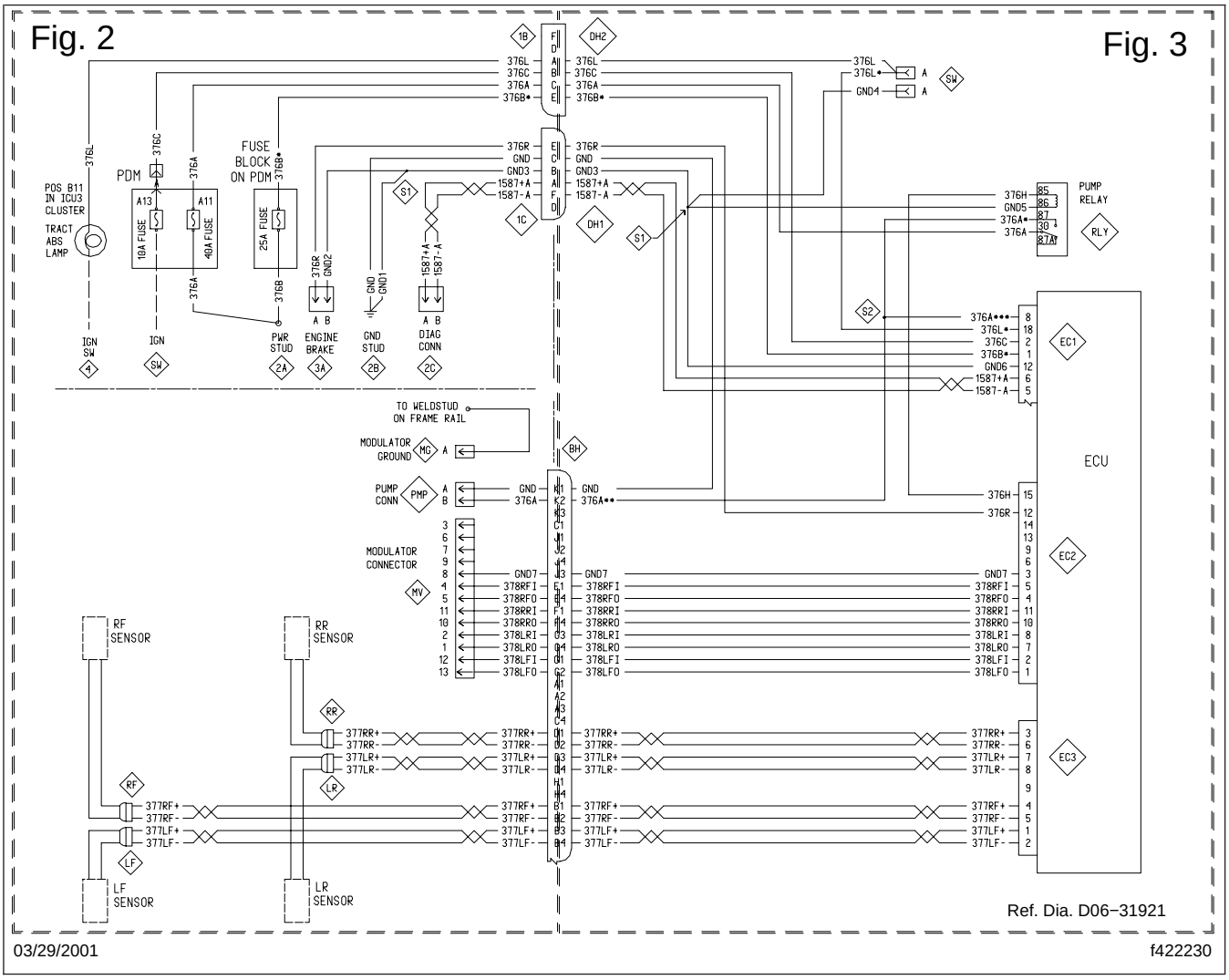


Fig. 1, ABS System Wiring (full view)

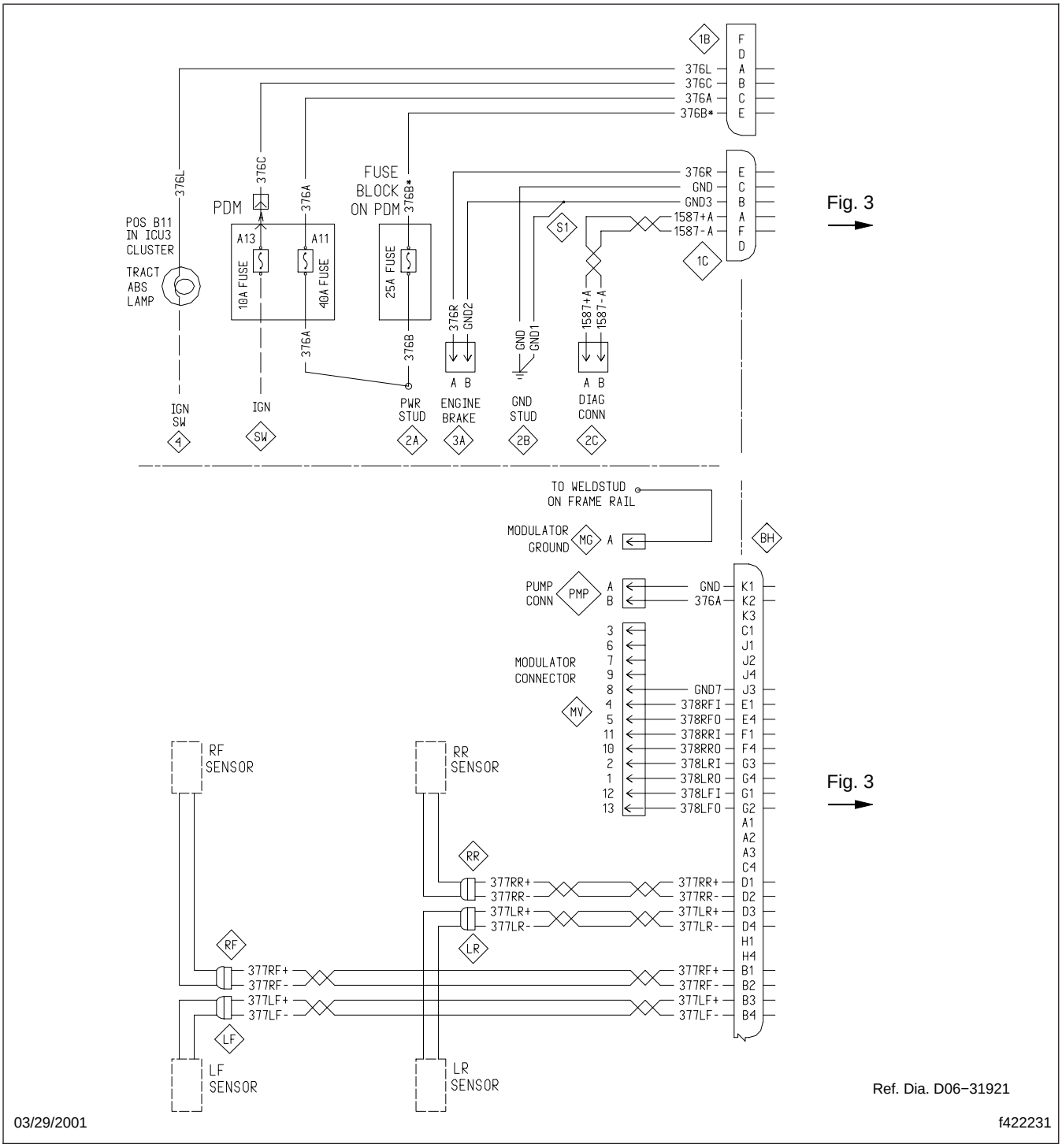


Fig. 2, ABS System Wiring (partial view)

Specifications

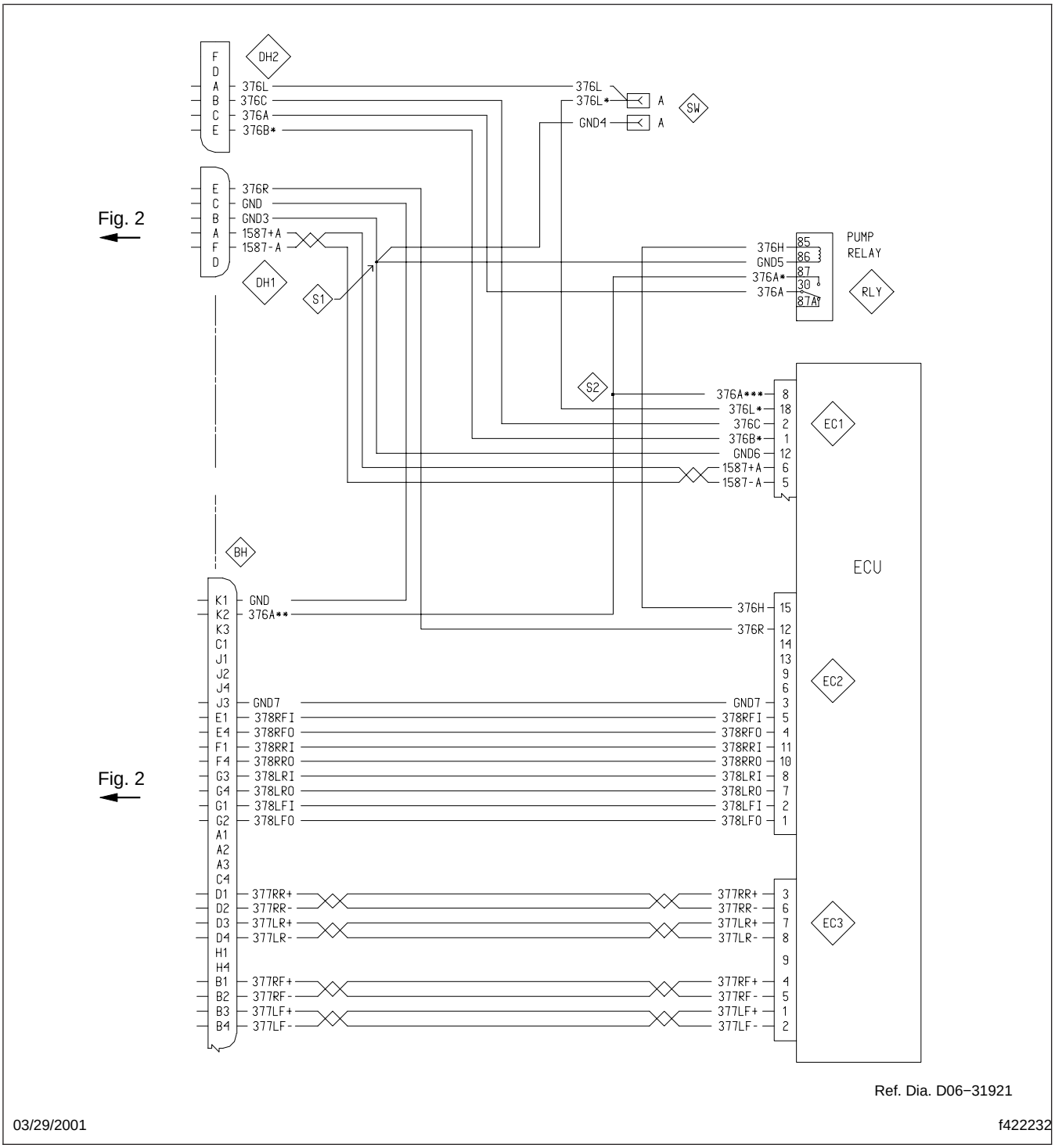
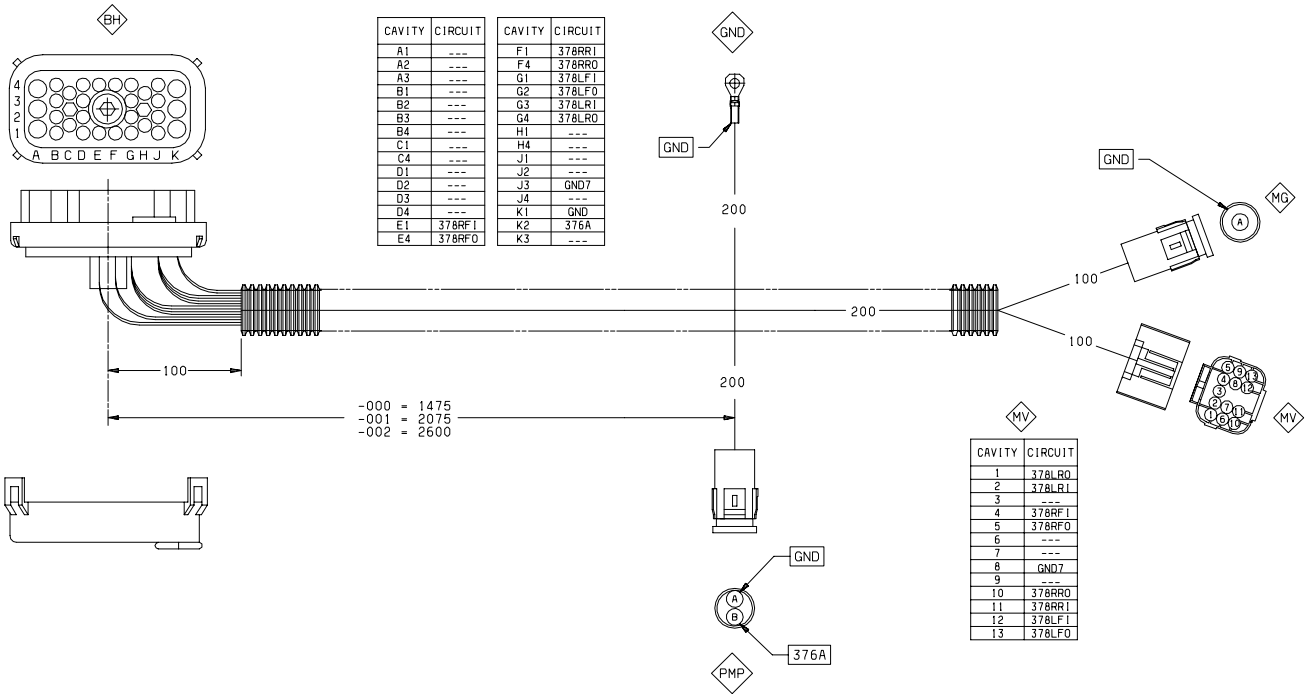


Fig. 3, ABS System Wiring (partial view)



F/L CIR NO.	WIRE ITEM NO.	FROM LOC	FROM TERM ITEM NO.	FROM SEAL INSL ITEM	FROM CONN CAV POS	TO LOC	TO TERM ITEM NO.	TO SEAL INSL ITEM	TO CONN CAV POS	APPROX LENGTH	APPROX LENGTH	APPROX LENGTH	CIRCUIT DESCRIPTION
376A	2	BH	5	6	K2	PMP	8	-	B	1675	2275	2800	CONSTANT PWR. MOD PUMP
378RFI	1	BH	27	4	E1	MV	12	13	4	1775	2375	2900	RIGHT FRONT VALVE, IN
378RFO	1	BH	27	4	E4	MV	12	13	5	1775	2375	2900	RIGHT FRONT VALVE, OUT
378RRI	1	BH	27	4	F1	MV	12	13	11	1775	2375	2900	RIGHT REAR VALVE, IN
378RRO	1	BH	27	4	F4	MV	12	13	10	1775	2375	2900	RIGHT REAR VALVE, OUT
378LFI	1	BH	27	4	G1	MV	12	13	12	1775	2375	2900	LEFT FRONT VALVE, IN
378LFO	1	BH	27	4	G2	MV	12	13	13	1775	2375	2900	LEFT FRONT VALVE, OUT
378LRI	1	BH	27	4	G3	MV	12	13	2	1775	2375	2900	LEFT REAR VALVE, IN
378LRO	1	BH	27	4	G4	MV	12	13	1	1775	2375	2900	LEFT REAR VALVE, OUT
GND7	1	BH	27	4	J3	MV	12	13	8	1775	2375	2900	GND, ECU REF
GND	2	BH	5	6	K1	PMP	8	-	A	1675	2275	2800	GND, MOD PUMP
GND	3	GND	25	26	-	MG	23	-	A	500	500	500	GND, MOD VLV

01/31/2001 Ref. Dia.: A06−31922, Chg. Ltr. − f543633

Fig. 4, Hydraulic ABS Modulator Valve and Pump Harness Wiring Diagram, "D" Basic Version

Specifications

F/L CIR NO	WIRE ITEM NO	FROM LOC	FROM TERM ITEM NO	FROM SEAL INSL ITEM	FROM CONN CAV POS	TO LOC	TO TERM ITEM NO	TO SEAL INSL ITEM	TO CONN CAV POS	APPROX LENGTH -000	APPROX LENGTH -001	APPROX LENGTH -002	DESCRIPTION
377LF-	1	BH	9	10	B4	LF	–	–	–	2030	2580	3105	LH SENSOR (BLK)
377LF+	1	BH	9	10	B3	LF	–	–	–	2030	2580	3105	LH SENSOR (BRN)
377RF-	1	BH	9	10	B2	RF	–	–	–	3345	3895	4420	RH SENSOR (BLK)
377RF+	1	BH	9	10	B1	RF	–	–	–	3345	3895	4420	RH SENSOR (BRN)

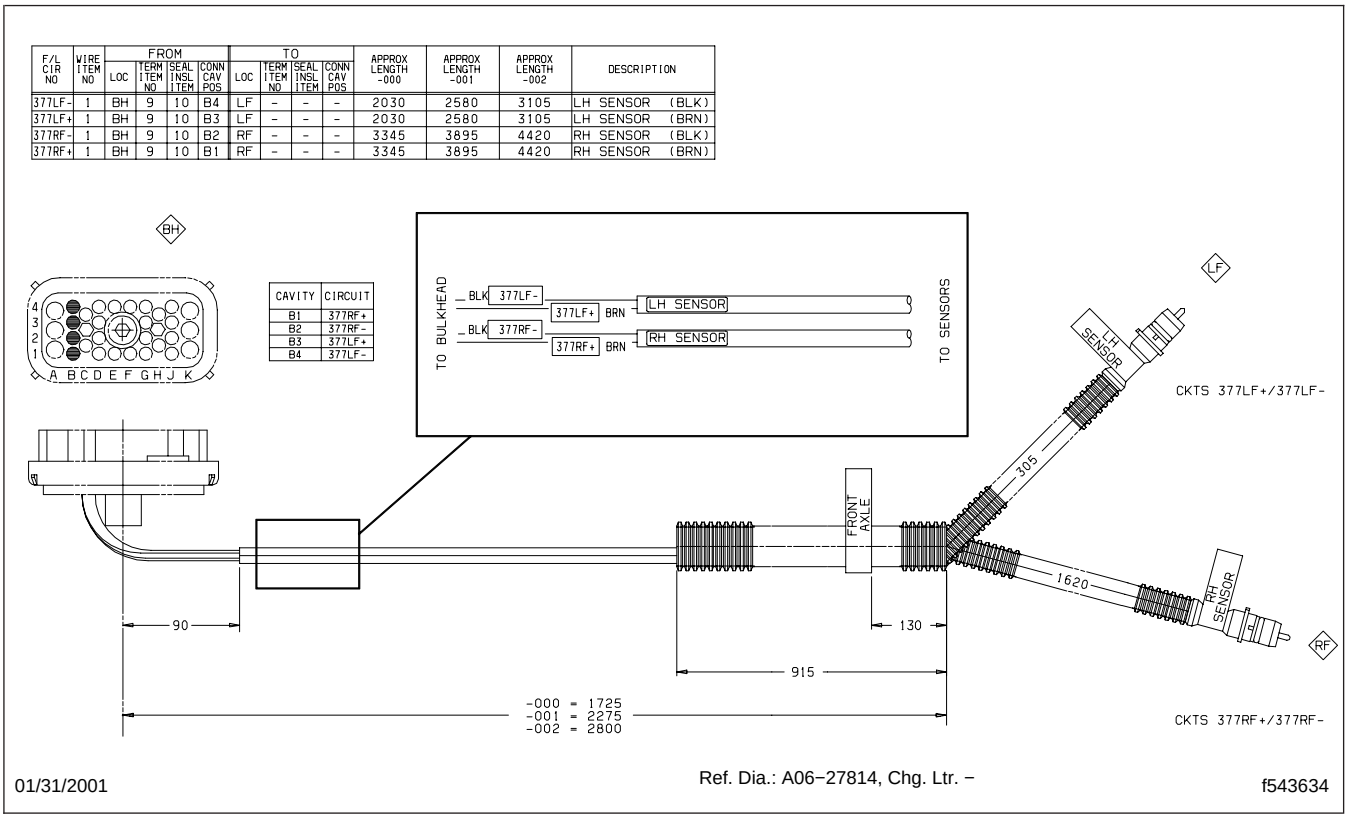


Fig. 5, Hydraulic ABS Front Axle Sensor Harness Wiring Diagram, "D" Basic Version

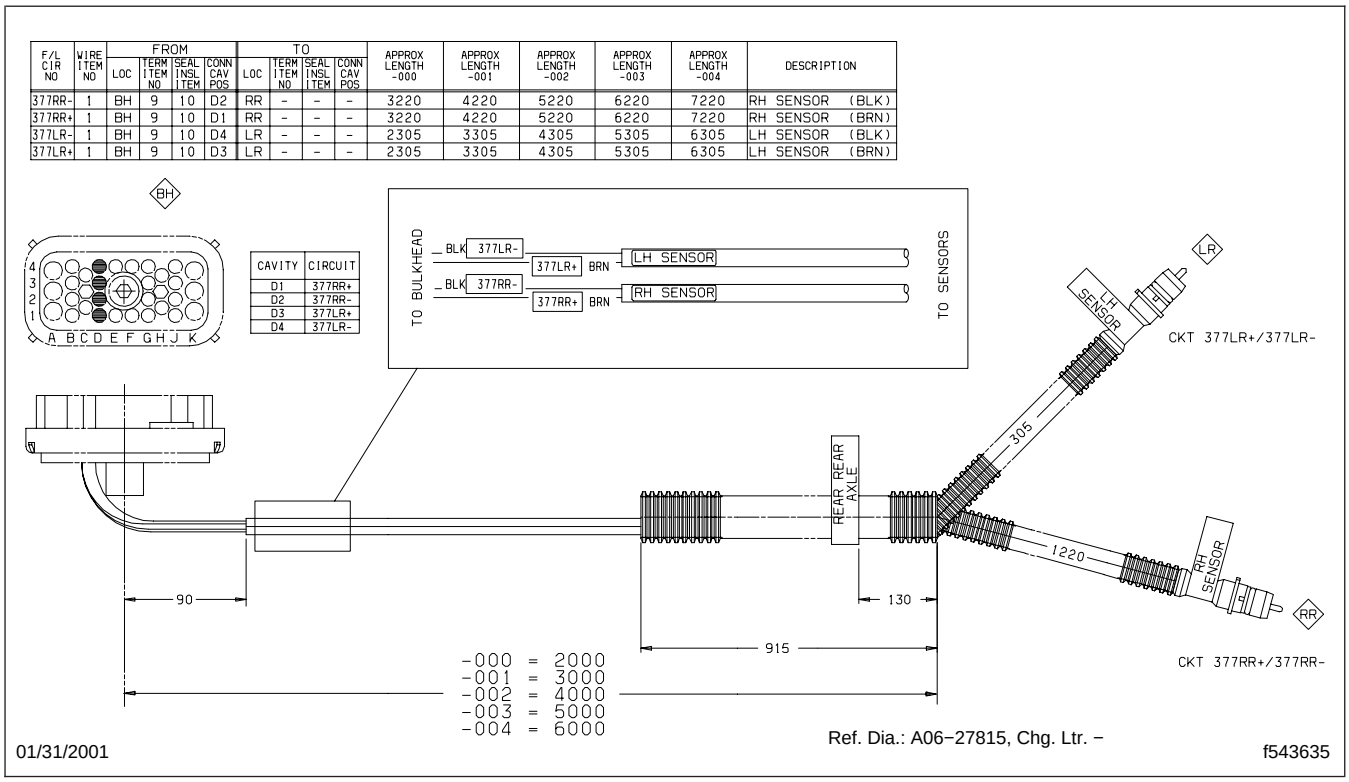
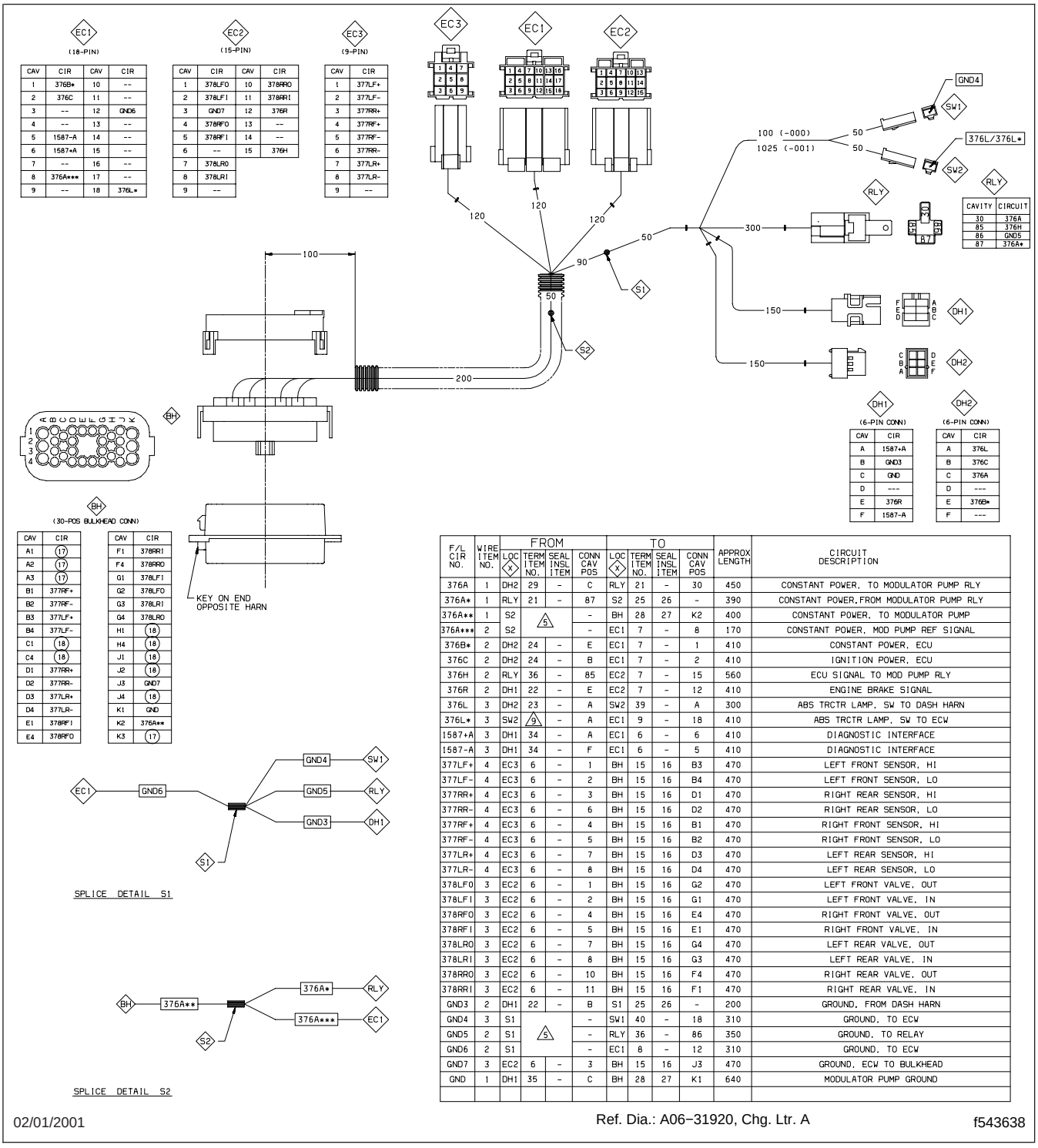


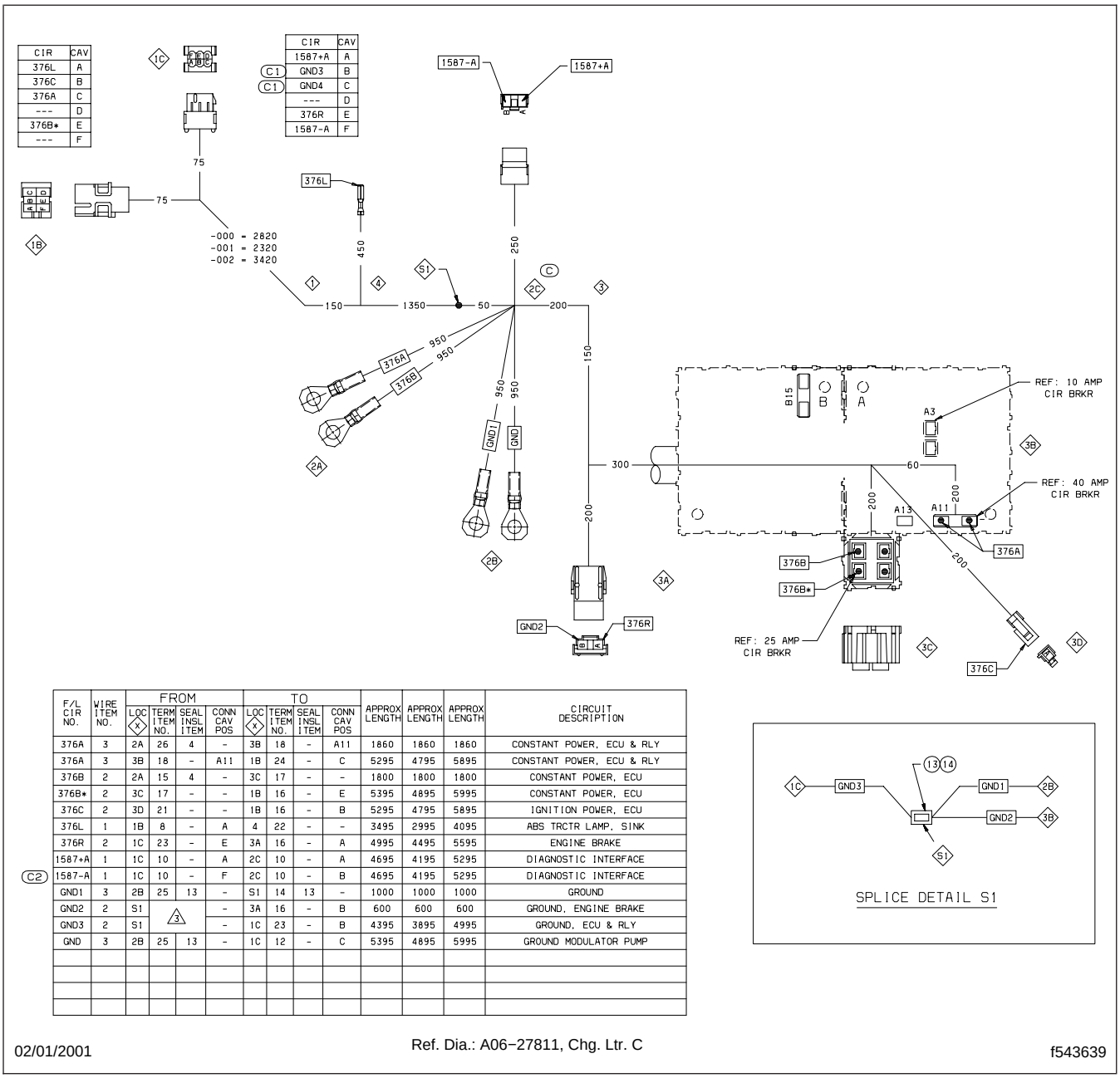
Fig. 6, Hydraulic ABS Rear Axle Sensor Harness Wiring Diagram, "D" Basic Version

Specifications



F/L CIR NO.	WIRE ITEM NO.	FROM LOC	FROM TERM ITEM NO.	FROM SEAL INSL ITEM	FROM CONN CAV POS	TO LOC	TO TERM ITEM NO.	TO SEAL INSL ITEM	TO CONN CAV POS	APPROX LENGTH	CIRCUIT DESCRIPTION
376A	1	DH2	29	-	C	RLY	21	-	30	450	CONSTANT POWER, TO MODULATOR PUMP RLY
376A*	1	RLY	21	-	87	S2	25	26	-	390	CONSTANT POWER,FROM MODULATOR PUMP RLY
376A**	1	S2	5		-	BH	28	27	K2	400	CONSTANT POWER, TO MODULATOR PUMP
376A***	2	S2			-	EC1	7	-	8	170	CONSTANT POWER, MOD PUMP REF SIGNAL
376B*	2	DH2	24	-	E	EC1	7	-	1	410	CONSTANT POWER, ECU
376C	2	DH2	24	-	B	EC1	7	-	2	410	IGNITION POWER, ECU
376H	2	RLY	36	-	85	EC2	7	-	15	560	ECU SIGNAL TO MOD PUMP RLY
376R	2	DH1	22	-	E	EC2	7	-	12	410	ENGINE BRAKE SIGNAL
376L	3	DH2	23	-	A	SW2	39	-	A	300	ABS TRCTR LAMP, SW TO DASH HARN
376L*	3	SW2	9	-	A	EC1	9	-	18	410	ABS TRCTR LAMP, SW TO ECW
1587+A	3	DH1	34	-	A	EC1	6	-	6	410	DIAGNOSTIC INTERFACE
1587-A	3	DH1	34	-	F	EC1	6	-	5	410	DIAGNOSTIC INTERFACE
377LF+	4	EC3	6	-	1	BH	15	16	B3	470	LEFT FRONT SENSOR, HI
377LF-	4	EC3	6	-	2	BH	15	16	B4	470	LEFT FRONT SENSOR, LO
377RR+	4	EC3	6	-	3	BH	15	16	D1	470	RIGHT REAR SENSOR, HI
377RR-	4	EC3	6	-	6	BH	15	16	D2	470	RIGHT REAR SENSOR, LO
377RF+	4	EC3	6	-	4	BH	15	16	B1	470	RIGHT FRONT SENSOR, HI
377RF-	4	EC3	6	-	5	BH	15	16	B2	470	RIGHT FRONT SENSOR, LO
377LR+	4	EC3	6	-	7	BH	15	16	D3	470	LEFT REAR SENSOR, HI
377LR-	4	EC3	6	-	8	BH	15	16	D4	470	LEFT REAR SENSOR, LO
378LF0	3	EC2	6	-	1	BH	15	16	G2	470	LEFT FRONT VALVE, OUT
378LFI	3	EC2	6	-	2	BH	15	16	G1	470	LEFT FRONT VALVE, IN
378RF0	3	EC2	6	-	4	BH	15	16	E4	470	RIGHT FRONT VALVE, OUT
378RFI	3	EC2	6	-	5	BH	15	16	E1	470	RIGHT FRONT VALVE, IN
378LR0	3	EC2	6	-	7	BH	15	16	G4	470	LEFT REAR VALVE, OUT
378LRI	3	EC2	6	-	8	BH	15	16	G3	470	LEFT REAR VALVE, IN
378RR0	3	EC2	6	-	10	BH	15	16	F4	470	RIGHT REAR VALVE, OUT
378RRI	3	EC2	6	-	11	BH	15	16	F1	470	RIGHT REAR VALVE, IN
GND3	2	DH1	22	-	B	S1	25	26	-	200	GROUND, FROM DASH HARN
GND4	3	S1	5		-	SW1	40	-	18	310	GROUND, TO ECW
GND5	2	S1			-	RLY	36	-	86	350	GROUND, TO RELAY
GND6	2	S1			-	EC1	8	-	12	310	GROUND, TO ECW
GND7	3	EC2	6	-	3	BH	15	16	J3	470	GROUND, ECW TO BULKHEAD
GND	1	DH1	35	-	C	BH	28	27	K1	640	MODULATOR PUMP GROUND

Fig. 7, Hydraulic ABS ECU Harness Wiring Diagram, "D" Basic Version



F/L CIR NO.	WIRE ITEM NO.	FROM LOC	FROM TERM ITEM NO.	FROM SEAL INSL ITEM	FROM CONN CAV POS	TO LOC	TO TERM ITEM NO.	TO SEAL INSL ITEM	TO CONN CAV POS	APPROX LENGTH	APPROX LENGTH	APPROX LENGTH	CIRCUIT DESCRIPTION
376A	3	2A	26	4	-	3B	18	-	A11	1860	1860	1860	CONSTANT POWER, ECU & RLY
376A	3	3B	18	-	A11	1B	24	-	C	5295	4795	5895	CONSTANT POWER, ECU & RLY
376B	2	2A	15	4	-	3C	17	-	-	1800	1800	1800	CONSTANT POWER, ECU
376B*	2	3C	17	-	-	1B	16	-	E	5395	4895	5995	CONSTANT POWER, ECU
376C	2	3D	21	-	-	1B	16	-	B	5295	4795	5895	IGNITION POWER, ECU
376L	1	1B	8	-	A	4	22	-	-	3495	2995	4095	ABS TRCTR LAMP, SINK
376R	2	1C	23	-	E	3A	16	-	A	4995	4495	5595	ENGINE BRAKE
1587+A	1	1C	10	-	A	2C	10	-	A	4695	4195	5295	DIAGNOSTIC INTERFACE
1587-A	1	1C	10	-	F	2C	10	-	B	4695	4195	5295	DIAGNOSTIC INTERFACE
GND1	3	2B	25	13	-	S1	14	13	-	1000	1000	1000	GROUND
GND2	2	S1	3		-	3A	16	-	B	600	600	600	GROUND, ENGINE BRAKE
GND3	2	S1			-	1C	23	-	B	4395	3895	4995	GROUND, ECU & RLY
GND	3	2B	25	13	-	1C	12	-	C	5395	4895	5995	GROUND MODULATOR PUMP

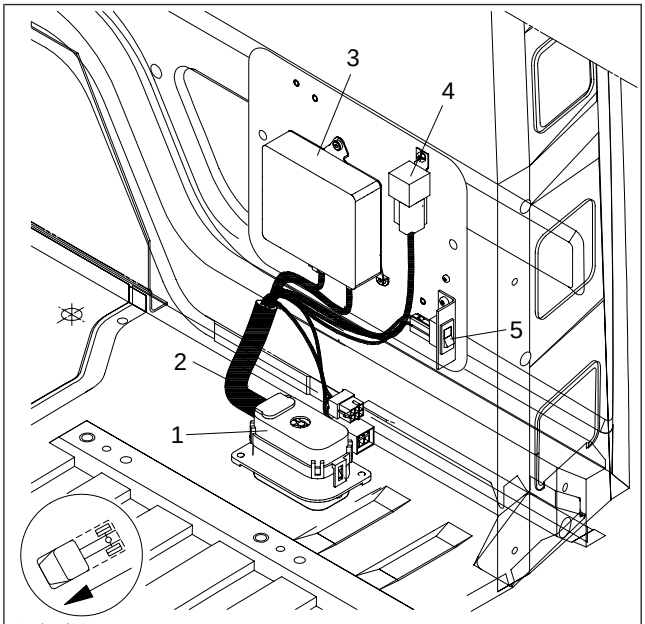
02/01/2001

Ref. Dia.: A06−27811, Chg. Ltr. C

f543639

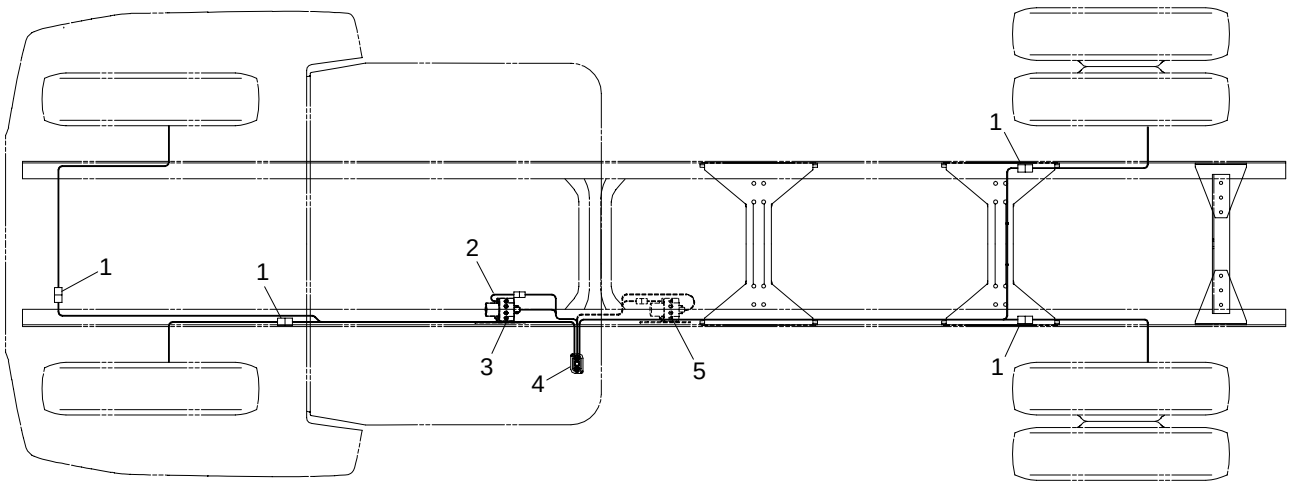
Fig. 8, Hydraulic ABS Dash Harness Wiring Diagram, "D" Basic Version

Specifications



1. Bulk Head Connector (back of cab)
2. Harness
3. ECU
4. ABS Pump Relay
5. ABS Check Switch

Fig. 9, ECU (Cover Removed)



01/31/2001 Ref. Dia.: D06−23574, Chg. Ltr. A f543636

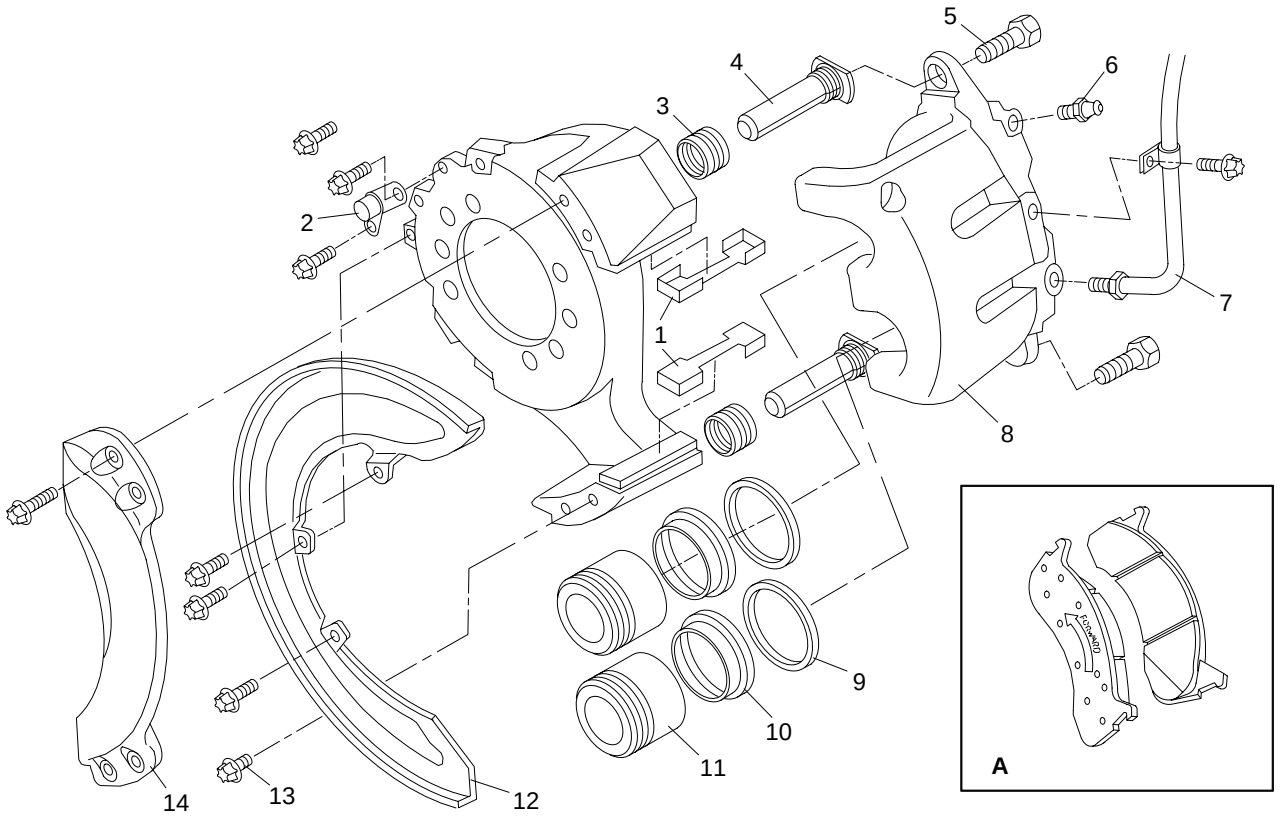
1. ABS Wheel Speed Sensor Connector
2. Modulator Valve Harness
3. Modulator Valve
4. Bulkhead Connector
5. Alternate Modulator Valve Location

Fig. 10, Hydraulic ABS Chassis Harness Routing Diagram, "D" Basic Version

General Information

Bosch hydraulic pin slide disc brakes are two piston sliding caliper brakes for use at both front and rear wheels. See **Fig. 1**. Each pin slide caliper disc brake wheel installation is comprised of three major components. See **Fig. 2**.

taches to and slides on sealed pins located in an anchor plate. The anchor plate is mounted on the steering knuckle flange on front axles or on the axle flange on rear axles. Two sizes of calipers are used: 66mm Twin (2 piston) and 73mm Twin (2 piston). See **Fig. 3**.



05/22/2001 f430241

A. Brake Pads
1. Slipper
2. Antilock Brakes Sensor Bracket
3. Guide Pin Boot
4. Guide Pin
5. Guide Pin Bolt
6. Bleed Screw
7. Brake Line
8. Caliper
9. Caliper Boot Seal
10. Piston Boot
11. Caliper Piston
12. Splash Shield
13. Plug (66mm only)
14. Tie Bar (73mm only)

Fig. 1, Pin Slide Brake (exploded view)

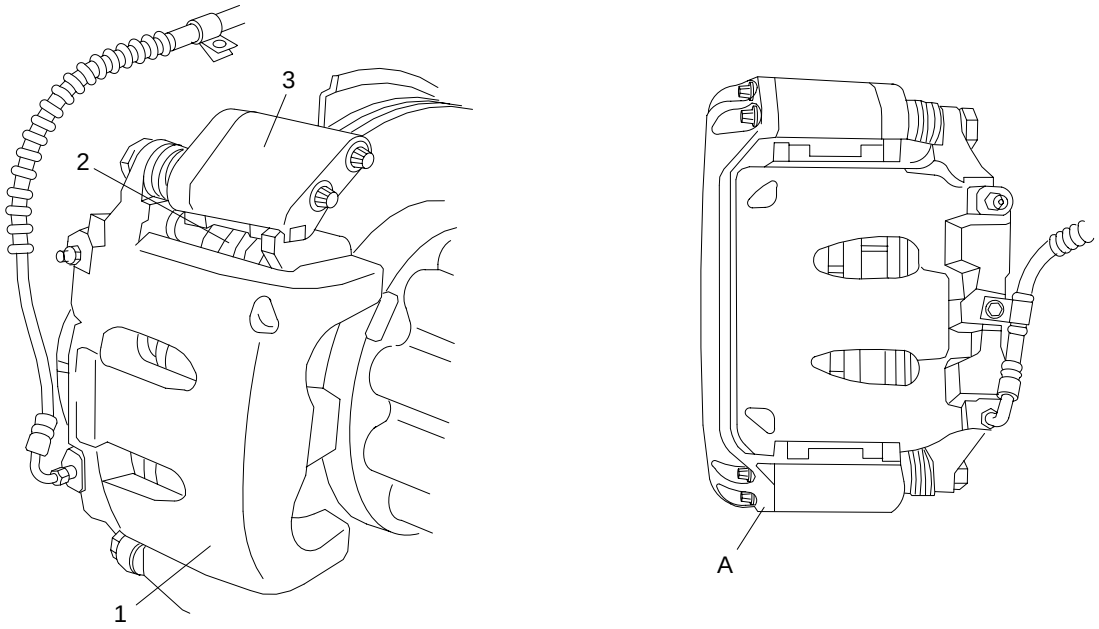
Caliper Assembly

The caliper assembly includes two hydraulic piston bores. The piston bores contain the pistons, piston seals and piston boots. The caliper assembly at-

Disc Brake Pads

The inboard and outboard disc brake pads are positioned with both ends mounted on the anchor plate pad abutments. The pads rest on stainless steel slip-

General Information



05/24/2001 f430246

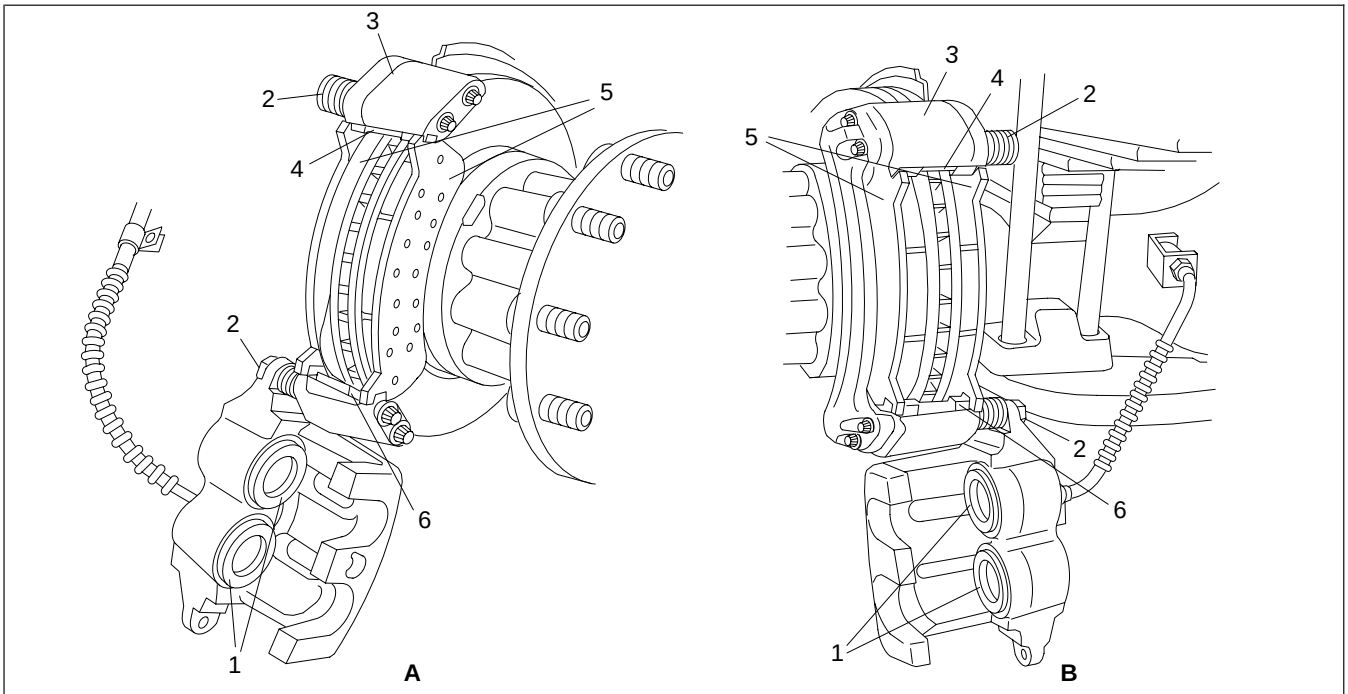
A. 73mm slider disc brakes incorporate a tie bar between the anchor plate abutment arms.
1. Caliper Assembly
2. Brake Pads
3. Anchor Plate Assembly

Fig. 2, Major Components

pers covering the anchor plate pad abutments. Inboard and outboard disc brake pads may be chamfered, and if so are marked with an arrow and the word "FORWARD" for proper installation. Brake pads may not be interchangeable inner to outer, so correct location is required during assembly.

Anchor Plate Assembly

The anchor plate includes lubricated floating guide pins sealed by rubber boots and anchor plate pad abutments protected by stainless steel slippers. A tie bar which spans the anchor plate abutment arms is used on 73mm pin slide disc brake installations only. A splash shield on the back of the rotor helps protect the brake assembly from road contamination. Bosses are provided for mounting an antilock brake system speed sensor. See **Fig. 4**.

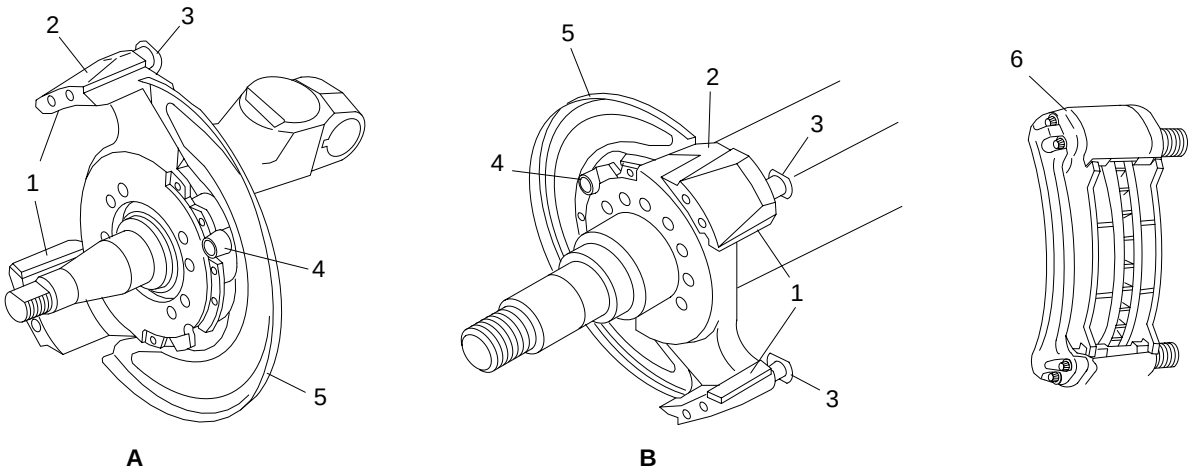


A. Front (66mm shown)
1. Hydraulic Pistons with Seals and Boots
2. Sealed Pins
3. Anchor Plate

B. Rear (73mm shown)
4. Upper Slipper
5. Brake Pads
6. Lower Slipper

Fig. 3, System Components

General Information



A. Front
1. Pad Abutment
2. Anchor Plate
3. Floating Guide Pin

B. Rear
4. Antilock Braking System Sensor Mounting
5. Splash Shield
6. Tie Bar (73mm brakes only)

Fig. 4, Anchor Plate and Splash Shield

Safety Precautions

⚠ WARNING

Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by NIOSH or MSHA. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.

Because many brake linings contain asbestos, you should know the potential hazards of asbestos and the precautions to be taken. Because medical experts believe that long-term exposure to some non-asbestos fibers could also be a health hazard, also observe the following precautions if servicing non-asbestos brake linings.

NOTE: The vehicle is originally equipped with non-asbestos brake linings.

Exposure to airborne brake lining dust can cause serious and possibly fatal diseases such as asbestosis (a chronic lung disease) and cancer.

During brake servicing, wear an air purifying respirator with high-efficiency filters. The respirator and filter must be approved by NIOSH or MSHA, and worn during all procedures.

OSHA recommends that enclosed cylinders equipped with vacuums and high-efficiency particulate air (HEPA) filters be used during brake repairs. Under this system, the entire brake assembly is placed within the cylinder and the mechanic works on the brake through sleeves attached to the cylinder. Compressed air is blown into the cylinder to clean the assembly, and the dirty air is then removed from the cylinder by the vacuum.

If such an enclosed system is not available, or can not be used, clean the brake assembly in the open air. During disassembly, carefully place all parts on the floor to minimize creating airborne dust. Using an industrial vacuum cleaner with an HEPA filter system, remove dust from the brake rotors, caliper assemblies, dust shields, and brake pads. After vacuuming, remove any remaining dust using a rag soaked in water and wrung until nearly dry.

⚠ WARNING

Hydraulic brake fluid is hazardous, and can cause blindness if it gets in your eyes. Always wear safety glasses when handling brake fluid or bleeding brake components. Brake fluid may also be a skin irritant. If you get it on your skin, wash it off as soon as possible.

Special care must be taken when disposing of used brake fluid. Put the fluid in a sealed plastic container and label it "Used Brake Fluid." Then dispose of it in an approved manner. Check with local and state regulations as to the correct disposal procedure.

IMPORTANT: During service procedures, keep grease and other foreign material away from caliper assemblies, disc brake pads, brake rotors and external surfaces of the hub. Handle parts carefully to avoid damage to the caliper, rotor, disc brake pads or brake lines.

Brake Pad Removal, Inspection and Installation

⚠ WARNING

Before starting the procedures below, read the information in Subject 100. Failure to do so could result in serious and permanent health damage.

IMPORTANT: It is recommended that all disc brake pads on the vehicle be replaced at the same time. This will maintain balanced braking. If complete replacement is not desirable or necessary, make sure that at a minimum all disc brake pads on one axle (both ends) are replaced at the same time.

Removal

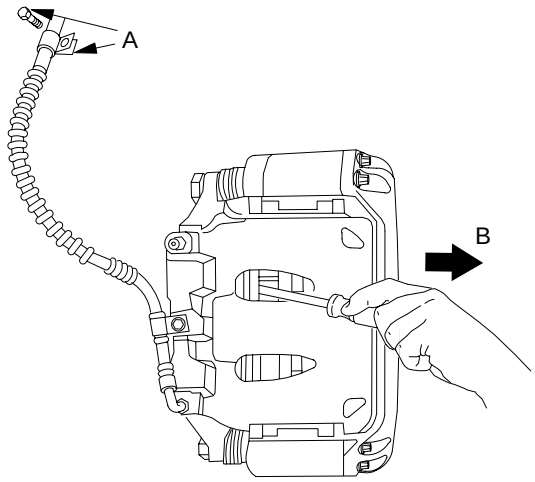
1. Park the vehicle on a level surface. Shut down the engine and apply the parking brake.
2. Open the hood.
3. If removing rear axle wheel pads, remove about half of the fluid from the rear section of the master cylinder reservoir. If removing front axle wheel pads, remove about half of the fluid from the front section.
4. Chock the front or rear tires, depending on which axle is being worked on. Jack up the axle and support it with jackstands.
5. Remove the tires.
6. Visually inspect all brake pad linings. Lining pads should be replaced when the remaining lining reaches 3/16-inch (5-mm) thickness or less.

⚠ CAUTION

Care must be taken when positioning the pry bar. Incorrect positioning of the pry bar could result in damage to the caliper.

7. Insert a pry bar in one of the rotor cooling fin slots and pry the caliper outboard, pushing the caliper pistons into the piston bores. See **Fig. 1**.
8. On front axles only, remove the brake line retaining clip from its support mounting. This will allow the brake line hose to hang free. See **Fig. 1**.

IMPORTANT: When servicing disc brake pads only, loosen and remove the upper (top) caliper pin mounting bolt. Do not loosen the lower (bottom) pin mounting bolt.



A. Remove this screw and clip on front axles only.
B. Move the caliper outboard to push the pistons in.

Fig. 1, Piston Retraction and Brake Line Clip Removal

9. Remove only the upper (top) pin mounting bolt. See **Fig. 2**.

⚠ CAUTION

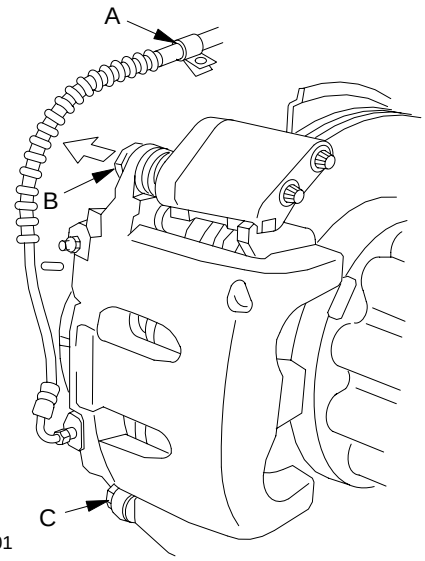
Do not pull on the guide pins. This may dislodge the guide pin boot from the guide pin or anchor plate grooves, which could damage the guide pin boot.

10. Swing the caliper assembly away from the rotor by carefully rotating the caliper on the lower pin mounting bolt and guide pin. See **Fig. 3**. Do not allow the brake line hose to become pinched or kinked.
11. Remove the inboard and outboard disc brake pads from the anchor plate pad abutment slippers.

IMPORTANT: Do not mark on the pad face.

12. If the original disc brake pads are to be reused, be sure to mark them in some manner so that they are installed in the same location.

Brake Pad Removal, Inspection and Installation



A. Make sure this clip is detached from the support bracket.
B. Loosen and remove the upper pin mounting bolt.
C. Do not loosen the lower pin mounting bolt.

Fig. 2, Remove Upper Pin Mounting Bolt

Inspection

IMPORTANT: Do not damage or dislodge the guide pin boots while cleaning the machined surfaces.

1. Inspect the machined surfaces of the caliper, guide pin mounting face, and anchor plate. If rust or corrosion is present, use a hand-held wire brush to clean the surfaces.
2. Inspect the caliper, piston seals, and pistons for leakage or damage. If leakage or damage is found, repair or replace the piston(s) as required.
3. Inspect the anchor plate for damage to the mating surfaces at the anchor plate pad abutment slippers and guide pin heads. If damage is found, repair or replace as required.
4. Inspect the rotor for scoring, warping, cracks bluing, heat spots or other damage. See **Fig. 4**. If any damage is found, repair or replace the rotor. For instructions, see **Subject 140**.

Installation

1. Position a metal plate across both caliper pistons. Use a C-clamp to push both pistons into the caliper to provide clearance for the new disc brake pads. See **Fig. 5**.

CAUTION

When replacing disc brake pads, make sure to use the same lining material on both axle ends. Mixing lining types can result in unbalanced braking, increased pad wear, or degraded stopping performance.

IMPORTANT: Inboard and outboard brake pads may not be interchangeable. The word "Forward" and a forward rotor rotation direction arrow may appear on each pad backing plate. Orient the pads as indicated by the arrow.

2. Position the inboard and outboard disc brake pads onto the anchor plate pad abutment slippers with the lining facing toward the rotor. See **Fig. 6**.

CAUTION

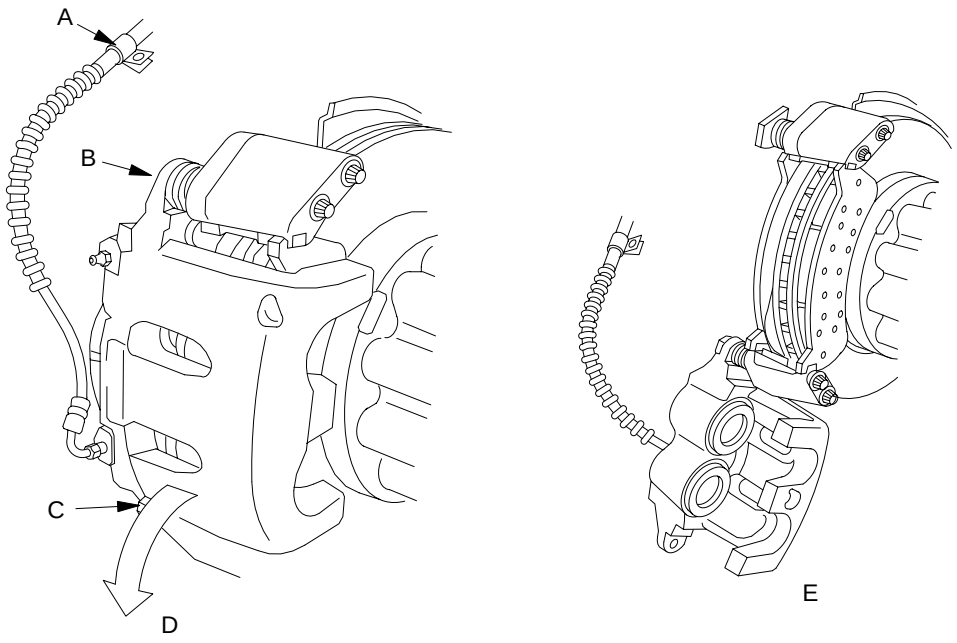
Use care when positioning the caliper over the disc brake pads, rotor, and upper guide pin head to avoid tearing, cutting, or dislodging the piston boots or guide pin boot.

3. Carefully rotate the caliper closed about the lower pin mounting bolt and guide pin. Do not allow the brake line hose to become pinched or kinked. Align the flat on the upper guide pin head with the flat on the caliper upper guide pin boss. See **Fig. 7**.

CAUTION

Always tighten caliper pin mounting bolts in the proper sequence. Do not overtighten caliper pin mounting bolts. Increased brake drag may result from incorrect tightening.

IMPORTANT: If the lower mounting bolt was loosened, see **Fig. 8** before tightening either the upper or lower mounting bolt.



A. Make sure this clip is detached from the support bracket.
B. Guide pin bolt has been removed.
C. Do not loosen the lower pin mounting bolt.
D. Swing the caliper down until it stops.
E. Caliper in the lowered position.

Fig. 3, Open Caliper to Access Brake Pads and Pistons

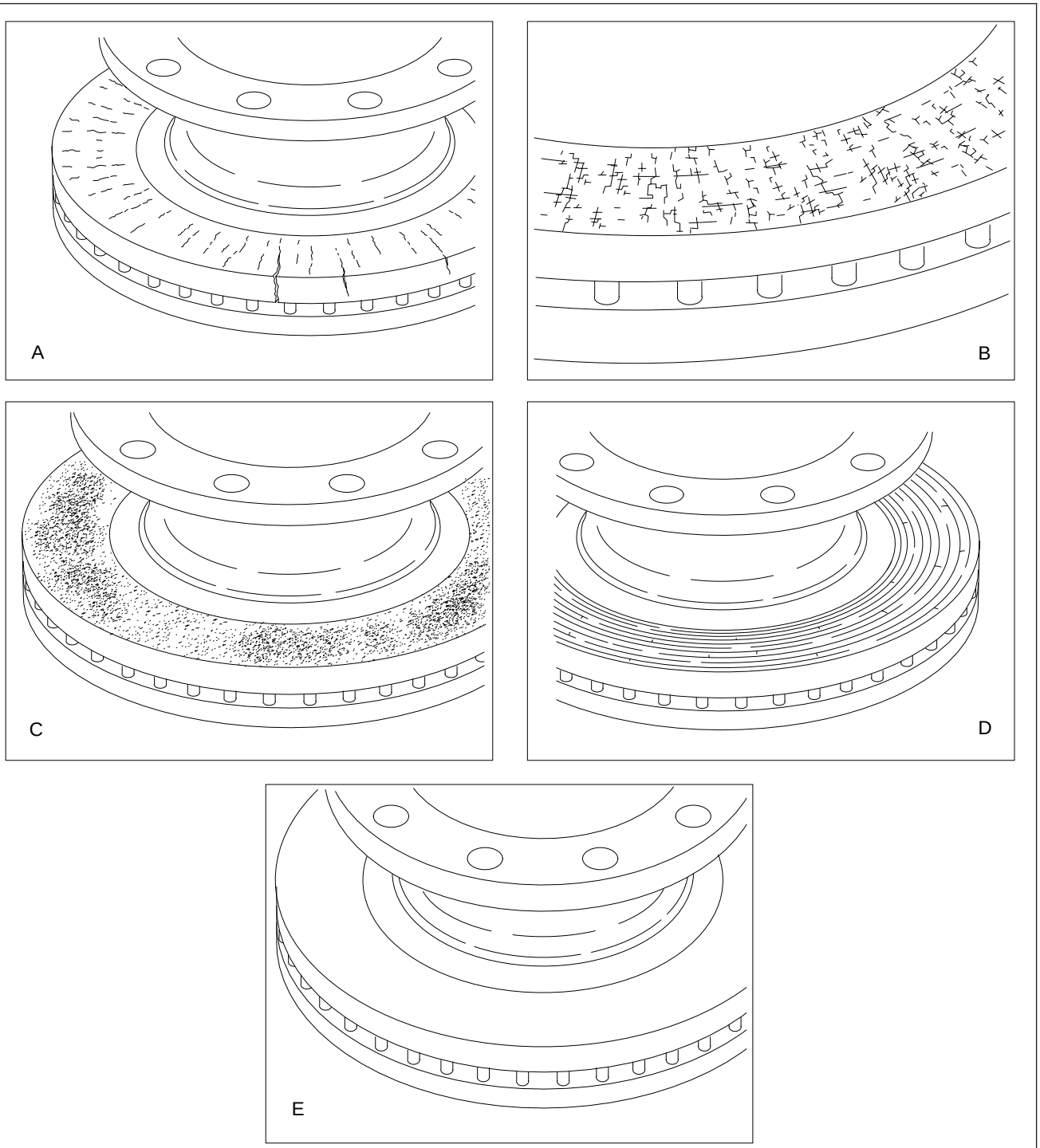
4. Hold the caliper in the closed position with the caliper upper guide pin boss hole aligned with the threaded hole in the upper guide pin head. Hand thread the pin mounting bolt. Tighten the bolt 70 to 80 lbf·ft (95 to 108 N·m). See **Fig. 8**.
5. On front axles only, install the previously removed brake line retaining clip. Make sure the brake line hose is not pinched or kinked.
6. Visually inspect all components serviced. Make sure the mounting pins are torqued according to the specifications in this procedure. Make sure the pads are seated and positioned to slide along the pad abutment slippers.
7. Install the tires, remove the jackstands and lower the vehicle.
8. Check the fluid level in the master cylinder reservoir and add the necessary amount of new DOT 3 approved brake fluid.
9. Pump the brake pedal until it feels firm. If it does not get firm, check for leaks or air in the brake system. Repair any leaks, if needed, then bleed the system, following the instructions in **Subject 170**.

⚠ WARNING

Do not move the vehicle until the brake pedal feels firm. To do otherwise could result in loss of vehicle control, causing an accident resulting in personal injury or property damage.

10. Close the hood and remove the chocks from the tires.
11. Road test the vehicle and seat the brake pads.
    - 11.1 Accelerate the vehicle to 30 mph (48 km/h), then brake to a stop, using medium brake pedal pressure. *Do not slam on the brakes.*
    - 11.2 Repeat this step between 20 and 30 times, allowing a 1-minute interval between brake applications.

Brake Pad Removal, Inspection and Installation



A. Cracking
B. Heat Checking
C. Discoloration
D. Scoring
E. Normal Finish

Fig. 4, Rotor Surface Check

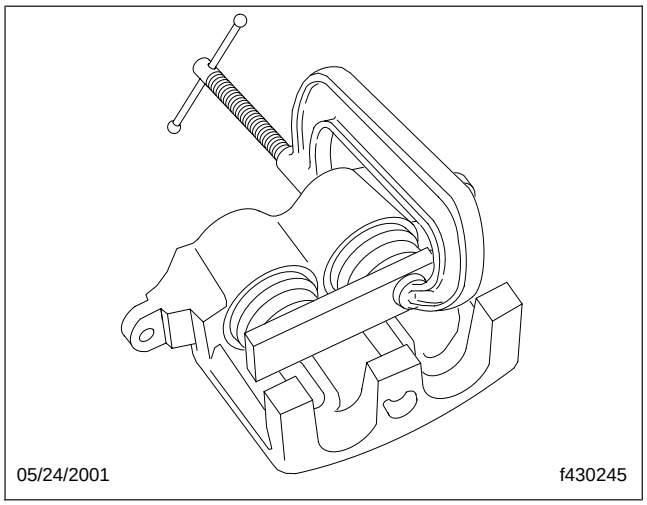
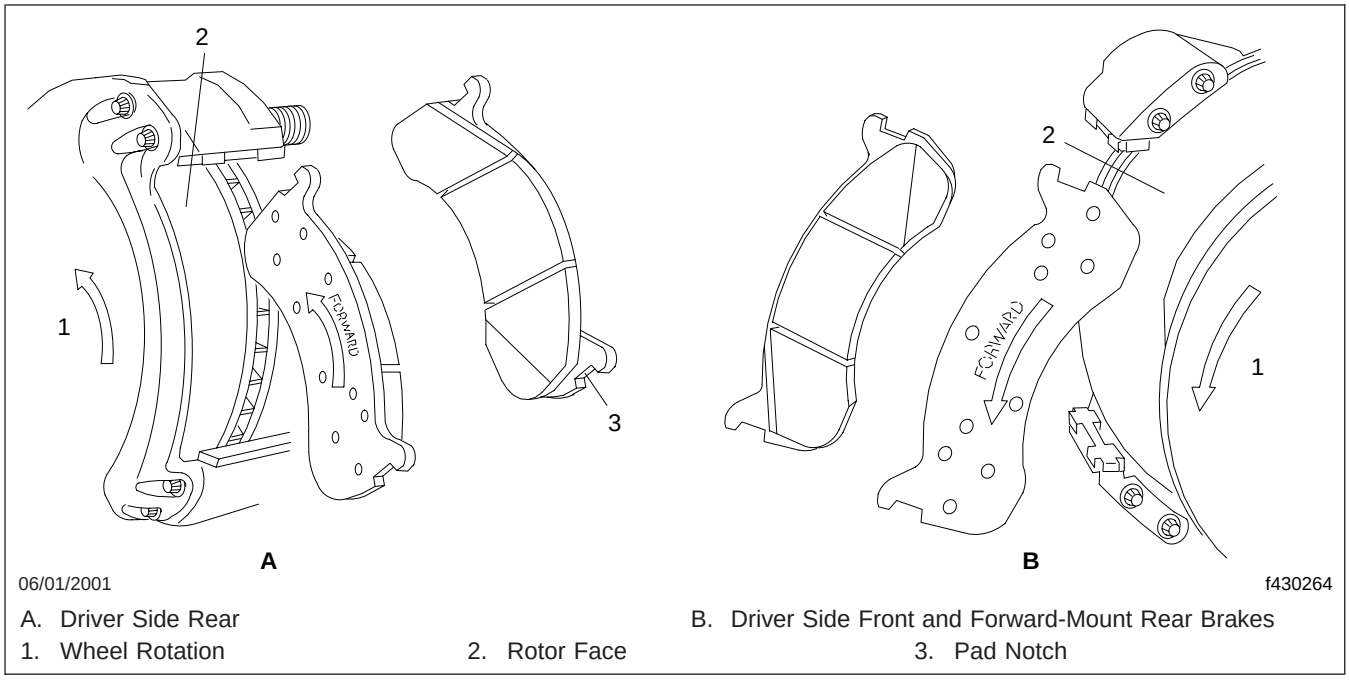


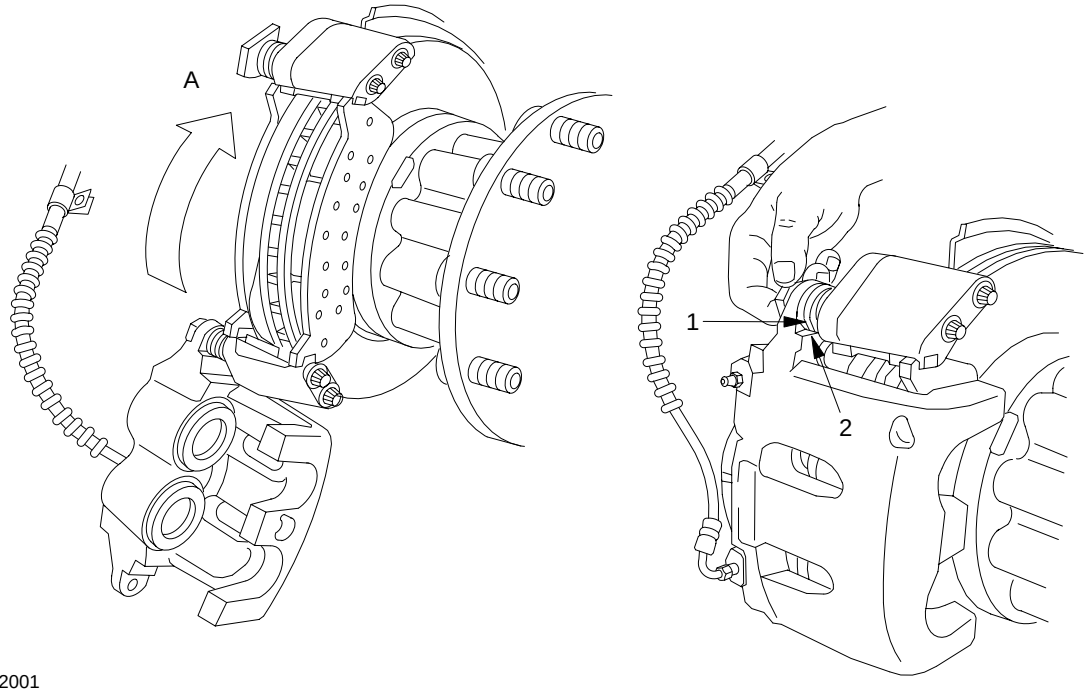
Fig. 5, Retract Pistons Into Caliper



A. Driver Side Rear
B. Driver Side Front and Forward-Mount Rear Brakes
1. Wheel Rotation
2. Rotor Face
3. Pad Notch

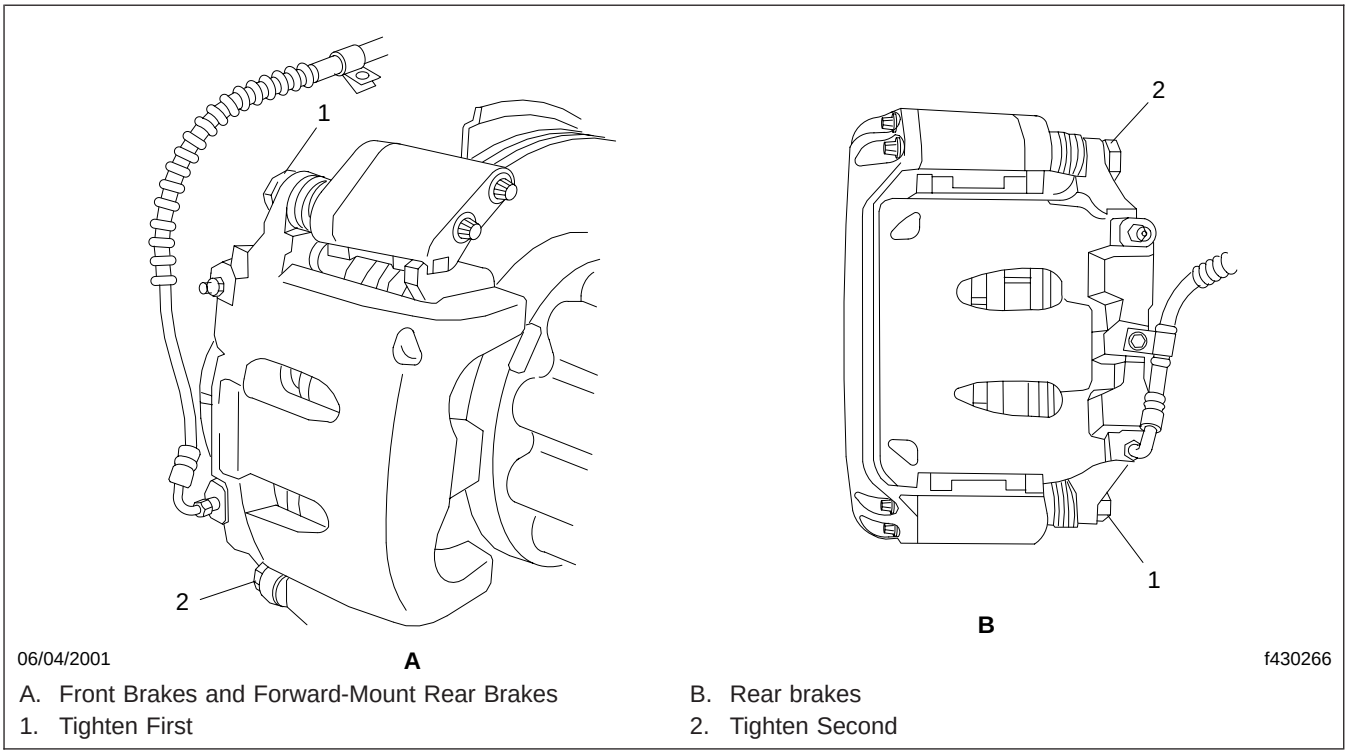
Fig. 6, Replacing Brake Pads on Front and Rear Brakes

Brake Pad Removal, Inspection and Installation



A. Swing the caliper up into position.
1. Flat on Guide Pin
2. Flat on Caliper

Fig. 7, Close Caliper Over Brake Pads and Rotor



A. Front Brakes and Forward-Mount Rear Brakes
1. Tighten First
B. Rear brakes
2. Tighten Second

Fig. 8, Tightening Sequence for Caliper Mounting Bolts

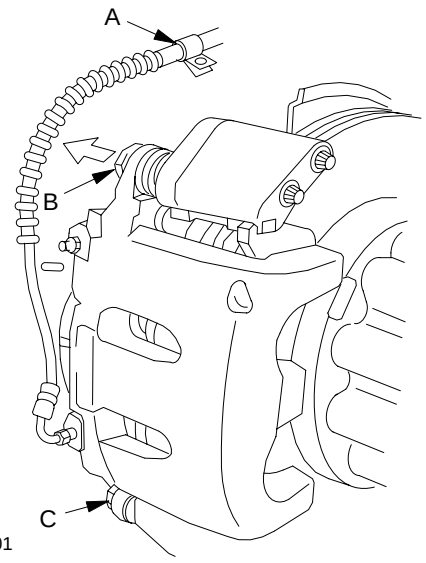
Brake Caliper Removal and Installation

WARNING

Before starting the procedures below, read the information in Subject 100. Failure to do so could result in serious and permanent health damage.

Removal

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine.
2. Open the hood.
3. If removing the rear wheel caliper(s), remove half the fluid from the rear section of the master cylinder reservoir. If removing the front wheel caliper(s), remove half the fluid from the front section.
4. Chock the front or rear tires, depending on which axle is being worked on. Jack up the axle and support it with jackstands.
5. Remove the tires.
6. On front axles only, remove the brake line retaining clip from its support mounting. This will allow the brake line hose to hang free. See Fig. 1.



A. Make sure this clip is detached from the support bracket.
B. Loosen and remove the upper pin mounting bolt.
C. Do not loosen the lower pin mounting bolt.

Fig. 1, Remove Upper Pin Mounting Bolt

7. Remove the upper (top) guide pin mounting bolt. See Fig. 1.

CAUTION

Do not pull on the guide pins. This may dislodge the guide pin boot from the guide pin or anchor plate grooves, which could damage the guide pin boot.

8. Swing the caliper assembly away from the rotor by carefully rotating the caliper on the lower pin mounting bolt and guide pin. See Fig. 2. Do not allow the brake line hose to become pinched or kinked.
9. Disconnect the brake fluid line from the caliper. See Fig. 3.
10. Remove the lower guide pin mounting bolt and remove the caliper from the anchor plate.

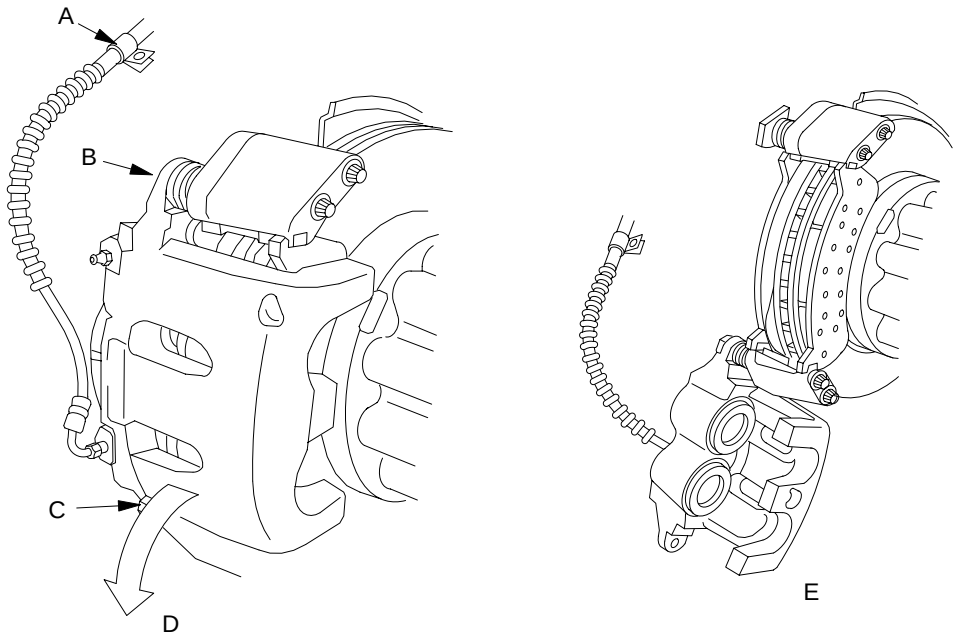
Installation

CAUTION

Use isopropyl alcohol to clean brake seals, boots, and pistons. Do not soak components for an extended period of time.

1. Clean contamination, dirt and debris from the exterior of the caliper, machined faces and around the caliper piston boots.
2. Visually inspect the caliper for brake fluid leakage or damage to pistons or piston boots. If there is leakage or damage, the caliper should be repaired or replaced. For repair instructions, see Subject 130.
3. Make sure the pistons are fully retracted into the caliper. Piston boots must be fully seated in the piston boot groove and boot grooves in the caliper face.
4. Position the caliper on the anchor plate with the caliper lower guide pin boss hole aligned with the threaded hole in the lower guide pin head. Hand thread the pin mounting bolt through the caliper and into the anchor plate.

Brake Caliper Removal and Installation



A. Make sure this clip is detached from the support bracket.
B. Guide pin bolt has been removed.
C. Lower Guide Pin Bolt
D. Swing the caliper down until it stops.
E. Caliper in the lowered position.

Fig. 2, Open Caliper

⚠ CAUTION

Use care when positioning the caliper over the disc brake pads, rotor, and upper guide pin head to avoid tearing, cutting, or dislodging the piston boots or guide pin boot.

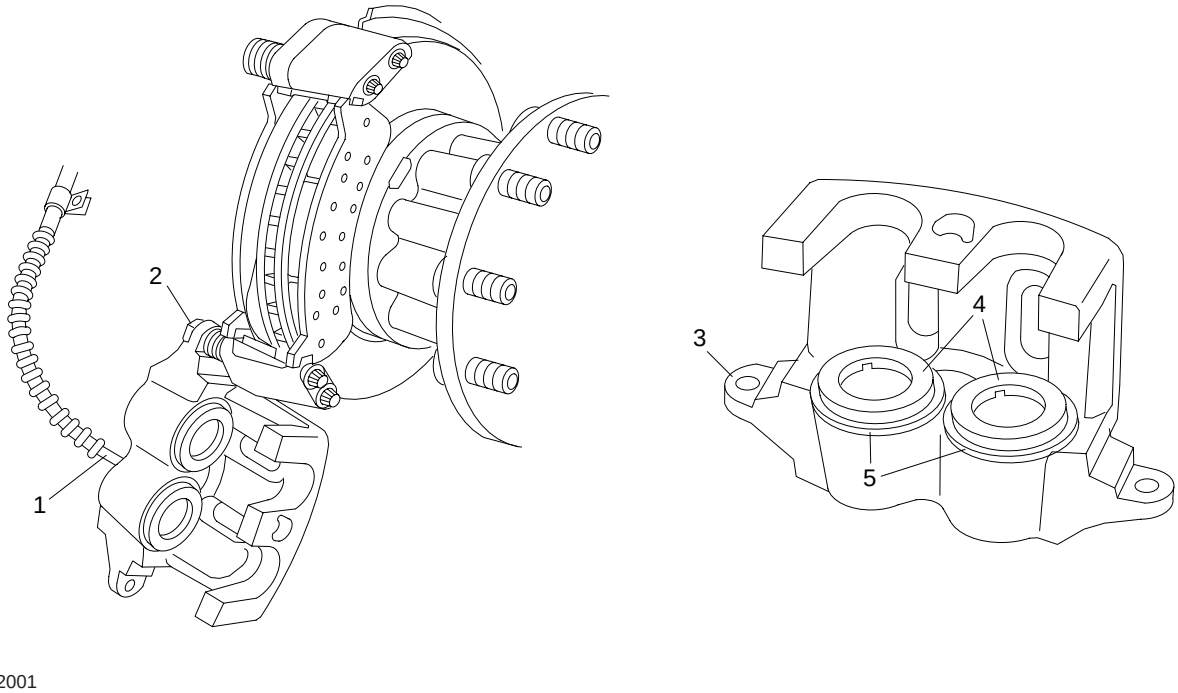
5. Carefully rotate the caliper closed about the lower pin mounting bolt and guide pin. Do not allow the brake line hose to become pinched or kinked. Align the flat on the upper guide pin head with the flat on the caliper upper guide pin boss. See **Fig. 4**.

⚠ CAUTION

Always tighten caliper pin mounting bolts in the proper sequence. Do not overtighten caliper pin mounting bolts. Increased brake drag may result from incorrect tightening.

IMPORTANT: See **Fig. 5** before tightening either the upper or lower mounting bolt.

6. Hold the caliper in the closed position with the caliper upper guide pin boss hole aligned with the threaded hole in the upper guide pin head. Hand thread the upper pin mounting bolt. Tighten the bolts 70 to 80 lbf·ft (95 to 108 N·m) in the order shown in **Fig. 5**.
7. On front axles only, install the previously removed brake line retaining clip. Make sure the brake line hose is not pinched or kinked.
8. If the brake supply hose was disconnected, connect it.
   - 8.1 Tighten the brake supply hose fitting 15 lbf·ft (20 N·m).
   - 8.2 Bleed the brake supply line to the caliper, following the instructions in **Subject 170**. If you have removed more than one brake caliper, bleed the entire brake system.
9. Install the tires, remove the jackstands and lower the vehicle.



1. Brake Line
2. Lower Guide Pin Bolt
3. Machined Face
4. Pistons
5. Piston Boots

Fig. 3, Remove Caliper From Anchor Plate

10. Check the fluid level in the master cylinder reservoir and add the necessary amount of new DOT 3 approved brake fluid.
11. Close and latch the hood.
12. Remove the chocks from the tires.

⚠ WARNING

Do not move the vehicle until the brake pedal feels firm. To do otherwise could result in loss of vehicle control, causing an accident resulting in personal injury or property damage.

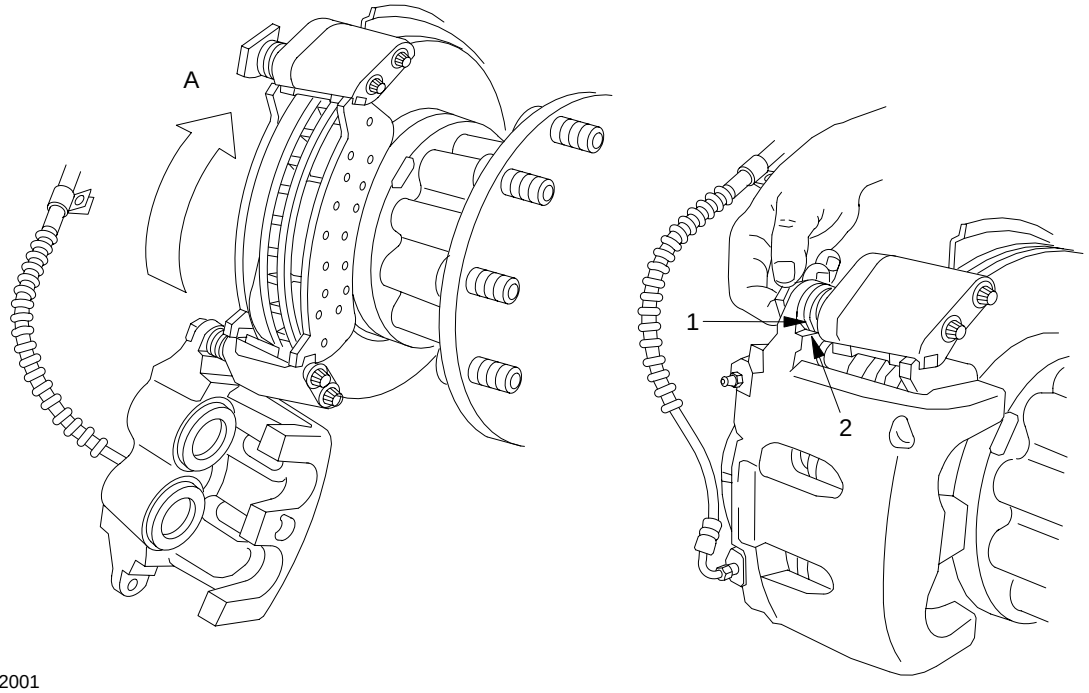
13. Seat the brake pads by pressing firmly on the brake pedal several times.

    If new brake pads were installed, road test the vehicle to seat the brake pads.

    13.1 Accelerate the vehicle to 30 mph (48 km/h), then brake to a stop, using medium brake pedal pressure. *Do not slam on the brakes.*

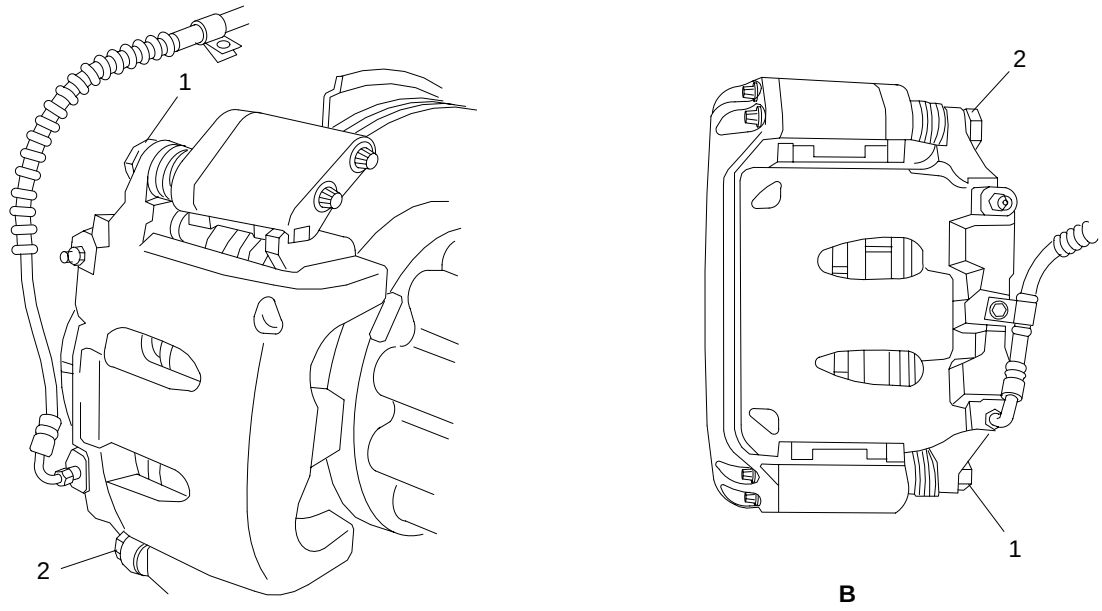
    13.2 Repeat this step between 20 and 30 times, allowing a 1-minute interval between brake applications.

Brake Caliper Removal and Installation



A. Swing the caliper up into position.
1. Flat on Guide Pin
2. Flat on Caliper

Fig. 4, Close Caliper Over Brake Pads and Rotor



A. Front Brakes and Forward-Mount Rear Brakes
1. Tighten First
B. Rear Brakes
2. Tighten Second

Fig. 5, Tightening Sequence for Caliper Mounting Bolts

WARNING

Before starting the procedure below, read the information in Subject 100. Failure to do so could result in serious and permanent health damage.

CAUTION

Use isopropyl alcohol to clean brake seals, boots, and pistons. Do not soak components for an extended period of time.

IMPORTANT: When using compressed air, use air lines that are completely free of oil and moisture.

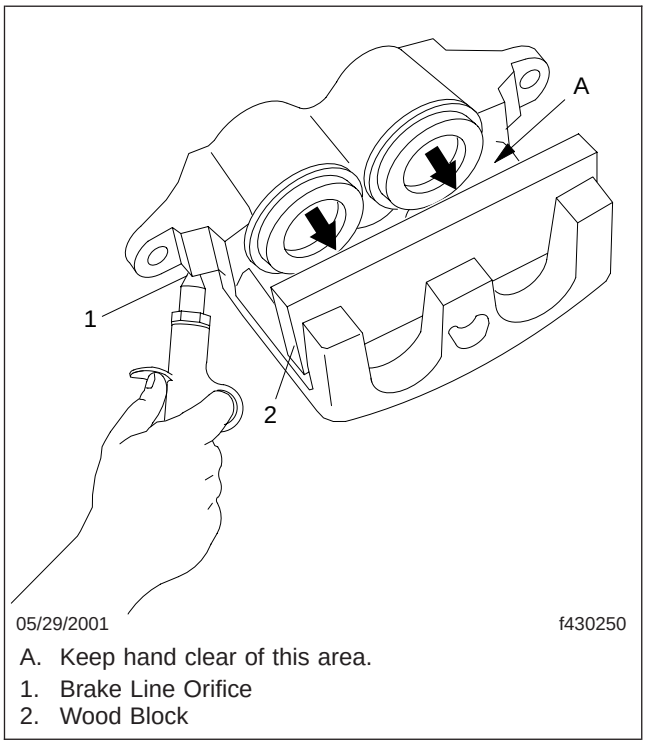
Rebuild

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine.
2. Open the hood.
3. Remove the caliper. For instructions, see Subject 120.
4. Clean contamination, dirt and debris from the exterior of the caliper, machined faces and around the caliper piston boots.
5. Drain all fluid from the caliper.
6. Place a block of wood between the caliper and piston faces. Leave approximately 1 to 1.5 inch clearance between the pistons and the block of wood. See Fig. 1.

WARNING

Always wear eye protection. Use just enough air pressure to ease the piston from the caliper bore. Keep hands clear of the piston face to avoid possible injury if the piston pops from its bore. Cover the pistons with a shop cloth to prevent brake fluid spray as the piston clears the bore.

7. Cover the pistons with a shop cloth to prevent brake fluid spray. Use an air blow gun to carefully apply low air pressure into the open caliper port to slowly push the pistons out of the caliper bores. The pistons should push out beyond the seal compression.

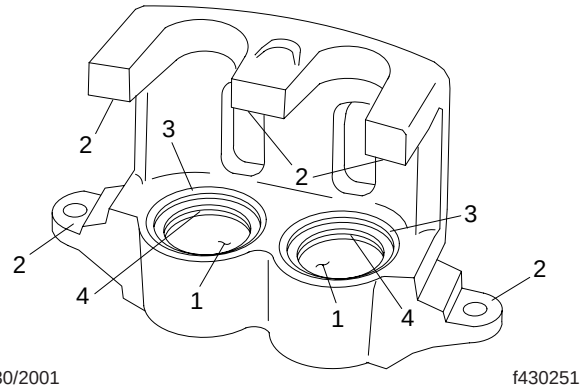


A. Keep hand clear of this area.
1. Brake Line Orifice
2. Wood Block

Fig. 1, Remove Pistons from Caliper Bore

8. Remove the block of wood and remove each piston from its piston boot.
9. Remove each piston boot from its boot groove in the caliper.
10. Using your fingers or a wooden or other non-metallic device, remove and discard the seals from the caliper bores. Do not nick, scratch or otherwise scar the piston bores or seal grooves.
11. Inspect the caliper for damage to the piston bores and boot grooves. If damage is found, repair or replace the caliper.
12. Check the machined surfaces of the caliper that come in contact with the guide pin heads, pistons, piston seals, piston boots and brake pads. See Fig. 2. If any rust or corrosion is present at these locations, carefully clean the surfaces with a hand-held wire brush.
13. Clean the caliper, caliper piston bores and fluid ports with solvent. Use compressed air to clean out and dry grooves and passages. If the piston bores are not clean, wipe out the bores with a clean, dry cloth and use 320 to 400 grit emery

Brake Caliper Rebuild



05/30/2001 f430251

1. Bores
2. Machined Surface
3. Boot Groove
4. Seal Groove

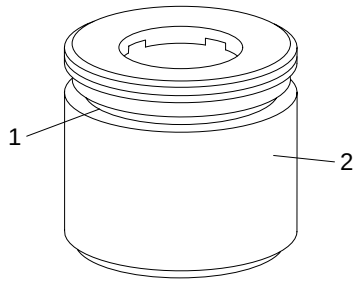
Fig. 2, Caliper Machined Surfaces

cloth to lightly clean the piston bores. Using a pick-type tool, make sure the caliper piston seal and boot grooves in the caliper are free of all foreign material.

14. Inspect the caliper piston bores and piston seal and boot grooves. Make sure they are free of foreign matter, pitting, scoring or corrosion. If damage or defects are found, repair or replace the caliper.
15. Inspect the tube seats in the caliper fluid ports. Make sure they are free of foreign matter and are in good condition. Replace tube seats if damaged.
16. Clean caliper pistons with isopropyl alcohol. Visually inspect each piston for pitting, scoring or excessive wear. If damage or defects are found, replace the piston. If foreign material is found in the caliper piston boot groove, use a fiber brush to remove it. See **Fig. 3**.
17. Clean the piston boots with isopropyl alcohol and visually inspect both the inside and the outside of the piston boot for cracks, tears, holes and flexibility. See **Fig. 4**. If damage or defects are found, the boot must be replaced.

NOTE: All brake parts must be clean and completely dried of cleaning fluids before assembly.

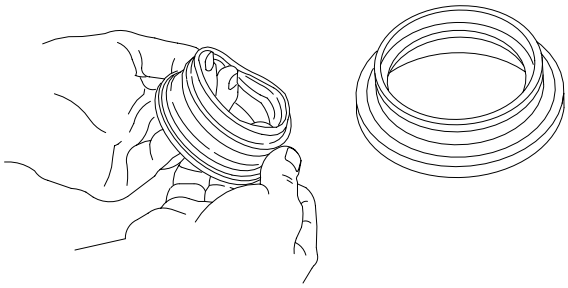
18. Dip new piston seals in clean DOT 3 or DOT 4 hydraulic brake fluid. Install the piston seal in the piston seal groove of the caliper piston bores. See **Fig. 5**.



05/30/2001 f430252

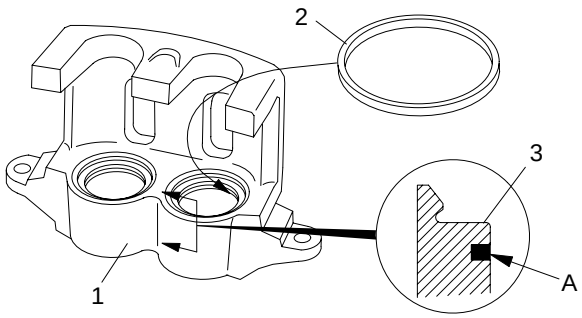
1. Piston Boot Groove
2. Piston

Fig. 3, Caliper Piston



06/01/2001 f430262

Fig. 4, Piston Boot



06/01/2001 f430263

A. Make sure the seal is seated squarely in the groove.

1. Caliper
2. Caliper Bore Seal
3. Seal Land

Fig. 5, Piston Seal Installation

19. With the piston seal positioned on the groove, gently work around the groove with clean fingers

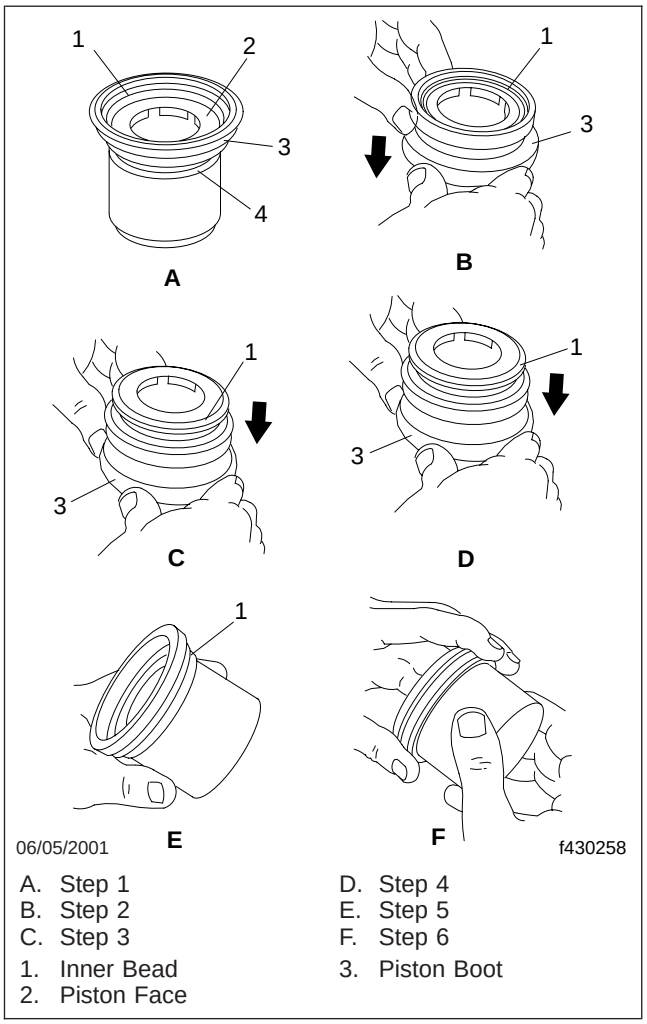
until the seal is properly seated into the groove. Make sure the seal is not twisted or rolled.

IMPORTANT: Use only silicone grease on the seal bead. Other greases may cause the seal to swell (grow) and impair proper piston movement.

20. Apply a thin film of silicone grease to the caliper bore seal land between the piston boot and seal grooves. Apply the grease around the entire circumference of the caliper bore.

NOTE: Clean DOT 3 or DOT 4 hydraulic brake fluid may be used on the boot inner bead and outer ring to ease assembly. Do not use any other lubricant.

21. Position the boot on top of the caliper piston with the boot flange properly oriented. See **Fig. 6**. Carefully pull the piston boot down over the top of the piston until the inner bead of the boot is seated in the piston boot groove. Return the boot to the collapsed or folded position. Make sure the boot is fully seated in the piston boot groove by grasping the piston boot flange and rotating the piston back and forth.
22. Apply DOT 3 or DOT 4 hydraulic brake fluid to the outside of the caliper piston and carefully position the piston with the piston boot into the caliper piston bore. See **Fig. 7**.
23. Position the caliper piston and boot installation tool (ZTSE4417 for 66mm brakes, ZTSE4418 for 73mm brakes) on top of a piston and piston boot so the word "Boot" is on the underside of the tool, toward the piston. See **Fig. 8**. Make sure to use the correct tool for the pistons being installed.
24. Using a "C" clamp or arbor press, gently press the piston past the piston seal and partially into the bore. Avoid cocking or binding the piston during installation. Continue to press the piston and piston boot into the bore until they are fully seated into the caliper.
25. Remove the "C" clamp or arbor press. Make sure the piston boot flange ring is fully seated into the top groove of the piston bore in the caliper face.
26. Repeat the procedure for the other piston.

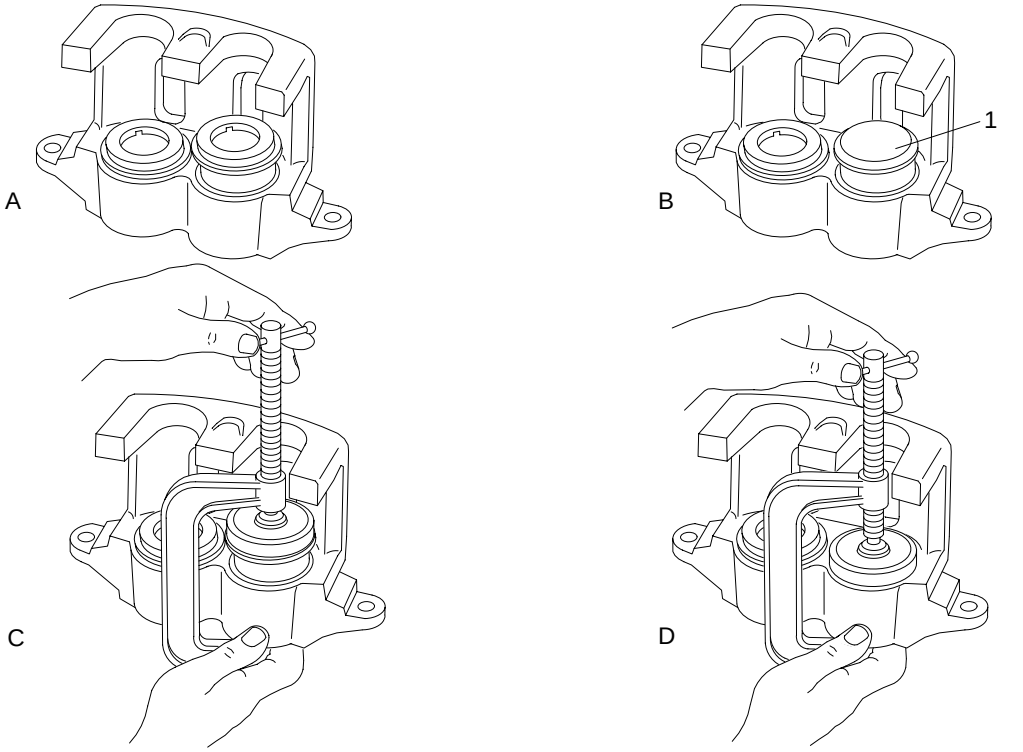


A. Step 1
B. Step 2
C. Step 3
D. Step 4
E. Step 5
F. Step 6
1. Inner Bead
2. Piston Face
3. Piston Boot

Fig. 6, Installing Piston Boot to Piston

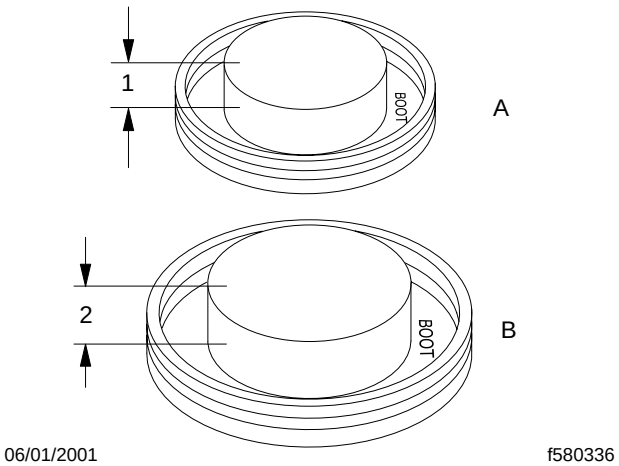
27. Inspect the caliper prior to installing it on its anchor plate. Pistons must be fully retracted into the caliper. Piston boots must be fully seated in the piston boot groove and boot grooves in the caliper face.
28. If the caliper bleed screw was removed, make sure that a bleed screw has been installed in the upper brake fluid port.
29. Install the caliper on the anchor plate. For instructions, see **Subject 120**.

Brake Caliper Rebuild



A. Position the piston square in the bore.
B. Position the installation tool.
C. Press the piston into the bore.
D. Seat the piston in the bore.

Fig. 7, Pressing Pistons into Caliper Bores



A. ZTSE4417
1. 66mm
B. ZTSE4418
2. 73mm

Fig. 8, Piston and Boot Installation Tools

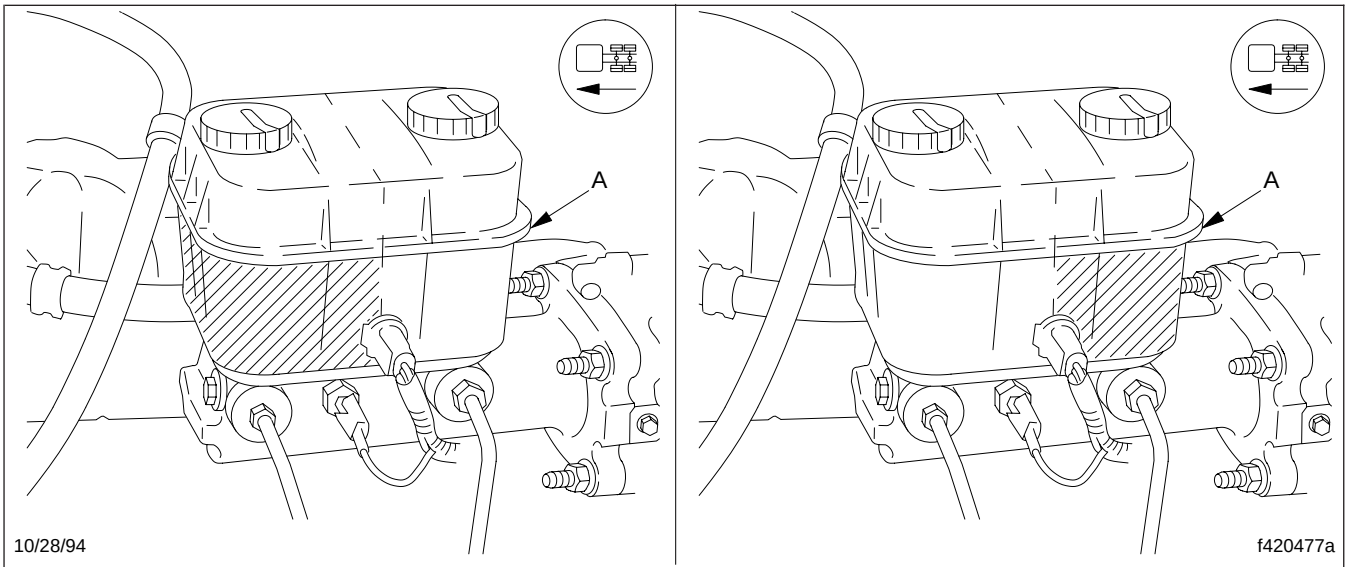
Brake Rotor Removal and Installation

⚠ WARNING

Before starting the procedures below, read the information in Subject 100. Failure to do so could result in serious and permanent health damage.

Removal

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the tires.
2. Open the hood.
3. Remove about half the brake fluid from the front section (if removing a front-axle rotor) or the rear section (rear-axle rotor) of the master cylinder reservoir. See **Fig. 1**.



A. Fill level for brake fluid.

Fig. 1, Master Cylinder Reservoir

4. Chock the front or rear tires, as required.
5. Jack up the vehicle. Support the axle with jack-stands.
6. Remove the tire.
7. Remove the brake caliper from the rotor, following the instructions in **Subject 120**.
8. Remove the hub and rotor assembly from the axle, following the instructions in **Group 33** for the front axle or **Group 35** for the rear axle. Put the hub on the floor so the rotor is facing up.
9. Remove the brake rotor from the wheel hub.
   - 9.1 Remove the hexbolts and washers that attach the rotor to the hub. See **Fig. 2**.
   - 9.2 Lift the brake rotor off the hub.

Installation

1. Visually inspect the rotors for scoring, warping, cracks, bluing or heat spots, or other damage. See **Fig. 3**. If signs of damage are found, the rotor should be resurfaced or replaced.
2. Install the rotor on the wheel hub.
   - 2.1 Position the rotor on the hub as shown in **Fig. 4**. Make sure the holes in the rotor are lined up with those of the hub.
   - 2.2 Install the mounting hexbolts and washers. Using a star pattern, tighten the hexbolts 130 lbf·ft (175 N·m). See **Fig. 5**.
3. Install the hub and rotor assembly on the axle, following the instructions in **Group 33** for the front axle or **Group 35** for the rear axle.

Brake Rotor Removal and Installation

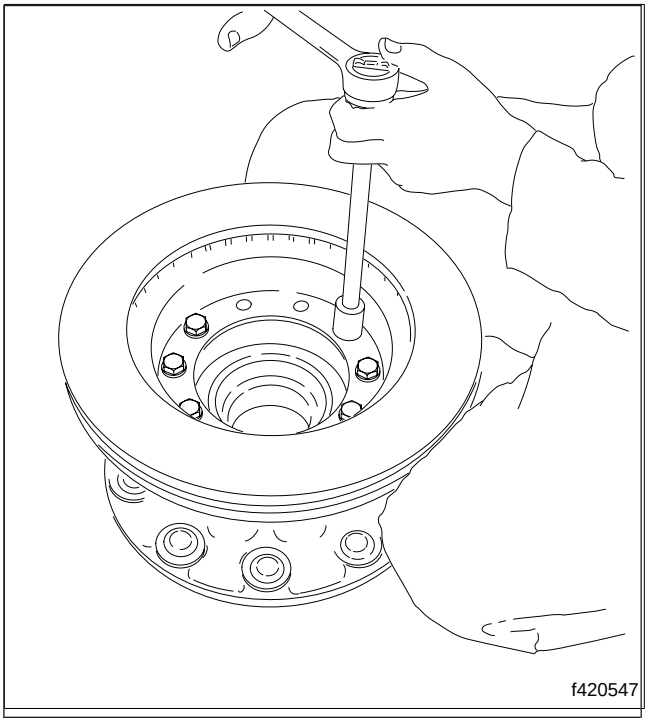
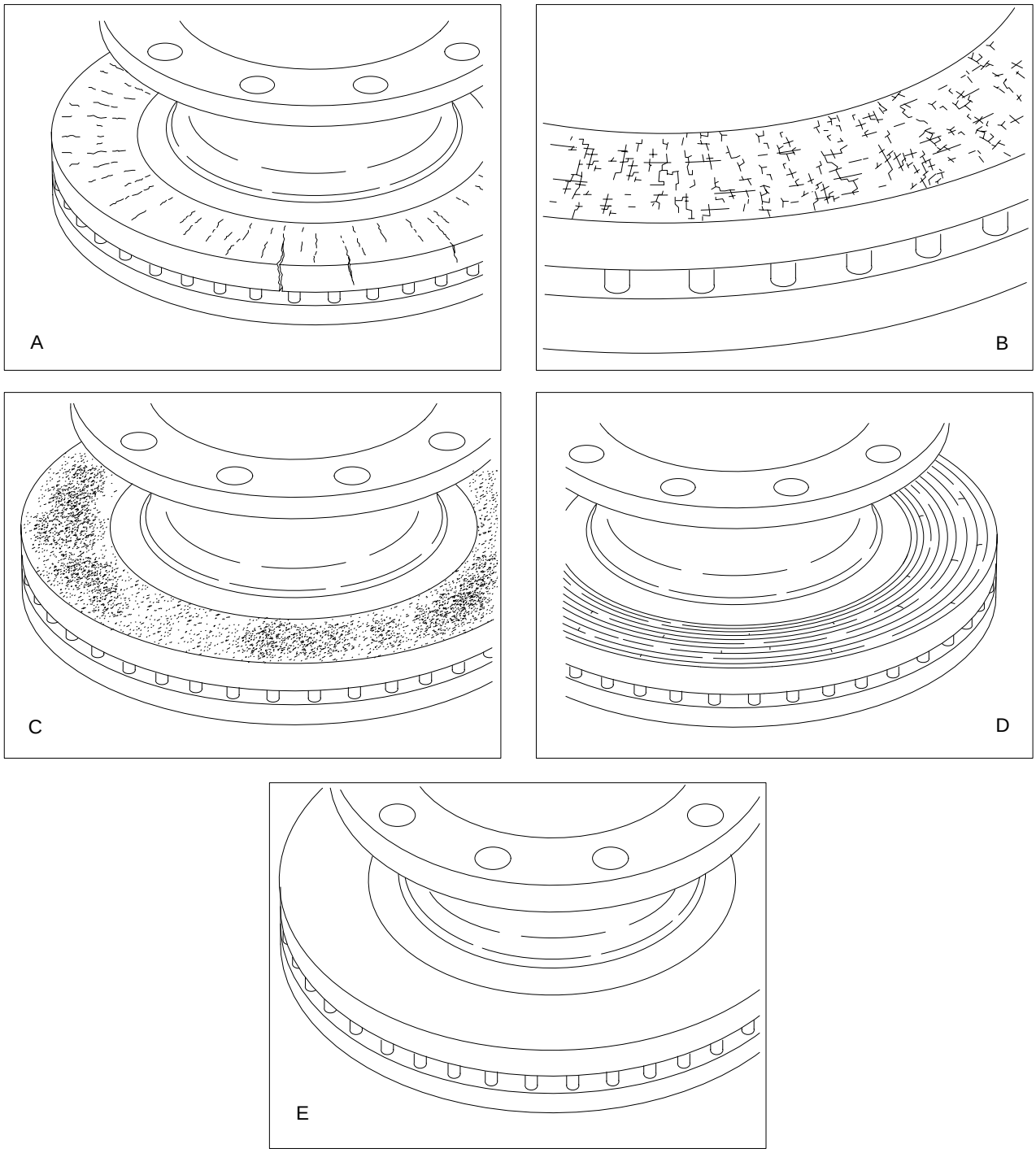


Fig. 2, Rotor-to-Hub Fasteners

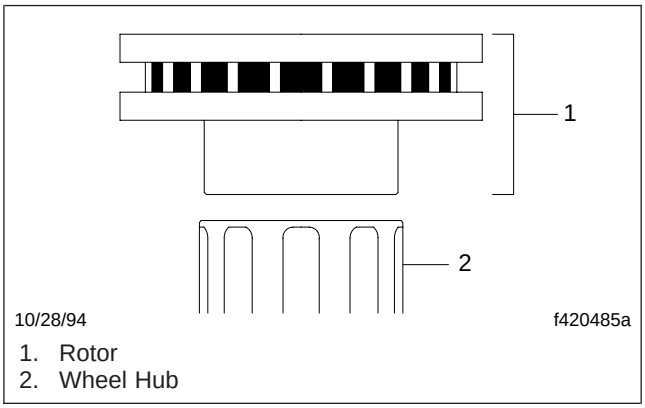
4. Check rotor runout and parallelism. For instructions, see **Subject 150**.
5. Install the brake caliper on the rotor, following the instructions in **Subject 120**.
6. Install the tire.
7. Remove the jackstands. Lower the vehicle.
8. Fill the applicable section of the master cylinder reservoir with new DOT 3 approved brake fluid. The brake fluid level should be even with the raised seam on the outside circumference of the reservoir. See **Fig. 1**.
9. Close and latch the hood.
10. Remove the chocks from the tires.



A. Cracking
B. Heat Checking
C. Discoloration
D. Scoring
E. Normal Finish

Fig. 3, Rotor Surface Check

Brake Rotor Removal and Installation



1. Rotor
2. Wheel Hub

Fig. 4, Rotor-to-Hub Position

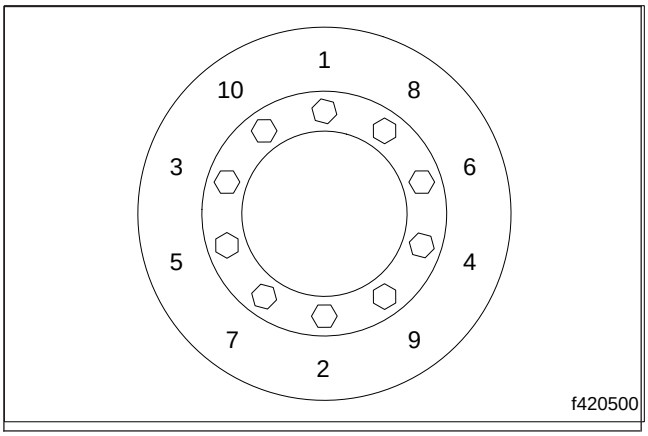


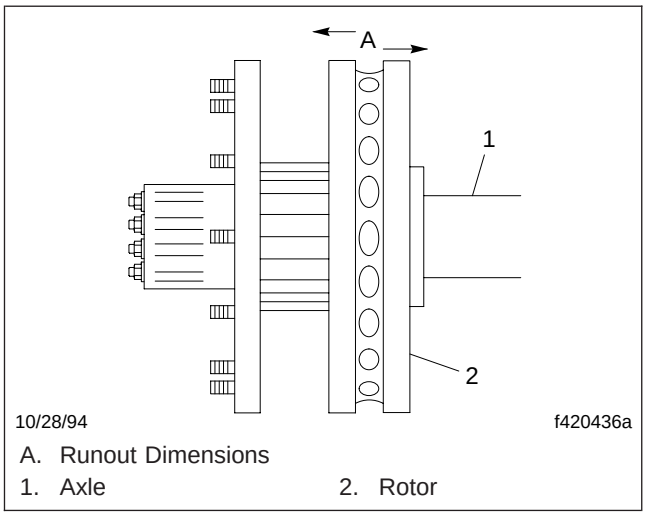
Fig. 5, Tightening Pattern

Brake Rotor Runout and Parallelism Check

Runout Check

Brake rotor runout refers to the amount of lateral wobble the rotor has when it is turning, with the wheel bearings correctly adjusted. See **Fig. 1**. Check the rotor runout whenever you replace the brake pads.

1. If not already done, chock the tires, jack up the axle you are working on and support it with jackstands. Remove the wheels and tires.
2. If working on the rear axle, put the transmission in neutral.
3. Using a dial indicator, measure the amount of runout while spinning the rotor, as shown in **Fig. 2**. Make sure the indicator is centered on the rotor face (between the outer and inner edges).
4. If the runout is more than 0.015 inch (0.38 mm), check that the rotor is securely mounted to the hub. Also check the wheel bearing end-play, following the instructions in **Group 33** for the front axle or **Group 35** for the rear axle.
5. Repeat the runout measurement. If the runout is still more than 0.015 inch (0.38 mm), replace the rotor.



A. Runout Dimensions
1. Axle 2. Rotor

Fig. 1, Brake Rotor Runout

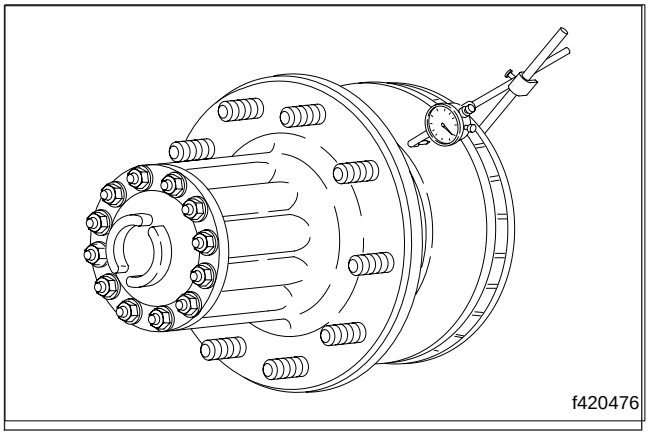


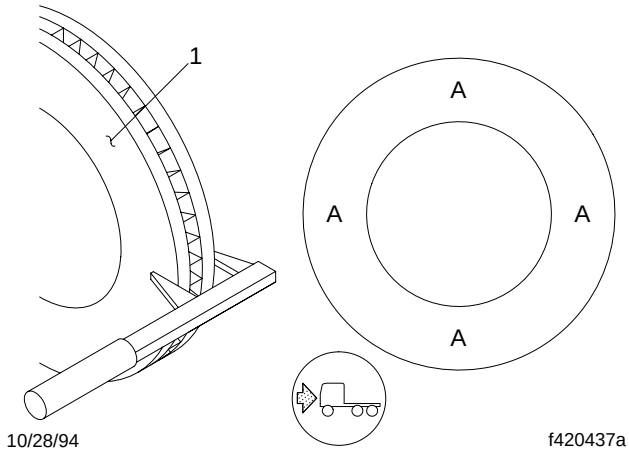
Fig. 2, Measure Runout

Parallelism Check

Parallelism is the difference in rotor thickness at different points around the rotor. It should be checked whenever the brake pads are replaced.

1. Using a vernier caliper or a micrometer, measure the thickness of the rotor (between the inboard and outboard faces) at four or more equally spaced points around the rotor. See **Fig. 3**.
2. If there is a difference of more than 0.005 inch (0.13 mm) between any two measurements, have the rotor resurfaced. If resurfacing will decrease the overall thickness of the rotor to 1.32 inches (33.5 mm) or less, replace the rotor.

Brake Rotor Runout and Parallelism Check



A. Measure thickness here.
1. Rotor Face

Fig. 3, Measure Rotor Thickness

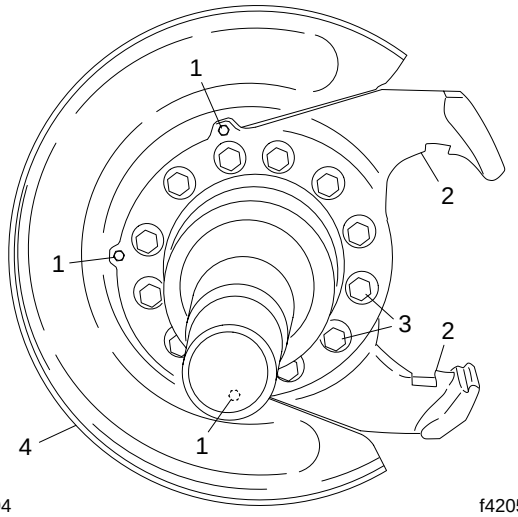
Anchor Plate Disassembly, Clean and Inspection, and Assembly

WARNING

Before starting the procedures below, read the information in Subject 100. Failure to do so could result in serious and permanent health damage.

Disassembly

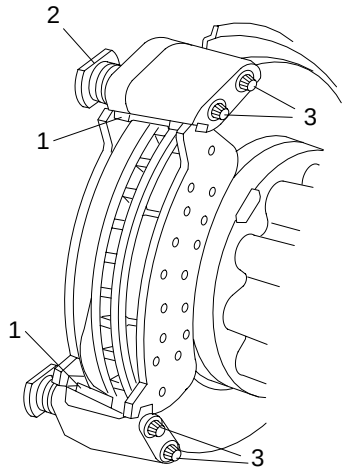
1. Park the vehicle on a level surface. Chock the rear or front tires, as required.
2. Jack up the vehicle. Support the axle with jackstands.
3. Remove the tire.
4. Remove the brake caliper from the anchor plate following the instructions in Subject 120.
5. Remove the tie bar from the anchor plate on 73mm brakes, or remove the plugs from the anchor plate on 66mm brakes.
6. Remove the brake pads from the anchor plate. For instructions, see Subject 110.
7. Remove the wheel hub and rotor assembly from the axle, following the instructions in Group 33 for the front axle or Group 35 for the rear axle.
8. Remove the anchor plate from the axle.
   - 8.1 Remove the three screws holding the dust shield to the anchor plate and remove the dust shield.
   - 8.2 Remove the hexbolts, washers and nuts that hold the anchor plate to the axle. See Fig. 1.
   - 8.3 Remove the anchor plate from the axle.
9. Remove contamination, dirt and debris from the exterior of the anchor plate.
10. Remove the brake pad abutment slipper using a blunt nose drift pin or screwdriver and a light hammer. Avoid marring the anchor plate abutment surfaces. See Fig. 2.
11. Remove the guide pins and guide pin boots by pulling out the guide pin with a slight twisting motion.
12. Remove the splash shield and antilock braking system sensor bracket from the anchor plate. See Fig. 3.



10/28/94 f420554a

1. Dust Shield Screw
2. Anchor Plate
3. Mounting Hexbolts
4. Dust Shield

Fig. 1, Axle End (typical)



05/31/2001 f430260

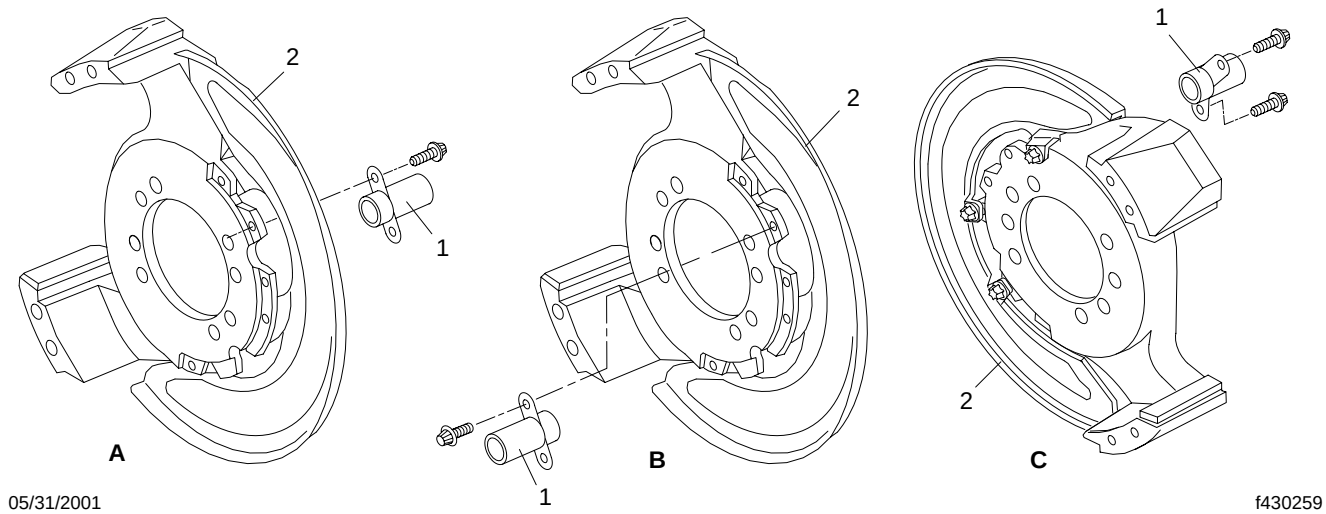
1. Pad Abutment Slipper
2. Guide Pin and Pin Boot
3. Plugs (66mm brakes only)

Fig. 2, Anchor Plate Components

Clean and Inspection

1. Clean the anchor plate with a brush and solvent. Make sure the anchor plate abutments, anchor plate tie bar mounting surfaces, axle flange

Anchor Plate Disassembly, Clean and Inspection, and Assembly

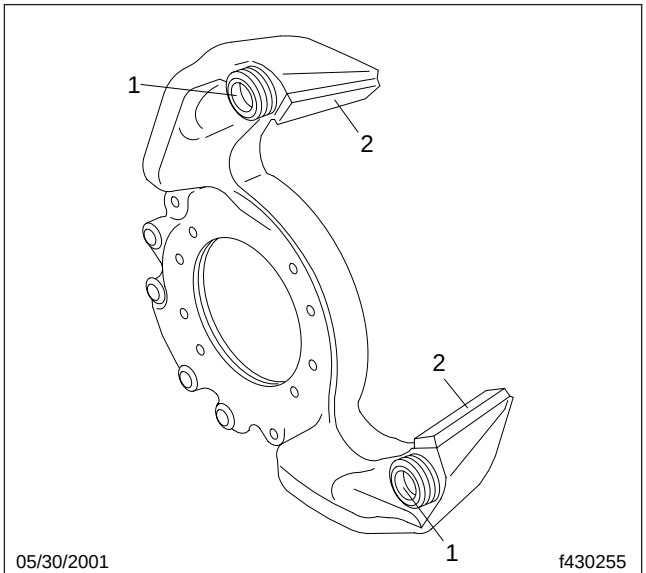


A. Driver Side Front Backing Plate Assembly (66mm brakes)
B. Driver Side Front Backing Plate Assembly (73mm brakes)
C. Driver Side Rear Backing Plate Assembly (typical)
1. Sensor Bracket
2. Anchor Plate

Fig. 3, Splash Shield and Sensor Mounting Bracket

mounting surface and anchor plate boot grooves are clean and free of any rust or corrosion. See **Fig. 4**. Use a hand-held wire brush to clean these surfaces. It is important to clean these areas of the anchor plate. Also make sure the tie bar bolt hole threads are clean and free of foreign matter.

2. Clean the guide pin bores with a bore brush and solvent. Use compressed air to clean out and dry guide pin bores. Check the guide pin bores for excessive wear. Replace the anchor plate, if necessary.
3. Clean the guide pin boots with isopropyl alcohol. Do not use solvent to clean the boots. Inspect each guide pin boot for cracks, tears, holes and flexibility. If damage is found, the boot must be replaced. See **Fig. 5**.
4. Clean the guide pins with isopropyl alcohol. Make sure the guide pins, and the threads in the guide pins, are free of foreign matter and corrosion. Use compressed air to clean out and dry guide pins and bolt threads in the guide pins. Check the guide pins for wear. Replace them if excessive wear is detected.

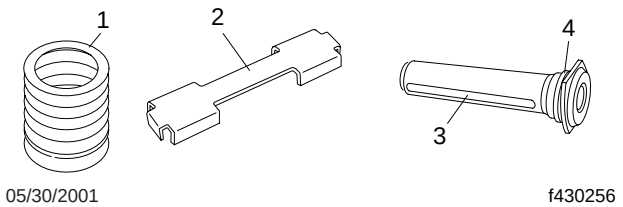


1. Guide Pin Bore and Boot Groove
2. Pad Abutment Slipper Mounting

Fig. 4, Anchor Plate Machined Surfaces

5. Inspect the pad abutment slippers for damage or wear and clean them with solvent. Replace them if damaged or excessive wear is detected.

Anchor Plate Disassembly, Clean and Inspection, and Assembly



05/30/2001 f430256

1. Guide Pin Boot
2. Pad Abutment Slipper
3. Guide Pin
4. Boot Groove

Fig. 5, Loose Anchor Plate Components

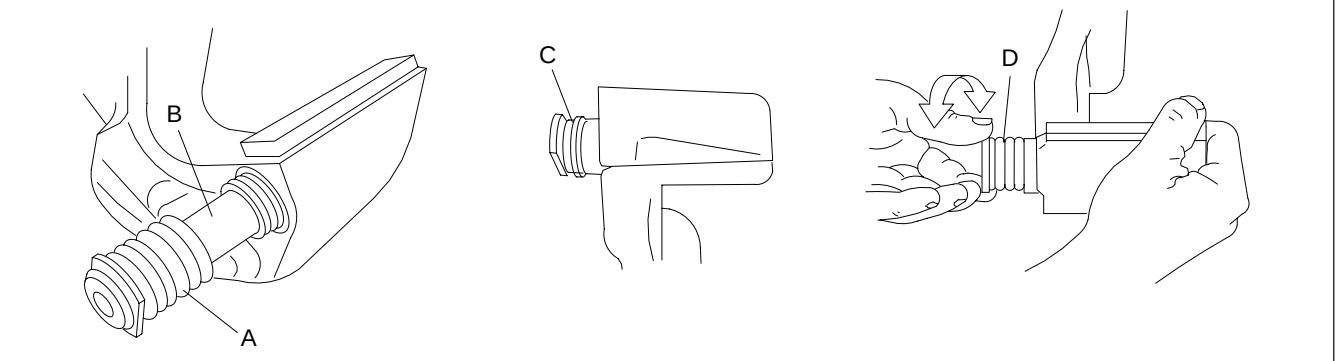
6. Visually inspect the anchor plate for worn or damaged slippers, and damaged or dislodged guide pin boots. If signs of wear or damage are found, the anchor plate should be repaired or replaced.

Assembly

NOTE: All brake parts must be clean and completely dry of cleaning fluids before assembly.

1. Uniformly apply Aeroshell Grade 5 grease to the entire guide pin bore and on the guide pin shaft. Use 1/8 ounce (3 grams) of grease to thoroughly lube each guide pin and guide pin bore set. See **Fig. 6**.
2. Apply a thin coat of Aeroshell Grade 5 grease to the inside opening at each end of the boot.
3. Slide the guide pin into the guide pin boot.
4. Insert the guide pin with the boot into the anchor plate guide pin bore until the boot is completely compressed.
5. Rotate the guide pin 1/4 to 1/2 turn back and forth in order to seat the guide pin boot.
6. Inspect the guide pin boot to make sure the boot is fully seated all around the guide pin and the anchor plate retaining grooves.
7. Install an anchor plate pad abutment slipper onto each anchor plate abutment. See **Fig. 7**. Use a soft brass or other light hammer to be sure the slipper is seated on the abutment. Avoid marring anchor plate abutment slipper surfaces.
8. Install the splash shield and antilock braking system sensor bracket to the anchor plate.

   When installing the splash shield and sensor bracket on the anchor plate for 66mm front and all rear brakes, the splash shield and sensor bracket are mounted on the inboard side of the anchor plate and the five bolts are installed from the inboard side. Tighten the bolts 12 to 16 lbf·ft (17 to 21 N·m).



06/01/2001 f430261

A. Lube the inside of the boot, both ends.
B. Apply Aeroshell Grade 5 grease to the bore and the pin.
C. Boot and pin in place.
D. Twist to seat in the groove.

Fig. 6, Install Guide Pins and Boots

Anchor Plate Disassembly, Clean and Inspection, and Assembly

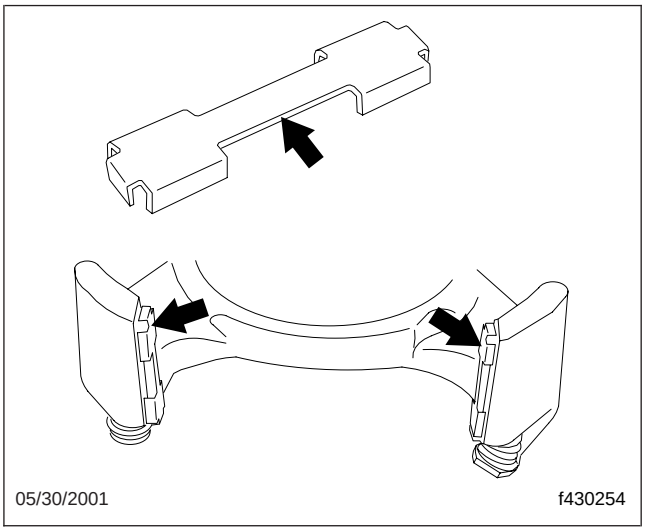
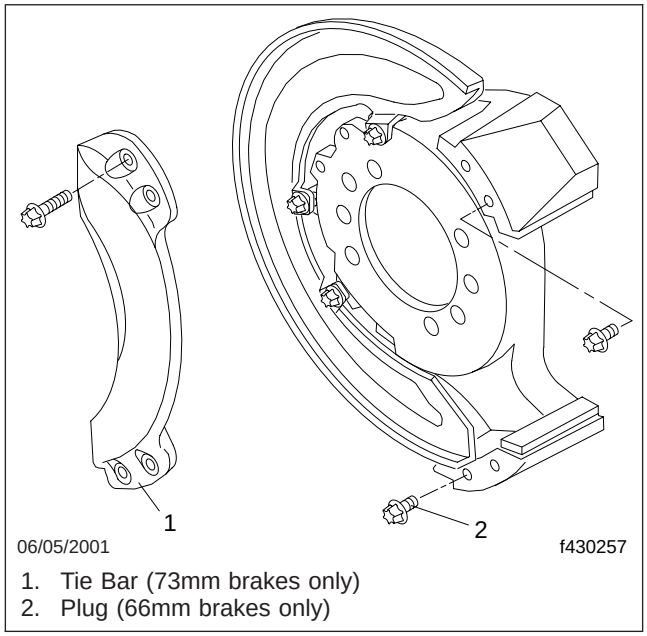


Fig. 7, Pad Abutment Slipper

For 73mm front brakes, the splash shield and sensor bracket are mounted on the outboard side of the anchor plate and the five bolts are installed from the outboard side. Tighten the bolts 12 to 16 lbf·ft (17 to 21 N·m).

9. Remove all traces of dirt, grease and oil from the knuckle and axle brake flange.
10. Install the anchor plate on the axle.
    - 10.1 Position the anchor plate against the outboard side of the axle flange, making sure the holes in both are lined up.
    - 10.2 From the outboard side of the anchor plate, install the hexbolts and washers. Install the nuts and remaining washers. See **Fig. 1**. Using a star pattern, tighten the hexnuts as follows:
      - Rear Axle; 105 lbf·ft (142 N·m)
      - Front Axle Type FC; 75 lbf·ft (102 N·m)
      - Front Axle Type FD/FF; 145 lbf·ft (197 N·m)
11. Install the dust shield on the anchor plate. See **Fig. 1**.
12. Install the wheel hub and rotor assembly onto the axle, following the instructions in **Group 33** for the front axle or **Group 35** for the rear axle.
13. On 66mm brakes, install the four bolt plugs into the anchor plate face. Tighten 16 to 27 lbf·ft (22 to 37 N·m). See **Fig. 8**.

    On 73mm brakes, install the anchor plate tie bar and the four tie bar bolts to the anchor plate face. Tighten 40 to 50 lbf·ft (54 to 68 N·m).



1. Tie Bar (73mm brakes only)
2. Plug (66mm brakes only)

Fig. 8, Plugs and Tie Bar

14. Install the brake caliper on the anchor plate following the instructions in **Subject 120**.
15. Install the brake pads into the anchor plate. For instructions, see **Subject 110**.
16. Install the tire.
17. Remove the jackstands. Lower the vehicle.
18. Remove the chocks.

Bleeding

⚠ WARNING

Before starting the procedure below, read the information in Subject 100. Failure to do so could result in serious and permanent health damage.

Whenever any hydraulic system fitting is loosened or disconnected, the entire system must be bled to remove any air that may have entered it.

⚠ CAUTION

Power steering fluid and brake fluid are incompatible. Never mix these two fluids or serious damage to both hydraulic systems will result. Use only brake fluid for the master cylinder and brake lines. Use only power steering fluid for the power booster.

Always use new, clean brake fluid that meets DOT 3 specifications when bleeding the master cylinder and service brake system. Never reuse brake fluid and do not use brake fluid containers for any other purpose. Keep brake fluid containers tightly closed to keep new brake fluid clean and dry.

IMPORTANT: Do not let brake fluid touch any painted surfaces, as it will remove the paint. Brake fluid may also damage certain non-metal surfaces. Do not let it get on brake pads or rotors.

Pressure Bleeding

NOTE: Pressure bleeding is the preferred method for bleeding the service brake system. It requires the use of a special pressure bleeder kit, consisting of a tank, pressure pump and valve, gauge, tubing and adapter. These are available from a number of manufacturers and include instructions for use. See **Fig. 1**.

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.

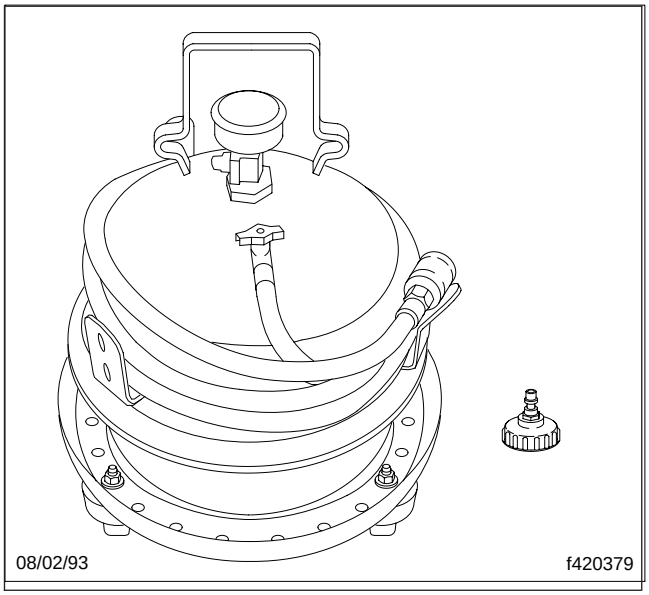


Fig. 1, Pressure Bleeder Kit

3. Connect the pressure bleeder to the brake master cylinder reservoir following the manufacturer's instructions.
   - 3.1 Fill the pressure bleeder with new DOT 3 approved brake fluid. Pressurize it according to the manufacturer's instructions.
   - 3.2 Using the supplied adapter, connect the pressure bleeder to the rear compartment of the master cylinder reservoir.
4. Bleed the hydraulic connections at the rear wheel calipers starting on the right side.
   - 4.1 Put a wrench on the bleeder fitting at the caliper. Attach a length of clear tubing to the bleeder fitting. Make sure the tube fits snugly. Submerge the tubing in a container of clean brake fluid. See **Fig. 2**.
   - 4.2 Loosen the bleeder fitting about 3/4 turn and let the brake fluid flow out of the fitting until it is free of air bubbles. Tighten the fitting firmly.
   - 4.3 Move to the left rear caliper and repeat steps for bleeding the caliper.
5. Disconnect the pressure bleeder from the rear compartment of the master cylinder reservoir. Connect it to the front compartment of the reservoir.

System Bleeding

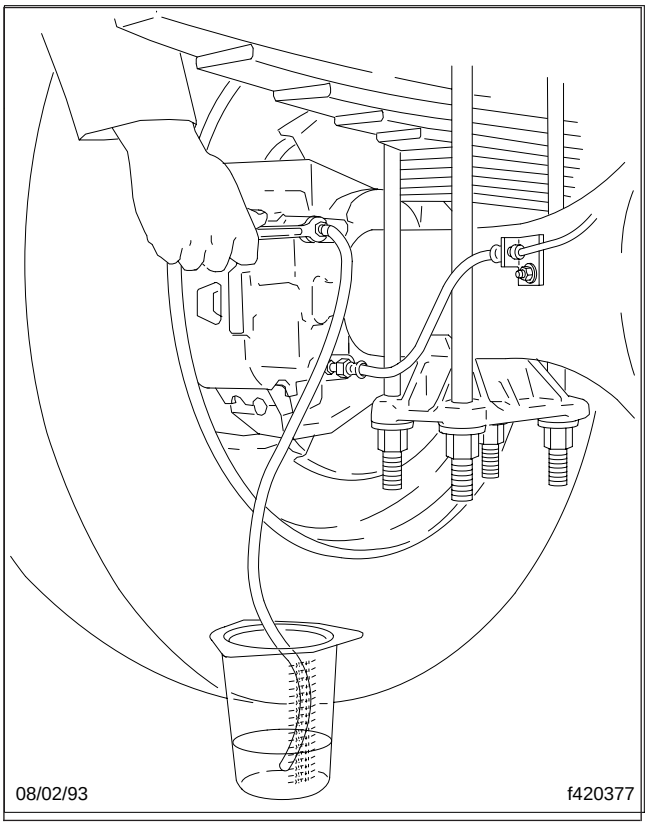


Fig. 2, Bleed the Hydraulic Connection

6. Bleed the front wheel brake calipers starting at the right side.
   - 6.1 Put a wrench on the bleeder fitting at the caliper. Attach a length of clear tubing to the bleeder fitting. Make sure the tube fits snugly. Submerge the tubing in a container of clean brake fluid. See **Fig. 2**.
   - 6.2 Loosen the bleeder fitting about 3/4 turn and let the brake fluid flow out of the fitting until it is free of air bubbles. Tighten the fitting firmly.
   - 6.3 Move to the left front wheel caliper and repeat steps for bleeding the caliper.
7. Check the brake fluid level in both compartments of the reservoir. Add new DOT 3 approved brake fluid if needed.
8. Check the operation of the brakes by depressing the brake pedal several times, until if feels firm. The brake pedal should not go all the way down to the floor. If it does, see **Troubleshooting, 300** and find the problem.
9. Close and latch the hood.
10. Remove the chocks from the rear tires.

Manual Bleeding

NOTE: If you do not have pressure bleeding equipment, you can use the manual bleeding procedure.

⚠ WARNING

Read over the information in Subject 100 before starting the procedure below. Failure to do so may result in either serious injury to yourself, or damage to the brake system, resulting in an accident causing serious personal injury or property damage.

IMPORTANT: Do not let the brake master cylinder run dry during manual bleeding operations. Keep the master cylinder reservoir filled with new, DOT 3 approved brake fluid. Failure to keep the brake reservoir filled could result in more air entering the system, making it impossible to effectively bleed the system.

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Open the hood.
3. Bleed the master cylinder.
   - 3.1 Using a wrench (and a rag to absorb leaking brake fluid), loosen the fitting at the rear outlet port on the master cylinder. See **Fig. 3**. Loosen the fitting about one turn.
   - 3.2 Have someone push the brake pedal down slowly by hand to the floor. Brake fluid, and any air in the master cylinder, will squirt from the fitting.
   - 3.3 *With the brake pedal held down*, tighten the rear hydraulic line fitting firmly.

   IMPORTANT: Do not release the brake pedal until the fitting is tightened, or more air will get into the system.

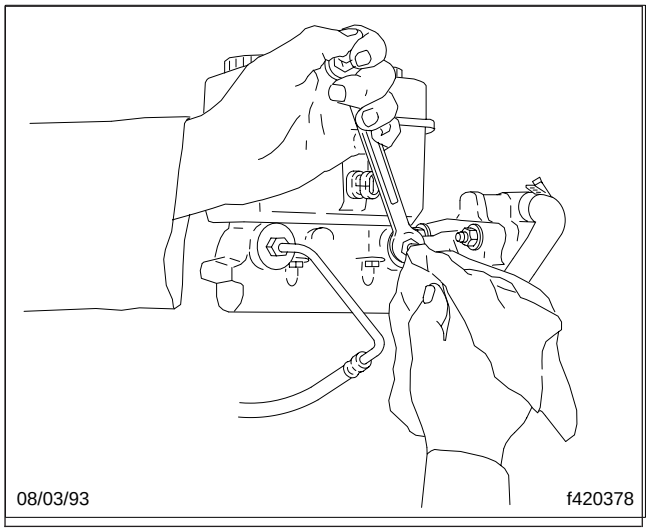


Fig. 3, Rear Outlet Port

3.4 Release the brake pedal.

3.5 Loosen the fitting again, and repeat steps for bleeding as required until no air escapes from the fitting, and the brake pedal feels firm.

3.6 Check the level of the rear compartment of the reservoir, then add new DOT 3 approved brake fluid if needed.

3.7 Using a wrench (and a rag to absorb leaking brake fluid), loosen the fitting at the front outlet port on the master cylinder. See **Fig. 4**. Loosen the fitting about one turn.

3.8 Repeat steps as required for the front outlet port.

3.9 Check the brake fluid level in the front compartment of the reservoir. Add new DOT 3 approved brake fluid if needed.

4. Bleed the hydraulic connections at the wheel calipers, starting at the right rear wheel caliper.

4.1 Put a wrench on the bleeder fitting at the caliper, then attach a length of clear tubing to the bleeder fitting. Make sure the tube fits snugly. Submerge the tubing in a container of clean brake fluid. See **Fig. 2**.

4.2 Loosen the bleeder fitting about 3/4 turn.

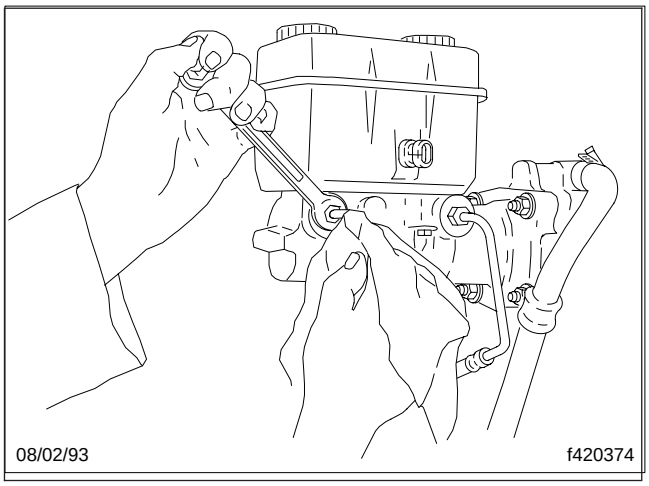


Fig. 4, Front Outlet Port

4.3 Have someone slowly push the brake pedal to the floor. *With the brake pedal depressed*, tighten the bleeder fitting.

IMPORTANT: Make sure the brake pedal stays depressed while you tighten the fitting. If it is released before you tighten the fitting, more air will get into the system.

4.4 Release the brake pedal. Check the fluid in the tube. If there are air bubbles present, repeat the steps as required until the fluid in the tube is completely free of air bubbles.

4.5 Check the brake fluid level in the reservoir. Add new DOT 3 approved brake fluid if needed.

4.6 Repeat the steps for bleeding the connections for the left rear caliper, the right front caliper and the left front caliper.

5. Close and latch the hood.

6. Remove the chocks from the rear tires.

Troubleshooting Tables

Problem—Noise and Chatter

Problem—Noise and Chatter	
Possible Cause	**Remedy**
Bent, damaged or incorrect pads	Replace with the correct pads in axle sets.
Worn out lining plates (plates rubbing rotor)	Resurface or replace the rotor. Replace the pads in axle set.
Rotor polished or linings glazed	Remove the polish or glaze.
Foreign material embedded in linings	Replace the pads in axle sets.
Excessive rotor thickness variations or lateral runout	Resurface or replace the rotor.

Problem—Brakes Grab

Problem—Brakes Grab	
Possible Cause	**Remedy**
Incorrect pads or pads loose on plate	Replace with the correct pads in axle sets.
Grease or brake fluid on linings	Repair the grease seal or caliper. Replace the pads in axle sets.
Loose caliper at anchor plate pins	Tighten to specifications.
Excessive rotor lateral runout	Check the bearing adjustment. Resurface or replace the rotor.

Problem—Vehicle Pulls to One Side

Problem—Vehicle Pulls to One Side	
Possible Cause	**Remedy**
Incorrect pads or loose lining on plates	Replace with the correct pads in axle sets.
Grease or brake fluid on linings	Repair the grease seal or caliper. Replace the pads in axle sets.
Loose caliper or anchor plate	Tighten to specifications.
Caliper piston sticking	Repair or replace the piston or replace the caliper.
Caliper guide pins sticking	Repair or replace the guide pins and boots. Clean the pin bores and lubricate.
Excessive rotor lateral runout	Check the bearing adjustment. Resurface or replace the rotor.

Problem—Pulsating Brake Pedal

Problem—Pulsating Brake Pedal	
Possible Cause	**Remedy**
Worn or damaged front wheel bearings	Replace the wheel bearings.
Excessive variation in rotor thickness	Resurface or replace the rotor.

Troubleshooting

Problem—Springy or Spongy Pedal

Problem—Springy or Spongy Pedal	
Possible Cause	**Remedy**
Excessive rotor lateral runout	Resurface or replace the rotor.
Poor quality brake fluid (low boiling point)	Drain and clean the system. Refill with the approved brake fluid.
Weak brake hoses that expand under pressure	Replace the hoses.
Air in hydraulic system	Bleed the system. For instructions, see **Subject 170**.

Problem—All Brakes Drag (or Both Brakes on Same Axle)

Problem—All Brakes Drag (or Both Brakes on Same Axle)	
Possible Cause	**Remedy**
Binding brake pedal	Free-up and lubricate the pedal.
Soft or swollen rubber parts caused by incorrect or contaminated brake fluid	Replace rubber parts. Flush the system and refill with approved brake fluid. For instructions, see **Subject 170**.
Trapped pressure in brake lines caused by master cylinder and/or booster not fully releasing	Repair or replace the master cylinder and/or booster as necessary.

Problem—One Brake Drags

Problem—One Brake Drags	
Possible Cause	**Remedy**
Loose or worn front wheel bearings	Adjust to specifications or replace.
Defective brake hose or hydraulic tube (preventing return of fluid)	Replace the hose or tube.
Sticking caliper piston	Repair or replace the caliper.
Swollen caliper piston seal	Replace the seal. Drain and flush the system. Refill with the approved brake fluid.
Sticking caliper guide pin(s)	Repair or replace the pin(s). Lubricate the pins and boots.

Problem—Low Pedal

Problem—Low Pedal	
Possible Cause	**Remedy**
Leak in hydraulic brake system	Check the master cylinder, calipers, hoses and tubes. Replace as necessary.
Air in hydraulic brake system	Bleed the system. For instructions, see **Subject 170**.
Poor quality brake fluid (low boiling point)	Drain the system. Flush and refill with approved brake fluid.
Weak brake hoses that expand under pressure	Replace the defective hoses.
Pad and piston knockback caused by loose wheel bearings	Adjust or tighten parts or replace faulty parts as necessary.

Specifications

Kent-Moore Tools	
Kent-Moore Part Number	**Tool**
ZTSE4417	Seating Tool for 66mm Caliper Pistons
ZTSE4418	Seating Tool for 73mm Caliper Pistons

Table 1, Kent-Moore Tools

Fastener Torques			
Description	**Size**	**Grade**	**Torque lbf·ft (N·m)**
Caliper Pin Mounting Bolts	M12 x 1.75	—	70–80 (95–108)
Brake Supply Hose Fitting	—	—	15 (20)
Tie Bar-to-Anchor Plate Mounting Bolt (73mm only)	M10 x 1.5	—	40–50 (54–68)
Tie Bar-to-Anchor Plate Hole Plug (66mm only)	M10 x 1.5	—	16–27 (22–37)
Splash Shield, ABS Sensor Mounting Bracket and Brake Line Clip Screw	5/16–18	—	12–16 (17–21)
Anchor Plate Mounting Hexnuts	—	—	Rear Axle: 105 (142) Front Axle Type FC: 75 (102) Front Axle Type FD/FF: 145 (197)
Caliper Bleed Screw	7/16–24	—	8–15 (10–20)
Rotor Mounting Hexbolts	9/16–12	8	130 (175)

Table 2, Fastener Torques

Approved Brake Fluid for Brake System	
Fluid Type	**Recommended Fluids**
DOT 3	Wagner-Premium Plus Super HD
	Delco Supreme II
	Dow HD 50-4

Table 3, Approved Brake Fluid for Brake System

Approved Brake System Grease	
Component	**Recommended Grease**
Anchor Plate Guide Pins, Guide Pin Boots, Guide Pin Bores	Aeroshell Grade 5 (ES-1246)
Caliper Piston Bores	Dow Corning DC-4

Table 4, Approved Brake System Grease

Component Specifications		
Item	**66mm Caliper**	**73mm Caliper**
Lining, Per Pad		
Thickness, New	0.49 inch (12.45 mm)	0.74 inch (18.79 mm)
Thickness, Discard	3/32 inch (2.38 mm)	
Area	20.85 square inch (530 square mm)	
Volume	10.22 cubic inch (259.59 cubic mm)	15.43 cubic inch (391.92 cubic mm)
Rotor (Typical)		
Outside Diameter	15.0 inch (381 mm)	

Specifications

Component Specifications		
Item	**66mm Caliper**	**73mm Caliper**
Thickness, New	1.435 inch (36.45 mm)	
Thickness, Discard	1.320 inch (33.53 mm)	
Total Swept Area	52.02 square inch (1321.31 square mm)	
Surface Finish	40–120 micro inch 40–100 micro inch (preferred)	
Torque Output (Typical), Post Burnish at 1800 psi *		
30 mph	83,800 lbf·in (946 820 N·cm)	106,100 lbf·in (1 198 780 N·cm)
60 mph	67,600 lbf·in (763 780 N·cm)	78,400 lbf·in (885 802 N·cm)
Caliper Fluid Displacement at 1800 psi		
Static †	0.38 cubic inch (9.65 cubic mm)	0.55 cubic inch (13.97 cubic mm)
Dynamic *	0.58 cubic inch (14.73 cubic mm)	0.82 cubic inch (20.83 cubic mm)
Reservoir Fluid Requirement Per Caliper (Typical)	10.24 cubic inch (260.09 cubic mm)	19.16 cubic inch (486.66 cubic mm)

* Typical, may change with friction material and wheel load.
† Typical, may change with friction material.

Table 5, Component Specifications

General Information

The R–12 (see **Fig. 1**) and R–14 (see **Fig. 2**) relay valves are control relay stations in the air brake system to speed the application and release of the brakes. Mounted at the rear of the vehicle, they are operated by remote control and give about the same amount of air pressure to the brake chambers as they receive from the service brake foot valve or other source.

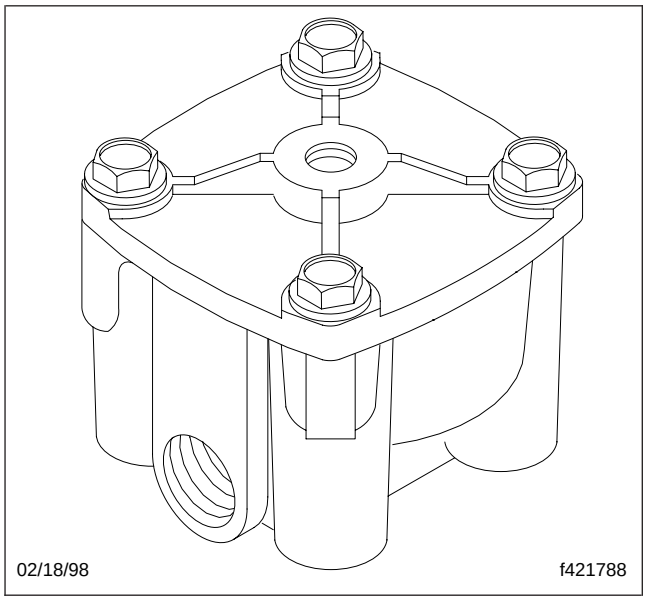


Fig. 1, R-12 Relay Valve

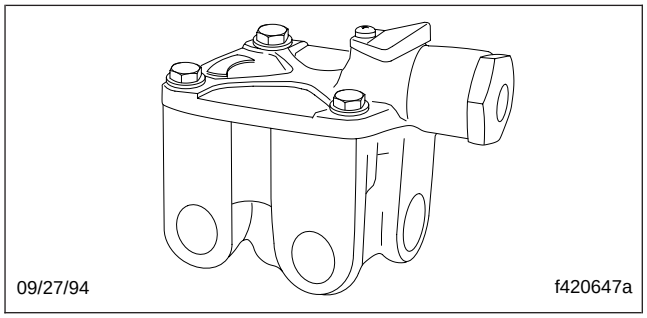


Fig. 2, R-14 Relay Valve

The valves are piston operated and have an insert-type inlet and exhaust valve that can be serviced.

Principles of Operation

See **Fig. 3 and Fig. 4** for sectional views of the R–12 and R–14 relay valves.

Application

Air pressure delivered to the service port enters the small cavity above the relay piston and moves the piston down. The exhaust seat moves down with the piston and seats on the inner or exhaust portion of the inlet/exhaust valve, sealing off the exhaust passage. At the same time, the outer or inlet portion of the inlet/exhaust valve moves off its seat, permitting supply air to flow from the reservoir, past the open inlet valve and into the brake chambers.

Balance

The air pressure being delivered by the open inlet valve also is effective on the bottom area of the relay piston. When air pressure beneath the piston equals the service air pressure above, the piston lifts slightly and the inlet spring returns the inlet valve to its closed position. The exhaust remains closed as the service line pressure balances the delivery pressure. As delivered air pressure is changed, the valve reacts to the change, holding the brake application at the same level.

Exhaust or Release

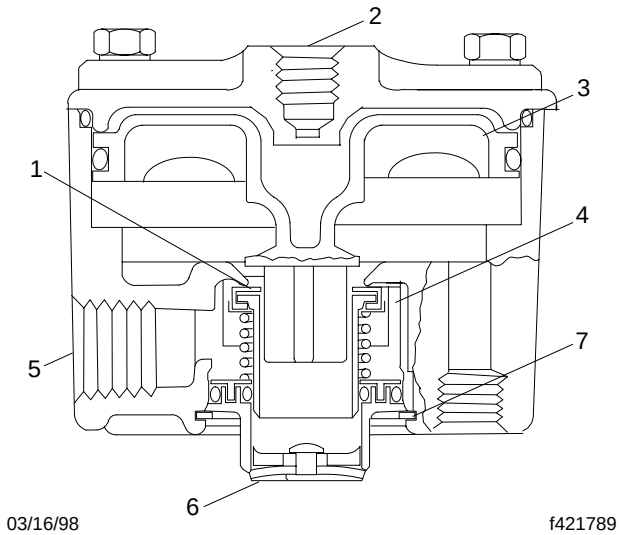
When air pressure is released from the service port and air pressure in the cavity above the relay piston is exhausted, air pressure beneath the piston lifts the piston, and the exhaust seat moves away from the exhaust valve, opening the exhaust passage. With the exhaust passage open, air pressure in the brake chambers is permitted to exhaust through the exhaust port, releasing the brakes.

Anti-Compounding (Simultaneous Service and Park Application), R–14 Valve

An "anti-compound" feature allows the R–14 valve to be used as either a service or spring brake relay valve. An exhaust cover is installed that protects the 1/8-inch balance port when the R–14 anti-compound feature is not in use. See **Fig. 4**.

In applications where the R–14 is used to control spring brake chambers, the anti-compound feature

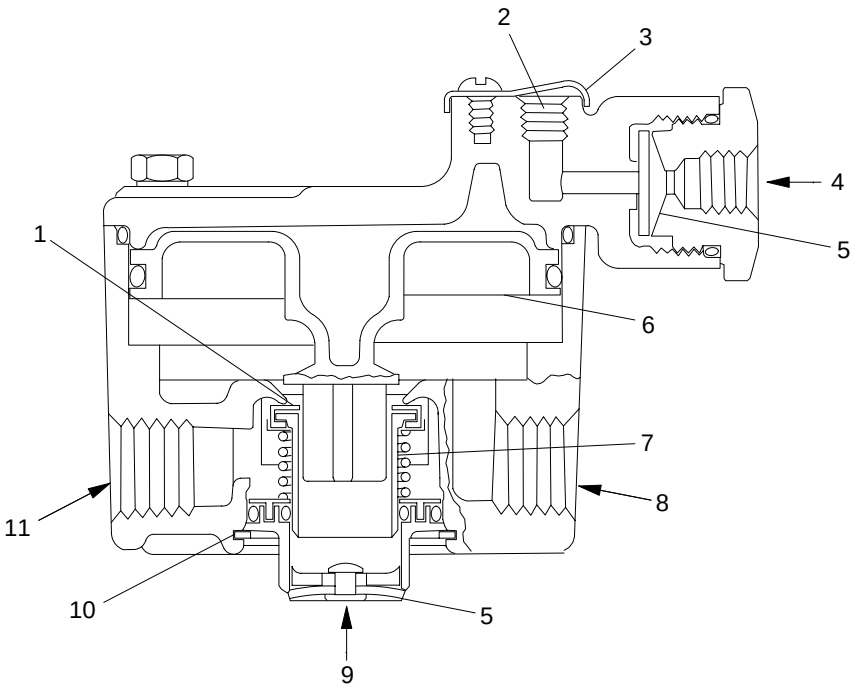
General Information



1. Exhaust Seat
2. Service Port
3. Relay Piston
4. Inlet/Exhaust Assembly
5. Supply Port
6. Exhaust Port
7. Retaining Ring

Fig. 3, R-12 Relay Valve (sectional view)

may be used. To use, the exhaust cover of the quick release portion of the R–14 is removed and a line is installed, which is connected to the delivery port of the service brake valve or relay valve. With no air pressure at the service port of the R–14, the parking brakes apply. When a service brake application is made, air from the service brake valve enters the exhaust port of the quick release of the R–14 and moves the diaphragm, blocking the service port. Air then proceeds into the cavity above the relay piston, forces the piston down, closing the exhaust and opening the inlet to deliver air to the spring brake cavity.



05/15/98 f420648b

1. Exhaust Seat
2. Balance/Quick Exhaust Port (Anti-Compound)
3. Exhaust Cover
4. Service Port
5. Double-Check Diaphragm
6. Relay Piston
7. Inlet/Exhaust Valve
8. Delivery Port
9. Exhaust Port
10. Retaining Ring
11. Supply Port

Fig. 4, R-14 Relay Valve (sectional view)

Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

A. Chock the tires and stop the engine before working under the vehicle. Releasing air from the system may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they will apply as air pressure drops.

B. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.

C. Never exceed recommended air pressure, and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.

D. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs and injury can result if not correctly disassembled. Use only correct tools and observe all precautions regarding use of those tools.

Operation Test

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions, 100**.

1. Start the vehicle and build the brake system to cut-out pressure, about 130 psi (827 kPa).
2. Using a soap and water solution, check all air line fittings on the valve for leakage. If the fittings or air lines are leaking, replace the fittings. For instructions, see **Section 42.03**.
3. Make several service brake applications and check for prompt application and release of the brakes.
4. If brake response is slow, troubleshoot the brake system. For instructions, see **Section 42.02** . If the valve is malfunctioning, repair or replace it.

Leakage Test

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions, 100**.

1. Start the vehicle and build the brake system to cut-out pressure, about 130 psi (827 kPa).
2. Using a soap and water solution, check for inlet valve and O-ring leakage.
   - 2.1 Make this check with the service brakes released when the R–12 or R–14 is used to control the service brakes.
   - 2.2 Make the check with the spring brakes (parking brakes) applied when the R–14 is used to control the spring brakes.
3. While holding a full service brake application, apply a soap solution to the exhaust port. Leakage at the exhaust port should not exceed a 1-inch (2.5-cm) bubble in three seconds.

NOTE: If the anti-compound feature is in use, the line attached to the balance port must be disconnected to perform this test.

4. Coat the outside of the valve where the cover joins the body to check for O-ring leakage; no leakage is permitted.
5. If the R–14 is used to control the spring brakes, release the parking brake, apply a soap solution to the balance port. Leakage at the balance port should not exceed a 1-inch (2.5-cm) bubble in three seconds.

IMPORTANT: If the valves do not function as described in the above test, or if leakage is excessive, replace it. For instructions, see **Subject 120**.

Relay Valve Removal and Installation

Removal

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions, 100**.

1. Chock the tires, and drain the air system.
2. Remove all air hoses from the valve. Cap the hoses and mark them for reassembly.
3. Remove the valve mounting bolts. Remove the valve.

Installation

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions, 100**.

1. Attach the valve to the vehicle, using the bolts, washers, and nuts. Tighten the nuts 132 to 180 lbf·in (1500 to 2040 N·cm).
2. Remove the caps from the air lines, then depending on the type of air hose, do one of the following.

   Nylon Tubing: Connect the air line fittings to the valve ports, and tighten the nuts finger-tight. Using a wrench, tighten the nuts at least two turns, or until one thread shows on the fittings.

   Wire Braid Hoses: Connect the hose fittings to the valve ports, and hand-tighten the nuts. Using a wrench, tighten the nuts until resistance is felt. Tighten one-sixth turn more. Do not overtighten.
3. Close the air reservoir drain cocks. Start the vehicle engine to pressurize the air system.
4. Test the valve following the instructions in **Subject 110**.

Relay Valve Disassembly, Cleaning and Inspection, and Assembly

Disassembly

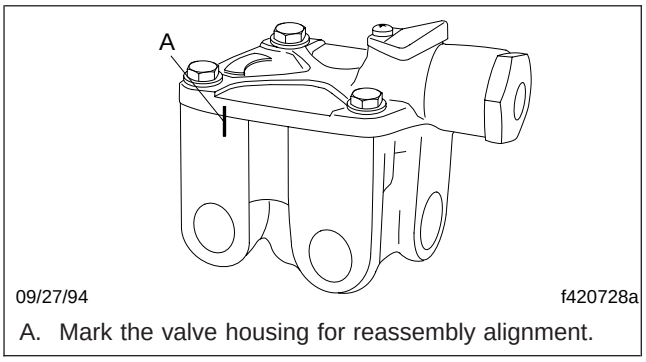
IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions, 100**.

1. Remove the valve from the vehicle. For instructions, see **Subject 120**.

NOTE: Prior to disassembly, draw an alignment mark across the valve cover and body, for reassembly alignment. See **Fig. 1**.

2. Disassemble the valve.

   2.1 Referring to **Fig. 2**, remove the four cover capscrews and integral lockwashers.



A. Mark the valve housing for reassembly alignment.

Fig. 1, Valve Marked for Reassembly (R-14 valve shown)

   2.2 Remove the valve cover and O-ring.

   2.3 Remove the relay piston, and the O-ring.

   2.4 While depressing the exhaust cover, remove the retainer ring; slowly remove the exhaust cover and the valve spring. Remove the O-rings from the exhaust cover.

   2.5 Remove the inlet/exhaust valve. Remove the valve retainer from the inlet/exhaust valve.

3. On R–14 valves, remove the Phillips screw and the exhaust cover. Then, remove the service port capnut, the O-ring, and the diaphragm located inside the service port.

Cleaning and Inspection

⚠ WARNING

Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.

IMPORTANT: Before working on or around air brake systems and components, see **Safety Precautions, 100**.

1. Wash all metal parts of the valve in cleaning solvent. Dry the metal parts of the disassembled valve with compressed air.
2. Wipe all rubber parts clean with a clean cloth. Examine all rubber parts for cracks, tears, or other deterioration. If any rubber parts are worn, cracked, torn, or otherwise damaged, replace them with new parts.
3. Examine all metal parts for wear, cracks, or other damage. If any metal parts are worn, cracked, or otherwise damaged, replace them with new parts.
4. Check the springs for distortion and corrosion. If the springs are distorted or corroded, replace them.
5. Inspect the exhaust seat of the quick release diaphragm in the R–14 cover and make sure all internal air passages in the area are open, clean, and free of nicks and scratches.

Assembly

IMPORTANT: Before working on or around air brake systems and components, refer to **Safety Precautions, 100**.

1. Lubricate the O-rings and all sliding parts with Dow Corning 55-M pneumatic grease or equivalent. Assemble the valve (see **Fig. 2**).

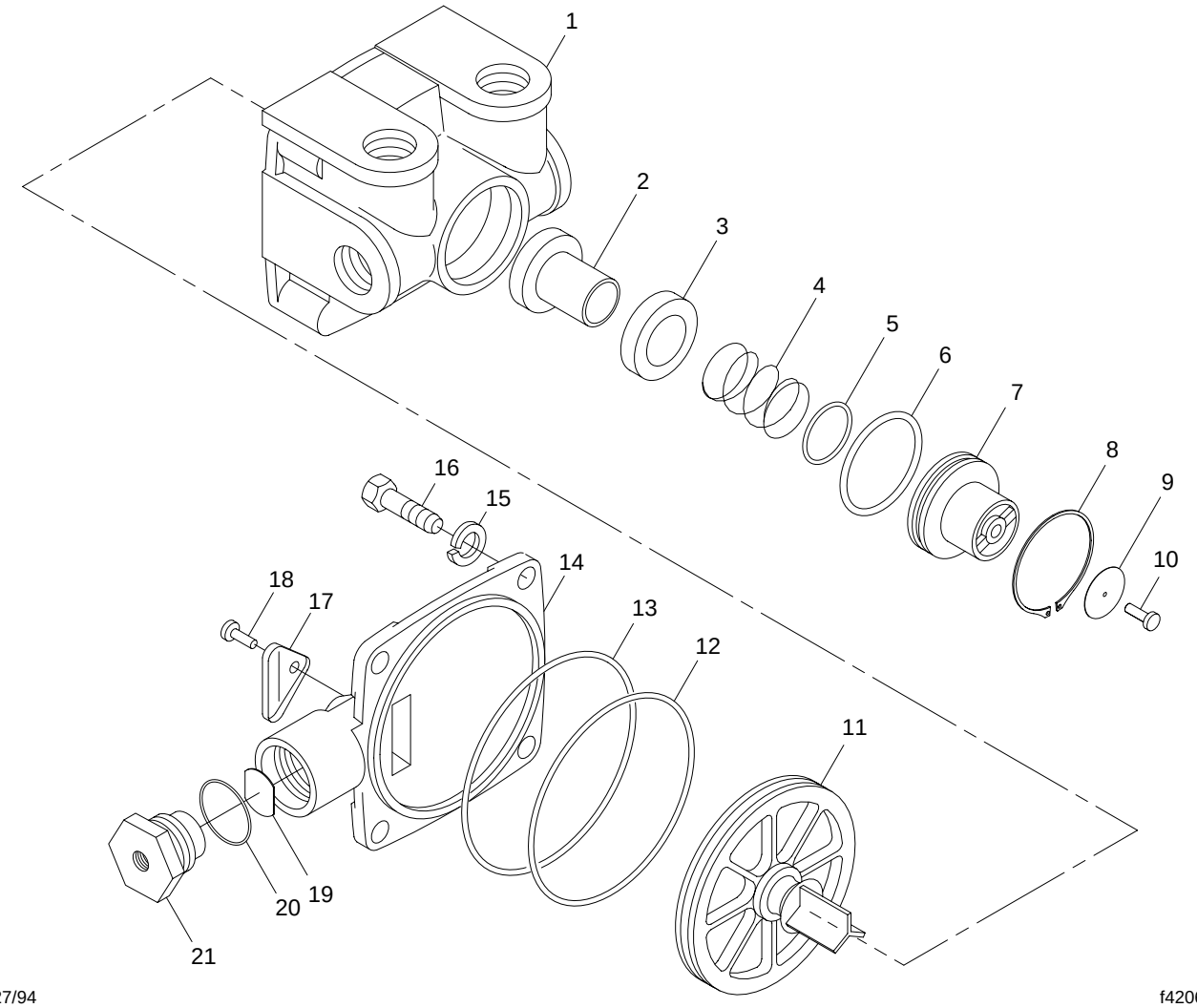
   1.1 Install the O-ring on the relay piston.

   1.2 Install the inner and outer O-rings on the exhaust cover.

   1.3 Install the O-ring on the valve cover.

   1.4 Install the relay piston in the body, taking care not to damage the piston O-ring.

Relay Valve Disassembly, Cleaning and Inspection, and Assembly



1. Body
2. Inlet/Exhaust Valve
3. Valve Retainer
4. Valve Spring
5. O-Ring
6. O-Ring
7. Exhaust Cover
8. Retainer Ring
9. Diaphragm
10. Rivet
11. Relay Piston
12. O-Ring
13. O-Ring
14. Valve Cover
15. Lockwasher (4 qty)
16. Capscrew (4 qty)
17. Exhaust Cover
18. Screw, Phillips #10–24
19. Diaphragm
20. O-Ring
21. Capnut

Fig. 2, R-14 Valve (R-12 similar)

1.5 Noting the reference mark made during disassembly, secure the valve cover with four capscrews and lockwashers. Torque the capscrews 80 to 120 lbf·in (900 to 1360 N·cm).

1.6 Install the valve retainer and spring on the inlet/exhaust valve assembly. Install the inlet/exhaust valve assembly in the body.

1.7 Install the exhaust cover. While depressing the exhaust cover, install the retaining

ring, making sure the retaining ring is completely seated in the groove.

1.8 On R–14 valves, place the diaphragm in the service port making sure it is positioned between the guide ribs. Install the service port cap nut and O-ring, then tighten it to 150 lbf·in (1700 N·cm).

1.9 Position the exhaust cover, then install the Phillips screw and tighten it to 25 lbf·in (280 N·cm).

2. Install the relay valve on the vehicle following the instructions in **Subject 120**.

3. Test the valve following the instructions in **Subject 110**.

Specifications

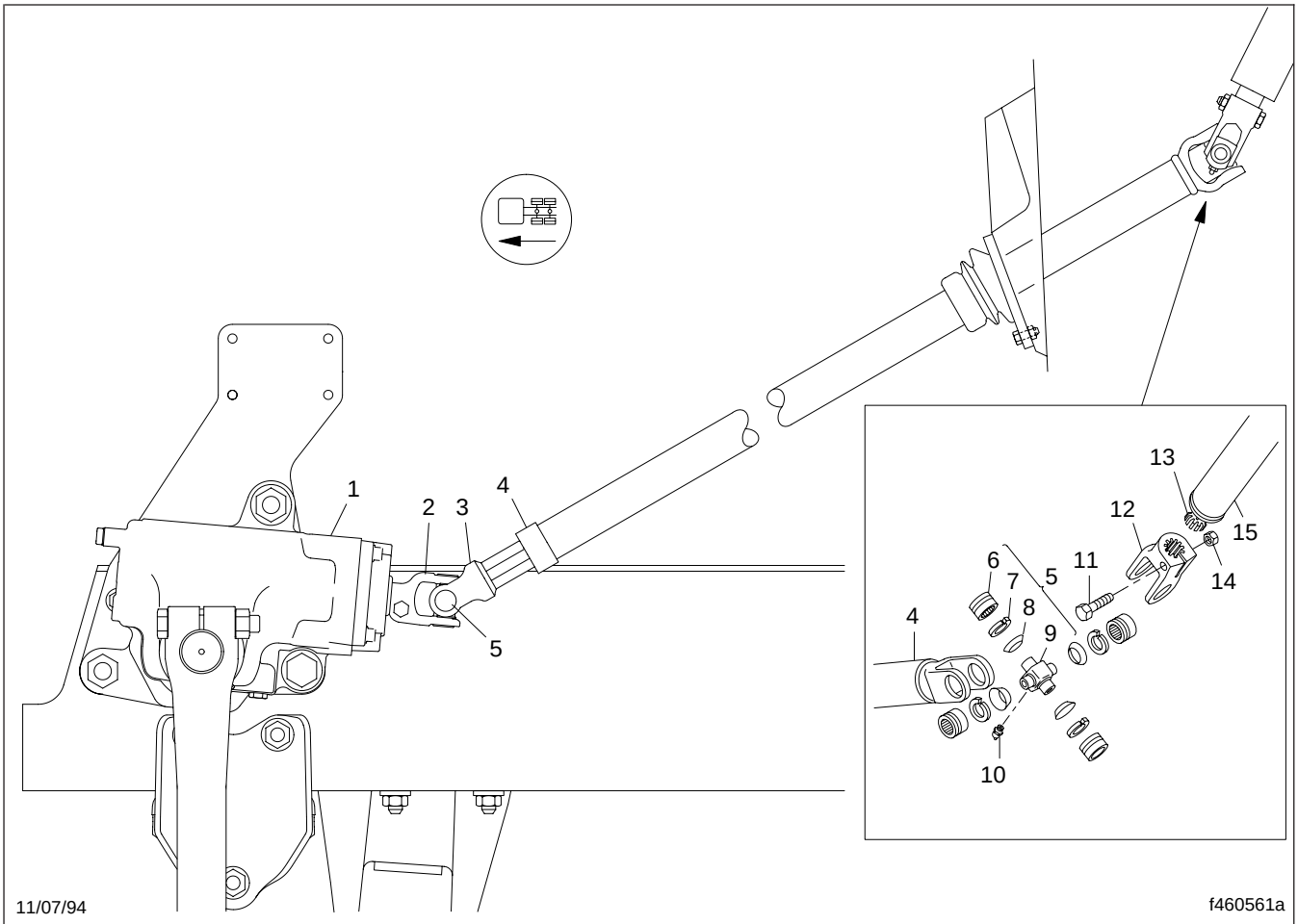
Torque Values	
Description	**Torque: lbf·in (N·cm)**
Valve Cover Capscrews	80–120 (900–1360)
Valve Mounting Capscrews	132–180 (1500–2040)
Service Port Capnut	150 (1700)
Phillips Screw, no. 10–24	25 (280)

Table 1, Torque Values

General Description

The steering driveline connects the steering column and jacket assembly to the steering gear by means of a telescoping shaft with integral yokes, an upper and a lower end yoke, and a pair of universal joints. **See Fig. 1.**

ternally splined lower section. The telescoping shaft eases installation and removal of the steering column, steering driveline, and steering gear. It also compensates for changes in distance between the steering column and steering gear, which occur when the relative positions of the frame rails and cab change during vehicle operation.



1. Ross Integral Power Steering Gear
2. Lower End Yoke
3. Driveline Shaft and Yoke Assembly
4. Driveline Tube and Yoke Assembly
5. U-Joint Assembly
6. Needle Bearing Cup
7. Needle Bearing Cup Snap Ring
8. U-Joint Cross Seal
9. U-Joint Cross
10. U-Joint Cross Lube Fitting
11. End Yoke Pinch Bolt
12. Upper End Yoke
13. Steering Column Shaft
14. Pinch-Bolt Nut
15. Upper Column and Jacket Assembly

Fig. 1, Steering Driveline

The driveline shaft consists of a tubular upper section, splined on the inside, which mates with an ex-

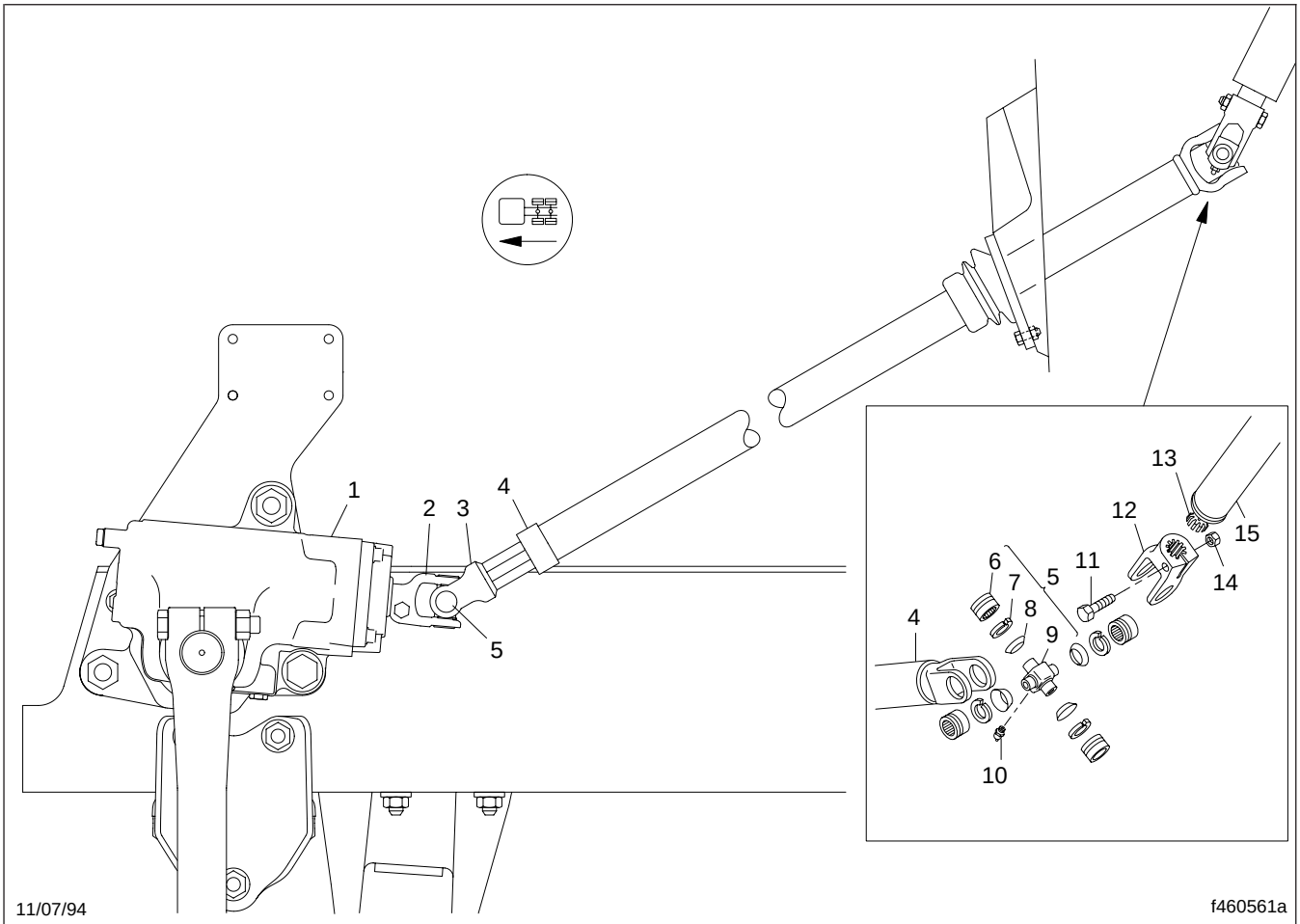
The upper end yoke is internally serrated to match the external serrations at the end of the steering col-

General Description

umn shaft; the lower end yoke is internally serrated to match the external serrations on the steering gear input shaft. Each end yoke is secured to its respective shaft by a pinch bolt that engages a notch in the shaft.

The universal joint at each end of the steering driveline allows the transfer of steering motion from the steering column shaft, to the steering driveline, and to the steering gear input shaft, even though the driveline is at an angle to both of the other shafts. Each universal joint cross rides in four needle bearing cups, two carried in the end yoke, and two carried in the steering driveline's integral yoke. The needle bearing cups are held in place in each yoke by snap rings.

Removal (See Fig. 1)



1. Ross Integral Power Steering Gear
2. Lower End Yoke
3. Driveline Shaft and Yoke Assembly
4. Driveline Tube and Yoke Assembly
5. U-Joint Assembly
6. Needle Bearing Cup
7. Needle Bearing Cup Snap Ring
8. U-Joint Cross Seal
9. U-Joint Cross
10. U-Joint Cross Lube Fitting
11. End Yoke Pinch Bolt
12. Upper End Yoke
13. Steering Column Shaft
14. Pinch-Bolt Nut
15. Upper Column and Jacket Assembly

Fig. 1, Steering Driveline

NOTE: It is not necessary to loosen the steering wheel and column assembly to do this procedure.

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service operations will be done.
2. Apply the parking brakes, and chock the tires. Tilt the hood.
3. Disconnect the lower end yoke.
   - 3.1 Remove the pinch-bolt nut and pinch bolt from the lower end yoke. **See Fig. 2.** Discard the nut.

Removal and Installation

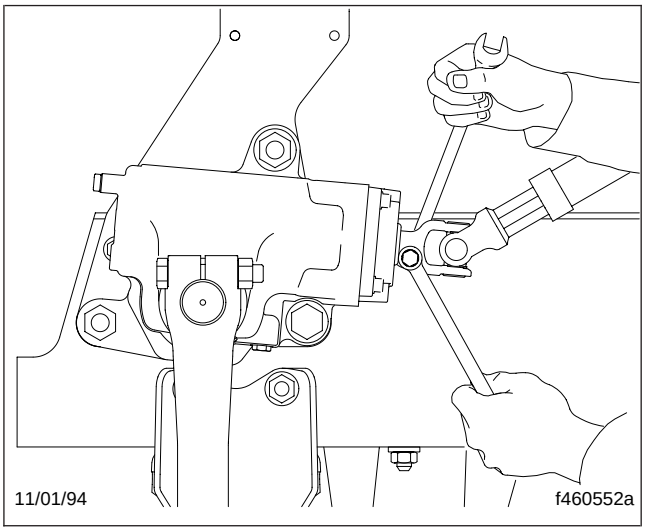


Fig. 2

3.2 Remove the yoke from the steering gear input shaft. **See Fig. 3.** Don't turn the steering gear input shaft when removing the lower end yoke. Push the driveline shaft into the driveline tube, as you remove the lower end yoke.

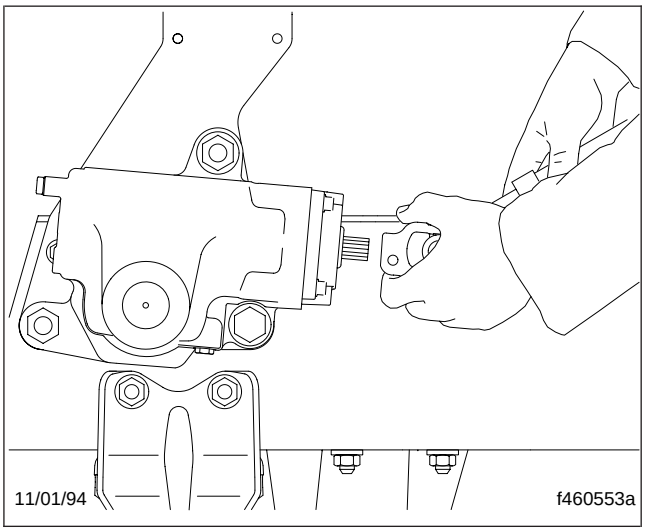


Fig. 3

4. Disconnect the upper end yoke.

4.1 Remove the four screws holding the steering driveline boot to the firewall. **See Fig. 4.**

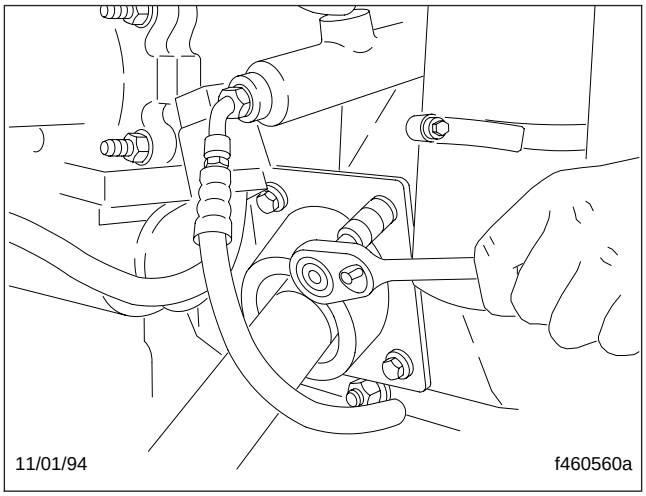


Fig. 4

4.2 Slide the boot down the steering driveline. **See Fig. 5.**

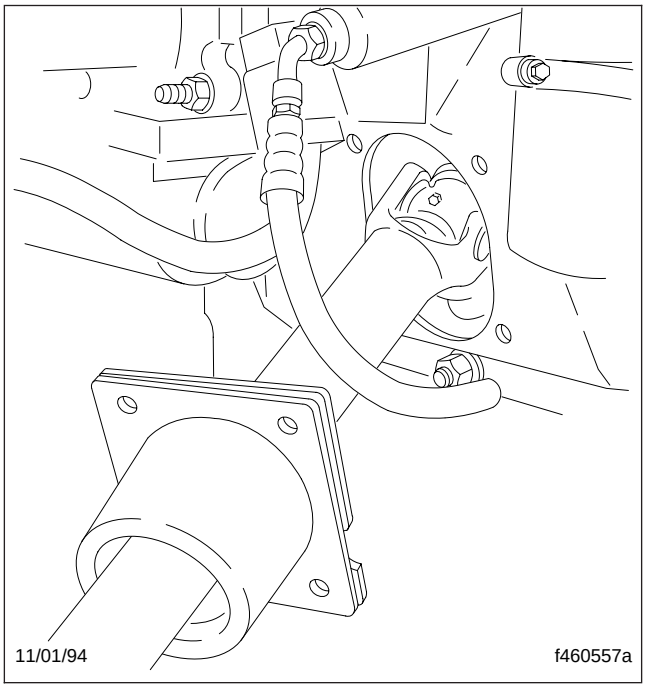


Fig. 5

4.3 Remove the pinch-bolt nut and pinch bolt from the upper end yoke. **See Fig. 6.** Discard the nut.

4.4 Remove the upper end yoke from the steering column shaft. **See Fig. 7.**

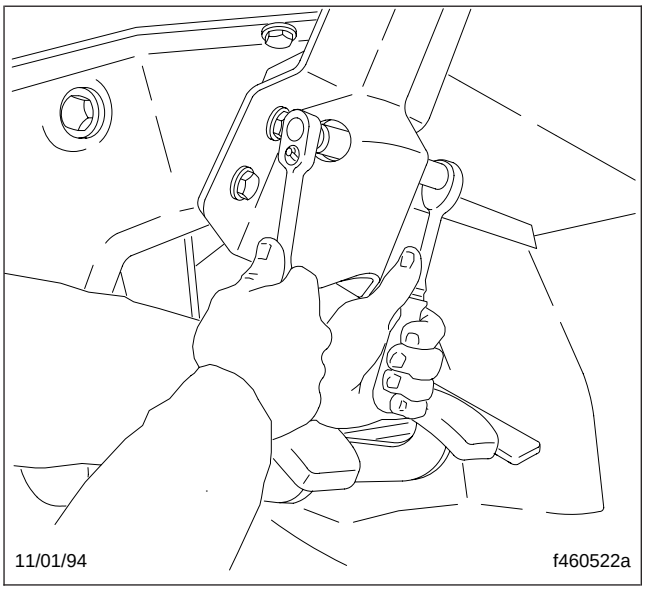


Fig. 6

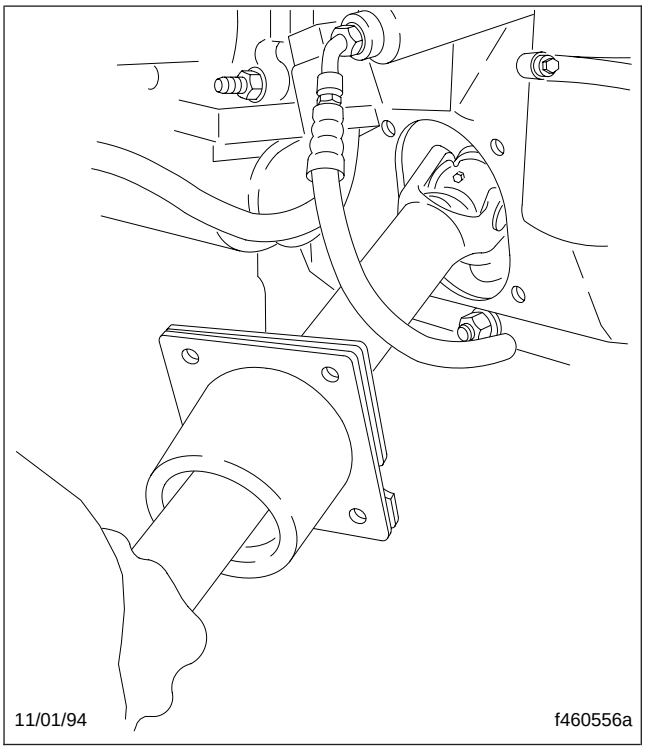
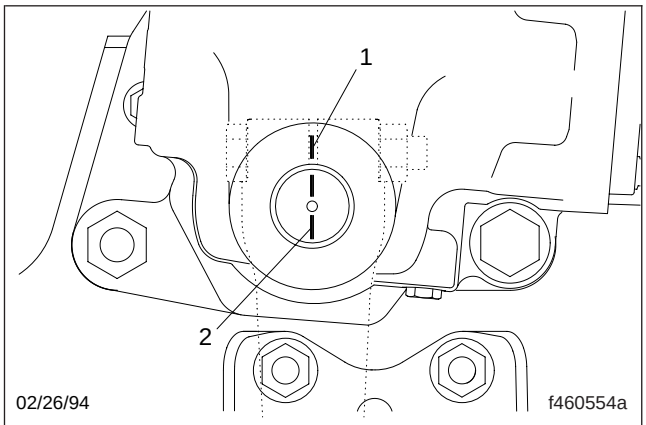


Fig. 7

Installation (See Fig. 1)

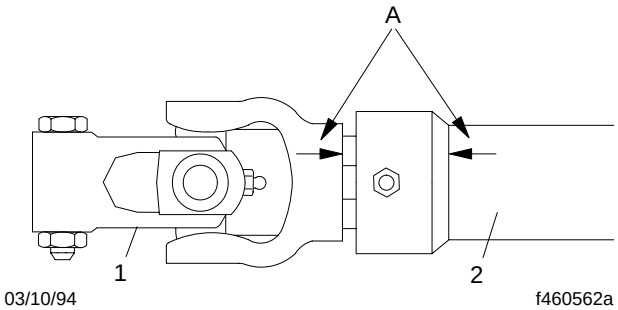
1. Clean the steering gear input shaft, steering column, and end yokes.
   - 1.1 Thoroughly clean the end yokes, the steering column shaft, and the steering gear input shaft with a clean, dry cloth.
   - 1.2 Apply a thin film of grease to the yoke splines. Use lithium-based grease, NLGI grade 2.
2. Slide the upper end yoke onto the steering column shaft, then install the end yoke pinch bolt. Before installing the pinch-bolt nut, make sure the pinch bolt is centered in the steering column shaft notch. The pinch bolt is centered if it can slip in and out of the end yoke with ease. Install a new pinch-bolt nut, and tighten it 75 to 88 N·m (55 to 65 lbf·ft).
3. Apply white Torque Seal F-900 to the exposed pinch-bolt thread and to the locknut.
4. Before attaching the lower end yoke to the steering gear input shaft, be sure the front tires are straight ahead, and the steering gear is centered with the timing mark on the end of the sector shaft in line with the mark on the housing trunnion. **See Fig. 8 .** Also, be sure the arrows on the driveline shaft and the driveline tube are aligned. **See Fig. 9.**



1. Timing Mark (Housing Trunnion)
2. Timing Mark (Sector Shaft)

Fig. 8

Removal and Installation



03/10/94 f460562a

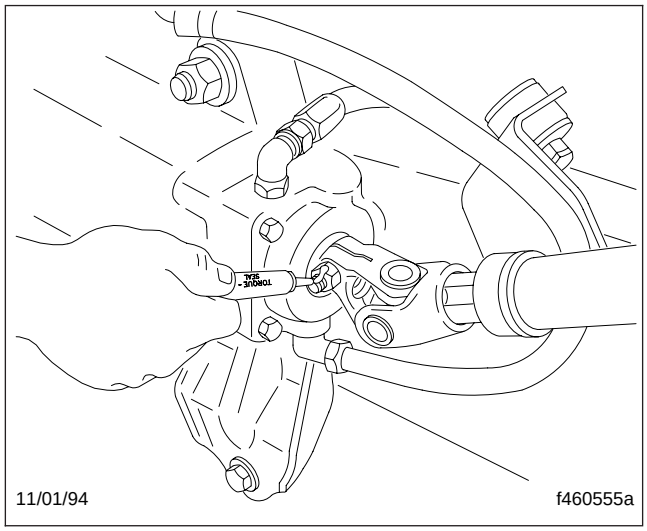
A. Align arrows.
1. Lower End Yoke
2. Driveline Tube and Yoke Assembly

Fig. 9

⚠ CAUTION

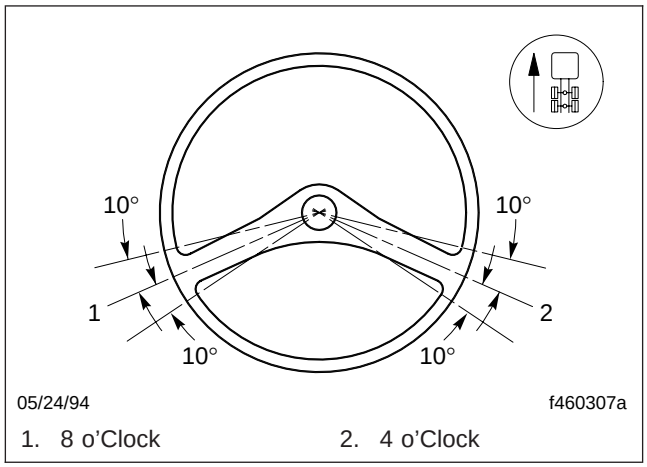
CAUTION: If the arrow on the driveline shaft is not aligned with the arrow on the driveline tube, the U-joints will not be correctly oriented. Assembling the driveline with the U-joints incorrectly oriented could cause binding at the U-joints.

5. Install the lower end yoke on the steering gear input shaft. Before installing the pinch-bolt nut, make sure the pinch bolt is centered in the steering gear input shaft notch. The pinch bolt is centered if it can slip in and out of the end yoke with ease. Install a *new* pinch-bolt nut, and tighten it 75 to 88 N·m (55 to 65 lbf·ft).
6. Apply white Torque Seal F-900 to the exposed pinch bolt thread and to the locknut. **See Fig. 10.**
7. Lubricate the driveline tube and both U-joints with lithium-based grease, NLGI grade 2. Apply until grease appears at the lower end of the tube splines and all four U-joint cross seals.
8. Align the steering wheel spokes.
   - 8.1 With the front tires pointing straight ahead, check the position of the steering wheel spokes. They must be pointing within ±10 degrees of the 4 o'clock and 8 o'clock positions. **See Fig. 11.**
   - 8.2 If not, remove the steering wheel and install it in the correct position. For instructions, refer to the applicable section in this group.



11/01/94 f460555a

Fig. 10



05/24/94 f460307a

1. 8 o'Clock 2. 4 o'Clock

Fig. 11

9. Lower the hood, and secure the hood latches. Leave the parking brakes applied and the chocks at the rear tires.
10. Raise the front of the vehicle, so that the front tires are off the ground, then place safety stands under the frame.

⚠ WARNING

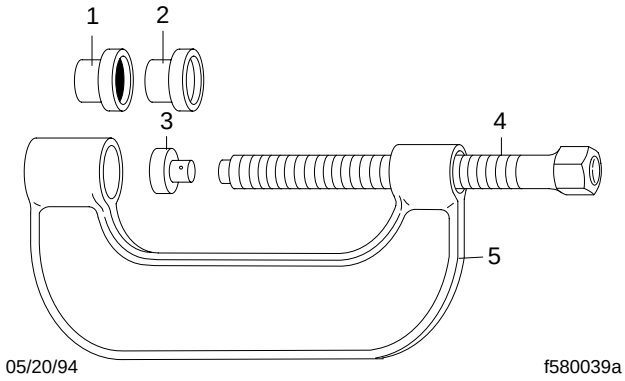
WARNING: Driving a vehicle with hard steering or binding in the steering system is hazardous and could result in partial or complete loss of steering control during vehicle operation.

11. Turn the steering wheel through full travel, checking for hard steering or binding. If there is difficulty, check the assembly and installation of the driveline parts. If the cause is not the driveline, refer to the applicable steering gear section in this group.
12. Remove the safety stands, lower the vehicle to the ground, and remove the chocks.

Disassembly

1. Remove the steering driveline from the vehicle. Refer to **Subject 100** for instructions.
2. Slide the driveline shaft and yoke assembly out of the driveline tube and yoke assembly.
3. Remove the steering driveline U-joint.

   3.1 Clamp the frame of a U-joint tool **(Fig. 1)** in a vise.



1. Bushing Adaptor
2. Bearing Driver
3. Expansion Plug
4. Pressure Screw
5. Frame

Fig. 1, Universal Joint Tool

   3.2 Wearing safety goggles, remove the needle bearing cup snap rings from the needle bearing cups by pushing an open end of each snap ring with a screwdriver.

⚠ WARNING

WARNING: Snap rings can become potentially harmful projectiles when they are being removed. Wear safety goggles to prevent eye injury.

   3.3 Select a U-joint tool expansion plug of slightly smaller diameter than the needle bearing cup, and place it on the pressure screw. Select a bushing adapter of slightly larger inside diameter than the needle bearing cup, and place it on the opposite end of the tool.

   3.4 Place the integral yoke of the driveline tube in the U-joint tool. Position the bushing adapter to receive a needle bearing cup, and place the expansion plug against the opposite needle bearing cup.

   3.5 Tighten the pressure screw to press one needle bearing cup out of the driveline yoke, then remove the cup. In some cases, it might be necessary to give the pressure screw a sharp blow with a brass hammer while the screw is under pressure.

   3.6 Reverse the driveline tube and yoke assembly, and press against the U-joint cross to force out the other needle bearing cup.

   3.7 Remove the driveline tube and yoke assembly from the U-joint tool, then remove the upper end yoke and the U-joint cross from the driveline yoke.

   3.8 Place the upper end yoke in the U-joint tool. Position the bushing adapter to receive a needle bearing cup, and place the expansion plug against the opposite needle bearing cup.

   3.9 Tighten the pressure screw to press one needle bearing cup out of the upper end yoke, then remove the cup. In some cases, it might be necessary to give the pressure screw a sharp blow with a brass hammer while the screw is under pressure.

   3.10 Reverse the upper end yoke in the U-joint tool, and press against the U-joint cross to force out the other needle bearing cup.

   3.11 Remove the upper end yoke from the U-joint tool, then remove the U-joint cross from the upper end yoke.

4. Repeat the applicable steps above for the driveline shaft and yoke assembly and the lower end yoke.

Assembly

1. Install the steering driveline U-joint.

   1.1 Clamp the frame of a U-joint tool **(Fig. 1)** in a vise.

   1.2 Select a U-joint tool expansion plug of a slightly smaller diameter than the needle

Disassembly and Assembly

bearing cup, and place it on the pressure screw. Place a bearing driver on the opposite end of the tool.

1.3 Position the U-joint cross in the upper end yoke so that the U-joint cross lube fitting points toward one of the yoke ears.

1.4 Make certain the U-joint cross seals are in place on the needle bearing cups, then start both needle bearing cups into the yoke ears from the outside. Place the upper end yoke in the U-joint tool with the bearing driver against one of the needle bearing cups and the expansion plug against the opposite needle bearing cup.

1.5 Tighten the pressure screw, making sure that both needle bearing cups press straight and true into the yoke ears. Work the U-joint cross during this operation to ensure free movement. If the needle bearing cups don't seat correctly, or if the U-joint binds, give the yoke shoulder near each cup a sharp blow with a brass hammer.

1.6 Press the needle bearing cup on the screw end of the U-joint tool all the way in, until there is enough clearance to insert a new needle bearing cup snap ring. Insert the snap ring, and fully seat it in its groove.

⚠ WARNING

WARNING: Use new snap rings when assembling the U-joints. Used snap rings are often distorted and overstressed from disassembly. Also, snap rings not fully seated in their grooves could work loose, resulting in a hazardous vehicle operating condition.

1.7 Reverse the upper end yoke in the U-joint tool, and push the other needle bearing cup until there is clearance to insert the other snap ring. Insert the snap ring, then remove the upper end yoke from the U-joint tool.

1.8 With the U-joint cross lube fitting facing away from the base of the upper end yoke, position the U-joint cross and the upper end yoke in the driveline tube and yoke assembly.

NOTE: The U-joint cross lube fitting should face away from the base of the upper end yoke to provide access for lubrication when the steering driveline is installed on the vehicle.

1.9 Make certain the U-joint cross seals are in place on the needle bearing cups, then start both needle bearing cups into the yoke ears. Place the driveline tube and yoke assembly in the U-joint tool with the bearing driver against one of the needle bearing cups and the expansion plug against the opposite needle bearing cup.

1.10 Tighten the pressure screw, making sure that both needle bearing cups press straight and true into the yoke ears. Work the U-joint cross during this operation to ensure free movement. If the needle bearing cups don't seat correctly, or if the U-joint binds, give the yoke shoulder near each cup a sharp blow with a brass hammer.

1.11 Press the needle bearing cup on the screw end of the U-joint tool all the way in, until there is enough clearance to insert a needle bearing cup snap ring. Insert the snap ring. Reverse the driveline tube and yoke assembly in the U-joint tool and push the other needle bearing cup until there is clearance to insert the other snap ring. Insert the snap ring.

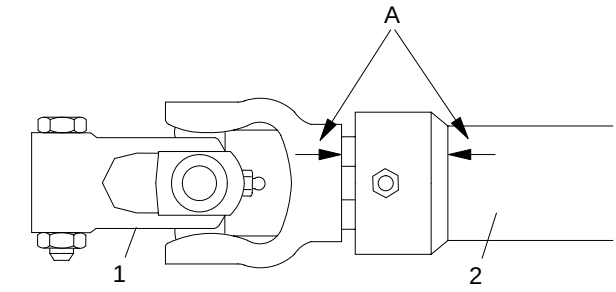
2. Remove the driveline tube and yoke assembly from the U-joint tool.

3. Repeat the applicable steps above for the lower end yoke and the driveline shaft and yoke assembly.

4. Slide the lower driveline shaft into the driveline tube, so that the arrow on the driveline shaft yoke is aligned with the arrow on the driveline tube. **See Fig. 2.**

⚠ CAUTION

CAUTION: If the arrow on the driveline shaft yoke isn't aligned with the arrow on the driveline tube, the U-joints will be out of phase. Assembling the driveline with the U-joints out of phase could result in binding at the U-joints.



A. Align arrows.
1. Lower End Yoke
2. Driveline Tube and Yoke Assembly

Fig. 2

5. Install the steering driveline in the vehicle. Refer to **Subject 100** for instructions.

Specifications

Description	Grade	Size	Torque N·m (lbf·ft)
End Yoke Pinch-Bolt Nut	8 or 8.2	7/16–20 UNF	75 to 88 (55 to 65)

Table 1, Torque Values

General Description

The drag link is nonadjustable, with non-removable socket ball studs at both ends. **See Fig. 1**.

The drag link connects the pitman arm to the front axle steering arm. The socket ball studs, one located at each end, rotate to allow for changing angles between the pitman arm and steering arm as the vehicle is steered and the suspension articulates.

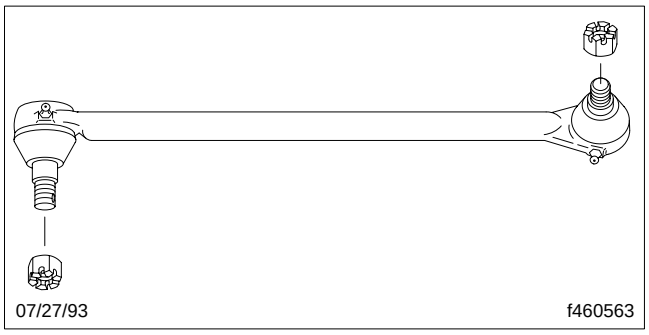


Fig. 1

Removal

1. If ball stud wear or looseness is suspected, check for wear of the ball studs before removing the drag link. Refer to **Subject 110** for instructions.
2. Position the tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service operations are to be performed. *Do not turn the steering wheel at any time while the drag link is still attached to both the pitman arm and the axle steering arm.* If the steering wheel is turned, the front tires will not be straight ahead.
3. Apply the parking brakes, and chock the rear tires.
4. Release the hood latches, and tilt the hood.
5. Remove the left-hand bumper extension or rotate it out of the way. See **Fig. 1**.

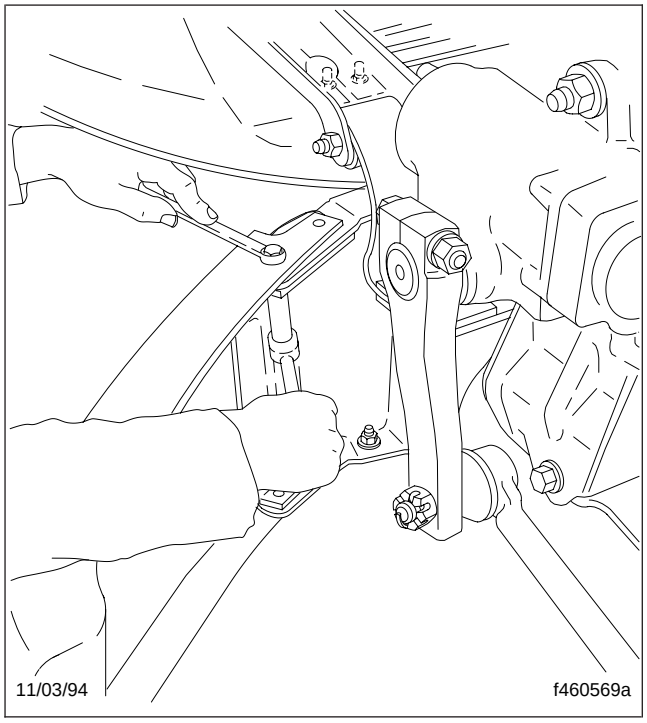


Fig. 1, Moving the Bumper Extension

6. Remove the drag link from the vehicle.
   - 6.1 At both ends of the drag link, remove the cotter pins and loosen the nuts on the socket ball studs. See **Fig. 2** and **Fig. 3**. Be sure the nuts are loosened far enough to allow use of a ball stud removal tool.

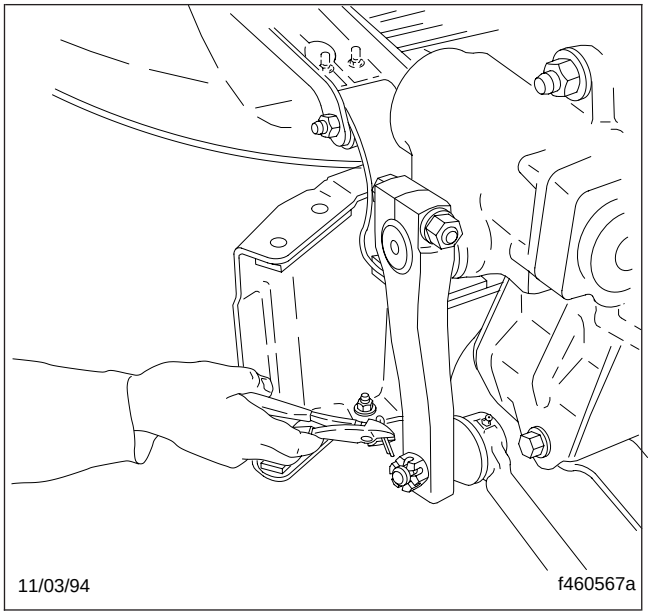


Fig. 2, Remove the Cotter Pin

   - 6.2 Using a ball stud removal tool, loosen the drag link from the pitman arm and the axle steering arm. See **Fig. 4**, **Fig. 5**, and **Fig. 6**.
   - 6.3 Remove the nuts and drag link.

IMPORTANT: Do not steer the gear with the linkage removed; unintended setting of the automatic poppets may result.

Installation

1. Before installing the drag link, check for damage or wear. Replace parts as needed.
   - 1.1 Check the ball stud covers or dust caps for extreme wear, cuts, or other damage; replace the covers (seals) if needed.
   - 1.2 Inspect the socket ball studs, ball stud nuts, drag link rod, and grease fittings for wear or damage. Replace the components as needed.
2. Install the drag link.

Removal and Installation

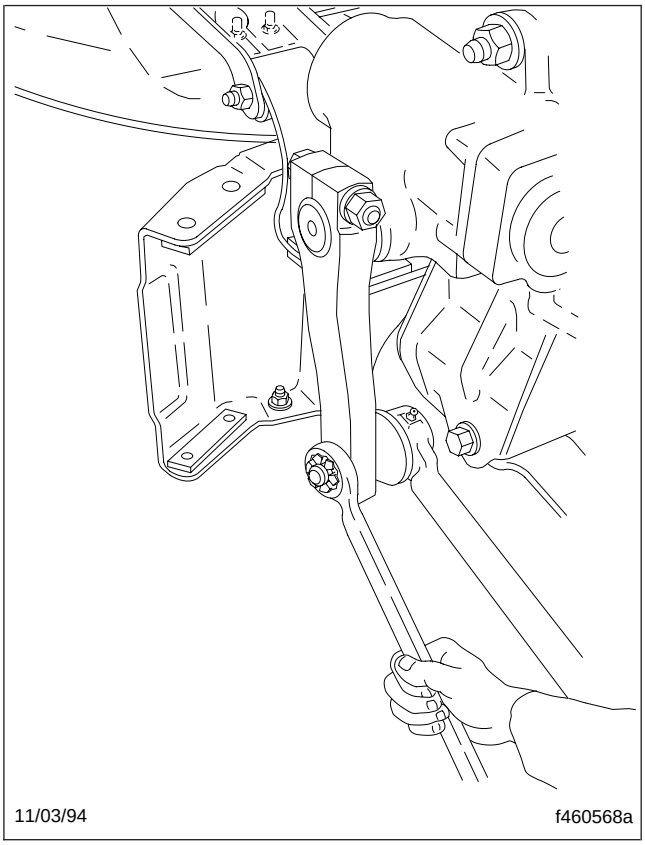


Fig. 3, Loosen the Nut

2.1 When installing the drag link, if needed, slightly turn the steering wheel to change the distance between the pitman arm and the steering arm.

2.2 Tighten the ball stud nuts as follows:

- 5/8–18, 60 to 115 lbf·ft (81 to 156 N·m)
- 3/4–16, 90 to 170 lbf·ft (122 to 230 N·m)
- 7/8–14, 160 to 300 lbf·ft (217 to 407 N·m)

2.3 If required, continue tightening each nut until a slot on the nut aligns with the hole in the ball stud. *Don't back off the nut when locating the cotter pin hole.*

2.4 Install new cotter pins through the ball studs and nuts, and lock the cotter pins in place.

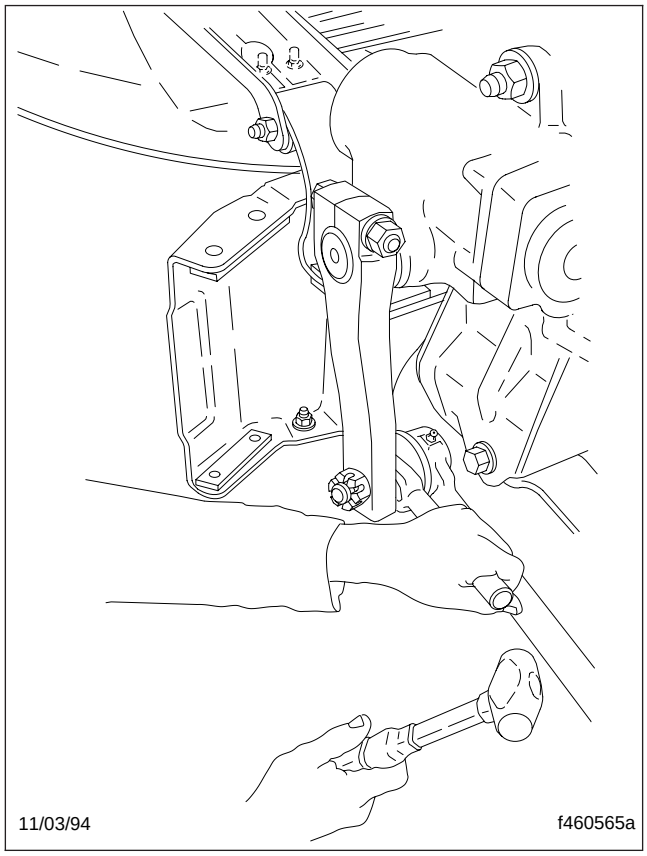


Fig. 4, Loosening the Drag Link from the Pitman Arm

⚠ WARNING

Failure to install and lock new cotter pins in the ball studs and nuts could result in disengagement of the parts and loss of steering control.

3. Wipe the dirt from the grease fittings. Apply chassis grease until the old grease is forced out.
4. Install the left-hand bumper extension.
5. Lower the hood, and fasten the hood latches.
6. Align the steering wheel spokes. With the front tires pointing straight ahead, check the position of the steering wheel spokes. They must be pointing within ±10 degrees of the 4 o'clock and 8 o'clock positions. See **Fig. 7**. If not, remove the steering wheel and install it in the correct position. For instructions, refer to the applicable section in this group.

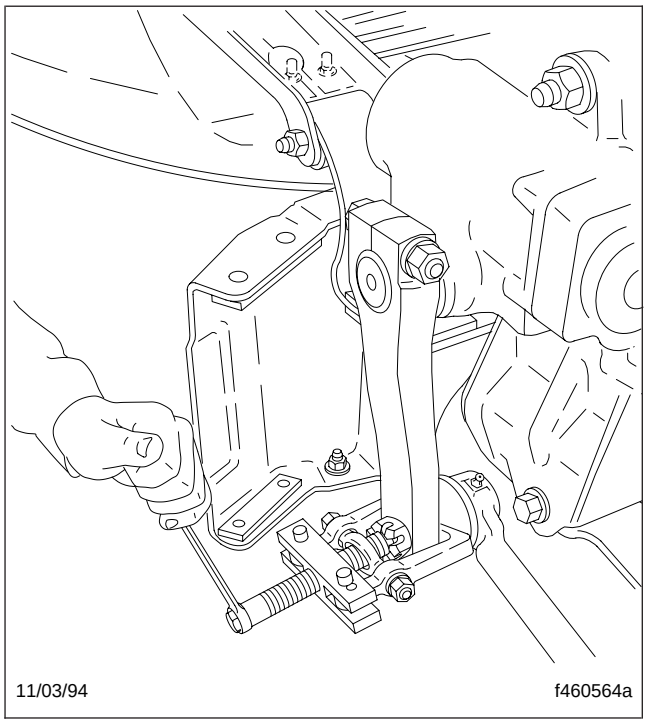


Fig. 5, Loosening the Drag Link from the Pitman Arm

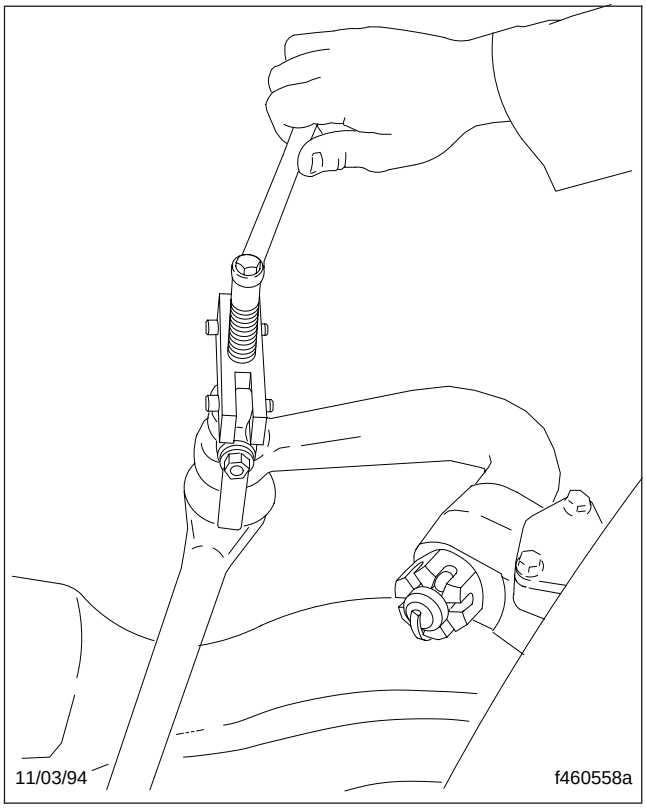


Fig. 6, Loosening the Drag Link from the Axle Steering Arm

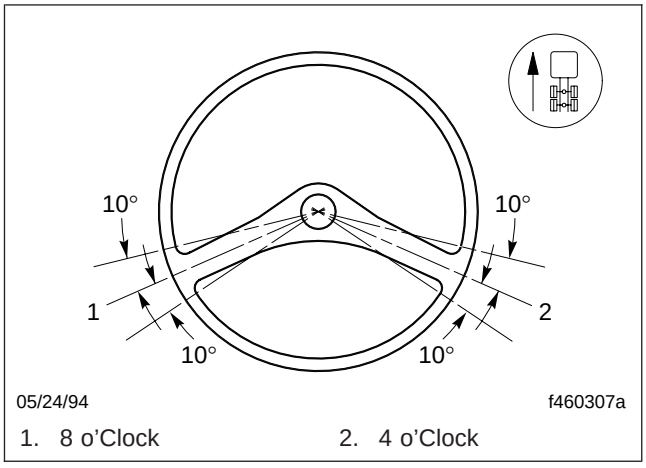


Fig. 7, Proper Steering Wheel Position (with the tires straight ahead)

Testing

Check for wear of the drag link ball stud end, and nut tightness as follows:

Have someone gently turn the steering wheel back and forth. Check for looseness between the ball stud end, and both the pitman arm and steering arm. Also check for looseness of the ball stud nut.

If the ball stud *end* is loose, replace the drag link. If the ball stud *nut* is loose, replace the nut and cotter key. Tighten the ball stud nut as follows:

- 5/8–18, 60 to 115 lbf·ft (81 to 156 N·m)
- 3/4–16, 90 to 170 lbf·ft (122 to 230 N·m)
- 7/8–14, 160 to 300 lbf·ft (217 to 407 N·m)

Grasp the drag link near the pitman arm end, push and pull laterally to check for axial looseness in the ball stud end. If there is looseness, replace the drag link. For instructions, refer to **Subject 100**. If there is 1/8 inch (3 mm) looseness or more, do not drive the vehicle until the drag link is replaced.

Grasp the drag link near the steering arm end. Push and pull vertically to check for axial looseness in the ball stud end. If there is looseness, replace the drag link. For instructions, refer to **Subject 100**. If there is 1/8 inch (3 mm) looseness or more, do not drive the vehicle until the drag link is replaced.

Grease the drag link until the old grease is purged.

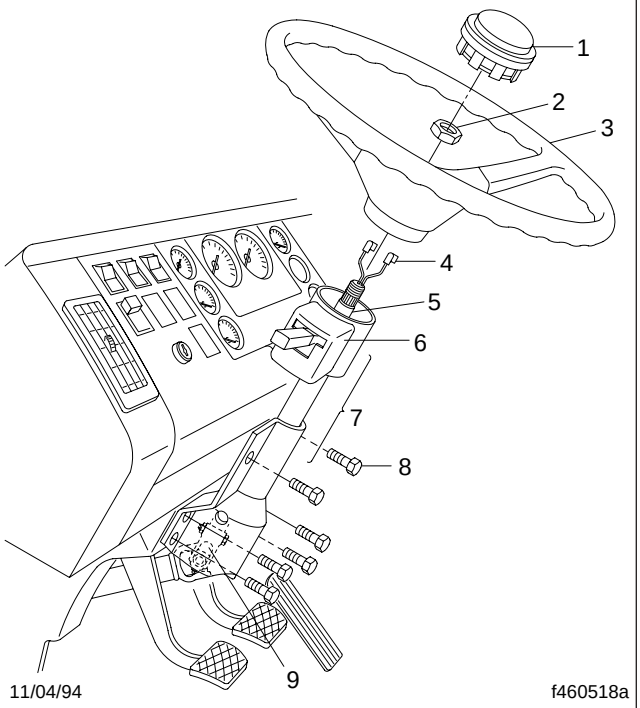
Specifications

Torque Values	
Nut Size	**Torque lbf·ft (N·m)**
5/8–18	60–115 (81–156)
3/4–16	90–170 (122–230)
7/8–14	160–300 (217–407)

Table 1, Torque Values

General Information

The steering wheel is cushioned and has two spokes. A horn button is mounted in the center of the steering wheel. See **Fig. 1**.



1. Horn Button
2. Steering Wheel Nut
3. Steering Wheel
4. Horn Wires
5. Steering Shaft
6. Turn Signal Switch
7. Tube Assembly
8. Steering Column Mounting Capscrews
9. Driveline End Yoke

Fig. 1, Steering Column Assembly, Left-Hand Drive

A turn signal switch is attached to the left side of the column, just below the steering wheel. If the vehicle is equipped with the optional trailer brake air switch, it is installed on the right side of the column.

The major parts of the steering column assembly are the shaft, the bearings, and the tube assembly.

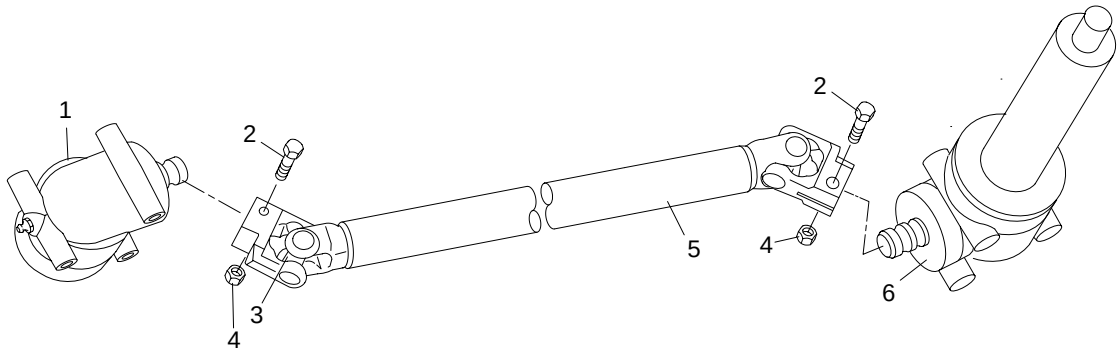
On vehicles with right-hand drive, a traverse shaft and two miter boxes connect the steering column with the steering driveline on the left side of the vehicle. See **Fig. 2**.

The steering shaft is installed in the tube assembly and held in place by the bearings. The upper end of the shaft is threaded. Below the threads are splines that correspond to those in the steering wheel.

On left-hand-drive vehicles the lower end of the shaft is splined for the steering driveline end yoke and has a groove for the pinch bolt. On right-hand-drive vehicles the lower end of the shaft is attached to a 90-degree miter box that has a splined output shaft on the left (inboard) side that attaches to the end yoke of the traverse shaft. A second 90-degree miter box connects the traverse shaft with the steering driveline.

On left-hand-drive vehicles, the steering column assembly is held in place by capscrews that attach the bracket end of the assembly to the lower dash and the pedal support bracket. On right-hand-drive vehicles, the steering column assembly is held in place by capscrews that attach the lower mounting plate to the lower dash and the clutch pedal box.

General Information



10/28/97 f461250

1. Left-hand Miter Box
2. Pinch Bolt
3. U-Joint
4. Prevailing Torque Nut
5. Traverse Shaft
6. Right-hand Miter Box

Fig. 2, Right-Hand Drive Traverse Shaft

Steering Wheel Removal and Installation

Removal

1. Put the front wheels in the straight ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping at the place where the work will be done.

   Don't turn the steering wheel at any time during the removal procedure.
2. Apply the parking brake and chock the tires.
3. Disconnect the batteries at the negative terminal.
4. Using a small screwdriver, carefully pry out the horn button. Disconnect the two wires from it. **See Fig. 1.**

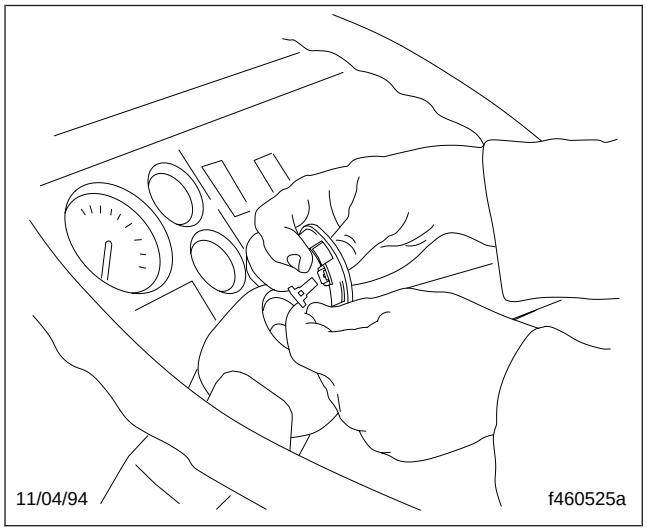


Fig. 1, Pry out the Horn Button

5. Using a deep socket to avoid damaging the wires, remove the steering wheel nut. **See Fig. 2.**
6. Using 1/4-inch sheet metal stock, make a wire protector about 4 cm x 1.5 cm (1-5/8 inches x 5/8 inch), like the one shown in **Fig. 3.** Then put it over the end of the steering column.
7. Using a steering wheel puller, remove the steering wheel from the steering column. **See Fig. 4.**

IMPORTANT: When you set the steering wheel aside, be careful not to damage the turn signal self-cancelling pin on the underside of the wheel. **See Fig. 5.**

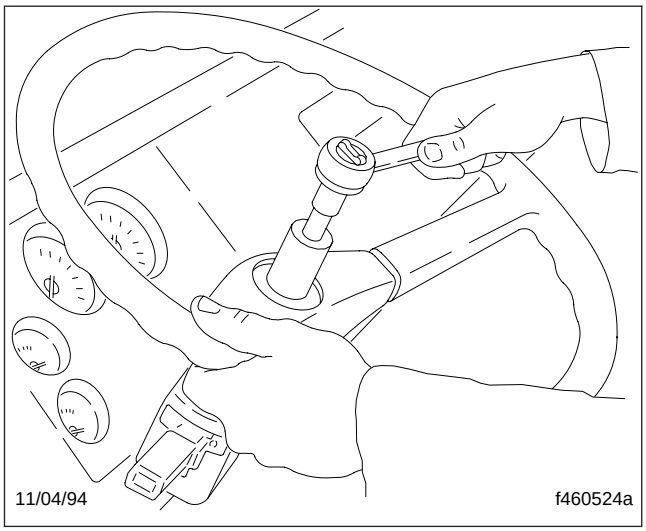


Fig. 2, Remove the Steering Wheel Nut

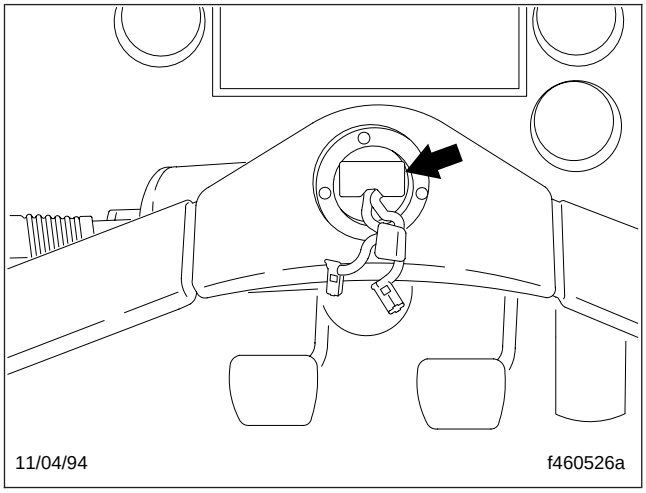


Fig. 3, Make a Wire Protector

Installation

1. Make sure the front tires are pointed straight ahead and the steering gear is centered.
2. Put the steering wheel on the steering column so that the spokes are within 10 degrees of the 4 o'clock and 8 o'clock positions. **See Fig. 6.**
3. Thread the two horn wires through the steering wheel nut, then install the nut. Tighten it 81 N·m (60 lbf·ft).

Steering Wheel Removal and Installation

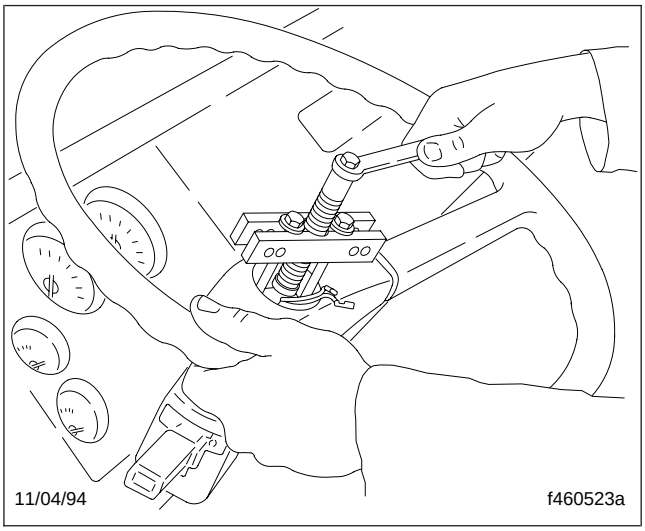


Fig. 4, Remove the Steering Wheel from the Column

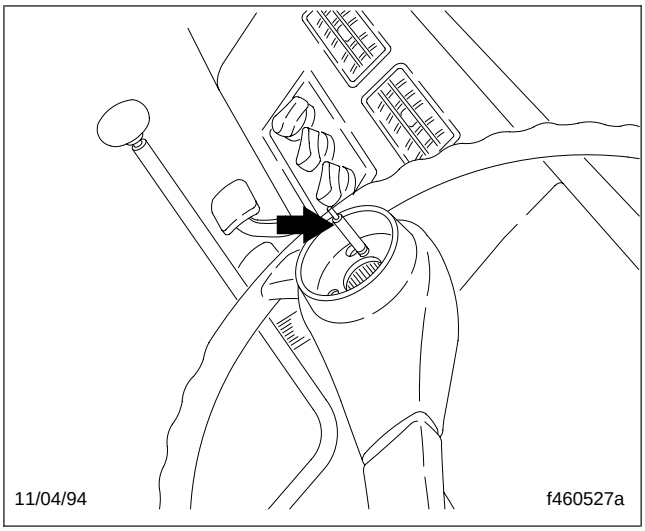


Fig. 5, Turn Signal Self-Cancelling Pin

4. Connect the two wires to the horn button. Pack the horn wires with dielectric grease.

NOTE: The horn wires may be connected to either terminal.

5. Install the horn button in the steering wheel hub so the logo on it is aligned with the steering wheel spokes. **See Fig. 7.**

6. Take the vehicle for a test drive to make sure the steering wheel is on correctly. If it isn't, remove it and install it again.

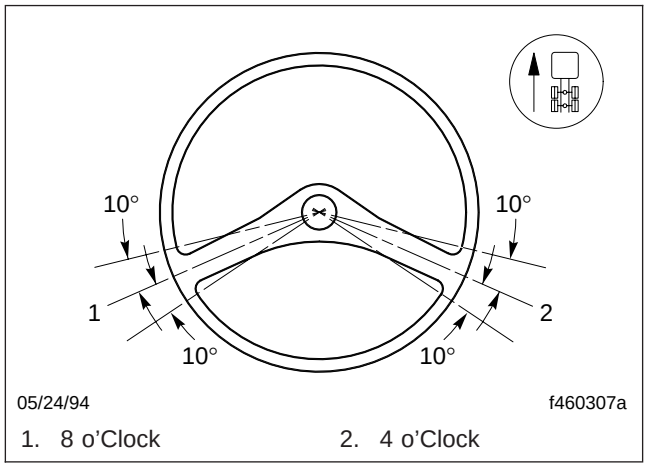


Fig. 6, Center the Steering Wheel

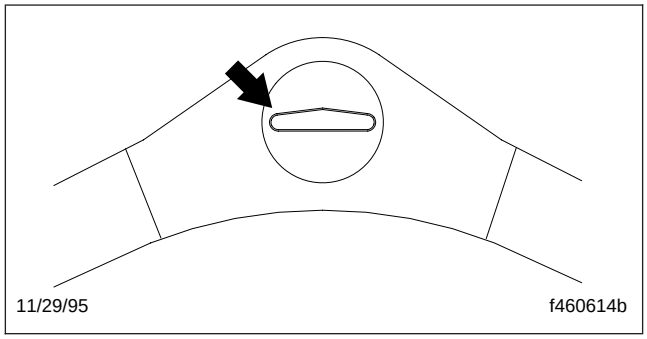


Fig. 7, Align the Logo

Left-Hand Drive (LH DR)

REMOVAL

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service work will be done. *Do not move the tires from the straight-ahead position during removal or at any time while the steering column is removed.*
2. Apply the parking brakes and chock the tires.
3. Remove the steering wheel, following the instructions in **Subject 100**.
4. Remove the plastic cover from the turn signal switch on the left (outboard) side of the steering column. See **Fig. 1**.

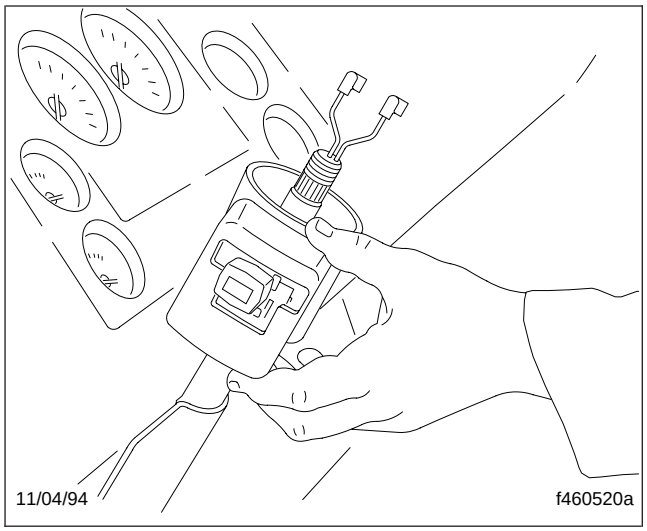


Fig. 1, Removing the Plastic Cover

5. Remove the two allen-head screws that attach the turn signal switch to the steering column (see **Fig. 2**), then swing the turn signal switch up and out of the way.
6. Disconnect the horn wire. See **Fig. 3**.
7. If installed, remove the trailer brake air lines from the switch mounted on the right (inboard) side of the steering column. Mark the lines for ease of installation. See **Fig. 4**.
8. Remove and discard the pinch bolt and nut from the steering driveline yoke. See **Fig. 5**.

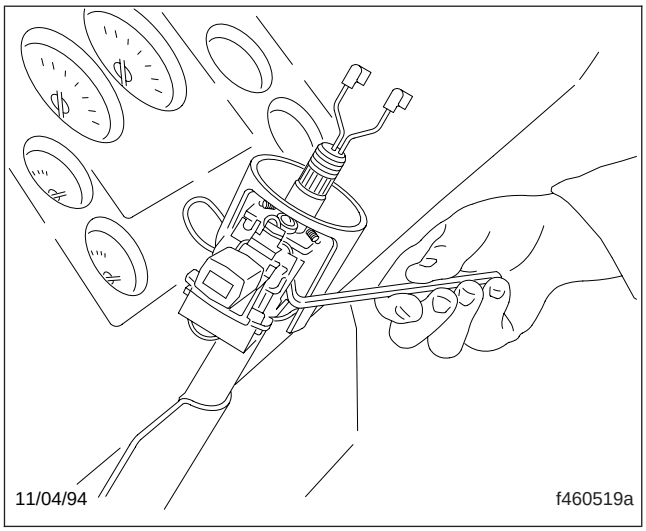


Fig. 2, Removing the Mounting Screws

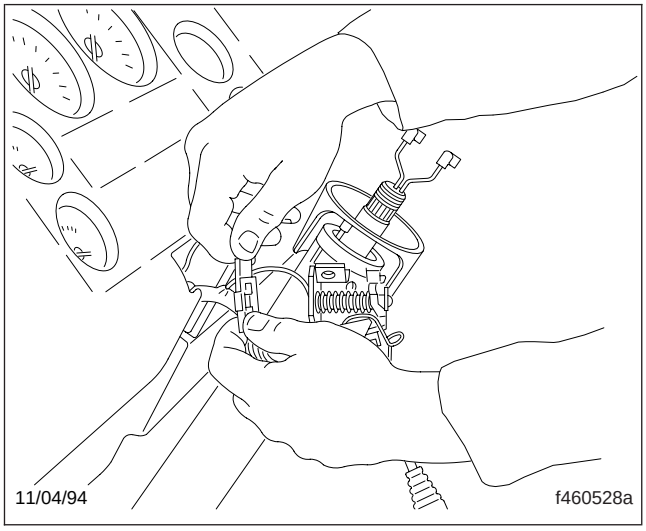


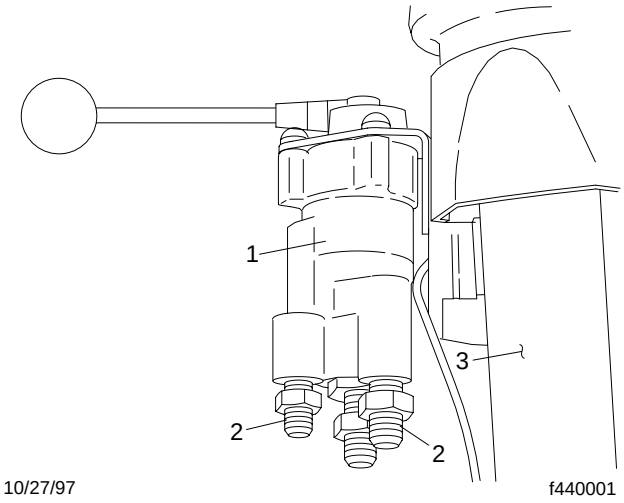
Fig. 3, Disconnecting the Horn Wire

9. Remove the six capscrews that attach the steering column bracket to the lower dash and to the pedal support bracket. See **Fig. 6**.
10. Disconnect the steering column from the steering driveline U-joint yoke.

INSTALLATION

1. Connect the lower steering column to the steering driveline.
   1.1 Slide the steering driveline U-joint yoke onto the lower end of steering column.

Steering Column Removal and Installation



This switch is mounted on the right side of the steering column on both LH DR and RH DR.

1. Switch
2. Fittings
3. Steering Column

Fig. 4, Trailer Brake Air Switch

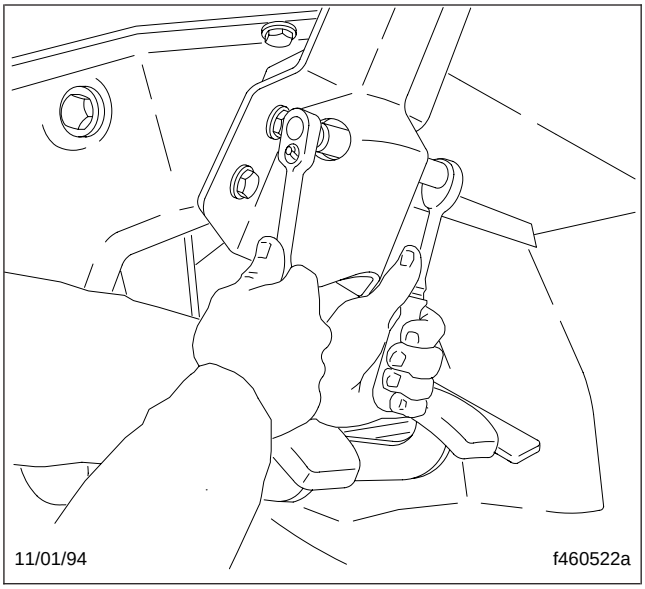


Fig. 5, Removing the Steering Driveline Pinch Bolt

1.2 Install a new pinch bolt and nut. Tighten the nut 37 lbf·ft (50 N·m), then apply white Torque Seal F-900® to the exposed threads of the pinch bolt.

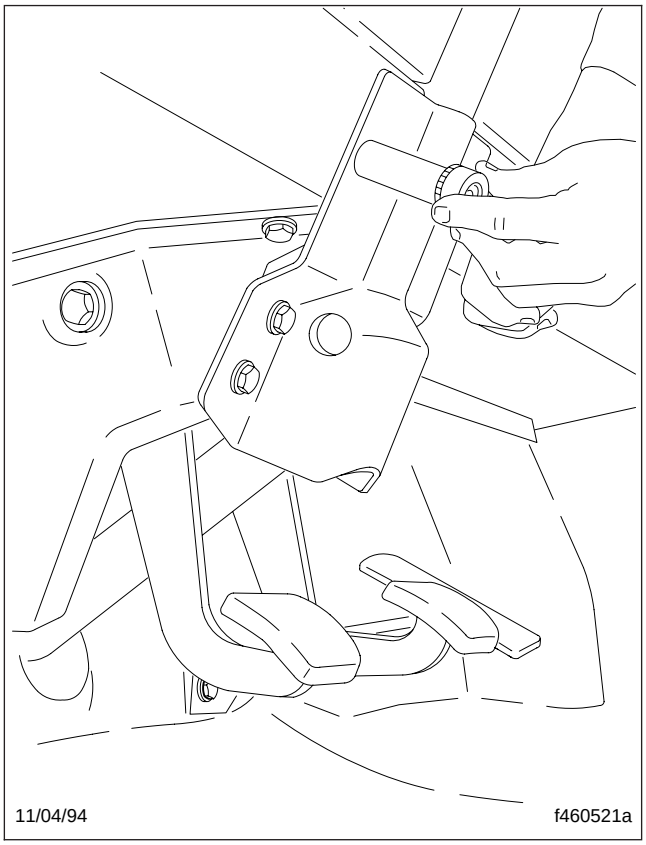


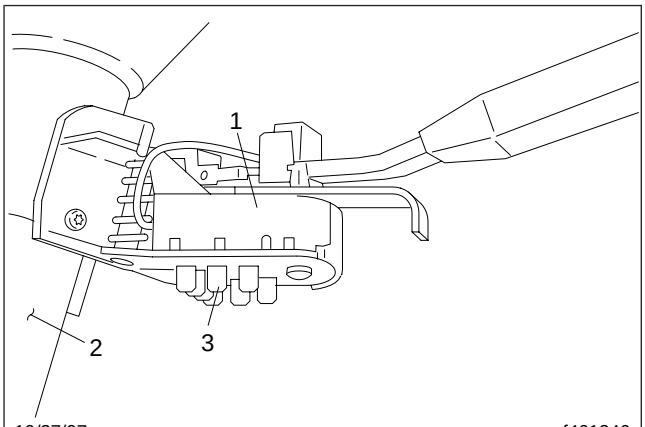
Fig. 6, Removing the Steering Column Mounting Capscrews (LH DR)

2. Line up the holes in the steering column bracket with those in the lower dash and the pedal support bracket.
3. Install the six capscrews (see **Fig. 5**), and tighten them in stages to a final torque of 40 lbf·ft (54 N·m).
4. Connect the horn wire, as shown in **Fig. 3**.
5. Install the turn signal switch on the left (outboard) side of the steering column. See **Fig. 2**. Tighten the screws firmly.
6. Install the trailer brake air lines, as marked. See **Fig. 4**.
7. Install the steering wheel, following the instructions in **Subject 100**.

Right-Hand Drive (RH DR)

REMOVAL

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service work will be done. *Do not move the tires from the straight-ahead position during removal or at any time while the steering column is removed.*
2. Apply the parking brakes and chock the tires.
3. Remove the steering wheel, following the instructions in **Subject 100**.
4. Remove the plastic cover from the turn signal switch on the left (inboard) side of the steering column. Disconnect the electrical connector and pull the turn signal harness down and out of the way. See **Fig. 7**.

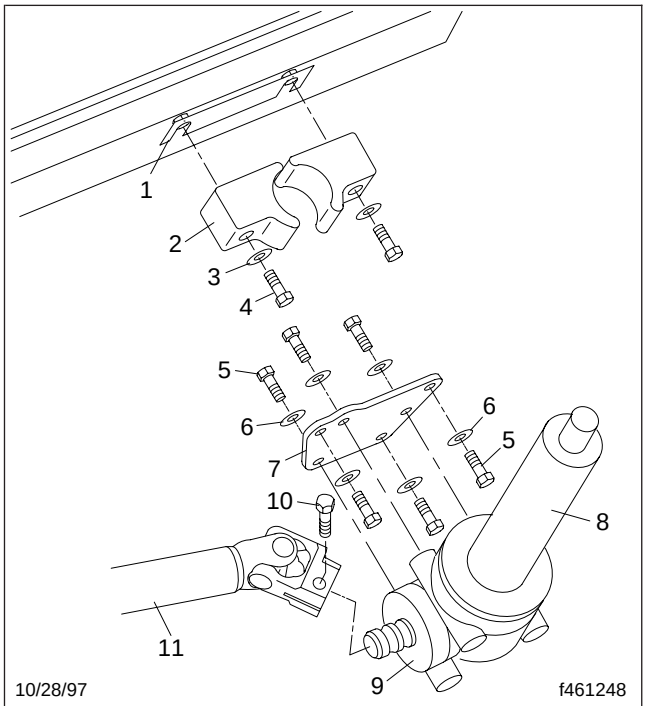


This switch is mounted on the left side of the steering column on both LH DR and RH DR.

1. Switch
2. Steering Column
3. Connector

Fig. 7, Turn Signal Switch Electrical Connector

5. Disconnect the horn wire. See **Fig. 3**.
6. If installed, remove the trailer brake air lines from the switch mounted on the right (outboard) side of the steering column. Mark the lines for ease of installation. See **Fig. 4**.
7. Remove the three 3/8–16 capscrews attaching the steering column cover to the RH miter box.
8. Remove and discard the pinch bolt and nut from the traverse shaft. See **Fig. 8**.



1. Support Shim
2. Steering Column Support
3. Hardened Washer
4. Capscrew, M10
5. Mounting Capscrew, 3/8–16
6. Lockwasher, 3/8-Inch
7. Lower Mounting Plate
8. Steering Column
9. RH Miter Box
10. Pinch Bolt, 7/16–20
11. Traverse Shaft

Fig. 8, Steering Column Removal, Right-Hand Drive

9. Remove the two steering column supports. Remove the support shim behind them.
10. Remove the six 3/8–16 capscrews and lockwashers that attach the steering column to the lower mounting plate and underdash panel. See **Fig. 6**.
11. Remove the steering column from the dash.

INSTALLATION

1. Position the steering column so that the bolt holes on the lower mounting plate line up with the holes on the pedal box.
2. Install the six capscrews and lockwashers attaching the steering column and lower mounting plate

Steering Column Removal and Installation

to the pedal box and underdash panel (see **Fig. 8**). Tighten all six capscrews 28 lbf·ft (38 N·m).

3. Attach the two steering column supports to the dash.
   - 3.1 Install the support shim between the supports and the dash.
   - 3.2 Install the two grade 10.9 M10 capscrews and lockwashers.
   - 3.3 Tighten the two capscrews 34 lbf·ft (46 N·m).

NOTE: Allow the turn signal switch harness to come out the left (inboard) side of the steering column.

4. Connect the steering column to the traverse shaft.
   - 4.1 Slide the traverse shaft U-joint yoke onto the splined shaft of the miter box, as marked on removal.
   - 4.2 Install a new pinch bolt and nut. Tighten the nut 60 lbf·ft (81 N·m), then apply white Torque Seal F-900® to the exposed threads of the pinch bolt.
5. Install the steering column cover to the RH miter box. Tighten the three 3/8–16 capscrews 28 lbf·ft (38 N·m).
6. Install the turn signal harness to the connector on the turn signal switch on the left (inboard) side of the steering column. See **Fig. 2**. Tighten the screws firmly and install the plastic cover.
7. Install the trailer brake air lines, as marked. See **Fig. 4**.
8. Connect the horn wire, as shown in **Fig. 3**.
9. Install the steering wheel, following the instructions in **Subject 100**.
10. Remove the chocks from the tires.

Disassembly (See Fig. 1)

1. Remove the steering wheel, following the instructions **under Subject 100**.
2. Remove the steering column assembly, following the instructions **under Subject 110**.
3. Unscrew the horn contact assembly (Ref. 4) from the side of the steering column.
4. Remove the retaining ring (Ref. 1) holding the upper shaft bearing (Ref. 2) in place, then remove the bearing. Remove the second retaining ring from the shaft.
5. Remove the retaining ring holding the lower shaft bearing (Ref. 6) in place, then remove the bearing.
6. Slide the shaft out of the bracket and bearing tube assembly (Ref. 5).

Assembly (See Fig. 1)

⚠ WARNING

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

1. Using a solvent, clean all the parts, then check them. If any are worn or damaged, replace them.
2. Grease the bearings, using a lithium based bearing grease.
3. Install the shaft (Ref. 3) into the bracket and bearing tube assembly.
4. Install a retaining ring in the lower groove on the upper part of the shaft, then install the upper bearing. Install a second retaining ring on top of the bearing.
5. Install the lower bearing on the shaft, then install the lower retaining ring.
6. Screw the horn contact assembly into the side of steering column assembly.
7. Install the steering column assembly and the steering wheel, following the instructions in this section.

Steering Column Disassembly and Assembly

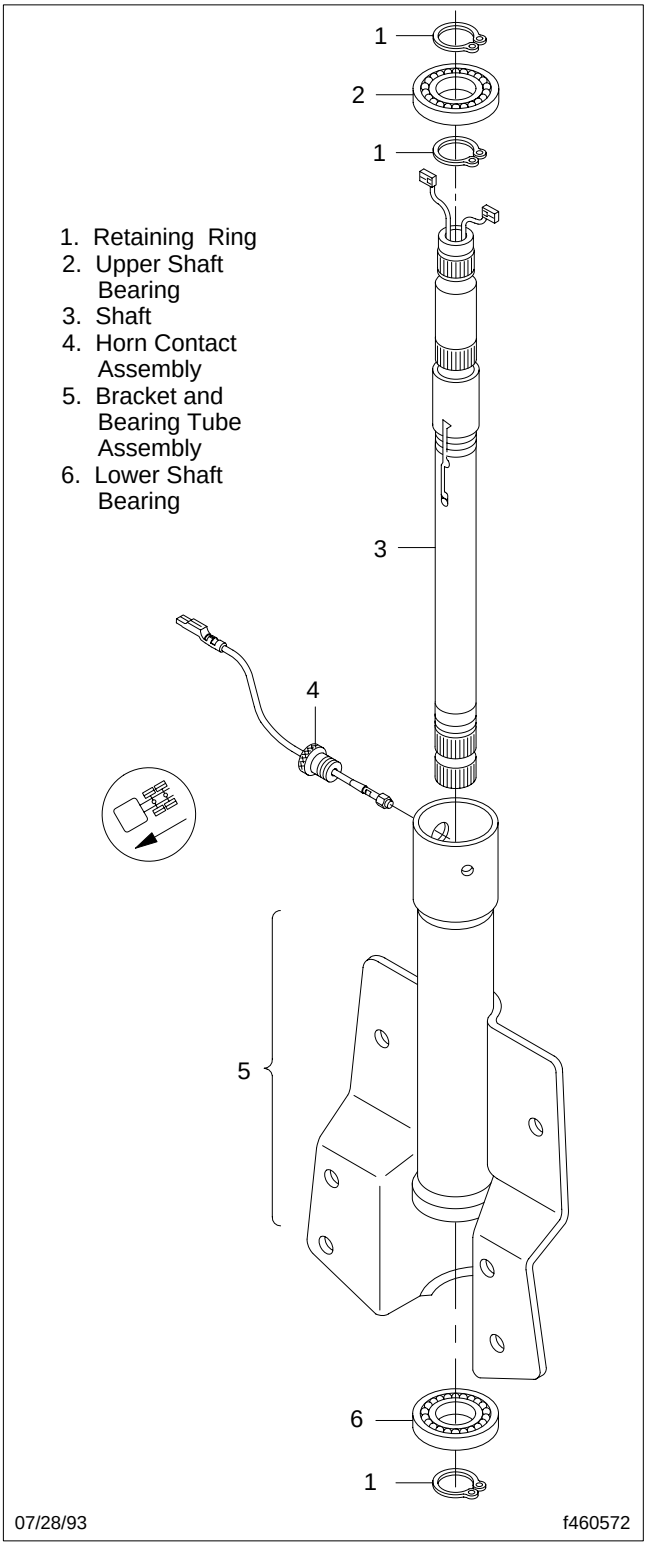


Fig. 1

Horn Contact Assembly Replacement

Replacement

1. Disconnect the horn wire from the wire lead-ing to the back of the dash. **See Fig. 1**.

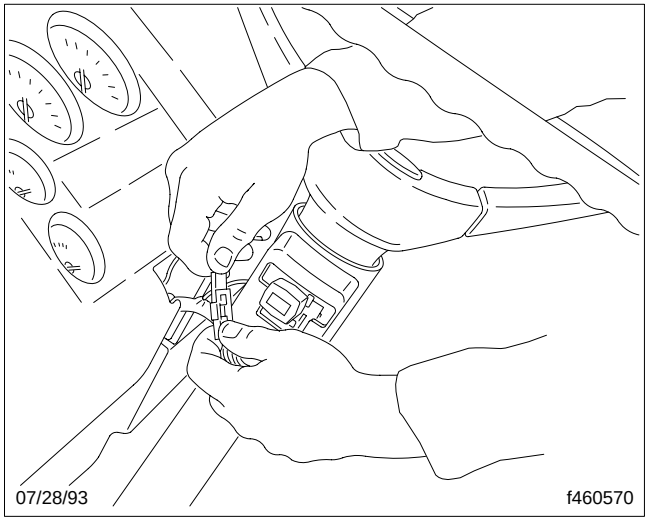


Fig. 1

2. Unscrew the horn contact assembly from the right-hand side of the steering column, and dis-card it. **See Fig. 2**.

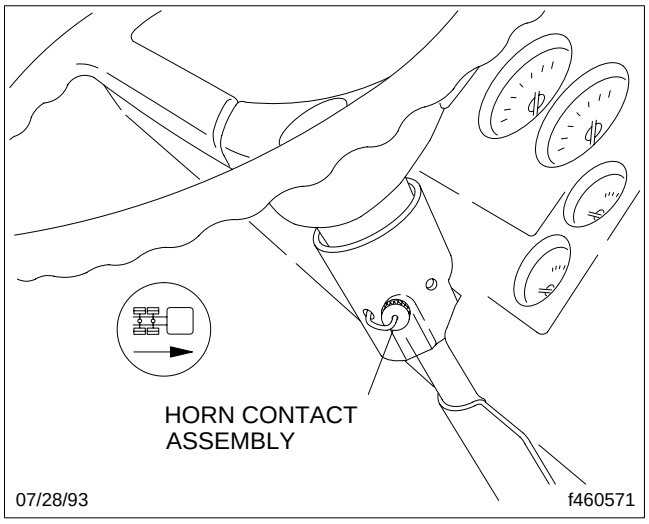


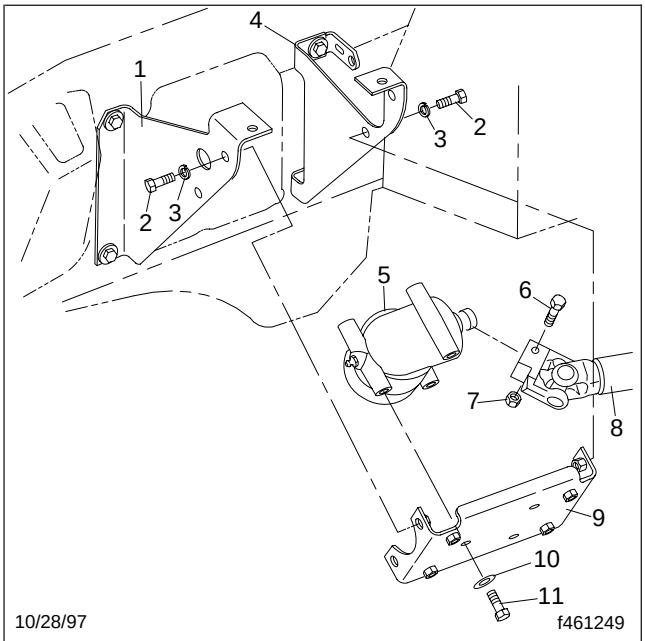
Fig. 2

3. Install a new horn contact assembly into the right-hand side of the steering column. Screw in the assembly firmly.
4. Connect the horn wire to the wire leading to the back of the dash.
5. Check the horn. If it doesn't work, heck the wir-ing to the horn, the horn itself, and the horn but-ton. Repair or replace parts as needed.

Traverse Shaft Removal and Installation, RH DR

Removal

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service work will be done. *Do not move the tires from the straight-ahead position during removal or at any time while the traverse shaft is removed.*
2. Apply the parking brakes and chock the tires.
3. Remove the dash kick panel. Remove the two shims inside the panel.
4. Remove the face plate. See **Fig. 1**.



10/28/97 f461249

1. Outboard (LH) Support Bracket
2. Face Plate Mounting Capscrew, 3/8–16
3. Face Plate Mounting Lockwasher
4. Inboard (RH) Support Bracket
5. LH Miter Box
6. Pinch Bolt, 7/16–20
7. Prevailing Torque Hexnut
8. Traverse Shaft
9. Face Plate
10. Miter Box Mounting Capscrew, 3/8–16
11. Miter Box Mounting Lockwasher

Fig. 1, Face Plate and Miter Box Removal

4.1 Remove the four face plate mounting capscrews and lockwashers.

4.2 Remove the three miter box mounting capscrews and lockwashers.

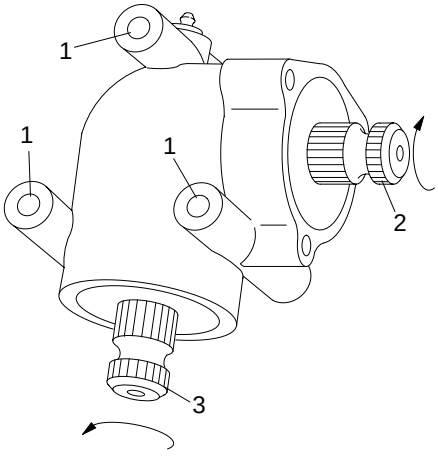
5. Remove the two pinch bolts that attach the LH miter box to the steering linkage.

5.1 Remove the pinch bolt and prevailing torque hexnut that connect the output shaft of the miter box to the steering driveline. Mark the splines for later assembly.

5.2 Remove the pinch bolt and prevailing torque hexnut that connect the input shaft of the miter box to the traverse shaft. Mark the splines for later assembly.

5.3 Discard the pinch bolts and nuts.

6. Remove the miter box from the vehicle. See **Fig. 2**. Take care not to damage the splined input (clockwise) or output (counterclockwise) shafts.



11/06/97 f461247

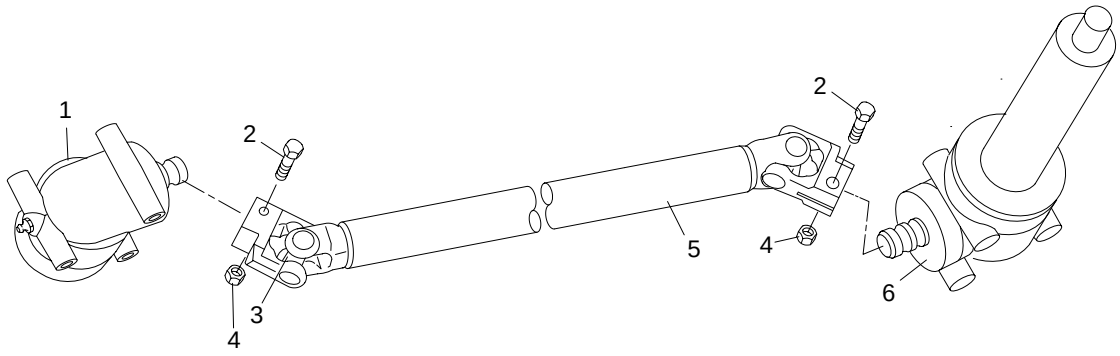
IMPORTANT: The input and output shafts turn in opposite directions. Be sure to install them correctly.

1. Threaded Hole, 3/8–16
2. Input (clockwise) Shaft
3. Output (counterclockwise) Shaft

Fig. 2, LH Miter Box

7. Remove and discard the pinch bolt and prevailing torque hexnut that attach the RH miter box to the traverse shaft. See **Fig. 3**.
8. Remove the traverse shaft from the vehicle. See **Fig. 3**. To gain clearance, loosen the upper bolts on the electrical power center (EPC) panel.

Traverse Shaft Removal and Installation, RH DR



1. LH Miter Box
2. Pinch Bolt, 7/16–20
3. U-Joint
4. Prevailing Torque Hexnut
5. Traverse Shaft
6. RH Miter Box

Fig. 3, Traverse Shaft Pinch Bolts

Installation

1. Position the traverse shaft through the EPC panel. Install new pinch bolts and prevailing torque hexnuts into the end yokes of the U-joints at each end of the shaft, but do not tighten.
2. Install the LH miter box. See **Fig. 2**.

⚠ CAUTION

The two shafts of the LH miter box turn in opposite directions. If they are not installed correctly, the steering linkage can be damaged when the wheels are turned.

   2.1 Using the alignment marks made on removal, install the input (clockwise) shaft of the miter box onto the traverse shaft.

   2.2 Using the alignment marks made on removal, install the output (counterclockwise) shaft of the LH miter box onto the steering driveline.

3. Connect the traverse shaft to the RH miter box. See **Fig. 3**).
4. Tighten the new pinch bolts and nuts. See **Fig. 3**.

   4.1 Tighten each nut 60 lbf·ft (81 N·m).

   4.2 Apply white Torque Seal F-900® to the exposed threads of the pinch bolts.

5. Install the face plate as shown in **Fig. 1**. Tighten the LH miter box and face plate mounting capscrews 28 lbf·ft (38 N·m)
6. Line up the shims inside the dash kick panel. Install the dash kick panel.
7. Tighten the bolts loosened on the EPC panel.
8. Remove the chocks from the tires.

Specifications

Fastener Torques, Left-Hand Drive	
Description	**Torque Value lbf·ft (N·m)**
Steering Column Bracket Hexbolts	40 (54)
Steering Driveline End-Yoke Pinch Bolt Nut	37 (50)
Steering Wheel Nut	60 (81)

Table 1, Fastener Torques, Left-Hand Drive

Fastener Torques, Right-Hand Drive	
Description	**Torque Value lbf·ft (N·m)**
Face Plate Mounting Capscrews	28 (38)
Miter Box Mounting Capscrews	28 (38)
Steering Column Cover Capscrews	28 (38)
Steering Column Mounting Plate Capscrews	28 (38)
Steering Column Support Capscrews	34 (46)
Steering Driveline End-Yoke Pinch Bolt Nut	60 (81)
Steering Wheel Nut	60 (81)
Traverse Shaft End-Yoke Pinch Bolt Nut	60 (81)

Table 2, Fastener Torques, Right-Hand Drive

General Information

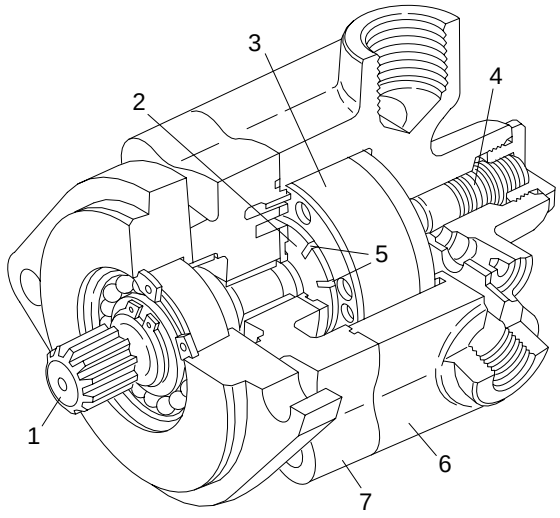
The LuK Automotive Hydraulics VT 7 Series power steering pump supplies power steering fluid for the operation of the power steering gear, and in vehicles so equipped, for the hydraulic brake power booster.

On Cummins B and C Series engines, the pump is mounted on the driver's side of the engine, at the rear of the gear case. It is powered by an adaptor gear in the engine.

On Detroit Diesel Series 50 engines, the pump is mounted on the driver's side of the engine at the front of the engine gear case.

On Dodge Magnum engines, the pump is mounted on the driver's side of the engine and is belt driven by the crankshaft pulley.

The main components of the power steering pump are the housing, driveshaft, cam ring, rotor, vanes, and control valve. See **Fig. 1**.



08/12/94 f460540a

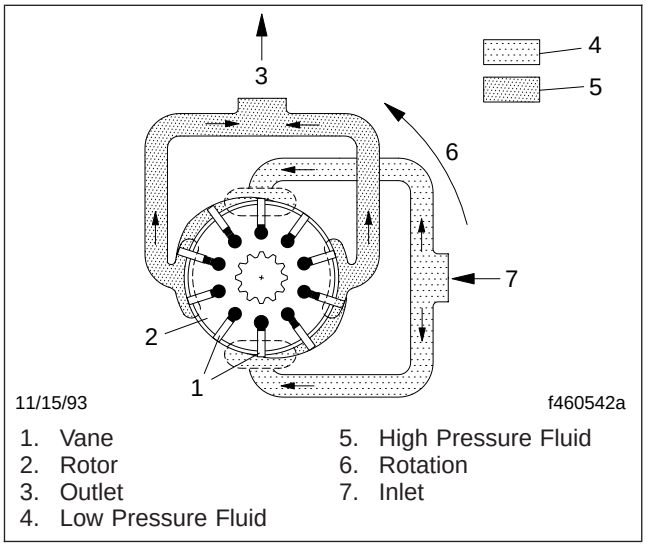
1. Driveshaft
2. Rotor
3. Cam Ring
4. Control Valve
5. Vane
6. Housing
7. Flange Assembly

Fig. 1, Power Steering Pump Components

Principles of Operation

The driveshaft, powered by the adaptor gear in the engine gear case or by the crankshaft pulley, turns the rotor, which is inside the cam ring. As the rotor turns, centrifugal force pushes the vanes out toward the surface of the cam ring. As fluid enters the cam ring through the inlet port, the rotor vanes force it out through the outlet port, and into the system. The fluid operates the steering gear, and if the vehicle is so equipped, the hydraulic brake power booster. Eventually the fluid returns to the power steering reservoir, then back to the power steering pump. See **Fig. 2**

If the system pressure gets too high, a poppet inside the control valve is forced off its seat, shunting fluid into a relief passage connected to the inlet port. The fluid then recirculates inside the pump instead of going to the outlet port. When the system pressure drops to the correct level, the poppet seats, closing off the relief passage to the inlet port. The fluid flow returns to normal, flowing from the inlet port to the outlet port, then into the power steering system.



11/15/93 f460542a

1. Vane
2. Rotor
3. Outlet
4. Low Pressure Fluid
5. High Pressure Fluid
6. Rotation
7. Inlet

Fig. 2, Power Steering Pump Fluid Flow

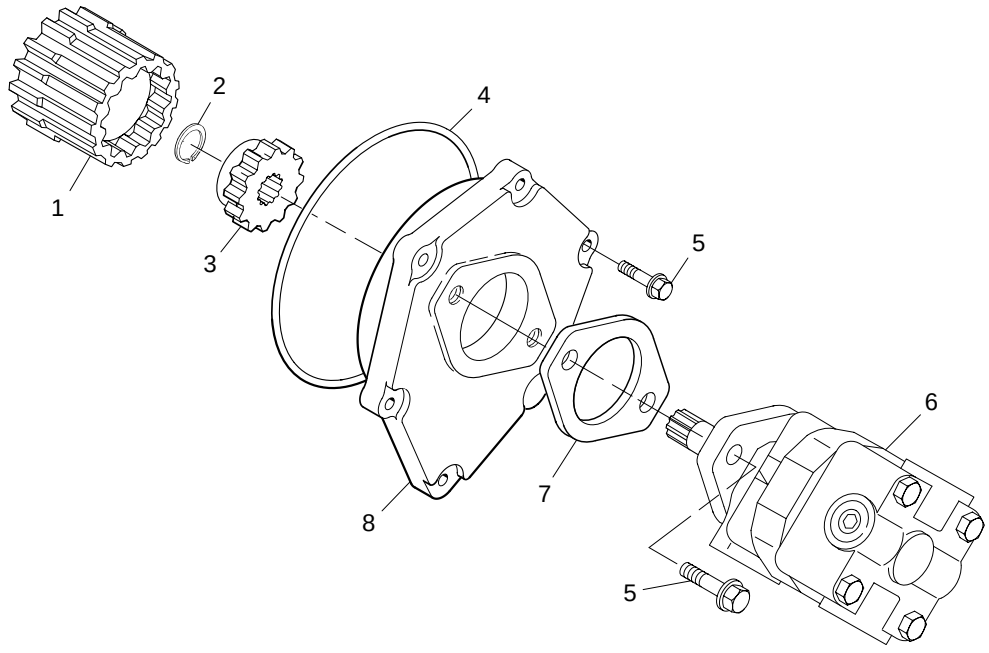
Removal

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Clean all dirt from around the fittings and hose connections.
4. Put a container under the pump, then disconnect the hoses from the fittings on the pump. Plug the hoses and cap the fittings to keep out dirt and to prevent fluid from leaking.
5. On Cummins engines, remove the pump.
   - 5.1 Remove the capscrews that attach the pump to the engine accessory drive mounting flange.
   - 5.2 Pull the pump straight out from the engine. Keep it level to avoid spilling fluid.
6. On Detroit Diesel Series 50 engines, remove the pump.
   - 6.1 Remove the capscrews that attach the pump to the adaptor flange. See **Fig. 1**.
   - 6.2 Slide the pump out of the coupling. Remove the sprocket from the shaft if necessary.
   - 6.3 Check around the adaptor flange for oil leaks. If there are leaks, remove the adaptor flange from the engine. Remove all old gasket material.
7. On Dodge Magnum engines, remove the pump.
   - 7.1 Loosen the nut from the pulley hub. See **Fig. 2**.
   - 7.2 Loosen the capscrews on the pulley assembly.
   - 7.3 Turn the belt tensioner counterclockwise to loosen the drive belt.
   - 7.4 Remove the capscrews from the pulley assembly, and remove the pulley assembly.
   - 7.5 Remove the bearing washer and nut from the pulley hub.
   - 7.6 Using an appropriate puller, remove the pulley hub.
   - 7.7 Remove the capscrews that attach the pump to the mounting bracket, and remove the pump.
8. Turn the pump upside down over a container and let the fluid drain out.
9. Discard the gasket from the pump mounting flange.

Installation

1. Using engine oil, lightly lubricate a new gasket and the pump shaft.
2. Install the pump.
   - 2.1 On Cummins engines, install a new gasket on the pump mounting flange, then place the pump on the engine accessory drive mounting. Install the washers and capscrews, and tighten them 27 to 32 lbf·ft (37 to 43 N·m).
   - 2.2 On Detroit Diesel Series 50 engines, make sure the clip is installed in the sprocket and that the coupling and sprocket are installed on the engine accessory drive. If the adaptor flange was removed, use engine oil to lightly lubricate a new O-ring. Install the O-ring on the flange, and install the flange on the engine. Cross tighten the capscrews 22 to 25 lbf·ft (30 to 34 N·m). Install the new gasket on the pump mounting flange, then position the pump on the adaptor flange. Turn the pump or shaft as needed to mesh the shaft with the sprocket. Install the capscrews and tighten them 27 to 32 lbf·ft (37 to 43 N·m).
   - 2.3 On Dodge Magnum engines, position the pump on the mounting bracket. See **Fig. 2**. Install the capscrews and tighten them 27 to 32 lbf·ft (37 to 43 N·m). Using an appropriately sized driver to protect the pump shaft, tap the pulley hub onto the pump shaft. Loosely install the bearing washer and nut. Position the pulley assembly and loosely install the six capscrews. Turn the belt tensioner counterclockwise and slip the belt over the pulley. Tighten the nut on the pulley hub 59 to 74 lbf·ft (80 to 100 N·m). Tighten the

Removal and Installation



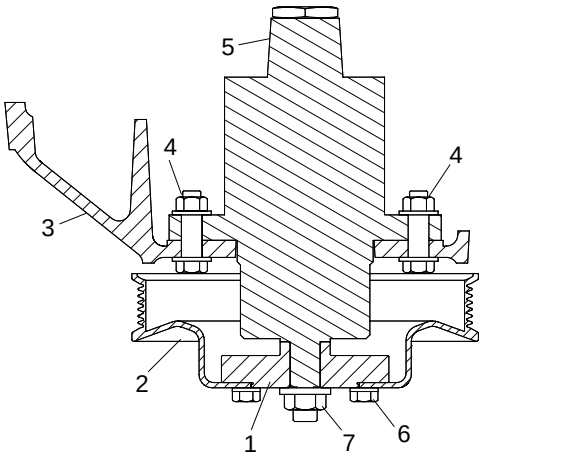
07/23/93 f460192a

1. Coupling
2. Clip
3. Sprocket
4. O-Ring
5. Capscrew
6. Power Steering Pump
7. Gasket
8. Adaptor Flange

Fig. 1, Power Steering Pump Assembly

capscrews on the pulley assembly 16 lbf·ft (22 N·m).

3. Connect the inlet hose (from the power steering reservoir) to the inlet port. Tighten it 20 lbf·ft (27 N·m).
4. Connect the outlet hose (from the power steering gear) to the outlet port. Install the hose clamp and tighten it firmly.
5. Bleed the power steering system.
   - 5.1 Check the fluid level in the power steering reservoir and if needed, fill it to the correct level with the approved power steering fluid in **Specifications 400**.
   - 5.2 Start the engine and let it idle for several minutes.
   - 5.3 Turn the wheels to a full-left and full-right turn. Repeat about three times.
   - 5.4 Check the fluid level in the power steering reservoir. If needed, add fluid. For approved power steering fluid, see **Specifications 400**.
   - 5.5 Shut down the engine.
6. Close the hood and remove the chocks from the tires.



1. Pully Hub
2. Pully Assembly
3. Mounting Bracket
4. Capscrew
5. Steering Pump
6. Pulley Assembly Capscrew
7. Nut

Fig. 2, Power Steering Pump Section View

Disassembly

WARNING

Wear safety goggles or glasses when disassembling the power steering pump. Some of the parts are held in place by springs or snap rings, which can release with considerable force, possibly causing injury.

CAUTION

Be careful when working on the pump housing; it is aluminum, and can be easily damaged. When putting it in a vise, pad the vise jaws. Tighten the vise just enough to hold the pump.

1. Remove the power steering pump from the engine following the instructions in **Subject 100**.
2. Carefully remove the end plug and spring from the pump body. See **Fig. 1**.
3. Remove the control valve from the pump body. Be careful not to scratch the control valve.
4. Remove and discard the O-ring from the plug.
5. Put the pump housing in a padded vise, and remove the capscrews that attach the housing to the flange assembly.
6. Remove the flange assembly from the pump housing.
7. Remove the pressure plate from the flange assembly.
8. Remove the cam ring.
9. Remove the rotor and vanes.
10. Remove the wear plate.
11. Remove the two guide pins from the seats.
12. Remove the large O-ring from the flange assembly.
13. Remove the driveshaft from the flange assembly.
    - 13.1 Remove the snap ring holding the shaft bearing in place.
    - 13.2 Put the flange assembly in a vise, then carefully tap out the driveshaft.
14. Check the driveshaft bearing. If it is damaged or worn, remove it from the driveshaft. If it is not damaged or worn, go to the next step.
    - 14.1 Remove the small snap ring from the driveshaft.
    - 14.2 Being careful to push only on the inner ring of the bearing, press the bearing off the driveshaft.
15. Remove and discard the shaft seal from the flange assembly.
16. Remove and discard the two O-rings and backup rings from the pump housing.

Inspection

1. Using a solvent compatible with the power steering fluid, clean all the parts. Then, using filtered compressed air, dry all the parts.
2. Check all the parts. Replace any that are damaged or worn.
3. Check the vanes on the rotor for damage or too much play in the rotor slots. If you can move the vanes from side to side in the slots, replace the whole rotor assembly.
4. Check the control valve.

   If obvious damage or wear is present, replace the control valve. If the control valve does not need replacing, continue with the next step.

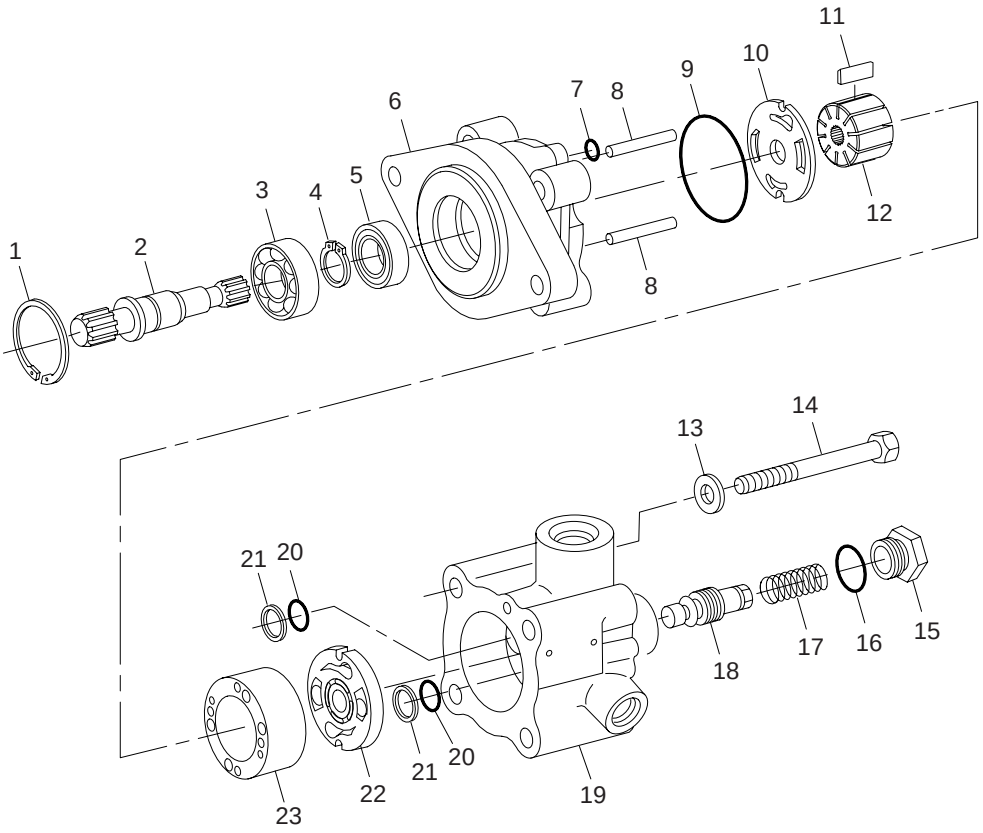
CAUTION

When putting the control valve in a vise, put only the end opposite the hex end of the control valve into the vise. Do not clamp the sealing surfaces (outer rings), or you will damage the valve.

5. Carefully put the control valve in a padded vise. See **Fig. 2**. Do not damage the sealing surfaces.

   Test the torque of the end plug. It should be 6 to 8 lbf·ft (8 to 11 N·m). If it is not, replace the control valve.
6. Coat the control valve with approved power steering fluid specified in **Specifications 400**. Then install it in the bore in the pump housing.

Disassembly, Inspection, and Assembly



08/15/94 f460541a

1. Snap Ring
2. Driveshaft
3. Driveshaft Bearing
4. Snap Ring
5. Shaft Seal
6. Flange Assembly
7. O-Ring
8. Guide Pin
9. O-ring
10. Wear Plate
11. Vane
12. Rotor
13. Washer
14. Capscrew
15. End Plug
16. O-Ring
17. Spring
18. Control Valve
19. Pump Housing
20. O-Ring
21. Backup Ring
22. Pressure Plate
23. Cam Ring

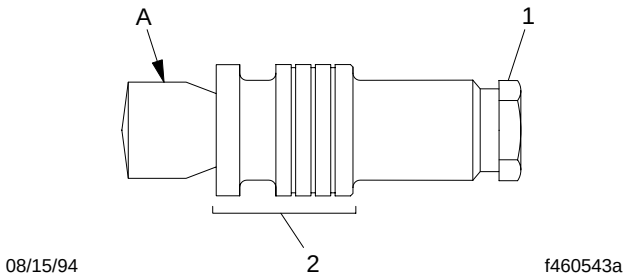
Fig. 1, Power Steering Pump Assembly

7. Spin the control valve all the way around in the bore while moving it in and out. If there is any binding, replace the control valve.

Assembly

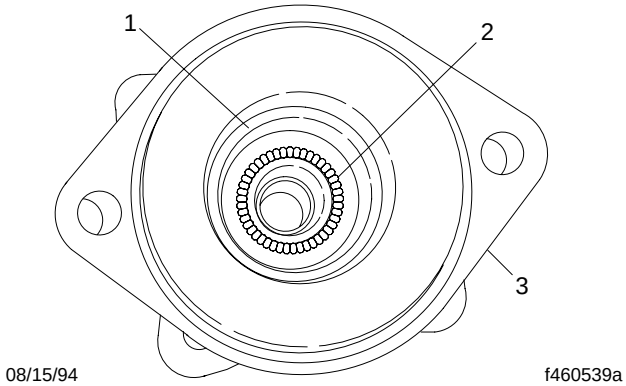
NOTE: To correctly install the driveshaft seal and bearing, it is necessary to make suitable drivers from tubular stock. Refer to **Specifications 400** for the applicable dimensions.

1. Coat all the parts in the approved power steering fluid specified in **Specifications 400**.
2. Using a suitable driver, install the shaft seal into the bore in the flange assembly. Make sure the spring side of the seal faces the flange. See **Fig. 3**. Seat the seal firmly against the shoulder in the bore.



A. Clamp vise here.
1. Hex End
2. Sealing Surfaces

Fig. 2, Control Valve Components



1. Shaft Seal
2. Garter Spring
3. Flange

Fig. 3, Seal Placement

CAUTION

When installing the driveshaft bearing, make sure that pressure is exerted only on the inner race of the bearing. Do not use any pressure on the outer race, or you may damage the bearing assembly.

3. If it was removed, install a new bearing on the driveshaft using a suitable driver and an arbor press.

   Install the small snap ring in the groove on the driveshaft with the sharp edge facing toward the bearing.

4. Install the driveshaft and bearing assembly in the flange assembly.

   4.1 Lubricate the shaft with power steering fluid.

   4.2 Slide the driveshaft into the bore of the flange assembly, being careful not to damage the shaft seal.

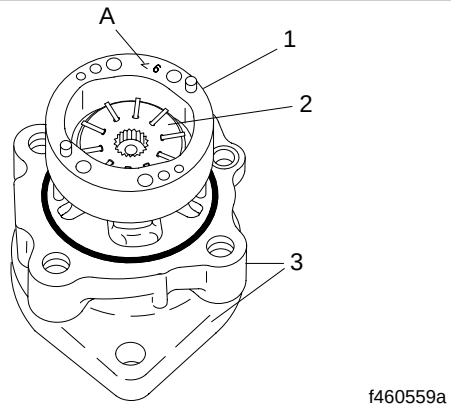
   4.3 Install the large snap ring into the groove in the flange assembly.

5. Using approved power steering fluid specified in **Specifications 400**, lubricate the new O-rings and backup rings, then install them in the pump housing.
6. Put the flange assembly in a padded vise, then install a new large O-ring in the flange assembly.
7. Install a new small O-ring in the flange assembly.
8. Install the two guide pins in their seats in the flange assembly.
9. Install the wear plate, bronze side up, on the flange assembly.
10. Install the rotor on the driveshaft.
11. Install the vanes, rounded edges outboard, in the rotor. Make sure that none of them are binding.
12. Install the cam ring over the rotor, on the flange assembly, and over the guide pins. Make sure that the arrow on the face of the cam ring is pointing in the direction of the shaft rotation. With the flange held shaft side down, the arrow should be pointing in a counterclockwise direction (left). See **Fig. 4**.
13. Install the pressure plate, bronze side down, on the rotor and cam ring assembly.
14. Lining up the mounting holes, install the pump housing over the flange assembly.
15. Install the capscrews and washers in the pump housing. Tighten them in a cross pattern 29 to 37 lbf·ft (40 to 50 N·m).
16. Install the control valve in the pump housing.

CAUTION

Make sure you install the control valve correctly in the bore. If it is installed backwards, the power steering pump will not work and will quickly overheat, which could cause severe damage to the pump.

Disassembly, Inspection, and Assembly

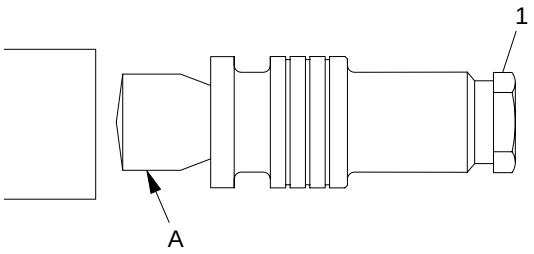


08/15/94 f460559a

A. Stamped arrow indicates rotation direction.
1. Cam Ring
2. Rotor
3. Flange Assembly

Fig. 4, Cam Ring Placement

16.1 Lubricate the control valve, then install it, with the hex end up, into the bore in the pump housing. See **Fig. 5**.



08/15/94 f460544a

A. Insert this end first.
1. Hex End

Fig. 5, Control Valve Installation

16.2 Install the spring over the hex end of the control valve.

16.3 Install a new O-ring on the end plug, then install the end plug. Tighten it 33 to 40 lbf·ft (45 to 54 N·m).

17. Install the power steering pump on the engine following the instructions in **Subject 100**.

Problem—The Power Steering Pump Doesn't Deliver Fluid

Problem—The Power Steering Pump Doesn't Deliver Fluid	
Possible Cause	**Remedy**
The pump driveshaft is broken, or not engaging.	Remove the pump. Repair or replace parts as needed.
The control valve is stuck open.	Remove and disassemble the pump. Clean the control valve in a solvent. Install the control valve, then check for any binding in its bore. If the control valve binds or feels gritty when you move it, replace it.
One or more rotor vanes is stuck.	Remove and disassemble the pump. Check the rotor and vanes for dirt or damage. If damaged, replace the rotor and vane assembly. If dirty, clean the rotor and vanes in a solvent, then assemble the parts and check for free vane movement. If the problem persists, replace the rotor and vane assembly.
Incorrect power steering fluid is used.	Check for the type of fluid used. If it is incorrect, drain, flush, and fill the system with power steering fluid. For approved power steering fluid, see **Specifications 400**.
The pump intake port is blocked.	Drain and flush the system. Fill the system with power steering fluid. For approved power steering fluid, see **Specifications 400**.
The air vent in the power steering reservoir is clogged, or the filter is dirty.	Remove the filter cap from the reservoir, then clean the air slot. Check the filter and replace it if needed.
A power steering hose is kinked or blocked.	Repair or replace the hose.

Problem—The Power Steering Pump Is Making Noise

Problem—The Power Steering Pump Is Making Noise	
Possible Cause	**Remedy**
The intake line or filter is plugged.	Drain the system. Clear the intake line if needed, then check the filter. Replace it if needed. Fill the system with power steering fluid. For approved power steering fluid, see **Specifications 400**.
There is an air leak at the pump connections, the fittings, the reservoir connections, or the shaft seal.	Check all the connections by pouring power steering fluid over them, then listen for a reduction in sound. Tighten all the connections as needed. If the problem persists, remove the pump, then disassemble it and replace the shaftseal.
The pump driveshaft is misaligned.	Remove and disassemble pump. Replace the shaft seal and bearing.

General Information

The TRW TAS40, TAS55, TAS65, and TAS85 power steering gears use pressurized hydraulic fluid to help the driver turn the front wheels. All four models mount on the left frame rail, and all operate in the same way.

The difference between the four gears is size. The TAS40 can be installed on vehicles with front axle capacities up to 9000 pounds (4086 kg). The TAS55 is for vehicles with front axle capacities up to 12,000 pounds (5448 kg), the TAS65 is for front axle capacities up to 14,300 pounds (6500 kg), and the TAS85 is for front axle capacities up to 18,000 pounds (8200 kg).

All four gears use more pressurized fluid when the driver turns the steering wheel quickly than when the driver turns the steering wheel slowly, but the minimum amount of power steering fluid is different for each model. With the driver turning the steering wheel 1-1/2 turns per second, the TAS40 needs at least 2.2 gallons (8.3 liters) of fluid per minute . At the same turning speed, the TAS55 needs 2.6 gpm (9.8 L/min), the TAS65 needs 3.0 gpm (11.4 L/min), and the TAS85 needs 3.6 gpm (13.6 L/min).

⚠ CAUTION

Never steam clean or high-pressure wash the steering gear. Internal damage to gear seals and ultimately the steering gear can result.

Principles of Operation

When the driver turns the steering wheel, that force travels down through the steering driveline to the steering gear input shaft. See **Fig. 1** and **Fig. 2**. The input shaft turns the worm shaft which moves the rack piston forward or backward in the gear housing by means of a series of recirculating balls in the spiral channels of the worm shaft. See **Fig. 3**.

Grooves in the rack piston mesh with teeth in the sector shaft, and as the piston slides back and forth, it turns the sector shaft. The sector shaft swings the pitman arm. The pitman arm pulls or pushes the drag link, and the drag link moves the axle steering arm, steering the vehicle.

Pressurized power steering fluid helps the worm shaft slide the rack piston forward or backward in the gear housing.

The input shaft is not connected directly to the worm shaft. Instead, a thin bar, the torsion bar, holds the input shaft to the worm shaft. The outside end of the torsion bar is fastened to the input shaft, and the inside end is fastened to the worm shaft; thus, the force of the driver turning the steering wheel travels from the input shaft to the worm shaft through the torsion bar.

With the force of the driver alone, the front axle would be difficult to steer. The weight on the front wheels, the friction of the tires against the road, and the inertia of the vehicle traveling in its current direction all combine to hold the sector shaft and the rack piston in place.

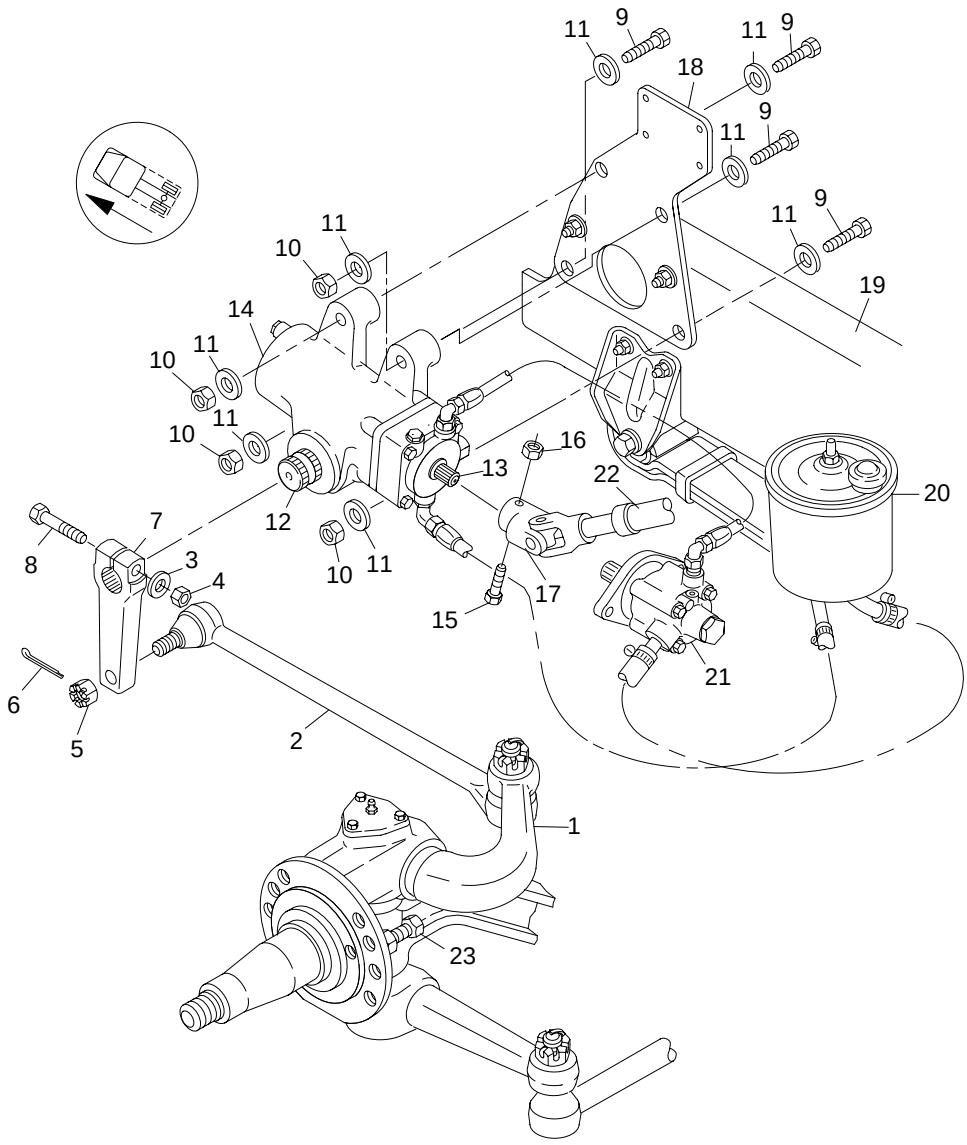
To overcome this resistance, the steering gear has a valve for directing pressurized hydraulic fluid either in front of the rack piston or behind it, thus using the fluid to push the rack piston in the direction the worm shaft is trying to slide it.

The torsion bar controls the hydraulic fluid. As the driver turns the steering wheel to turn the input shaft, and the front wheels resist turning and hold the rack piston and worm shaft in place, the torsion bar connecting the input shaft and worm shaft twists slightly. That twisting aligns holes in the hydraulic control valve with channels that carry hydraulic fluid. Depending on the direction the driver turns the steering wheel—the direction the torsion bar twists—the valve aligns the channels to direct hydraulic fluid in front of the rack piston or behind it. The fluid provides the extra force the worm shaft needs to overcome the resistance from the front wheels, and the worm shaft can then slide the rack piston in the gear housing.

The rack piston slides, and turns the sector shaft. The sector shaft swings the pitman arm. The pitman arm pulls or pushes the drag link. The drag link moves the axle steering arm, and the front wheels turn.

As the front wheels reach the axle stop—the farthest the wheels can turn in that direction—a poppet (unloading valve) in the rack piston trips to prevent steering gear damage. The tripped poppet reduces steering fluid pressure, heat generated by the power steering fluid pump, and outside forces from acting on the steering linkage.

General Information

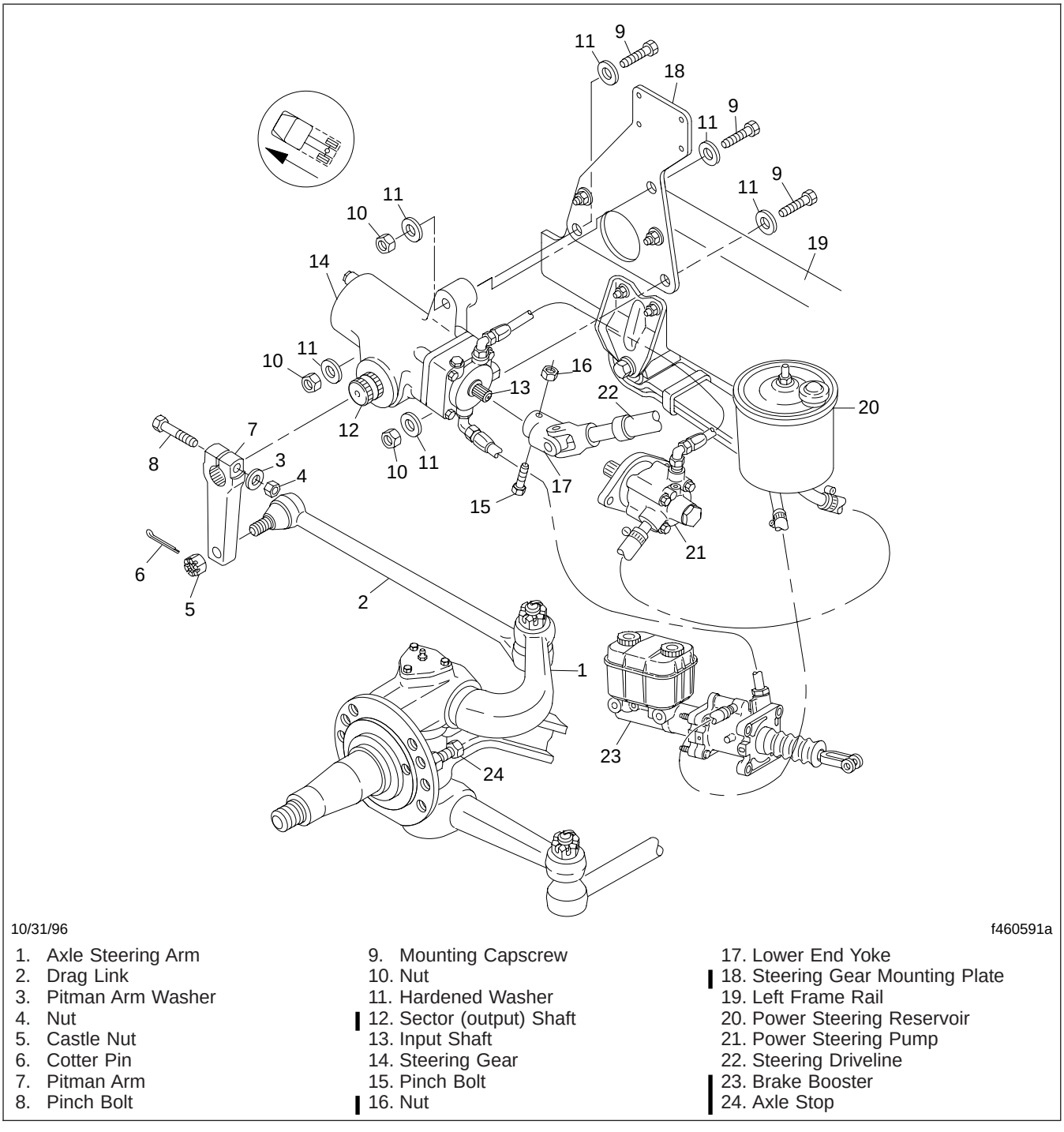


10/31/96 f460594a

1. Axle Steering Arm
2. Drag Link
3. Washer
4. Nut
5. Castle Nut
6. Cotter Pin
7. Pitman Arm
8. Pinch Bolt
9. Mounting Capscrew
10. Nut
11. Hardened Washer
12. Sector (output) Shaft
13. Input Shaft
14. Steering Gear
15. Pinch Bolt
16. Nut
17. Lower End Yoke
18. Steering Gear Mounting Plate
19. Left Frame Rail
20. Power Steering Reservoir
21. Power Steering Pump
22. Steering Driveline
23. Axle Stop

Fig. 1, TRW TAS85 Power Steering Installation (vehicles with air brakes)

The hydraulic fluid around the rack piston also prevents road shocks from moving the steering wheel. When the vehicle hits an obstacle, the shock travels up through the front tires and the steering linkage to



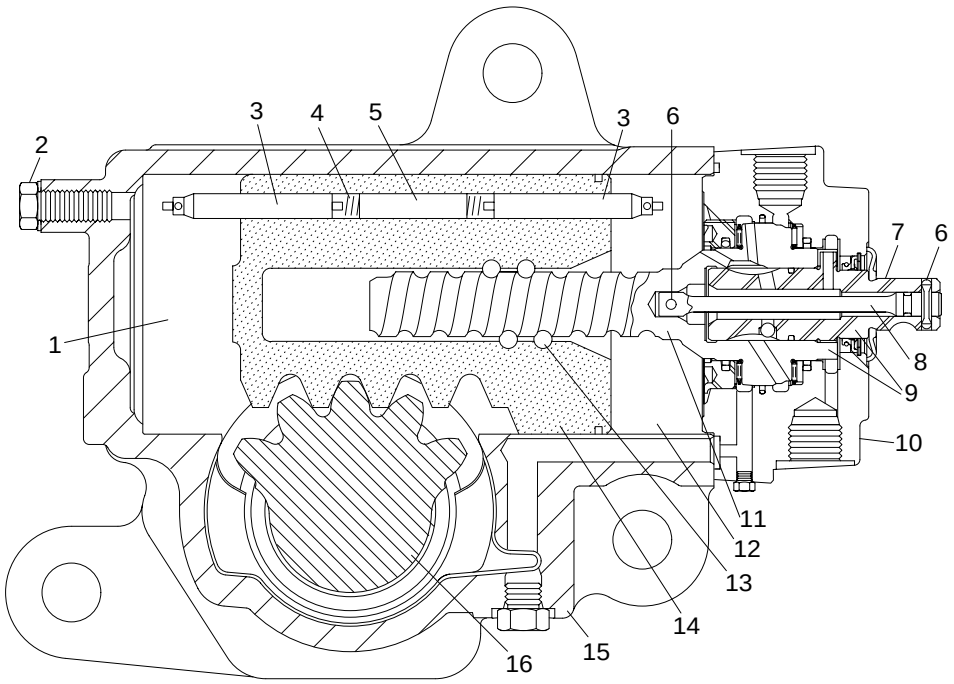
10/31/96 f460591a

1. Axle Steering Arm
2. Drag Link
3. Pitman Arm Washer
4. Nut
5. Castle Nut
6. Cotter Pin
7. Pitman Arm
8. Pinch Bolt
9. Mounting Capscrew
10. Nut
11. Hardened Washer
12. Sector (output) Shaft
13. Input Shaft
14. Steering Gear
15. Pinch Bolt
16. Nut
17. Lower End Yoke
18. Steering Gear Mounting Plate
19. Left Frame Rail
20. Power Steering Reservoir
21. Power Steering Pump
22. Steering Driveline
23. Brake Booster
24. Axle Stop

Fig. 2, TRW TAS40/55/65 Power Steering Installation (vehicles with hydraulic brakes)

the steering gear. There, the sector shaft would transmit the shock to the rack piston, but the power steering fluid helps to hold the piston in place and

General Information



10/31/96 f460581a

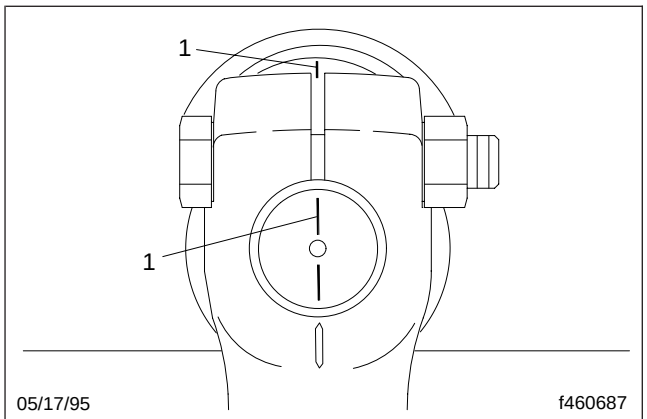
1. Lower Cylinder Cavity
2. Poppet Fixed Stopscrew
3. Poppet Assembly
4. Poppet Spring
5. Push Tube
6. Pin
7. Input Shaft
8. Torsion Bar
9. Control Valve
10. Valve Housing
11. Worm Shaft
12. Upper Cylinder Cavity
13. Ball (recirculating)
14. Rack Piston
15. Gear Housing
16. Sector Shaft

Fig. 3, Steering Gear Section View

dampen the shock before it can move up the worm shaft to the steering driveline and the steering wheel.

Sector Shaft Adjustment

1. Position the sector (output) shaft at its center of travel by turning the steering wheel until the alignment mark on the sector shaft is at a right angle to the input shaft centerline, and in line with the timing mark on the end of the housing trunnion. See **Fig. 1**.



1. Housing Trunnion Timing Mark
2. Sector Shaft Timing Mark

Fig. 1, Timing Mark Placement

2. Disconnect the drag link from the pitman arm. Do not turn the input shaft/valve/worm assembly more than 1-1/2 turns in either direction from its center of travel while the drag link is disconnected from the pitman arm. Turning the input shaft more than 1-1/2 turns from center will cause misadjustment of the automatic poppets. This may require the installation of a service poppet adjustment tool to manually reset the poppets.
3. With the sector shaft in the center position, grasp the pitman arm and gently try to move it back and forth. Fingertip force is adequate to detect lash (free play) of a loose sector shaft. See **Fig. 2**. There should be no movement of the input shaft or sector shaft. Loosen the sector shaft adjusting screw jam nut. See **Fig. 3**. If no lash was detected, turn the shaft adjusting screw counterclockwise until lash is detected.
4. To adjust, move the adjusting screw clockwise until no lash is felt at the pitman arm. Use no more than 10 lbf·ft (14 N·m) of torque. Slowly turn the adjusting screw clockwise an additional one-eighth turn. Hold the adjusting screw in place and tighten the jam nut 40 to 45 lbf·ft (54 to 61 N·m).

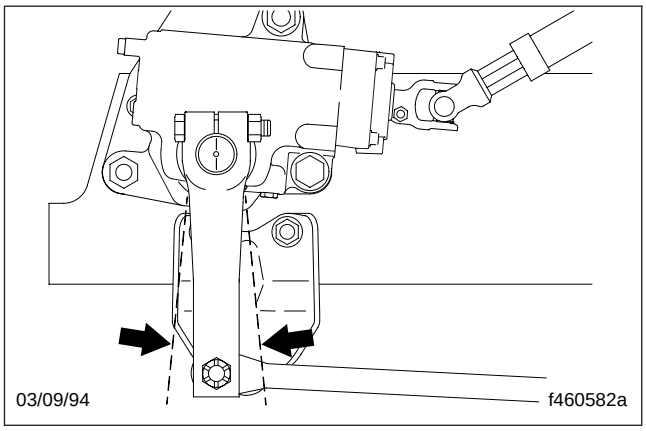


Fig. 2, Free Play Check

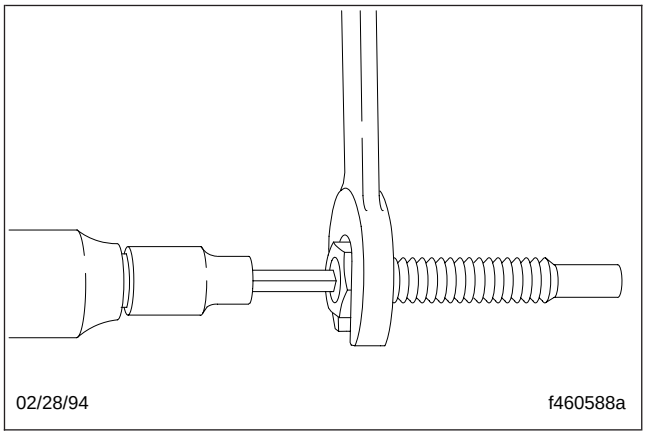


Fig. 3, Jam Nut

5. Again, check the pitman arm for lash. Turn the steering wheel one-quarter turn each side of center. No lash should be felt. If lash exists, readjust the sector shaft.
6. Connect the drag link to the pitman arm. For instructions, refer to the applicable section in this group.

Poppet Valves Adjustment

TAS40, TAS55, TAS65, and TAS85 steering gears have automatic poppet valves that reset themselves if the axle stops are reset for increased steering travel. However, if the axle stops are reset for **de-**

In-Vehicle Adjustments

creased steering travel, the poppet valves must be reset manually, through the use of a special service poppet adjusting screw and sealing jam nut kit, unless they were reset for automatic adjustment while the steering gear was disassembled.

Use the following procedure for manually resetting the poppet valves.

1. Verify correct axle stop adjustment. For instructions, refer to **Group 33**.

IMPORTANT: The axle stops must be set so that there are at least 1-3/4 steering wheel turns from a straight-ahead position to both a full-left and a full-right turn; otherwise the poppet valves will not work.

2. If both axle stops were set for increased travel, the steering gear poppets have reset automatically and gear adjustments are complete. No further action is required.

   If either axle stop was set for decreased travel, the steering gear poppets must be set manually. Continue with the following steps.

3. Install the steering gear manual poppet adjusting screw.

   3.1 Screw the special poppet adjusting screw (from TRW kit number 021407-X1) into the nonsealing end of the sealing jam nut, until the drive end of the screw is flush with the nut. See **Fig. 3**.

   3.2 With the vehicle unloaded, the engine off, and the front wheels in the straight-ahead position, remove and discard the poppet fixed stopscrew and washer from the lower end of the steering gear housing. See **Fig. 4**.

NOTE: With the wheels straight ahead and the timing marks on the sector shaft and gear housing aligned, the steering gear is centered. See **Fig. 1**.

   3.3 Using an Allen wrench turn the adjusting screw and nut, without rotating the nut, into the steering gear housing until the nut is firmly against the housing. See **Fig. 5**. Tighten the nut 33 to 37 lbf·ft (45 to 50 N·m).

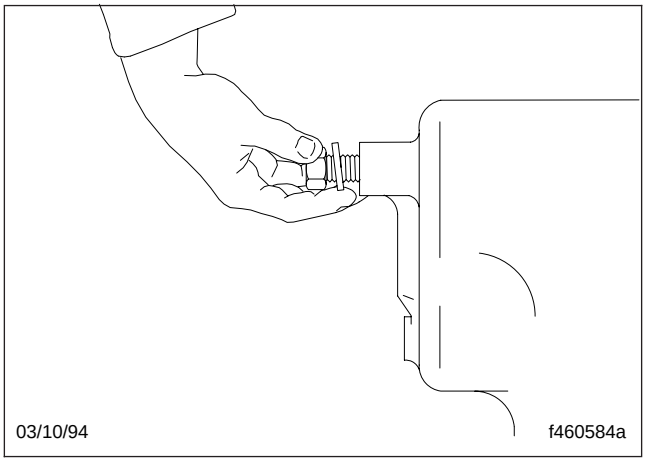


Fig. 4, Poppet Fixed Stopscrew

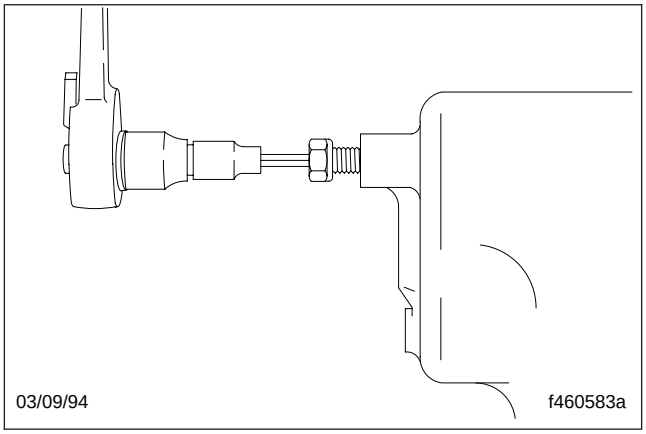


Fig. 5, Stopscrew Adjustment

NOTE: It may be necessary to move the sector shaft slightly from the straight-ahead position to assemble the service adjusting screw as instructed and then return it to straight ahead.

4. Adjust the poppets manually.

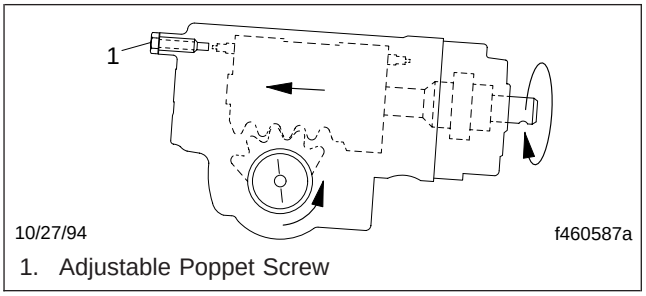
   4.1 Check the fluid level and fill the power steering reservoir with the power steering fluid specified in **Specifications 400**.

   4.2 Make sure the engine is off.

   4.3 Place a jack under the center of the front axle, and raise the steer tires off the ground.

   4.4 Turn the steering wheel to the right until the axle stopscrew contacts the axle stop,

or the end of the gear travel is reached. This pushes out the left-hand turn poppet to prepare it for setting. See **Fig. 6**.



1. Adjustable Poppet Screw

Fig. 6, Stopscrew Contact

4.5 Turn the steering wheel to the left until the left-hand stop makes contact. This sets the left-turn poppet. Release the steering wheel and do not steer again until the adjusting screw has been backed out and the sealing nut tightened.

4.6 Loosen the sealing nut on the gear housing and back out the adjusting screw until it is 1 to 1-1/16 inches (25 to 27 mm) beyond the sealing nut. See **Fig. 7**. Tighten the sealing nut 33 to 37 lbf·ft (45 to 50 N·m).

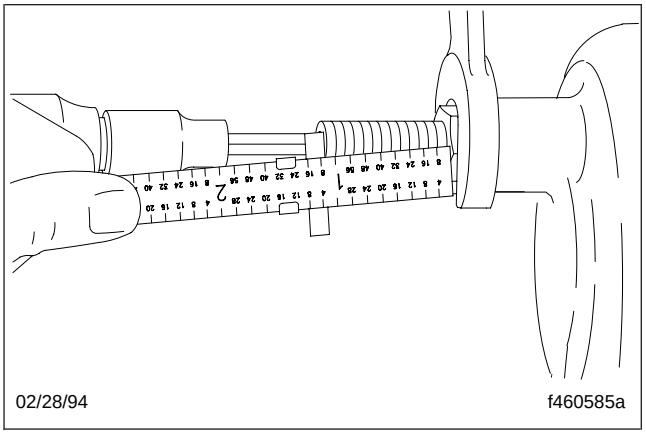


Fig. 7, Backing Out the Adjusting Screw

IMPORTANT: Make sure the adjusting screw does not protrude more than 1-1/16 inches (27 mm) beyond the sealing nut.

4.7 Have someone turn the steering wheel all the way to the right and hold it in place when the axle stops are contacted.

4.8 With the steering wheel held in place, loosen the sealing nut one turn, and while holding the sealing nut, turn the adjusting screw using an Allen wrench. Do not force the screw. Use one or two fingers and turn the Allen wrench until it comes to a stop. When this happens contact has been made with the poppet seat; **do not turn it any further**. Back out the screw 3-1/4 turns. Have the steering wheel released at this time.

4.9 While holding the adjusting screw in place, tighten the sealing nut firmly against the gear housing. See **Fig. 8**. Tighten it 33 to 37 lbf·ft (45 to 50 N·m).

Check the adjusting screw. If it extends more than 1-1/16 inches (27 mm) from the sealing nut, loosen the sealing nut, and turn the adjusting screw in as needed. Tighten the sealing nut 33 to 37 lbf·ft (45 to 50 N·m). See **Fig. 7** and **Fig. 8**.

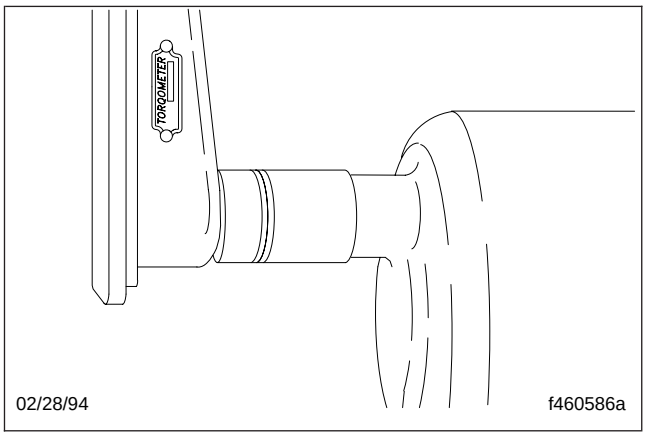


Fig. 8, Tighten the Sealing Nut

⚠ WARNING

If the adjusting screw protrudes more than 1-1/16 inches (27 mm) from the sealing nut, the screw could fall out of the steering gear, resulting in loss of power steering. This could cause an accident resulting in serious personal injury or property damage.

IMPORTANT: Once the poppet adjusting screw and sealing nut are in place and the poppet valves have been manually adjusted,

the adjustment procedure must be repeated if steering travel is either increased or decreased in the future.

Removal

IMPORTANT: Before removing the steering gear, see the troubleshooting procedures in **Section 46.11, Subject 300**.

1. Verify correct axle stop adjustment. For instructions, refer to **Group 33**. Ensuring correct axle stop adjustment now will eliminate the possibility of resetting steering gear poppet valves after the gear is reinstalled.
2. Place the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where the work is to be done. Apply the parking brakes and chock the tires.
3. Remove the left-hand bumper extension.
4. Clean all outside dirt from around the fittings and hose connections.
5. Drain the power steering system. Disconnect all hydraulic lines from the gear, marking the lines for later assembly reference. Seal the lines and the fittings to keep out dirt.
6. Disconnect the pitman arm from the steering gear sector shaft.
   - 6.1 Remove the pinch bolt, washer, and nut from the pitman arm. Discard the pinch bolt and nut. See **Fig. 1** or **Fig. 2**.
   - 6.2 Remove the pitman arm using a suitable puller, and swing the pitman arm and drag link out of the way.
7. Disconnect the steering driveline from the steering gear input shaft.
   - 7.1 Remove and discard the pinch bolt and nut from the steering driveline lower end yoke.

CAUTION

Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.

   - 7.2 Remove the lower end yoke from the input shaft.
8. Clean the entire assembly before removing the gear.

WARNING

The steering gear is heavy. Use caution when removing, lifting, or carrying the steering gear. Failure to do so could cause personal injury.

9. Remove the fasteners that attach the steering gear to the frame rail. Remove the steering gear.

Installation

1. Install the steering gear and fasteners as shown in **Fig. 3** or **Fig. 4**.

   Torque the 7/8–14 fasteners 278 to 352 lbf·ft (377 to 477 N·m).
2. If not previously done, center the steering gear. The sector (output) shaft alignment mark must be at a right angle to the steering gear input shaft centerline. Make sure the steering gear remains centralized as the service work continues.
3. Install the pitman arm.
   - 3.1 Position the pitman arm on the steering gear, aligning the timing mark as shown in **Fig. 5**.

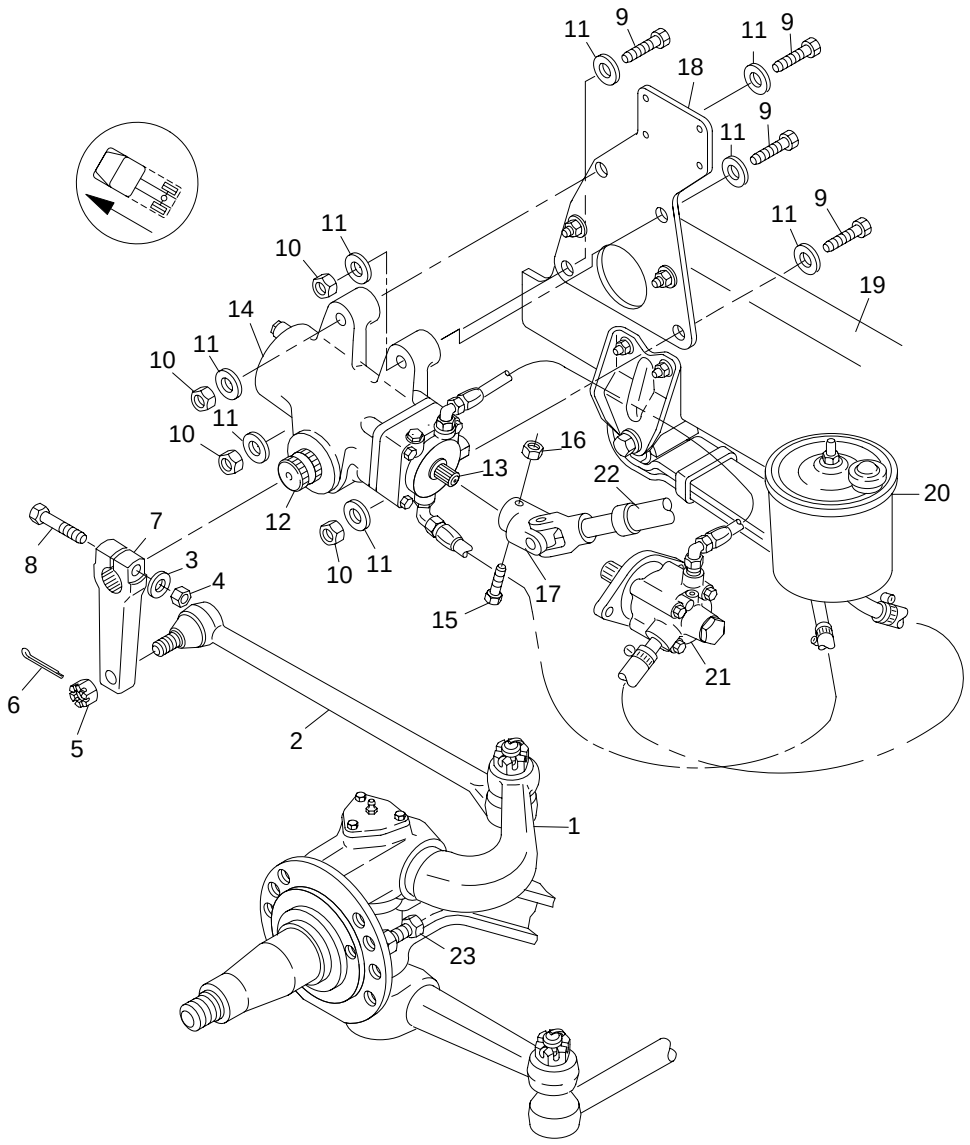
WARNING

Never leave a chisel wedged in the pitman arm slot. When using a chisel to spread the slot in the pitman arm, maintain a firm grip on the chisel at all times. Otherwise the chisel may fly loose, which could cause an injury.

NOTE: The pitman arm may not fit over the splines on the sector shaft without spreading the slot in the arm. Use a ball-peen hammer to drive a chisel into the slot. Hold the chisel in place. Install the pitman arm on the sector shaft. Remove the chisel from the slot.

   - 3.2 Install a new pinch bolt, washer, and nut. Tighten the nut to one of the following torque specs:
     - 120 to 140 lbf·ft (163 to 190 N·m) for a 5/8–14 nut
     - 215 to 245 lbf·ft (291 to 332 N·m) for a 3/4–16 nut

Steering Gear Removal and Installation



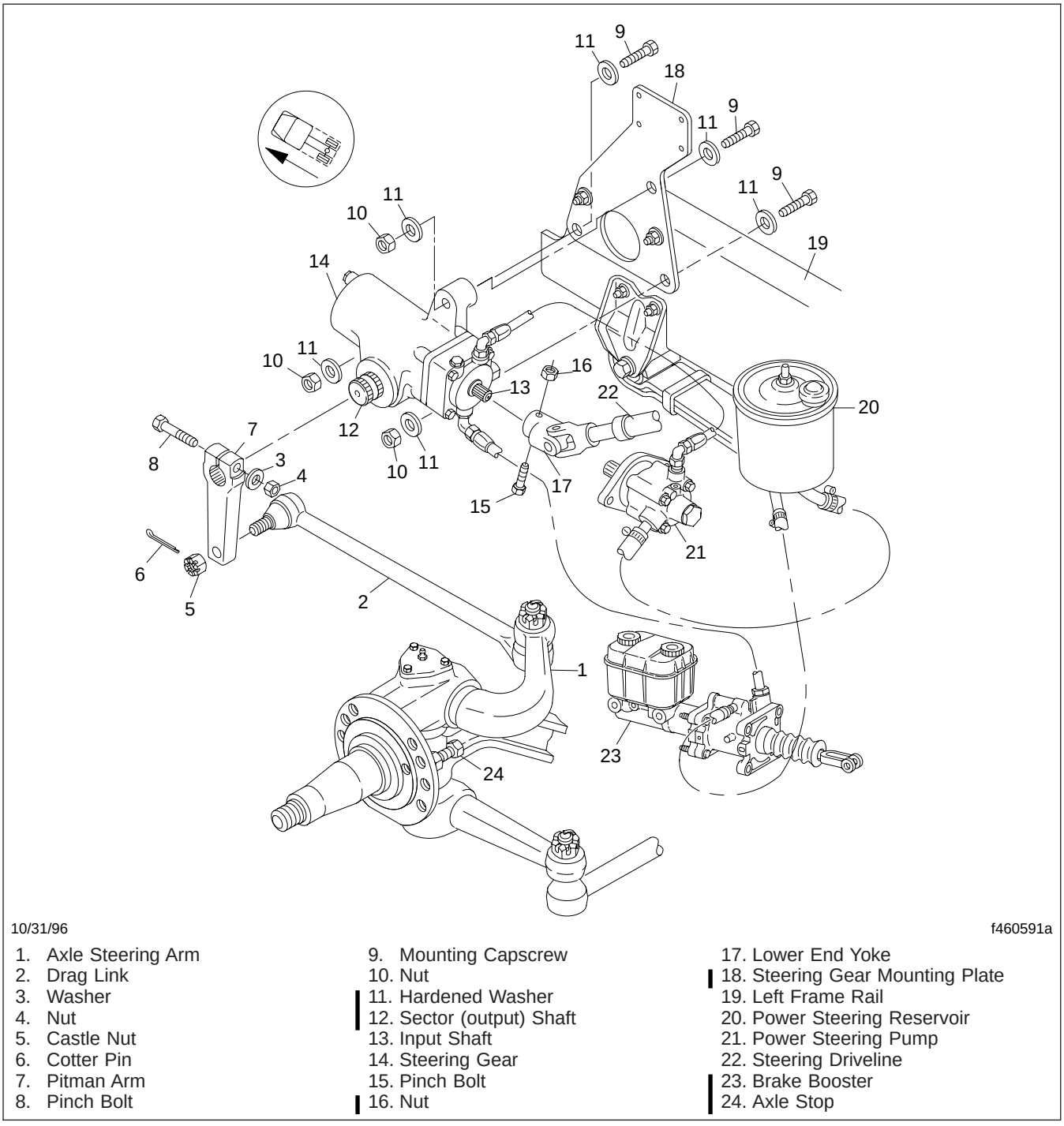
10/31/96 f460594a

1. Axle Steering Arm
2. Drag Link
3. Washer
4. Bolt Nut
5. Castle Nut
6. Cotter Pin
7. Pitman Arm
8. Pinch Bolt
9. Mounting Capscrew
10. Nut
11. Hardened Washer
12. Sector (output) Shaft
13. Input Shaft
14. Steering Gear
15. Pinch Bolt
16. Nut
17. Lower End Yoke
18. Steering Gear Mounting Plate
19. Left Frame Rail
20. Power Steering Reservoir
21. Power Steering Pump
22. Steering Driveline
23. Axle Stop

Fig. 1, TRW TAS85 Power Steering Installation (vehicles with air brakes)

3.3 Apply torque seal, OGP F900WHITE, to the exposed threads and to the nut.

4. Connect the steering driveline to the steering gear input shaft.



10/31/96 f460591a

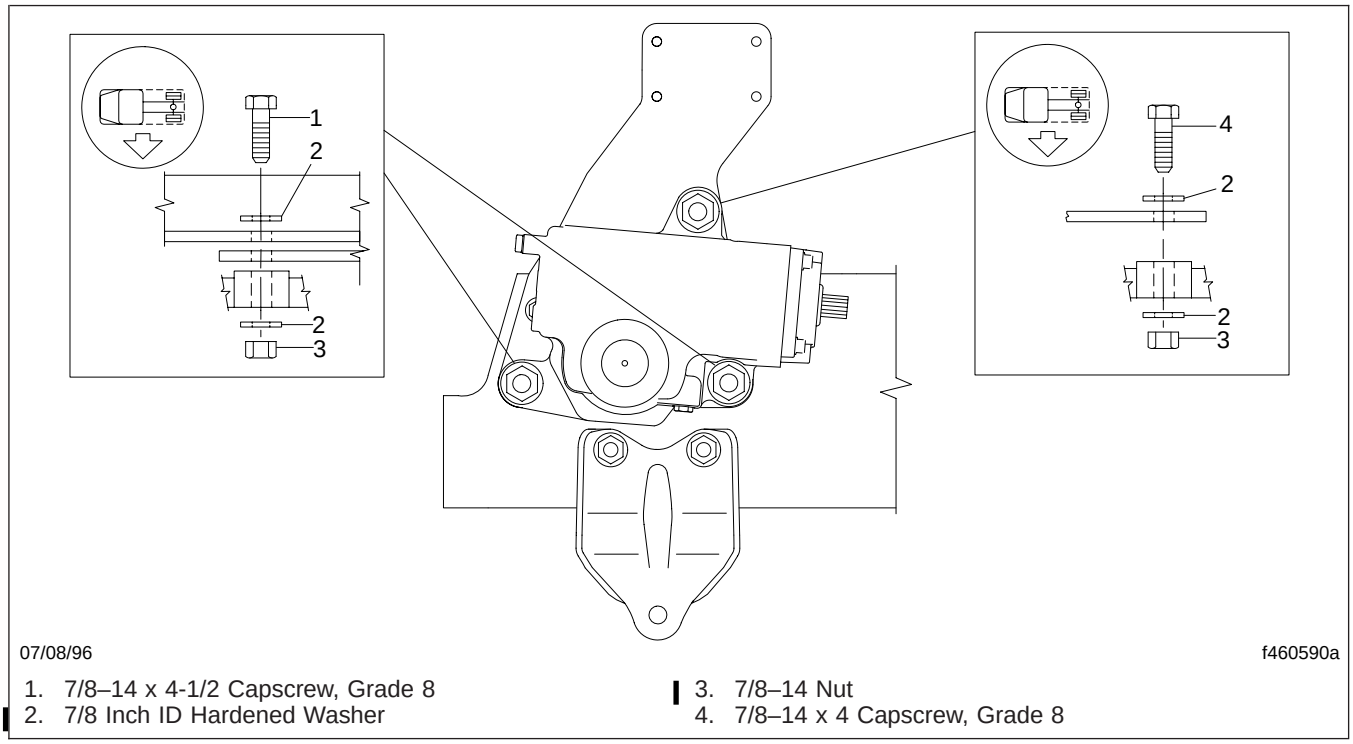
1. Axle Steering Arm
2. Drag Link
3. Washer
4. Nut
5. Castle Nut
6. Cotter Pin
7. Pitman Arm
8. Pinch Bolt
9. Mounting Capscrew
10. Nut
11. Hardened Washer
12. Sector (output) Shaft
13. Input Shaft
14. Steering Gear
15. Pinch Bolt
16. Nut
17. Lower End Yoke
18. Steering Gear Mounting Plate
19. Left Frame Rail
20. Power Steering Reservoir
21. Power Steering Pump
22. Steering Driveline
23. Brake Booster
24. Axle Stop

Fig. 2, TRW TAS40/55/65 Power Steering Installation (vehicles with hydraulic brakes)

4.1 Clean the steering gear input shaft and the inside of the driveline yoke.

4.2 Apply a thin film of grease to the yoke spline.

Steering Gear Removal and Installation



1. 7/8–14 x 4-1/2 Capscrew, Grade 8
2. 7/8 Inch ID Hardened Washer
3. 7/8–14 Nut
4. 7/8–14 x 4 Capscrew, Grade 8

Fig. 3, Steering Gear Installation, TAS40/55/65

4.3 Slide the yoke on the input shaft and install a new pinch bolt and nut. Tighten the nut to one of the following torque specs:

- 55 to 65 lbf·ft (75 to 88 N·m) for a 7/16–20 pinch bolt and nut
- 30 to 35 lbf·ft (41 to 47 N·m) for an M10 x 1.25 pinch bolt and nut

4.4 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and to the nut.

5. Connect the hydraulic lines.

5.1 If they were removed, attach the hydraulic line elbow fittings to the steering gear. Tighten the fittings 38 lbf·ft (51 N·m). Tighten the pressure line fitting jam nut 41 lbf·ft (56 N·m).

5.2 Remove the plugs from the hydraulic lines. Connect the lines to the steering gear as previously marked. Tighten the nut on each fitting finger-tight. Then, use a wrench to tighten the nut until there is firm resistance. Tighten one-sixth turn more.

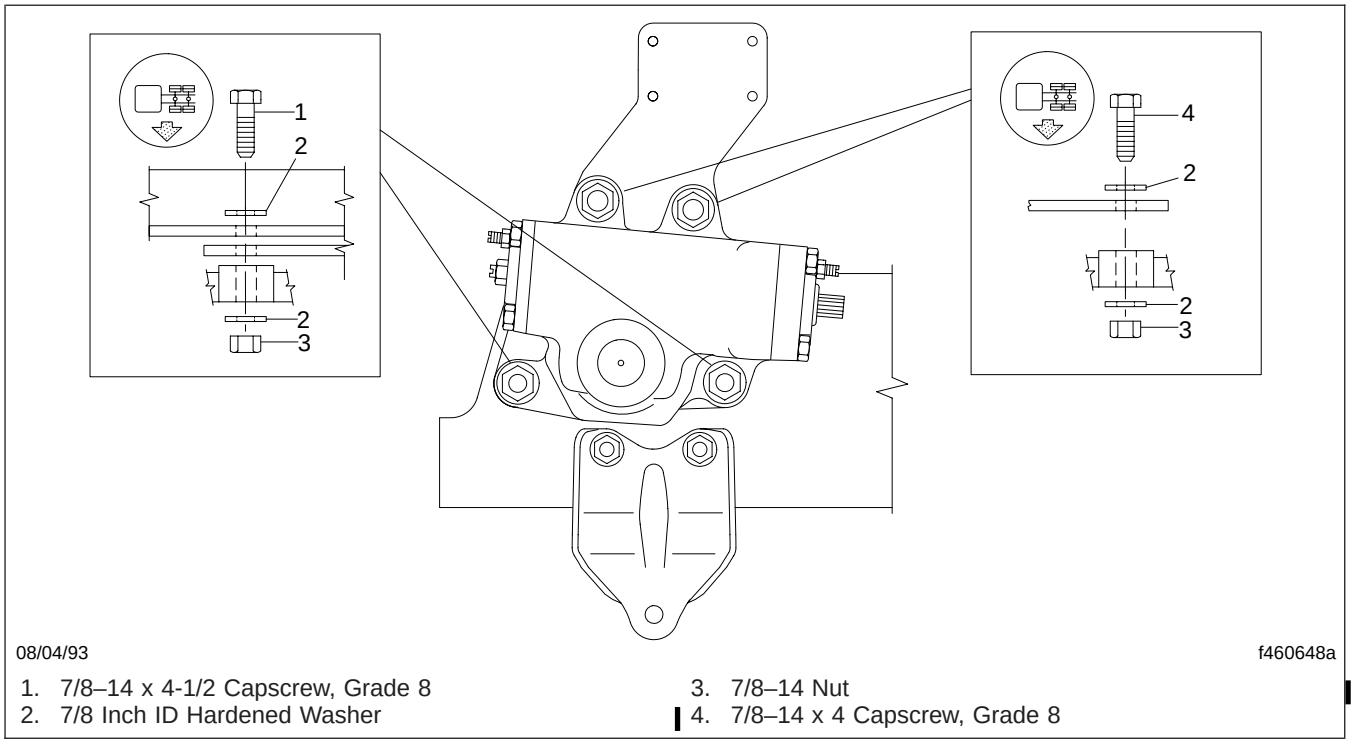
6. Fill and bleed the steering system.

IMPORTANT: Do not turn the steering wheel until instructed. Doing so can cause air to enter the system, which can make it more difficult and time-consuming to bleed air from the system.

6.1 Fill the power steering reservoir with the power steering fluid specified in **Specifications 400** until nearly full. Crank the starter for 10 seconds without allowing the engine to start. If the engine does start, shut it down immediately. Check and fill the reservoir as needed. Repeat this procedure three times, each time checking and filling the reservoir.

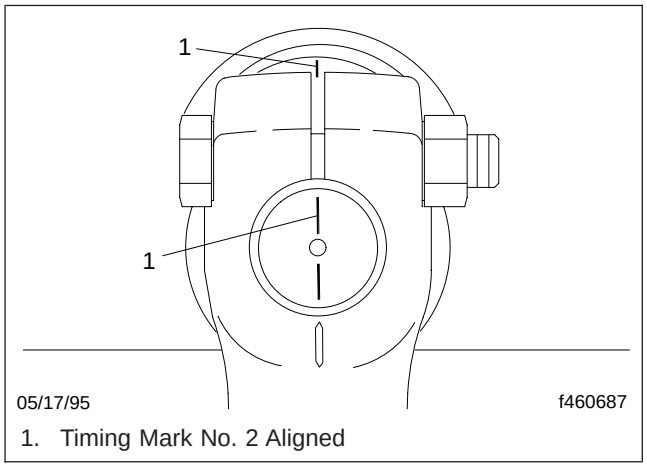
6.2 Start the engine and let it idle for two minutes. Shut down the engine, and check the fluid level in the reservoir.

6.3 Start the engine again. Steer the vehicle from full-left to full-right, several times. As necessary, add fluid to the full line on the reservoir dipstick.



1. 7/8–14 x 4-1/2 Capscrew, Grade 8
2. 7/8 Inch ID Hardened Washer
3. 7/8–14 Nut
4. 7/8–14 x 4 Capscrew, Grade 8

Fig. 4, Steering Gear Installation, TAS85



1. Timing Mark No. 2 Aligned

Fig. 5, Typical Pitman Arm and Timing Marks

IMPORTANT: If the poppet adjuster seat and sleeve assemblies were not set for automatic adjustment during the assembly of the steering gear, **and** if the axle stops have been adjusted for **decreased** steering travel or the steering gear is installed on a different vehicle, the poppets must be set manually following the procedure in **Subject 100**.

7. Go to **Subject 140** and do the checks as instructed.
8. Install the left-hand bumper extension.
9. Test drive the vehicle or take a ride with the driver.

   Check the steering wheel spoke position. With the front tires pointing straight ahead, check the position of the steering wheel spokes. They must be within ±10 degrees of the 4 o'clock and 8 o'clock positions. See **Fig. 6**. If not, remove the steering wheel and install it in the correct position. For instructions, refer to the applicable section in this group.

Steering Gear Removal and Installation

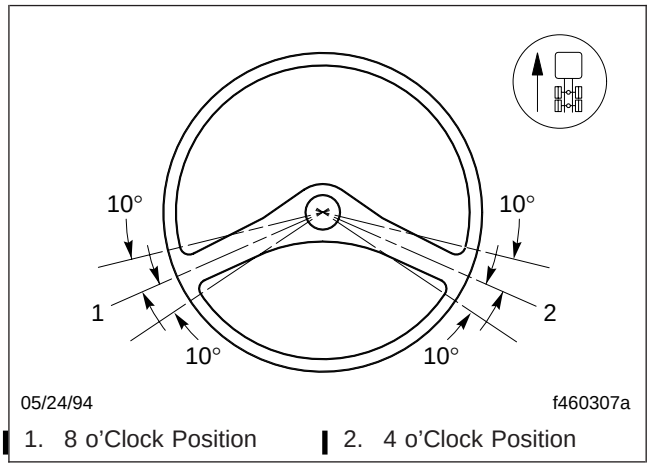


Fig. 6, Steering Wheel Centered

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

Disassembly

Be sure that required tools are available before beginning the service procedures described here. See the special tools table in **Specifications 400**. The special tools required for disassembly and assembly of the steering gear components are available from the SPX Kent-Moore or an affiliated dealer.

IMPORTANT: When the sector shaft is disconnected from the vehicle steering linkage, do not allow the input shaft to move more than 1-1/2 turns from the straight-ahead position. If the input shaft moves more than 1-1/2 turns, the initial setting of the poppet valves will be changed.

Make sure that the steering gear is placed on a clean surface. Clean and dry the gear before disassembly. As the gear is disassembled, clean all parts in a clean, petroleum-based solvent, and blow-dry them only.

Never steam clean or high-pressure wash the hydraulic steering components. Do not force or abuse closely fitted parts. Doing so could cause damage to steering system parts.

Keep each part separate to avoid nicks and burrs. Discard all seals, O-rings, and gaskets, and replace them with new parts.

See **Fig. 1** for an exploded, assembly drawing of the steering gear.

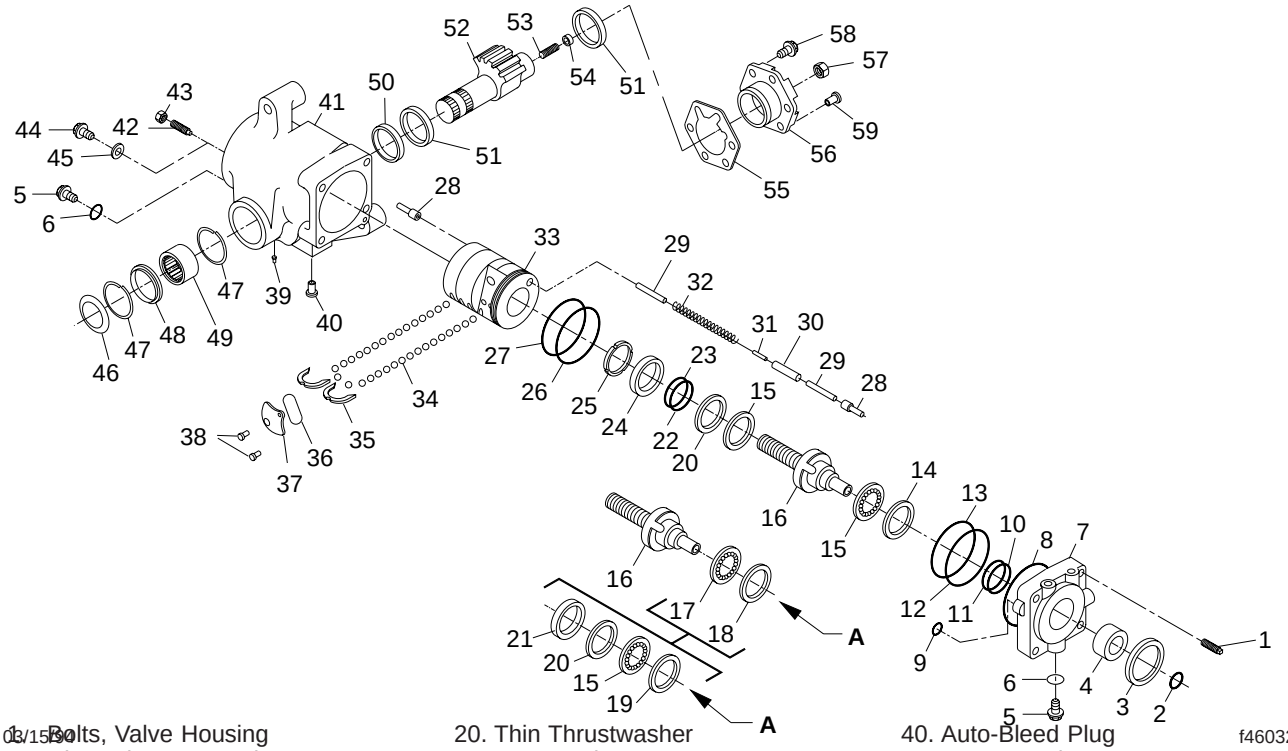
1. Place the steering gear in a vise so that the output shaft is horizontal. Clamp the gear at the mounting flange.
2. Put a basin under the hydraulic ports, and remove both hydraulic port plugs from the gear.
3. Using a 3/4-inch or 11/16-inch socket wrench, turn the input shaft so that the timing mark on the end of the sector shaft is lined up with the timing mark on the end of the housing trunnion. See **Fig. 2**.
4. Remove sector shaft/side cover assembly.
   - 4.1 Using a small screwdriver, remove and discard the water seal from the housing trunnion. See **Fig. 3**. Remove any dirt, paint, or corrosion from the sector shaft with a piece of fine emery cloth. See **Fig. 4**.
   - 4.2 Tape the splines and the bolt groove of the sector shaft, using one layer of masking tape. See **Fig. 5**.
   - 4.3 Using a 3/4-inch socket, remove the jam nut from the sector shaft adjusting screw. See **Fig. 6**.
   - 4.4 Put a container under the side cover to catch any drainage, then remove the special bolts from the side cover. See **Fig. 7**.

     IMPORTANT: These special bolts are equipped with either an integral ring or washer on the underside of the head. See **Fig. 8**. If replacing one or more bolts, use bolts of the same **type and length** as those that were removed. Do not use a substitute; do not mix different types of bolts.
   - 4.5 Remove the side cover and the sector shaft assembly as a unit from the steering gear housing. See **Fig. 9**. If necessary, start the removal by tapping the end of the sector shaft with a rubber or wooden mallet. Remove and discard the side cover gasket.
5. Disassemble the sector shaft/side cover assembly.
   - 5.1 Using a screwdriver, screw the sector shaft adjusting screw into the side cover and remove. See **Fig. 10**.
   - 5.2 Remove the sector shaft from the side cover.
   - 5.3 Remove the side cover seal.

     IMPORTANT: Be careful when you are removing the side cover seal or you may damage the side cover bore, the DU bushing (if a TAS40/55/65 model), or the bearing (if a TAS85 model).
   - 5.4 Screw a 1/2–20 x 3 bolt into the hole in the side cover where the sector shaft adjusting screw was.

     Make sure the bolt is in far enough so that it will support a rolling head (lady-foot) type pry bar. See **Fig. 11**.
   - 5.5 With the pry bar supported by the bolt end, pry up the side cover seal and re-

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments



1. Bolts, Valve Housing
2. Dirt and Water Seal
3. Retaining Ring
4. Seal
5. Auxiliary Port Plug
6. O-Ring, Auxiliary Port Plug
7. Valve Housing and Ball Plug Assembly
8. Large Seal Ring
9. Small Seal Ring
10. O-Ring
11. Seal Ring
12. Valve Housing O-Ring
13. Seal Ring
14. Thick Thrustwasher
15. Roller Thrust Bearing
16. Input Shaft/Valve/Worm Assembly
17. Ball Bearing Assembly (valve/worm)
18. Ball Bearing Race
19. Thick Thrustwasher
20. Thin Thrustwasher
21. Spacer Sleeve
22. Seal Ring
23. O-Ring
24. Bearing Adjuster
25. Adjuster Locknut
26. Rack Piston Seal Ring
27. O-Ring (backup)
28. Poppet Adjuster Seat and Sleeve Assembly
29. Poppet
30. Push Tube
31. Spacer Rod
32. Poppet Spring
33. Rack Piston
34. Steel Ball
35. Ball Return Guide Halves
36. Ball Return Guide Cap Seal
37. Ball Return Guide Cap
38. Torx Screws
39. Grease Fitting
40. Auto-Bleed Plug
41. Gear Housing
42. Service Poppet Adjusting Screw
43. Service Sealing Jam Nut
44. Fixed Stopscrew, Poppet
45. Washer, Stopscrew
46. Dirt and Water Seal (trunnion)
47. Retaining Ring
48. Dirt Seal
49. Roller Bearing
50. Washer (spacer)
51. Output Seal
52. Sector Shaft
53. Shaft Adjusting Screw
54. Adjusting Screw Retainer
55. Side Cover Gasket
56. Side Cover and Bushing Assembly
57. Jam Nut
58. Special Bolts, Side Cover
59. Side Cover Vent Plug

03/15/04 f460320a

Fig. 1, Steering Gear Assembly

move it. Discard the side cover seal and remove the 3-inch bolt from the side cover.

5.6 Remove and discard the vent plug from the side cover.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

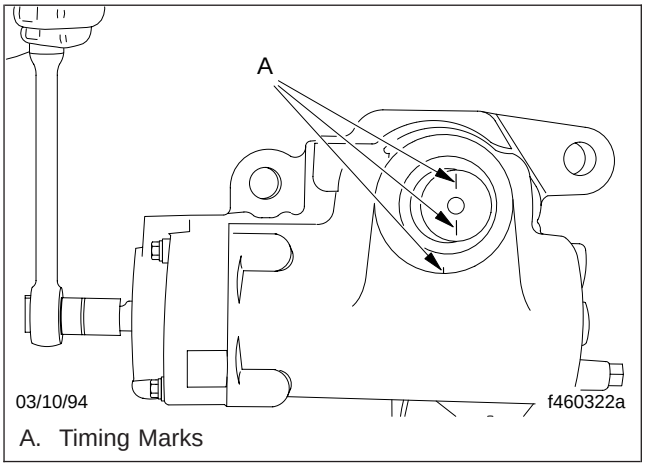


Fig. 2, Line Up the Timing Marks

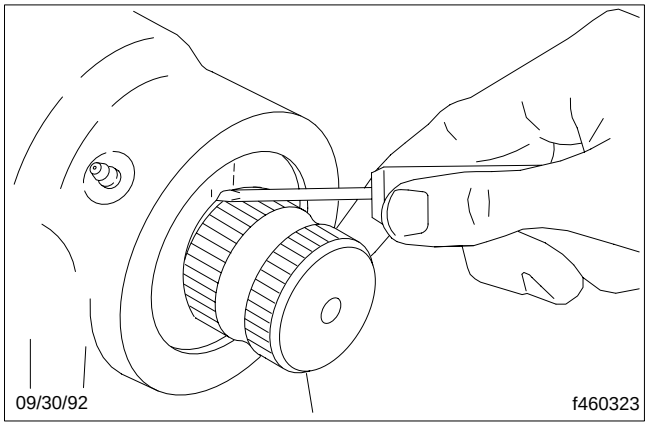


Fig. 3, Remove the Water Seal

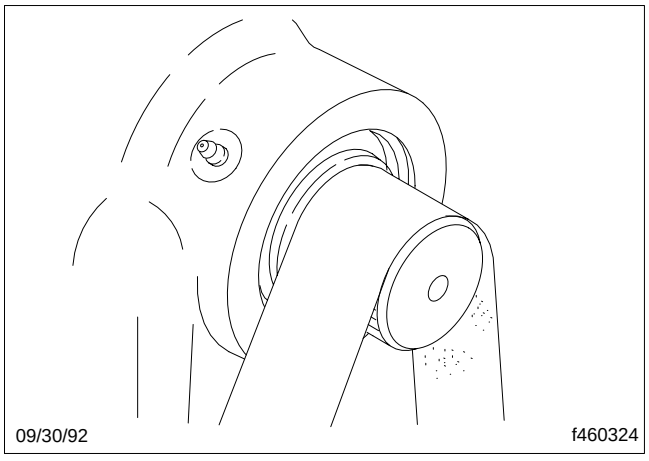


Fig. 4, Clean the Sector Shaft

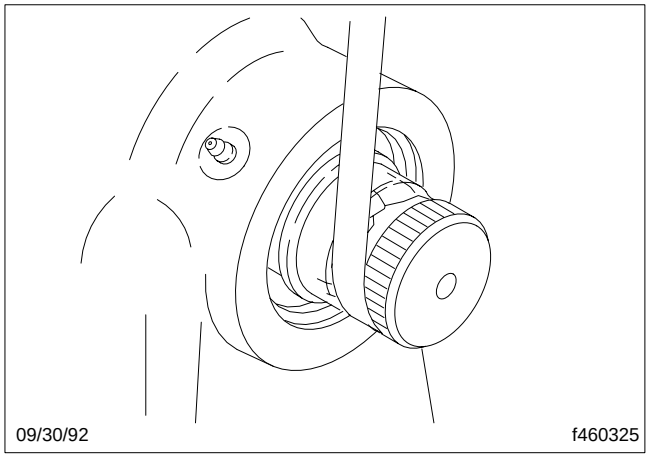


Fig. 5, Tape the Splines and the Bolt Groove

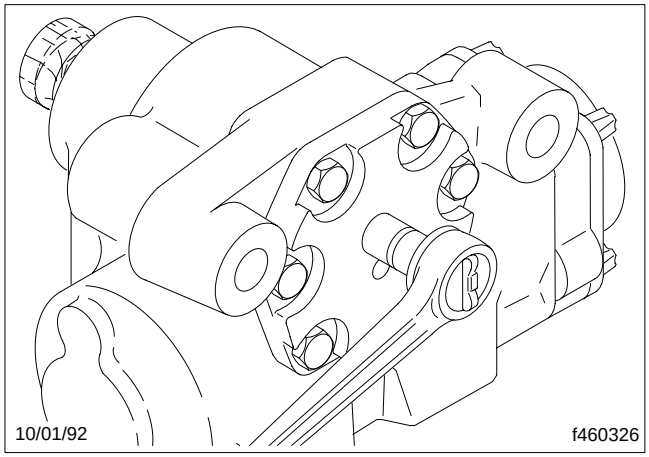


Fig. 6, Remove the Jam Nut

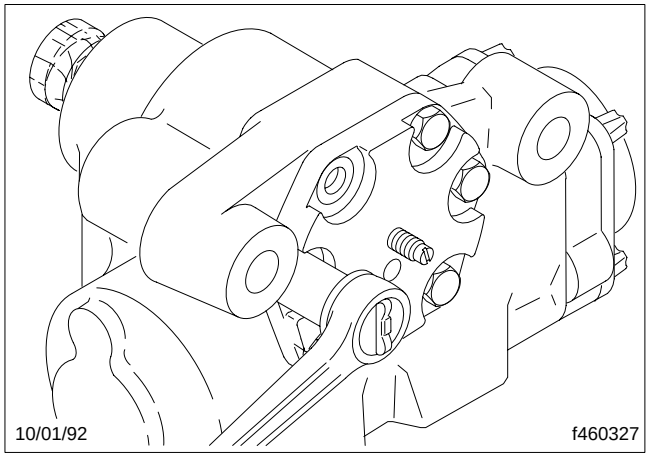


Fig. 7, Remove the Bolts

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

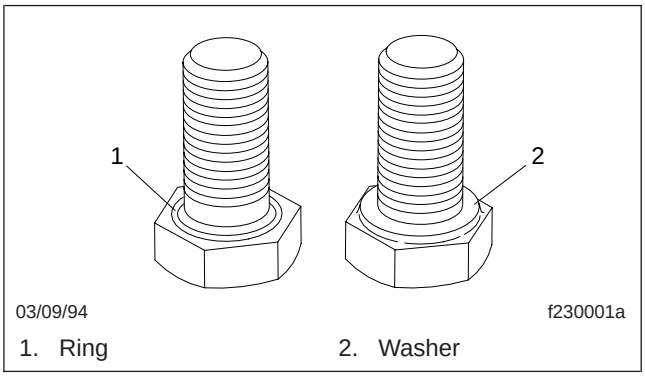


Fig. 8, Bolts With Ring or Washer

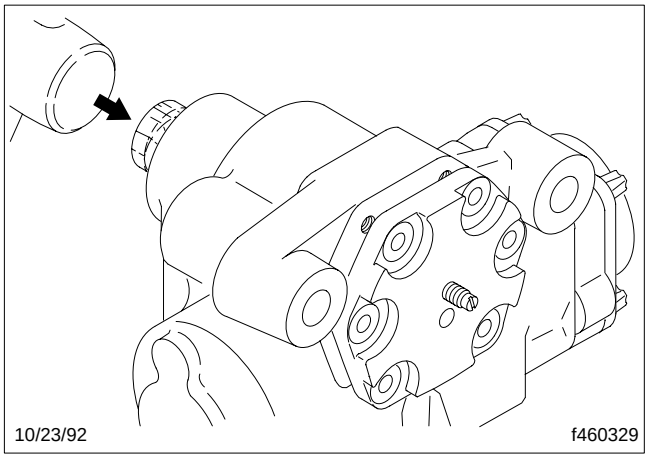


Fig. 9, Remove the Side Cover and Sector Shaft Assembly

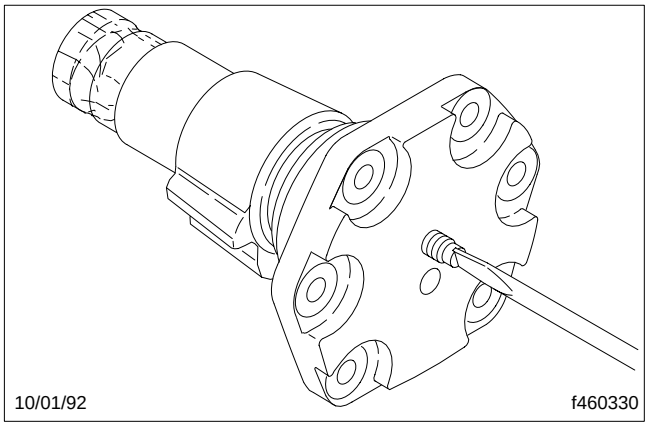


Fig. 10, Disassemble the Sector Shaft/Side Cover Assembly

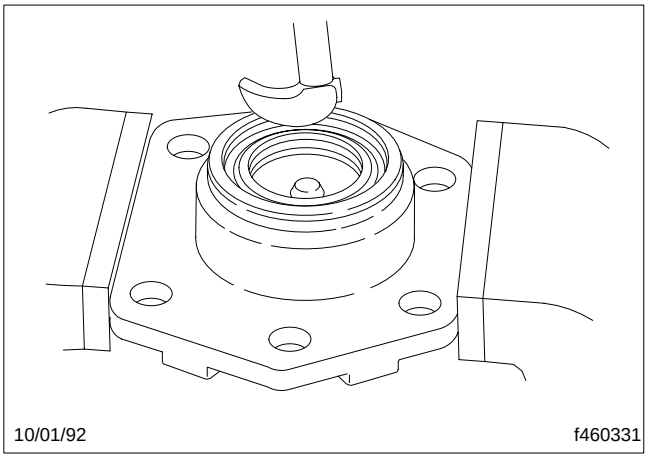


Fig. 11, Rolling Head Pry Bar

6. Remove the adjusting screw if required. Removal is required only if deemed necessary after the inspection procedure.

   6.1 Put the sector shaft in a padded vise and, using a chisel, unstake the adjusting screw retainer. See **Fig. 12**.

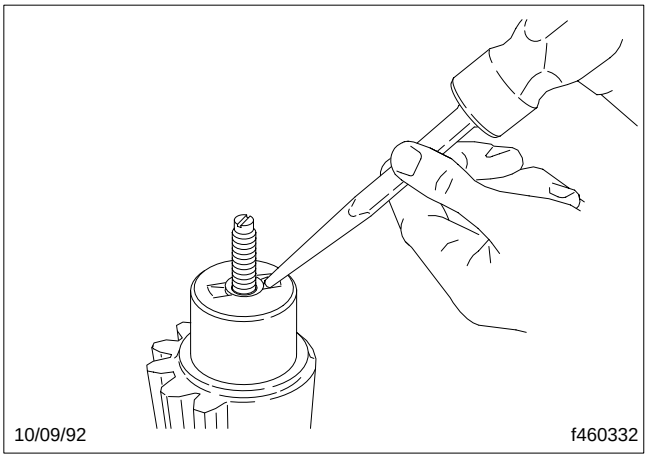


Fig. 12, Unstake the Adjusting Screw Retainer

   6.2 Unscrew the retainer and remove it from the sector shaft.

   6.3 Remove the adjusting screw. Discard the retainer.

7. If equipped with relief valve components, remove the relief valve cap, the O-ring, and the two-piece relief valve from the valve housing. Discard the O-ring.

8. Remove the input shaft, valve housing, and rack piston.

   8.1 Remove and discard the dirt and water seal from the input shaft. Clean the exposed part of the input shaft, using a fine grade emery cloth. See **Fig. 13**.

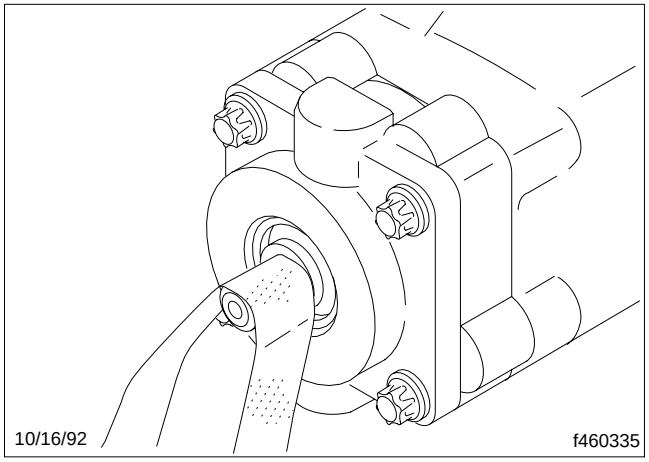


Fig. 13, Clean the Input Shaft

   8.2 Using an E-16 Torx® socket wrench, remove the four valve housing bolts. See **Fig. 14**.

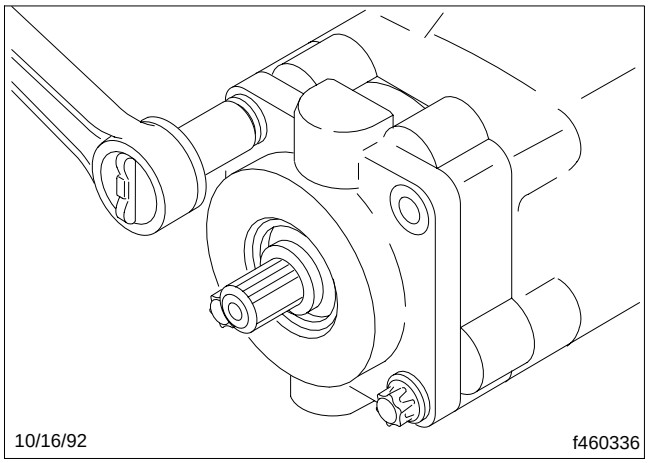


Fig. 14, Remove the Valve Housing Bolts

   8.3 Remove the valve housing from the main gear housing, together with the worm shaft and rack piston assembly. See **Fig. 15**. Set the assembly on a clean bench.

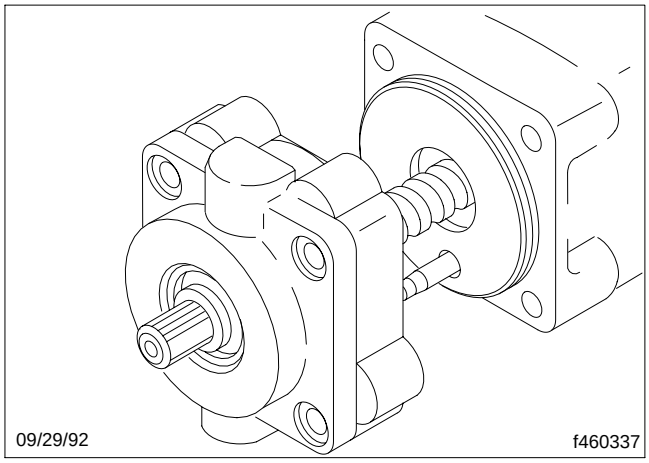


Fig. 15, Remove the Valve Housing

   8.4 Remove and discard the seal rings from the valve housing.

   IMPORTANT: If you are not going to remove, reset, or replace the poppet valves on the steering gear, make sure that the setting for them is not accidentally changed. Mark the gear, identifying the vehicle from which it was removed, and note that the poppet valve adjustments are for that particular vehicle.

9. Remove the steel balls.

   9.1 Remove the two sealing screws holding the ball return guide cap to the rack piston. See **Fig. 16**.

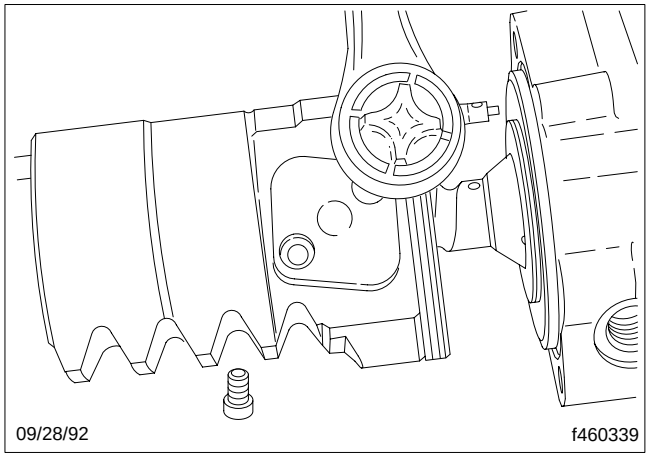


Fig. 16, Remove the Sealing Screws

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

9.2 Remove the cap and its seal. See **Fig. 17**. Discard the two screws and the seal.

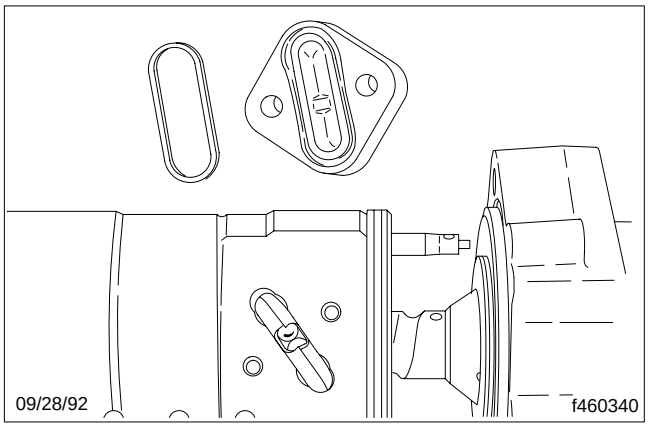


Fig. 17, Remove the Cap and Seal

9.3 Remove the ball return guide halves from the rack piston by carefully prying up on them with a screwdriver. See **Fig. 18**.

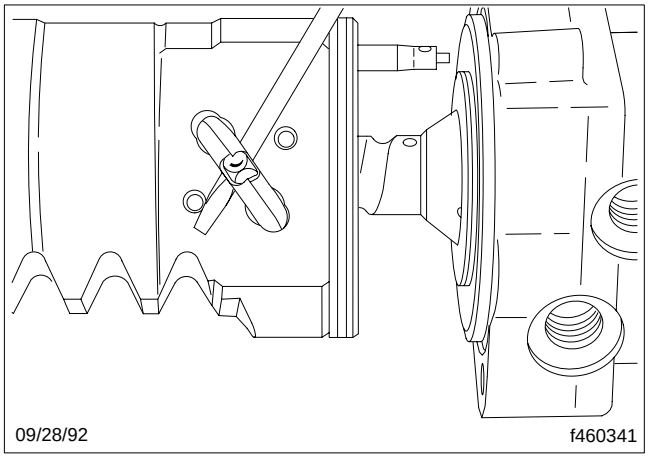


Fig. 18, Remove the Ball Return Guide Halves

9.4 Remove the 29 (TAS40), 31 (TAS55), 32 (TAS65), or 34 (TAS85) steel balls from the rack piston by turning the worm shaft until all of them are out. See **Fig. 19**. **Do not lose any of these balls or you will have to replace the entire set.**

10. Remove the worm shaft and valve housing assembly from the rack piston. See **Fig. 20**.

11. Cut and remove the Teflon® seal ring and the O-ring from the rack piston. See **Fig. 21**.

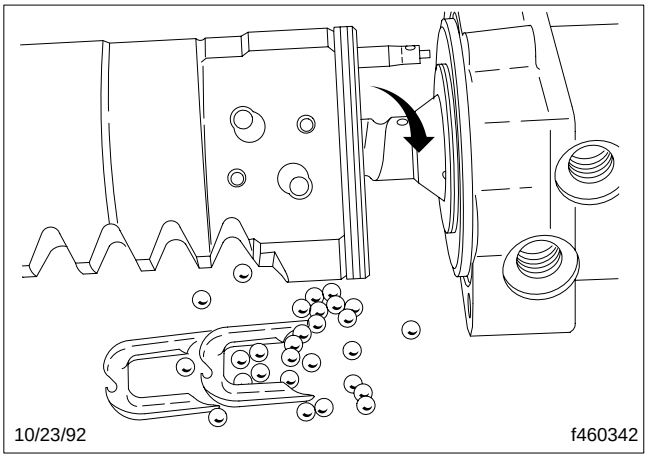


Fig. 19, Remove the Steel Balls

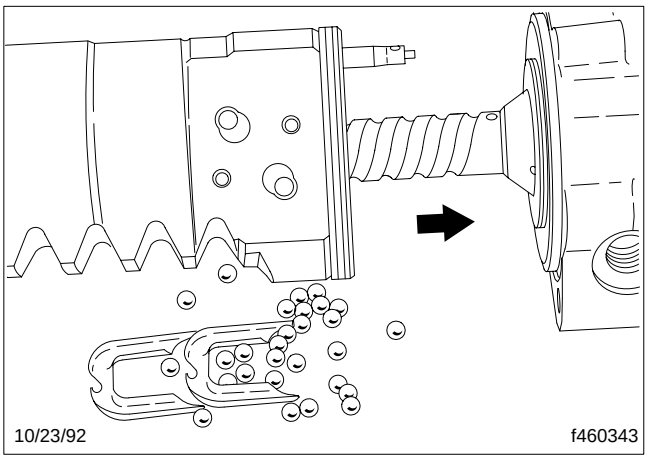


Fig. 20, Remove the Worm Shaft and Valve Housing Assembly

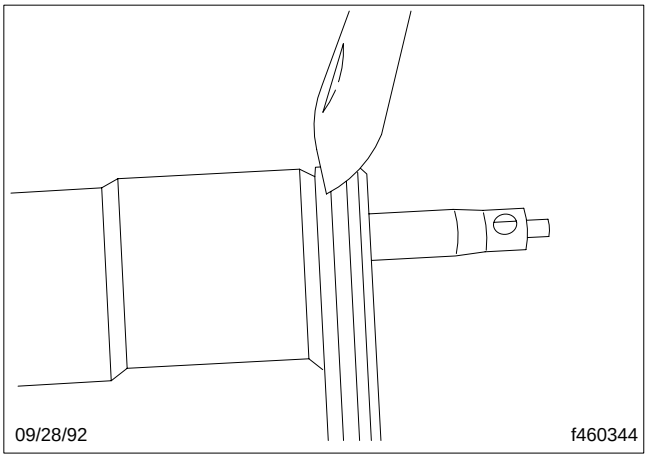


Fig. 21, Remove the Seal Ring and the O-Ring

12. If replacing poppet assemblies, remove the poppet valve assemblies.

    IMPORTANT: Do not use special tool J38713 on a rack piston that does not have a counterbore in the hole for the seat and sleeve assembly.

    12.1 Put the rack piston in a padded vise.

    12.2 Slide the special tool J38713 (preferred) or J36452 over the poppet adjuster seat, then turn the tool so that its prongs fit into the slot on the threaded adjustment sleeve. See **Fig. 22**. Hit the end of the tool firmly four or five times with a 16 oz. hammer to loosen the Loctite®. See **Fig. 23**.

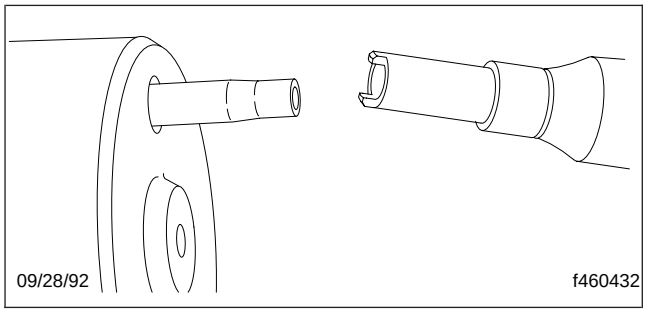


Fig. 22, Slide the Tool Over the Poppet Adjuster

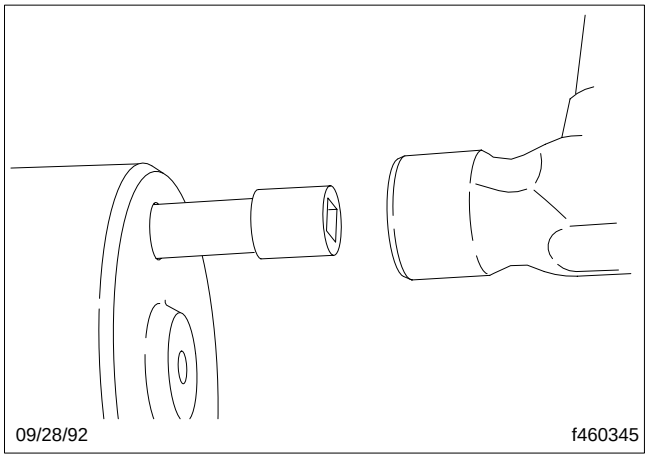
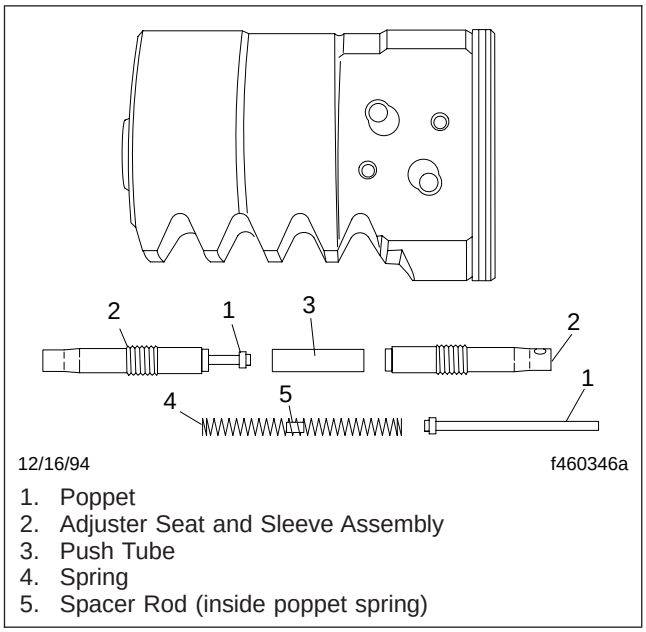


Fig. 23, Use the Tool to Loosen the Loctite®

    12.3 Using a breaker bar, unscrew the adjuster seat and sleeve assemblies from the rack piston. If the assembly will not loosen, hit the end of the tool several more times with a hammer.

    12.4 Remove both poppets, and the spring, spacer rod, and push tube. See **Fig. 24**.

    Repeat the above steps for the other poppet adjuster seat and sleeve assembly.



1. Poppet
2. Adjuster Seat and Sleeve Assembly
3. Push Tube
4. Spring
5. Spacer Rod (inside poppet spring)

Fig. 24, Remove the Poppets Spring, Spacer Rod, and Push Tube

13. Disassemble the valve housing if needed.

    IMPORTANT: Do not disassemble the valve housing unless you find signs of extreme heat, internal leakage, bearing damage or roughness, or if the worm shaft preload adjustment is needed.

    13.1 Put the worm shaft and valve housing assembly into a padded vise, with the worm shaft in a vertical position as shown in **Fig. 25**.

    13.2 Unstake the adjuster locknut, using a punch. See **Fig. 25**.

    13.3 Using special tools J37464 and J37070 with a breaker bar, unscrew the adjuster locknut, then the bearing adjuster from the valve housing. See **Fig. 26**.

    NOTE: The bearing adjuster has either two slots or two drill points on its face. Special

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

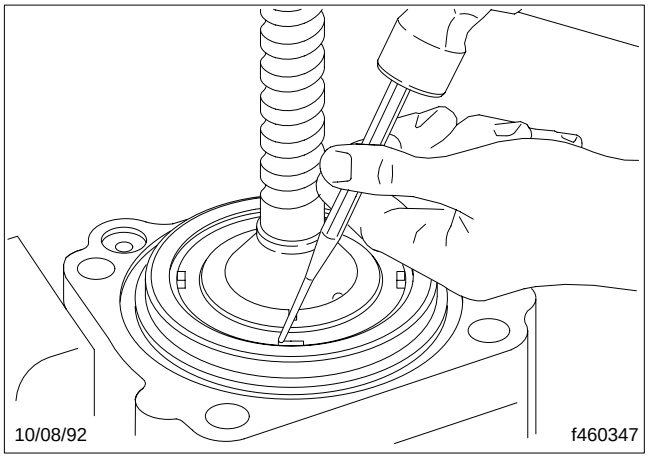


Fig. 25, Unstake the Adjuster Locknut

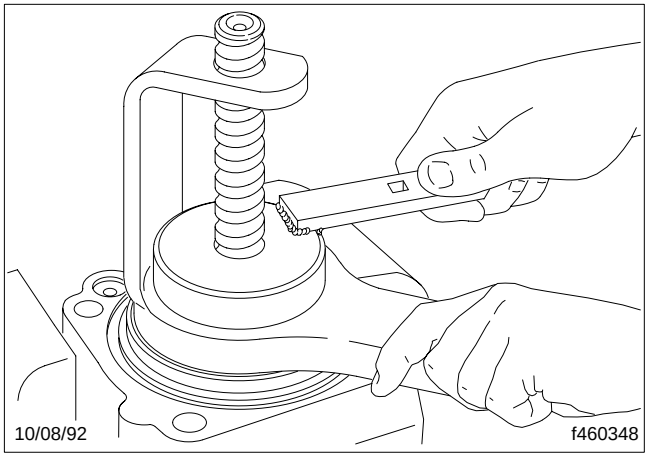


Fig. 26, Unscrew the Adjuster Locknut

tool J37070 can be used for removing and installing either style of bearing adjuster. See **Fig. 26**.

13.4 Remove and discard the seal ring and the O-ring from the bearing adjuster. See **Fig. 27**.

13.5 Remove the thin washer, thrust bearing, input shaft, rotary valve, and worm shaft assembly from the valve housing. See **Fig. 28**.

IMPORTANT: Do not disassemble the input shaft or worm shaft assembly any further. These are not serviceable.

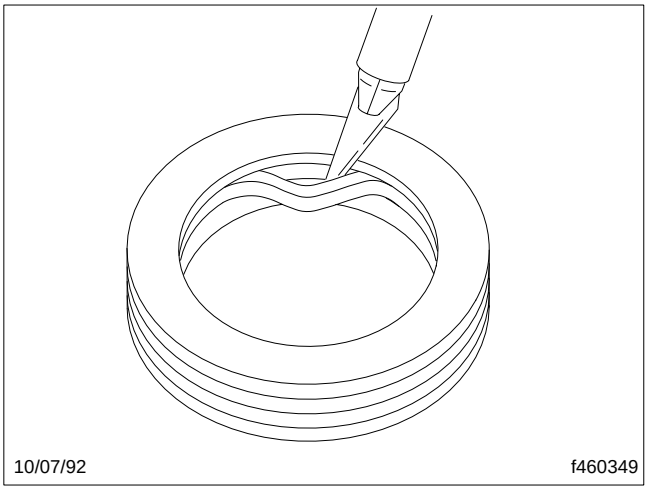


Fig. 27, Remove the Seal Ring

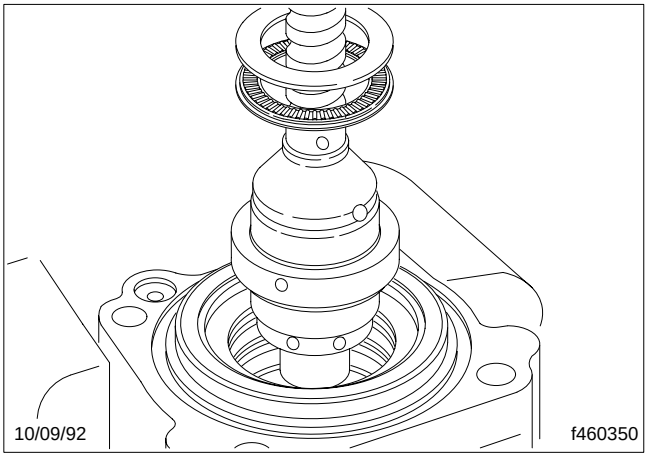


Fig. 28, Remove the Washer, Thrust Bearing, Input Shaft, Rotary Valve, and Worm Shaft Assembly

13.6 Remove the roller thrust bearing assembly and the thick thrustwasher from the valve housing. See **Fig. 29**.

13.7 Using a small knife, a probe, or a pick, remove and discard the seal rings and O-rings from the valve housing. See **Fig. 30**.

13.8 Turn the valve housing over and remove the retaining ring. See **Fig. 31**.

13.9 Using a 1-1/8 inch socket, tap out the seal from the valve housing. See **Fig. 32**. Discard the seal.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

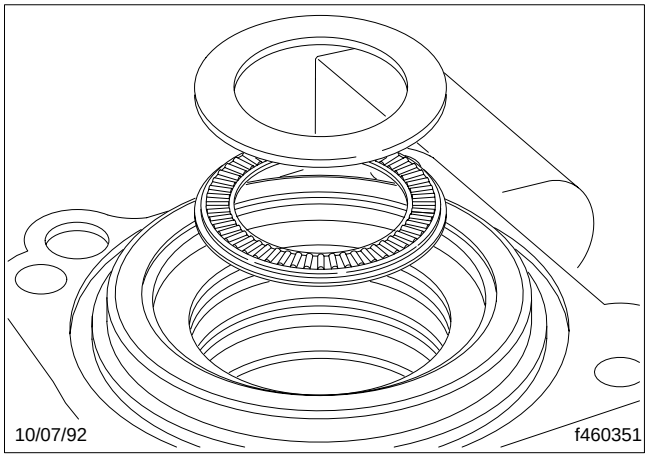


Fig. 29, Remove the Roller Thrust Bearing Assembly

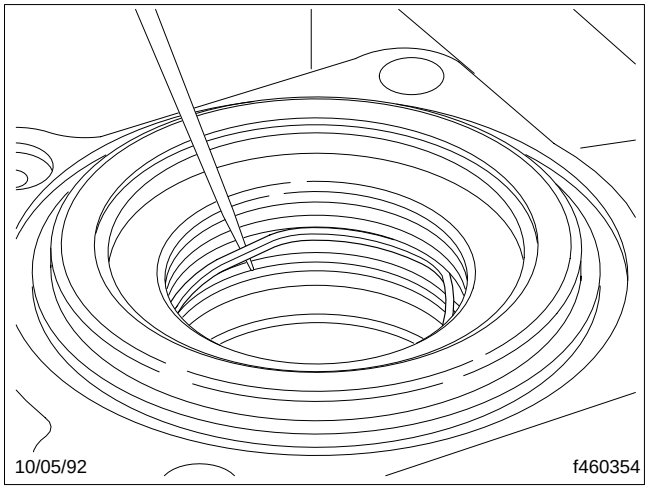


Fig. 30, Remove the Seal Rings and O-Rings

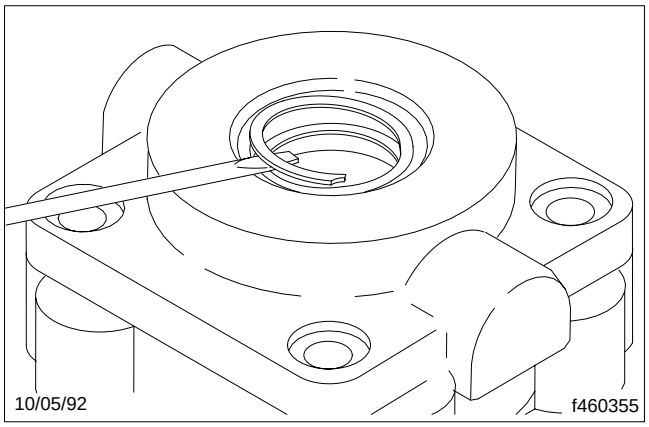


Fig. 31, Remove the Retaining Ring

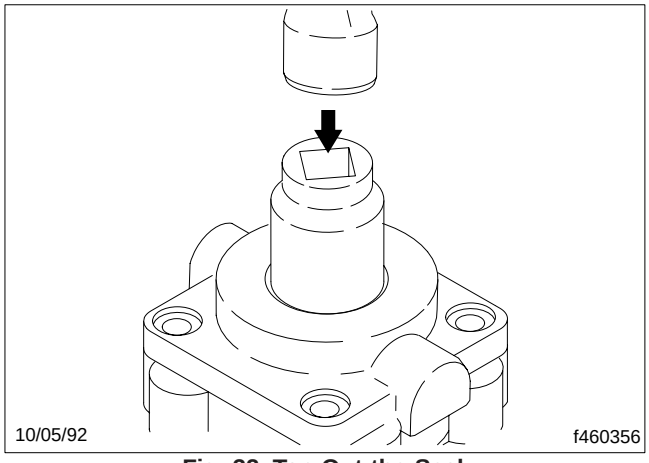


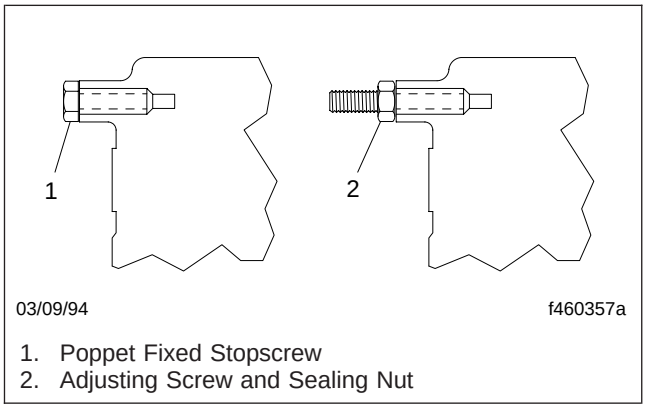
Fig. 32, Tap Out the Seal

13.10 If replacing either of the auxiliary port plugs, remove them. Be sure to remove and discard the O-rings.

14. Disassemble the housing.

NOTE: The steering gear is equipped with either a poppet fixed stopscrew, or an adjusting screw and sealing nut. See **Fig. 33**.

14.1 If the poppet fixed stopscrew needs replacement, remove it.



1. Poppet Fixed Stopscrew
2. Adjusting Screw and Sealing Nut

Fig. 33, Steering Gear Adjusting Screws

14.2 If the adjusting screw and sealing nut need replacing, remove them.

14.3 Remove the retaining ring from the output end of the housing trunnion. See **Fig. 34**.

14.4 Remove and discard the dirt seal. See **Fig. 35**.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

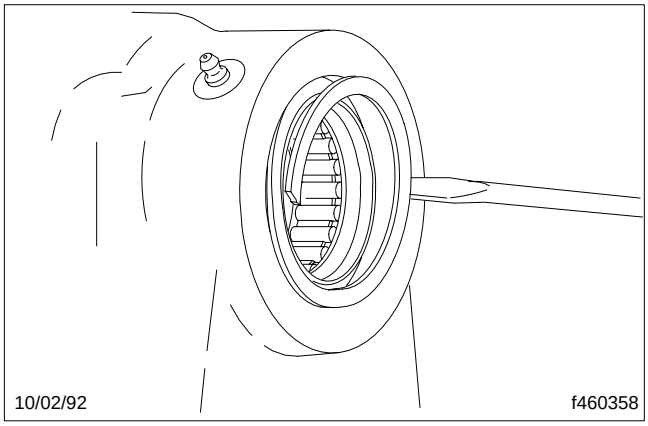


Fig. 34, Remove the Retaining Ring

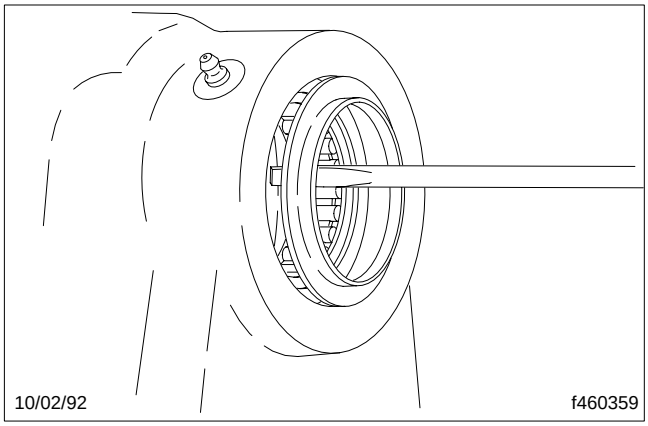


Fig. 35, Remove the Dirt Seal

14.5 Insert a screwdriver into the gear housing, and carefully push the seal and the spacer washer out of the other end of the bearing bore. See **Fig. 36**. Be careful not to damage the sealing area of the bore. Discard the seal.

14.6 If replacing the roller bearing in the housing, remove it using special tool J37705 (TAS40), J37071 (TAS55/65), or J38779 (TAS85). Press the roller bearing out of the trunnion end of the housing from the side of the bore where the side cover was attached. See **Fig. 37**.

14.7 If replacing the retaining ring, remove it through the trunnion end opposite the end where the side cover was attached. See **Fig. 38**. Be careful not to damage the pressure seal bore area.

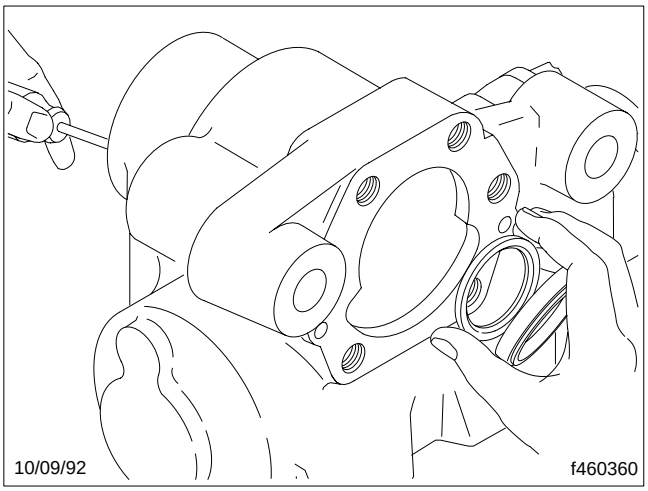


Fig. 36, Remove the Seal and Spacer Washer

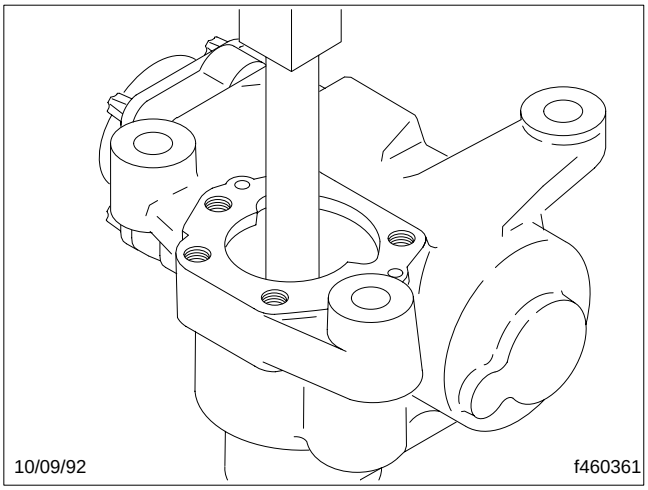


Fig. 37, Press the Roller Bearing Out of the Housing

Inspection

All sealing surfaces and seal cavities must be free of nicks and corrosion. If any part is nicked or corroded where sealing occurs, the part must be replaced to ensure proper sealing.

Wash all parts in a clean petroleum-based solvent. Blow-dry them with air.

1. Inspect the rack piston teeth for cracks and wear. See **Fig. 39**. If a step can be detected by running your fingernail horizontally across the teeth surfaces, the rack piston, the sector shaft, and the set of steel balls must be replaced.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

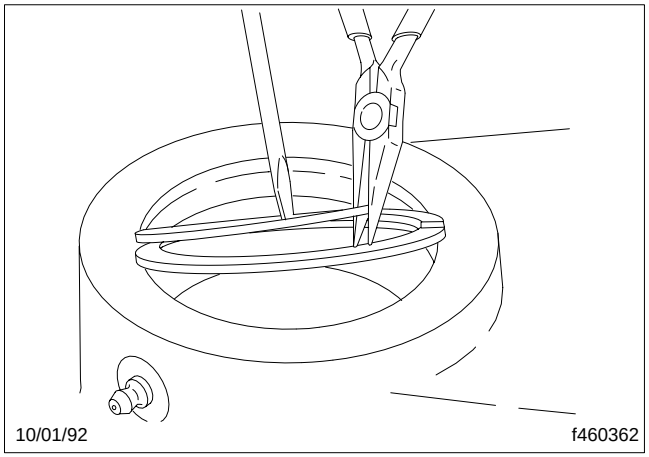


Fig. 38, Remove the Retaining Ring

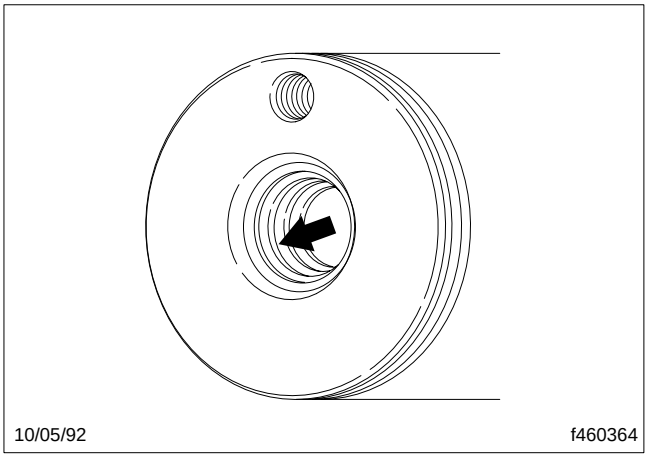


Fig. 40, Inspect the Rack Piston

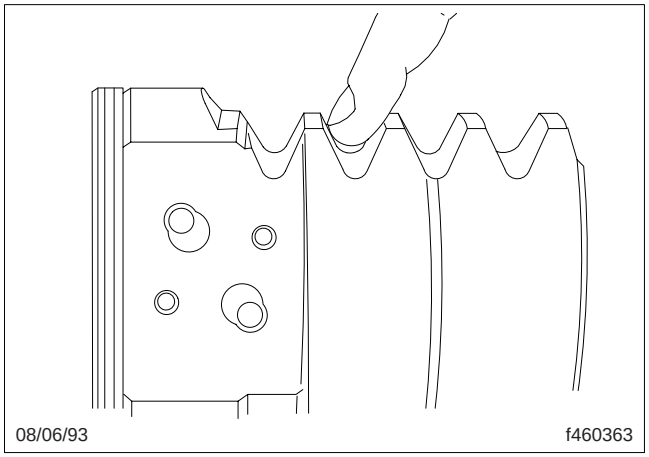


Fig. 39, Inspect the Rack Piston Teeth

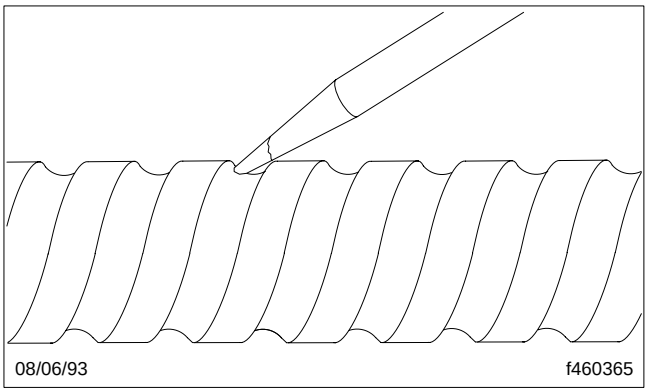


Fig. 41, Inspect the Worm Shaft

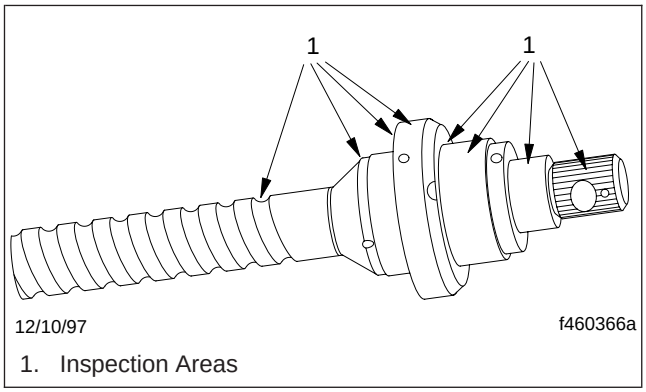


Fig. 42, Inspection Areas on the Upper Worm Shaft

2. Inspect the rack piston internal ball-track grooves for brinelling (dents) or spalling (flaking). See **Fig. 40**. If either condition exists, replace the rack piston, the valve/worm shaft assembly, and the set of 29 (TAS40), 31 (TAS55), 32 (TAS65), or 34 (TAS85) steel balls.
3. Inspect the worm shaft ball-track grooves for brinelling or spalling. See **Fig. 41**. If either condition exists, replace the worm/input shaft assembly, the rack piston, and the set of steel balls. Inspect the upper shaft-seal area near the input shaft serrations for nicks. Run your fingernail across the sealing surface to detect steps. See **Fig. 42**.
4. Inspect the housing cylinder bore. See **Fig. 43**. Minor scoring marks running lengthwise through the bore are normal, and should not be compared to the scoring that might be found in the cylinder bores of an internal combustion engine. Replace the housing only if it has been tested for internal leakage, and it is determined that the

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

scoring is the cause of internal leakage greater than 1 gpm (3.8 L/min). For troubleshooting procedures, see **Section 46.11, Subject 300**.

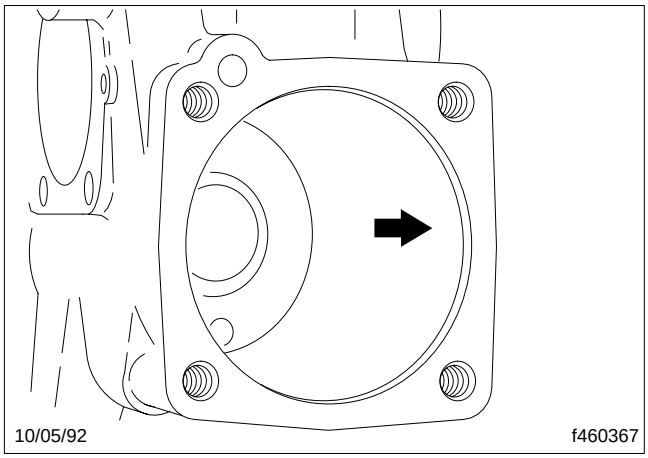


Fig. 43, Inspect the Housing Cylinder Bore

NOTE: In evaluating this test, make sure that internal leakage of more than 1 gpm (3.8 L/min) can be attributed only to the housing and not to the seals in the worm shaft, rack piston, and valve assembly.

5. Inspect the housing faces for nicks that would prevent proper sealing. See **Fig. 44**. Replace the gear housing if these nicks cannot be easily removed with a fine-toothed flat file without changing the dimensional characteristics.

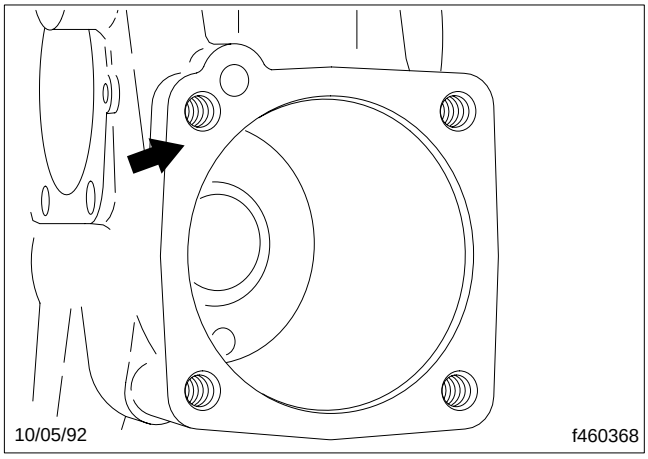


Fig. 44, Inspect the Housing Faces

6. Inspect the housing roller bearing for brinelling or spalling. If either condition exists, replace the housing bearing. See **Fig. 45**.

   For a TAS40/55/65 steering gear, inspect the side cover bushing. If the clearance between the bushing and the sector shaft is more than 0.008 inch (0.20 mm), replace the side cover and bushing assembly. See **Fig. 46**.

   For a TAS85 steering gear, inspect the side cover bearing for brinelling or spalling. If the bearing is damaged, replace the side cover and bearing assembly.

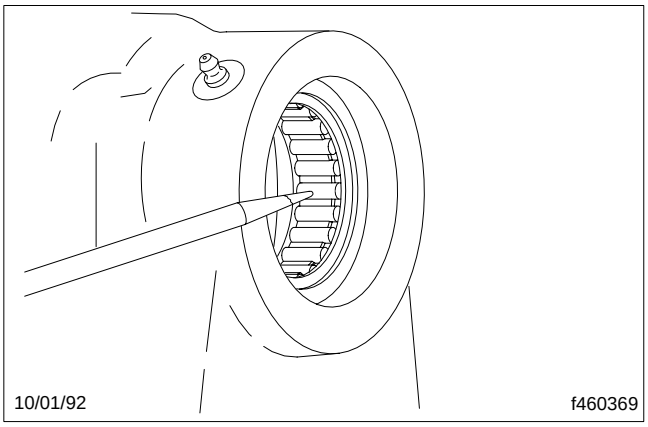


Fig. 45, Inspect the Housing Roller Bearing

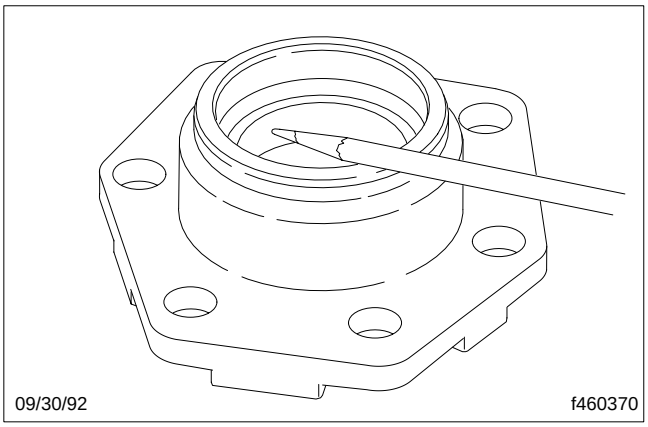
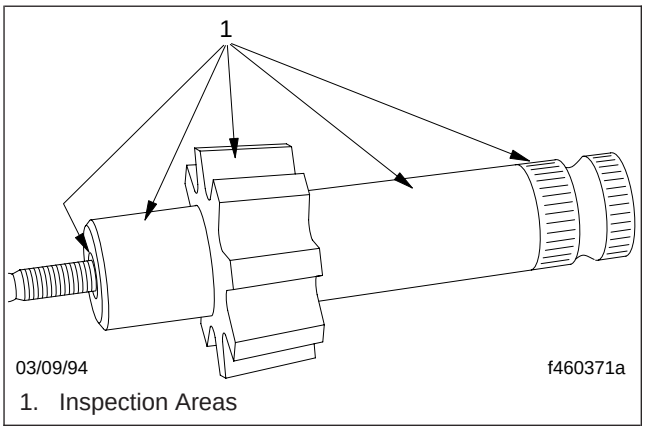


Fig. 46, Inspect the Side Cover Bushing

7. Inspect the sector shaft bearing sealing areas for brinelling or spalling. See **Fig. 47**. Run your fingernail across these areas to detect steps. Also, inspect for cracks. If any of these conditions exist, replace the sector shaft.



1. Inspection Areas

Fig. 47, Inspect the Sector Shaft Bearing Sealing Areas

8. Check the sector shaft assembly for damaged adjusting screw threads. Make sure the adjusting screw retainer is locked in place and has no cracks. The adjusting screw must turn by hand with no end play (lash). If the adjusting screw is damaged, replace it and its retainer.
9. Inspect the thrust bearing rollers for any deterioration. Inspect the thrustwashers for brinelling, spalling, or cracks. See **Fig. 48**. Replace any part if these conditions are detected.

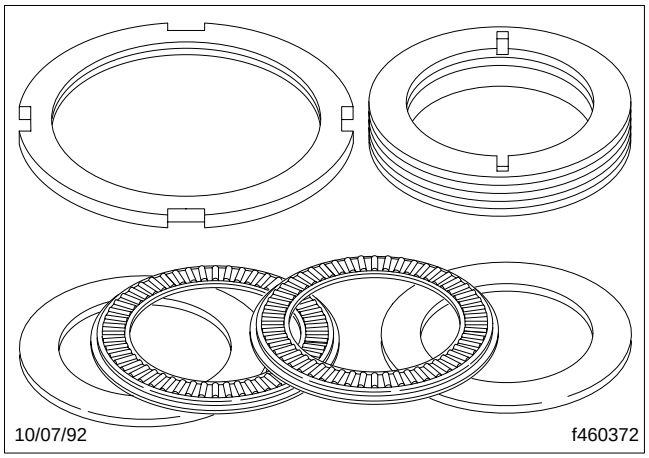


Fig. 48, Thrust Bearing Rollers

Assembly

IMPORTANT: Be sure that required tools are available before beginning the service procedures described here. See the special tools table in **Specifications 400**. The special tools required for disassembly and assembly of the steering gear parts are available from the SPX Kent-Moore or an affiliated dealer.

After inspection, clean all parts again in a clean petroleum-based solvent and blow-dry them with air.

All seals, seal rings, and gaskets must be replaced with new ones each time the gear is disassembled. Individual seals, seal rings, and gaskets—as well as complete seal kits—are available from Freightliner parts distributors.

1. If required, install a new sector shaft roller bearing; otherwise, go on to the next step.
   - 1.1 Put the gear housing on its side with the trunnion end of the bore facing up as shown in **Fig. 49**.

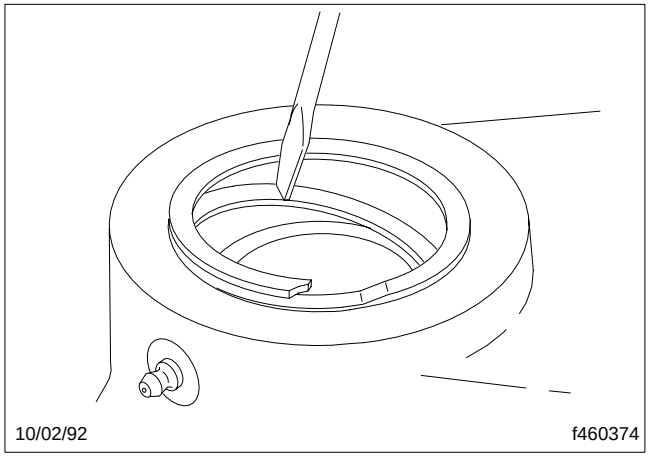


Fig. 49, Install the Retaining Ring

   - 1.2 Install the retaining ring in the groove closest to the side cover end of the bore. See **Fig. 49**. Then lubricate the bore.
   - 1.3 Place the new roller bearing on the housing bore with the lettered side of the bearing shell facing up.
   - 1.4 Using the installation end of the special tool, press the roller bearing into the housing until it seats against the retaining ring. See **Fig. 50**.
2. Install the sector shaft seals.
   - 2.1 Put the gear housing on its side with the side cover end of the bore facing up as shown in **Fig. 51**.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

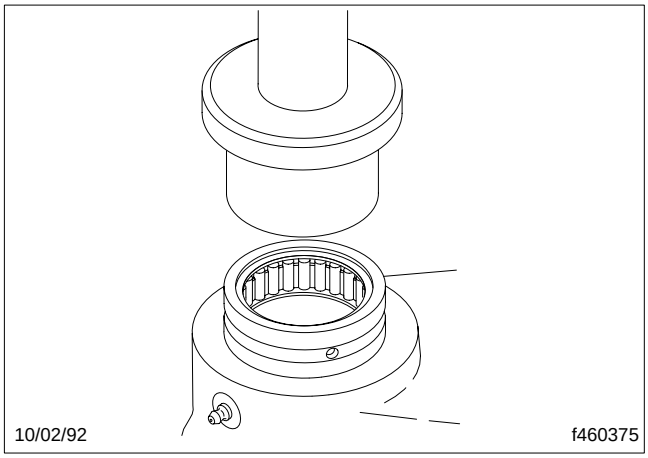


Fig. 50, Press the Roller Bearing into the Housing

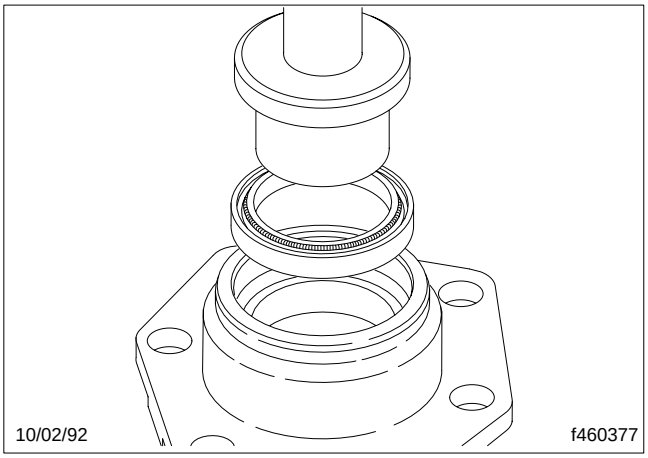


Fig. 52, Attach the New Seal to the Tool

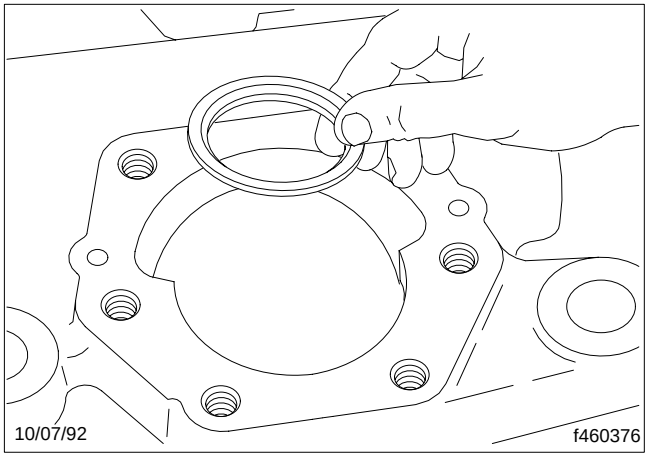


Fig. 51, Install the Washer in the Bore

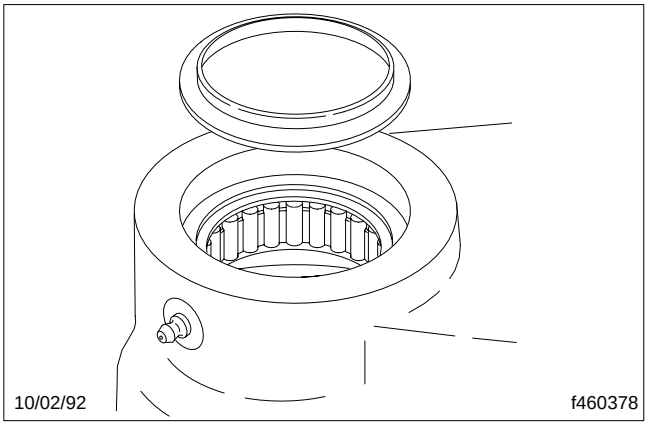


Fig. 53, Install the New Seal

2.2 Install the washer in the bore with the small diameter end of it facing the roller bearing retaining ring. See **Fig. 51**.

2.3 Put the new seal on special tool J37705 (TAS40), J37071 (TAS55/65), or J38779 (TAS85) so that the lip of the seal with the garter spring is toward the shoulder of the tool. See **Fig. 52**.

2.4 From the side cover end of the bore, press the new seal onto the washer (and the roller bearing below it) with a force of 100 to 800 lbf (445 to 3560 N).

2.5 Turn the gear housing over so that the trunnion end of the bore is up. Install the new dirt seal against the roller bearing with the lip facing up. See **Fig. 53**.

2.6 Install the second retaining ring seating it firmly into the groove in the bore. See **Fig. 54**.

2.7 Pack the area between the dirt seal and the pressure seal (including the roller bearing) with Mobil Temp® 1 grease or equivalent. See **Fig. 55**.

3. Assemble the valve housing.

3.1 Put the valve housing in a vise so the input/worm shaft can be installed with the worm shaft up.

3.2 Lubricate and install a new O-ring in the valve housing. See **Fig. 56**.

3.3 Lubricate a new large diameter O-ring and a new seal ring, then install them in the valve housing. See **Fig. 56** and **Fig. 57**.

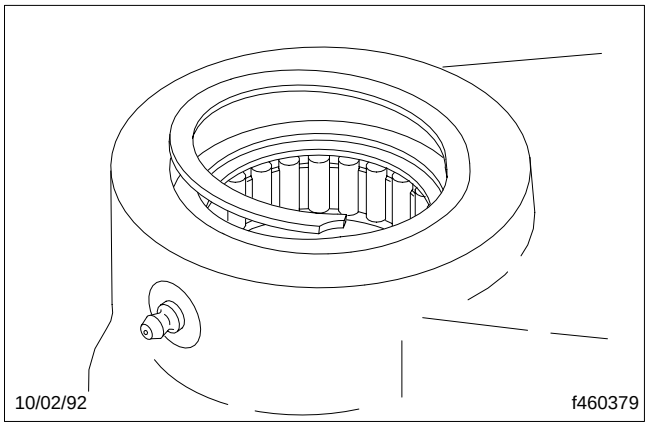


Fig. 54, Install the Second Retaining Ring

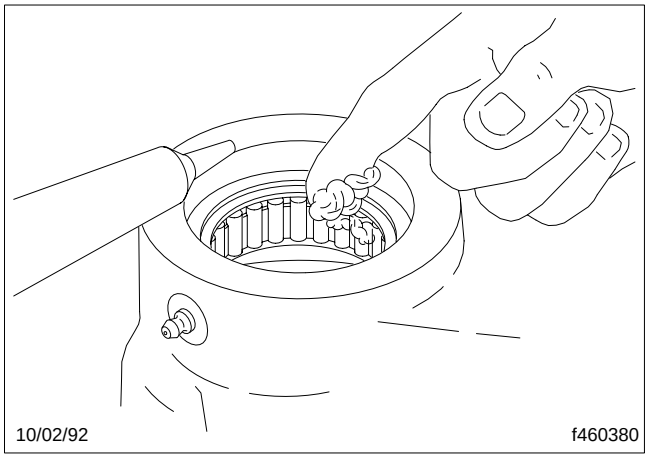


Fig. 55, Lubricate the Area Between the Seals

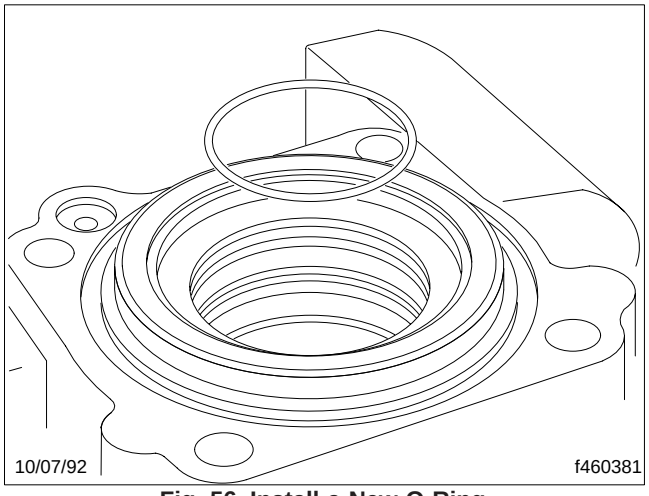


Fig. 56, Install a New O-Ring

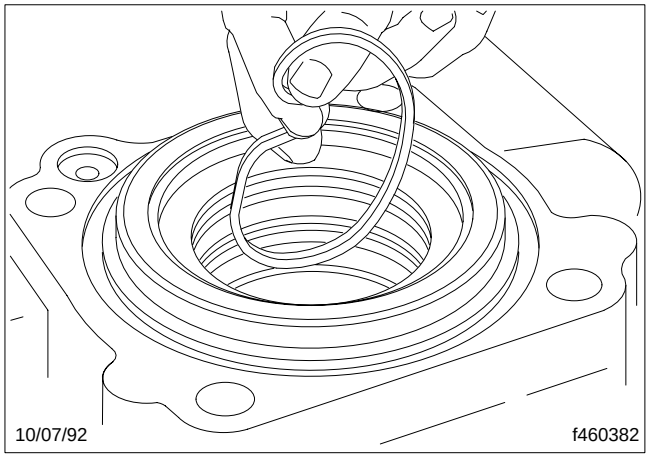


Fig. 57, Installing a New O-Ring

3.4 Install the roller thrust bearing and the thick thrustwasher on the input-shaft thrust face. See **Fig. 58**.

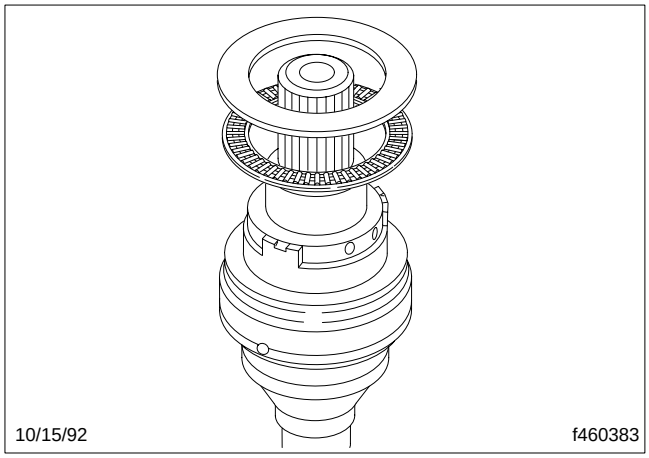


Fig. 58, Installing the Roller Thrust Bearing and Thrustwasher

3.5 Install a new seal ring on the input shaft and against the thick thrustwasher. See **Fig. 1**.

3.6 Lubricate, then install the input shaft/valve/worm assembly in the valve housing seating it firmly. See **Fig. 59**.

3.7 Lubricate, then install a second thrust bearing and thin washer over the worm shaft. See **Fig. 60**.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

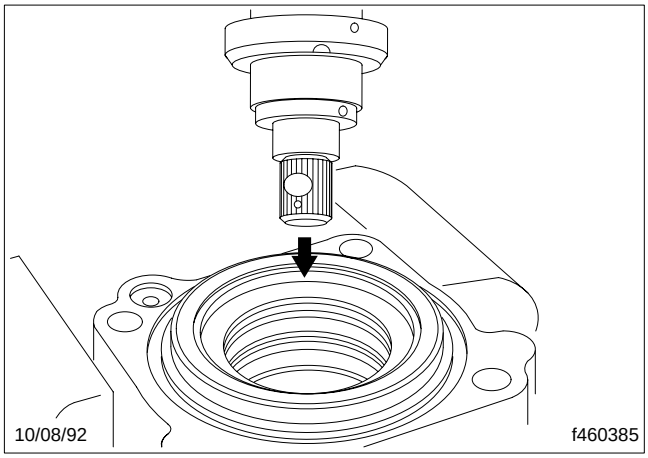


Fig. 59, Install the Input Shaft/Valve/Worm Assembly

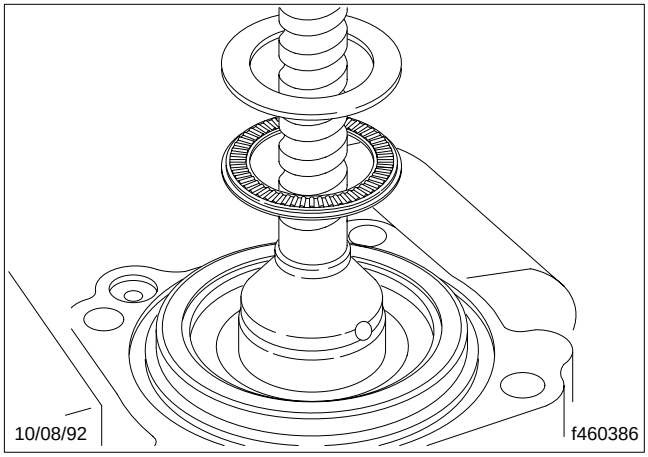


Fig. 60, Installing a Second Thrust Bearing

3.8 Lubricate the new O-ring and seal ring. Install the O-ring, then the seal ring in the groove of the bearing adjuster. See **Fig. 61**.

3.9 Making sure the bearing adjuster threads are clean and free of any stake burrs, lubricate and then install the bearing adjuster over the worm shaft and into the valve housing.

3.10 Using a torque wrench and bearing adjuster tool J37070, tighten the valve adjuster 11 to 15 lbf·ft (15 to 20 N·m), then back it off 1/4 to 1/2 turn. See **Fig. 62**.

3.11 Turn the valve housing over in the vise so that the worm shaft is facing down.

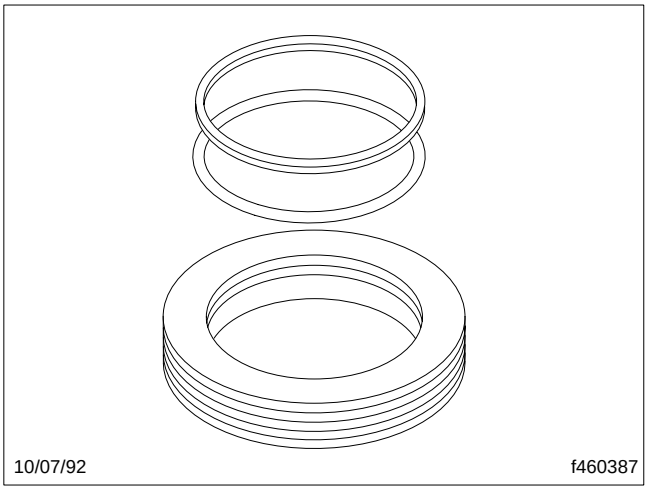


Fig. 61, Installing the O-Ring and Seal Ring

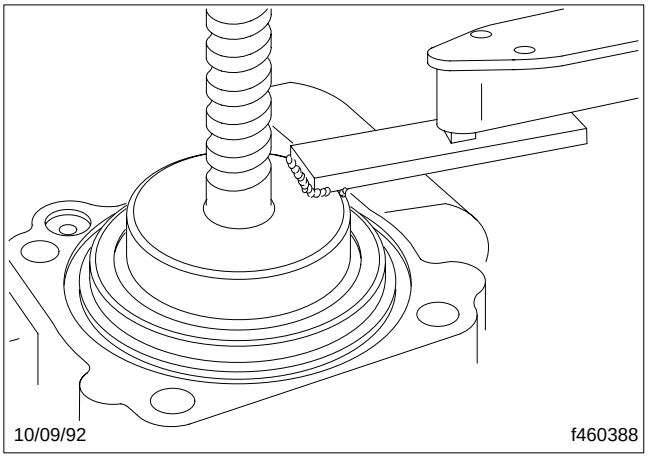


Fig. 62, Tighten the Valve Adjuster

3.12 Using an inch-pound torque wrench, check the torque needed to turn the input shaft slowly 360 degrees clockwise and counterclockwise. Tighten the bearing adjuster until the torque needed to turn the input shaft increases by 5 to 10 lbf·in (60 to 120 N·cm). See **Fig. 63**.

3.13 Turn the valve housing over in the vise again so that the worm shaft is facing up.

3.14 Oil and install the locknut on the bearing adjuster and, using special tools J37070 and J37464, tighten the locknut 101 to 122 lbf·ft (137 to 165 N·m) while holding the bearing adjuster. See **Fig. 64**.

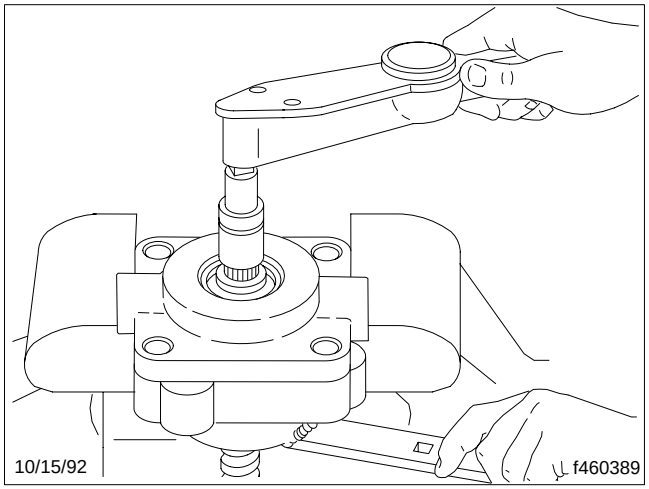


Fig. 63, Checking the Torque

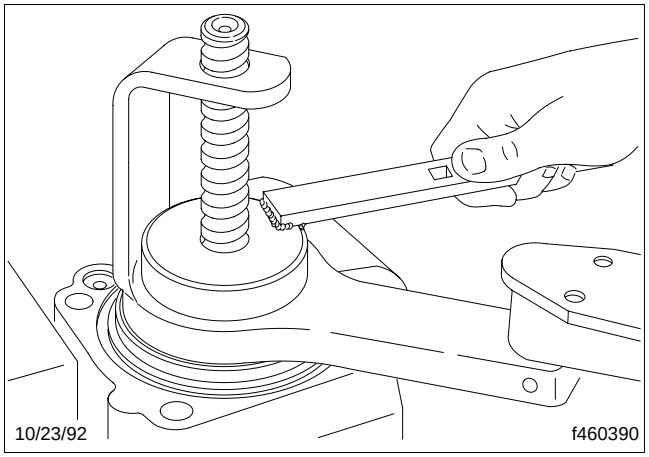


Fig. 64, Installing the Locknut on the Bearing Adjuster

3.15 Check the torque needed to turn the input shaft again. If the torque has not increased 5 to 10 lbf·in (60 to 120 N·cm), remove the locknut from the bearing adjuster and repeat the steps above beginning with tightening the valve adjuster, then backing it off.

3.16 Using a punch, stake the locknut to the valve housing at two opposite slots in the locknut. Stake each slot in the most clockwise corner as shown in **Fig. 65**.

3.17 Stake the locknut to the bearing adjuster at two places 180 degrees apart. See **Fig. 65**. Do not use a spot that was staked before.

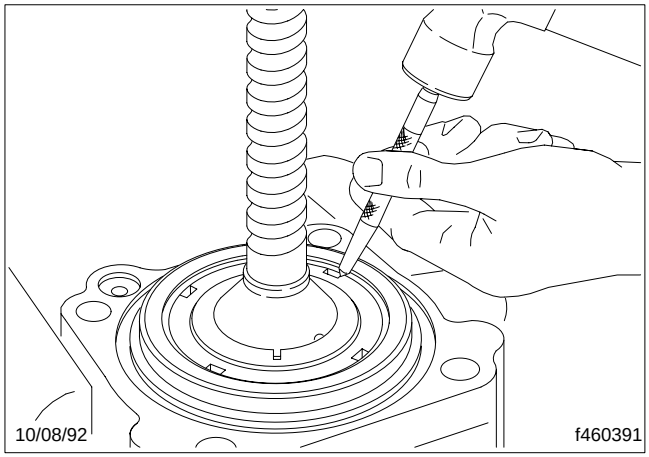


Fig. 65, Stake Each Slot

3.18 Check the torque needed to turn the input shaft. If the torque is not greater than 5 to 10 lbf·in (60 to 120 N·cm) the torque previously noted, unstake the locknut from the bearing adjuster and repeat the steps above beginning with tightening the valve adjuster, then backing it off.

NOTE: The torque needed to turn the input shaft must not be more than 22 lbf·in (240 N·cm).

3.19 Oil the new seal rings and install them in the valve housing. See **Fig. 66**.

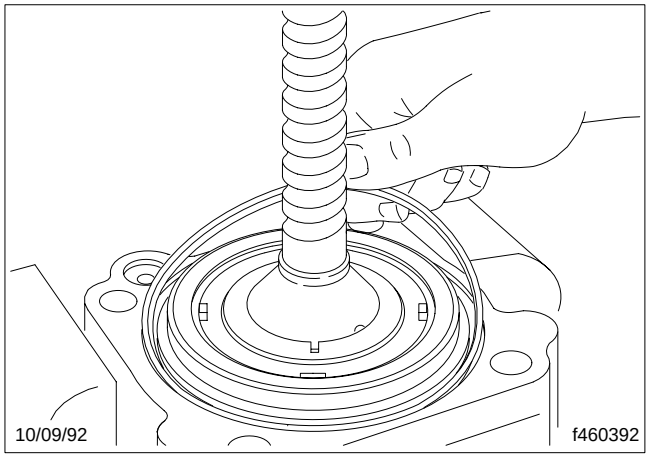


Fig. 66, Installing New Seal Rings

4. Reset the automatic poppet valves.

IMPORTANT: Make sure the poppet adjuster seat and sleeve assemblies and the

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

threaded holes in the rack piston are free of Loctite®. Use 7/16-20 thread chasers to remove the Loctite®.

4.1 Turn the poppet adjuster seat and sleeve assembly so that it is in the **opposite** direction in which it was installed, and loosely screw it into the threaded hole in the rack piston. See **Fig. 67**.

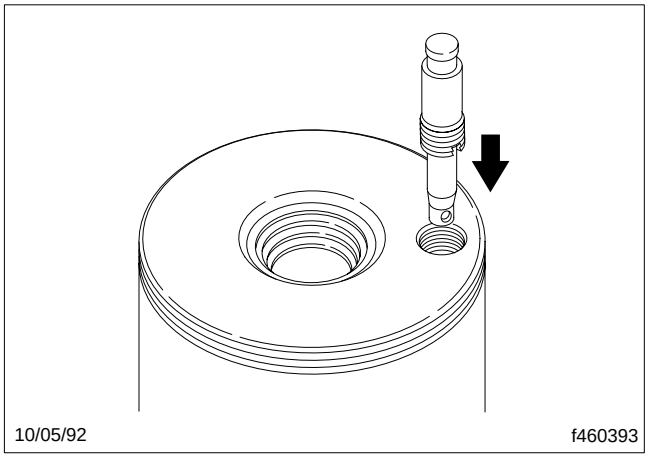


Fig. 67, Installing the Poppet Adjuster Seat and Sleeve Assembly in the Rack Piston

4.2 Press the adjuster seat into the adjuster sleeve with a force of 500 to 2500 lbf (2224 to 11 120 N) until the shoulder on the seat bottoms on the sleeve. See **Fig. 68** and **Fig. 69**.

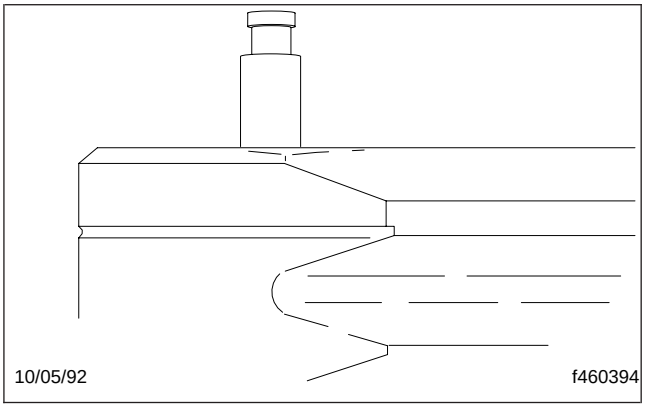


Fig. 68, The Adjuster Seat in the Adjuster Sleeve

4.3 Remove the adjuster seat and sleeve assembly from the rack piston.

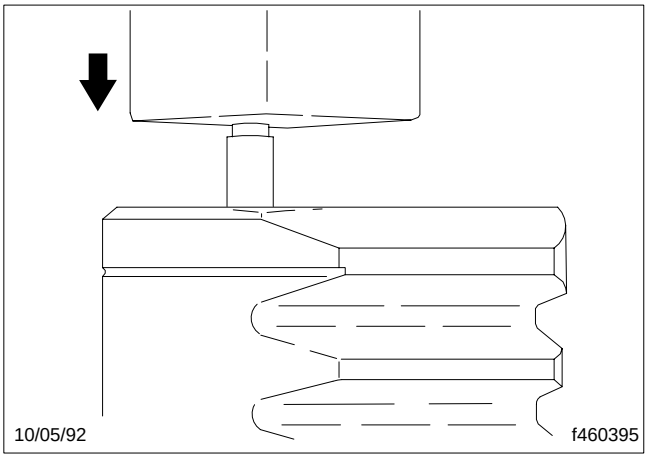


Fig. 69, Installing the Adjuster Seat into the Adjuster Sleeve

4.4 Repeat the previous steps for the other poppet adjuster seat and sleeve assembly.

5. Install the rack piston seal. Install a new backup O-ring and new Teflon® seal ring on the rack piston. See **Fig. 70**. Do not stretch them more than necessary when installing them.

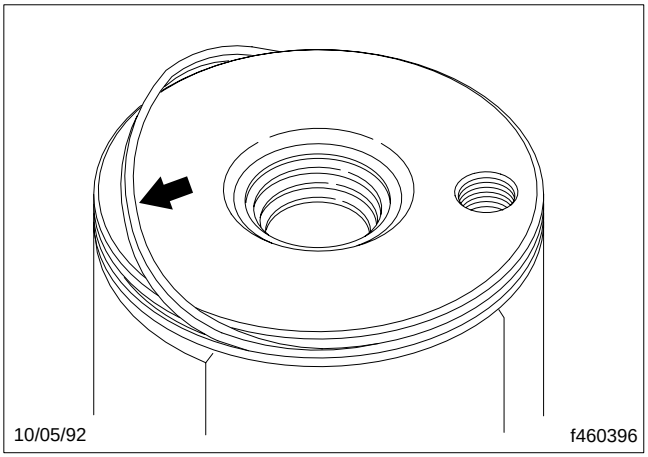


Fig. 70, Installing the Rack Piston Seal

6. Install the automatic poppets.

NOTE: If you are installing new poppet adjuster seat and sleeve assemblies, they may already have Dri-Loc® 200 on them. If so, more Loctite® is not needed.

6.1 Apply Locquic primer T to the threaded poppet holes in the rack piston and to the threads on the poppet adjuster seat and

sleeve assemblies. Let dry for ten minutes, then apply Loctite® RC680 to the same threads. See **Fig. 71**.

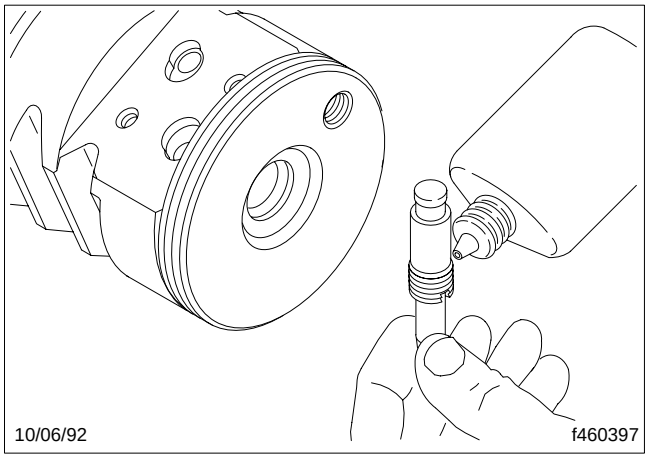


Fig. 71, Apply Primer to the Threaded Poppet Holes

6.2 Place the rack piston in a padded vise, and install a poppet adjuster seat and sleeve assembly, slotted end out, into the threaded hole at one end of the rack piston. See **Fig. 72**.

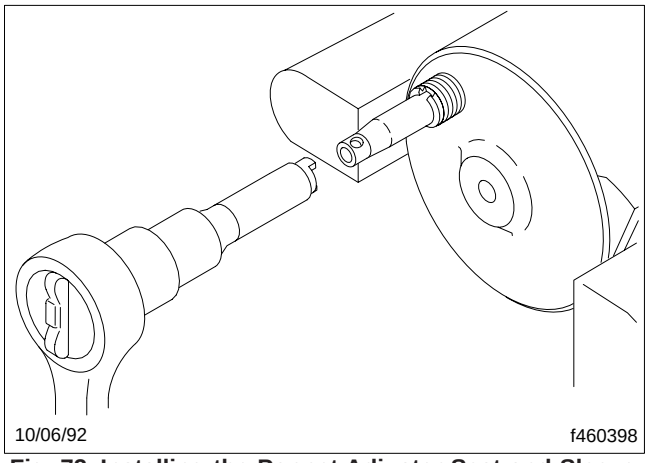


Fig. 72, Installing the Poppet Adjuster Seat and Sleeve Assembly into the Rack Piston

6.3 In the other end of the hole, install the poppet assembly parts in the following order: one poppet, the poppet spring, the nylon spacer rod, the push tube, the other poppet, and the other poppet adjuster seat and sleeve assembly. See **Fig. 73**.

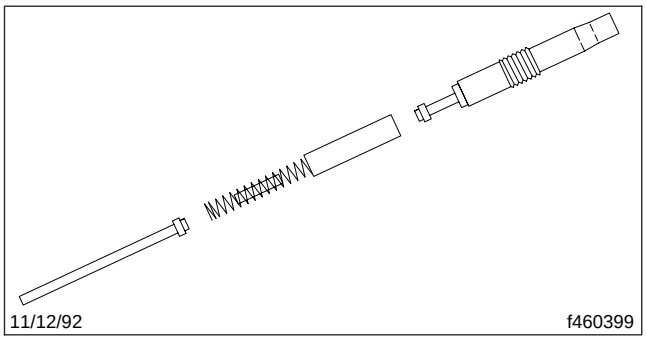


Fig. 73, Installing the Poppet Assembly Parts

6.4 Using special tool J36452 or J38713 (preferred), tighten both poppet adjuster seat and sleeve assemblies using one of the following torque specs:

- 10 lbf·ft (14 N·m) for a TAS40/55/65 steering gear
- 18 lbf·ft (24 N·m) for a TAS85 steering gear

7. Install the worm shaft and valve housing assembly into the rack piston.

7.1 Put the rack piston on a clean, cloth-covered bench with the worm end of the piston near the edge of the bench and the ball guide holes facing up.

NOTE: When made to the correct dimensions to raise and support the piston, a wooden V-block will make the following steps easier.

7.2 Insert the worm shaft and input shaft assembly into the worm end of the rack piston close to the maximum depth without the valve housing contacting the upper poppet. See **Fig. 74**.

7.3 Line up the grooves in the worm shaft with the ball guide holes in the rack piston. Make sure the valve housing extends over the edge of the bench or the rack piston is put on a V-block so that the valve housing and worm shaft can turn freely.

8. Install the steel balls.

8.1 Install new ball return guide halves in the rack piston. See **Fig. 75**. Make sure they are correctly seated.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

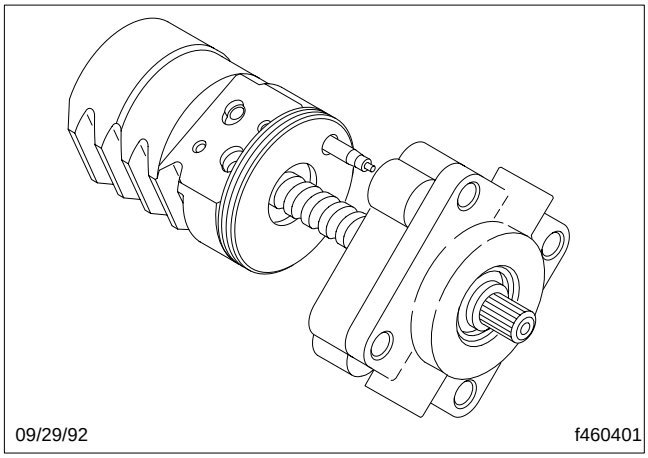


Fig. 74, Inserting the Worm Shaft and Input Shaft Assembly into the Rack Piston

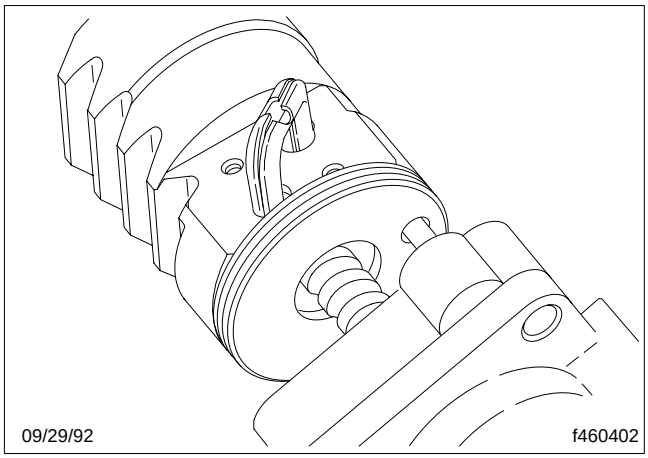


Fig. 75, Installing the New Ball Return Guide Halves

NOTE: The worm gear may have to be rotated slightly to seat guide halves. Left-hand ball return guide halves are copper-plated; right-hand guide halves are not. Make sure the correct new ball return guide halves are installed by comparing them with the old ones. Then discard the old ones.

8.2 Insert the 29 (TAS40), 31 (TAS55), 32 (TAS65), or 34 (TAS85) steel balls in the ball return guide hole as shown in **Fig. 76**. As the balls are dropped into the guide, turn the worm shaft so that the balls are pulled down into its grooves.

8.3 If the ball guide halves rise up at any time during or after the installation of the steel balls, remove all of the balls and the input shaft/valve/worm assembly from the rack piston. Repeat the previous steps beginning with inserting the worm shaft and input shaft assembly into the worm end of the rack piston.

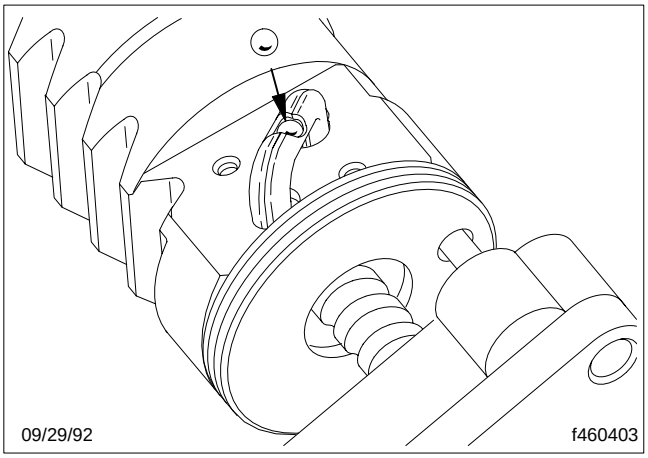


Fig. 76, Inserting the Steel Balls in the Return Guide Hole

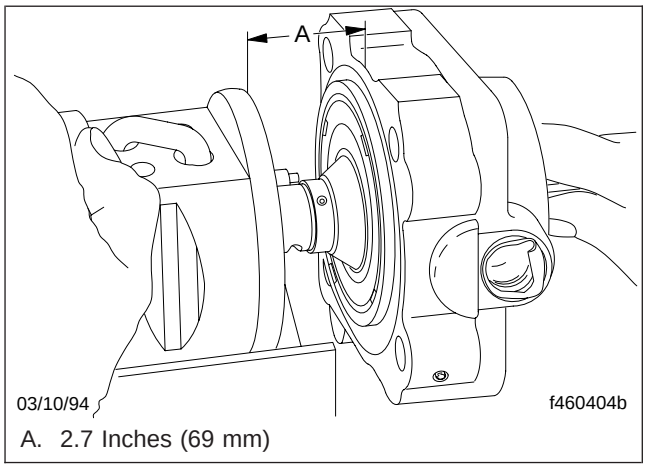
IMPORTANT: Do not let the valve housing pilot face touch the poppet adjuster or move more than 2.7 inches (69 mm) from the upper end of the rack piston. See **Fig. 77**. If this happens, the poppet adjuster could be incorrectly preset or the worm could be backed out beyond the closed ball loop.

8.4 Lubricate the new seal for the ball return guide cap and install it in the groove in the cap. See **Fig. 78**.

8.5 Using a 5/32 inch Allen socket and two new 5/32 inch Allen head screws (or a T-30 Torx socket and two new Torx head screws), install the ball return guide cap on the rack piston. Make sure the seal makes full contact with the rack piston surface. Tighten the fasteners alternately once or twice, to a final torque of 14 to 22 lbf·ft (19 to 30 N·m).

8.6 To ensure that the steel balls have been correctly installed, turn the worm shaft from one end of travel to the other without allowing the valve housing to contact the poppet adjuster and without moving the valve housing pilot face more than 2.7

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments



A. 2.7 Inches (69 mm)

Fig. 77, Maximum Distance Between the Valve Housing Pilot Face and the Upper End of the Rack Piston

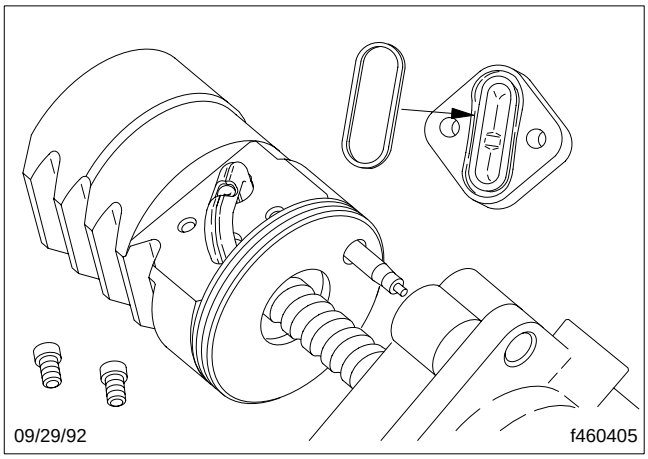


Fig. 78, Install the Seal in the Ball Return Guide

inches (69 mm) from the input end (upper end) of the rack piston. See **Fig. 77**.

8.7 If the worm shaft does not turn, remove all of the steel balls, and install them again.

9. Install the poppet stopscrew. If the poppet stopscrew is being replaced, install the new one and its washer in the gear housing. See **Fig. 79**. Tighten it 38 to 42 lbf·ft (52 to 57 N·m).

10. Preset the poppet adjusting screw, if equipped.

10.1 If the service poppet adjusting screw and the service sealing jam nut are being used for automatic poppet adjustment, turn the adjusting screw into the jam nut until 1.03

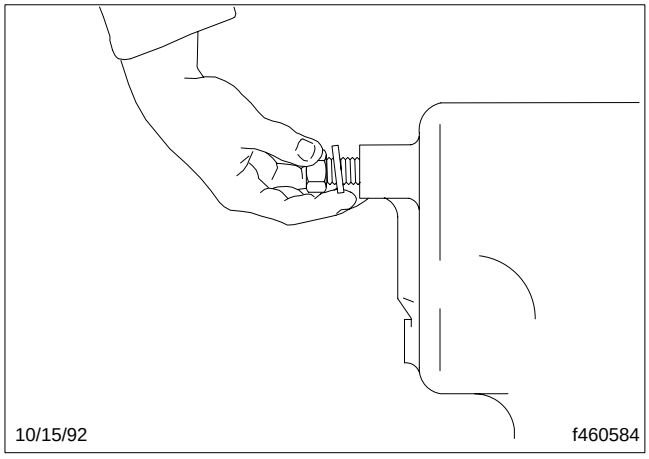
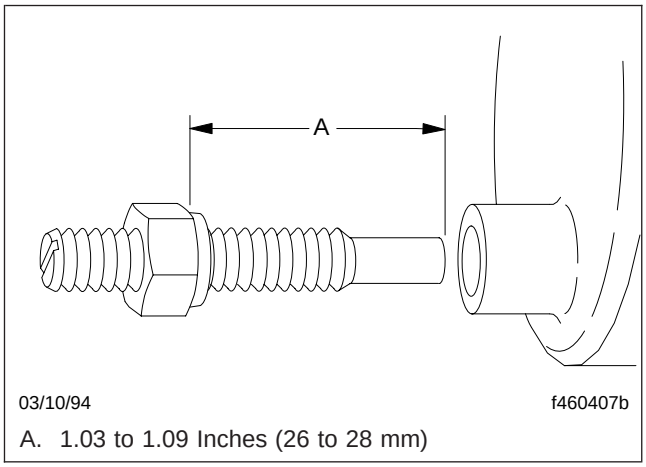


Fig. 79, Installing the Poppet Stopscrew

to 1.09 inches (26 to 28 mm) protrudes from the bottom of the jam nut. See **Fig. 80**.



A. 1.03 to 1.09 Inches (26 to 28 mm)

Fig. 80, Turn the Adjusting Screw into the Jam Nut

10.2 Install the assembly into the gear housing. Tighten the jam nut 33 to 37 lbf·ft (45 to 50 N·m).

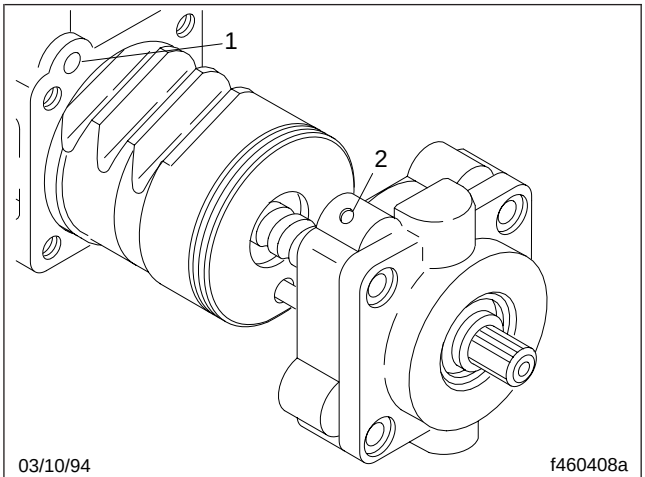
11. Install the rack piston/valve housing assembly into the gear housing.

11.1 Put clean oil on the rack piston Teflon® seal ring and into the bore of the gear housing. Position the rack piston on the worm gear with a gap of 10 to 13 mm (3/8 to 1/2 inch) between the valve housing and the upper poppet adjuster seat and sleeve assembly.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

IMPORTANT: This gap is to ensure that the poppets do not make contact with anything while the steering gear is being assembled.

11.2 Install the rack piston and worm shaft assembly in the gear housing, being careful not to damage the seal ring on the rack piston. Do not let the poppet adjuster sleeve assemblies bottom out inside the gear housing. Install the piston with the rack teeth toward the sector shaft hole in the housing. See **Fig. 81**. Be sure the valve housing cylinder feed hole lines up with the gear housing feed hole.



1. Gear Housing Feed Hole
2. Valve Housing Cylinder Feed Hole Boss

Fig. 81, Installing the Rack Piston and Worm Shaft Assembly in the Gear Housing

11.3 Using an E-16 Torx socket wrench, install and tighten the four valve housing bolts using one of the following torque specs:

- 75 to 85 lbf·ft (102 to 115 N·m) for a TAS40/55/65 steering gear
- 108 to 128 lbf·ft (146 to 174 N·m) for a TAS85 steering gear

12. Install the relief valve components, if equipped.

12.1 Assemble a new O-ring on the relief valve cap.

12.2 Assemble the small end of tapered spring onto the pin on the other part of the relief valve and insert the assembly, tapered spring end first, into the relief valve cap cavity. See **Fig. 82**.

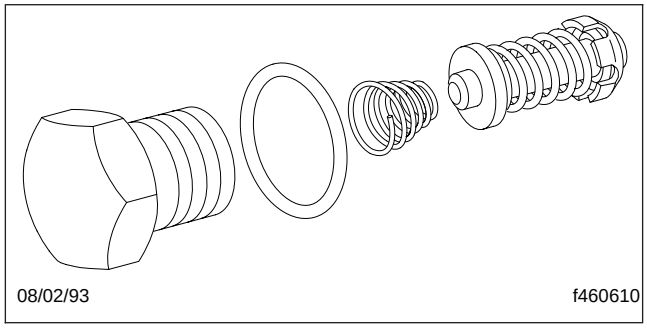


Fig. 82, Assemble the Spring and Pin into the Relief Valve Cap

12.3 Turn the relief valve cap as assembled into the valve housing and torque it to 30 lbf·ft (41 N·m). See **Fig. 83**.

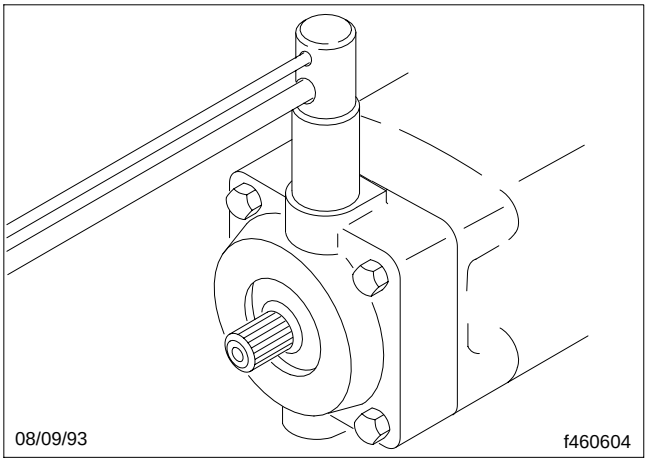


Fig. 83, Turn the Relief Valve Cap into the Valve Housing

13. If the sector shaft adjusting screw is being replaced, do the following. Otherwise go to the next step and install the sector shaft/side cover components.

13.1 Coat the end of the new adjusting screw with wheel bearing grease and, with the sector shaft in a padded vise, insert the new adjusting screw into the recess in the sector shaft end.

13.2 Install a new sector-shaft screw retainer in the sector shaft. Adjust the retainer so that the sector shaft adjusting screw can be

turned freely by hand. It should have a maximum end play of 0.002 inch (0.05 mm).

13.3 Stake the sector-shaft screw retainer to the slots in the sector shaft. See **Fig. 84**. Check the adjusting screw again for free movement and end play.

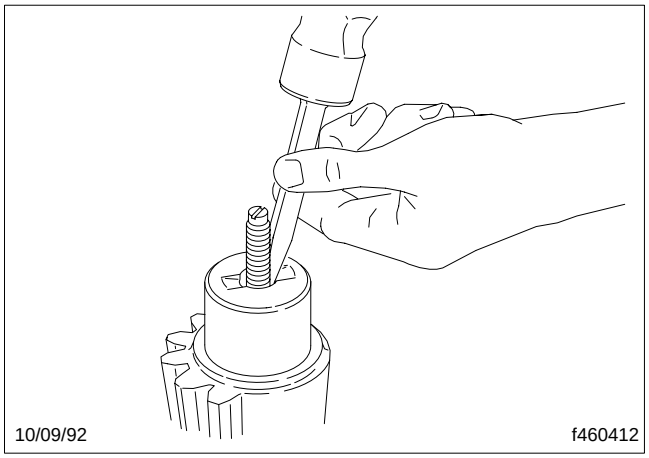


Fig. 84, Stake the Sector-Shaft Screw Retainer to the Sector Shaft

14. Install the sector shaft/side cover components.

14.1 For a TAS40/55/65 steering gear, lightly oil the side cover DU bushing. Do not grease it. See **Fig. 85**.

For a TAS85 steering gear, heavily grease the side cover bearing with Mobile Temp 1 or 2 grease. Do not oil it.

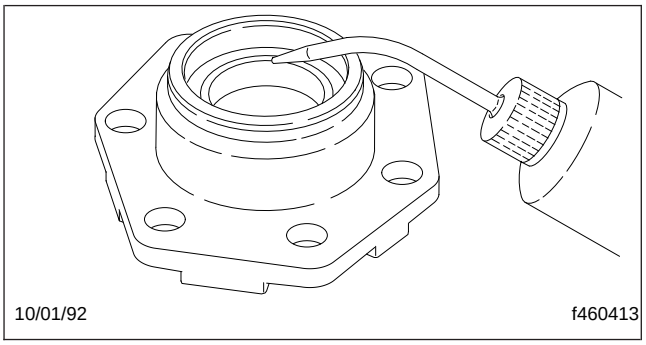


Fig. 85, Oil the Side Cover DU Bushing

14.2 Put a new seal on special tool J37705 (TAS40), J37071 (TAS55/65), or J38779 (TAS85) so that the garter spring is against the shoulder of the tool. See **Fig. 86**. Press the new seal into the side cover with a force of 100 to 800 lbf (445 to 3560 N). Make sure the seal is seated against the bottom of the counterbore.

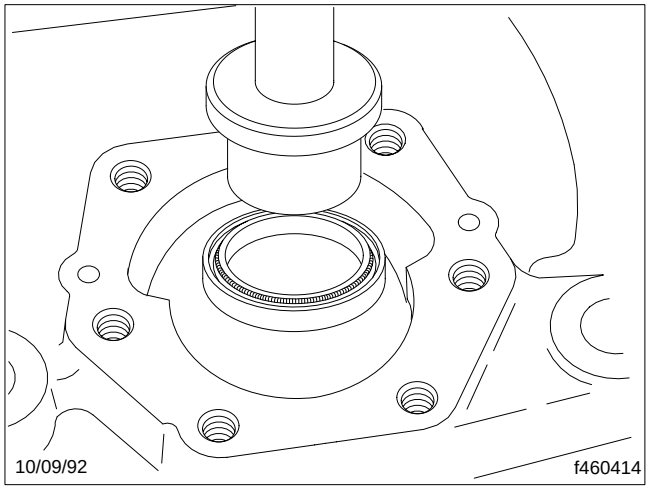


Fig. 86, Put a New Seal on the Tool

14.3 For a TAS40/55/65 steering gear, lightly oil the short bearing end of the sector shaft.

For a TAS85 steering gear, heavily grease the short bearing end of the sector shaft.

Insert the sector shaft into the side cover. Screw the sector shaft adjusting screw counterclockwise into the side cover until the screw seats. See **Fig. 87**. Then rotate the adjusting screw clockwise one turn so that the side cover rotates freely on the sector shaft.

14.4 Install the sector-shaft adjusting screw jam nut onto the sector-shaft adjusting screw a few threads. See **Fig. 88**. Final adjustment will be made later.

14.5 Press a new rubber plug into the hole provided in the side cover until the plug is flush. See **Fig. 89**.

15. Install the sector shaft/side cover assembly.

15.1 Apply clean grease to a new side cover gasket and install it on the side cover. See **Fig. 90**. Apply enough grease to hold the gasket in place.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

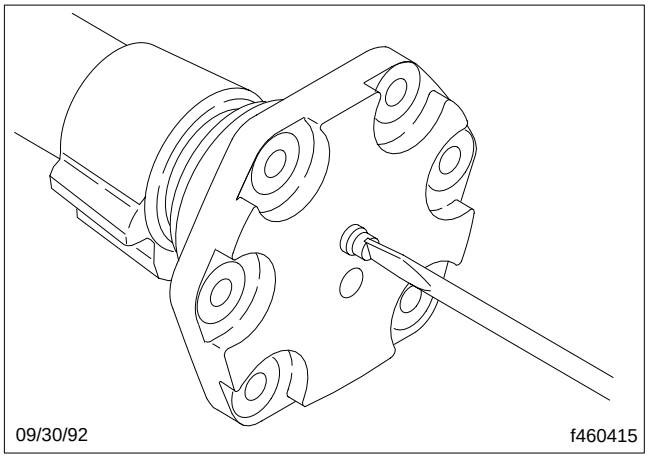


Fig. 87, Screw the Sector Shaft Adjusting Screw into the Side Cover

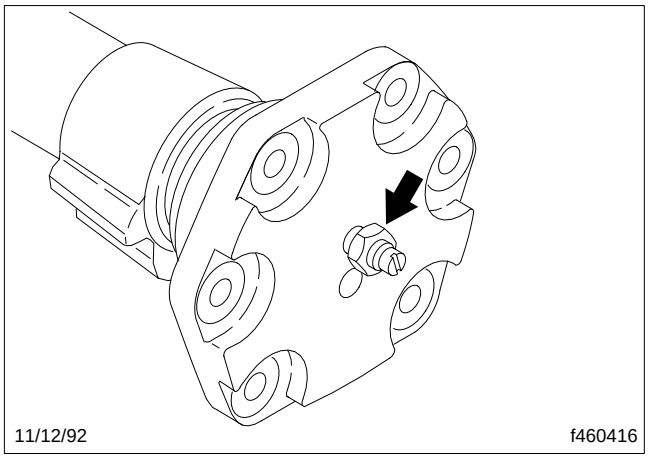


Fig. 88, Install the Jam Nut Onto the Sector-Shaft Adjusting Screw

15.2 There are four teeth on the rack piston. Turn the input shaft as needed to position the rack piston so that the tooth space identified by the pencil in **Fig. 91** (it is the third space between the second and the third tooth), is in the center of the sector shaft opening. See **Fig. 92**. This will center the rack piston in the opening.

15.3 Remove all tape from the sector shaft splines. Retape the splines and the bolt groove with **one** layer of masking tape.

15.4 Install the sector shaft and side cover as an assembly in the gear housing. See **Fig. 93**. Make sure the center tooth of the

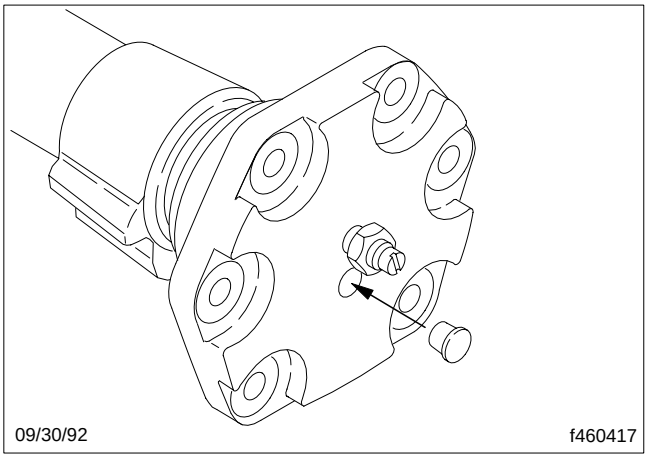


Fig. 89, Install a New Plug into the Side Cover

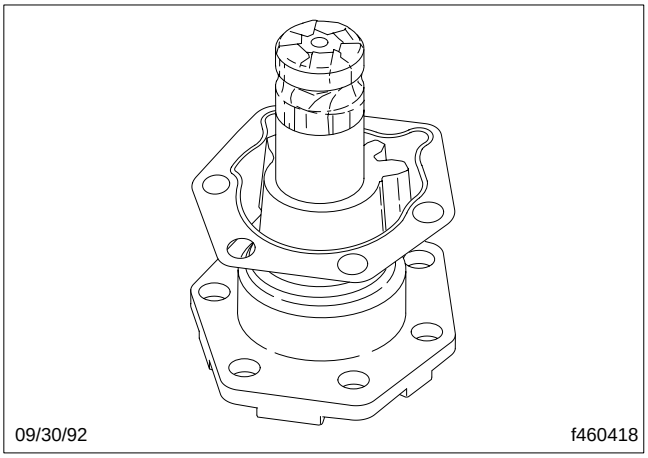


Fig. 90, Install a New Gasket on the Side Cover

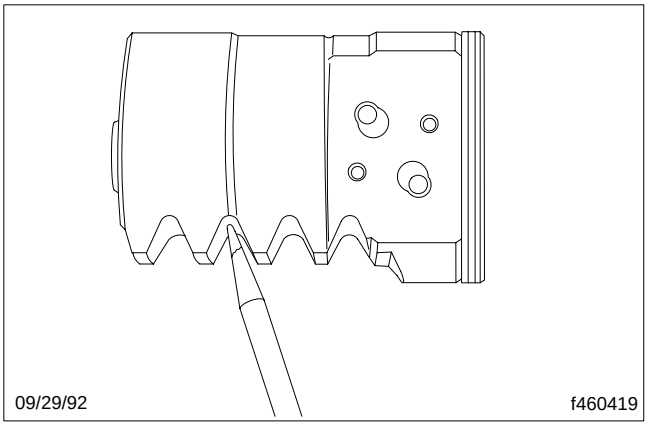


Fig. 91, Positioning the Rack Piston

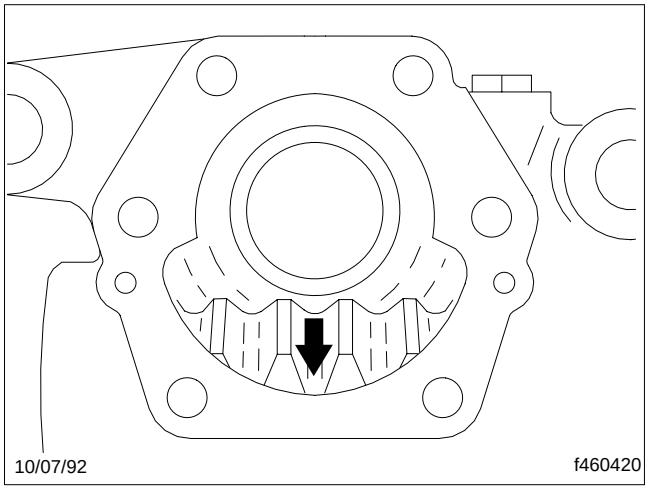


Fig. 92, Positioning the Rack Piston

sector engages the center space (between the second and third teeth) of the rack piston.

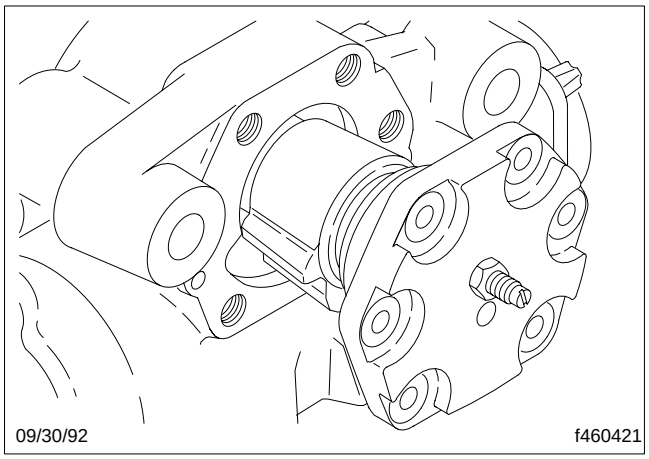


Fig. 93, Install the Sector Shaft/Side Cover Assembly in the Gear Housing

15.5 Install the special side cover bolts in the side cover. Using the torque pattern shown in **Fig. 94** or **Fig. 95**, tighten the bolts using one of the following torque specs:

- 118 lbf·ft (160 N·m) for lubricated bolts or 160 lbf·ft (217 N·m) for dry bolts on a TAS40 steering gear
- 170 lbf·ft (230 N·m) for lubricated bolts or 230 lbf·ft (312 N·m) for dry bolts on a TAS55/65/85 steering gear

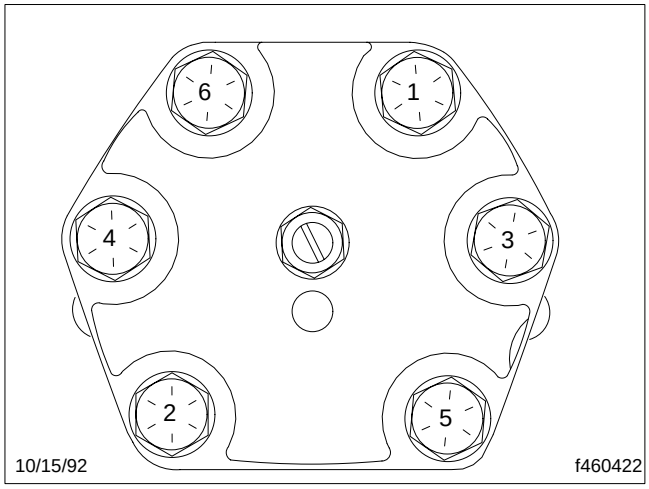


Fig. 94, Tightening Sequence

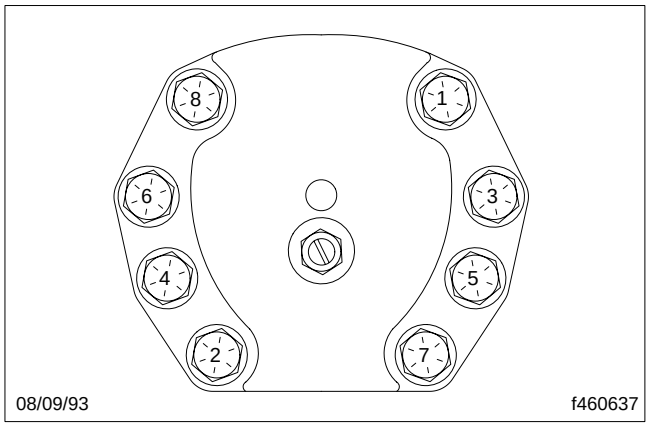


Fig. 95, Tightening Sequence

16. Install the sector shaft seal.

    Remove the tape from the sector shaft and pack the end of the housing trunnion area at the sector shaft with Mobil Temp 1 or 2 grease or equivalent. Put grease on the new trunnion dirt seal and install it over the sector shaft and into the trunnion bore. See **Fig. 96**.

17. Install the input shaft seals and retaining ring.

    IMPORTANT: Make sure the input shaft seal is installed squarely in the seal bore.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

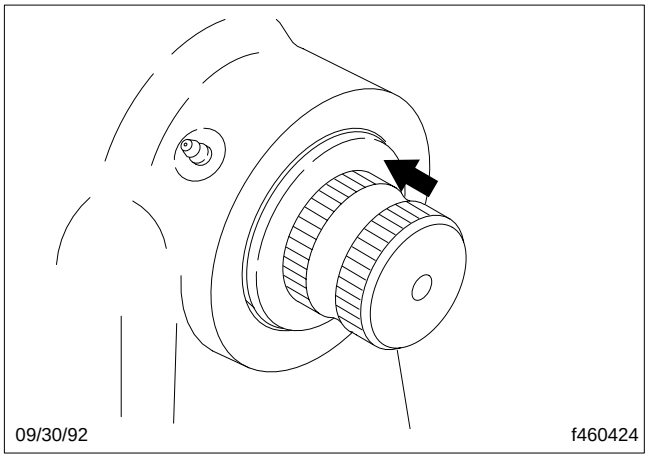


Fig. 96, Install the Sector Shaft Seal

17.1 Apply clean grease to the new input shaft seal. Then place it—garter spring side first—over the input shaft. Using special tool J37073 and a mallet, tap the seal installer tool until the tool shoulder is square against the valve housing. See **Fig. 97**. Remove any seal material that may have sheared off in the retaining groove.

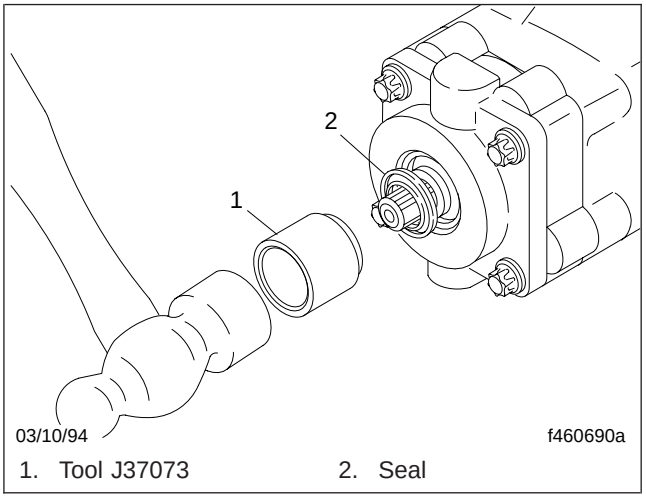


Fig. 97, Tap the Seal Installing Tool Against the Valve Housing

17.2 Install a new retaining ring into its groove in the valve housing. See **Fig. 98**.

17.3 Pack the end of the valve housing bore (around the input shaft) with Mobil Temp 1 or 2 grease or equivalent. Apply grease to the new dirt and water seal and install it

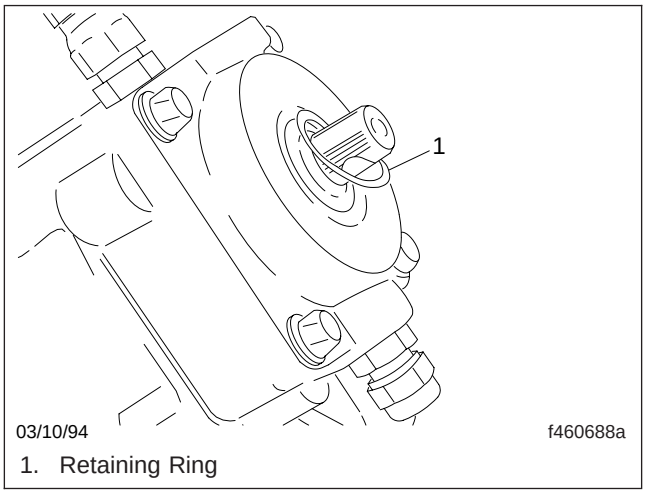


Fig. 98, Install a New Retaining Ring

over the input shaft. Seat the dirt and water seal in the groove behind the serrations of the input shaft and against the valve housing. See **Fig. 99**.

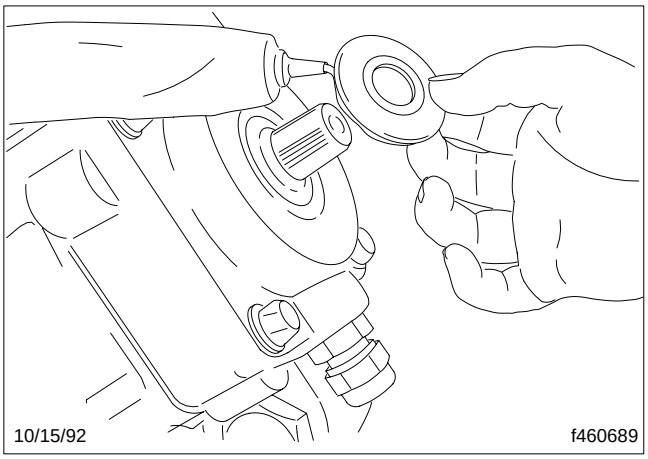


Fig. 99, Install the Dirt and Water Seal

18. Install the grease fitting and auxiliary port plug.

18.1 If the grease fitting is being replaced, install a new one in the gear housing using a piece of metal tubing over the head of the new fitting as shown in **Fig. 100**. Tap the new grease fitting in place.

18.2 If the auxiliary port plugs were removed, install new O-rings on them and install the plugs in the gear housing. Tighten them 25 to 35 lbf·ft (34 to 47 N·m).

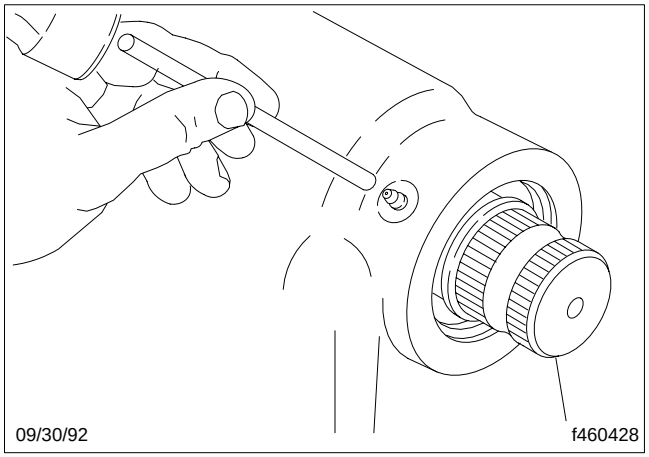


Fig. 100, Tap the Grease Fitting in Place

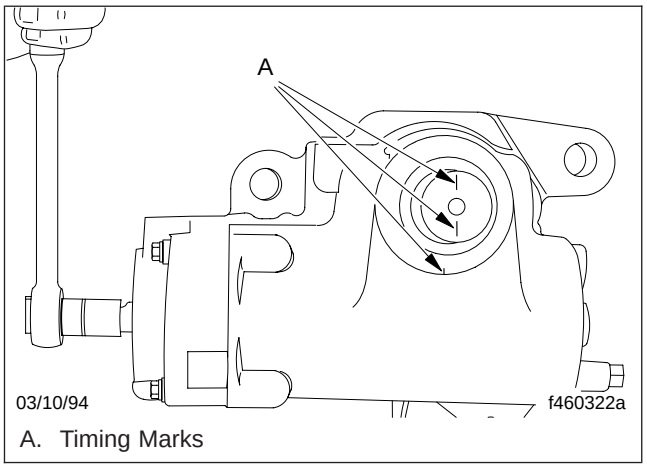


Fig. 101, Line Up the Timing Marks

Final Adjustments

Before installing the steering gear on the vehicle, make these adjustments.

NOTE: Worm shaft preload adjustment was done when the input shaft was installed in the valve housing during the assembly procedure.

1. Adjust the sector shaft preload.

   1.1 Center the steering gear by turning the input shaft until the timing mark on the end of the sector shaft is in line with the timing mark on the end of the housing trunnion. See **Fig. 101**. Use a 12-point, 11/16 or 3/4 inch socket wrench to turn the input shaft. If the input shaft is turned more than 1-1/2 turns from the center position, you will have to either disassemble the gear to adjust the poppets again or install the special poppet adjusting screw kit 021407-X1.

   NOTE: If new or reset poppets are in the gear, they will be moved when the input shaft is turned less than one rotation in either direction from the center position. This will not affect the function of the poppets.

   1.2 With the adjusting screw nut loose, adjust the sector shaft adjusting screw while turning the input shaft 180 degrees each side of center until the input shaft reaches a torque of 45 to 50 lbf·in (500 to 560 N·cm). See **Fig. 102**. Use a 12-point socket and an inch-pound torque wrench to turn the input shaft.

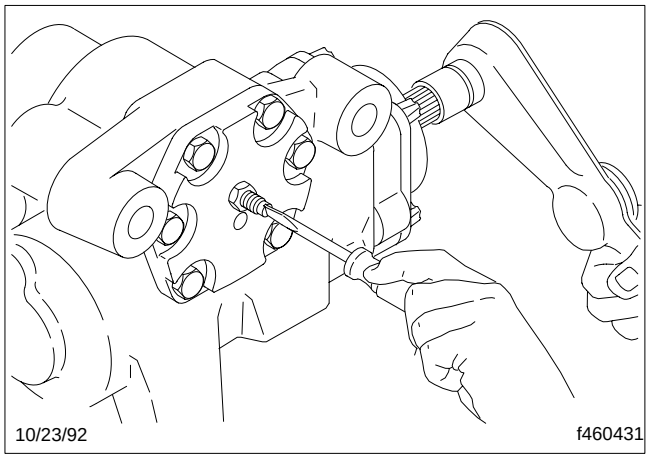


Fig. 102, Adjust the Sector Shaft Adjusting Screw

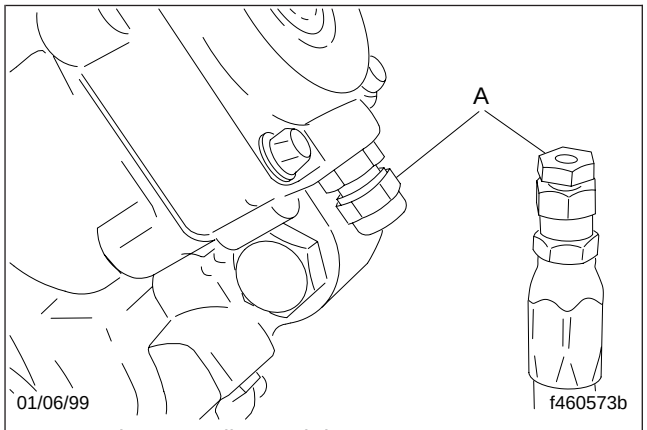
   1.3 Back out the sector shaft adjusting screw one-half turn. Note the torque needed to turn the input shaft through 180 degrees each side of center.

   1.4 Tighten the sector shaft adjusting screw so that the torque noted in the above substep is increased by 6 to 8 lbf·in (60 to 100 N·cm). Then, while holding the adjusting screw in place, tighten the sector shaft adjusting screw jam nut 40 to 45 lbf·ft (54 to 61 N·m).

2. Check the torque needed to turn the input shaft. If it is more than 40 lbf·in (452 N·cm), readjust the input shaft.

Removal

1. Disconnect the return line from the steering gear and plug the line. See **Fig. 1**. Also cap the return port of the gear with a high pressure fitting.



A. Cap the return line and the return port.

Fig. 1, Disconnect the Return Line

2. Disconnect the steering driveline from the steering gear input shaft.

   2.1 Remove and discard the pinch bolt and nut from the steering driveline lower end yoke.

CAUTION

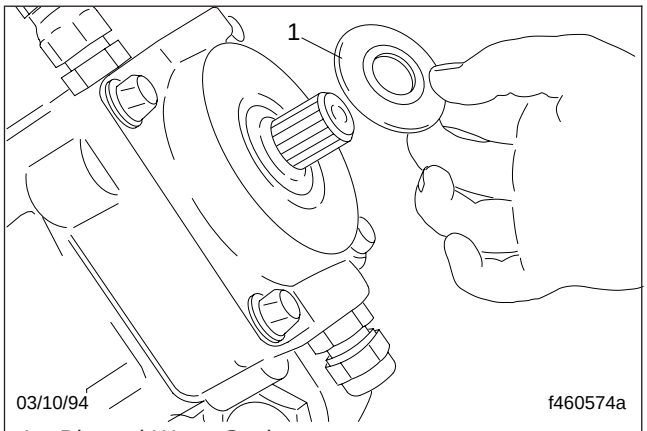
Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.

   2.2 Remove the lower end yoke from the input shaft. Do not turn the steering gear input shaft when removing the lower end yoke. Push the driveline shaft into the driveline tube as you remove the lower end yoke.

3. Remove the dirt and water seal from the steering gear. See **Fig. 2**.

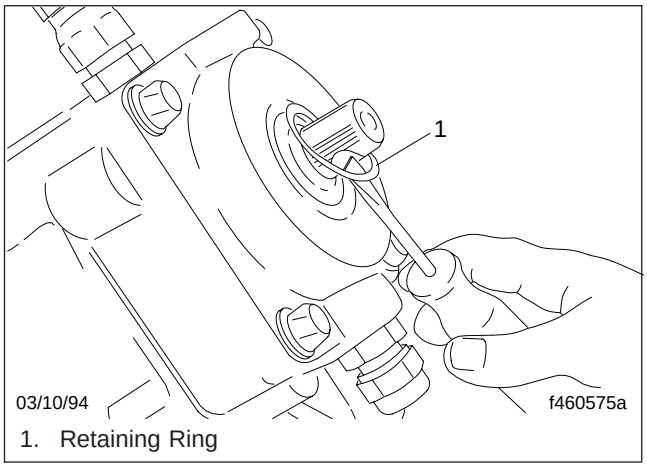
4. Wipe out the grease and then remove the spiral retaining ring. See **Fig. 3**. Use a screwdriver inserted into the notch formed in the end of the ring.

5. Slip the input yoke back on the input shaft with the pinch bolt installed but not tightened. **Fig. 4**



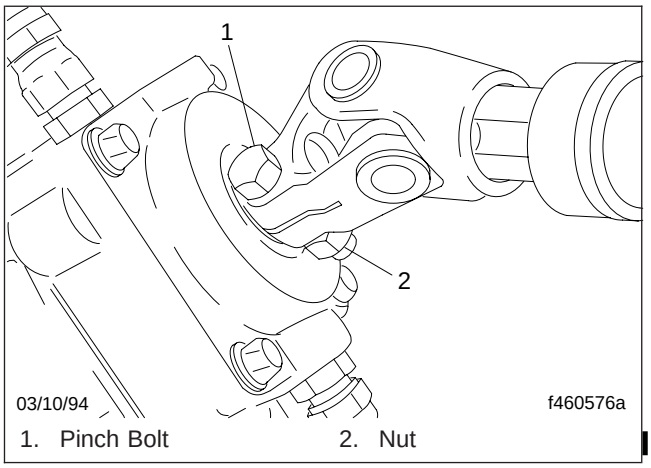
1. Dirt and Water Seal

Fig. 2, Remove the Dirt and Water Seal



1. Retaining Ring

Fig. 3, Remove the Retaining Ring

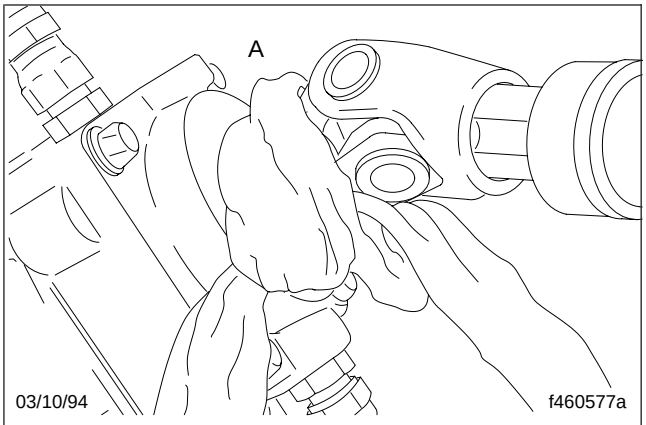


1. Pinch Bolt 2. Nut

Fig. 4, Install the Pinch Bolt

Input Shaft Seal Removal and Installation

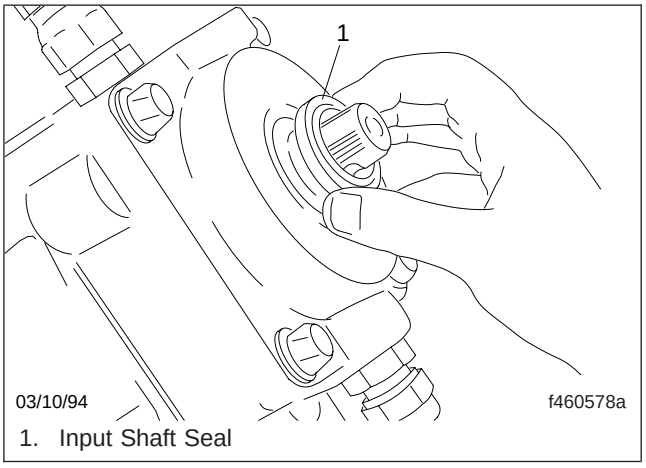
6. Tie or wrap a shop towel around the input shaft area and place a drip pan under the vehicle to catch the oil. See **Fig. 5**.



A. Cover the input shaft area.

Fig. 5, Shop Towel Covering the Input Shaft

7. Add the power steering fluid specified in **Specifications 400** as necessary to the fill line on the dipstick.
8. With the vehicle in neutral, momentarily turn the starter (quickly turn off the engine if it starts).
9. Remove the shop towel, pinch bolt, and input yoke.
10. Remove the seal. See **Fig. 6**.



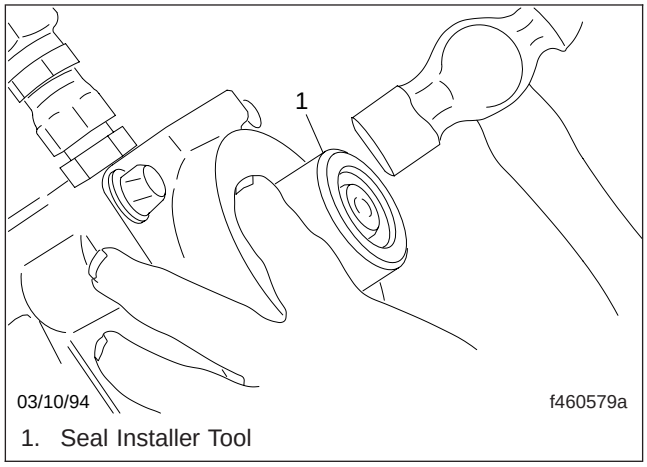
1. Input Shaft Seal

Fig. 6, Remove the Input Shaft Seal

11. Check the seal area of the valve housing for any seal fragments. Remove any that are found.
12. Check the seal for heat damage. If the seal is stiff, brittle, and not pliable like the new seal, it is probably heat damaged. You need to determine and fix the cause of excessive heat in the vehicle. For troubleshooting procedures, see **Section 46.11, Subject 300**.

Installation

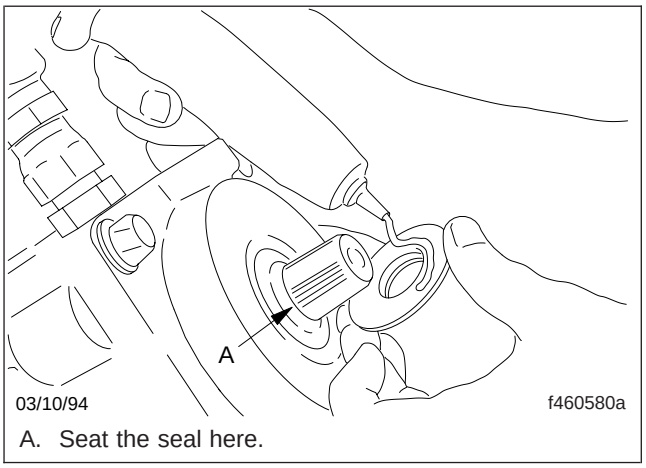
1. Put clean grease on the new input shaft seal and place it over the input shaft, garter spring side first. See **Fig. 6**. Place seal installer tool J37073 over the input shaft and against the seal, small diameter end first. See **Fig. 7**. Tap the seal installer tool until the tool shoulder is square against the valve housing. Remove any seal material that may have sheared off in the seal bore or retaining ring groove.



1. Seal Installer Tool

Fig. 7, Position the Seal Installer Tool

2. Insert the new retaining ring into the groove.
3. Pack the end of the valve housing bore around the input shaft with clean high temperature industrial grease (Mobil Temp 1 or 2 or equivalent). Apply more of the grease to a new dirt and water seal and install it over the input shaft. See **Fig. 8**. Seat it in the groove behind the serrations and against the valve housing.
4. Connect the steering driveline to the steering gear input shaft.
   4.1 Clean the input shaft and the inside of the driveline yoke.



A. Seat the seal here.

Fig. 8, Install the Dirt and Water Seal

4.2 Apply a thin film of grease to the yoke splines. Use lithium-based grease, NLGI grade 2.

4.3 Slide the yoke on the input shaft and install the a new pinch bolt. Before installing the nut, make sure the pinch bolt is centered in the steering column shaft notch. The pinch bolt is centered if it can slip in and out of the end yoke with ease. Install a new nut and tighten it to one of the following torque specs:

- 55 to 65 lbf·ft (75 to 88 N·m) for a 7/16–20 pinch bolt and nut
- 30 to 35 lbf·ft (41 to 47 N·m) for an M10 x 1.25 pinch bolt and nut

4.4 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and to the nut.

5. Connect the return line to the steering gear return port.

6. Fill and bleed the steering system.

IMPORTANT: Do not turn the steering wheel in the following steps until instructed. Doing so can cause air to enter the system, which can make it more difficult and time-consuming to bleed air from the system.

6.1 Fill the power steering reservoir with the steering fluid specified in **Specifications 400** until nearly full.

Crank the engine for 10 seconds without allowing it to start. If the engine does start, shut it down immediately. Check and fill the reservoir as needed.

Repeat this procedure three times, each time checking and filling the reservoir.

6.2 Start the engine and let it idle for two minutes. Shut down the engine and check the fluid level in the reservoir.

6.3 Start the engine again. Steer the vehicle from full left to full right several times. As needed, add fluid to the full line on the reservoir dipstick.

Post-Service Checks |

After power steering components have been worked on and before the vehicle is placed into service, make the following checks.

⚠ WARNING

Failure to make the following checks could result in damage to the power steering system. This could cause a loss of hydraulic assist, which could cause personal injury or property damage.

1. With the engine turned off and warm, check the power steering reservoir fluid level.
2. Check for air in the system.
   - 2.1 Place a thermometer in the power steering reservoir. Then warm the hydraulic system to normal operating temperature of 125° to 135°F (51° to 57°C) by operating the engine at low idle while turning the steering wheel through several full-left and full-right turns.
   - 2.2 With the engine running and the power steering system at operating temperature, turn the steering wheel slowly from stop to stop while checking the power steering reservoir for frothing or a change in the fluid level (a sign that air is trapped in the system). If air is present, inspect the system for leaking hoses or loose fittings. Replace the hoses or tighten the fittings as needed. Bleed the air from the system.
3. At full-left and full-right wheel cuts, be sure the axle stops (on the rear-side of the spindle) are set so there is at least 1/2-inch (13-mm) clearance between the tires and any fixed components that are attached to the vehicle. Clearance between moving components should be 3/4 inch (19 mm). If clearance is less than this, reset the axle stops.
4. Check that the automatic poppets or the manual poppet adjusting screw (if equipped) are set correctly. If needed, adjust them. For instructions, see **Subject 100**.
5. If there are still problems with the power steering system, see **Section 46.11, Subject 300**. Otherwise, go to the next step.
6. Test drive the vehicle or take a ride with the driver.

   Check the steering wheel spoke position. With the front tires pointing straight ahead, check the position of the steering wheel spokes. They must be within ±10 degrees of the 4 o'clock and 8 o'clock positions. See **Fig. 1**. If they are not, remove the steering wheel and install it in the correct position. For instructions, refer to the applicable section in this group.

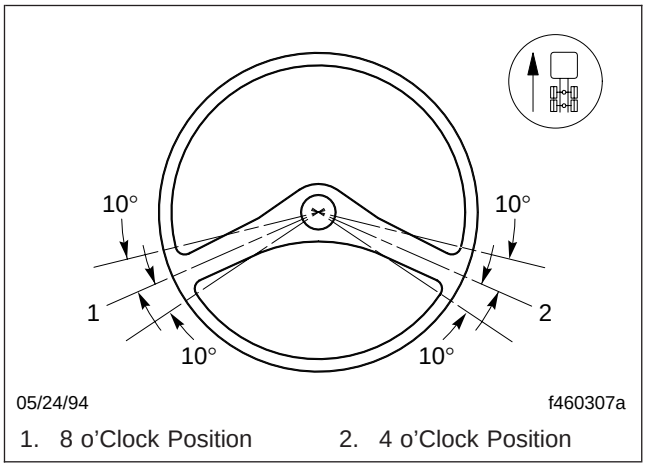


Fig. 1, Steering Wheel Centered

Specifications

SPX Kent-Moore, Warren, Michigan 48092, 1-800-328-6657			
Part Number			Tool
TAS40	TAS55/65	TAS85	
J37070	J37070	J37070	Adjuster Tool
J37464	J37464	J37464	Adjuster Locknut Tool
J37705	J37071	J38779	Bearing and Seal Tool
J37073	J37073	J37073	Input Seal Installer
J38713	J38713	J38713	Poppet Adjuster Seat Tool, Heavy-Duty (preferred)
J36452	J36452	J36452	Poppet Adjuster Seat Tool
J37130	J37130	J37130	Relief Valve Plug
J8092	J8092	J8092	Tool Handle

Table 1, SPX Kent-Moore, Warren, Michigan 48092, 1-800-328-6657

⚠ WARNING

Fill only with approved clean power steering fluid. Any mixture or any unapproved fluid could lead to seal deterioration and leaks. Any fluid leak could eventually cause loss of power steering assist.

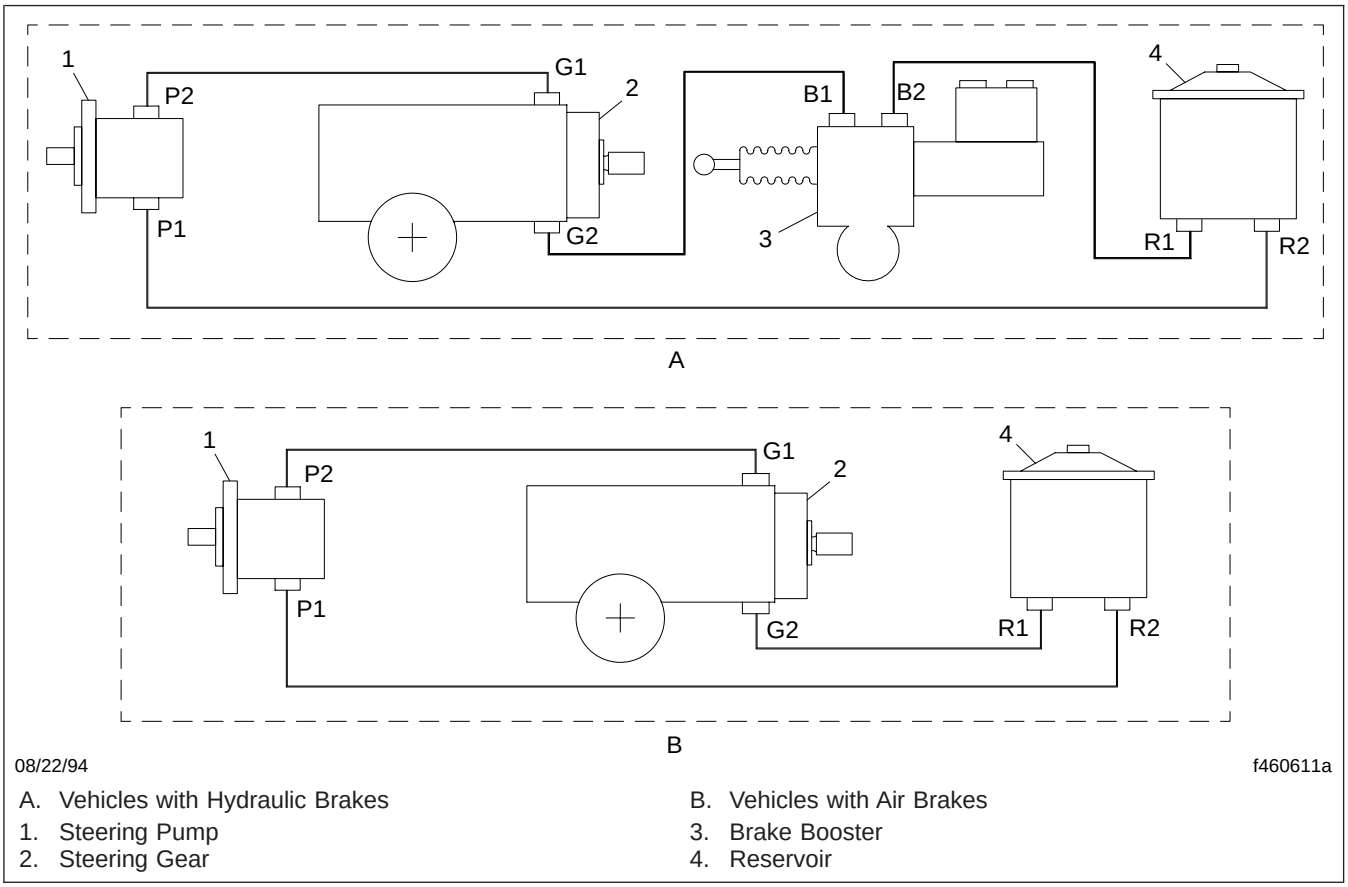
Approved Power Steering Fluids	
Fluid Type	**Approved Fluid**
Automatic Transmission Fluid*	Dexron® II Dexron® III
Heavy-Duty Engine Oil* IMPORTANT: Do not use heavy-duty engine oil in vehicles built from November 4, 2002. **⚠ WARNING** **Do not use heavy-duty engine oil in vehicles equipped with a Hydro-Max® brake booster. Engine oil is not compatible with the seals in the brake booster. If the vehicle is equipped with a Hydro-Max brake booster, use only automatic transmission fluid in the power steering system. Failure to follow this precaution could cause loss of hydraulic brake assist, possibly resulting in personal injury and property damage.**	Union 10W–40 Texaco 10W–40 Chevron 10W–40 Mobil Super 10W–40 Union 15W–40 Shell Rotella T 30W

* Do not mix engine oil with automatic transmission fluid (ATF). Use the same lubricant for parts as is in the power steering system.

Table 2, Approved Power Steering Fluids

See **Fig. 1** for a steering system plumbing diagram.

Specifications



A. Vehicles with Hydraulic Brakes
1. Steering Pump
2. Steering Gear

B. Vehicles with Air Brakes
3. Brake Booster
4. Reservoir

Fig. 1, Steering System Plumbing Diagram

General Information

The TRW HFB70 power steering gears can be installed on vehicles with front axle capacities up to 16,000 pounds (7257 kg). The steering gear is mounted on the vehicle frame rail. The steering gear incorporates a manual steering mechanism, hydraulic control valve, and a hydraulic power cylinder. The control valve is a rotary design, which directs oil flow from the power steering pump to the upper or lower cylinder cavity. See **Fig. 1**.

Principles of Operation

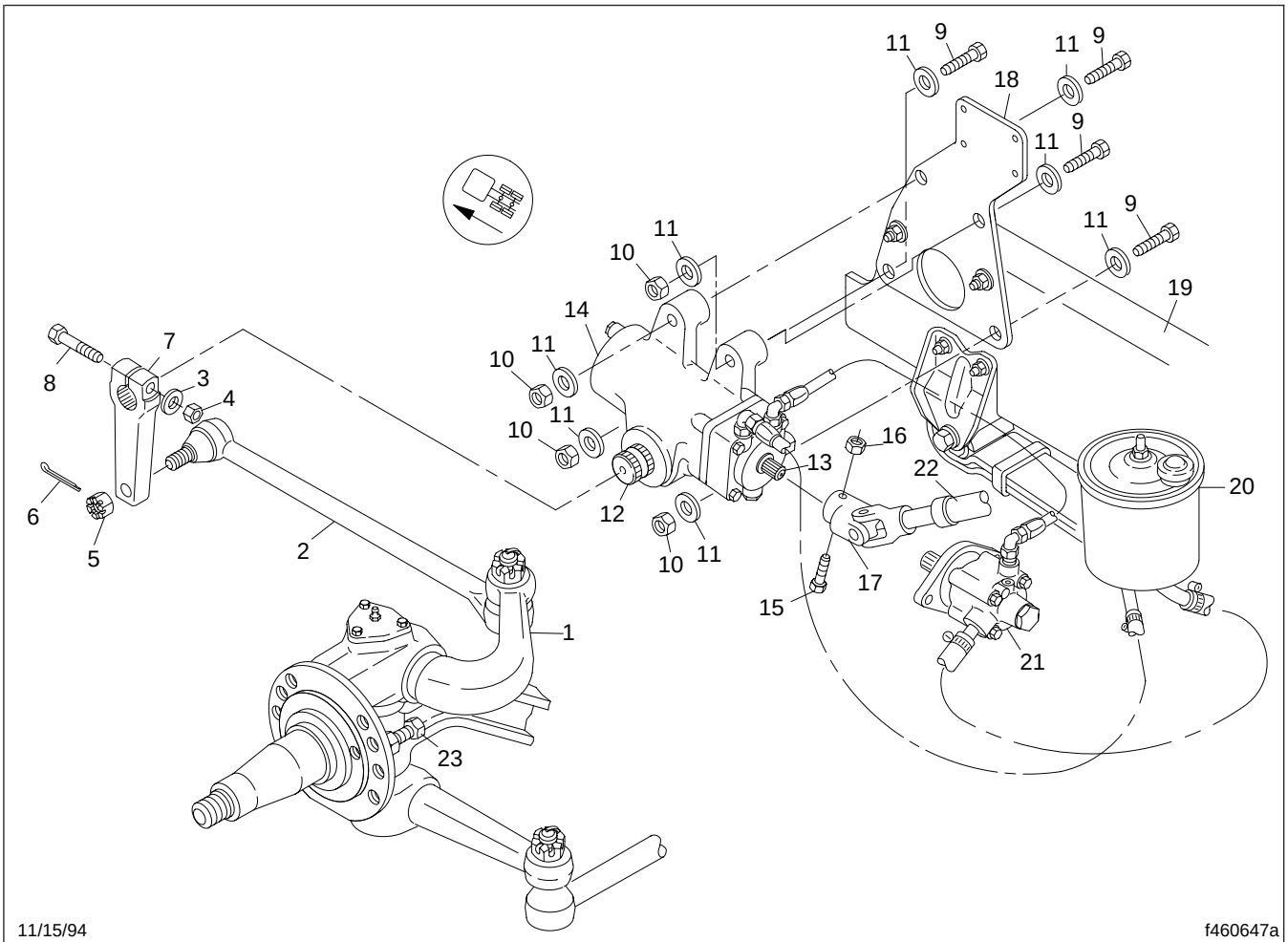
When the steering wheel is turned, force is transmitted from the steering wheel to the steering gear input shaft. A torsion bar, pinned at one end to the input shaft and at the other to the worm shaft, turns with the input shaft and exerts a rotational force on the worm shaft. In response, the worm shaft, acting through the recirculating ball mechanism, tries to move the rack piston up or down (as applicable) in the gear housing cylinder bore. See **Fig. 2**.

The movement of the rack piston is resisted by its engagement to the sector shaft, which is linked to the steered wheels. Because of this resistance, the torsion bar is twisted by the input shaft, thereby actuating the control valve. Pressurized fluid, directed by the control valve to the upper or lower cylinder cavity (depending on the direction or turn), assists in moving the rack piston up or down in the cylinder bore. The rack piston then turns the sector shaft to steer the vehicle.

If the steered wheels receive a shock load, the shock forces are transmitted through the sector shaft to the rack piston and on to the worm shaft. The internal construction of the steering gear causes the control valve to send high-pressure fluid to the correct cylinder cavity to resist the shock forces. By absorbing the shock forces hydraulically, the steering gear prevents kickback at the steering wheel.

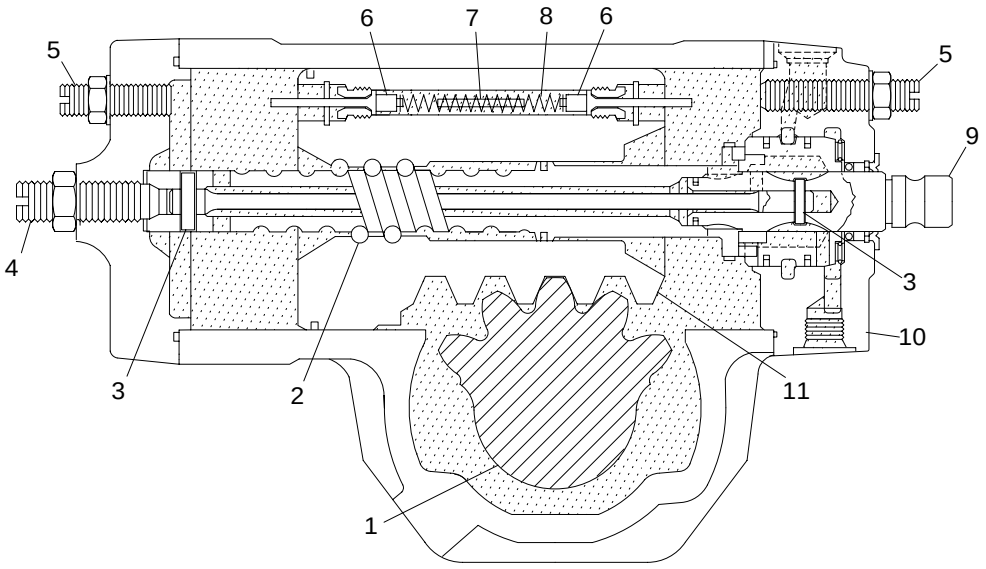
On each end of the rack piston is a poppet (unloading valve). The appropriate poppet will trip as the steered wheels approach the axle stop for that direction of turn. The tripped poppet reduces pressure in the gear, heat generated by the pump, and outside forces acting on the steering linkage.

General Information



1. Axle Steering Arm
2. Drag Link
3. Washer
4. Nut
5. Castle Nut
6. Cotter Pin
7. Pitman Arm
8. Pinch Bolt
9. Mounting Capscrew
10. Nut
11. Hardened Washer
12. Sector (output) Shaft
13. Input (worm) shaft
14. Steering Gear
15. Pinch Bolt
16. Nut
17. Lower End Yoke
18. Steering Gear Mounting Plate
19. Left Frame Rail
20. Power Steering Reservoir
21. Power Steering Pump
22. Steering Driveline
23. Axle Stop

Fig. 1, TRW HFB70 Power Steering Installation

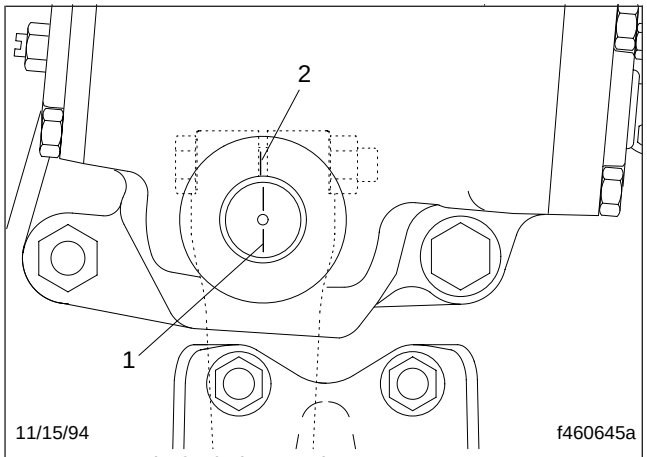


1. Sector Shaft
2. Ball (recirculating)
3. Pin
4. Preload Adjusting Screw
5. Poppet Adjusting Screw
6. Poppet Assembly
7. Spacer Rod
8. Poppet Spring
9. Input Shaft
10. Gear Housing
11. Rack Piston

Fig. 2, Steering Gear Section View |

Sector Shaft Adjustment

1. Position the sector (output) shaft at its center of travel by turning the steering wheel until the alignment mark on the sector shaft is at a right angle to the input shaft centerline, and in line with the timing mark on the end of the housing trunnion. See **Fig. 1**.



1. Sector Shaft Timing Mark
2. Housing Trunnion Timing Mark

Fig. 1, Align the Timing Marks

2. Disconnect the drag link from the pitman arm. For instructions, refer elsewhere in this group.
3. With the sector shaft centered, grasp the pitman arm and gently try to move it back and forth. Fingertip force is adequate to detect lash (free play) of a loose sector shaft. See **Fig. 2**. There should be no movement of the input shaft or sector shaft. If there is no lash, no adjustment is needed.

   If there is lash, loosen the sector shaft adjusting screw jam nut and turn the adjusting screw clockwise until the sector shaft and rack piston are in contact. Use no more than 10 lbf·ft (14 N·m) of torque. Then turn the adjusting screw counterclockwise one turn. At this point, there should be lash at the pitman arm.
4. To adjust, slowly turn the adjusting screw clockwise until no lash is felt at the pitman arm. Hold the adjusting screw in place and tighten the jam nut 40 to 45 lbf·ft (54 to 61 N·m).

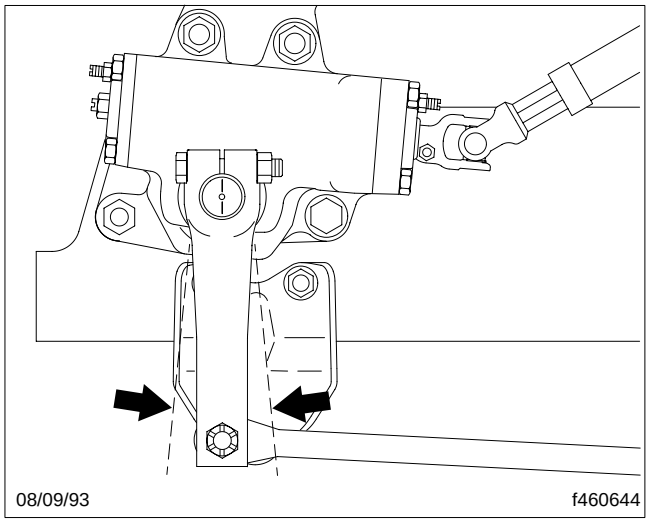


Fig. 2, Check the Free Play

5. Again check the pitman arm for lash. Turn the steering wheel one-quarter turn each side of center. No lash should be felt. If lash exists, readjust.
6. Connect the drag link to the pitman arm. For instructions, refer elsewhere in this group.

Poppet Valves Adjustment

1. Check the settings of the axle stops and adjust them if necessary. For instructions, refer to the front axle section in this manual.
2. Install a flow meter kit in the supply line from the pump to the steering gear. Make sure that the flow meter can be pressurized. Warm the power steering fluid to an operating temperature of 125° to 135°F (51° to 57°C).
3. Loosen both of the poppet valve adjusting screw jam nuts.
4. With the engine at idle, have someone turn the steering wheel to the full-lock right position. Check the pressure gauge.

⚠ CAUTION

If power steering pump relief pressure is reached while the steering wheel is at full lock, release the steering wheel from this position. Do not allow the pump relief pressure to be maintained for

In-Vehicle Adjustments

longer than five seconds, or damage to the pump may result.

IMPORTANT: When the steering wheel is at the full-lock position, make sure the stop screw on the back of the wheel spindle contacts the axle boss. Failure to maintain contact while adjusting the poppet valve could cause incorrect adjustment.

5. If the pressure gauge reading is less than 2000 psi (13 800 kPa), back out the poppet valve adjusting screw until the relief pressure reading is 1960 psi (13 514 kPa).

NOTE: The right-turn poppet valve adjusting screw is at the rear of the steering gear.

6. If system pressure exceeds the maximum pump relief pressure, repair the power steering pump. Refer elsewhere in this group for pump repair instructions.
7. Release the steering wheel from the full-lock right position enough to allow insertion of a 1/16- to 1/8-inch (1.6- to 3.2-mm) thick flatwasher between the axle beam and the right-side axle stop pin.
8. Bring the steering wheel back to the full-lock right position against the flatwasher. While holding the poppet valve adjusting screw jam nut in place with a wrench, immediately screw in the poppet valve adjusting screw until the pressure gauge reading drops by 200 to 400 psi (1379 to 2758 kPa).

   While holding the poppet valve adjusting screw in place, tighten the jam nut 12 to 18 lbf·ft (16 to 24 N·m).
9. With the engine at idle, have someone turn the steering wheel to the full-lock left position. Check the pressure gauge. Adjust the other poppet valve adjusting screw using the applicable steps above.

NOTE: The left-turn poppet valve adjusting screw is on the front of the steering gear.

Removal

IMPORTANT: Before removing the steering gear, see **Section 46.11, Subject 300** to identify the problem.

1. Verify correct axle stop adjustment. For instructions, refer to the front axle section in this manual. Ensuring correct axle stop adjustment now will eliminate the possibility of resetting steering gear poppet valves after the gear is reinstalled.
2. Place the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where the work is to be done. Apply the parking brakes and chock the tires.
3. Remove the left-hand bumper extension.
4. Clean all outside dirt from around the fittings and hose connections.
5. Drain the power steering system. Disconnect all hydraulic lines from the gear, marking the lines for later assembly reference. Seal the lines and the fittings to keep out dirt.
6. Disconnect the pitman arm from the steering gear sector shaft. See **Fig. 1**.
   - 6.1 Remove and discard the pinch bolt, washer, and nut from the pitman arm.
   - 6.2 Using a suitable puller, remove the pitman arm and swing the pitman arm and drag link out of the way.
7. Disconnect the steering driveline from the steering gear input shaft.
   - 7.1 Remove and discard the pinch bolt and nut from the steering driveline lower end yoke.

CAUTION

Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.

   - 7.2 Remove the lower end yoke from the input shaft.
8. Clean the entire assembly before removing the gear.

WARNING

The steering gear is heavy. Use caution when removing, lifting, or carrying the steering gear. Failure to do so could cause personal injury.

9. Remove the fasteners that attach the steering gear to the frame rail. Remove the steering gear.

Installation

1. Install the steering gear and fasteners as shown in **Fig. 2**.

   Tighten the fasteners 427 lbf·ft (579 N·m).
2. If not previously done, center the steering gear. The sector (output) shaft alignment mark must be at a right angle to the steering gear input shaft centerline. Make sure the steering gear remains centralized as the service work continues.
3. Install the pitman arm.
   - 3.1 Position the pitman arm on the steering gear, aligning the timing mark as shown in **Fig. 3**.

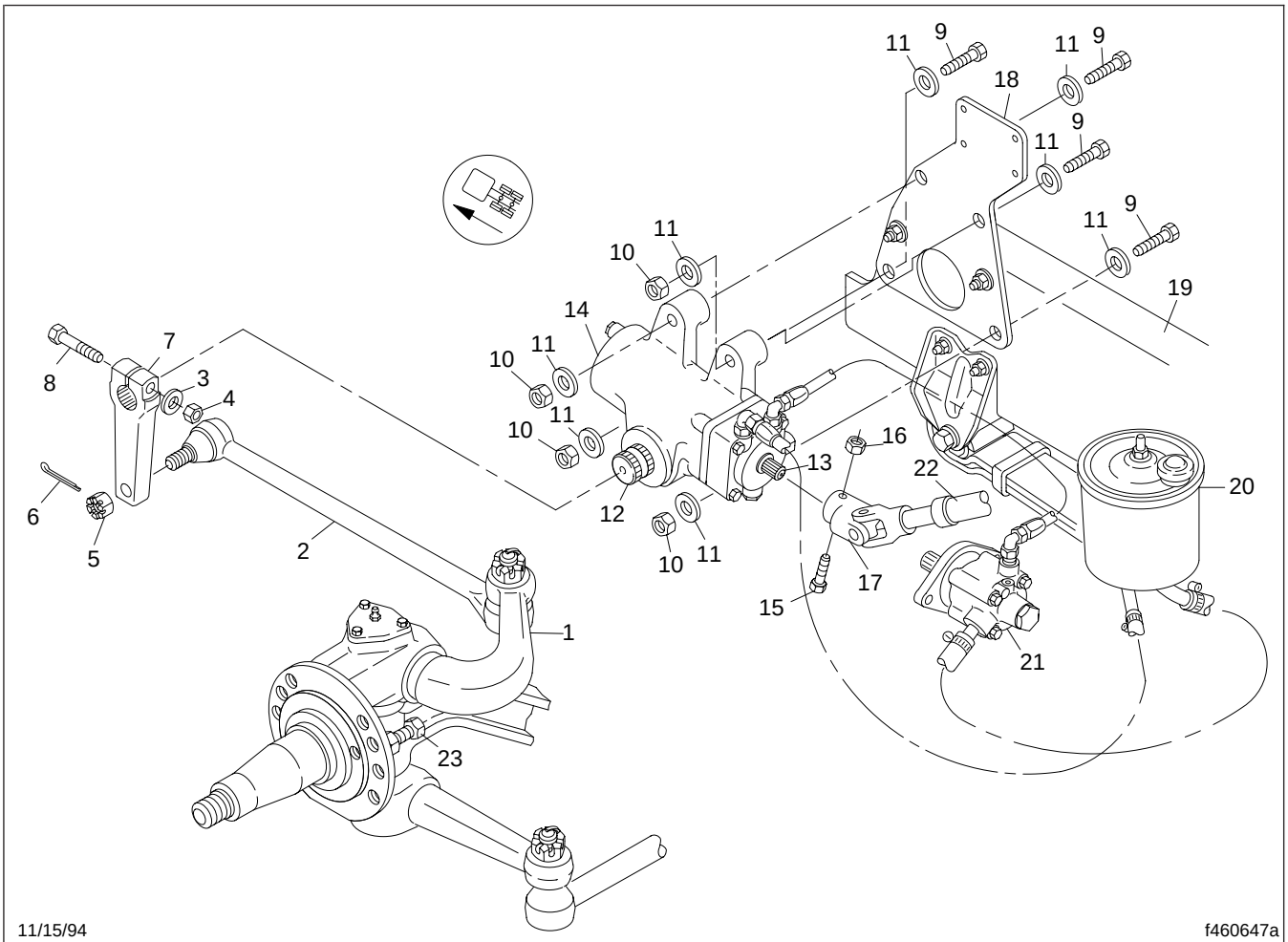
WARNING

Never leave a chisel wedged in the pitman arm slot. When using a chisel to spread the slot in the pitman arm, maintain a firm grip on the chisel at all times. Otherwise the chisel may fly loose, which could cause an injury.

   NOTE: The pitman arm may not fit over the splines on the sector shaft without spreading the slot in the arm. Use a ball-peen hammer to drive a chisel into the slot. Hold the chisel in place. Install the pitman arm on the sector shaft. Remove the chisel from the slot.

   - 3.2 Install a new pinch bolt, washer, and nut. Tighten the nut 215 to 245 lbf·ft (292 to 332 N·m).
   - 3.3 Apply torque seal, OGP F900WHITE, to the exposed threads and to the nut.
4. Connect the steering driveline to the steering gear input shaft.
   - 4.1 Clean the steering gear input shaft and the inside of the driveline yoke.

Steering Gear Removal and Installation



1. Axle Steering Arm
2. Drag Link
3. Washer
4. Nut
5. Castle Nut
6. Cotter Pin
7. Pitman Arm
8. Pinch Bolt
9. Mounting Capscrew
10. Nut
11. Hardened Washer
12. Sector (output) Shaft
13. Input Shaft
14. Steering Gear
15. Pinch Bolt
16. Nut
17. Lower End Yoke
18. Steering Gear Mounting Plate
19. Left Frame Rail
20. Power Steering Reservoir
21. Power Steering Pump
22. Steering Driveline
23. Axle Stop

Fig. 1, TRW HFB70 Power Steering Installation

4.2 Apply a thin film of grease to the yoke spline.

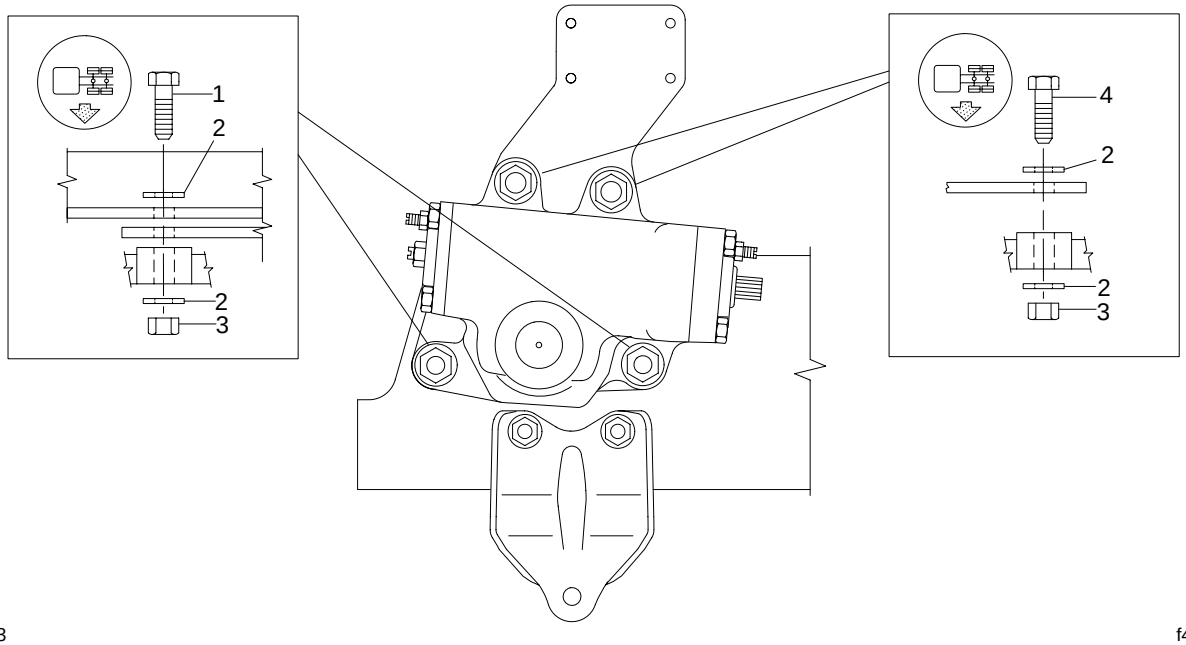
4.3 Slide the yoke on the input shaft and install a new pinch bolt and nut. Tighten the nut to one of the following torque specs:

- 55 to 65 lbf·ft (75 to 88 N·m) for a 7/16–20 pinch bolt and nut
- 30 to 35 lbf·ft (41 to 47 N·m) for an M10 x 1.25 pinch bot and nut

4.4 Apply torque seal, OGP F900WHITE, to the exposed threads and to the nut.

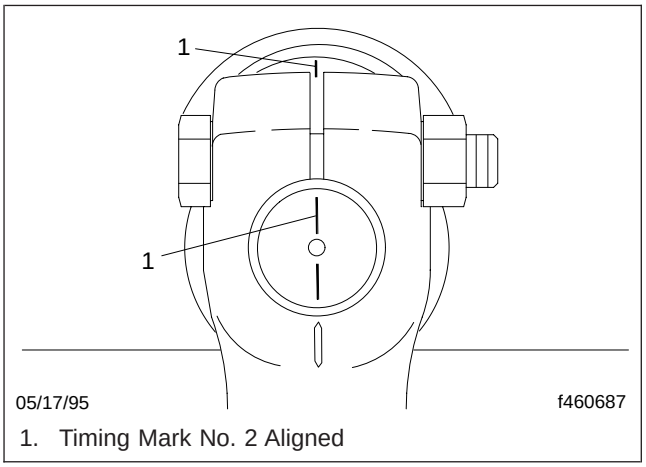
5. Connect the hydraulic lines.

5.1 If they were removed, attach the hydraulic line elbow fittings to the steering gear.



1. 7/8–14 x 4-1/2 Capscrew, Grade 8
2. 7/8 Inch ID Hardened Washer
3. 7/8–14 Nut
4. 7/8–14 x 4 Capscrew, Grade 8

Fig. 2, Steering Gear Mounting (top view)



1. Timing Mark No. 2 Aligned

Fig. 3, Typical Pitman Arm and Timing Marks

Tighten the fittings 38 lbf·ft (51 N·m). Tighten the pressure line fitting jam nut 41 lbf·ft (56 N·m).

5.2 Remove the plugs from the hydraulic lines. Connect the lines to the steering gear as previously marked. Tighten the nut on each fitting finger-tight. Then use a wrench to tighten the nut until there is firm resistance. Tighten one-sixth turn more.

6. Fill and bleed the steering system.

   IMPORTANT: Do not turn the steering wheel until instructed in the following steps. Doing so can cause air to enter the system, which can make it more difficult and time-consuming to bleed air from the system.

   6.1 Fill the power steering reservoir with the steering fluid specified in **Specifications 400** until nearly full. Crank the starter for 10 seconds without allowing the engine to start. If the engine does start, shut it down immediately. Check and fill the reservoir as needed. Repeat this procedure three times, each time checking and filling the reservoir.

   6.2 Start the engine and let it idle for two minutes. Shut down the engine and check the fluid level in the reservoir.

   6.3 Start the engine again. Steer the vehicle from full left to full right several times. As

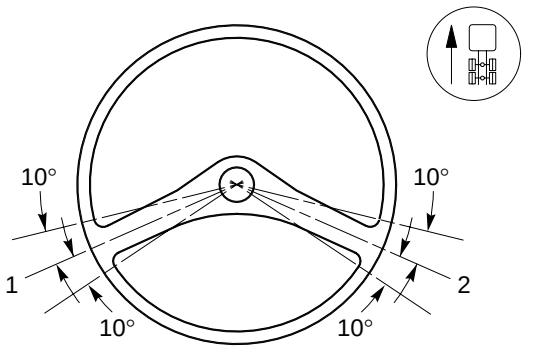
Steering Gear Removal and Installation

necessary, add fluid to the full line on the reservoir dipstick.

NOTE: Adjust the poppets following the procedure in **Subject 100**.

7. Go to **Subject 150** and do the checks as instructed.
8. Install the left-hand bumper extension.
9. Test drive the vehicle or take a ride with the driver.

   Check the steering wheel spoke position. With the front tires pointing straight ahead, check the position of the steering wheel spokes. They must be within ±10 degrees of the 4 o'clock and 8 o'clock positions. See **Fig. 4**. If not, remove the steering wheel and install it in the correct position. For instructions, refer to the applicable section in this group.



1. 8 o'Clock Position
2. 4 o'Clock Position

Fig. 4, Steering Wheel Centered

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

Disassembly

IMPORTANT: The special tools required for disassembly and assembly of the steering gear parts are available from SPX Kent-Moore or an affiliated dealer. See the special tools Table in **Specifications 400** to be sure that you have the required tools before beginning the service procedures.

Make sure that the steering gear is placed on a clean surface. Clean and dry the gear before disassembly. As the gear is disassembled, clean all parts in a clean, petroleum-based solvent, and blow-dry them only.

Keep each part separate to avoid nicks and burrs. Discard all seals, O-rings, and gaskets, and replace them with new parts.

See **Fig. 1** for an exploded, assembly drawing.

1. Clamp the gear mounting bosses in a vise, so that the gear's input shaft is horizontal. Rotate the input shaft to position the alignment mark on the sector shaft halfway between two trunnion cover bolts and pointing up. See **Fig. 2**.
2. Remove and discard the pinch bolt and nut from the pitman arm. Using a suitable puller, remove the pitman arm.
3. Remove the protective boot, the grease fittings, and the dirt and water seal from the trunnion cover. See **Fig. 3**. Discard the boot and the seal.
4. Using a fine grade of emery paper, remove any paint or corrosion from the nonserrated area of the sector shaft. Loosen the sector shaft adjusting screw jam nut.
5. Remove the four trunnion cover bolts and washers. See **Fig. 4**. Remove the trunnion cover. Remove and discard the trunnion cover O-ring, the Teflon® backup washer, and the two-piece sector shaft seal. See **Fig. 5**.
6. Tape the serrations and bolt groove of the sector shaft, using **one**layer of masking tape. See **Fig. 6**.
7. Prepare for fluid to drain, then remove the eight special bolts from the side cover.

IMPORTANT: These special bolts are equipped with either a ring or washer-design on the underside of the head. See **Fig. 7**. If replacing one or more bolts, use bolts that are the same **type and length** as those that were removed. Do not use substitutes.

8. Begin to remove the side cover and sector shaft as an assembly. See **Fig. 8**. As a means of starting the removal of the side cover and sector shaft assembly, a soft hammer or wooden handle may be used. Stop removal when the bearing rolls in the housing bearing are half exposed. Coat the bearing rolls with grease. See **Fig. 9**.

IMPORTANT: Be sure that no rolls are lost during disassembly. If one or more of the rolls is lost, the entire bearing must be replaced. If the bearing is identified as BR-970, there are 41 rolls. If the bearing is identified as BR-970-1, there are 42 rolls.

NOTE: The housing bearing may have caged (retained) rolls, which do not require special precautions. However, if the bearing rolls are not caged, remove this assembly slowly or it may come out too quickly to allow the bearing rolls in the housing bearing race to be retained. Follow the shaft end with bearing tool J26743 to retain the rolls, or when the rolls are half exposed, coat them with grease to retain them in the housing bearing. See **Fig. 9**.

NOTE: The number on the housing bearing may not be visible while it is in place.

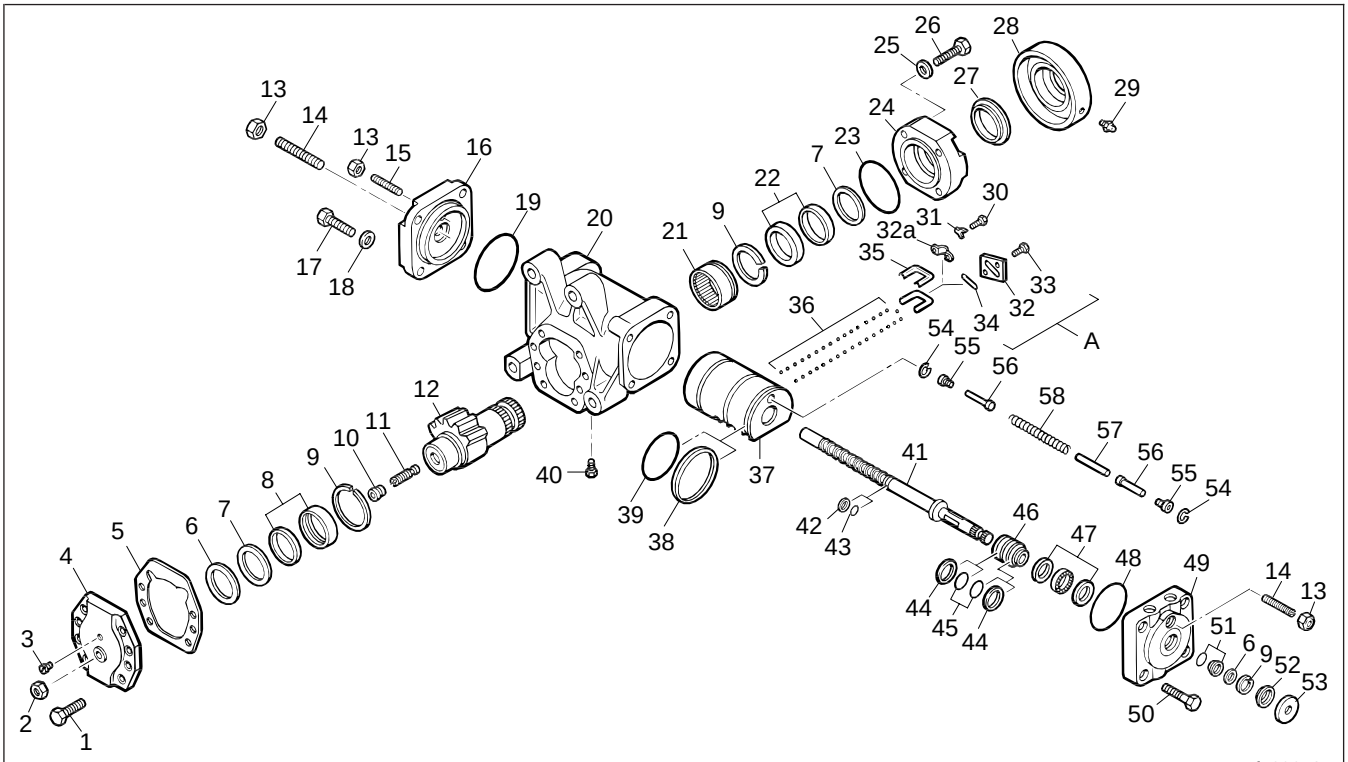
9. Finish removing the side cover and sector shaft as an assembly. Remove and discard the side cover gasket.
10. If the housing bearing race is damaged or if one or more of the rolls are lost, replace the housing bearing.

    10.1 Using bearing mandrel J26743, apply pressure from the side cover opening and press the bearing and retaining ring out through the trunnion cover opening and away from the cylinder bore.

    NOTE: Maintain firm, square contact between the housing and the base of the press to avoid damaging the housing bearing bore.

    10.2 Remove the retaining ring from the bearing and discard the bearing.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

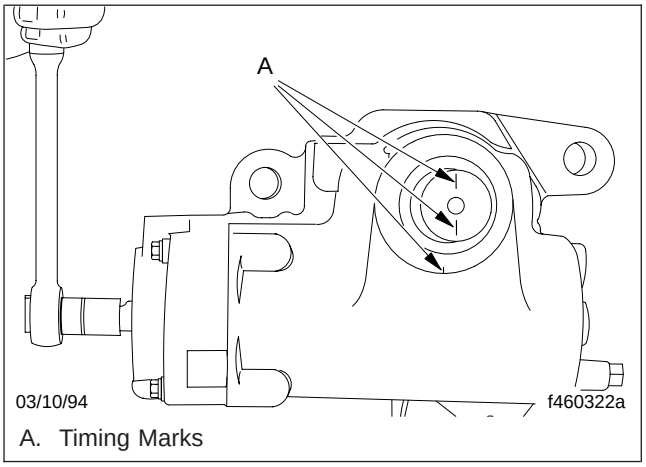


1. Ring Head Bolt
2. Jam Nut
3. Vent Plug
4. Side Cover (with bushing or roller bearing)
5. Side Cover Gasket
6. Backup Washer (steel)
7. Backup Washer (Teflon®)
8. Two-Piece Side Cover Seal
9. Retaining Ring
10. Adjusting Screw Retainer
11. Sector Shaft Adjusting Screw
12. Sector (output) Shaft
13. Adjusting Screw Jam Nut
14. Worm Shaft Adjusting Screw
15. Poppet Adjusting Screw
16. End Cover
17. End Cover Bolt
18. End Cover Washer
19. End Cover O-Ring
20. Gear Housing
21. Housing Bearing
22. Two-Piece Sector Shaft Seal
23. Trunnion Cover O-Ring
24. Trunnion Cover
25. Washer
26. Trunnion Cover Bolt
27. Dirt and Water Seal
28. Protective Boot
29. Grease Fitting
30. Bolt
31. Locktab
32. Ball Return Guide Cap
33. Allen Head Screw
34. Guide Cap Seal
35. Ball Return Guide Halves
36. Steel Balls
37. Rack Piston
38. Rack Piston Seal
39. Rack Piston O-Ring
40. Bleed Screw
41. Worm (input) Shaft
42. Worm Shaft Seal
43. Input Shaft O-Ring
44. Valve Sleeve Seal
45. Valve Sleeve O-Ring
46. Valve Sleeve
47. Thrustwashers and Thrust Bearing
48. Valve Housing O-Ring
49. Valve Housing
50. Valve Housing Bolt
51. Two-Piece Input Shaft Seal
52. Dirt and Water Seal, Valve Housing
53. Seal Protector
54. Poppet Retaining Ring
55. Poppet Seal
56. Poppet
57. Nylon Spacer Rod
58. Spring

Fig. 1, Steering Gear Assembly

IMPORTANT: If the bearing is cocked while pressing it out, it will burnish the bore causing it to become oversized. If this happens, the steering gear housing will have to be replaced.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments



A. Timing Marks

Fig. 2, Timing Marks

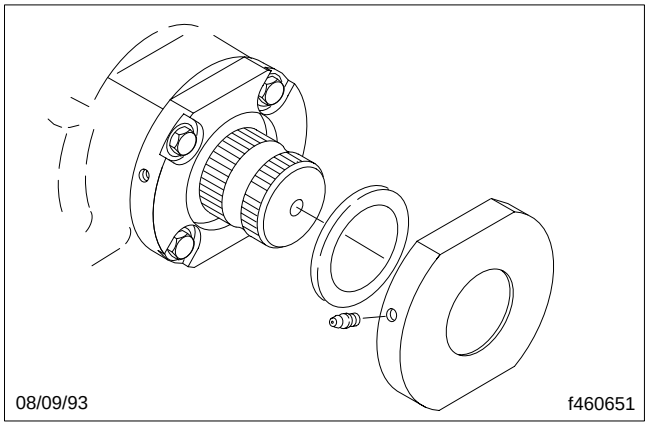


Fig. 3, Remove the Boot, Fittings, and Seal

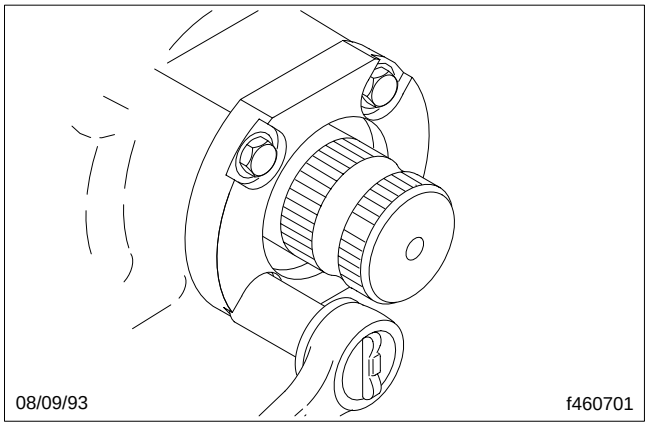


Fig. 4, Remove the Bolts and Washers

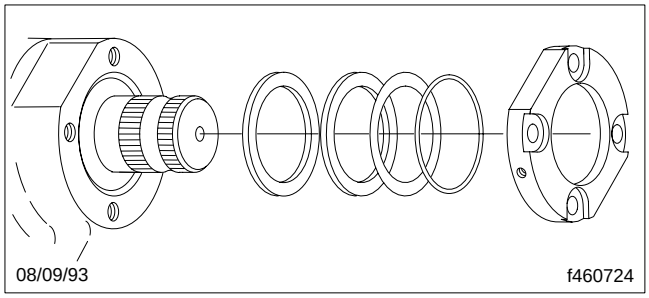


Fig. 5, Remove the Trunnion Cover

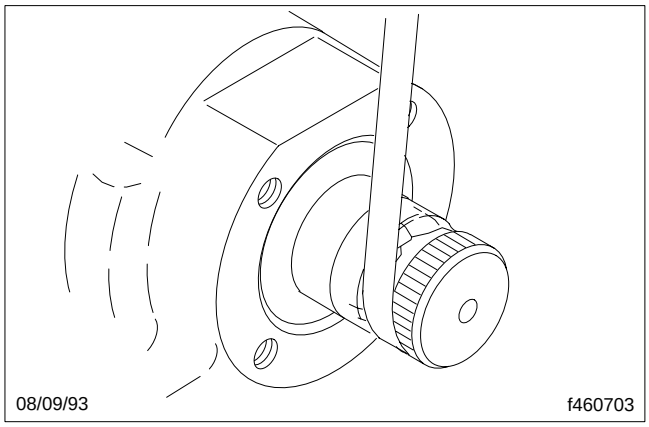
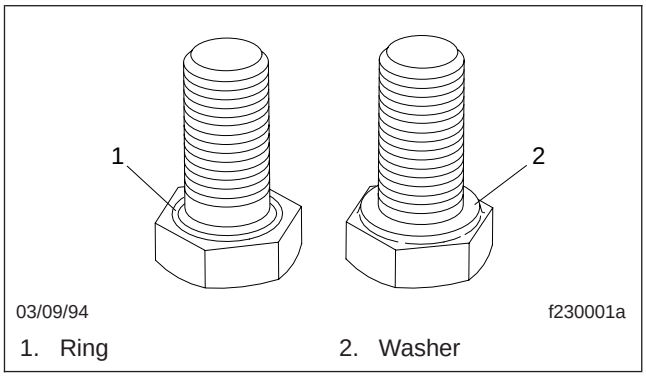


Fig. 6, Tape the Serrations and Bolt Groove



1. Ring
2. Washer

Fig. 7, Bolts With Ring or Washer

11. Remove the sector shaft adjusting screw jam nut.
12. Screw the sector shaft adjusting screw through the side cover. See **Fig. 10**. Place the side cover exterior side down and lift the sector shaft out vertically. See **Fig. 11**.

IMPORTANT: This will allow the side cover bearing rolls to fall into the side cover where

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

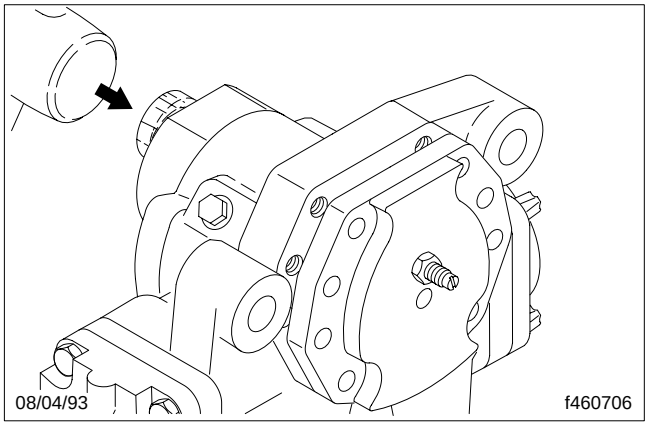


Fig. 8, Remove the Side Cover and Sector Shaft

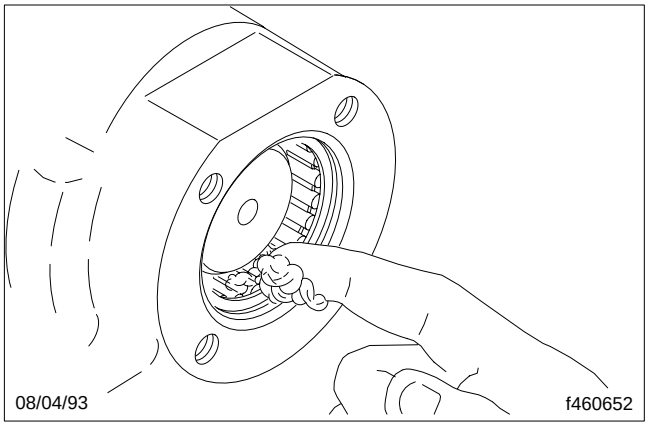


Fig. 9, Lubricate the Bearing Rollers

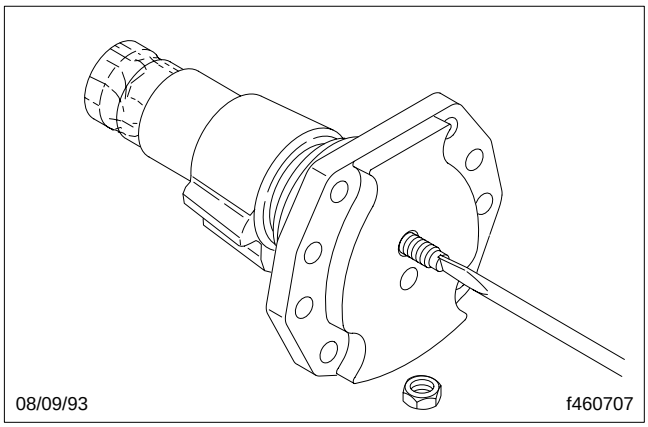


Fig. 10, Sector Shaft Adjusting Screw

they can easily be collected. Immediately collect all of the side cover bearing rolls and count them. Do not lose any rolls during disassembly, or the complete side cover assembly will have to be replaced.

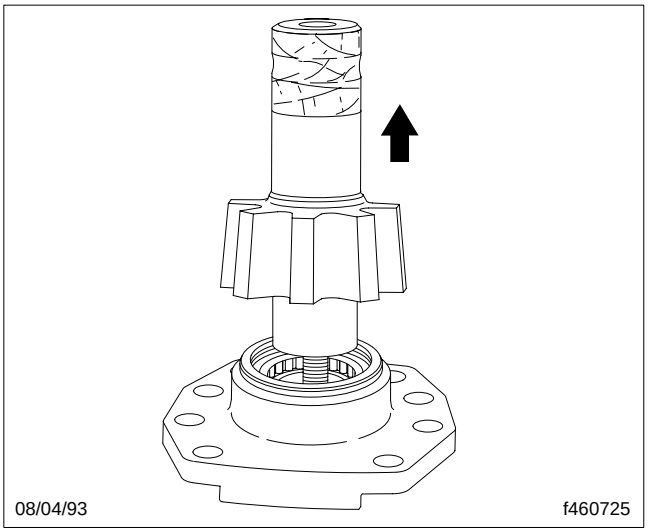


Fig. 11, Lift the Sector Shaft Out Vertically

13. Remove the side cover retaining ring, the two-piece side cover seal, the Teflon® backup washer, and the steel backup washer from the side cover. See **Fig. 12** and **Fig. 13**. Discard the two-piece seal and the Teflon® backup washer. Remove and discard the rubber plug.

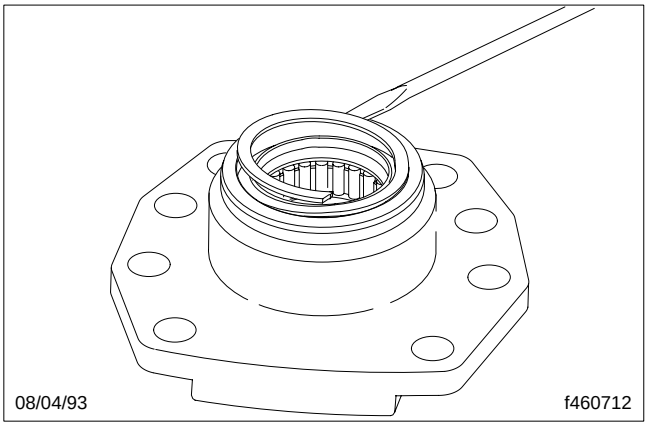


Fig. 12, Remove the Retaining Ring

14. Loosen the worm shaft preload adjusting screw jam nut. Loosen the worm shaft preload adjusting screw about two turns. See **Fig. 14**. Loosen the poppet adjusting screw jam nut and the poppet adjusting screw about two turns.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

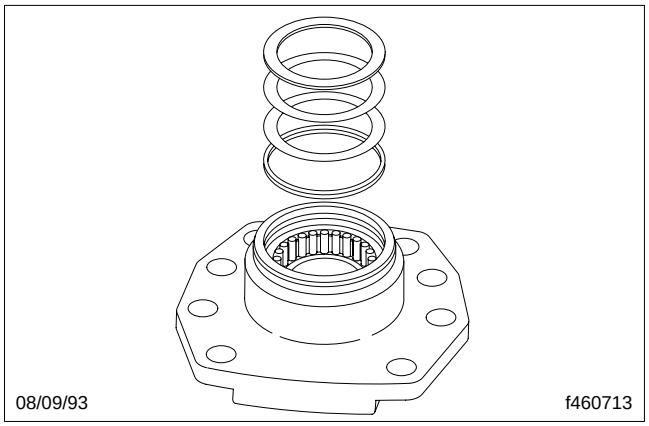


Fig. 13, Remove the Retaining Ring, Seal, and Washers

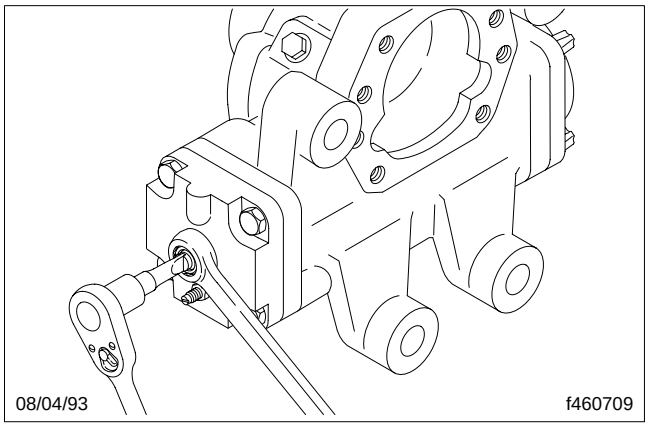


Fig. 14, Loosen the Jam Nut and Adjusting Screw

15. Remove the four end cover bolts. See **Fig. 15**. Prepare for some fluid to drain, then remove the end cover. See **Fig. 16**.

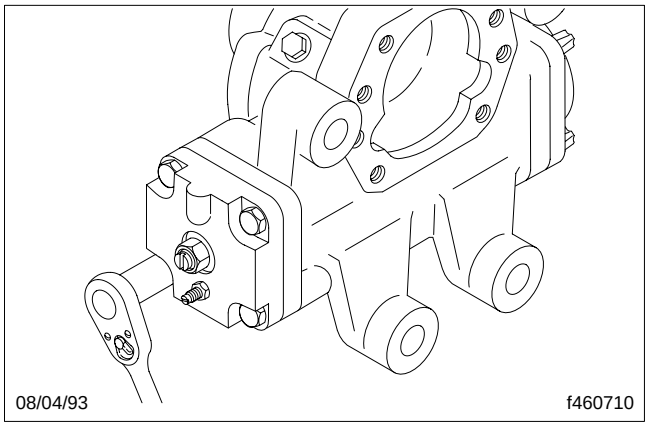


Fig. 15, Remove the End Cover Bolts

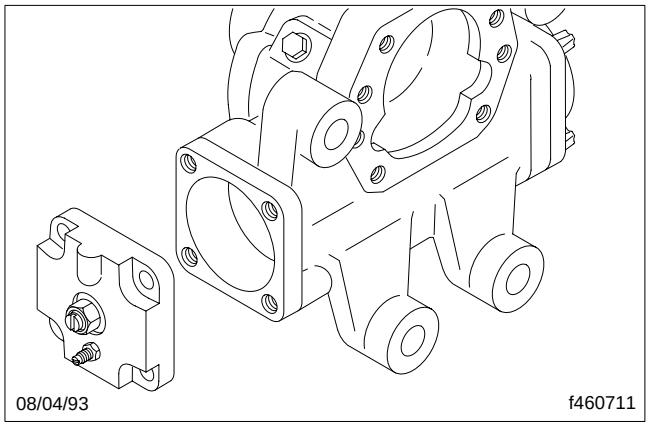


Fig. 16, Remove the End Cover

16. Remove and discard the end cover O-ring. See **Fig. 17**.

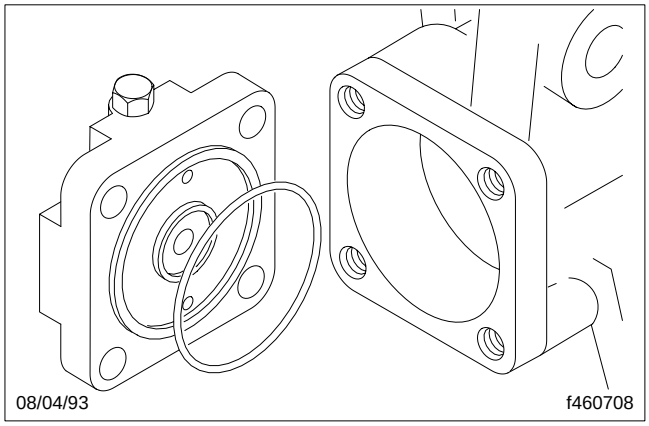


Fig. 17, Remove the O-Ring

17. Using a fine grade of emery paper, clean any paint or foreign material from the nonserrated area of the input shaft. See **Fig. 18**.
18. Loosen the valve housing poppet adjusting screw jam nut and poppet adjusting screw about two turns.
19. Remove the four valve housing bolts. See **Fig. 19**. Prepare for some fluid to drain, then remove the valve housing. See **Fig. 20**.
20. If the valve sleeve is still in the housing, remove it. See **Fig. 21**.
21. Remove the first thrustwasher, the thrust bearing, and the second thrustwasher from the valve housing. See **Fig. 22**.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

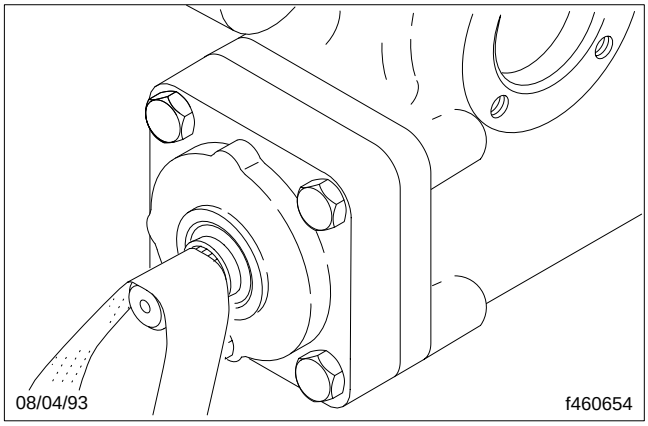


Fig. 18, Clean the Input Shaft

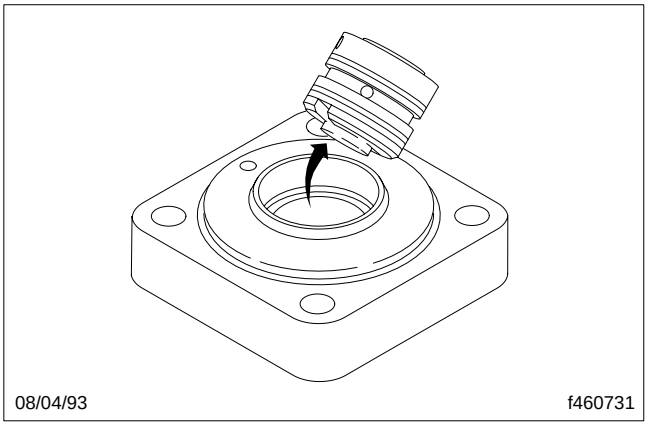


Fig. 21, Remove the Valve Sleeve

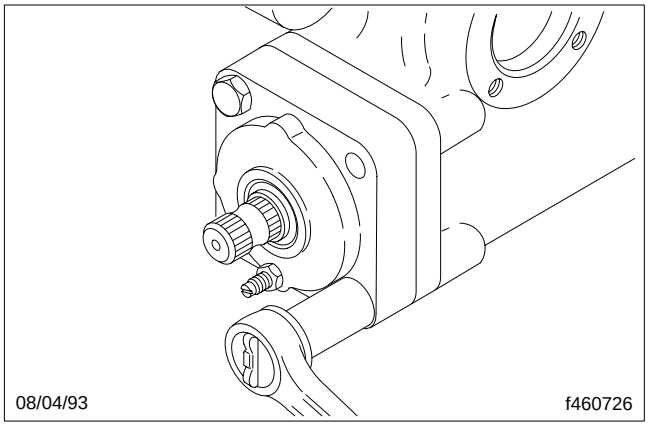


Fig. 19, Remove the Valve Housing Bolts

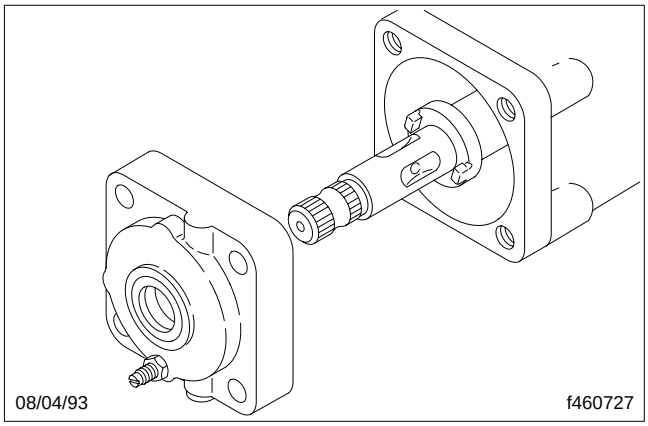


Fig. 20, Remove the Valve Housing

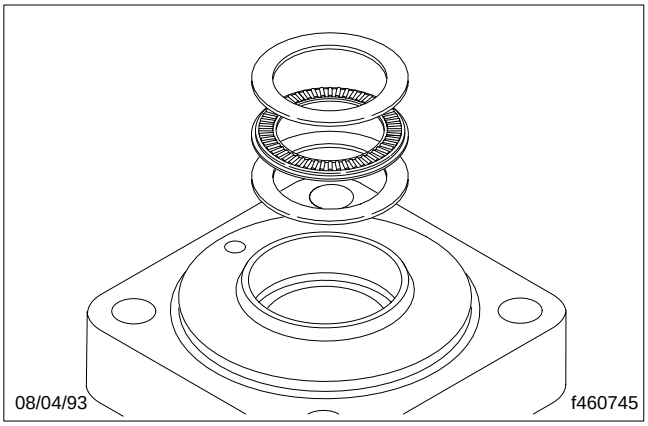


Fig. 22, Remove the Thrustwashers and Thrust Bearing

NOTE: The first thrustwasher may stay on the end of the valve sleeve. If so, remove it from the sleeve.

22. Remove and discard the valve housing O-ring.
23. Remove and discard the valve housing the dirt and water seal. See **Fig. 23**.
24. Remove the valve housing retaining ring. See **Fig. 24**.
25. Remove the steel backup washer and the two-piece input shaft seal from the valve housing. See **Fig. 25**. Discard the shaft seal.
26. Remove and discard the two Teflon® seal rings from the valve sleeve. See **Fig. 26**.
27. Remove and discard the two backup O-rings from the grooves in the valve sleeve. See **Fig. 27**.

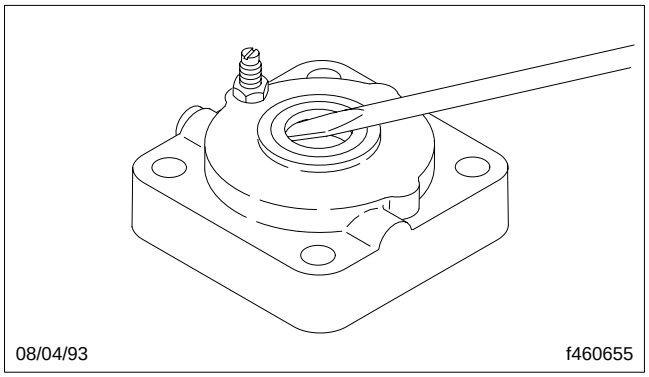


Fig. 23, Remove the Dirt and Water Seal

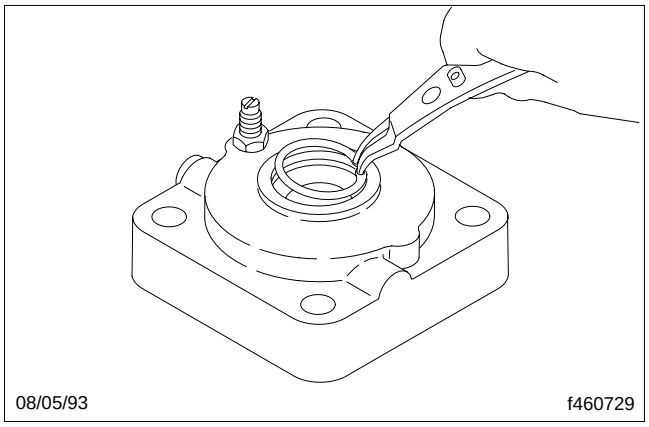


Fig. 24, Remove the Valve Housing Retaining Ring

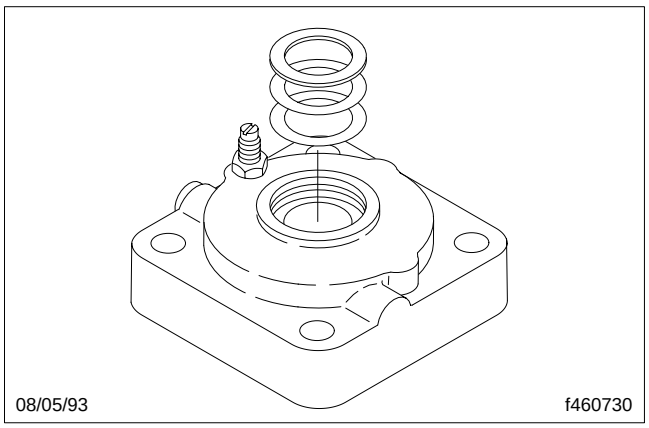


Fig. 25, Remove the Washer and Seals

28. Remove the rack piston and worm shaft from the gear housing as an assembly. See **Fig. 28**.

NOTE: The worm shaft portion of the assembly will be inside the rack piston with the input shaft portion of the worm protruding from the rack. Be careful when removing this assembly from the housing. Removing the rack piston assembly from the long end of the housing prevents the Teflon® rack piston seal from getting caught in the sector shaft cavity.

29. Set the rack piston and worm shaft assembly on a clean rag, to keep the piston from rolling.

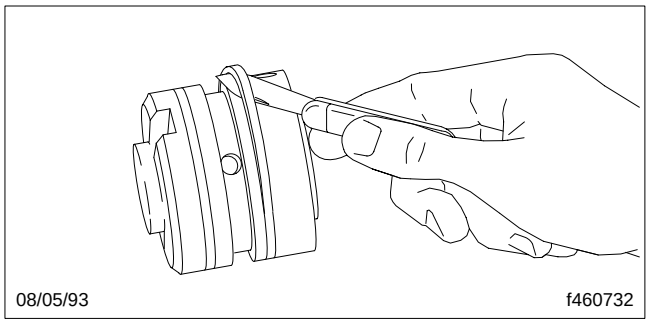


Fig. 26, Remove the Seal Rings

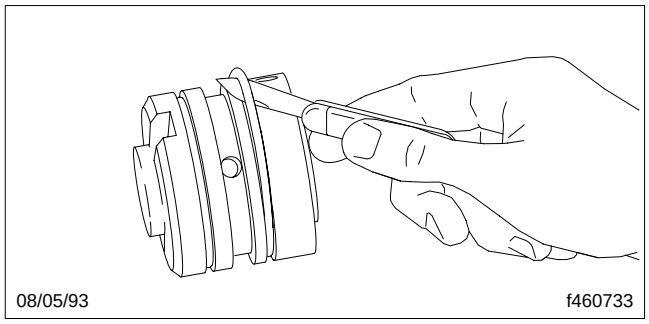


Fig. 27, Remove the O-Rings

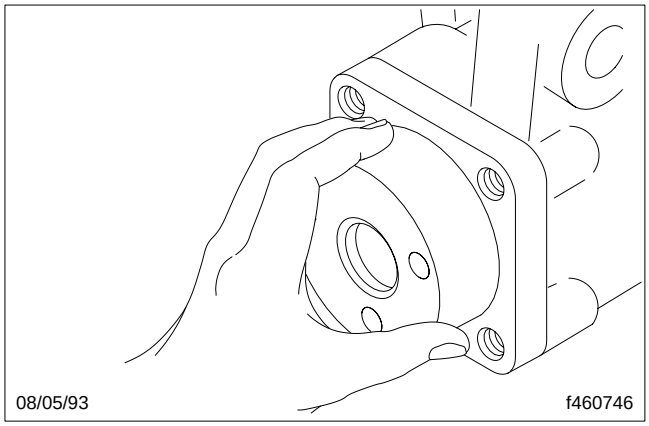


Fig. 28, Remove the Rack Piston and Worm Shaft

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

30. For rack pistons with a ball return guide clip, bend the tangs down on the two ball return guide clip locking tabs. See **Fig. 29**. Remove the two bolts, the locking tabs, and the guide clip. Discard the locking tabs. See **Fig. 30**.

    For rack pistons with a ball return guide cap, remove the two Allen head screws, the ball return guide cap, and the ball return guide cap seal. See **Fig. 31** and **Fig. 32**. Discard the screws and the cap seal.

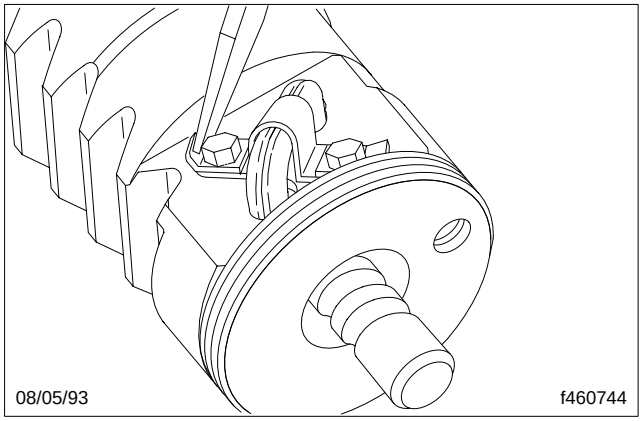


Fig. 29, Bend the Tangs

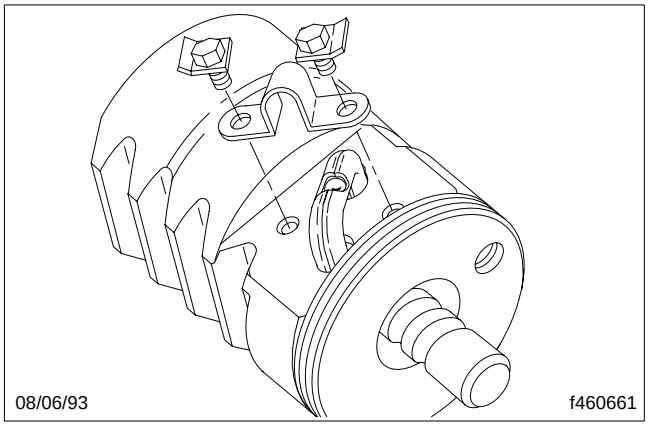


Fig. 30, Remove the Bolts, Tabs, and Guide Clip

31. Remove the halves of the ball return guide. See **Fig. 33**. Then remove the 34 steel balls from the rack piston by rotating the worm shaft until the balls fall out. See **Fig. 34**. **Do not loose any of these balls or you will have to replace the entire set**.

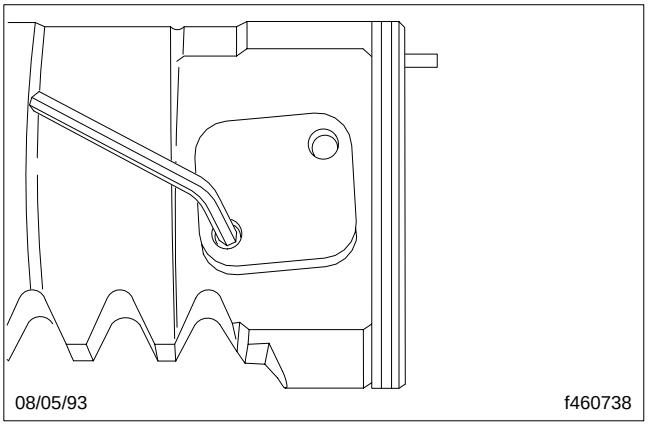


Fig. 31, Remove the Allen Head Screws

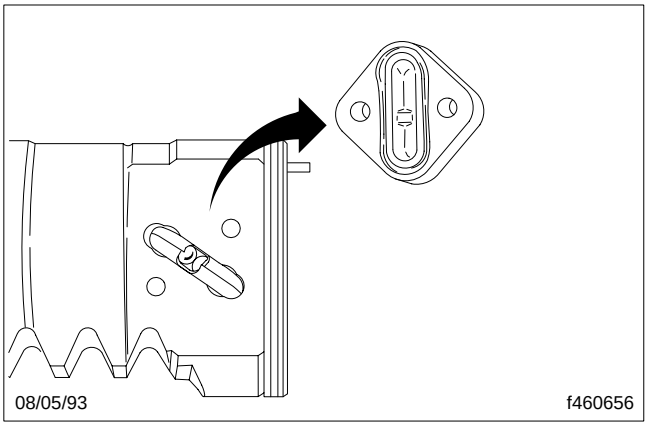


Fig. 32, Remove the Return Guide Cap Seal

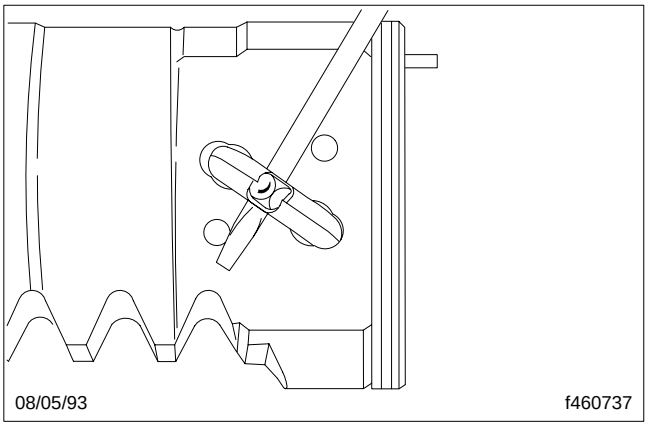


Fig. 33, Remove the Ball Return Guide Halves

NOTE: The ball return guide is closely fitted with the rack piston. It may be necessary to remove

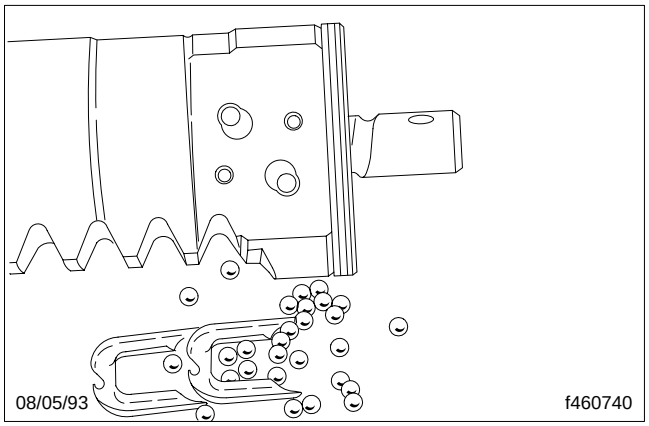


Fig. 34, Remove the Steel Balls

the halves by carefully inserting a screwdriver between the rack and the guide.

32. Remove the worm shaft from the rack piston. See **Fig. 35**.

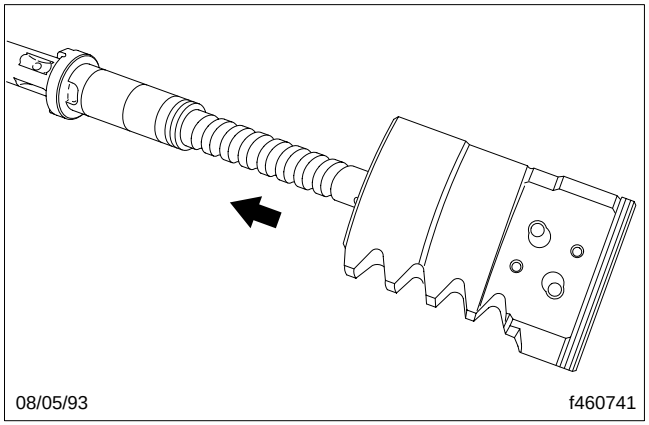


Fig. 35, Remove the Worm Shaft

33. Remove and discard the rack piston seal ring and the backup O-ring. See **Fig. 36** and **Fig. 37**.

34. Remove and discard the worm shaft seal ring and O-ring. See **Fig. 38**.

IMPORTANT: Do not disassemble the input shaft or worm shaft assembly any further. These are not serviceable. See **Fig. 39**.

35. The poppets will usually not require servicing. If it is necessary to service the poppets, position the rack piston in a soft-jawed vise. Remove the two poppet retaining rings, two poppet seats, two

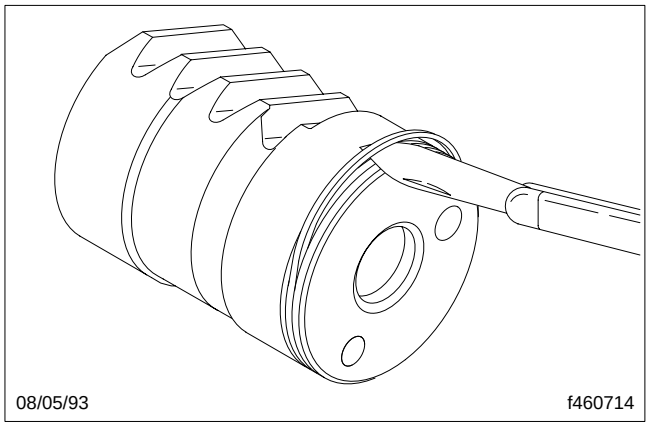


Fig. 36, Remove the Seal Ring

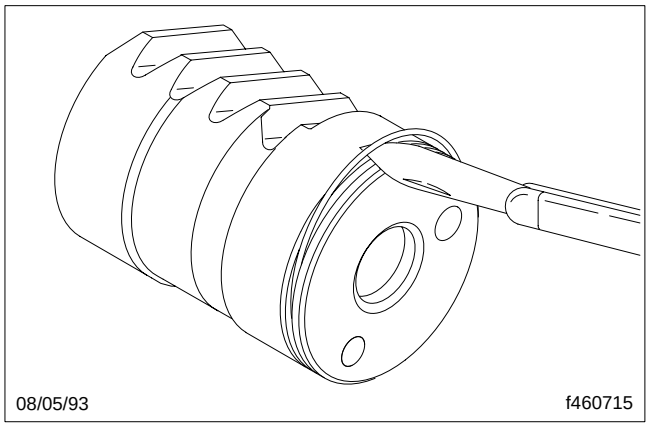


Fig. 37, Remove the O-Ring

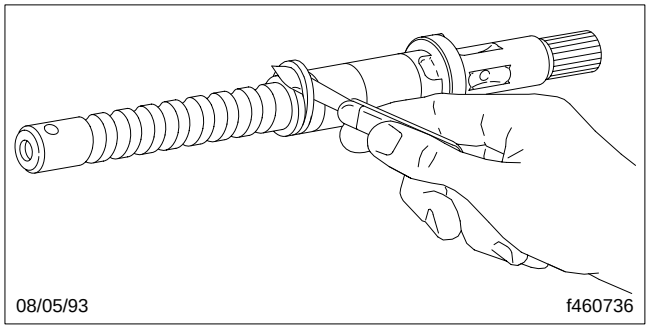


Fig. 38, Remove the Seal Ring and O-Ring

poppets, the nylon spacer rod, and the poppet spring. See **Fig. 40**, **Fig. 41**, and **Fig. 42**.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

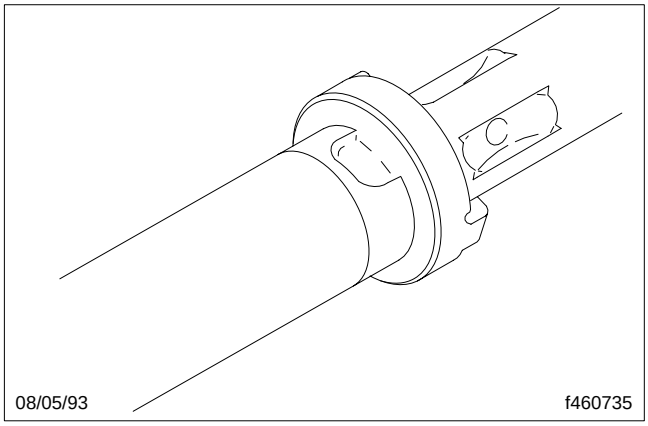


Fig. 39, Input Shaft/Worm Shaft Assembly

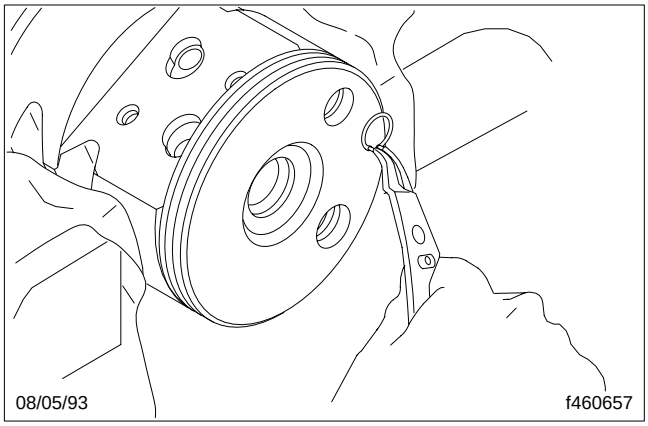


Fig. 40, Remove the Poppet Retaining Rings

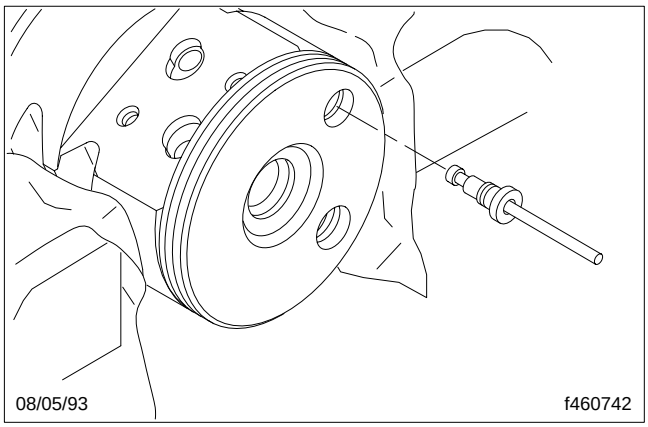


Fig. 41, Remove the Poppet Seats

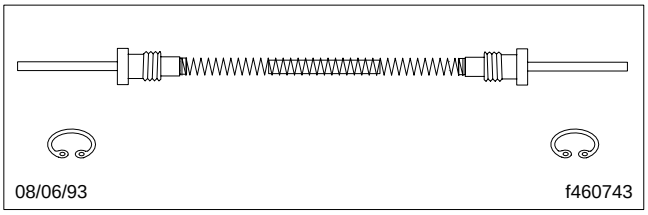


Fig. 42, Remove the Poppets, Spacer Rod, and Spring

Inspection

All sealing surfaces and seal cavities must be free of nicks and corrosion. If any part is nicked or corroded where sealing occurs, replace the part to ensure proper sealing.

Wash all parts in clean petroleum-based solvent, then blow-dry them.

1. Inspect the rack piston teeth for cracks and wear. See **Fig. 43**. If a step can be detected by running your fingernail horizontally across the teeth surfaces, replace both the rack piston and the sector shaft.

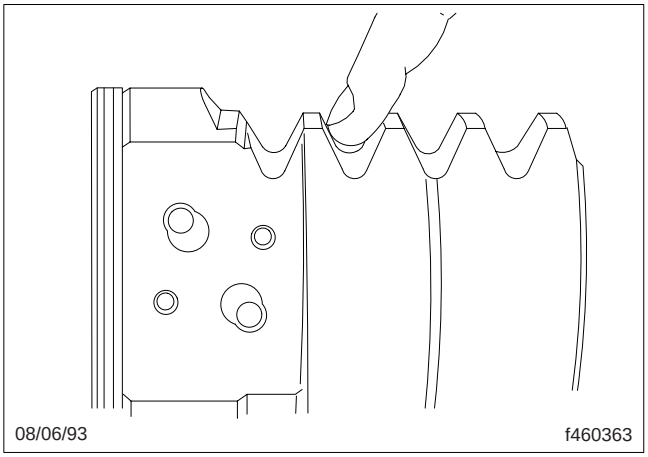


Fig. 43, Inspect the Rack Piston Teeth

2. Inspect the rack piston internal ball-track grooves for brinelling (dents) or spalling (flaking). See **Fig. 44**. If either condition exists, replace the rack piston, the worm shaft/input shaft assembly, the set of 34 steel balls, and the valve sleeve.
3. Inspect the worm shaft ball-track grooves for brinelling or spalling. See **Fig. 45**. If either condition exists, replace the worm shaft/input shaft assembly, the rack piston, the set of 34 steel balls, and the valve sleeve. Inspect the upper

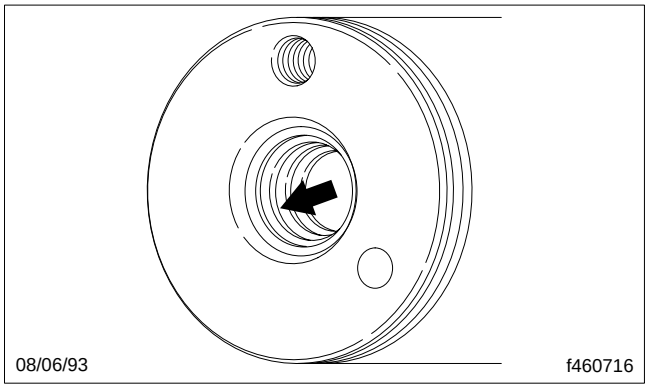


Fig. 44, Inspect the Rack Piston Internal Grooves

shaft seal area near the input shaft serrations for nicks. Run your fingernail across the sealing surface to detect steps. See **Fig. 46**.

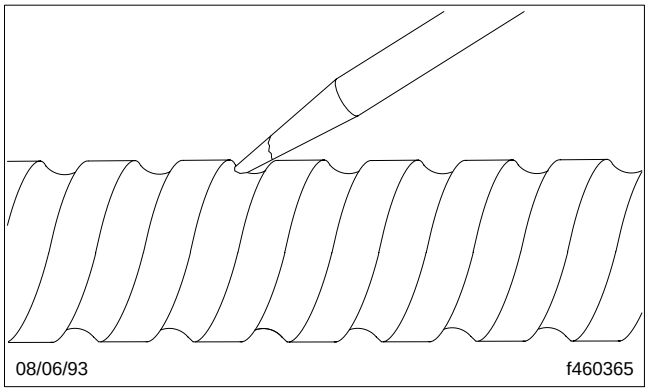


Fig. 45, Inspect the Worm Shaft

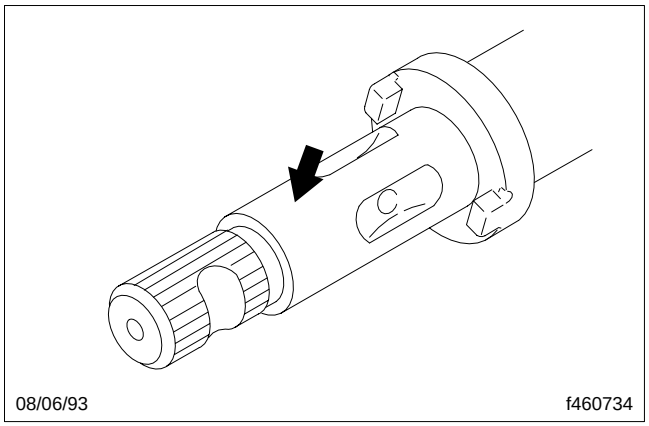


Fig. 46, Inspect the Sealing Surface

NOTE: The input shaft is pinned to the worm shaft by the torsion bar pin. The assembly is flexible and may appear slightly bent at this joint. See **Fig. 47**. This slight bend is normal.

4. Inspect the housing cylinder bore. See **Fig. 48**. Minor scoring marks running lengthwise through the bore are normal, and should not be compared to the scoring that might be found in the cylinder bores of an internal combustion engine. Replace the housing only if it has been tested for internal leakage, and it is determined that the scoring is responsible for internal leakage greater than 1.5 gpm (5.7 L/min). For troubleshooting procedures, see **Section 46.11, Subject 300**.

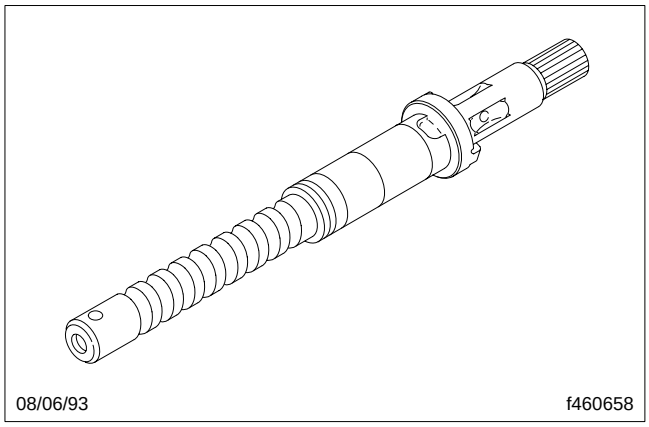


Fig. 47, Input Shaft/Worm Shaft Assembly

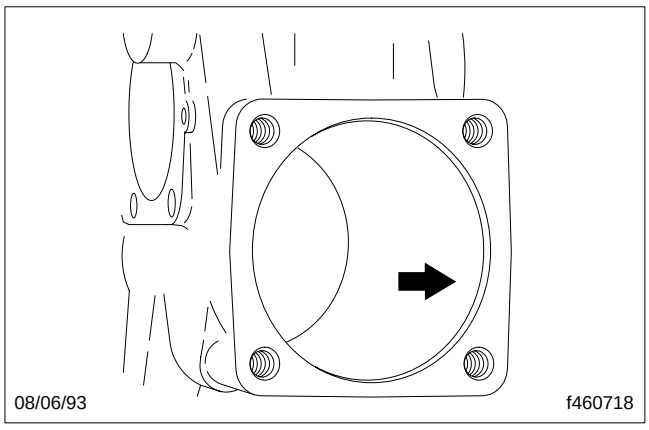


Fig. 48, Inspect the Housing Cylinder Bore

NOTE: In evaluating the results of this test, make sure that internal leakage exceeding 1.5 gpm (5.7 L/min) is attributed only to the housing, and not to the seals in the worm shaft, rack piston, and valve assembly.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

5. Inspect the housing faces for nicks that would prevent proper sealing. See **Fig. 49**. Replace the gear housing if these nicks cannot be easily removed with a fine-toothed flat file without changing the dimensional characteristics.

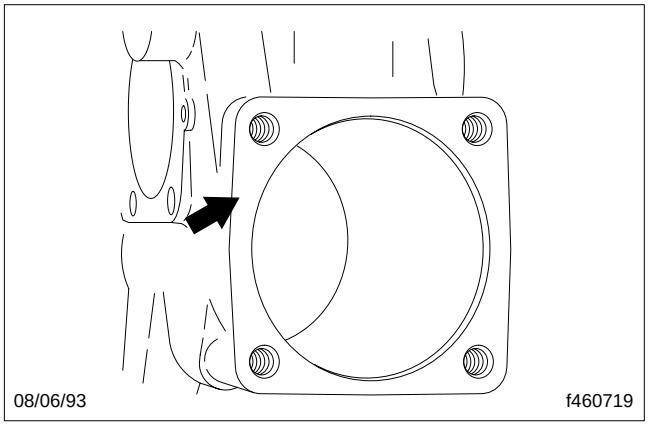


Fig. 49, Inspect the Housing Faces

6. Inspect the housing bearing for brinelling or spalling. If either condition exists, replace the housing bearing. See **Fig. 50**.

   Inspect the side cover bearing for brinelling or spalling. If the side cover bearing is damaged, replace the complete side cover assembly. See **Fig. 51**.

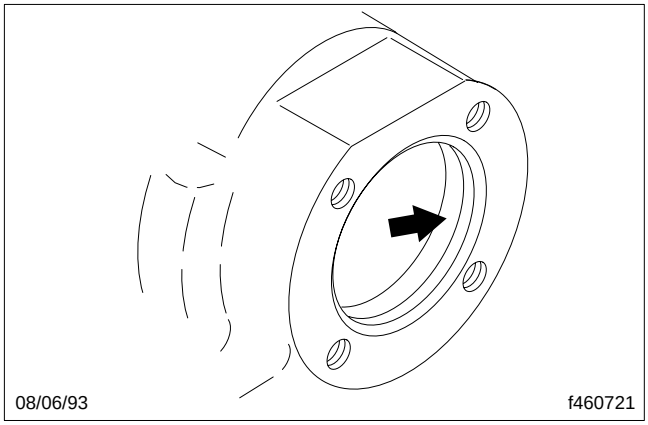


Fig. 50, Inspect the Housing Bearing

7. Inspect the sector shaft bearing sealing areas for brinelling or spalling. See **Fig. 52**. Run your fingernail across these areas to detect steps. Also inspect for cracks. If any of these conditions exist, replace the sector shaft.

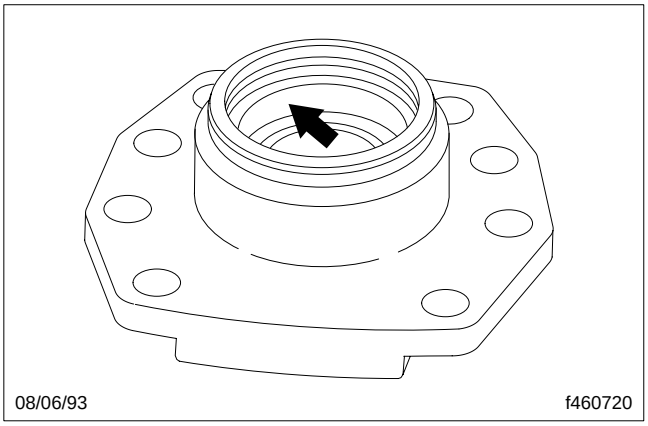


Fig. 51, Inspect the Side Cover Bearing

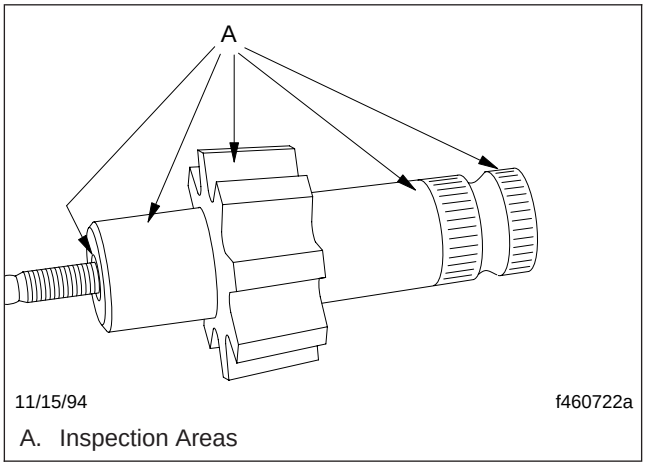


Fig. 52, Sector Shaft Bearing

8. Check the sector shaft assembly for damaged adjusting screw threads. Make sure the adjusting screw retainer is locked in place and has no cracks. The adjusting screw must turn by hand with no end play (lash). If the adjusting screw is damaged, replace it and its retainer.

9. Inspect the thrust bearing rollers for any deterioration. Inspect the two thrustwashers for brinelling, spalling, or cracks. See **Fig. 53**. Replace any part if these conditions are detected.

Assembly

IMPORTANT: The special tools required for disassembly and assembly of the steering gear parts are available from SPX Kent-Moore or an

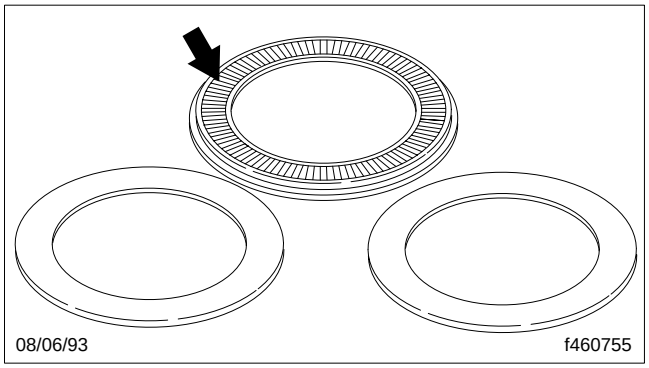
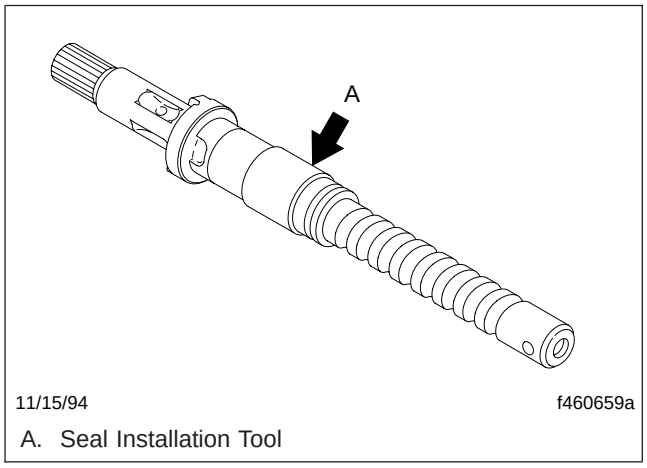


Fig. 53, Thrust Bearing Rollers and Thrustwashers

affiliated dealer. See the special tools Table in **Specifications 400** to be sure that you have the required tools before beginning the service procedures.

Replace all seals, seal rings, and gaskets with new ones each time the gear is disassembled. Individual seals, seal rings, and gaskets—as well as complete seal kits—are available from Freightliner part distributors.

1. Using seal installation tool J26739, assemble the new worm shaft backup O-ring, then the new Teflon® worm shaft seal ring. See **Fig. 54** and **Fig. 55**. Compress the seal ring with compression tool J26740 and set the worm shaft aside for 10 minutes. See **Fig. 56**.



A. Seal Installation Tool

Fig. 54, Worm Shaft Backup O-Ring

2. If installing a new housing bearing, install the retaining ring into the groove on the bearing's outside diameter. Then press the bearing into the housing from the trunnion side, using bearing mandrel J26743 against the lettered end of the bearing shell so the retaining ring end is away from the housing bore. See **Fig. 57**. Be sure the bearing mandrel is clean. Be sure the housing is square with the press base and that the bearing is not cocked.

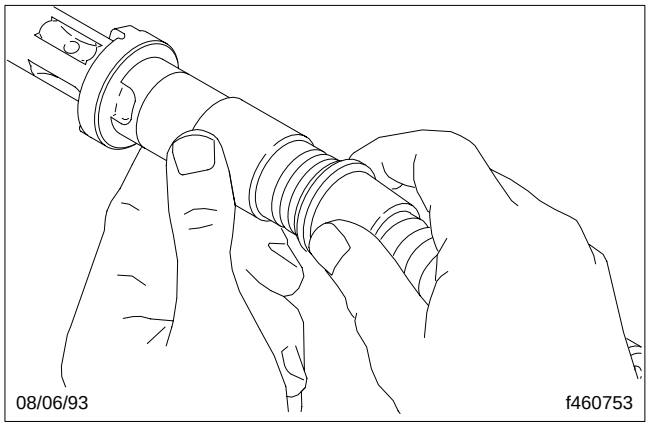


Fig. 55, Worm Shaft Seal Ring

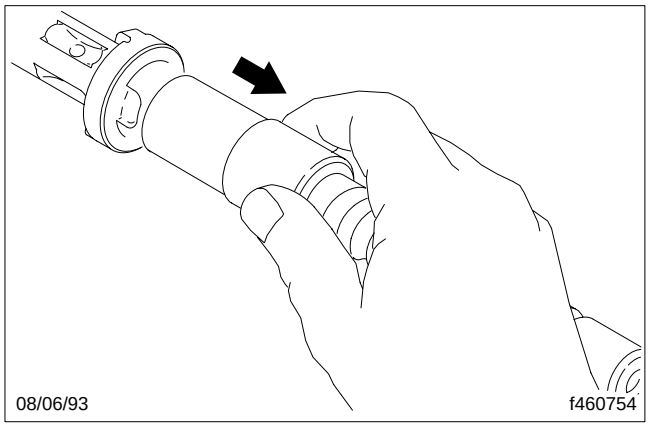


Fig. 56, Compress the Seal Ring

3. Whether or not a new bearing race was installed, apply a generous amount of clean grease to the bearing race to retain the bearing rolls. Then place the bearing rolls into the bearing race. Be sure that the rolls have been counted correctly and the quantity matches the quantity required for the housing bearing part number.

NOTE: If bearing BR-970 is being installed, install 41 rolls. If bearing BR-970-1 is being installed, install 42 rolls.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

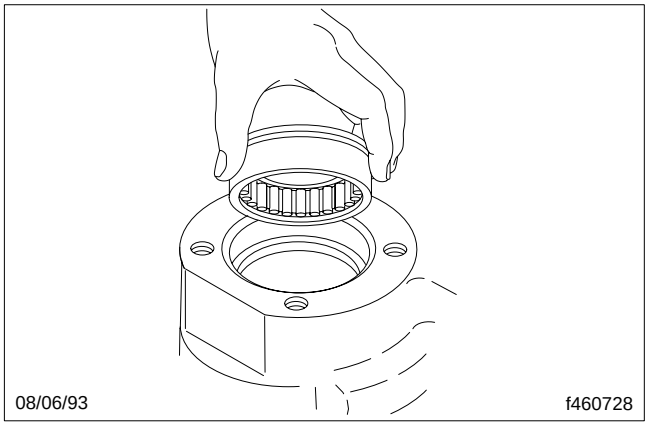


Fig. 57, Press the Bearing into the Housing

4. Install a new rack piston backup O-ring and a new Teflon® rack piston seal ring. See **Fig. 58** and **Fig. 59**. Do not stretch these rings when installing them. After they are installed, coat them with a liberal amount of grease.

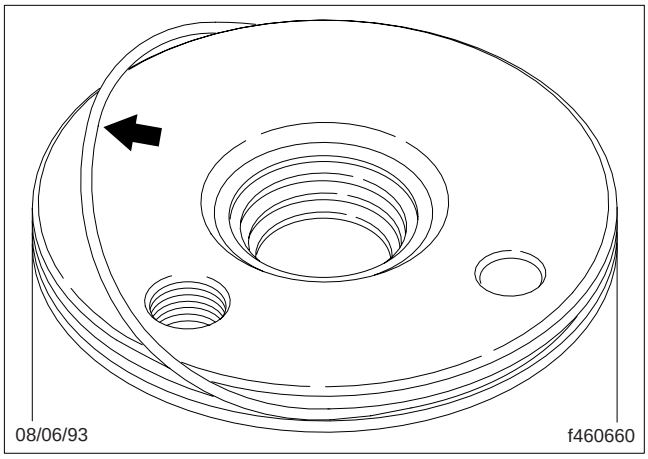


Fig. 58, Install the Backup O-Ring

5. Install the parts of the poppet assembly in the following order: one poppet seat, then (from the other end of the poppet hole in the piston) one poppet, the poppet spring, the nylon spacer rod, the other poppet, and the other poppet seat. See **Fig. 60**, **Fig. 61**, and **Fig. 62**.
6. Tighten the poppet seats 20 to 25 lbf·ft (27 to 34 N·m). Install both retaining rings.
7. If more than 10 minutes have passed since installing the worm shaft seal and ring, grease the sealing surface inside the rack piston and install

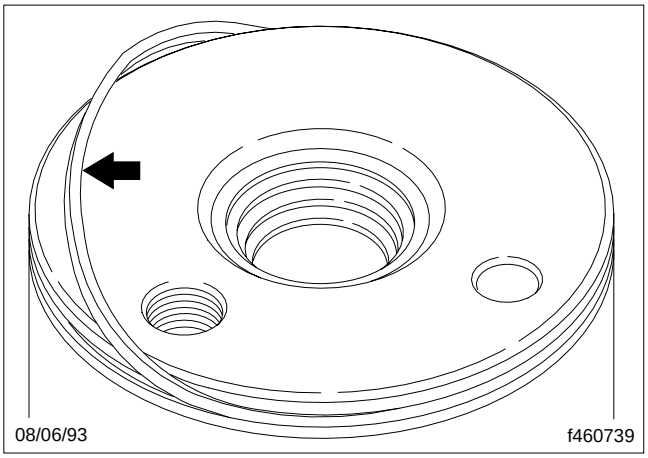


Fig. 59, Install the Seal Ring

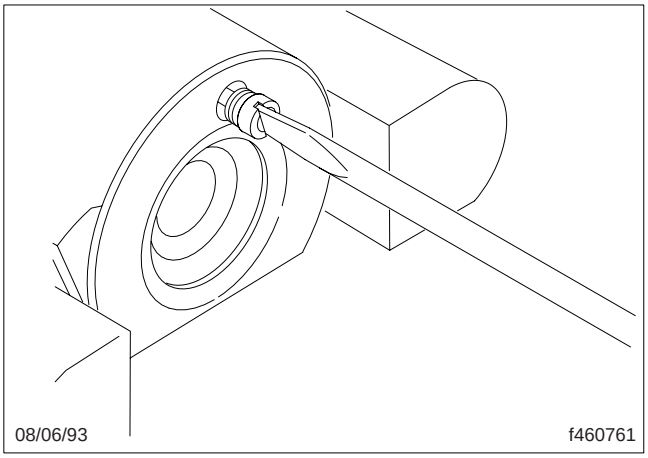


Fig. 60, Install the Poppet Assembly

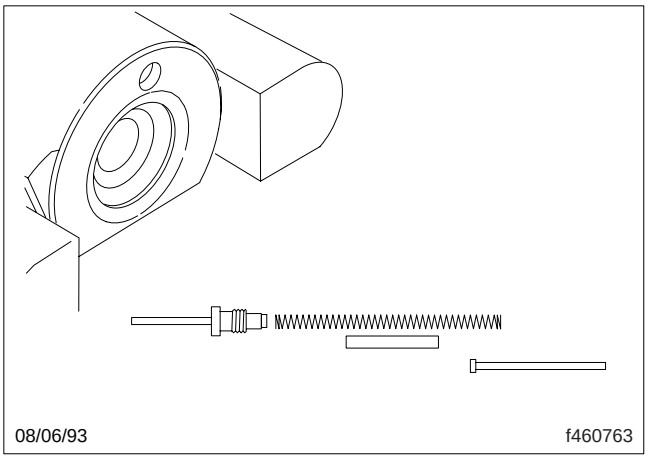


Fig. 61, Poppet, Spring, and Spacer Rod

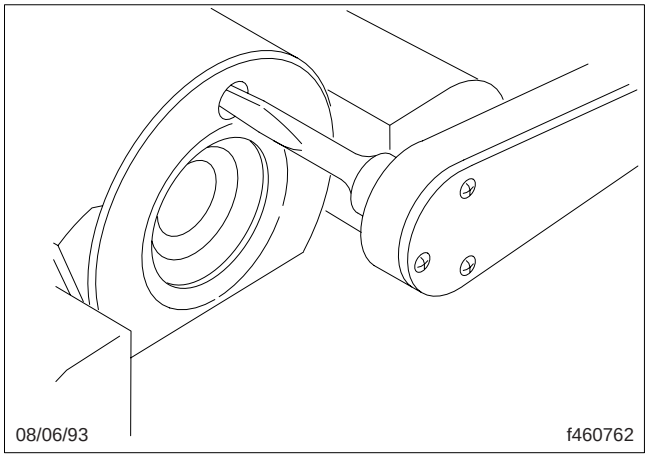


Fig. 62, Poppet and Poppet Seal

the worm shaft/input shaft assembly into the rack piston. See **Fig. 63**.

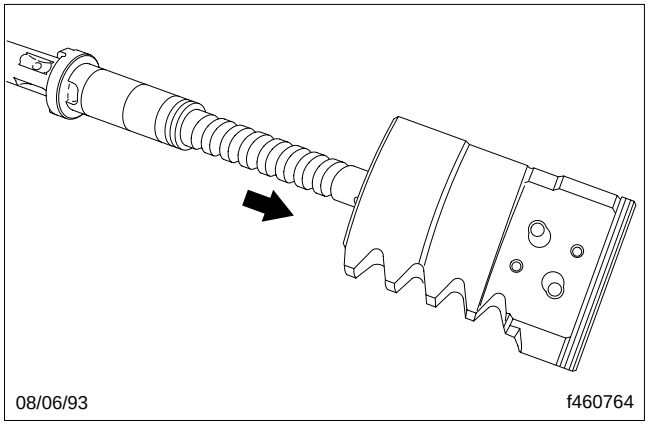


Fig. 63, Install the Worm Shaft/Input Shaft Assembly

8. Install the ball return guides.

   8.1 For ball return guides with a hole in the top, install the guides in the rack piston. Make sure they are seated.

   8.2 Place the 34 balls in the ball return guides and rack piston. Drop them through the hole provided in the ball return guides. As the balls are dropped into the guide, turn the worm shaft to pull them down into the grooves. See **Fig. 64**.

   8.3 For ball return guides without a hole in the top, insert the eraser end of a pencil into one hole of the rack piston as far as it will go. Drop 22 of the 34 balls into the other hole of the rack piston. See **Fig. 65**. Turn the worm shaft to advance the balls toward the other hole. There will be resistance after the 22nd ball is dropped. A ball will be visible at the base of each hole. Remove the pencil.

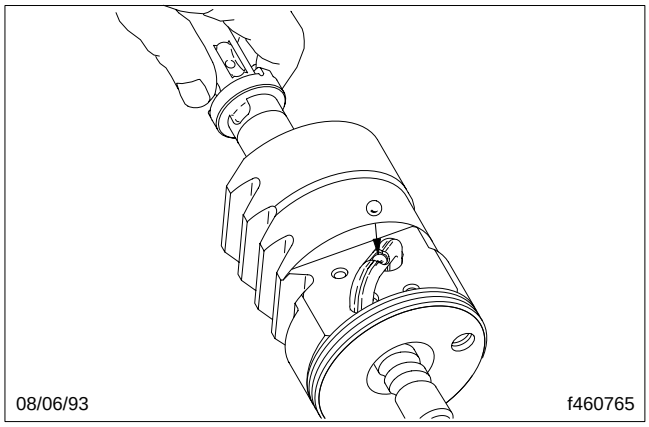


Fig. 64, Install the Steel Balls

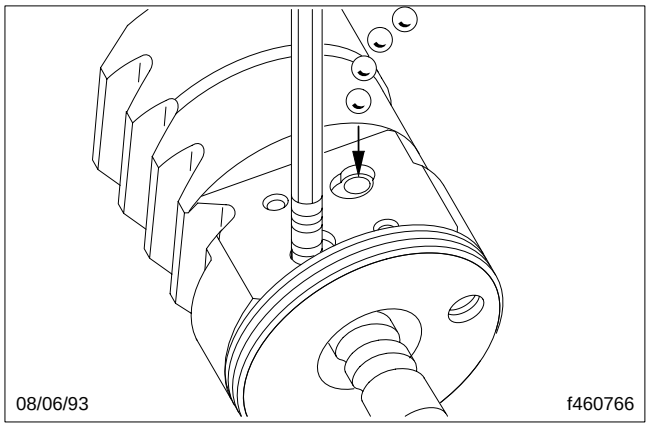


Fig. 65, Install the Steel Balls

   8.4 Apply a generous amount of clean grease on the ball return guides and insert the remaining 12 balls into a guide half. See **Fig. 66**. Join the guide halves and install in the rack piston.

9. If equipped with the ball return guide clip, assemble it and make sure that both bolt hole faces are in full contact with the rack piston surface. Install the two locktabs and the two bolts. Tighten the bolts 14 to 22 lbf·ft (19 to 30 N·m). See **Fig. 67** and **Fig. 68**. Bend the locking tabs up against the bolt head flats. See **Fig. 69**.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

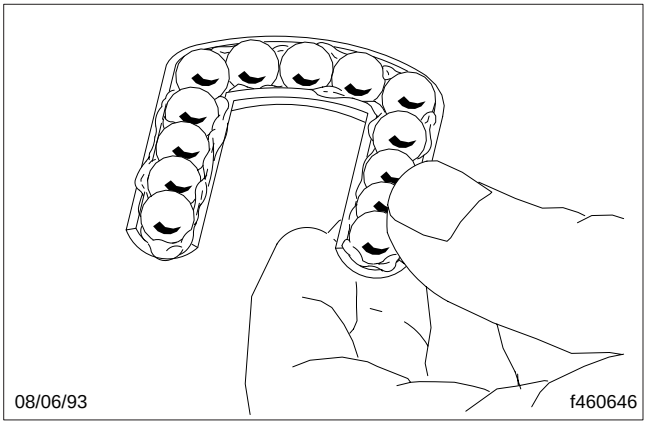


Fig. 66, Steel Balls in a Guide Half

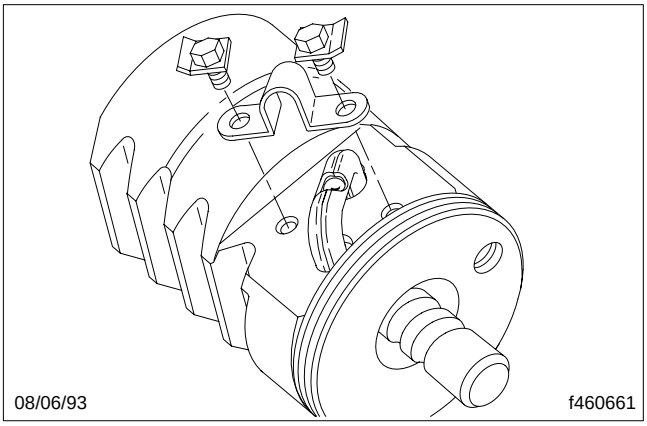


Fig. 67, Install the Ball Return Guide Clip

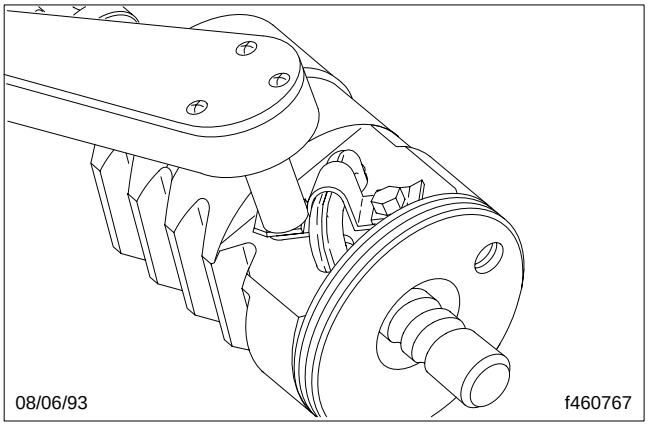


Fig. 68, Tighten the Bolts

10. If equipped with the ball return guide cap, grease the cap seal and install the seal in the ball return guide cap groove. Install the guide cap so that the seal is in full contact with the rack piston surface. Install two new Allen head screws and tighten them 14 to 22 lbf·ft (19 to 30 N·m). See **Fig. 70** and **Fig. 71**.

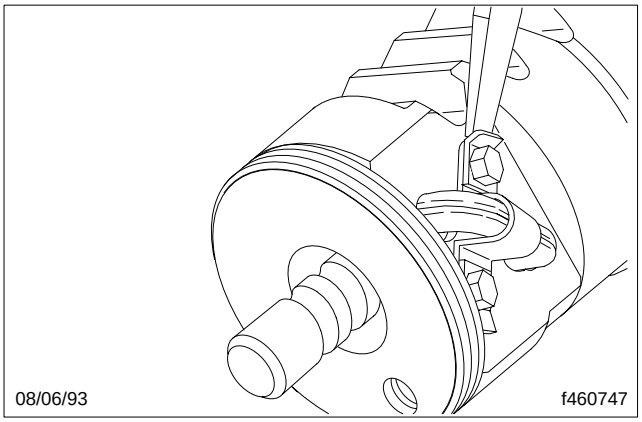


Fig. 69, Bend the Locking Tabs

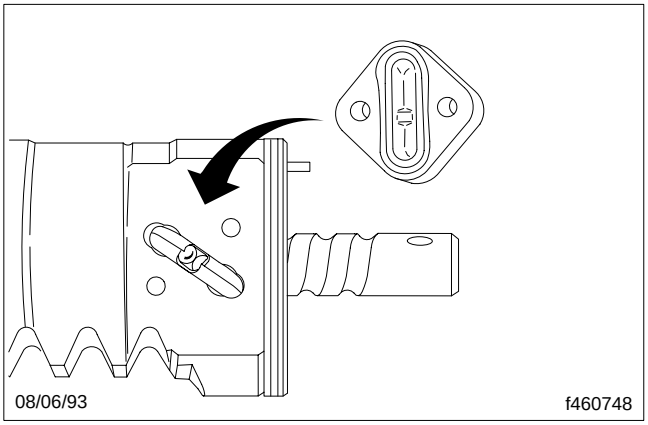


Fig. 70, Install the Ball Return Guide Cap

11. Apply a generous amount of clean grease to the Teflon® rack piston seal and to the housing cylinder bore. See **Fig. 72**. Install the rack piston and worm shaft as an assembly in the gear housing, so that the Teflon® rack piston seal goes in last. See **Fig. 73**.

NOTE: To ease the later assembly of the sector shaft, turn the rack piston and worm shaft assembly in the housing so that the rack teeth are exposed in the sector shaft cavity of the housing.

12. Install the worm shaft adjusting screw jam nut on the nonslotted end of the worm shaft preload ad-

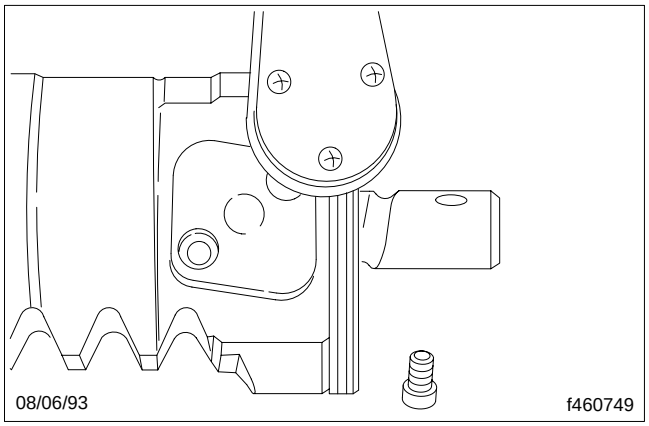


Fig. 71, Tighten the Allen Head Screws

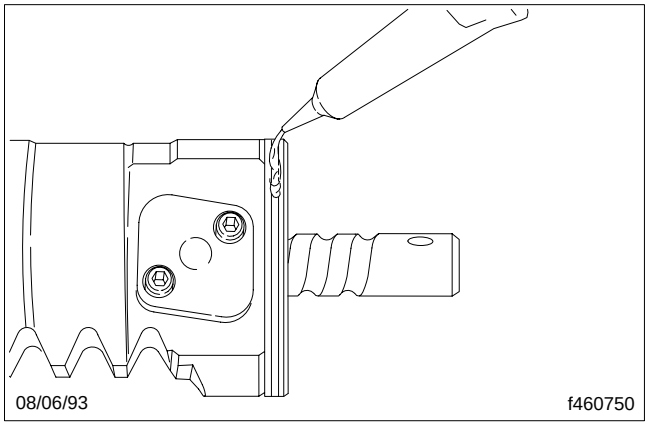


Fig. 72, Lubricate the Seal and Housing Cylinder Bore

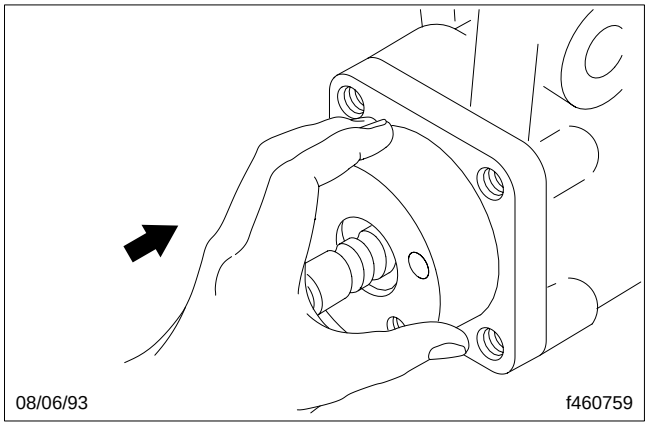


Fig. 73, Install the Rack Piston/Worm Shaft Assembly

justing screw so that the seal on the jam nut faces the end cover.

13. Assemble and install one poppet valve adjusting screw and jam nut in the same manner. Assemble the other poppet valve adjusting screw jam nut onto the poppet valve adjusting screw.

NOTE: The poppet valve adjusting screws may not be of the same length. If not, insert the shorter adjusting screw into the end cover a few turns.

14. Install the worm shaft preload adjusting screw in the end cover a few turns.

15. Grease the end cover O-ring groove and install the new end cover O-ring. See **Fig. 74**.

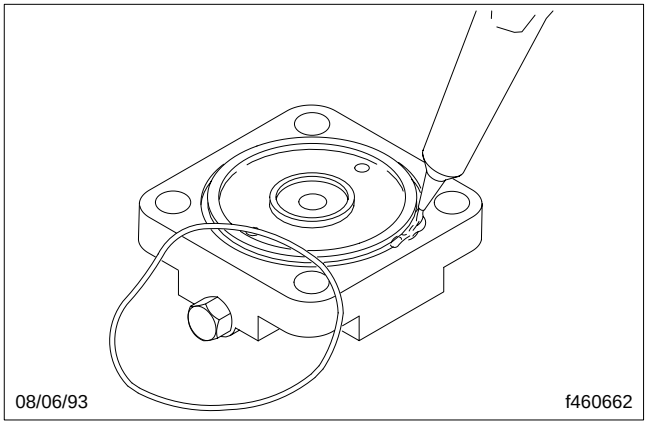


Fig. 74, Lubricate the End Cover O-Ring Groove

NOTE: When installed, the O-ring should extend slightly above the machined surface of the end cover.

16. Position the end cover so that the poppet adjusting screw is aligned with the end of the poppet. See **Fig. 75**.

    Make sure the rack piston teeth are fully visible in the sector shaft cavity of the housing. This ensures proper location of the poppets so that the poppet adjusting screw will contact the poppets.

    Install the four end cover bolts and tighten 150 to 170 lbf·ft (203 to 230 N·m). See **Fig. 76**.

17. Grease two new valve-sleeve backup O-rings and two new Teflon® seal rings. Install the backup O-rings on the valve sleeve. See **Fig. 77**. Then use seal installation tool J26741 to install the seal rings on the valve sleeve. See **Fig. 78**.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

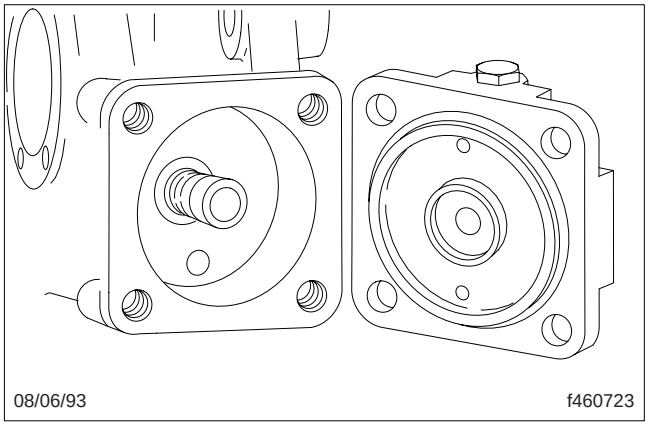


Fig. 75, Position the End Cover

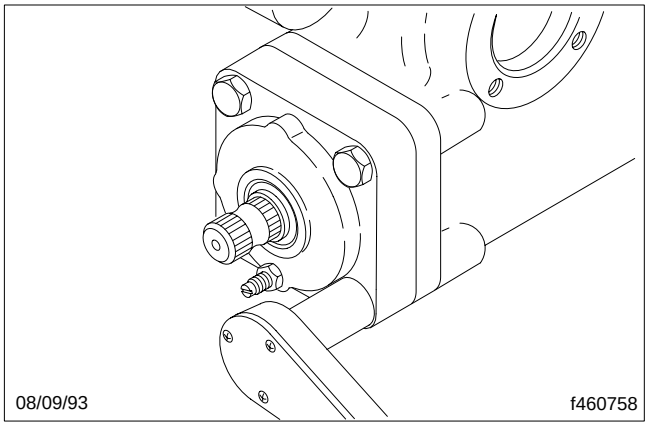


Fig. 76, Install the End Cover Bolts

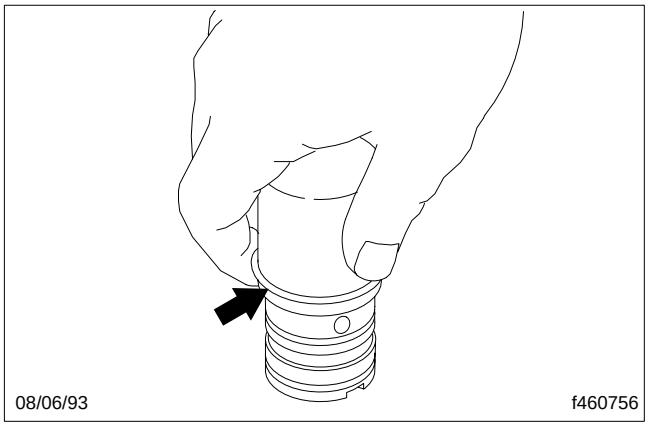


Fig. 77, Install the O-Rings on the Valve Sleeve

18. Using special tool J26742, compress the Teflon® seal rings. See **Fig. 79**. Leave the tool on for 10 minutes.

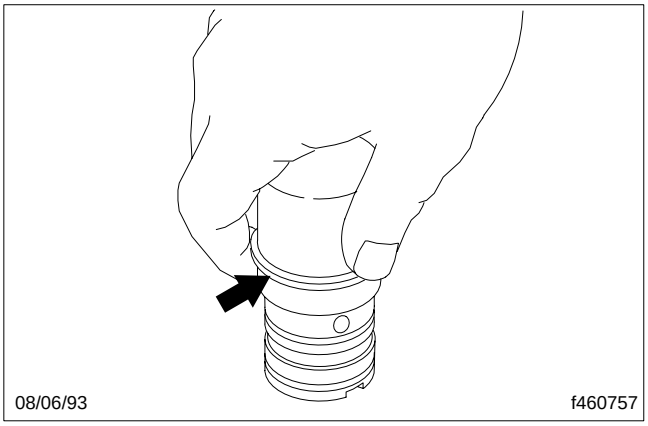


Fig. 78, Install the Seal Rings on the Valve Sleeve

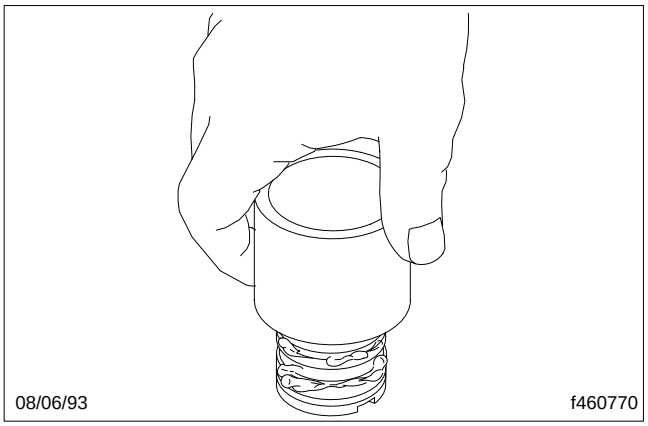


Fig. 79, Compress the Seal Rings

19. Turn the poppet valve adjusting screw into the valve housing 4 or 5 turns. Final adjustments will be made later.

20. Apply clean grease to the O-ring groove in the valve housing. Install a new valve housing O-ring in the groove. See **Fig. 80**.

NOTE: When installed, the valve housing O-ring should extend slightly above the machined surface of the valve housing.

21. Apply a generous amount of clean grease to one thrustwasher. Install the thrustwasher into the valve housing. Be sure the washer is centered. See **Fig. 81**.

22. Apply a generous amount of clean grease to the thrust bearing. Install the bearing in the valve housing and onto the first thrustwasher. Be sure the bearing is centered. See **Fig. 82**.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

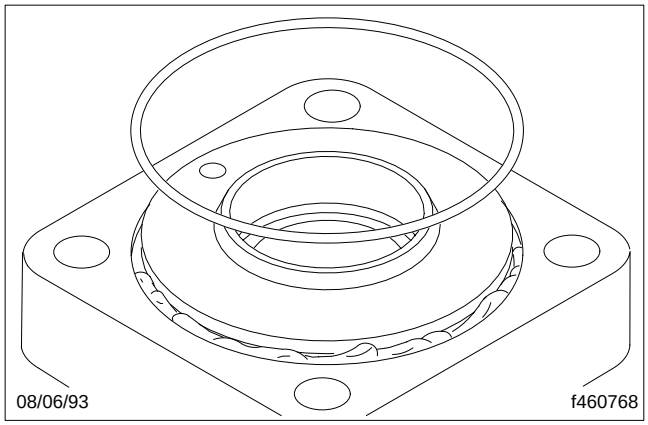


Fig. 80, Install the Valve Housing O-Ring

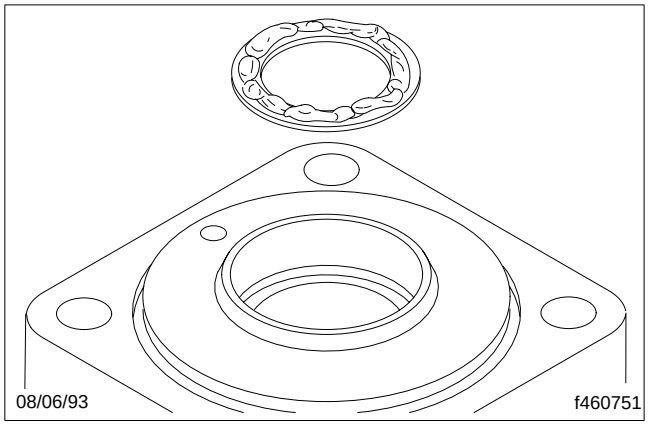


Fig. 81, Install the Thrustwasher in the Valve Housing

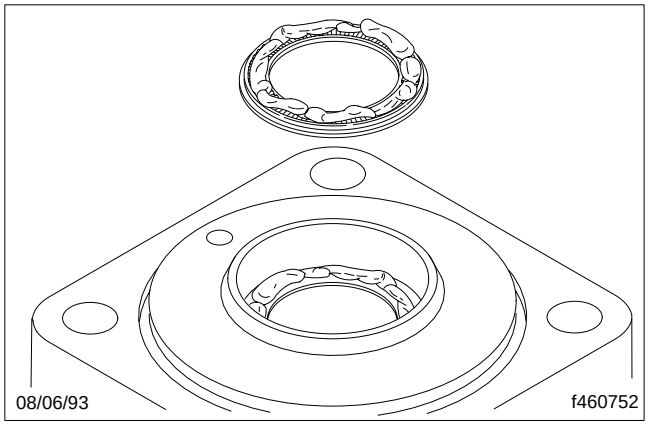


Fig. 82, Install the Bearing in the Valve Housing

23. Remove the compression tool from the valve sleeve. Apply more grease to the valve sleeve seals. Grease the thrustwasher face on the end of the valve sleeve that is without the drive slots. Place the second thrustwasher on this face. See **Fig. 84**.

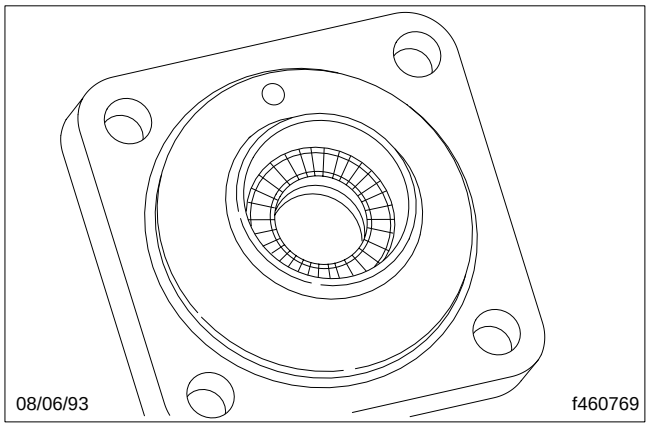


Fig. 83, Thrustwasher and Thrust Bearing

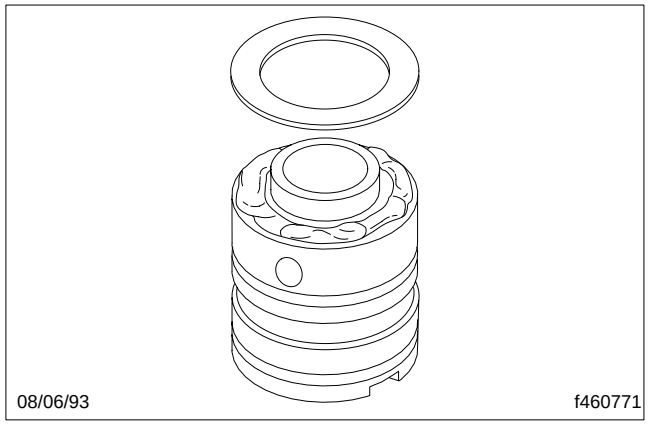


Fig. 84, Install the Second Thrustwasher

24. Install the valve sleeve and the attached thrustwasher into the valve housing. See **Fig. 85**. When the valve sleeve is in place, it should measure between 0.370 and 0.400 inch (9 and 10 mm) above the face of the valve housing to the end of the valve sleeve nose. See **Fig. 86**.
25. Move the rack piston flush with the open end of the gear housing. Turn the worm shaft until it extends out of the rack piston as far as it will go.
26. Locate the timing mark (a faint punched mark on the chamfered edge of the valve sleeve or an indented mark on the front of the sleeve). See **Fig. 87**. Locate the timing mark on the worm shaft. See **Fig. 88**.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

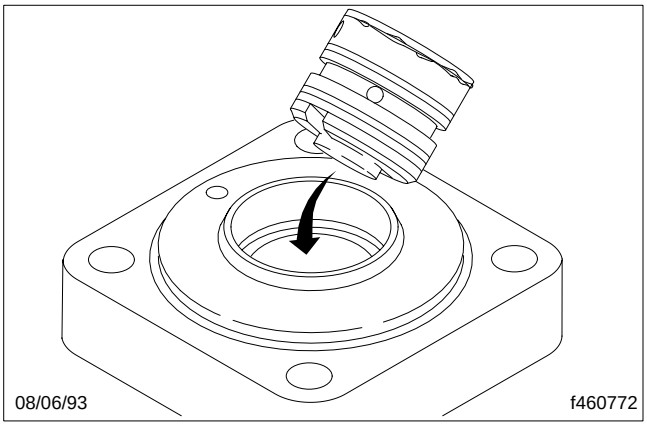


Fig. 85, Install the Sleeve into the Valve Housing

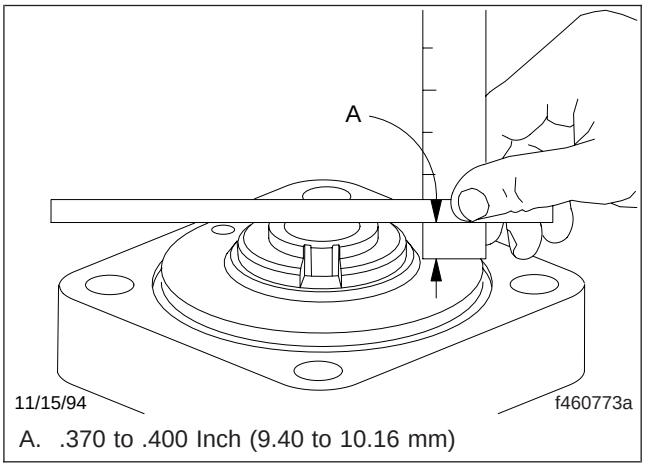


Fig. 86, Measure the Placement of the Valve Sleeve

Grasp the valve housing and valve sleeve as an assembly with your thumbs on the valve housing and your fingers applying pressure on the valve sleeve to keep it in the valve housing. See **Fig. 89**.

Align the previously located timing marks. See **Fig. 87** and **Fig. 88**. Place the valve housing and valve sleeve as an assembly on the input-shaft end of the worm shaft until the drive lugs are fully engaged. See **Fig. 90**.

NOTE: Valve sleeves are identified with and matched to a right- or left-hand lead of the worm screw. Because the screw has a right-hand thread (that is, goes into the rack piston when turned clockwise), the valve sleeve will have the letter R stamped between the seal

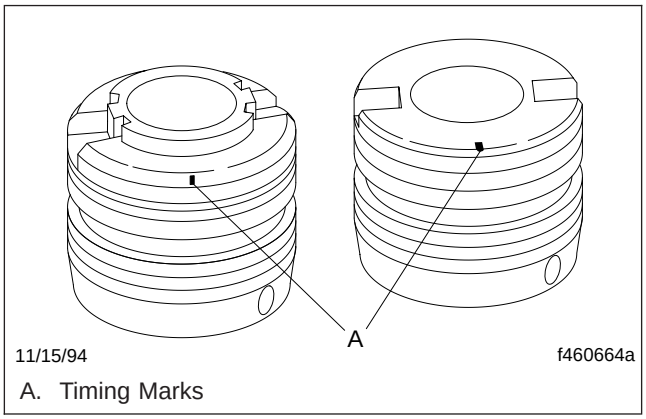


Fig. 87, Locate the Timing Marks

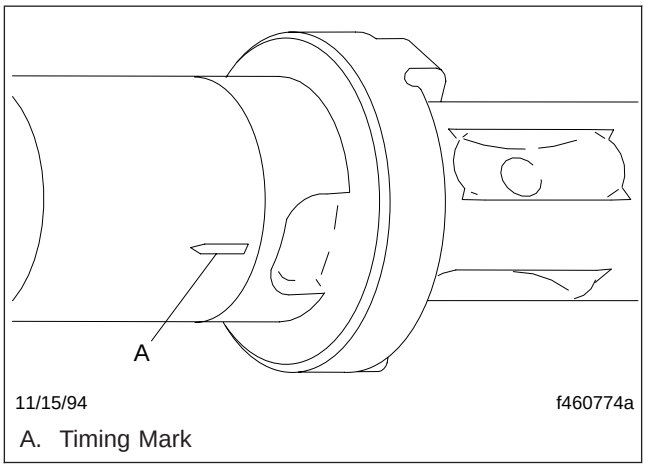


Fig. 88, Timing Mark on the Worm Shaft

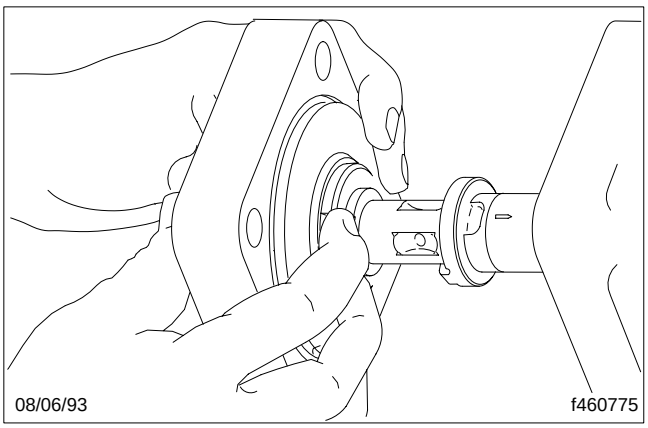
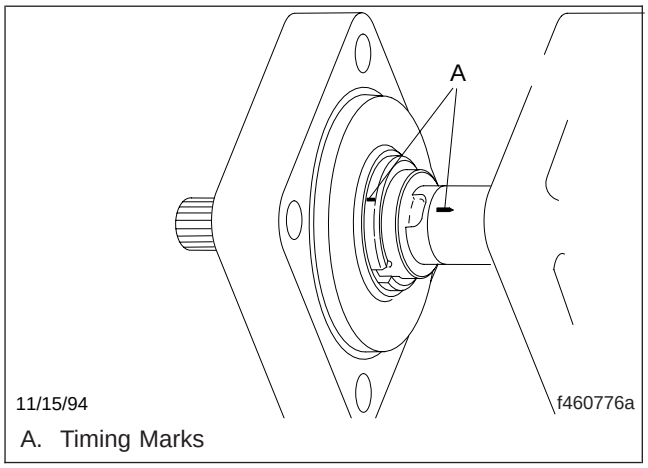


Fig. 89, Valve Housing and Valve Sleeve

lands. For a left-hand worm lead (which will come out of the rack piston when turned clock-



A. Timing Marks

Fig. 90, Install the Valve Housing/Valve Sleeve Assembly on the Worm Shaft

wise), the mating valve sleeve has no identifying letter or has the letter L stamped between the seal lands.

27. Maintain pressure on the valve end of the valve housing to ensure continued engagement of the drive lugs and thrust bearing package. See **Fig. 91**. While maintaining this pressure, turn the valve housing and align the poppet adjusting screw with the poppet in the rack piston. While continuing pressure, turn the input shaft to bring the valve housing into contact with the gear housing face.

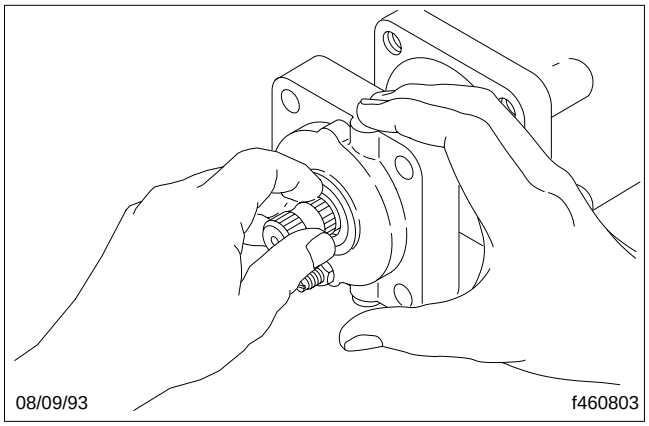


Fig. 91, Valve Housing

28. Install the four valve housing bolts in the valve housing, and tighten them 145 to 155 lbf·ft (197 to 210 N·m). See **Fig. 92**.

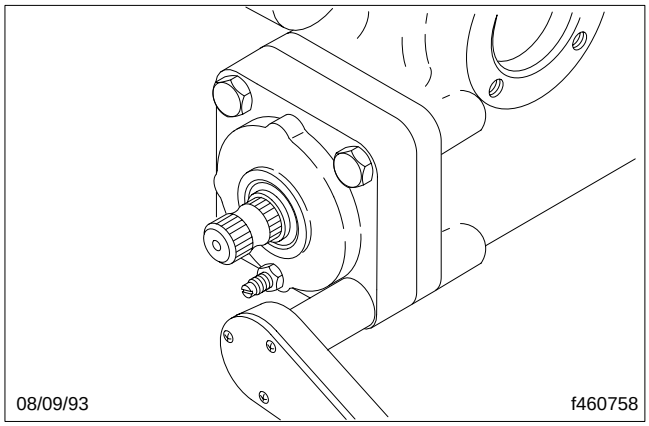


Fig. 92, Install the Valve Housing Bolts

29. Apply a generous amount of clean wheel bearing grease (do not substitute another type of grease) to the bearing race inside the side cover.

30. Insert the bearing rolls into the side cover bearing race. See **Fig. 93**. If equipped with bearing BR-970, insert 41 rolls. If equipped with bearing BR-970-1, insert 42 rolls.

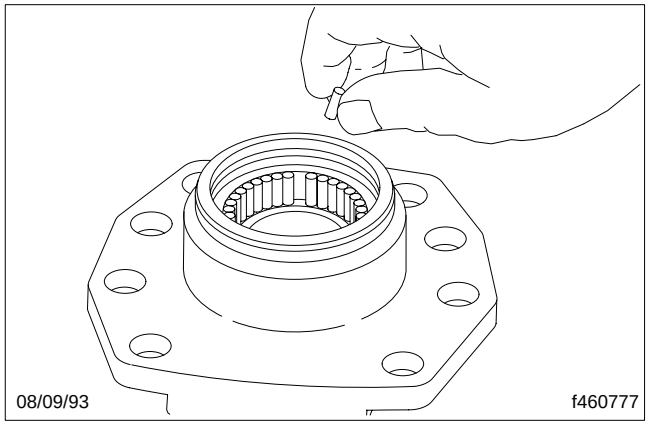


Fig. 93, Insert the Bearing Rolls into the Side Cover Bearing Race

NOTE: Apply clean wheel bearing grease to loose rolls to retain them in the bearing race.

31. Install the steel backup washer, a new Teflon® backup washer, and a new two-piece side cover seal in the side cover. See **Fig. 94**.

NOTE: In newer seal kits and on some units, the Teflon® backup washer is an integral part of the two-piece seal.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

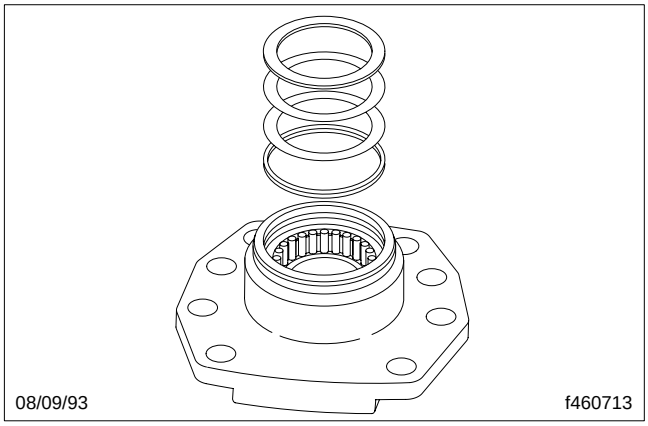


Fig. 94, Install the Washers and the Side Cover Seal

32. Assemble the two-piece seal so that the words OIL SIDE are visible after it is installed.
33. Install the side cover retaining ring in the ring groove of the side cover. See **Fig. 95**.

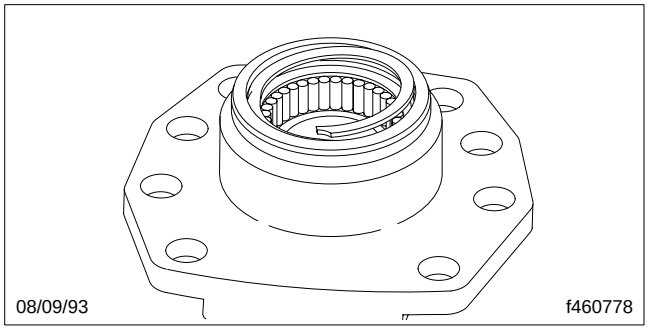


Fig. 95, Install the Retaining Ring

34. Apply a generous amount of clean grease to the short bearing area of the sector shaft. Insert the sector shaft into the side cover. Turn the sector shaft adjusting screw into the side cover, until it seats. See **Fig. 96**. Then back out the adjusting screw one turn, so that the side cover turns freely on the sector shaft.
35. Install the sector shaft adjusting screw jam nut onto the sector shaft adjusting screw a few threads. Final adjustment will be made later.
36. Press a new rubber plug into the hole provided in the side cover until the plug is flush. See **Fig. 97**.
37. Apply clean grease to a new side cover gasket and install it on the side cover. See **Fig. 98**. Apply enough grease to hold the gasket in place.

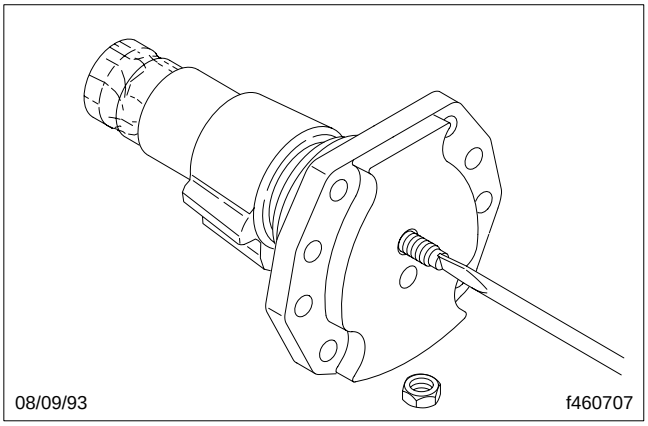


Fig. 96, Install the Sector Shaft Adjusting Screw

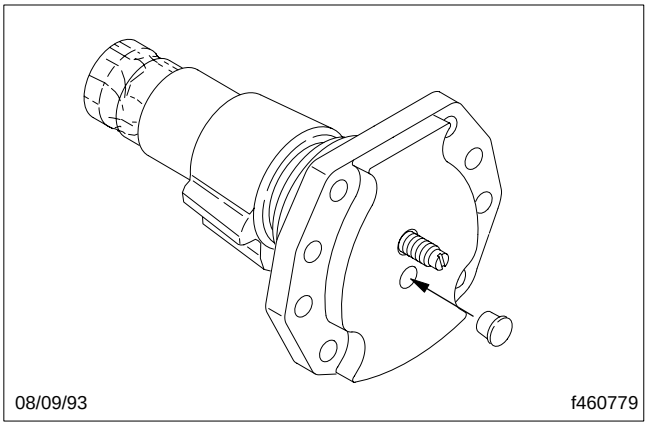


Fig. 97, Install a New Plug in the Side Cover

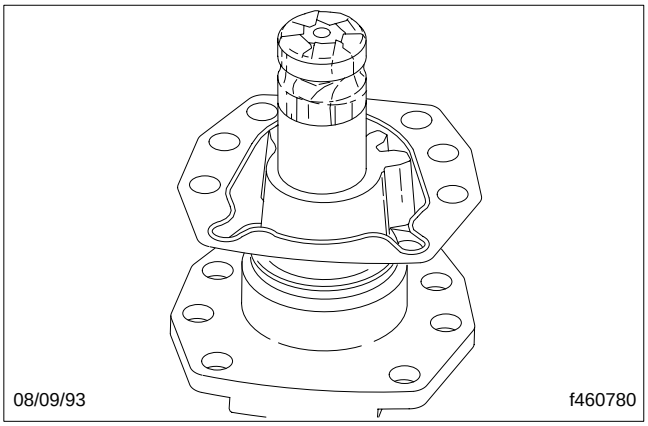
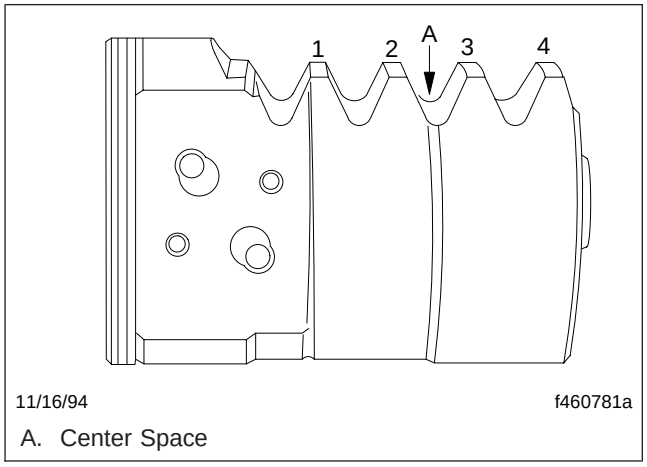


Fig. 98, Install the Side Cover Gasket on the Side Cover

38. There are four teeth on the rack piston. See **Fig. 99**. Position the rack piston so that the tooth

space identified by the pencil in **Fig. 100** (it is the space between the second and the third tooth) is in the center of the sector shaft opening.



A. Center Space

Fig. 99, Rack Piston Teeth

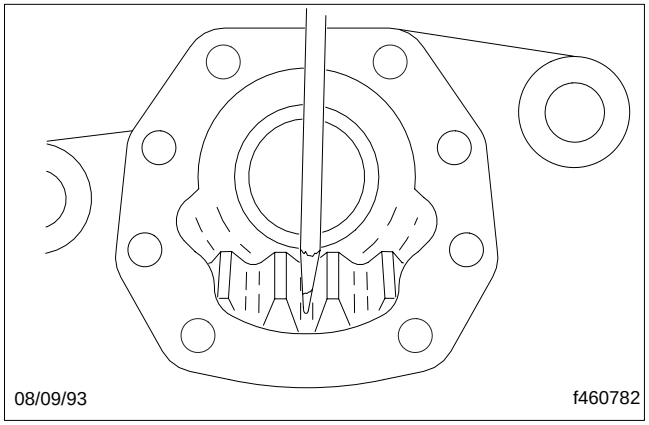


Fig. 100, Position the Rack Piston

39. With the rack piston centered, tighten the worm shaft adjusting screw 15 to 20 lbf·ft (20 to 27 N·m). Then loosen the adjusting screw 1/4 to 1/2 turn and note the torque required to rotate the input shaft 90 degrees each side of center. See **Fig. 101**. Loosen the adjusting screw if the noted input shaft torque exceeds 15 lbf·in (169 N·cm). Return the rack piston to the center position.
40. Remove any tape on the sector shaft serrations. Retape the serrations and bolt groove with **one** layer of masking tape. Install the sector shaft and side cover as an assembly into the gear housing. Make sure that the center tooth of the sector shaft engages the center space (between the second and third teeth) of the rack piston.

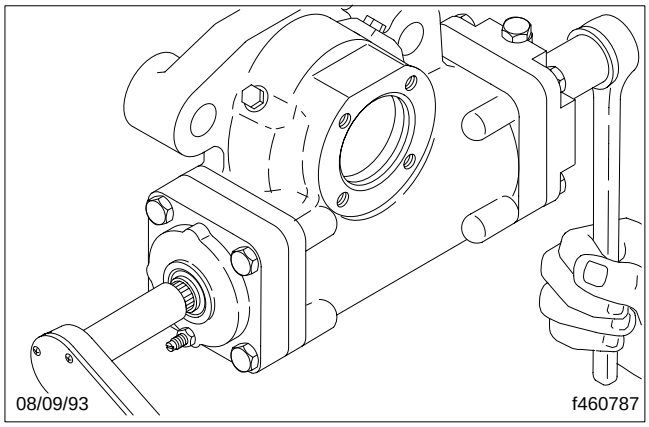


Fig. 101, Loosen the Adjusting Screw

41. Install the eight special side cover bolts into the side cover and tighten them 150 to 170 lbf·ft (203 to 230 N·m).
42. Place the trunnion cover on a bench with the exterior side down. Install a new Teflon® backup washer.
43. Install a new two-piece sector shaft seal so that the words OIL SIDE are visible after the seal is in place. See **Fig. 102**.

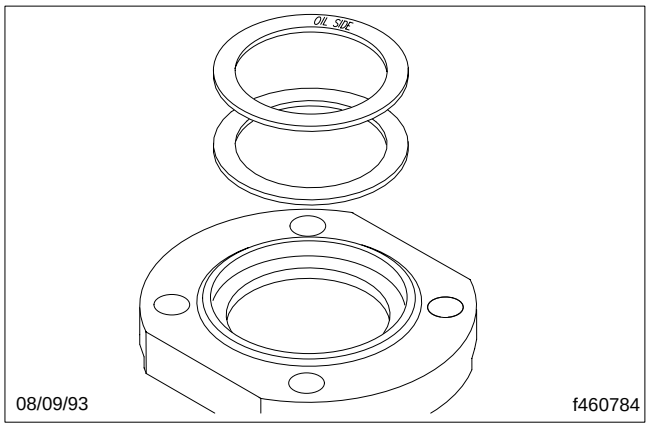


Fig. 102, Install the Sector Shaft Seals

44. Grease a new trunnion cover O-ring and install it in the trunnion cover O-ring groove.
45. Inspect the housing bearing to make sure that all the bearing rolls are in place. Then install the trunnion cover. See **Fig. 103**. Install the four

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

trunnion cover bolts and tighten them 15 to 22 lbf·ft (20 to 30 N·m). See **Fig. 104**. Pack the cavity around the seal area of the sector shaft with Mobil Temp 1 or 2 grease or an equivalent.

Using a suitable blunt-end drift, install a new dirt and water seal. Install a new protective boot on the sector shaft and trunnion cover. Locate the boot grease fitting hole toward the input shaft end of the gear assembly. See **Fig. 105**. Insert the grease fitting into the protective boot.

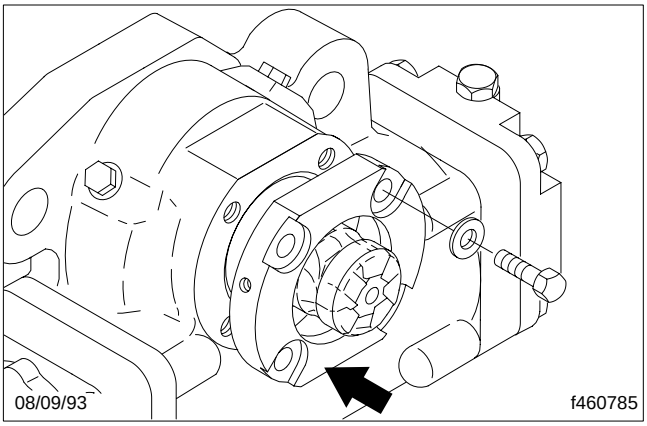


Fig. 103, Install the Trunnion Cover

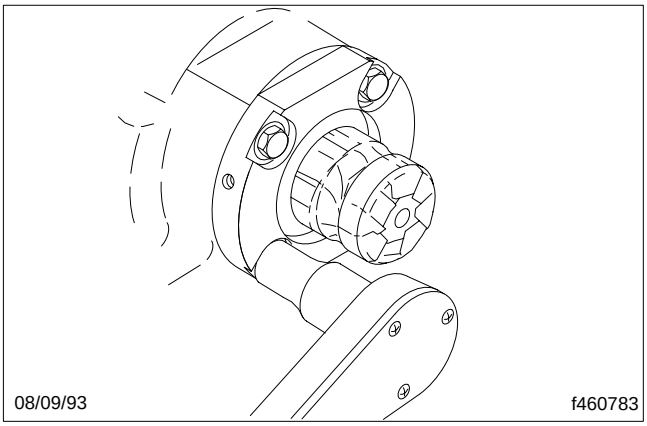


Fig. 104, Install the Trunnion Bolts

46. Apply clean grease to the input shaft seal assembly (seal and O-ring) and to the input shaft. Install a new two-piece input shaft seal (with the flat side out), and the steel backup washer, using seal driving tool J28490. See **Fig. 106** and **Fig. 107**. Install the retaining ring.

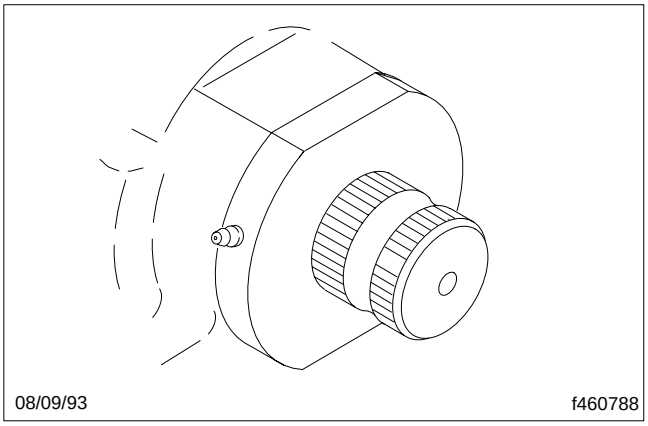


Fig. 105, Position the Grease Fitting Hole

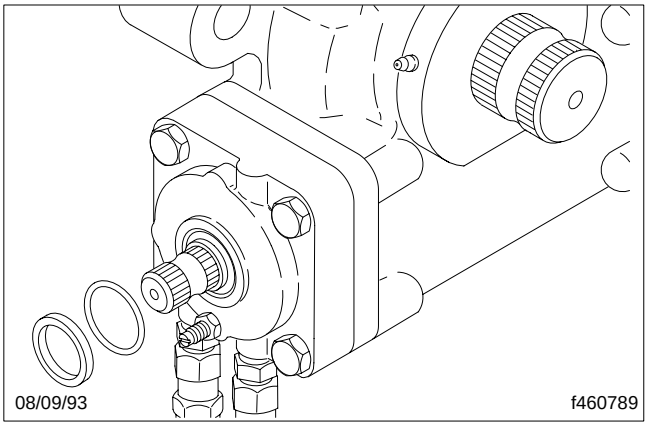
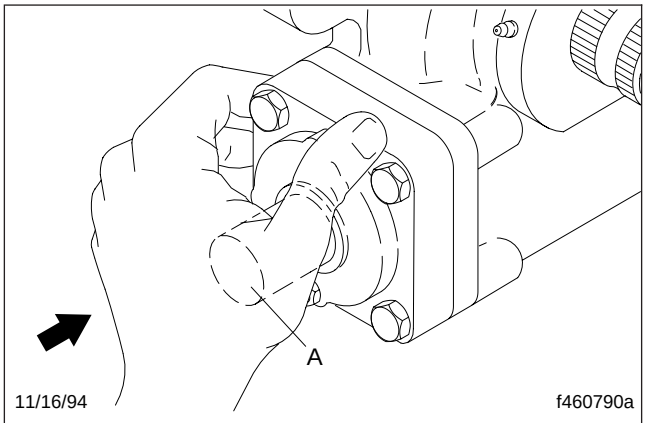


Fig. 106, Install the Input Shaft Seal and Washer



A. Seal Driving Tool J28490

Fig. 107, Install Input Shaft Seal and Backup Washer

47. Pack the area around the input shaft with clean water-resistant grease and install the dirt and water seal, using seal driving tool J28490 or a suitable blunt-end drift.
48. Apply clean grease to the cupped side of the new seal protector and install it, cupped side in, on the input shaft and into the serration relief groove. See **Fig. 108**.

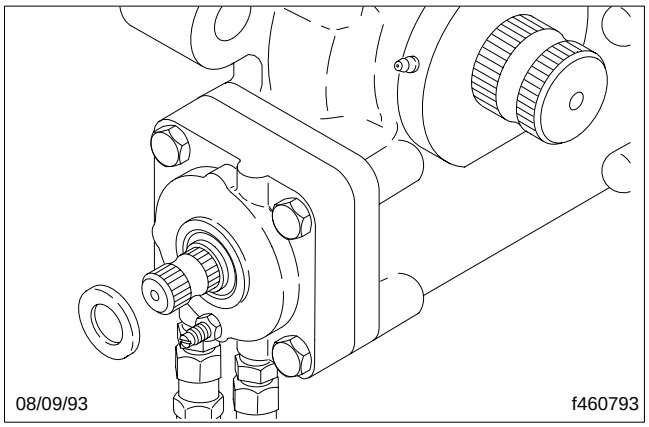


Fig. 108, Install the Seal Protector on the Input Shaft

49. Install the manual bleed screw (if equipped) and tighten it 27 to 33 lbf·in (305 to 373 N·cm).

Final Adjustments

Before installing the steering gear on the vehicle, make these adjustments.

NOTE: Worm shaft preload adjustment was done when the input shaft was installed in the valve housing during the assembly procedure.

1. To center the steering gear, turn the input shaft until the timing mark on the end of the sector shaft is at a right angle to the input shaft. See **Fig. 109**.

NOTE: Use a 12-point socket and an inch-pound torque wrench to turn the input shaft.

2. Adjust the sector shaft adjusting screw while turning the input shaft 180 degrees each side of center until the input shaft reaches a torque of 25 to 30 lbf·in (280 to 340 N·cm). See **Fig. 110**.
3. Back out the sector shaft adjusting screw one turn. Note the torque now required to turn the input shaft 180 degrees each side of center. Then tighten the adjusting screw to increase the noted torque by 2 to 4 lbf·in (23 to 45 N·cm).

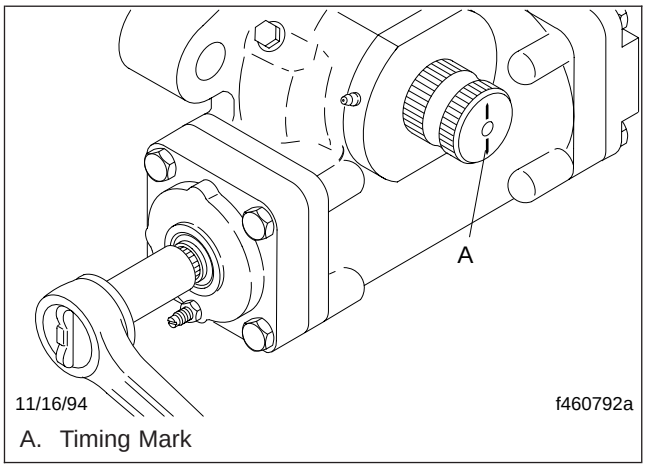


Fig. 109, Center the Steering Gear

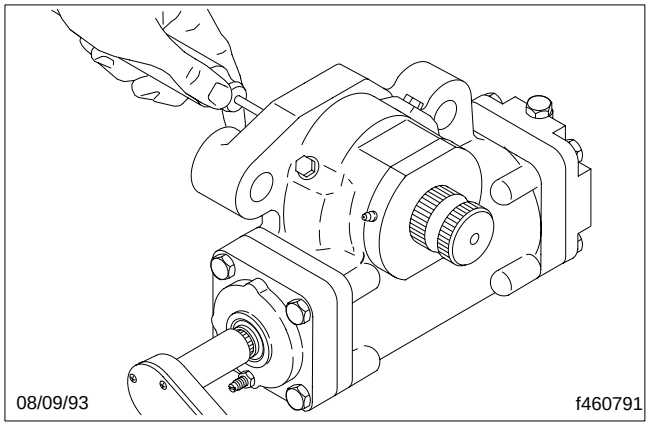


Fig. 110, Adjust the Sector Shaft Adjusting Screw

4. Tighten the sector shaft adjusting screw jam nut 40 to 45 lbf·ft (54 to 61 N·m). The torque now required to turn the input shaft should not exceed 20 lbf·in (226 N·cm) at any point in the steering gear travel. If it does exceed 20 lbf·in (226 N·cm), repeat the previous steps beginning with the procedure of backing out the adjusting screw one turn and noting the torque required to turn the input shaft 180 degrees.
5. While turning the input shaft back and forth slightly, adjust the worm shaft preload adjusting screw to increase the maximum noted input torque by 10 to 15 lbf·in (113 to 169 N·cm). Make sure that the worm shaft adjusting screw

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

jam nut does not contact the end cover while making this adjustment.

Tighten the jam nut 70 to 80 lbf·ft (95 to 108 N·m). Be sure that the adjusting screw does not move.

6. The torque now required to turn the input shaft should not exceed 35 lbf·in (395 N·cm). If it does exceed 35 lbf·in (395 N·cm), repeat the previous step.

Removal

1. Disconnect the return line from the steering gear and plug the line. See **Fig. 1**. Also cap the return port of the gear with a high pressure fitting.

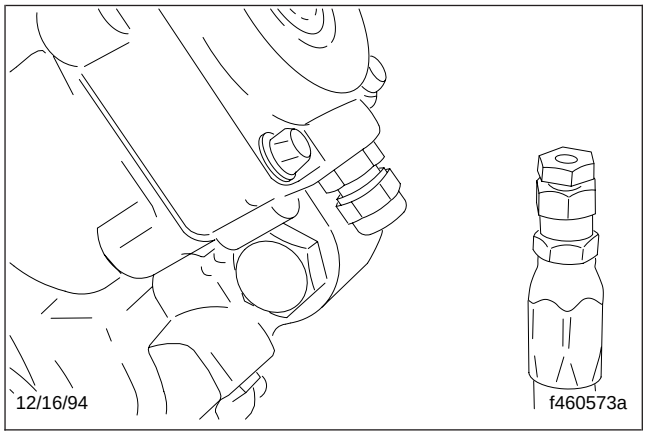


Fig. 1, Disconnect the Return Line

2. Disconnect the steering driveline from the steering gear input shaft.
   - 2.1 Remove and discard the pinch bolt and nut from the steering driveline lower end yoke.

⚠ CAUTION

Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.

   - 2.2 Remove the lower end yoke from the input shaft. Do not turn the steering gear input shaft when removing the lower end yoke. Push the driveline shaft into the driveline tube as you remove the lower end yoke.

3. Remove the dirt and water seal from the steering gear. See **Fig. 2**.
4. Wipe out the grease and then remove the spiral retaining ring. See **Fig. 3**. Use a screwdriver inserted into the notch formed in the end of the ring.
5. Slip the input yoke back onto the input shaft with the pinch bolt installed, but not tightened. See **Fig. 4**.

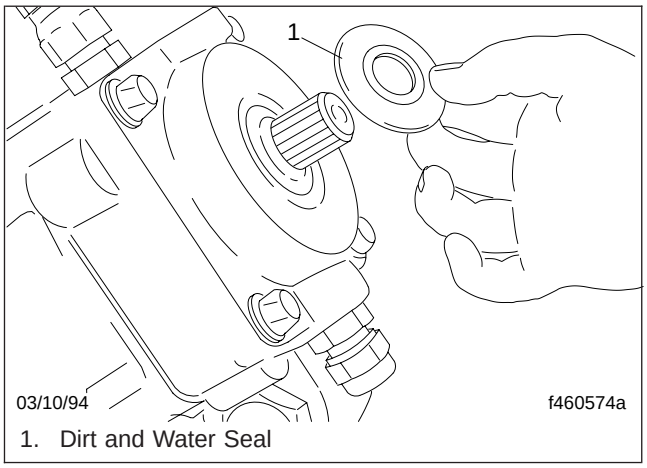


Fig. 2, Remove the Dirt and Water Seal

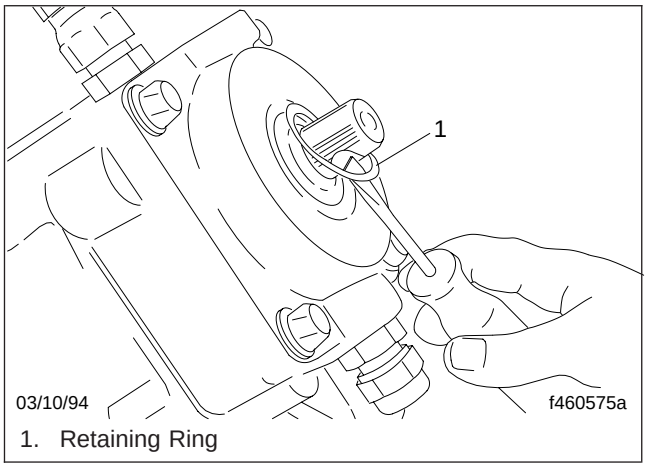


Fig. 3, Remove the Retaining Ring

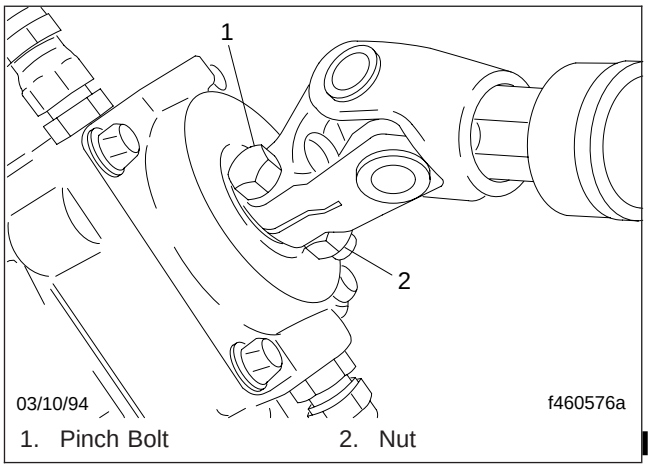
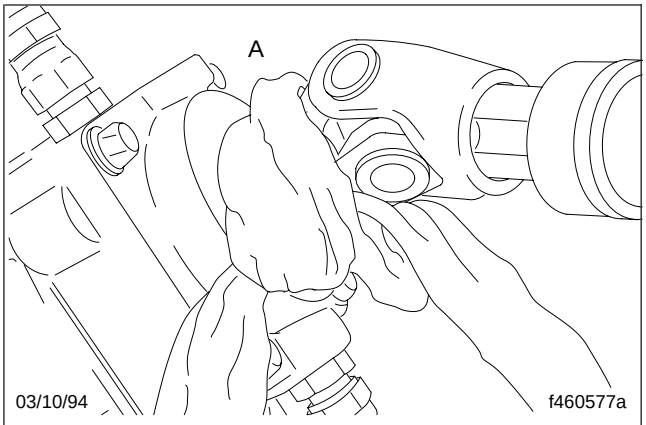


Fig. 4, Install the Pinch Bolt

Input Shaft Seal Removal and Installation

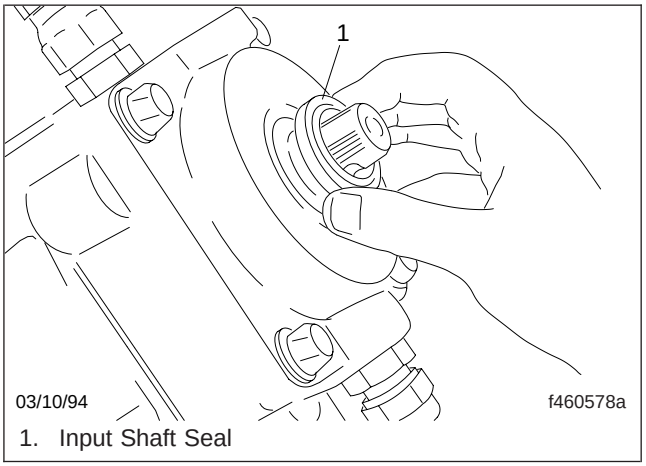
6. Tie or wrap a shop towel around the input shaft area and place a drip pan under the vehicle to catch the oil. See **Fig. 5**.



A. Cover the input shaft area.

Fig. 5, Shop Towel Covering the Input Shaft

7. Add the power steering fluid specified in **Specifications 400** as necessary to the fill line on the dipstick.
8. With the vehicle in neutral, momentarily turn the starter (quickly turn off the engine if it starts).
9. Remove the shop towel, pinch bolt, and input yoke.
10. Remove the seal. See **Fig. 6**.



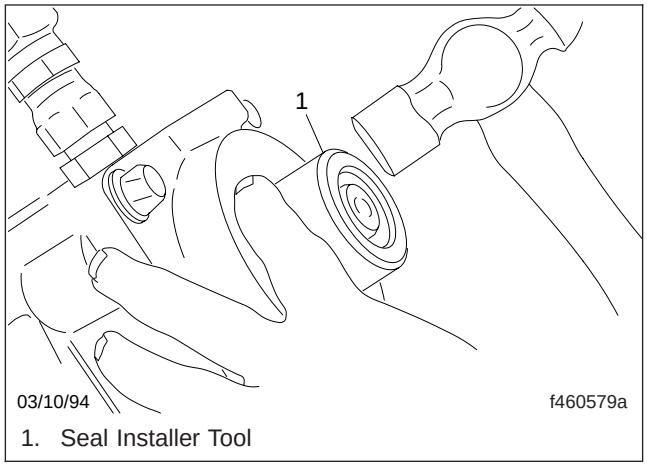
1. Input Shaft Seal

Fig. 6, Remove the Input Shaft Seal

11. Check the seal area of the valve housing for any seal fragments. Remove any that are found.
12. Check the seal for heat damage. If the seal is stiff, brittle, and not pliable like the new seal, it is probably heat damaged. You need to determine and fix the cause of excessive heat in the vehicle. For troubleshooting procedures, see **Section 46.11, Subject 300**.

Installation

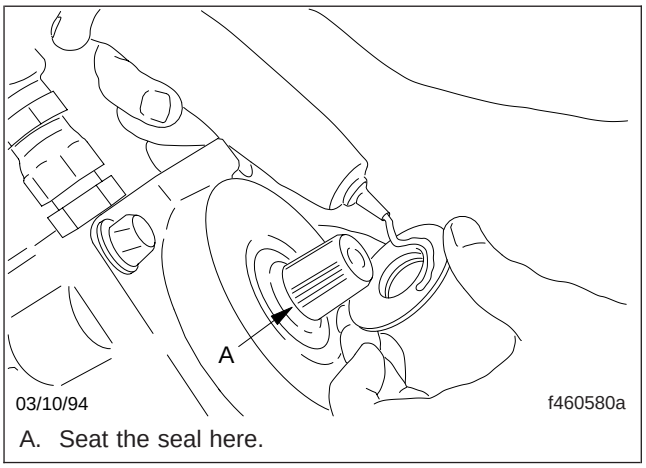
1. Put clean grease on the new input shaft seal and place it over the input shaft, garter spring side first. See **Fig. 6**. Place seal installer tool J37073 over the input shaft and against the seal, small diameter end first. See **Fig. 7**. Tap the seal installer tool until the tool shoulder is square against the valve housing. Remove any seal material that may have sheared off in the seal bore or retaining ring groove.



1. Seal Installer Tool

Fig. 7, Position the Seal Installer Tool

2. Insert the new retaining ring into the groove.
3. Pack the end of the valve housing bore around the input shaft with clean high temperature industrial grease (Mobil Temp 1 or 2 or equivalent). Apply more of the grease to a new dirt and water seal and install it over the input shaft. See **Fig. 8**. Seat it in the groove behind the serrations and against the valve housing.
4. Connect the steering driveline to the steering gear input shaft.
   4.1 Clean the input shaft and the inside of the driveline yoke.



A. Seat the seal here.

Fig. 8, Install the Dirt and Water Seal

4.2 Apply a thin film of grease to the yoke splines. Use lithium-based grease, NLGI grade 2.

4.3 Slide the yoke on the input shaft and install a new pinch bolt. Before installing the nut, make sure the pinch bolt is centered in the steering column shaft notch. The pinch bolt is centered if it can slip in and out of the end yoke with ease. Install a new nut and tighten it to one of the following torque specs:

- 55 to 65 lbf·ft (75 to 88 N·m) for a 7/16–20 pinch bolt and nut
- 30 to 35 lbf·ft (41 to 77 N·m) for an M10 x 1.25 pinch bolt and nut

4.4 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and to the nut.

5. Connect the return line to the steering gear return port.

6. Fill and bleed the steering system.

IMPORTANT: Do not turn the steering wheel in the following steps until instructed. Doing so can cause air to enter the system, which can make it more difficult and time-consuming to bleed air from the system.

6.1 Fill the power steering reservoir with the steering fluid specified in **Specifications 400** until nearly full.

Crank the engine for 10 seconds without allowing it to start. If the engine does start, shut it down immediately. Check and fill the reservoir as needed.

Repeat this procedure three times, each time checking and filling the reservoir.

6.2 Start the engine and let it idle for two minutes. Shut down the engine and check the fluid level in the reservoir.

6.3 Start the engine again. Steer the vehicle from full-left to full-right several times. As needed, add fluid to the full line on the reservoir dipstick.

Sector Shaft Seal Removal and Installation

Removal

NOTE: For clarity, the figures in this subject show the steering gear mounted on a mock-up frame and steering driveline.

If there is a leak in the trunnion cover area, remove the trunnion cover and replace the sector shaft seal package.

1. Place the front tires in a straight-ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service operations are to be performed. Apply the parking brakes and chock the tires.
2. Remove and discard the pinch bolt, washer, and nut from the pitman arm.

NOTE: If factory alignment marks are not present, use a marking pen or paint to make a reference mark on the pitman arm and the sector (output) shaft.

3. Using a suitable puller, remove the pitman arm. Swing the pitman arm and drag link out of the way.
4. Remove the protective boot, the grease fitting, and the dirt and water seal from the trunnion cover. See **Fig. 1** and **Fig. 2**. Discard the protective boot and the dirt and water seal.

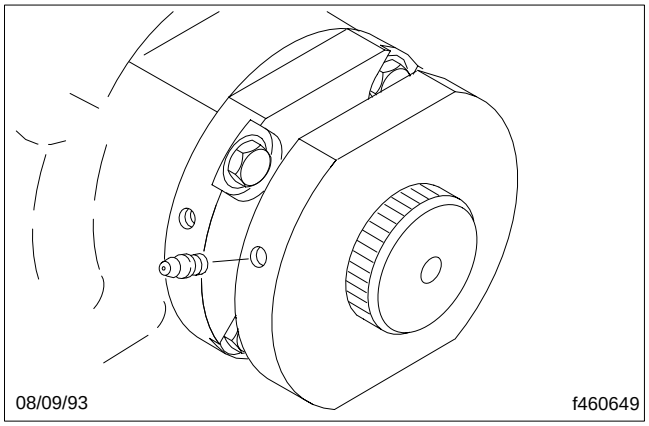


Fig. 1, Grease Fitting

5. Clean the nonserrated area of the sector shaft with a fine grade of emery paper as shown in **Fig. 3**. Be sure to remove any paint.

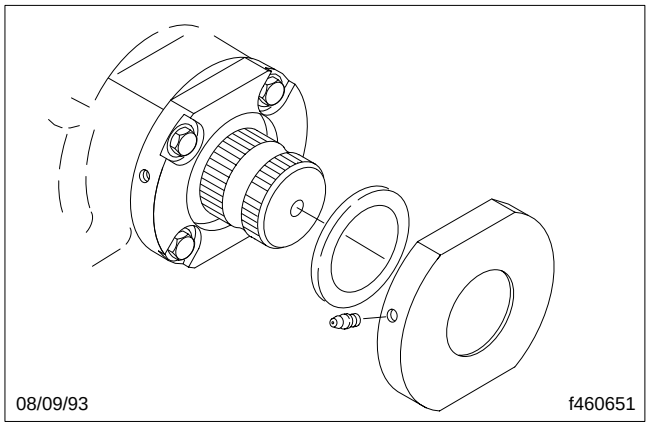


Fig. 2, Protective Boot

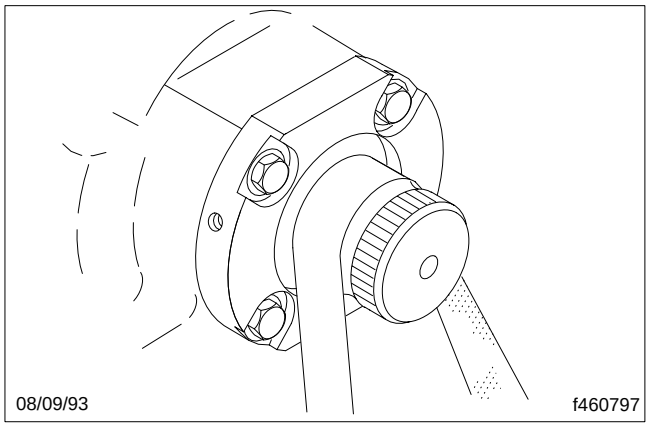


Fig. 3, Clean the Shaft Area

6. Remove the four trunnion cover bolts and trunnion cover as shown in **Fig. 4**. Remove and discard the sector shaft seal package, consisting of the Teflon® backup washer, the two-piece sector shaft seal, and the trunnion cover O-ring. See **Fig. 5**.

Installation

1. Clean the trunnion cover in petroleum-based solvent and inspect its seal cavity and sealing face for nicks or corrosion. Replace the trunnion cover with a new one if these conditions exist.
2. Place the trunnion cover on a bench to install the new seal package. Start with the new Teflon® backup washer. Install the new two-piece sector shaft seal so that the words OIL SIDE are visible after the seal is in place. See **Fig. 6**.

Sector Shaft Seal Removal and Installation

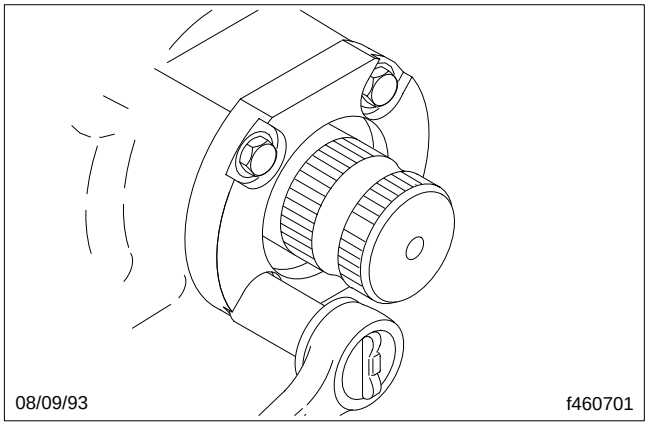


Fig. 4, Removing the Trunnion Cover Bolts

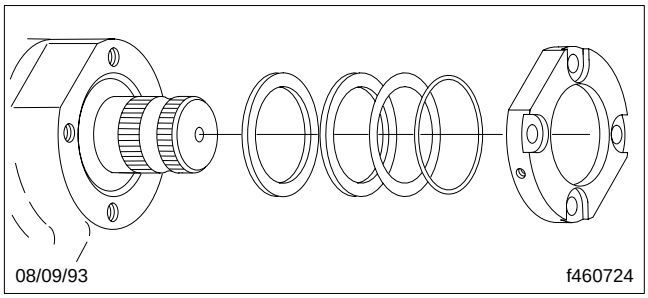


Fig. 5, Trunnion Cover and Seals

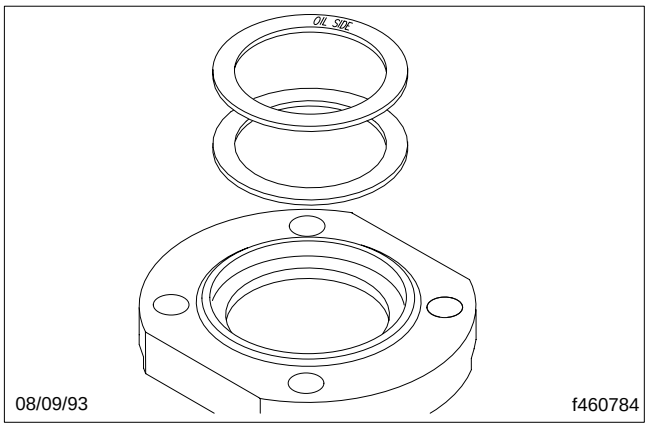


Fig. 6, Sector Shaft Seal Installation

⚠ WARNING

The words OIL SIDE must be visible after the seal is in place, as shown in Fig.6. If not, the seal will malfunction. This could cause a loss of power steering assist and result in an accident possibly causing personal injury or property damage.

3. Grease the new trunnion cover O-ring and install it in the cover groove.
4. Cover the serrations of the sector shaft with one layer of masking tape to avoid damaging the seals during trunnion cover installation. See **Fig. 7**.

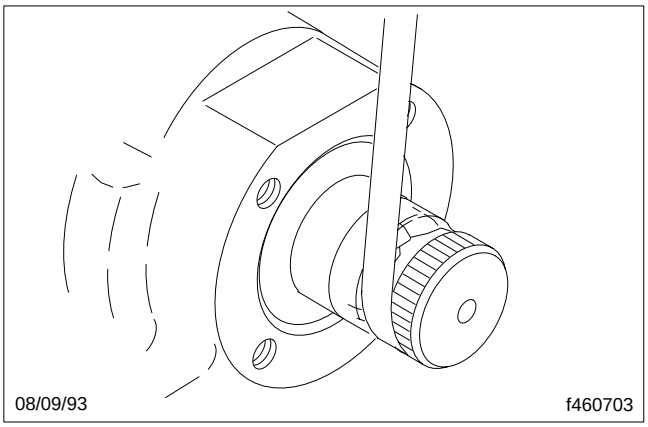


Fig. 7, Masking Tape Cover

5. Install the trunnion cover. See **Fig. 8**.

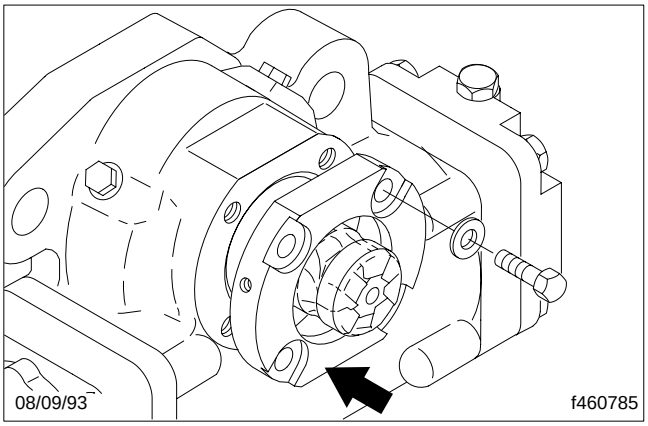


Fig. 8, Trunnion Cover, Installation

6. Install the four trunnion cover bolts. Torque the bolts 15 to 22 lbf·ft (20 to 30 N·m). See **Fig. 9**. Pack the cavity around the seal area of the sector shaft with Mobil Temp® 1 or 2 grease or an equivalent. Install a new dirt and water seal using a suitable blunt-end drift as shown in **Fig. 10**.
7. Grease the new protective boot inside the smaller diameter ring, and install it on the sector shaft. See **Fig. 11**. Position the protective boot

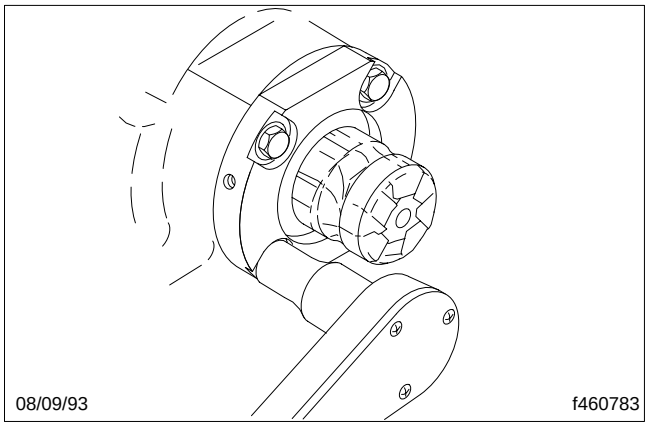


Fig. 9, Tighten Trunnion Cover Fasteners

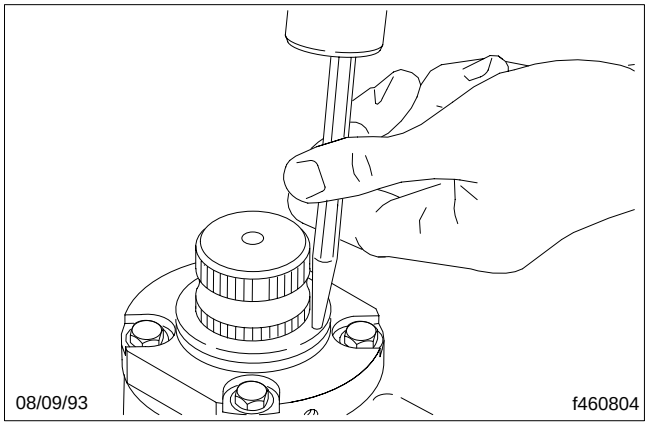


Fig. 10, Dirt and Water Seal Installation

so that the grease fitting hole faces toward the input shaft end of the gear assembly.

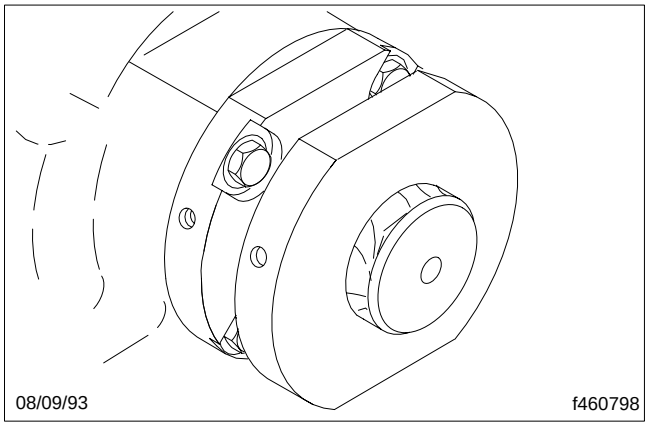


Fig. 11, Boot Installation

8. Insert the grease fitting into the protective boot. Remove the tape from the sector shaft.
9. Attach the pitman arm to the sector shaft. Be sure that the mark on the pitman arm aligns with the mark on the sector shaft. See **Fig. 12**.

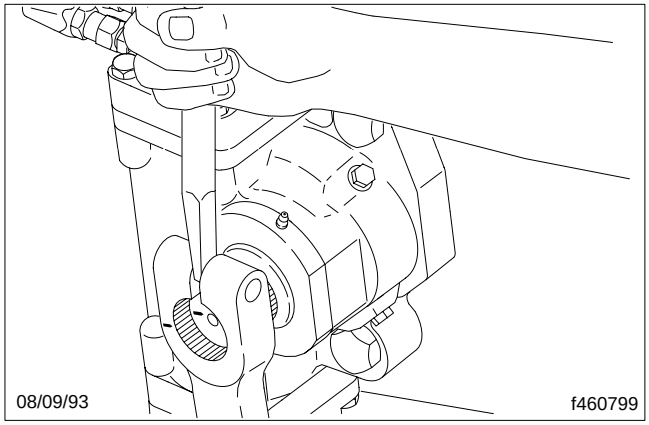


Fig. 12, Pitman Arm Installation

⚠ WARNING

Never leave a chisel wedged in the pitman arm slot. When using a chisel to spread the slot in the pitman arm, maintain a firm grip on the chisel at all times. Otherwise, the chisel may fly loose, which could cause an injury.

NOTE: The pitman arm may not fit over the splines on the sector shaft without spreading the slot in the arm. Use a ball-peen hammer to drive a chisel into the slot. Hold the chisel in place. Install the pitman arm on the sector shaft. Remove the chisel from the slot.

10. Install a new pinch bolt, washer, and nut. See **Fig. 13**. Tighten the nut 215 to 245 lbf·ft (290 to 332 N·m).
11. Fill and bleed the steering system.

    IMPORTANT: Do not turn the steering wheel until instructed in the following steps. Doing so can cause air to enter the system, which can make it more difficult and time-consuming to bleed air from the system.

    11.1 Fill the power steering reservoir with the steering fluid specified in **Specifications 400** until nearly full.

Sector Shaft Seal Removal and Installation

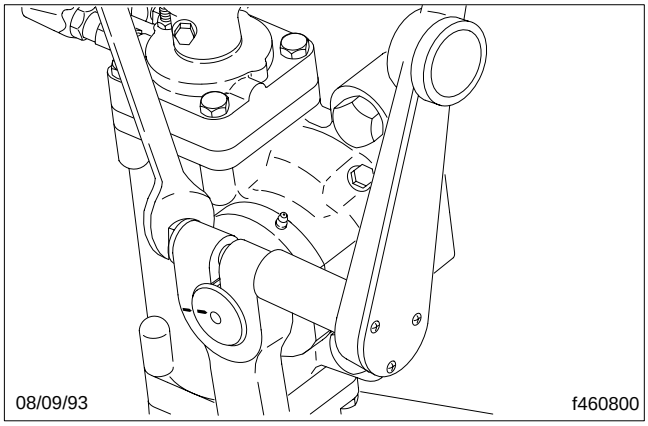


Fig. 13, Pinch Bolt Installation

Crank the engine for 10 seconds without allowing it to start. If the engine does start, shut it down immediately. Check and fill the reservoir as needed.

Repeat this procedure three times, each time checking and filling the reservoir.

11.2 Start the engine and let it idle for two minutes. Shut down the engine and check the fluid level in the reservoir.

11.3 Start the engine again. Steer the vehicle from full left to full right several times. As needed, add fluid to the full line on the reservoir dipstick.

NOTE: If needed, remove air from the system by adjusting the poppets. For instructions, see **Subject 100**.

Post-Service Checks |

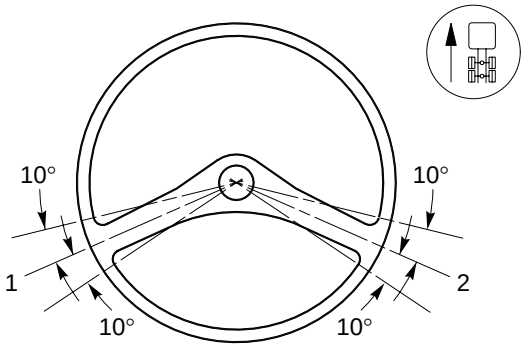
After power steering components have been worked on and before the vehicle is placed into service, make the following checks.

⚠ WARNING

Failure to make the following checks could result in damage to the power steering system. This could cause a loss of hydraulic assist, which could cause personal injury or property damage.

1. With the engine turned off and warm, check the power steering reservoir fluid level.
2. Check for air in the system.
   - 2.1 Place a thermometer in the power steering reservoir, then warm the hydraulic system to normal operating temperature of 125° to 135°F (51° to 57°C) by operating the engine at low idle while turning the steering wheel through several full-left and full-right turns.
   - 2.2 With the engine running and the power steering system at operating temperature, turn the steering wheel slowly from stop to stop while checking the power steering reservoir for frothing or a change in the fluid level (a sign that air is trapped in the system). If air is present, inspect the system for leaking hoses or loose fittings. Replace the hoses or tighten the fittings as needed. Bleed the air from the system.
3. At full-left and full-right wheel cuts, be sure the axle stops (on the rear-side of the spindle) are set so there is at least 1/2-inch (13-mm) clearance between the tires and any fixed components that are attached to the vehicle. Clearance between moving components should be 3/4 inch (19 mm). If clearance is less than this, reset the axle stops.
4. If there are still problems with the power steering system, see the troubleshooting procedures in **Section 46.11, Subject 300**. Otherwise, go to the next step.
5. Test drive the vehicle or take a ride with the driver.

Check the steering wheel spoke position. With the front tires pointing straight ahead, check the position of the steering wheel spokes. They must be within ±10 degrees of the 4 o'clock and 8 o'clock positions. See **Fig. 1**. If they are not, remove the steering wheel and install it in the correct position. For instructions, see the applicable section in this group.



1. 8 o'Clock Position
2. 4 o'Clock Position

Fig. 1, Steering Wheel Centered

SPX Kent-Moore Tools, Warren, MI 48092, 1-800-328-6657		
Part Number	**Tool**	**Application**
J26739	Seal Installation Tool	Worm Shaft Seal Installation
J26740	Seal Compression Tool	Worm Shaft Seal Compression
J26741	Seal Installation Tool	Valve Sleeve Seal Ring Installation
J26742	Seal Compression Tool	Valve Sleeve Teflon Seal Ring Compression
J26743	Bearing Mandrel	Housing Bearing Removal and Installation
J28490	Seal Driving Tool	Input Shaft Seal Installation

Table 1, SPX Kent-Moore Tools, Warren, MI 48092, 1-800-328-6657

Steering Gear Torque Values			
Description	**Bolt or Nut Size**	**Torque**	
		lbf·ft (N·m)	**lbf·in (N·cm)**
Trunnion Cover Bolts	5/16–18	15–22 (20–30)	—
Worm Shaft Preload Adjusting Screw	—	—	60–70 (678–791)
Worm Shaft Adjusting Screw Jam Nut	—	70–80 (95–108)	—
Poppet Adjusting Screw Jam Nuts	—	12–18 (16–24)	—
Poppet Seats	—	20–25 (27–34)	—
Ball Return Guide Clip Hexagon Head Bolts	—	14–22 (19–30)	—
Ball Return Guide Cap Allen Head Bolts	—	14–22 (19–30)	—
End Cover Bolts	9/16–18	150–170 (203–230)	—
Valve Housing Bolts	9/16–18	145–155 (197–210)	—
Sector Shaft Adjusting Screw Jam Nut	—	40–45 (54–61)	—
Side Cover Ring-Head Bolts	—	150–170 (203–230)	—
Manual Bleed Screw	—	—	27–33 (305–373)
Pitman Arm Pinch Bolt Nut	3/4–16	215–245 (292–332)	—
Steering Gear Mounting Bolt Nuts *	7/8–14	427 (579)	—

* Torque values are for a plain capscrew with a phosphate- and oil-coated locknut with a hardened washer.

Table 2, Steering Gear Torque Values

⚠ WARNING

Fill only with approved clean power steering fluid. Any mixture or any unapproved fluid could lead to seal deterioration and leaks. Any fluid leak could eventually cause loss of power steering assist.

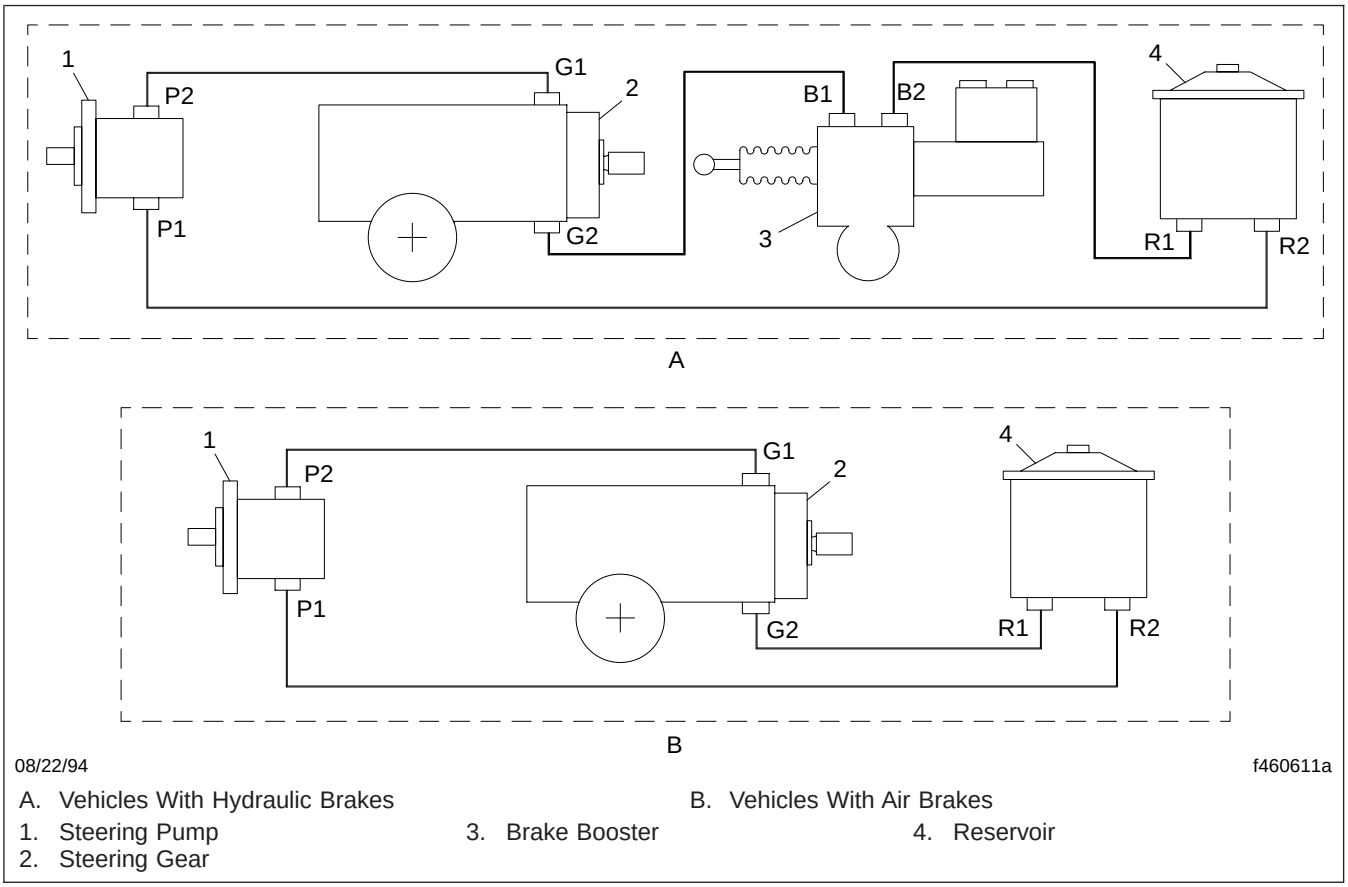
Specifications

Approved Power Steering Fluids	
Fluid Type	**Approved Fluid**
Automatic Transmission Fluid*	Dexron® II Dexron® III
Heavy-Duty Engine Oil* IMPORTANT: Do not use heavy-duty engine oil in vehicles built from November 4, 2002. **⚠ WARNING** **Do not use heavy-duty engine oil in vehicles equipped with a Hydro-Max® brake booster. Engine oil is not compatible with the seals in the brake booster. If the vehicle is equipped with a Hydro-Max brake booster, use only automatic transmission fluid in the power steering system. Failure to follow this precaution could cause loss of hydraulic brake assist, possibly resulting in personal injury and property damage.**	Union 10W–40 Texaco 10W–40 Chevron 10W–40 Mobil Super 10W–40 Union 15W–40 Shell Rotella T 30W

* Do not mix engine oil with automatic transmission fluid (ATF). Use the same lubricant for parts as is in the power steering system.

Table 3, Approved Power Steering Fluids

See **Fig. 1** for a steering system plumbing diagram.



A. Vehicles With Hydraulic Brakes
B. Vehicles With Air Brakes
1. Steering Pump
2. Steering Gear
3. Brake Booster
4. Reservoir

Fig. 1, Steering System Plumbing Diagram

General Description (Refer to Fig. 1)

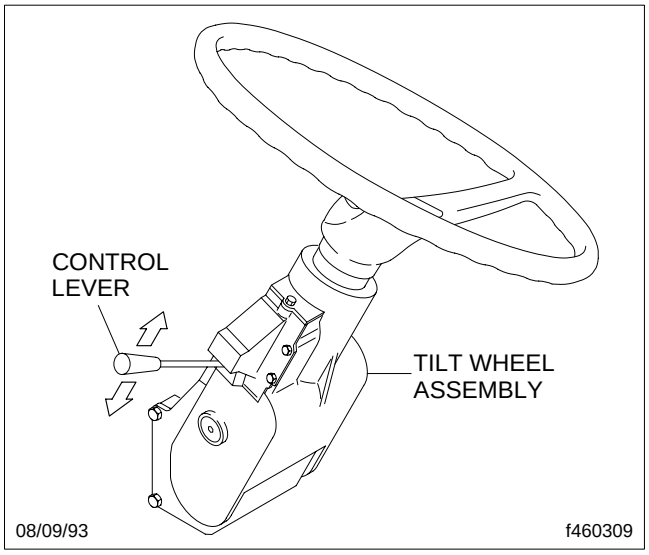


Fig. 1

The tilt/telescoping steering column has a tilt range of 15 degrees, and a telescoping range of 67 mm (2-5/8 inches). A control lever is located just below the turn signal switch. For operating instructions, refer to the vehicle driver's manual.

The upper end of the steering column assembly is threaded for the steering wheel nut, and just below the threads are splines that correspond to those in the steering wheel hub. At the lower end, the shaft is splined for the steering driveline end yoke, and has a groove for the end-yoke pinch bolt.

The steering column assembly is held in place by six hexbolts that attach the assembly to the lower dash and the pedal support bracket.

Steering Wheel Removal and Installation

Removal

1. Put the front wheels in the straight ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping at the place where the work will be done.

   Don't turn the steering wheel at any time during the removal procedure.
2. Apply the parking brake and chock the tires.
3. Disconnect the batteries at the negative terminal.
4. Using a small screwdriver, carefully pry out the horn button. Disconnect the two wires from it. **See Fig. 1.**

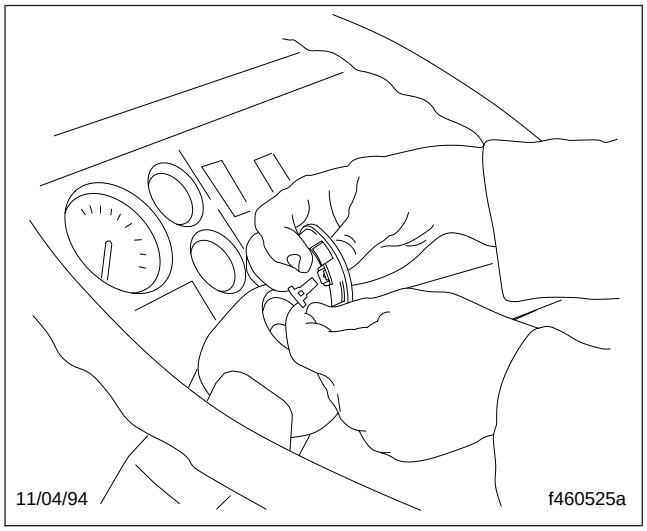


Fig. 1, Pry out the Horn Button

5. Using a deep socket to avoid damaging the wires, remove the steering wheel nut. **See Fig. 2.**
6. Using 1/4-inch sheet metal stock, make a wire protector about 4 cm x 1.5 cm (1-5/8 inches x 5/8 inch), like the one shown in **Fig. 3.** Then put it over the end of the steering column.
7. Using a steering wheel puller, remove the steering wheel from the steering column. **See Fig. 4.**

IMPORTANT: When you set the steering wheel aside, be careful not to damage the turn signal self-cancelling pin on the underside of the wheel. **See Fig. 5.**

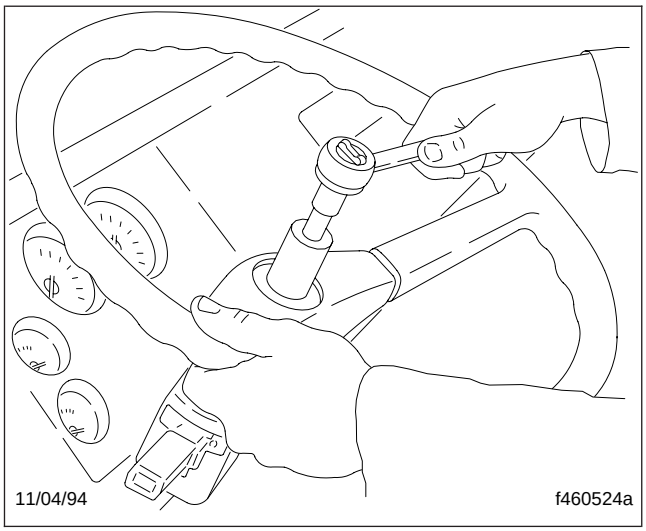


Fig. 2, Remove the Steering Wheel Nut

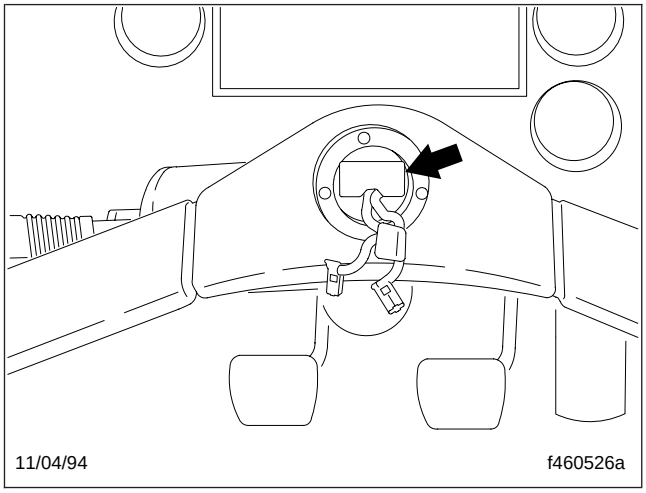


Fig. 3, Make a Wire Protector

Installation

1. Make sure the front tires are pointed straight ahead and the steering gear is centered.
2. Put the steering wheel on the steering column so that the spokes are within 10 degrees of the 4 o'clock and 8 o'clock positions. **See Fig. 6.**
3. Thread the two horn wires through the steering wheel nut, then install the nut. Tighten it 81 N·m (60 lbf·ft).

Steering Wheel Removal and Installation

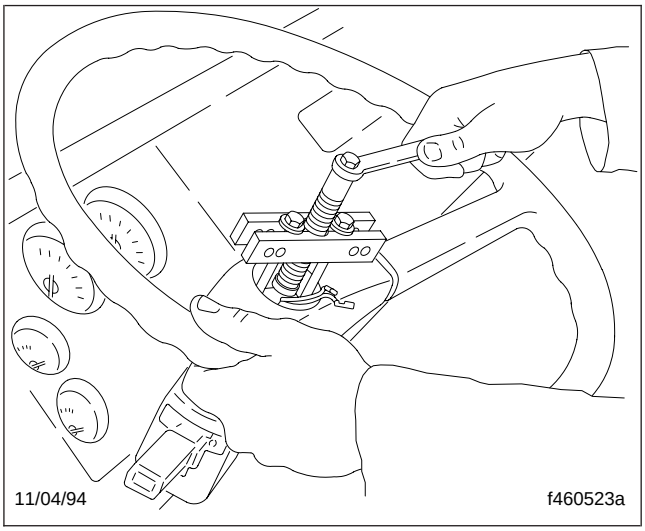


Fig. 4, Remove the Steering Wheel from the Column

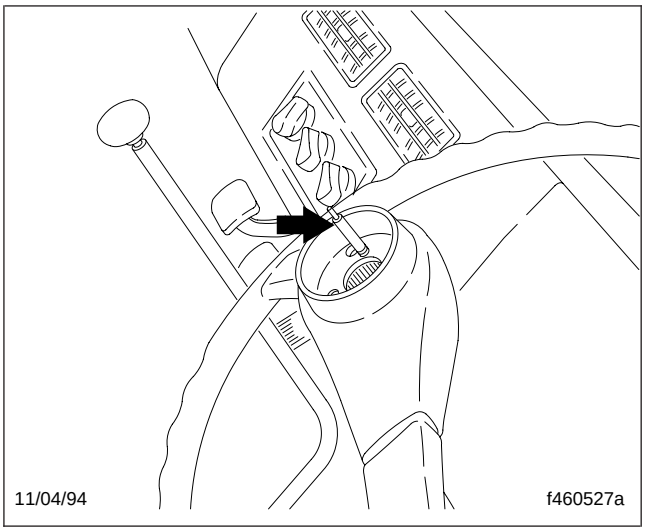


Fig. 5, Turn Signal Self-Cancelling Pin

4. Connect the two wires to the horn button. Pack the horn wires with dielectric grease.

NOTE: The horn wires may be connected to either terminal.

5. Install the horn button in the steering wheel hub so the logo on it is aligned with the steering wheel spokes. **See Fig. 7.**

6. Take the vehicle for a test drive to make sure the steering wheel is on correctly. If it isn't, remove it and install it again.

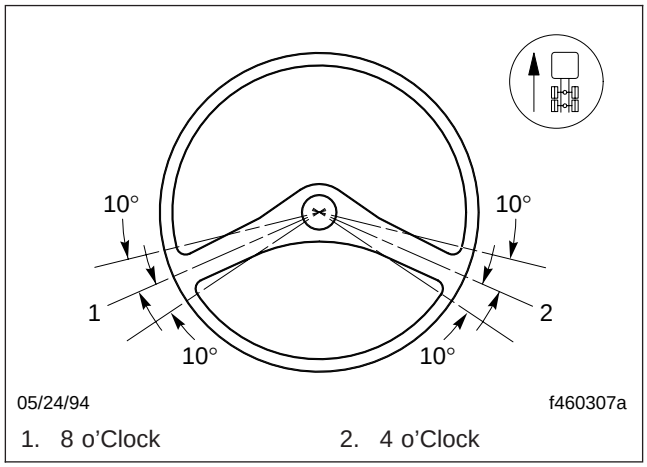


Fig. 6, Center the Steering Wheel

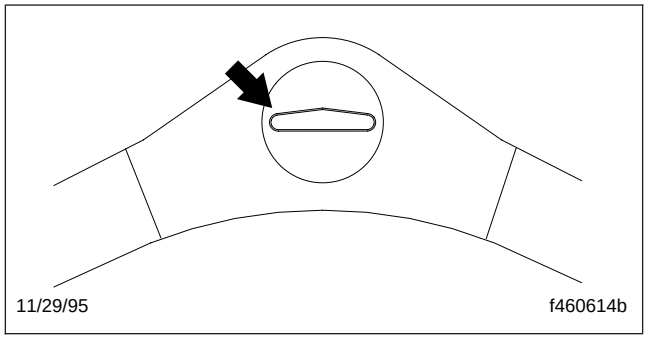
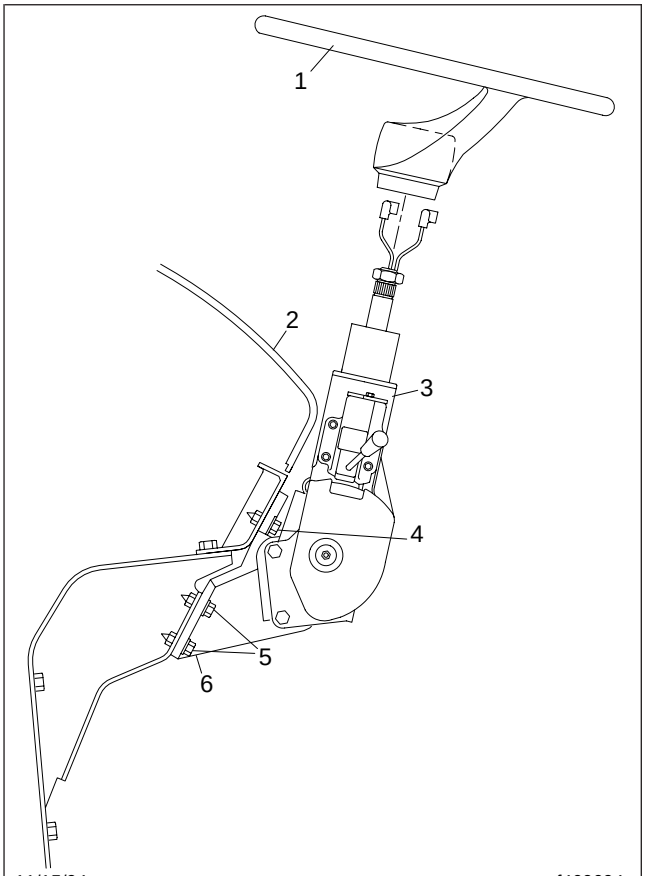


Fig. 7, Align the Logo

Removal (See Fig. 1)



1. Steering Wheel
2. Instrument Panel
3. Tilt Steering Column Assembly
4. Upper Mounting Hexbolts
5. Lower Mounting Hexbolts
6. Steering Column Mounting Bracket

Fig. 1, Steering Column Assembly

1. Park the vehicle on a level surface. Make sure the front tires are pointing forward. Apply the parking brakes. Shut down the engine. Chock the tires.

IMPORTANT: Once the vehicle is parked, do not turn the steering wheel at any time during the following procedures.

2. Disconnect the batteries.
3. Remove the plastic cover from the turn signal switch on the left side of the steering column.
4. Remove the two allen-head screws that attach the turn signal switch to the steering column. Swing the turn signal switch up and out of the way.
5. Disconnect the horn wire.
6. Remove and discard the pinch bolt and nut from the steering driveline yoke.
7. Remove the four hexbolts that attach the steering column bracket to the lower dash and to the pedal support bracket.
8. Disconnect the steering column from the steering driveline U-joint yoke.
9. Loosen the two upper mounting bracket hexbolts. Remove the steering column assembly from the vehicle.
10. If replacing the column, remove the steering wheel. For instructions, see **Subject 100**.

Installation (See Fig. 1)

1. Install the steering wheel. For instructions, see **Subject 100**.
2. Wipe the end of the column shaft with a clean, dry cloth.
3. Slide the upper end yoke onto the column shaft. Install a new end yoke pinch bolt. Before installing the pinch-bolt nut, make sure the pinch bolt is centered in the steering column shaft notch. The pinch bolt is centered if it can slip in and out of the end yoke with ease. Install and tighten a new pinch-bolt nut. For the proper torque, see **Specifications, 400**.
4. Apply torque seal OGP F900WHITE to the exposed pinch-bolt threads and to the locknut.
5. Align the upper mounting bracket holes with the upper mounting bracket hexbolts. Position the column assembly under the lower dash.
6. Line up the four lower holes in the steering column bracket with those in the lower dash and the pedal support bracket.
7. Install the four hexbolts and tighten them in stages to a final torque of 40 lbf·ft (54 N·m).
8. Connect the horn wire.

Steering Column Removal and Installation

9. Install the turn signal switch on the left side of the steering column. Tighten the screws firmly. Install the plastic cover.
10. Connect the batteries.
11. Remove the chocks from the tires.
12. Test drive the vehicle and make sure the steering column assembly operates smoothly. If it does not operate smoothly, repeat the service operations.

Disassembly (Refer to Fig. 1)

WARNING

WARNING: All steering mechanisms are critical safety items. Because of this, follow the instructions in this subject to the letter. Failure to do so may result in loss of steering, which could cause an accident resulting in personal injury or property damage.

Wear eye protection during disassembly of the tilt steering wheel column assembly. Parts of the assembly are spring-loaded, and could be ejected, which could result in serious eye injury.

NOTE: If replacing only the control lever (Ref. 36), spring cover plate (Ref. 33), actuator housing (Ref. 35), spring (Ref. 31), cam actuator (Ref. 38), pivot pin (Ref. 39), lockpin (Ref. 30), anti-rattle spring (Ref. 37), plate (Ref. 29), spring and wedgelock (Refs. 28 and 40), and spring and lockbar (Refs. 27 and 41), it is not necessary to remove the steering wheel and column assembly from the vehicle.

1. To minimize spring tension within the column assembly, hold the control lever all the way down, then move the steering wheel to the upright (non-tilt) position; release the control lever.

   Pull up the control lever and move the steering wheel up until it stops; release the control lever.

2. Remove the steering wheel from the column assembly. **Refer to Subject 100 for instructions**.

3. Remove the steering column assembly from the vehicle. **Refer to Subject 110 for instructions**.

4. Unscrew the control lever (Ref. 36).

5. Remove the 10-24 x 5/8-inch tapping screw (Ref. 32) from the spring cover plate (Ref. 33). Remove the plate.

6. Remove the four self-tapping screws (Refs. 32 and 34) from the actuator housing and bushing assembly (Ref. 35). Remove the actuator housing.

NOTE: On some tilt/telescoping column assemblies, two of the self-tapping screws (Ref. 32) are 5/8-inch long, and the other two screws (Ref. 34) are 7/8-inch long.

7. Remove the spring (Ref. 31), cam actuator (Ref. 38), pivot pin (Ref. 39), lockpin (Ref. 30), and anti-rattle spring (Ref. 37).

8. Remove the disengagement plate (Ref. 29), spring and wedgelock (Refs. 28 and 40), and spring and lockbar (Refs. 27 and 41).

   Remove all grease from the wedgelock/ lockbar cavity.

9. Detach the springs (Refs. 43 and 45) from the main housing assembly (Ref. 26). Remove the upper spring cover (Ref. 42).

10. Remove the four bolts (Ref. 8) from the support bracket (Ref. 25) and lower bearing housing (Ref. 21).

11. Remove the spring (Ref. 18) from the jacket tube (Ref. 16).

12. Remove the lower spring cover (Ref. 44), springs (Refs. 43 and 45), and spring retaining rod (Ref. 22) from the lower bearing housing.

13. Remove the retaining ring (Ref. 19) from the lower end of the universal joint assembly (Ref. 23). Remove the universal joint assembly from the lower bearing housing.

14. Using a suitable bearing puller, remove the bearings (Ref. 20) from the lower bearing housing.

    Using a 3/16-inch allen wrench, remove the pipe plug (Ref. 24) from the end of the universal joint assembly.

15. Remove the stopscrew (Ref. 2) and lockwasher (Ref. 1) from the main housing assembly (Ref. 26).

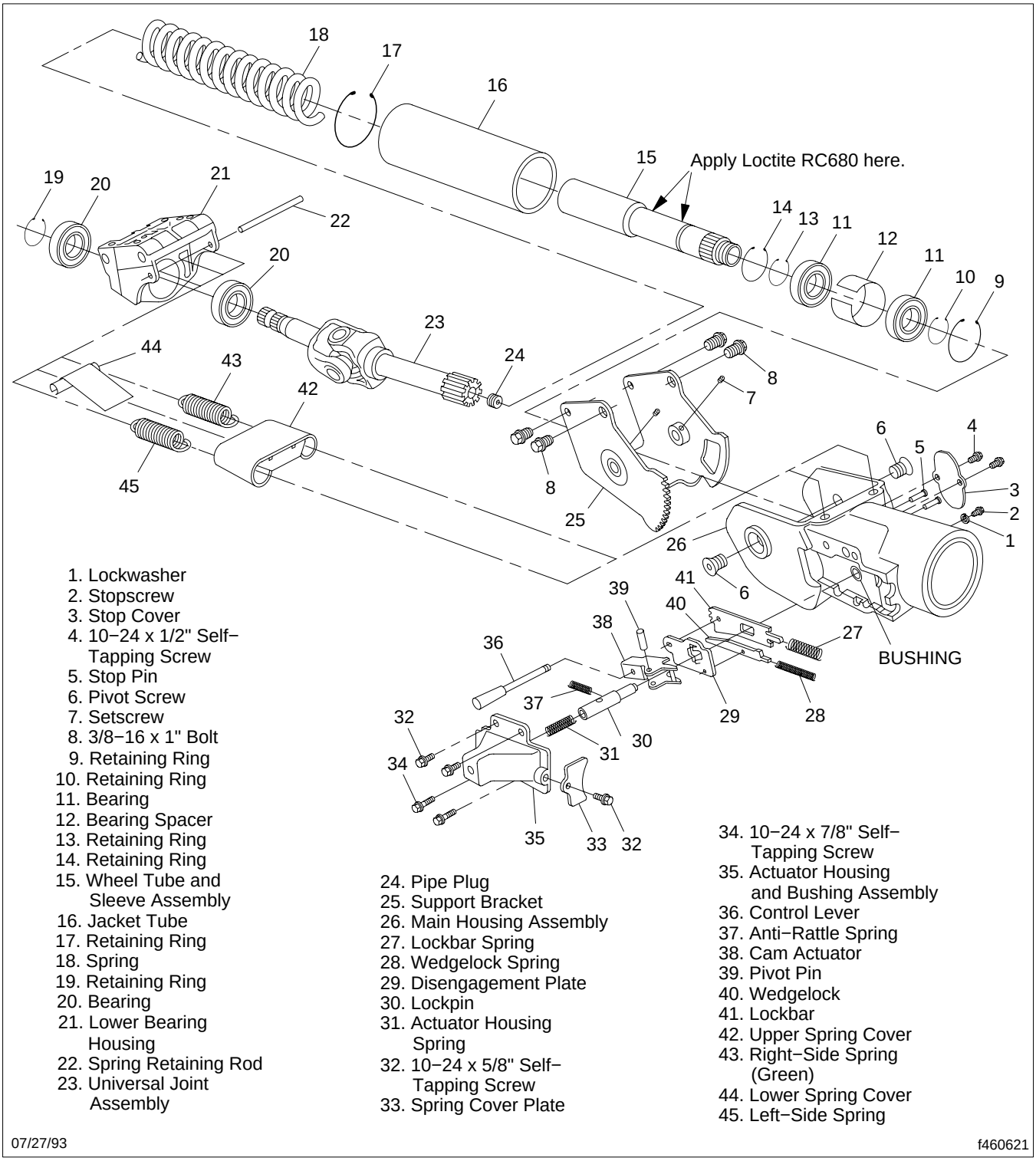
16. Push the wheel tube and jacket tube (Refs. 15 and 16) out through the lower end of the main housing assembly.

17. Remove the two retaining rings (Refs. 9 and 10) from the top end of the wheel tube and sleeve assembly and the jacket tube.

CAUTION

CAUTION: Keep the jacket tube clean and free of lubricant. Also, don't dent or scratch the jacket

Column Disassembly and Assembly



1. Lockwasher
2. Stopscrew
3. Stop Cover
4. 10−24 x 1/2" Self−Tapping Screw
5. Stop Pin
6. Pivot Screw
7. Setscrew
8. 3/8−16 x 1" Bolt
9. Retaining Ring
10. Retaining Ring
11. Bearing
12. Bearing Spacer
13. Retaining Ring
14. Retaining Ring
15. Wheel Tube and Sleeve Assembly
16. Jacket Tube
17. Retaining Ring
18. Spring
19. Retaining Ring
20. Bearing
21. Lower Bearing Housing
22. Spring Retaining Rod
23. Universal Joint Assembly
24. Pipe Plug
25. Support Bracket
26. Main Housing Assembly
27. Lockbar Spring
28. Wedgelock Spring
29. Disengagement Plate
30. Lockpin
31. Actuator Housing Spring
32. 10−24 x 5/8" Self−Tapping Screw
33. Spring Cover Plate
34. 10−24 x 7/8" Self−Tapping Screw
35. Actuator Housing and Bushing Assembly
36. Control Lever
37. Anti−Rattle Spring
38. Cam Actuator
39. Pivot Pin
40. Wedgelock
41. Lockbar
42. Upper Spring Cover
43. Right−Side Spring (Green)
44. Lower Spring Cover
45. Left−Side Spring

07/27/93 f460621

Fig. 1

tube. Dents or scratches could restrict the telescoping action of the tilt steering column assembly.

18. Insert a 20 x 2 cm (8 x 3/4-inch) rod into the splined sleeve end of the wheel tube. Using a press, press out the wheel tube and sleeve assembly. Remove the retaining ring (Ref. 14).
19. Using a suitable bearing removal tool, press the bearings (Ref. 11) off of the wheel tube and sleeve assembly. Remove the retaining ring (Ref. 13).
20. Remove the self-tapping screws (Ref. 4), stop cover (Ref. 3), and the stop pins (Ref. 5) from the main housing assembly.
21. Remove the setscrews (Ref. 7) from the support bracket. Remove the two pivot screws (Ref. 6), then separate the support bracket (Ref. 25) from the main housing.

⚠ WARNING

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

NOTE: For ease of removal, it may be necessary to heat the setscrews and pivot screws. Don't exceed 260°C (500°F) as the material hardness of these fasteners will be affected.

22. Using a petroleum-based solvent, clean the pivot screws, setscrews, and the internal threads of the support bracket.

Assembly (Refer to Fig. 1)

⚠ WARNING

WARNING: Wear eye protection during assembly of the tilt steering wheel column assembly. Parts of the assembly are spring-loaded, and could be ejected, which could result in serious eye injury.

1. Position the support bracket (Ref. 25) in the main housing (Ref. 26). Make sure that the bracket teeth are on the same side of the housing as the cam actuator (Ref. 38).
2. Install but don't tighten the pivot screws (Ref. 6). Insert a 13 x 76 mm (1/2 x 3 inch) bolt and nut through the center of the support bracket, between the bracket flanges.

   Back off the nut to spread the flange bosses against the main housing and provide clearance for installation of the lower bearing housing (Ref. 21).

   Remove the pivot screws (Ref. 6).
3. Apply a light coating of lithium grease under the head of each pivot screw (Ref. 6) then, apply Loctite RC680 to the threads of the pivot screws.

NOTE: Use care and avoid getting any grease on the pivot screw threads, or Loctite RC680 under the pivot screw head.

4. First tighten the pivot screw on the cam-actuator side of the housing 460 to 500 N·cm (40 to 45 lbf·in). Install and tighten the other pivot screw 460 to 500 N·cm (40 to 45 lbf·in).
5. Apply Loctite RC680 to the threads of the setscrews (Ref. 7). Install the setscrews and tighten them 560 to 680 N·cm (50 to 60 lbf·in).

NOTE: Use care and avoid getting any Loctite RC680 under the setscrew head.

6. Remove the 1/2 x 3-inch bolt and nut from the support bracket.
7. Install two new retaining rings (Refs. 13 and 14) on the top end of the wheel tube and sleeve assembly (Ref. 15).
8. Apply Loctite RC680 around the wheel tube in the bearing support area. Install a new bearing (Ref. 11) against the upper retaining ring.
9. Install the bearing spacer (Ref. 12). Install a new bearing (Ref. 11) until it clears the upper retaining ring groove. Install a new retaining ring (Ref. 10).
10. Insert the wheel tube and sleeve assembly (Ref. 15) into the jacket tube (Ref. 16). Align the split in the bearing spacer (Ref. 12) with the screw hole in the top end of the jacket tube.
11. Using a tubular bearing installation tool, apply pressure against the outer race of the upper bearing and press the wheel tube and sleeve assembly into the jacket tube.

Column Disassembly and Assembly

Install retaining rings (Refs. 9 and 17) in the grooves of the jacket tube.

12. Place the jacket tube assembly spring-end down on a pedestal that is about 10 cm (4 inches) high and 6 cm (2-1/4 inches) in diameter. Make sure that the cutouts on the lower collet in the main housing assembly are aligned with the holes for the lockpin (Ref. 30) and stopscrew (Ref. 2).
13. Slide the main housing assembly down over the jacket tube assembly. As the upper end of the jacket tube approaches the upper tapered collet of the main housing, push the collet down with a screwdriver (or other suitable tool) to pilot the wheel tube assembly into the housing bore.
14. Align the jacket tube's guide slot with the stopscrew (Ref. 2) hole in the main housing assembly (Ref. 26). Install the lockwasher and stopscrew (Refs. 1 and 2). Tighten the stopscrew 14 to 20 N·m (10 to 15 lbf·ft).
15. Press a new bearing (Ref. 20) into each end of the lower bearing housing (Ref. 21).
16. Slide the shaft of the universal joint assembly (Ref. 23) into the lower bearing housing until it seats against the lower bearing.

    Install the retaining ring (Ref. 19) on the universal joint shaft.
17. Install the pipe plug (Ref. 24) in the slotted end of the universal joint shaft. Tighten the pipe plug finger-tight.

NOTE: Don't overtighten the pipe plug. Overtightening will make it difficult to install the universal joint shaft in the wheel tube and sleeve assembly (Ref. 15).

18. Install the spring retaining rod (Ref. 22) in the lower bearing housing.
19. Hook one end of the green spring (Ref. 43) on the right side of the spring retaining rod (Ref. 22). Hook one end of the other spring (Ref. 45) on the left side of the spring retaining rod.
20. Clamp the serrated end of the wheel tube and sleeve assembly (Ref. 15) in a soft-jawed vise.
21. Push all the way down on the jacket tube (Ref. 16), then install the spring (Ref. 18).
22. Install the universal joint assembly (Ref. 23) through the spring (Ref. 18) and into the wheel tube and sleeve assembly (Ref. 15). Make sure that a slot in the splined shaft of the universal joint assembly aligns with the wide groove in the splined sleeve of the wheel tube and sleeve assembly.
23. Holding down on the universal joint assembly, align the lower bearing housing (Ref. 21) and support bracket (Ref. 25) screw holes. Install the bolts (Ref. 8). Tighten them 34 to 47 N·m (25 to 35 lbf·ft).
24. Position the lockbar (Ref. 41) on the main housing. Make sure that the lockbar locating pin is out, and that the teeth mesh with the support bracket teeth.
25. With the tapered end pointing towards the support bracket teeth, place the wedgelock (Ref. 40) on the main housing, under the lockbar.
26. Position the disengagement plate (Ref. 29) over the lockbar and wedgelock locating pins.
27. Insert the lockpin (Ref. 30) into the cam actuator (Ref. 38). Make sure that the spring hole in the cam and lockpin are facing each other.

    Insert the pivot pin (Ref. 39) through the cam actuator and lockpin. Check that the pivot pin is flush at the bottom of the cam actuator.
28. Attach one end of the anti-rattle spring (Ref. 37) to the lockpin, and the other end to the cam actuator.

    Lightly oil the lockpin assembly. Insert the lockpin into the bushing on the main housing assembly. Make sure that the ears on the cam actuator (Ref. 38) fit under the raised tabs on the disengagement plate (Ref. 29).
29. Insert the actuator housing spring (Ref. 31) into the end of the lockpin (Ref. 30). Using four self-tapping screws (Refs. 32 and 34), attach the actuator housing (Ref. 35) to the main housing. Tighten the screws 460 to 680 N·cm (40 to 60 lbf·in).

NOTE: On some tilt/telescoping column assemblies, two of the self-tapping screws (Ref. 32) are 5/8-inch long, and the other two screws (Ref. 34) are 7/8-inch long.

30. Attach the lockbar and wedgelock springs (Refs. 27 and 28). Install the spring cover plate (Ref. 33) over the lockbar and wedgelock springs.

Tighten the self-tapping screw (Ref. 32) 460 to 680 N·cm (40 to 60 lbf·in).

31. Screw the control lever (Ref. 36) into the cam actuator (Ref. 38).
32. Push down on the control lever and tilt the steering column all the way down. Release the control lever.
33. Snap the lower spring cover (Ref. 44) onto the retaining rod, between the springs.
34. Slide the upper spring cover (Ref. 42) over the springs, engaging the slot on the lower spring cover.
35. Push down on the control lever, then tilt the steering column all the way up. Release the control lever. Using a suitable spring assembly tool, hook the loose ends of the springs (Refs. 43 and 45) in the holes of the main housing assembly (Ref. 26).
36. Insert and lightly tap the stop pins (Ref. 5) to seat them into the holes lettered "D" and "K."
37. Install the stop cover (Ref. 3) with the self-tapping screws (Ref. 4). Tighten the screws 460 to 680 N·cm (40 to 60 lbf·in).
38. Push the jacket tube (Ref. 16) and wheel tube assembly (Ref. 15) all the way down. Using a 3/16-inch allen wrench that is 30-cm (12-inches) long, tighten the pipe plug (Ref. 24) just enough to keep the jacket tube and wheel tube assembly in position when the lockpin (Ref. 30) is disengaged.

    Loosen the pipe plug about a one-eighth turn to allow the wheel tube assembly to telescope freely under spring tension.
39. Check the operation of the tilt/telescoping column assembly as follows:

    39.1 Unlock the column assembly by pushing and holding the control lever all the way down. Tilt the column to any position, then release the control lever to lock it in place. Tilt the column to several other positions to ensure proper operation.

    39.2 Unlock the column assembly by pulling and holding the control lever all the way up. Move the column up or down to any position, then release the control lever to lock it in place. Telescope the column to several other positions to ensure proper operation.

    If the column telescoping action is sluggish or sticks, spray a small amount of Tri-Flow lubricant, or an equivalent, on the jacket tube (Ref. 16) while the column is all the way up.

NOTE: The tilt/telescoping column assembly must sit at room temperature for 24 hours to allow the Loctite RC680 to dry.

40. Install the tilt/telescoping column assembly. **Refer to Subject 110 for instructions**.
41. Install the steering wheel. **Refer to Subject 100 for instructions**.

Horn Contact Assembly Replacement

Replacement

1. Disconnect the horn wire from the wire lead-ing to the back of the dash. **See Fig. 1**.

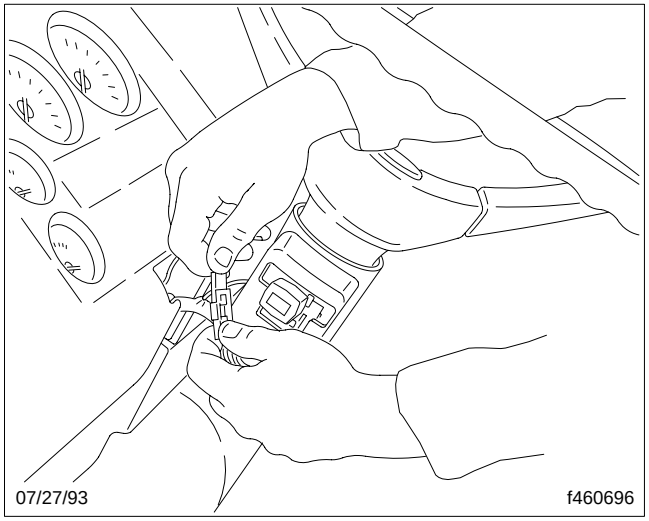


Fig. 1

2. Unscrew the horn contact assembly from the right-hand side of the steering column, and dis-card it. **See Fig. 2**.

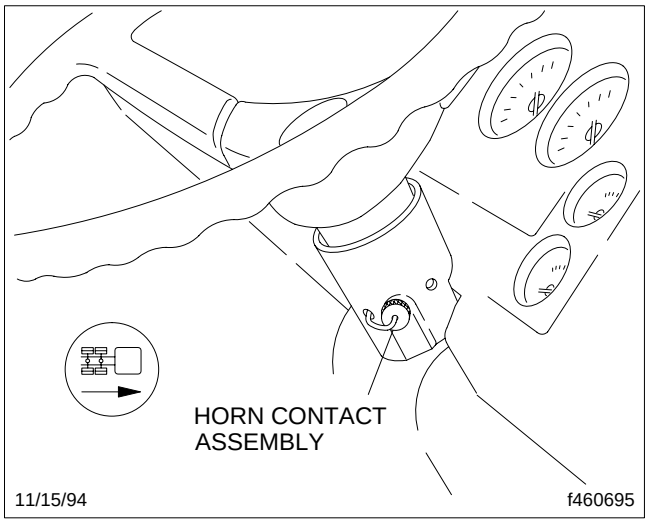


Fig. 2

3. Install a new horn contact assembly into the right-hand side of the steering column. Screw in the assembly firmly.
4. Connect the horn wire to the wire leading to the back of the dash.
5. Check the horn. If it doesn't work, check the wir-ing to the horn, the horn itself, and the horn but-ton. Repair or replace parts as needed.

Specifications

Fastener Torques			
Description	**Size**	**Torque**	
		lbf·in (N·cm)	**lbf·ft (N·m)**
Self-Tapping Screws	10–24	40–60 (460–680)	—
Bolts	3/8 x 16 x 1 Inch	—	25–35 (34–47)
Main Housing Stopscrew	—	—	10–15 (14–20)
Support Bracket Setscrews	—	50–60 (560–680)	—
Main Housing Pivot Screws	—	40–45 (460–500)	—
Steering Column Mounting Bracket Hexbolts	—	—	40 (54)
Upper End Yoke Pinch Bolt	3/18–16	—	37 (50)
	3/18–24	—	44 (60)
	7/16–20	—	55 (75)
Steering Wheel Nut	—	—	60 (81)

Table 1, Fastener Torques

General Information

The TRW PS Series power steering pump supplies power steering fluid for the operation of the power steering gear.

The main parts of the power steering pump are the housing, input shaft, cam ring, rotor, vanes, control valve, and cover assembly.

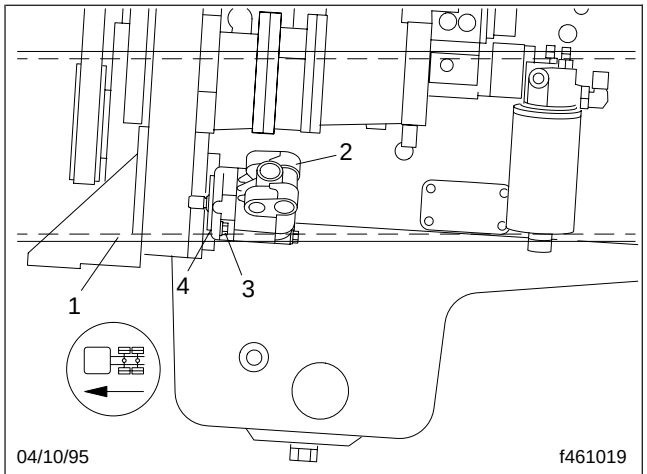
Principles of Operation

The input shaft, powered by the adaptor gear in the engine gear case or by the crankshaft pulley, turns the rotor, which is inside the cam ring. As the rotor turns, centrifugal force pushes the vanes out toward the surface of the cam ring. As fluid enters the cam ring through the inlet port, the rotor vanes force it out through the outlet port and into the system. The fluid operates the steering gear. Eventually the fluid returns to the power steering reservoir, then back to the power steering pump.

If the system pressure gets too high, a relief valve inside the control valve is forced off its seat, shunting fluid into a relief passage connected to the inlet port. The fluid then recirculates inside the pump instead of going to the outlet port. When the system pressure drops to the correct level, the relief valve seats, closing off the relief passage to the inlet port. The fluid flow returns to normal, flowing from the inlet port to the outlet port and then into the power steering system.

Removal

1. Apply the parking brake, chock the tires, then tilt the hood.
2. Clean all outside dirt from around the fittings and hose connections.
3. Put a container under the pump, then disconnect the hoses from the fittings on the pump. Plug the hoses and cap the fittings to keep out dirt and to prevent fluid from leaking.
4. Remove the pump.
   - 4.1 Remove the mounting capscrews and washers that attach the pump to the engine accessory drive mounting flange. See **Fig. 1**. Hold the pump as you remove the second mounting bolt.



1. Frame Rail
2. Steering Pump
3. M10 x 35 Capscrew and 7/16-inch Washer
4. Gasket

Fig. 1, TRW PS Series Power Steering Pump Mounting

   - 4.2 Pull the pump straight out from the engine. Keep it level to avoid spilling fluid.
5. Turn the pump upside down over a container and let the fluid drain out.
6. Discard the gasket from the pump mounting flange.

Installation

1. Using engine oil, lightly lubricate a new gasket and the pump shaft.
2. Install the pump.
   - 2.1 Install a new gasket on the pump mounting flange, then place the pump on the engine's accessory drive mounting.
   - 2.2 Install the washers and capscrews, and tighten them 46 N·m (35 lbf·ft).
3. Connect the inlet hose (from the power steering reservoir) to the inlet port. Tighten it 35 N·m (26 lbf·ft).
4. Connect the outlet hose (from the power steering gear) to the outlet port.
5. Bleed the power steering system.
   - 5.1 Check the fluid level in the power steering reservoir and if needed, fill it to the correct level.
   - 5.2 Start the engine and let it idle for several minutes.
   - 5.3 Turn the wheels to a full-left and full-right turn. Repeat about three times.
   - 5.4 Check the fluid level in the power steering reservoir. Add fluid as necessary to the full line on the reservoir dipstick.
   - 5.5 Shut down the engine.
6. Close the hood and remove the chocks from the tires.

Steering Pump Disassembly, Inspection, and Assembly

CAUTION

Be careful when working on the pump housing; it is aluminum, and can be easily damaged. When putting the pump in a vise, pad the vise jaws and clamp only the cover. Tighten the vise just enough to hold the pump.

Disassembly

WARNING

Wear safety goggles or glasses when disassembling the power steering pump. Some of the parts are held in place by springs or snap rings, which can release with considerable force, possibly causing injury.

NOTE: Prepare for fluid drainage before disassembling the pump.

1. Remove the power steering pump from the engine, following the instructions in **Subject 100**.
2. Carefully remove the end plug from the pump housing. Remove the spring if it did not come out with the end plug. See **Fig. 1**, **Fig. 2**, and **Fig. 3**.
3. Remove and discard the O-ring from the plug.

IMPORTANT: TRW does not recommend disassembly of the control valve spool assembly.

4. Remove the control valve spool assembly by hand or by pushing it with a small rod. See **Fig. 4**. Do not push on the small screen in the relief valve seat assembly.
5. Using a solvent-proof marker, make a mark across the housing and the cover. See **Fig. 5**. Remove the four screws and washers holding the housing and the cover together. See **Fig. 6**. Using a twisting motion, separate the housing from the cover.
6. Remove the spring. See **Fig. 7**.
7. Using a solvent-proof marker, draw a line across the top plate and the bottom plate. See **Fig. 8**.
8. Holding the cam ring in place, remove the top plate. See **Fig. 9**. Remove and discard the O-ring and backup O-ring.
9. Holding the bottom plate in place, remove the cam ring. Note and record whether the dots near the locating pin holes on the cam ring are up or down. See **Fig. 10**.
10. Look for wear on the outside edge of the vanes. Note and record the direction of the wear for assembly. Carefully remove the rotor and vanes, as the vanes will slip from their slots in the rotor. See **Fig. 11**.
11. Remove the locating pins. See **Fig. 12**. Make marks on the outside of the cover (not on the sealing surface) to note from which holes the locating pins were removed.
12. Remove the bottom plate. See **Fig. 13**.
13. Turn the cover over and remove the large retaining ring. See **Fig. 14.**
14. Press out the input shaft and ball bearing assembly. See **Fig. 15**.
15. Remove the spacer from the cover. See **Fig. 16**.
16. Using care not to damage the bore, remove the shaft seal. See **Fig. 17**.

Inspection

1. Using a solvent compatible with the power steering fluid, clean all the parts. Then use filtered, compressed air to dry all the parts.

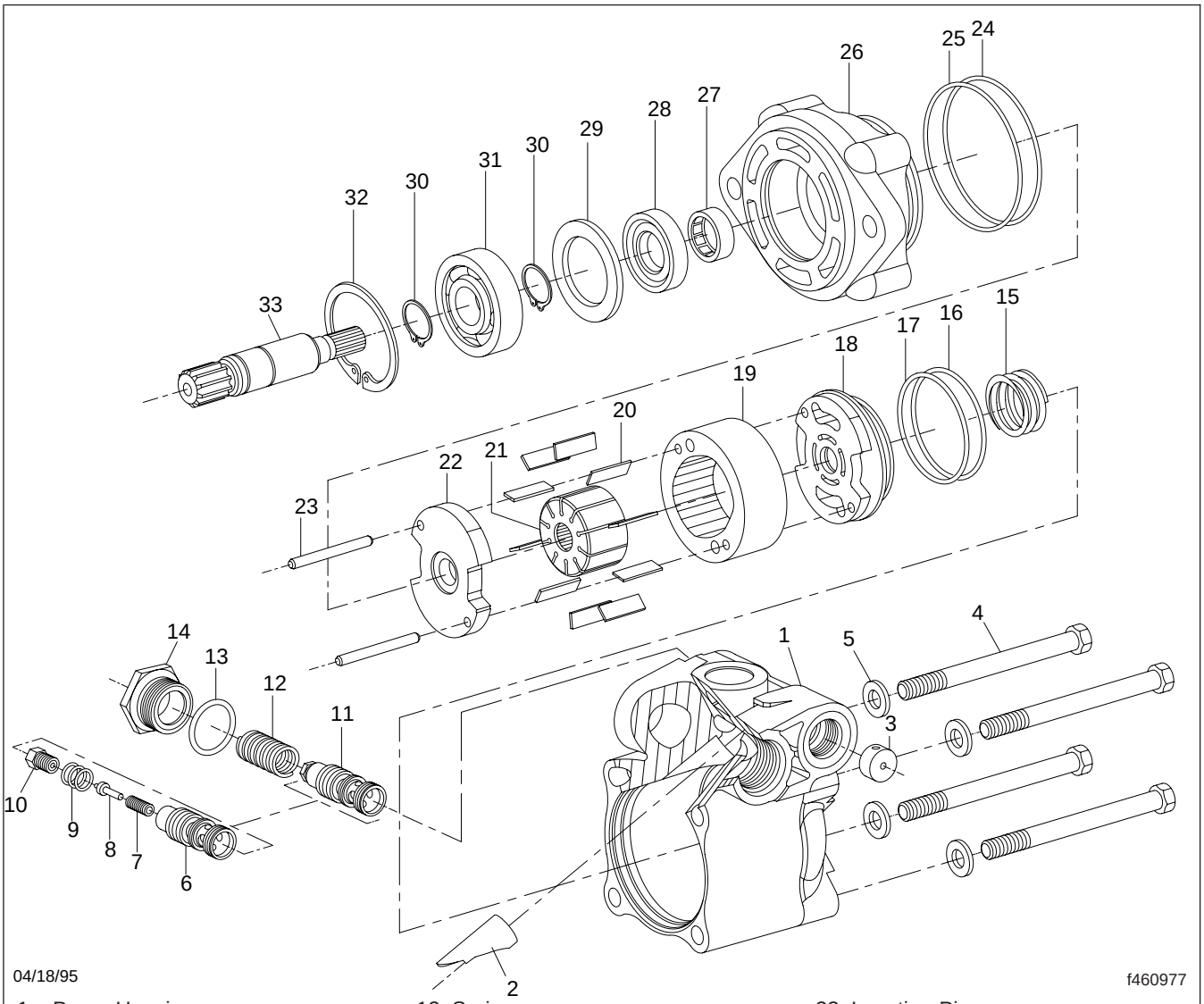
NOTE: Replace any parts that are damaged or worn.

2. Inspect the housing for cracks, stripped threads, a damaged valve bore, and damaged sealing areas. See **Fig. 18**.
3. Inspect the cover for nicks in the O-ring seal grooves. Make sure that the seal drain hole is open and that the seal bore is free of nicks and other damage. See **Fig. 19**.

   Make sure that the surface on which the bottom plate rests is flat and free of nicks and other damage.
4. Check that the needles roll freely in the needle bearing. If needed, replace the needle bearing.

   4.1 Place the cover in a press with the flange side down. Using an 11/16-inch socket,

Steering Pump Disassembly, Inspection, and Assembly



1. Pump Housing
2. Boost Tube
3. Orifice
4. Mounting Bolt
5. Washer
6. Spool
7. Spring
8. Poppet
9. Shims
10. Relief Valve Seat Assembly
11. Control Valve Spool Assembly
12. Spring
13. O-Ring
14. Plug
15. Spring
16. O-Ring
17. Backup O-Ring
18. Top Plate
19. Cam Ring
20. Vane
21. Rotor
22. Bottom Plate
23. Locating Pin
24. Small O-Ring
25. Large O-Ring
26. Cover
27. Needle Bearing
28. Shaft Seal
29. Spacer
30. Small Retaining Ring
31. Ball Bearing
32. Large Retaining Ring
33. Input Shaft

Fig. 1, Steering Pump

press the needle bearing out of the cover. See **Fig. 20**.

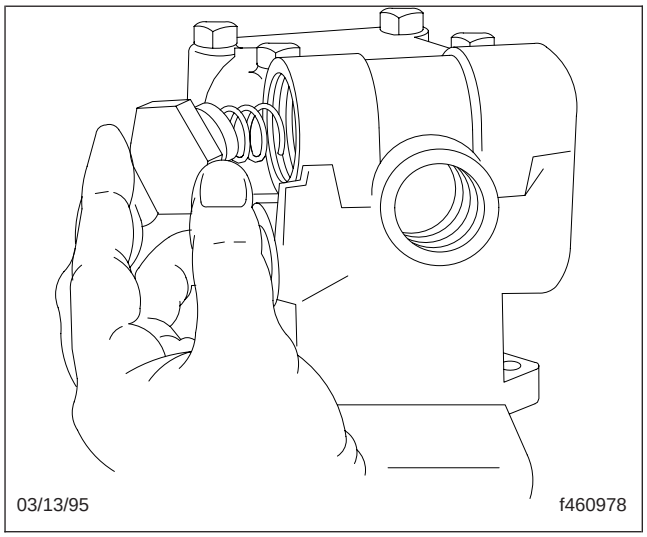


Fig. 2, Remove the End Plug

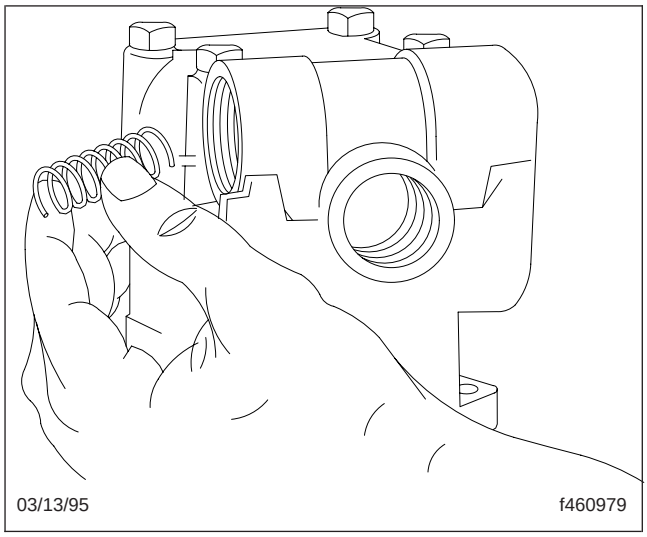


Fig. 3, Remove the Spring

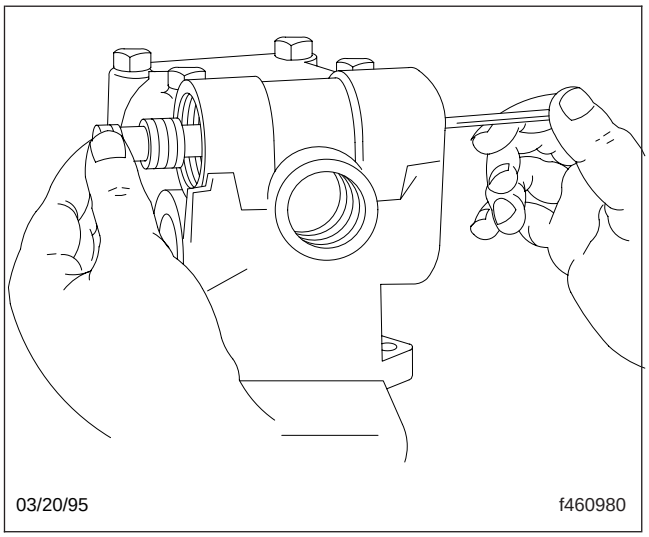


Fig. 4, Remove the Control Valve Assembly

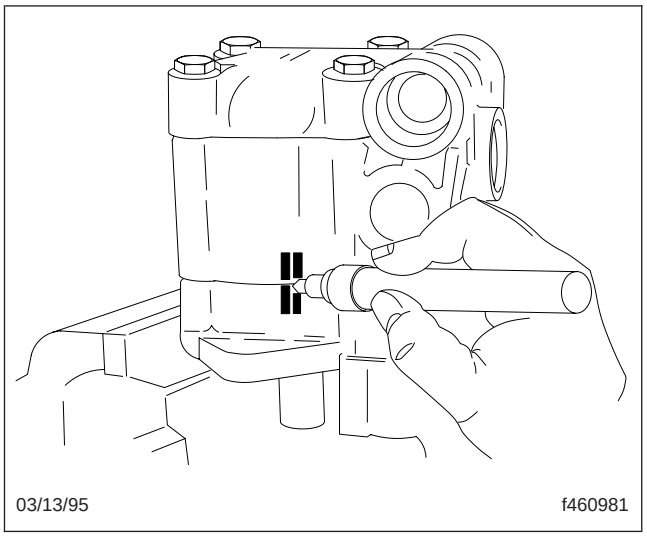


Fig. 5, Mark the Housing and the Cover

CAUTION

Make sure that the press is clean and free of debris. Debris could damage the face of the cover, which will affect pump operation.

4.2 Put the cover in a clean press with the flange side up. Make sure that the lettered side of the needle bearing is facing toward the press.

4.3 Using a 7/8-inch deep socket, press the new needle bearing into the cover until it is flush with the inside surface of the cover. See **Fig. 21**.

5. Inspect the top plate for seal area nicks and abnormal wear or erosion. A polished pattern from the rotor and vanes is normal; grooves you can feel with your fingernail are not normal.

6. Look for abnormal wear, erosion, or surface damage on the inside of the cam ring.

Steering Pump Disassembly, Inspection, and Assembly

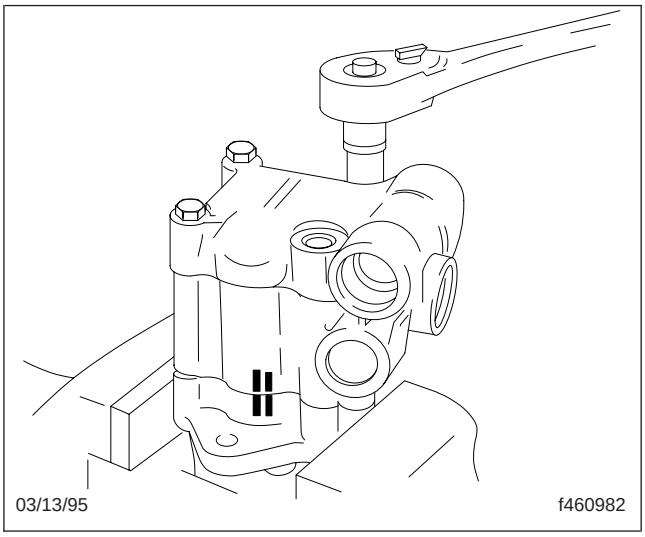


Fig. 6, Remove the Screws and Washers

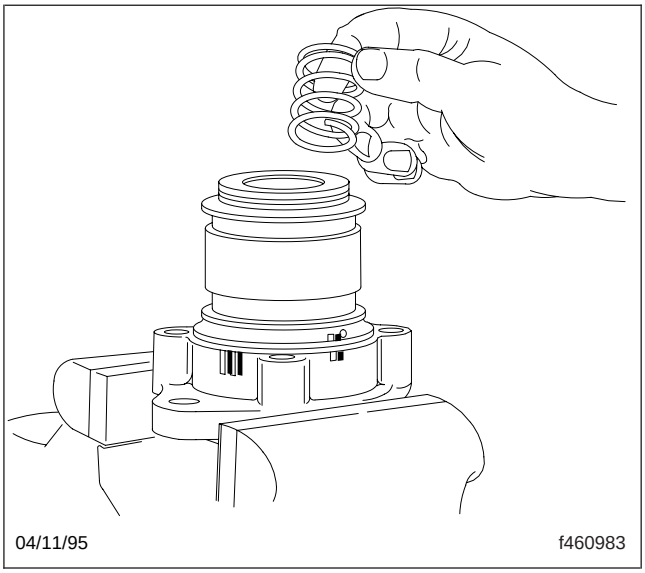


Fig. 7, Remove the Spring

7. Check the vanes on the rotor for damage or too much play in the rotor slots. See **Fig. 22**. If you can move the vanes from side-to-side in the slots, replace the whole rotor assembly.

NOTE: If the vanes are removed, make sure they are installed with the rounded edge out.

8. Check the bottom plate for abnormal wear patterns.

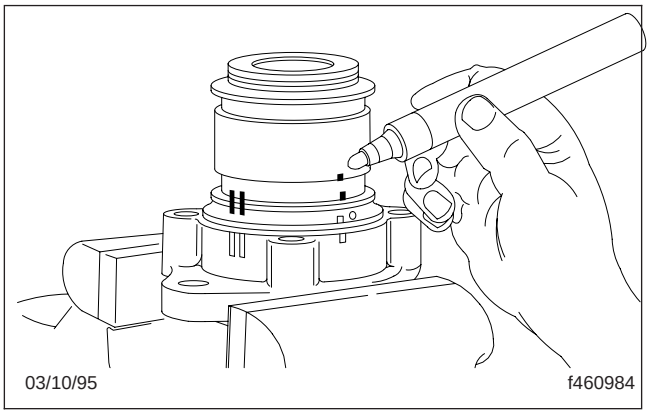


Fig. 8, Mark the Top Plate and the Bottom Plate

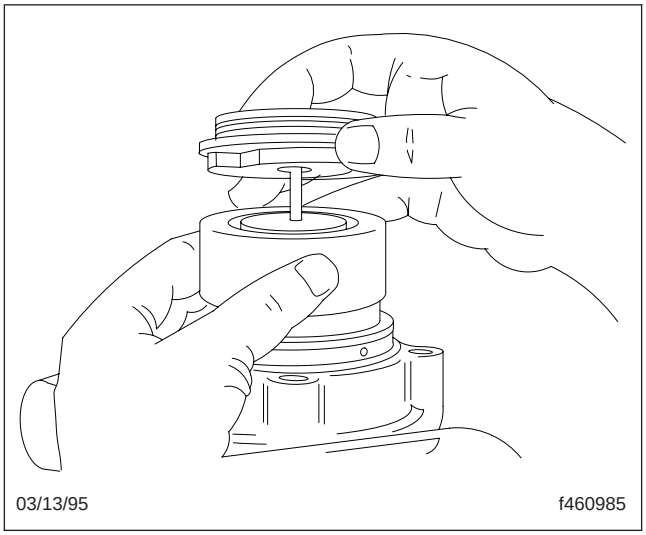


Fig. 9, Remove the Top Plate

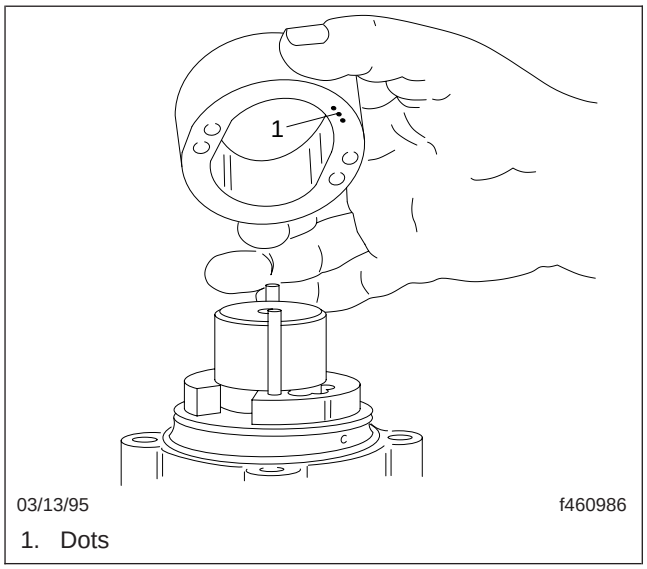
9. Check the input shaft for damaged splines and abnormal wear grooves around the seal area. See **Fig. 23**. Replace the input shaft if there are grooves that can be detected with your fingernail.

   9.1 Remove the retaining ring (engine drive end) from the shaft. See **Fig. 24**.

   Remove the Woodruff key, if equipped.

   9.2 Applying pressure to the engine drive end of the input shaft, press the input shaft from the ball bearing. See **Fig. 25**.

   9.3 Press the new input shaft (from the small splined end) into the ball bearing until the shaft bottoms out on the retaining ring. See **Fig. 26**.



1. Dots

Fig. 10, Check Whether the Dots Are Up or Down

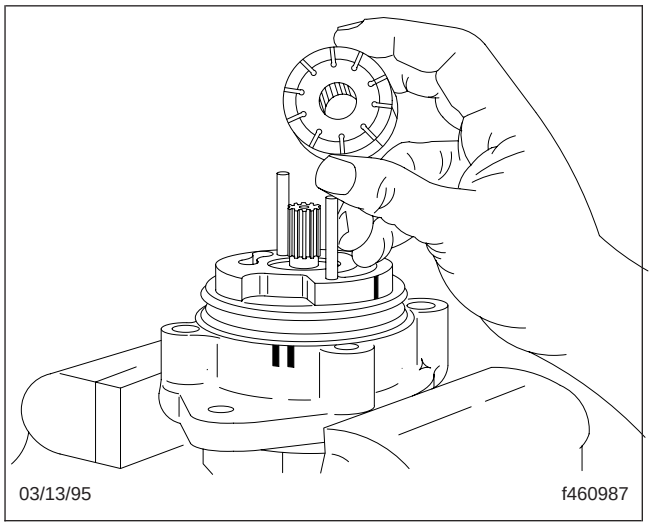


Fig. 11, Remove the Rotor and Vanes

9.4 Install the retaining ring on the input shaft with the sheared edge pointing away from the bearing. Make sure that the retaining ring is properly seated.

IMPORTANT: TRW does not recommend disassembly of the control valve spool assembly.

10. Check the control valve spool assembly for wear or chipping. If needed, back-flush with air and solvent. Check the assembly for nicks or burrs.

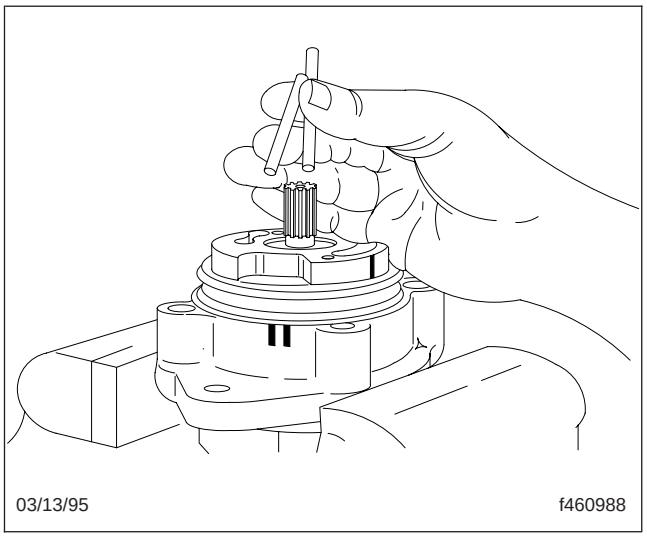


Fig. 12, Remove the Locating Pins

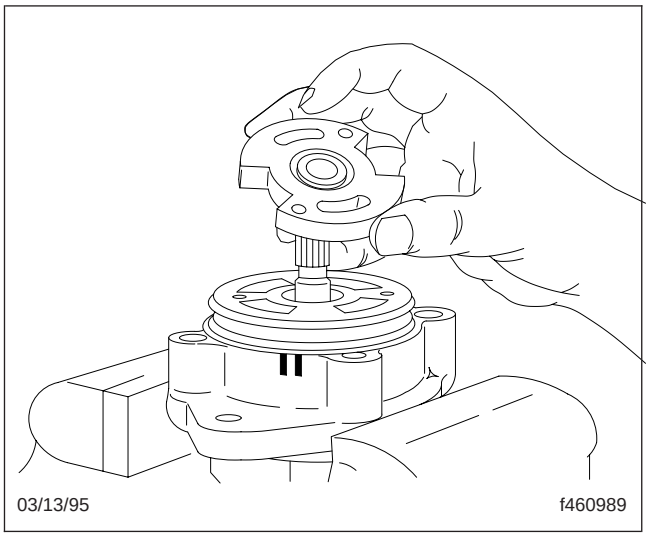


Fig. 13, Remove the Bottom Plate

Assembly

CAUTION

Make sure that the press is clean and free of debris. Debris could damage the face of the cover, which will affect pump operation.

1. Coat the outside surface of the shaft seal with a petroleum-based chassis grease. With the lettered side facing toward the needle bearing,

Steering Pump Disassembly, Inspection, and Assembly

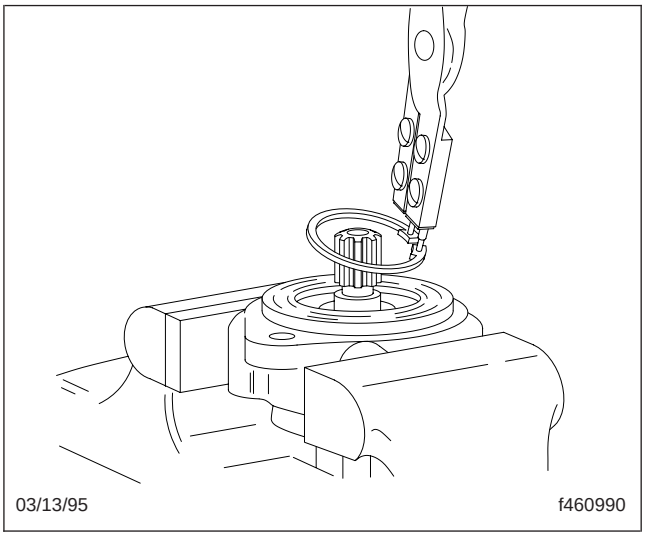


Fig. 14, Remove the Large Retaining Ring

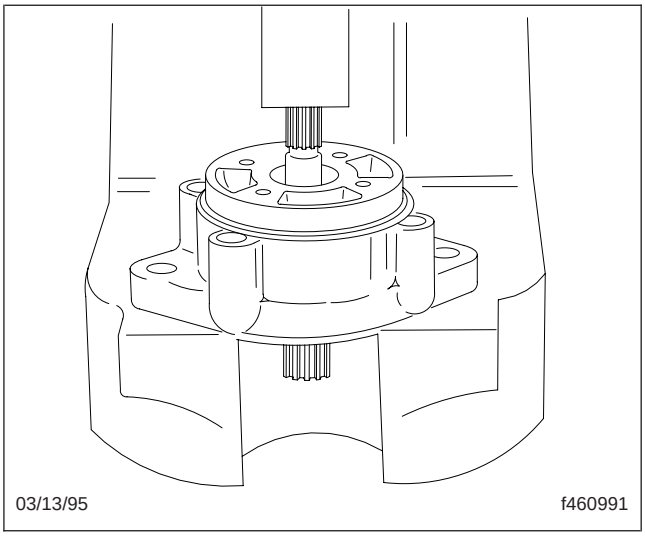


Fig. 15, Press Out the Input Shaft and Ball Bearing Assembly

press the seal into the cover. See **Fig. 27**. The installed seal should be flush with, or just below, the sealing surface on the cover.

2. Grease the inside surface of the shaft seal using a petroleum-based chassis grease.
3. Install the spacer. See **Fig. 16**. Make sure that it lies flat.

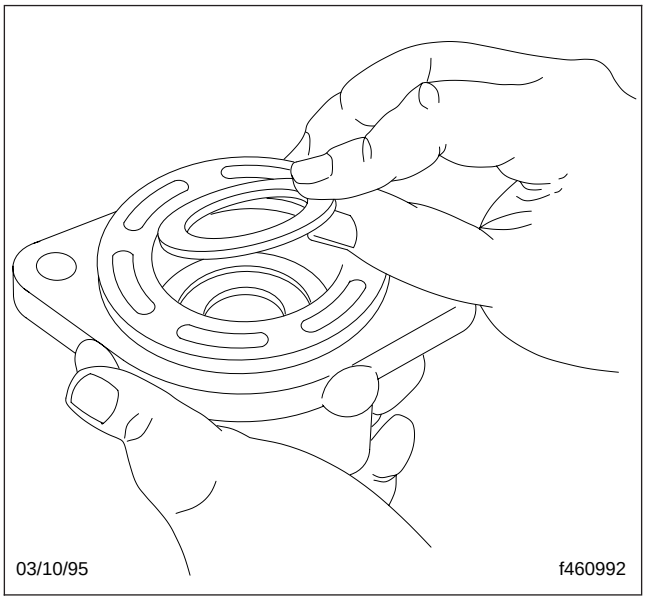


Fig. 16, Remove the Spacer

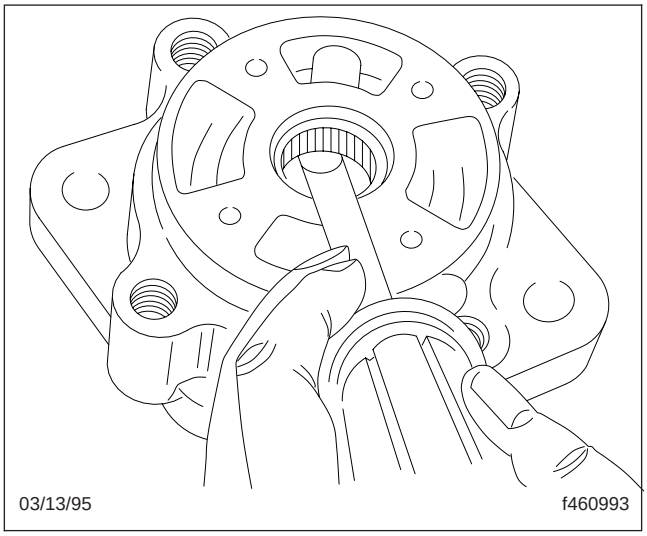
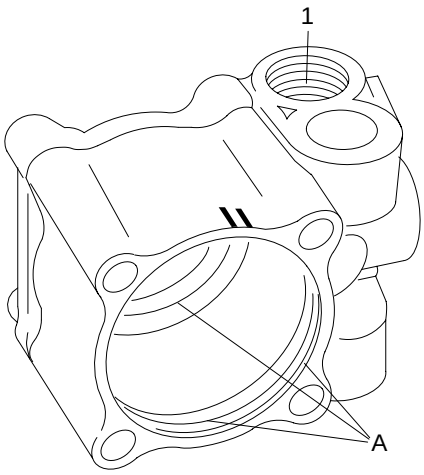


Fig. 17, Remove the Shaft Seal

CAUTION

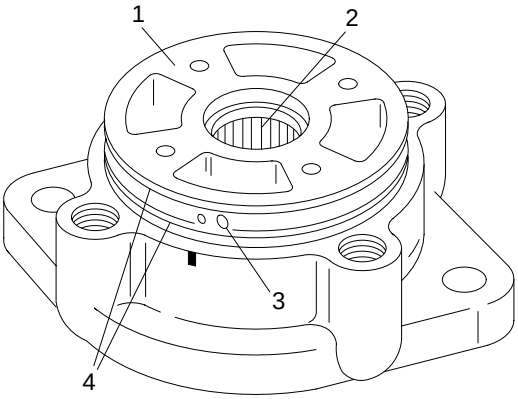
Do not allow the splines to contact the shaft seal. The splines could damage the shaft seal.

4. Insert the input shaft (small splined end first) into the cover. Do not allow the splines to contact the shaft seal. Insert the shaft into the seal by hand until the ball bearing contacts the cover.



A. Sealing Areas
1. Valve Bore

Fig. 18, Inspect the Housing



1. Bottom Plate Surface
2. Needle Bearing
3. Seal Drain Hole
4. Seal Grooves

Fig. 19, Inspect the Cover

Using a 7/8-inch socket, press the shaft and bearing into the cover. See **Fig. 28**.

CAUTION

When placing the cover in a padded vise, do not use excessive clamping force. This could damage the cover.

5. Place the cover in a padded vise and install the large retaining ring with the sheared edge out.

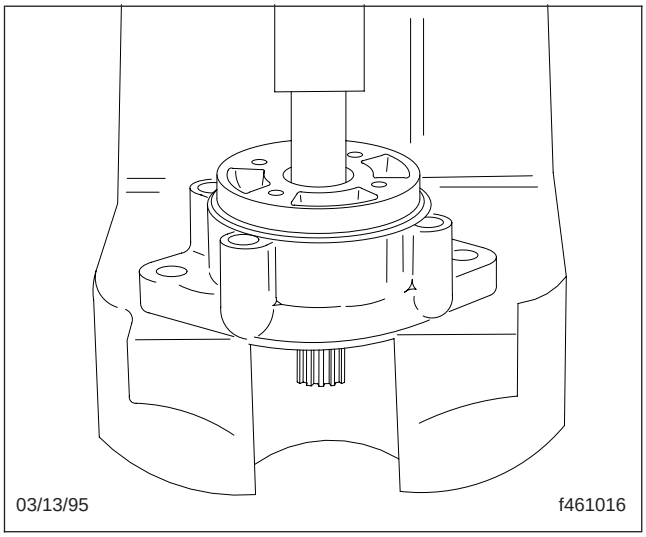


Fig. 20, Press the Needle Bearing Out of the Cover

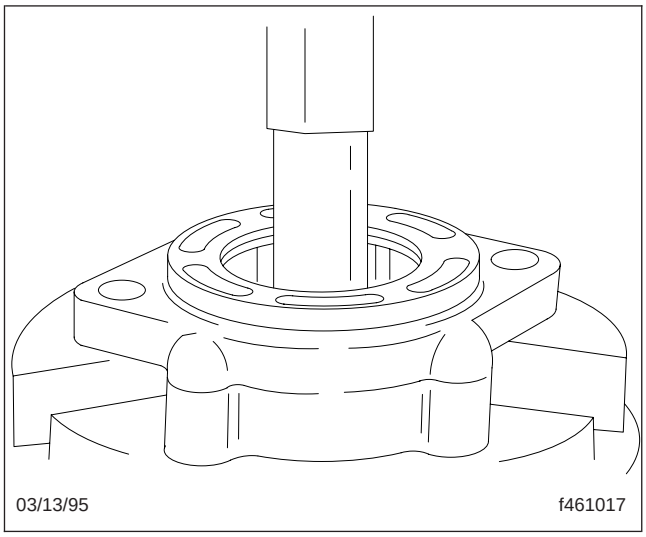


Fig. 21, Press a New Needle Bearing into the Cover

Turn the cover assembly over.

6. Install the new large and small O-rings in the cover. Make sure that they are seated properly. See **Fig. 29**.
7. Using the marks made during disassembly as a guide, install the locating pins.

IMPORTANT: In one of the four cutouts in the cover there is a bar. When installed, the bottom plate must cover this bar.

Steering Pump Disassembly, Inspection, and Assembly

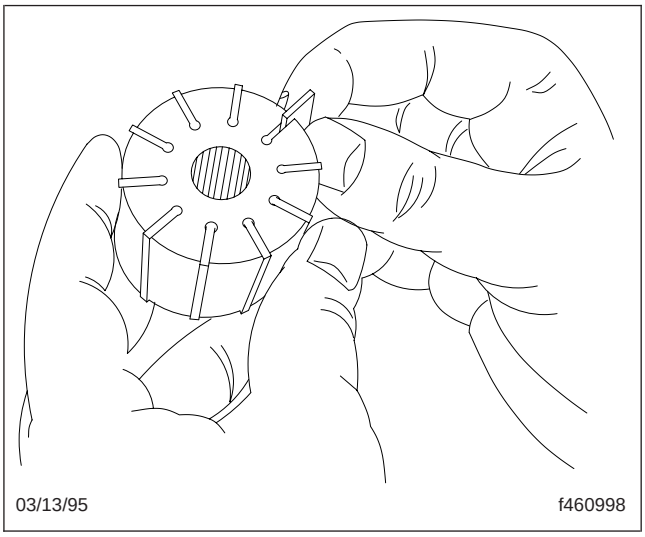
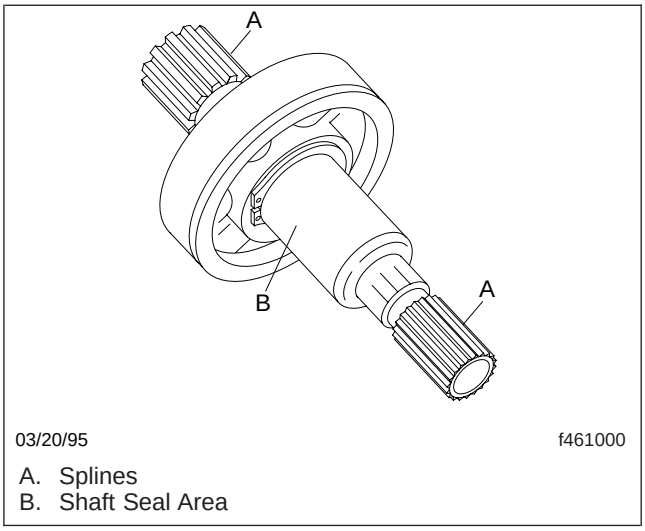


Fig. 22, Check the Vanes



A. Splines
B. Shaft Seal Area

Fig. 23, Check the Input Shaft

8. Install the bottom plate with the pockets facing up. See **Fig. 30**. Make sure that the marks made during disassembly are aligned.

9. Install the cam ring with the dots facing up or down as noted during disassembly. Make sure that the cam ring is flush with the bottom plates large outside diameter and that the marks made during disassembly are aligned. See **Fig. 31**.

10. Install the rotor and vanes. Make sure that squared edge on each vane points toward the center of the rotor. See **Fig. 32**.

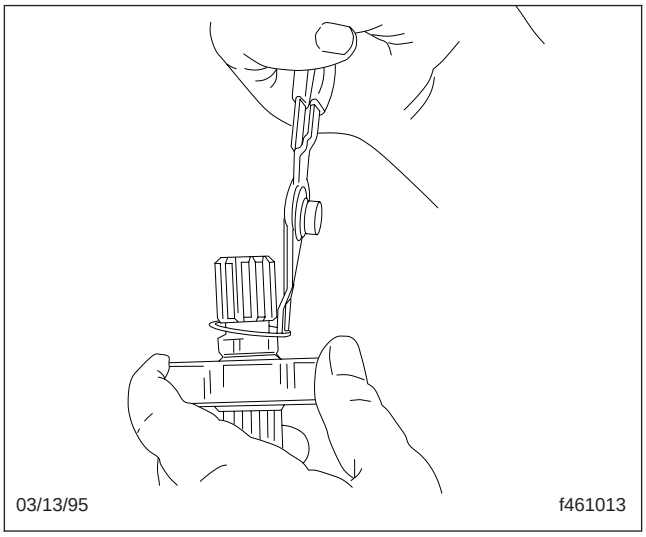


Fig. 24, Remove the Retaining Ring

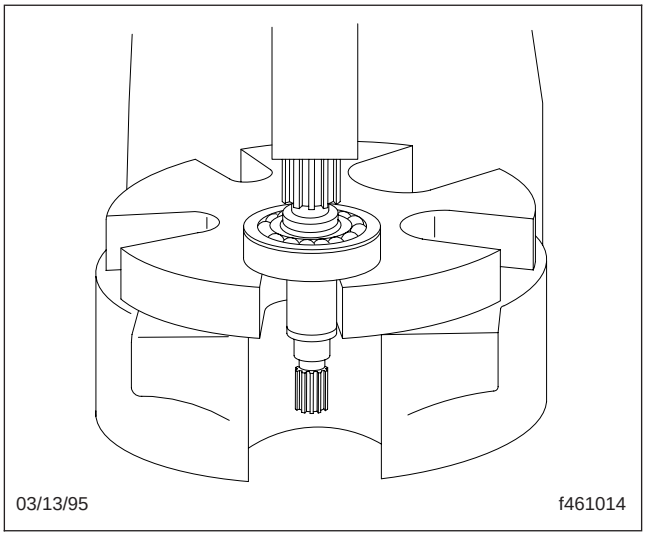


Fig. 25, Press the Input Shaft

11. Install the top plate with the pin holes down. Make sure that the locating pins are engaged in the pin holes, not the pockets. See **Fig. 33**.

    Make sure that the top plate is flush with the cam and that the marks made during disassembly are aligned.

NOTE: The backup O-ring will fit tighter on the top plate after loosely wrapping (no twisting) it around two fingers, then allowing it to unwrap.

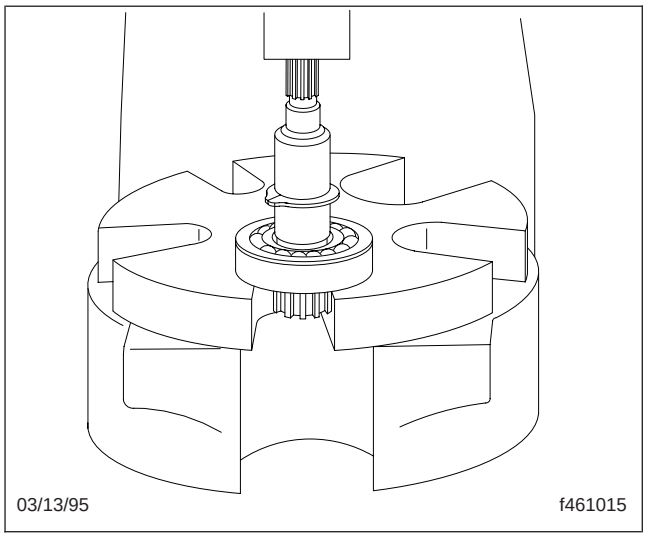


Fig. 26, Press the New Input Shaft

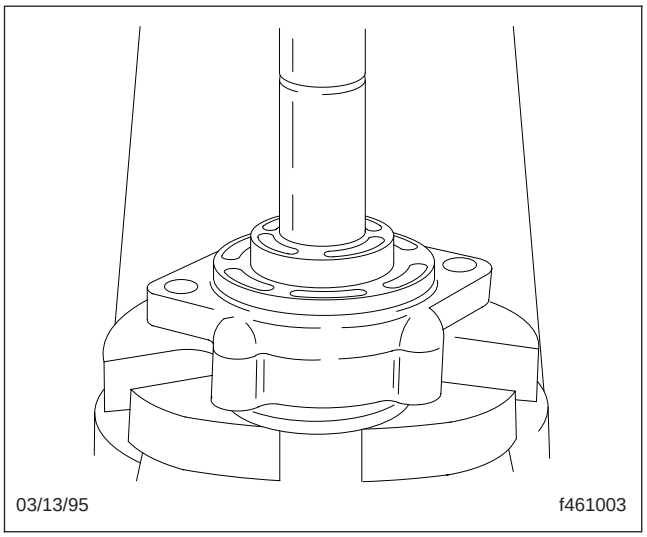


Fig. 28, Press the Shaft and Bearing into the Cover

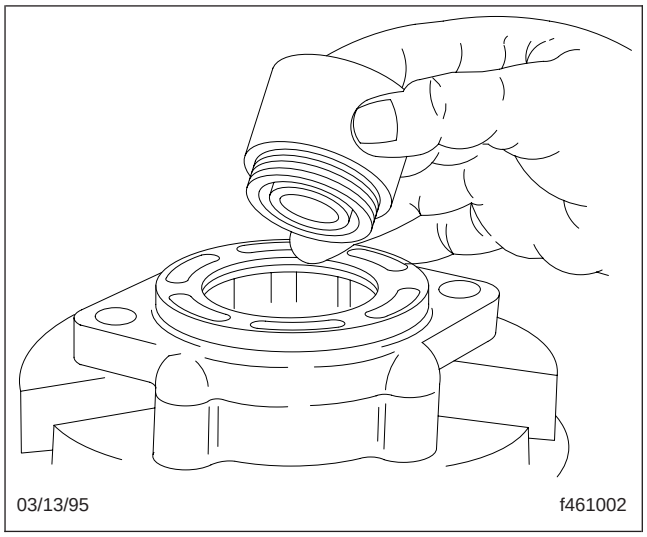


Fig. 27, Install the Seal in the Cover

12. Install the backup O-ring on the top plate. Seat the O-ring at the bottom of the groove.
13. Install a new O-ring (without allowing it to roll) on the top plate. Seat the O-ring at the top of the groove.
14. Grease both the O-ring and the backup O-ring. See **Fig. 34**.

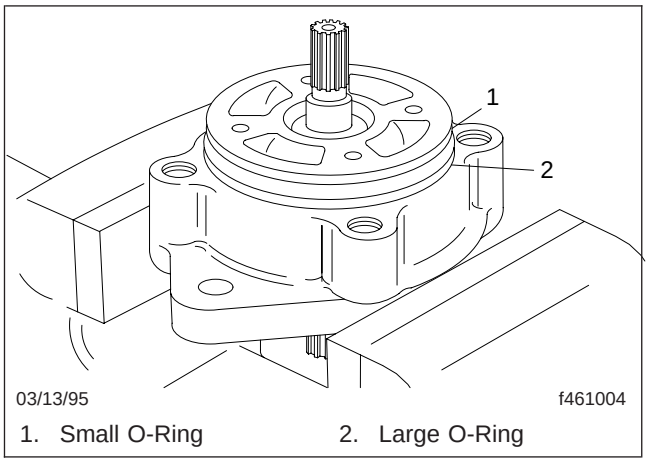


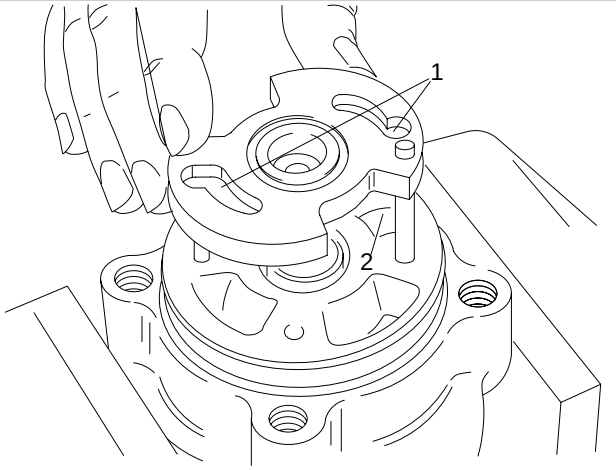
Fig. 29, Install the O-Rings

CAUTION

The housing may have sharp edges. Use care to not cut your finger when applying grease to the housing.

15. Grease the sealing areas of the housing. See **Fig. 35**.
16. Place the spring on the top plate.
17. Place the housing over the cover assembly. Make sure that the marks made during disassembly are aligned. See **Fig. 36**.

Steering Pump Disassembly, Inspection, and Assembly



1. Pockets 2. Bar

Fig. 30, Install the Bottom Plate

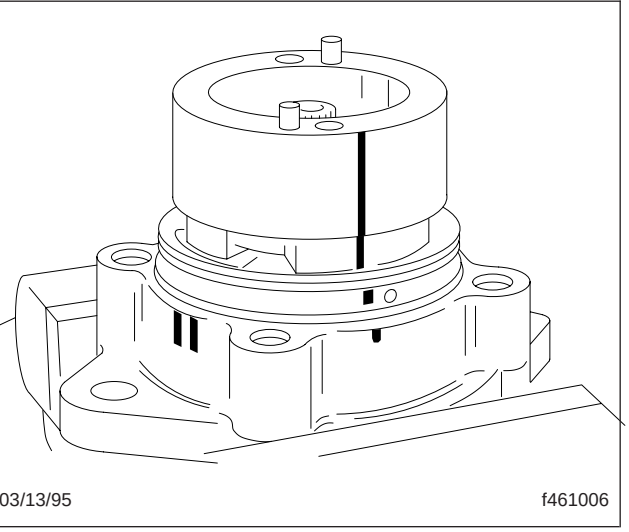
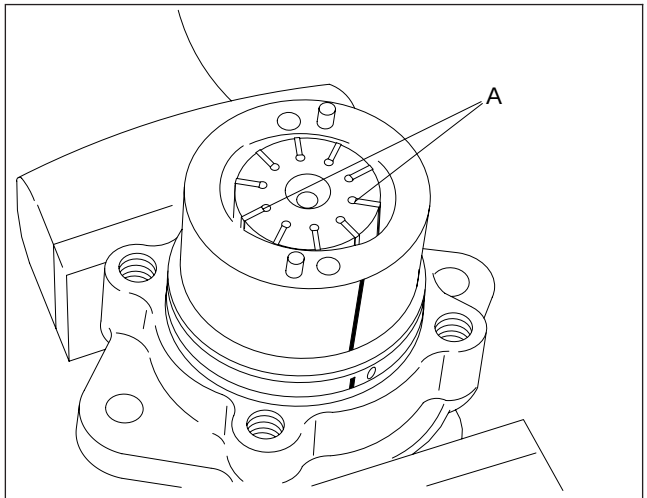


Fig. 31, Install the Cam Ring

⚠ CAUTION

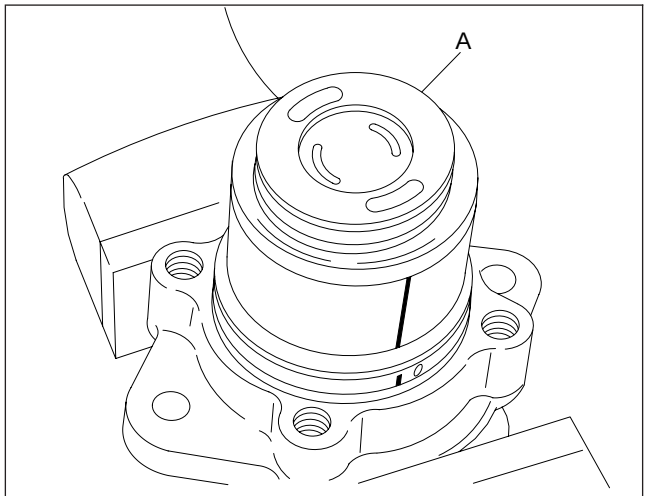
Evenly thread the capscrews into the cover. If not evenly threaded into the cover, damage could occur to the seals, top plate, or housing.

18. Install the mounting bolts and washers. Evenly thread all four bolts into the cover. Alternately tighten the bolts 41 N·m (30 lbf·ft).



A. Squared edge of vane pointing toward the center of the rotor.

Fig. 32, Install the Rotor and the Vanes



A. Top plate installed with pin holes down.

Fig. 33, Install the Top Plate

19. Screw the relief valve seat assembly into the control valve spool assembly. Tighten the assembly 982 N·cm (87 lbf·in).

NOTE: Placing the spool assembly in a collet will assist the tightening procedure.

Steering Pump Disassembly, Inspection, and Assembly

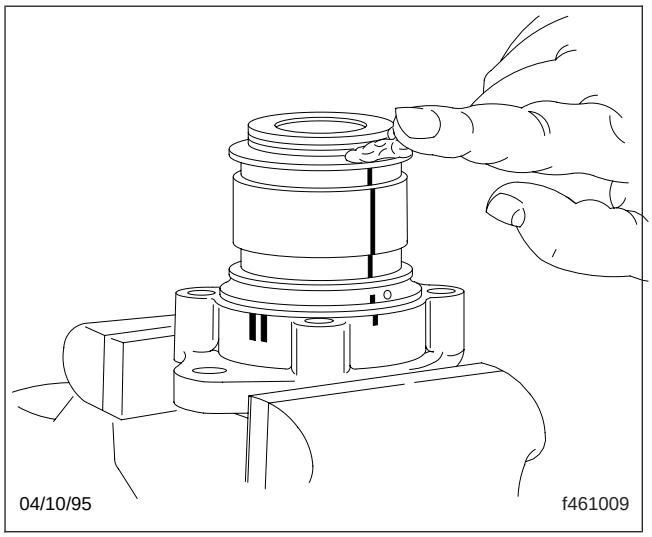


Fig. 34, Grease the O-Rings

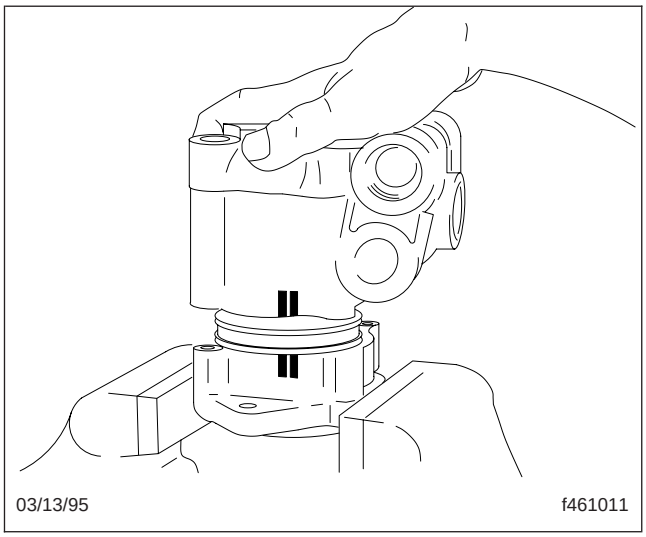


Fig. 36, Install the Housing

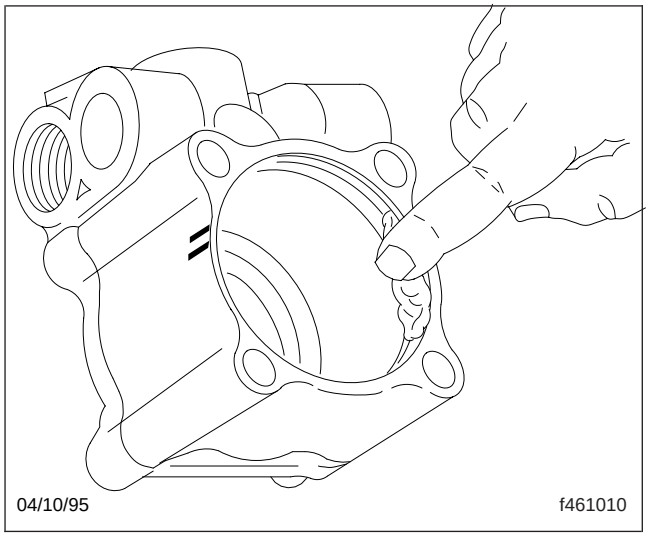


Fig. 35, Grease the Sealing Areas

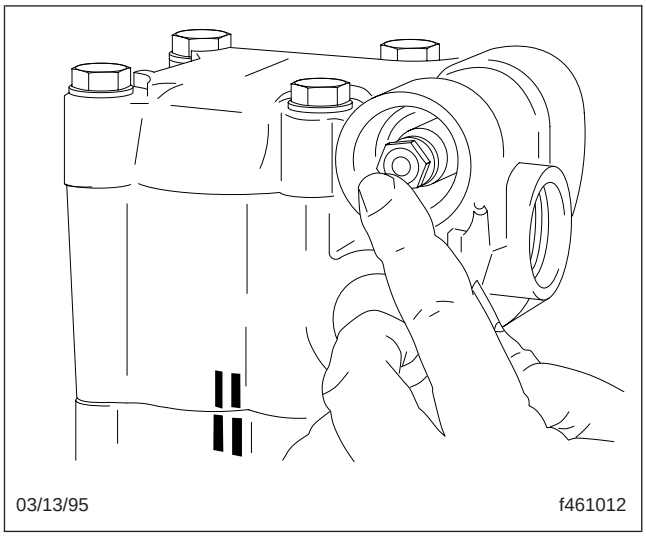


Fig. 37, Install the Valve Spool Assembly

20. Insert the valve spool assembly (screen end last) into the housing. Make sure that the spool slides freely in the housing. See **Fig. 37**.
21. Install the spring in the housing.
22. Install a new O-ring on the end plug.
23. Lightly grease the O-ring and the end plug threads. Install the end plug and tighten 41 N·m (30 lbf·ft).
24. Install the Woodruff key into the new input shaft (if removed during the input shaft replacement).
25. Turn the pump by hand and make sure that it turns freely.
26. Install the power steering pump on the engine, following the instructions in **Subject 100**.

Specifications

Approved Power Steering Fluids	
Fluid Type	**Approved Fluid**
Automatic Transmission Fluid*	Dexron® II Dexron® III
Heavy-Duty Engine Oil* IMPORTANT: Do not use heavy-duty engine oil in vehicles built from November 4, 2002. **⚠ WARNING** **Do not use heavy-duty engine oil in vehicles equipped with a Hydro-Max® brake booster. Engine oil is not compatible with the seals in the brake booster. If the vehicle is equipped with a Hydro-Max brake booster, use only automatic transmission fluid in the power steering system. Failure to follow this precaution could cause loss of hydraulic brake assist, possibly resulting in personal injury and property damage.**	Union 10W–40 Texaco 10W–40 Chevron 10W–40 Mobil Super 10W–40 Union 15W–40 Shell Rotella T 30W

* Do not mix engine oil with automatic transmission fluid (ATF). Use the same lubricant for parts as is in the power steering system.

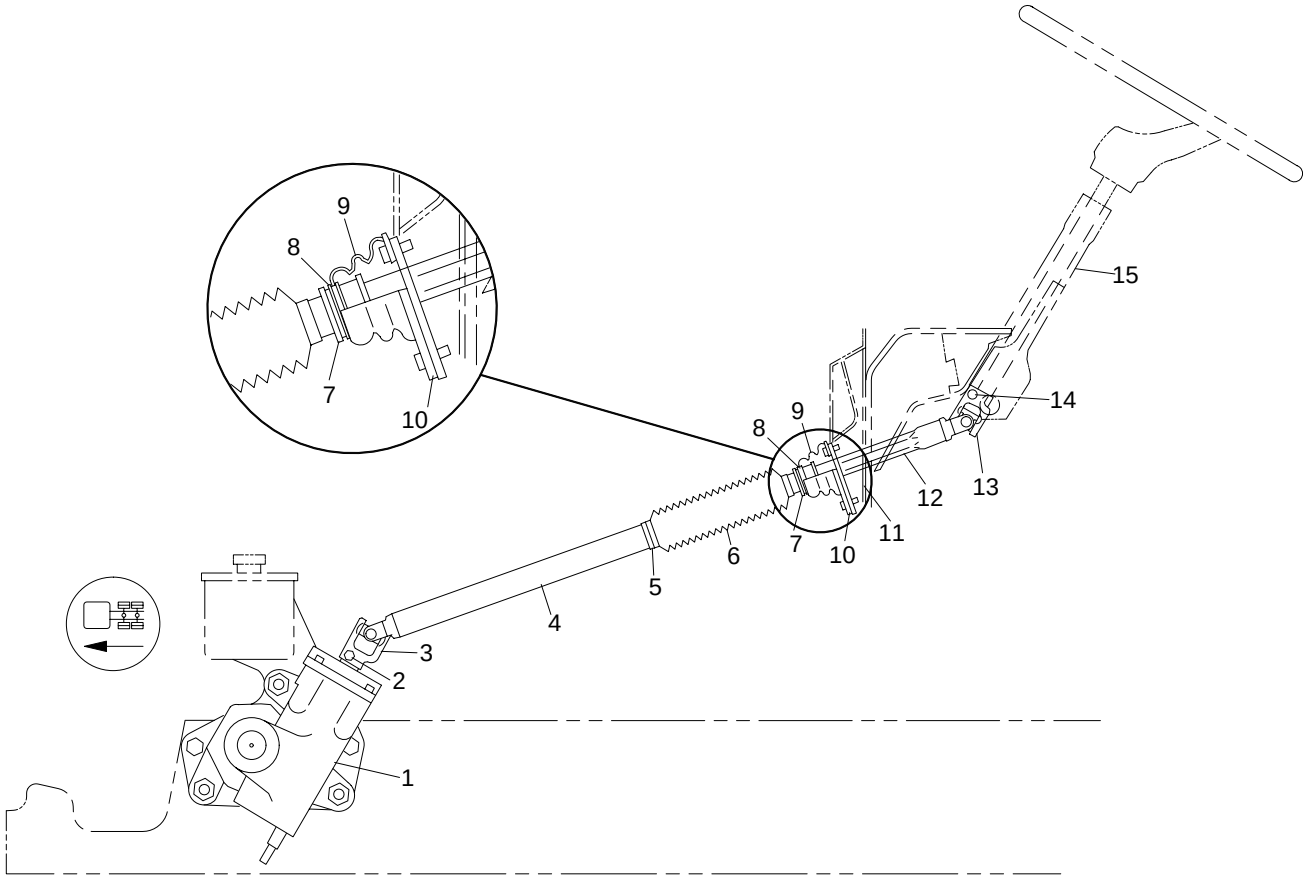
Table 1, Approved Power Steering Fluids

General Description

The steering driveline connects the steering column and jacket assembly to the steering gear by means of a telescoping shaft with integral yokes, an upper and a lower end yoke, and a pair of universal joints. **See Fig. 1.**

umn, steering driveline, and steering gear. It also compensates for changes in distance between the steering column and steering gear, which occur when the relative positions of the frame rails and cab change during vehicle operation.

The upper end yoke is internally serrated to match



08/01/95 f461033

1. Power Steering Gear
2. Lower End Yoke Pinch Bolt and Nut
3. Lower End Yoke Assembly
4. Outer Tube
5. Boot Clamp
6. Steering Driveline Boot
7. Steering Driveline Adaptor
8. Bushing
9. Upper Steering Driveline Boot
10. Retainer
11. Pie Pan Assembly
12. Inner Tube
13. Upper End Yoke Assembly
14. Upper End Yoke Pinch Bolt and Nut
15. Fixed Steering Column Assembly

Fig. 1, Steering Driveline Installation

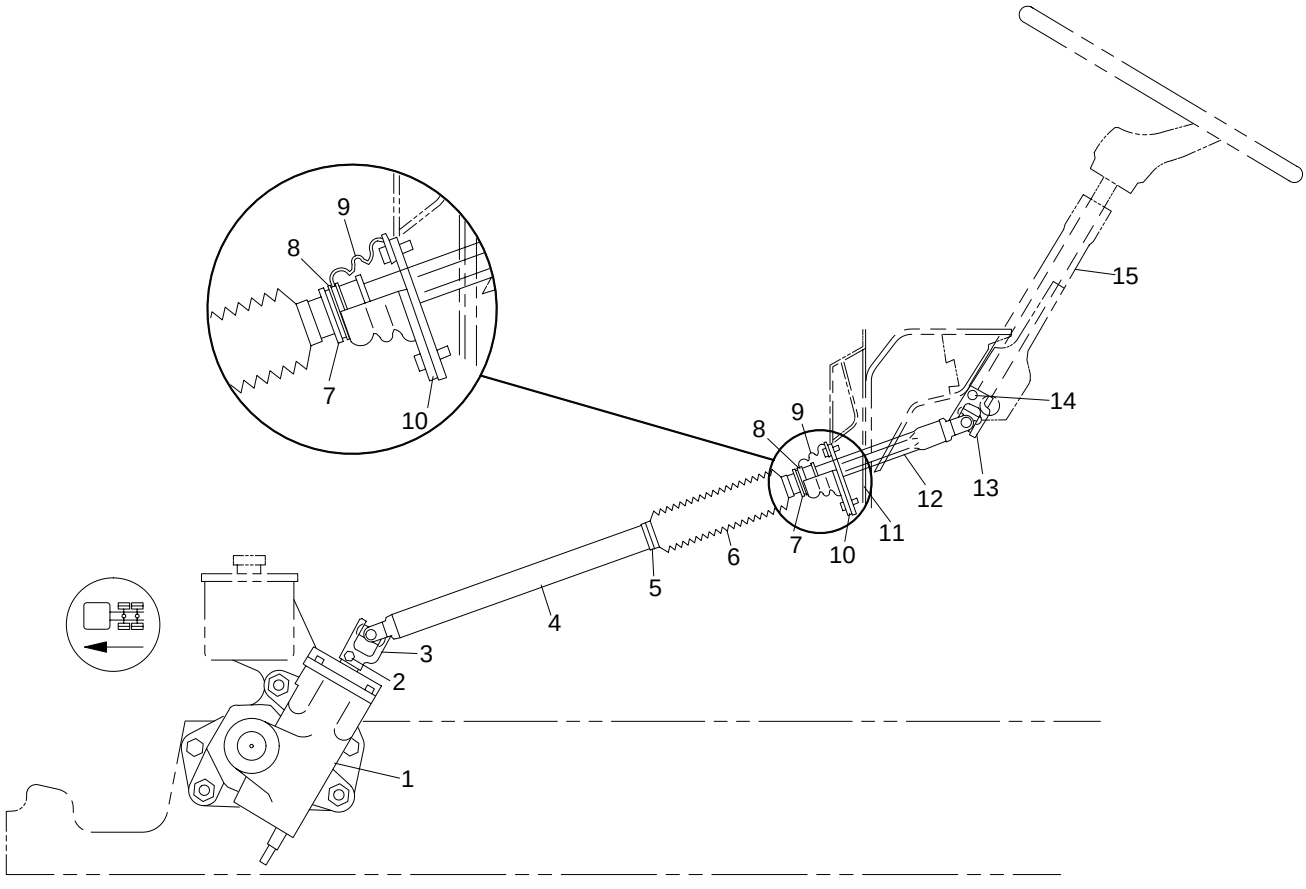
The driveline shaft consists of a tubular upper section, splined on the outside, which mates with an internally splined lower section. The telescoping shaft eases installation and removal of the steering column shaft; the lower end yoke is internally serrated to match the external serrations on the steering gear

General Description

input shaft. Each end yoke is secured to its respective shaft by a pinch bolt that engages a notch in the shaft.

The universal joint at each end of the steering driveline allows the transfer of steering motion from the steering column shaft, to the steering driveline, and to the steering gear input shaft, even though the driveline is at an angle to both of the other shafts. Each universal joint cross rides in four needle bearing cups, two carried in the end yoke, and two carried in the steering driveline's integral yoke. The needle bearing cups are held in place in each yoke by snap rings.

Removal (See Fig. 1)



08/01/95 f461033

1. Power Steering Gear
2. Lower End Yoke Pinch Bolt and Nut
3. Lower End Yoke Assembly
4. Outer Tube
5. Boot Clamp
6. Steering Driveline Boot
7. Steering Driveline Adaptor
8. Bushing
9. Upper Steering Driveline Boot
10. Retainer
11. Pie Pan Assembly
12. Inner Tube
13. Upper End Yoke Assembly
14. Upper End Yoke Pinch Bolt and Nut
15. Fixed Steering Column Assembly

Fig. 1, Steering Driveline Installation

NOTE: It is not necessary to loosen the steering wheel and column assembly to do this procedure.

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service operations will be done.
2. Apply the parking brakes, and chock the tires. Tilt the hood.
3. Disconnect the lower end yoke.
   - 3.1 Remove the pinch-bolt nut and pinch bolt from the lower end yoke. **See Fig. 2.** Discard the nut.
   - 3.2 Remove the yoke from the steering gear input shaft. Don't turn the steering gear

Steering Driveline Removal and Installation

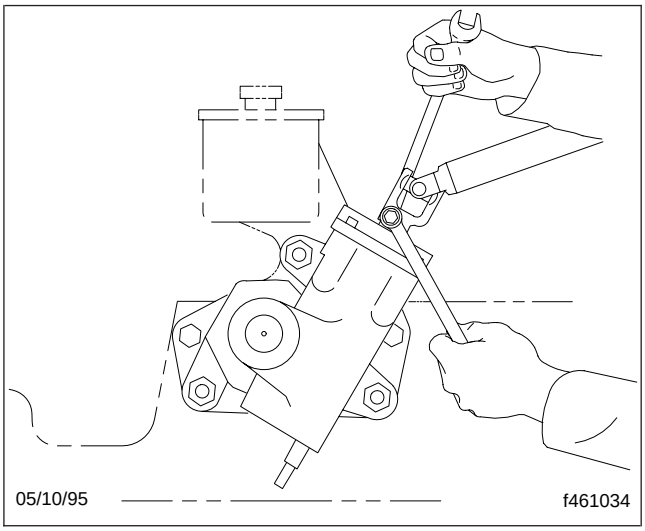


Fig. 2, Disconnect the Lower End Yoke

input shaft when removing the lower end yoke. Push the driveline shaft into the driveline tube, as you remove the lower end yoke.

4. Disconnect the upper end yoke.

   NOTE: One of the screws must be removed from inside the cab. **See Fig. 3,** Ref. A.

   4.1 Remove the four screws holding the upper steering driveline boot to the firewall.

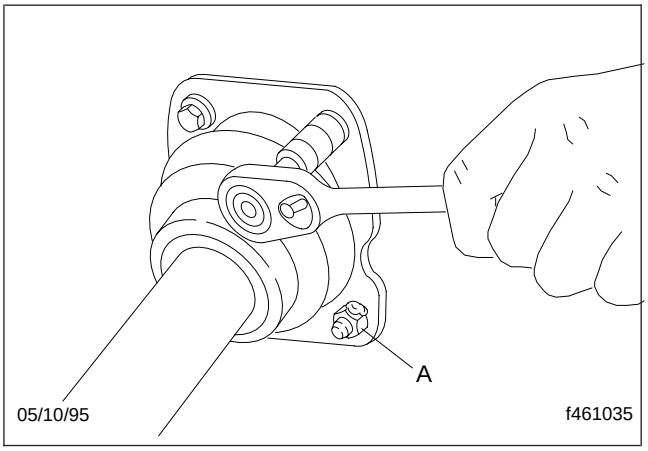


Fig. 3, Remove the Steering Driveline Boot Fasteners

   4.2 Remove the pinch-bolt nut and pinch bolt from the upper end yoke. **See Fig. 4.** Discard the nut.

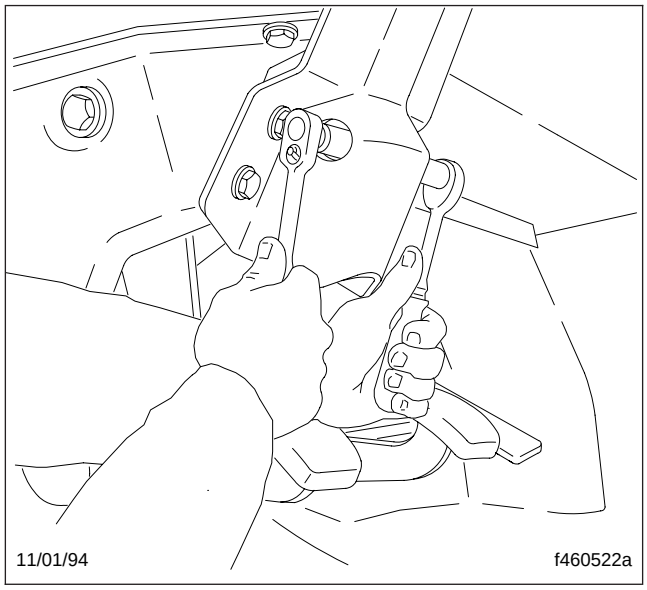


Fig. 4, Remove the Pinch-Bolt Nut and Pinch Bolt from the Upper End Yoke

   4.3 Remove the upper end yoke from the steering column shaft.

5. Remove the driveline from the engine compartment.

Installation (See Fig. 1)

1. Clean the steering gear input shaft, steering driveline, and end yokes. Do not separate the steering driveline.

   1.1 Thoroughly clean the end yokes, the steering driveline, and the steering gear input shaft with a clean, dry cloth.

   1.2 Apply a thin film of grease to the yoke splines. Use lithium-based grease, NLGI grade 2.

2. Make sure that the upper steering driveline boot is in position on the inner tube.

3. Slide the driveline's upper end yoke onto the steering column shaft, then install the end yoke pinch bolt. Before installing the pinch-bolt nut, make sure the pinch bolt is centered in the steering column shaft notch. The pinch bolt is centered if it can slip in and out of the end yoke with ease. Install a new pinch-bolt nut, and tighten it 75 to 88 N·m (55 to 65 lbf·ft).

4. Apply white Torque Seal F-900 to the exposed pinch-bolt thread and to the locknut.
5. Install the four screws that attach the upper steering driveline boot to the firewall.
6. Before attaching the lower end yoke to the steering gear input shaft, be sure the front tires are straight ahead, the steering gear is centered, the arrows on the driveline inner tube and the outer tube are aligned, and the driveline slides freely.

CAUTION

CAUTION: If the arrow on the driveline inner tube is not aligned with the arrow on the outer tube, the U-joints will not be correctly oriented. Assembling the driveline with the U-joints incorrectly oriented could cause binding at the U-joints.

7. Install the lower end yoke on the steering gear input shaft. Before installing the pinch-bolt nut, make sure the pinch bolt is centered in the steering gear input shaft notch. The pinch bolt is centered if it can slip in and out of the end yoke with ease. Install a *new* pinch-bolt nut, and tighten it 75 to 88 N·m (55 to 65 lbf·ft).
8. Apply white Torque Seal F-900 to the exposed pinch bolt thread and to the locknut. **See Fig. 5.**

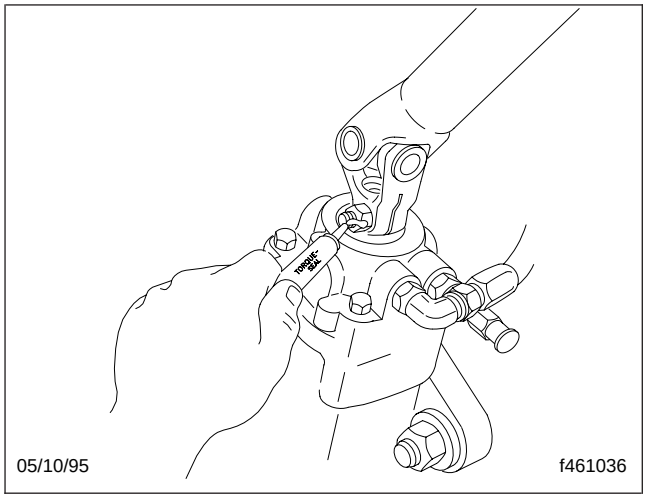
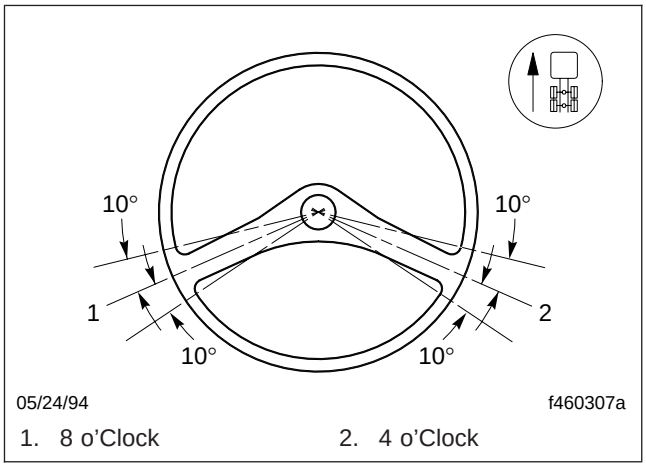


Fig. 5, Apply White Torque Seal F-900

9. Using a hand-type grease gun, lubricate the driveline tube at the lower end yoke assembly with lithium-based grease, NLGI grade 2. Apply until grease appears at all four U-joint cross seals.
10. With the front tires pointing straight ahead, check the position of the steering wheel spokes. They must be pointing within ±10 degrees of the 4 o'clock and 8 o'clock positions. **See Fig. 6.**

    If not, remove the steering wheel and install it in the correct position. For instructions, refer to the applicable section in this group.



1. 8 o'Clock 2. 4 o'Clock

Fig. 6

11. Lower the hood, and secure the hood latches. Leave the parking brakes applied and the chocks at the rear tires.
12. Raise the front of the vehicle so that the front tires are off the ground, then place safety stands under the frame.

WARNING

WARNING: Driving a vehicle with hard steering or binding in the steering system could result in partial or complete loss of steering control during vehicle operation, possibly causing personal injury and property damage.

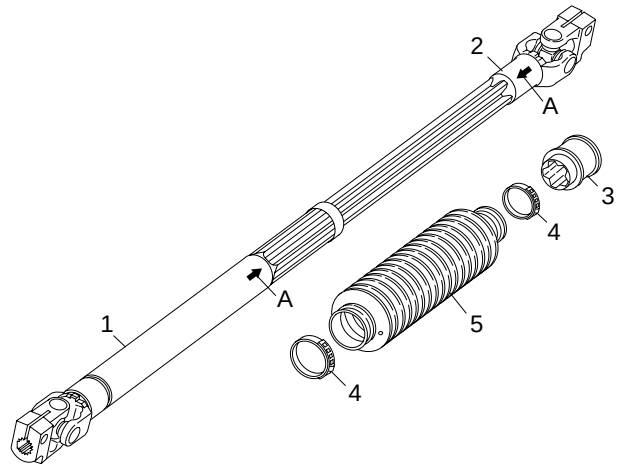
13. Turn the steering wheel through full travel, checking for hard steering or binding. If there is difficulty, check the assembly and installation of the driveline parts. If the cause is not the driveline, refer to the applicable steering gear section in this group.

Steering Driveline Removal and Installation

14. Remove the chocks from the tires, and secure the hood.

Steering Driveline Boot and Adaptor Replacement

Replacement (See Fig. 1)



A. Alignment Arrows
1. Outer Tube (to the steering gear)
2. Inner Tube (to the steering column)
3. Adaptor
4. Clamp
5. Boot

Fig. 1, Steering Driveline

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service operations will be done.
2. Apply the parking brakes, and chock the tires. Tilt the hood.
3. Disconnect the lower end yoke.
   - 3.1 Remove the pinch-bolt nut and pinch bolt from the lower end yoke. Discard the nut.
   - 3.2 Remove the yoke from the steering gear input shaft. Don't turn the steering gear input shaft when removing the lower end yoke. Push the driveline outer tube into the inner tube as you remove the lower end yoke.
4. Slide the inner tube out of the outer tube. Leave the adaptor in place.
5. Using pliers, remove the clamps that secure the boot on the outer tube and inner tube.
6. Discard the boot, clamps, and the adaptor.
7. Using a clean, dry cloth, clean the splined section of the inner tube.
8. Place the adaptor over the inner tube. Align the arrows on the adaptor and the inner tube.
9. Clamp the small end of the new boot on the adaptor.
10. Apply a thin film of grease to the splined portion of the inner tube. Use lithium-based grease, NLGI grade 2.

⚠ CAUTION

CAUTION: If the arrow on the driveline inner tube is not aligned with the arrow on the outer tube, the U-joints will not be correctly oriented. Assembling the driveline with the U-joints incorrectly oriented could cause binding at the U-joints.

11. Align the arrows on the driveline inner tube and the outer tube.
12. Slide the inner tube into the outer tube.
13. Clamp the boot on the outer tube (just above the formed section).
14. Stroke the driveline several times to ensure that the boot and adaptor are firmly in place, and that the driveline slides freely.
15. Before attaching the lower end yoke to the steering gear input shaft, be sure the front tires are straight ahead, the steering gear is centered, the arrows on the driveline inner tube and the outer tube are aligned, and the driveline slides freely.
16. Install the lower end yoke on the steering gear input shaft. Before installing the pinch-bolt nut, make sure the pinch bolt is centered in the steering gear input shaft notch. The pinch bolt is centered if it can slip in and out of the end yoke with ease. Install a *new* pinch-bolt nut, and tighten it 75 to 88 N·m (55 to 65 lbf·ft).
17. Apply white Torque Seal F-900 to the exposed pinch bolt thread and to the locknut. **See Fig. 2.**
18. Remove the chocks from the tires, and secure the hood.

Steering Driveline Boot and Adaptor Replacement

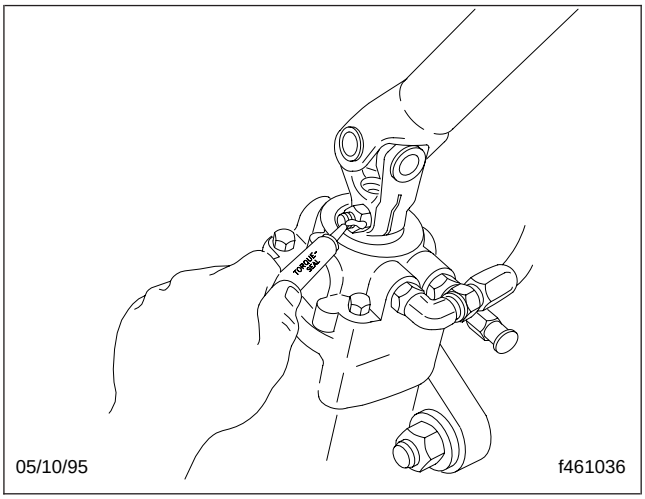


Fig. 2, Apply White Torque Seal F-900

Specifications

Description	Grade	Size	Torque N·m (lbf·ft)
End Yoke Pinch-Bolt Nut	8 or 8.2	7/16–20 UNF	75 to 88 (55 to 65)

Table 1, Torque Values

General Information

The LuK Automotive Hydraulics LF 73 power steering pump supplies power steering fluid for the operation of the power steering gear.

The pump, used on Cummins B and C series engines, is mounted on the driver's side of the engine, at the rear of the gear case or the air compressor. It is powered by an adaptor gear in the engine. See **Fig. 1**.

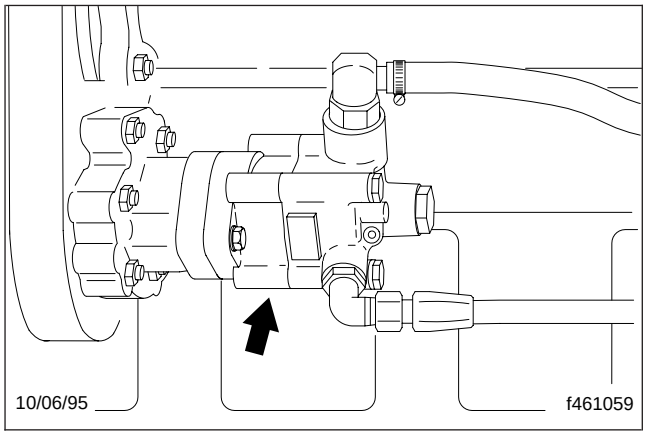


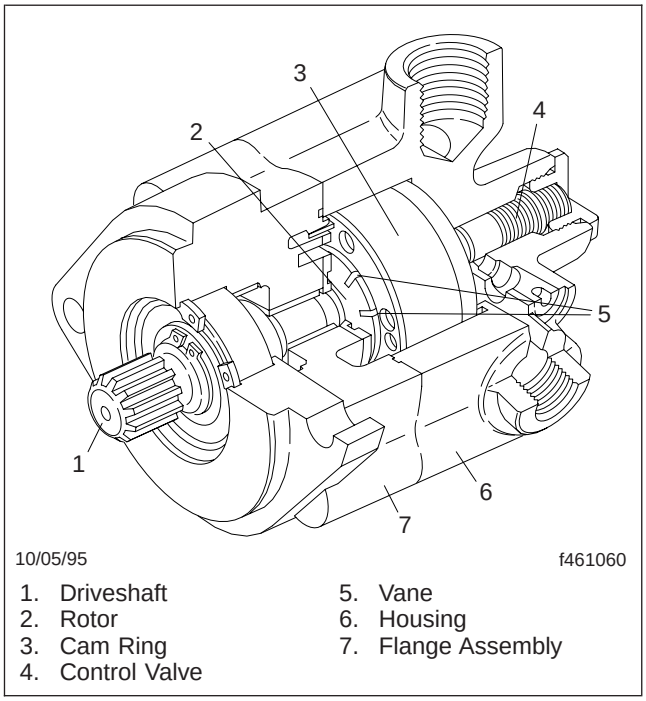
Fig. 1, Power Steering Pump

The main parts of the power steering pump are the housing, driveshaft, cam ring, rotor, vanes, and control valve. See **Fig. 2**.

Principles of Operation

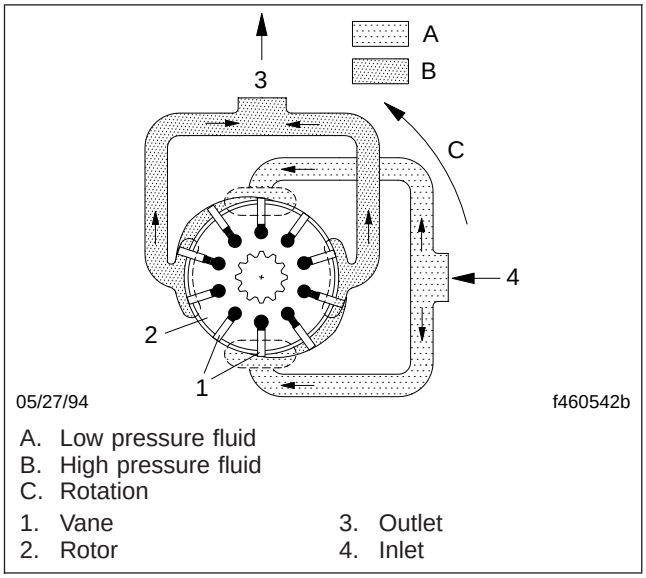
The driveshaft, powered by the adaptor gear in the engine gear case, turns the rotor, which is inside the cam ring. As the rotor turns, centrifugal force pushes the vanes out toward the surface of the cam ring. As fluid enters the cam ring through the inlet port, the rotor vanes force it out through the outlet port and into the system. The fluid operates the steering gear. Eventually the fluid returns to the power steering reservoir, then back to the power steering pump. See **Fig. 3**.

If the system pressure gets too high, a poppet inside the control valve is forced off its seat shunting fluid into a relief passage connected to the inlet port. The fluid then recirculates inside the pump instead of going to the outlet port. When the system pressure drops to the correct level, the poppet seats, closing off the relief passage to the inlet port. The fluid flow returns to normal, flowing from the inlet port to the outlet port and then into the power steering system.



1. Driveshaft
2. Rotor
3. Cam Ring
4. Control Valve
5. Vane
6. Housing
7. Flange Assembly

Fig. 2, Pump Components



A. Low pressure fluid
B. High pressure fluid
C. Rotation

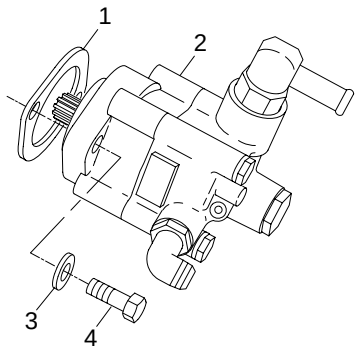
1. Vane
2. Rotor
3. Outlet
4. Inlet

Fig. 3, Pump Fluid Flow Diagram

Removal

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Clean all dirt from around the fittings and hose connections.
4. Put a container under the inlet port of the pump, then disconnect the hose from the fitting. Plug the hose to keep out dirt and to prevent fluid from leaking.

   Repeat this step at the pump outlet port.
5. Remove the capscrews that attach the pump to the engine accessory drive mounting flange. See **Fig. 1**. Slide the pump out of the shaft sleeve and remove the pump from the engine.



02/15/2000 f461079

1. Gasket
2. Pump
3. Washer
4. Capscrew

Fig. 1, Power Steering Pump Mounting

Installation

1. Using engine oil, lightly lubricate a new gasket and the pump shaft.
2. Install the new gasket on the pump mounting flange, then place the pump on the engine accessory drive mounting. Turn the pump or shaft as needed to mesh the shaft with the shaft sleeve. Seat the pilot of the pump mounting flange in the accessory drive mounting, without applying unnecessary force. Install the washers and capscrews. Tighten the capscrews 27 to 32 lbf·ft (37 to 43 N·m).
3. Connect the hoses to the pump inlet and outlet ports.
4. Check the fluid level of the power steering reservoir and add fluid if necessary. Start the engine and let it idle for two minutes. Do not turn the steering wheel; doing so can cause air to enter the system.

   Turn off the engine and check the fluid level in the reservoir.
5. Start the engine again. To remove air from the system, steer the vehicle from full left to full right several times.

   Add fluid as necessary to the full line on the reservoir dipstick.
6. If the steering gear does not have a manual bleed screw, turn the steering wheel from full lock to full lock two or three times with the engine running at idle. Repeat this step and add fluid as necessary until there are no bubbles in the reservoir.

   If the steering gear is equipped with a manual bleed screw, turn the steering wheel from full lock to full lock two or three times with the engine running at idle. Then loosen the manual bleed screw about one turn and look for clear fluid or fluid mixed with bubbles at the threaded area of the bleed screw. Repeat this step and add fluid as necessary until only clear fluid shows. Tighten the manual bleed screw 27 to 33 lbf·in (305 to 373 N·cm). If necessary, fill the reservoir to the full line on the dipstick.
7. Close the hood and remove the chocks from the tires.

⚠ CAUTION

Be careful when working on the pump housing; it is aluminum, and can be easily damaged. When putting it in a vise, pad the vise jaws. Tighten the vise just enough to hold the pump.

Replacement

⚠ WARNING

Wear safety goggles or glasses when disassembling the power steering pump. Some of the parts are held in place by springs or snap rings, which can release with considerable force, possibly causing injury.

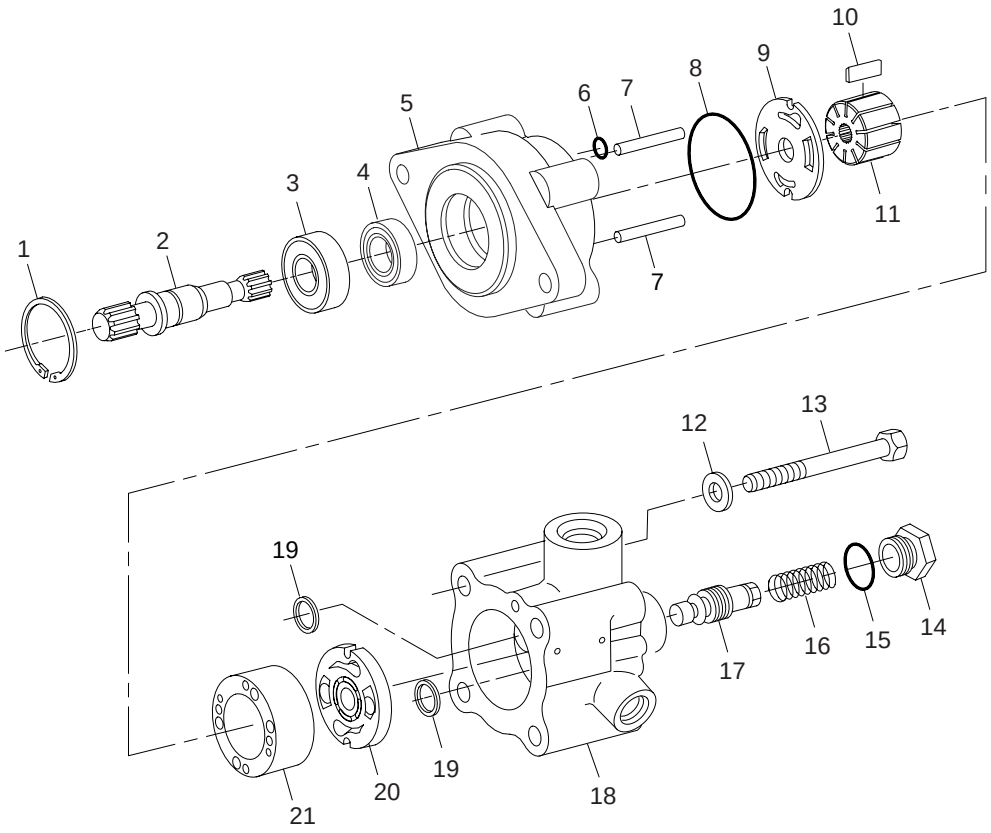
NOTE: The shaft seal kit contains a replacement seal for LF and VT series pumps. The seal for the LF series pump is smaller.

1. Remove the power steering pump from the engine following the instructions in **Subject 100**.
2. Carefully remove the end plug and the spring from the pump body. See **Fig. 1**.
3. Remove the control valve from the pump body. Be careful not to scratch the control valve.
4. Remove and discard the O-ring from the plug.
5. Put the pump housing in a padded vise and remove the capscrews that attach the housing to the flange assembly.
6. Remove and discard the combination O-rings/backup rings from the pump housing.
7. Remove the pressure plate, guide pins, cam ring, rotor, vanes, and wear plate as a unit and set it aside.
8. Remove and discard the small and large O-rings from the flange assembly.
9. Remove the snap ring that holds the shaft seal in place. Discard the snap ring.
10. Put the flange assembly in a vise with the inner end of the shaft pointing up. Carefully tap out the driveshaft.
11. Remove and discard the shaft seal.
12. Clean all the parts using a solvent compatible with the power steering fluid. Then, using filtered compressed air, dry all the parts.
13. Coat all the parts with clean power steering fluid. For approved power steering fluids, see **Specifications 400**.
14. Place the spacer over the outer (drive) end of the shaft with the cupped side of the spacer facing the inner end of the shaft.
15. Using power steering fluid, lubricate the new shaft seal. Carefully place the seal over the outer (drive) end of the shaft up against the spacer. The lettered side of the seal should be visible.

NOTE: To correctly install the driveshaft seal, it is necessary to make a suitable driver from tubular stock. See **Fig. 2** for the applicable dimensions.

16. Using a suitable driver, install the shaft seal into the bore in the flange assembly. Make sure the spring side of the seal faces the flange. See **Fig. 3**. Seat the seal firmly against the shoulder in the bore.
17. Install the small snap ring in the groove on the driveshaft with the sharp edge facing toward the bushing.
18. Put the flange assembly in a padded vise with the drive end of the shaft pointing up. Install a new large O-ring in the flange assembly.
19. Install a new small O-ring in the flange assembly.
20. Install the pressure plate, guide pins, cam ring, rotor, vanes, and wear plate as a unit. Make sure that the two guide pins are seated in the flange assembly.
21. Using power steering fluid, lubricate the new combination O-ring/backup rings. Install the rings in the pump housing with the black side facing the housing and the white, plastic side exposed.
22. Install the pump housing over the flange assembly lining up the mounting holes.
23. Install the capscrews and washers in the pump housing. Tighten them in a cross pattern 29 to 37 lbf·ft (40 to 50 N·m).
24. Install the control valve in the pump housing.

Steering Pump Shaft Seal Replacement



10/16/95 f461063

1. Snap Ring
2. Driveshaft
3. Driveshaft Bushing
4. Shaft Seal
5. Flange Assembly
6. Small O-Ring
7. Guide Pin
8. Large O-Ring
9. Wear Plate
10. Vane
11. Rotor
12. Washer
13. Capscrew
14. End Plug
15. End Plug O-Ring
16. Spring
17. Control Valve
18. Pump Housing
19. Combination O-Ring/Backup Ring
20. Pressure Plate
21. Cam Ring

Fig. 1, Power Steering Pump Assembly

⚠ CAUTION

Make sure you install the control valve correctly in its bore. If it is installed backwards, the power steering pump will not work and will quickly overheat, which could cause severe damage to the pump.

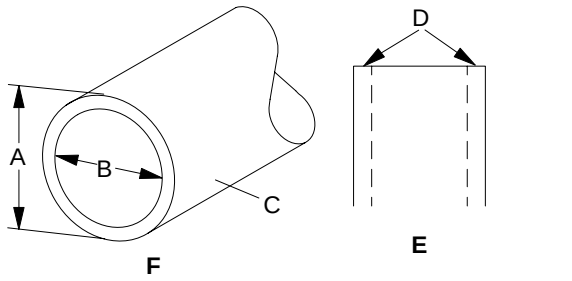
24.1 Lubricate the control valve with power steering fluid, then install it—with the hex end up—in the bore in the pump housing. See **Fig. 4**.

24.2 Install the spring over the hex end of the control valve.

24.3 Install a new O-ring on the end plug, then install the end plug. Tighten it 33 to 40 lbf·ft (45 to 55 N·m).

25. Turn the shaft by hand. It should turn smoothly and without binding.

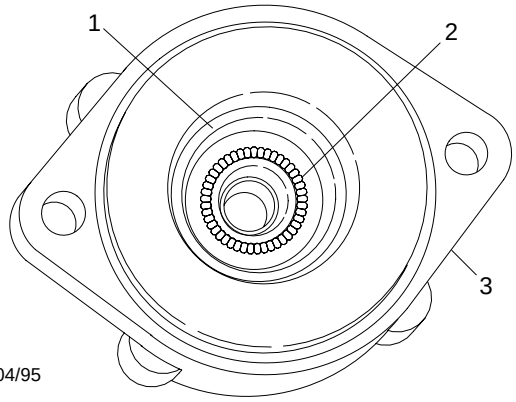
26. Install the power steering pump on the engine. For instructions, see **Subject 100**.



05/10/95 f460546a

A. Slightly smaller than the o.d. of the shaft seal.
B. Slightly larger than the o.d. of the driveshaft.
C. To be made of tubular stock.
D. The ends must be square.
E. Side View
F. Front View

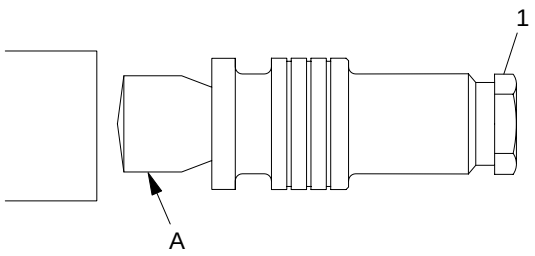
Fig. 2, Shaft Seal Installation Tool



10/04/95 f461068

1. Shaft Seal
2. Garter Spring
3. Flange

Fig. 3, Install the Shaft Seal



08/15/94 f460544a

A. Insert this end first.
1. Hex End

Fig. 4, Install the Control Valve

Model Code Description*	
Model Code	**Description**
LF73V	Flange Type
21	Displacement (cubic cm/rev)
16	Control Flow (L/min)
163	Pressure Limit (bar)
L	Direction of Rotation
P	Inlet Port Connection
U	Pressure Port Connection
D	Pressure Port View from Cover End
02	Shaft
11	Design Number
GE11	With Gear and Locknut

* Model codes contain specifications in metric units.

Table 1, Model Code Description

Pump Specifications			
LuK Model Code	**Pump Displacement cubic inch/rev (cubic cm/rev)**	**Control Flow gpm (L/min)**	**Maximum Pressure psi (kPa)**
LF73V-21-16-163-L-P-U-D-02-11-GE11	1.28 (21)	4.2 (16)	2396 (16 520)

Table 2, Pump Specifications

Pump Port Specifications			
Code	**Size**	**Shaft Minor Diameter Inches (mm)**	**O-Ring Chamfer**
Inlet Port			
M	M26 x 1.5	0.63 (16)	—
P	1-1/16–12	0.79 (20)	SAE J514
U	1-5/16–12		
Outlet Port			
M	M16 x 1.5	0.55 (14)	—
N	M18 x 1.5		—
U	3/4–16		SAE J514

Table 3, Pump Port Specifications

Specifications

Approved Power Steering Fluids	
Fluid Type	**Approved Fluid**
Automatic Transmission Fluid*	Dexron® II Dexron® III
Heavy-Duty Engine Oil* IMPORTANT: Do not use heavy-duty engine oil in vehicles built from November 4, 2002. **⚠ WARNING** **Do not use heavy-duty engine oil in vehicles equipped with a Hydro-Max® brake booster. Engine oil is not compatible with the seals in the brake booster. If the vehicle is equipped with a Hydro-Max® brake booster, use only automatic transmission fluid in the power steering system. Failure to follow this precaution could cause loss of hydraulic brake assist, possibly resulting in personal injury and property damage.**	15W–40

* Do not mix engine oil with automatic transmission fluid (ATF). Use the same lubricant for parts as is in the power steering system.

Table 4, Approved Power Steering Fluids

Pressure Settings	
Code	**Pressure in psi (kPa)**
80	1116.5–1261.5 (7700–8700)
100	1406.5–1551.5 (9700–10 700)
110	1551.5–1696.5 (10 700–11 700)
115	1624–1769 (11 200–12 200)
120	1696.5–1841.5 (11 700–12 700)
130	1841.5–1986.5 (12 700–13 700)
135	1914–2059 (13 200–14 200)
140	1986.5–2131.5 (13 700–14 700)
145	2059–2204 (14 200–15 200)
150	2131.5–2276.5 (14 700–15 700)
155	2204–2349 (15 200–16 200)
163	2320–2465 (16 000–17 000)
000	—

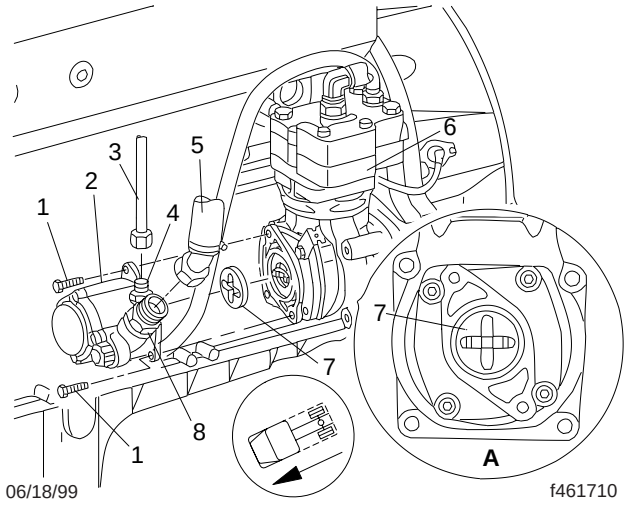
Table 5, Pressure Settings

General Information

The LuK Automotive Hydraulics LF 80 power steering pump supplies power steering fluid for the operation of the power steering gear.

The power steering pump, used on the MBE900 engine, is mounted on the air compressor. See **Fig. 1**. The power steering pump is powered by a cross plate in the air compressor.

The main parts of the power steering pump are the housing, driveshaft, cam ring, rotor, vanes, and control valve.



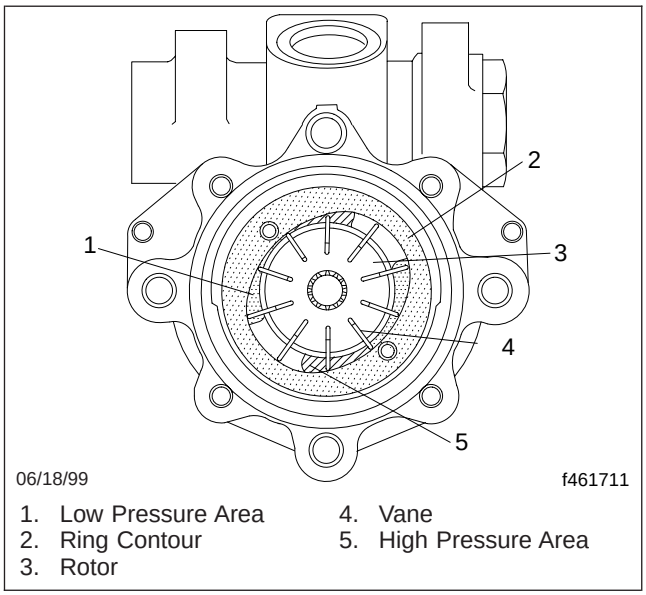
A. Cross plate shown installed on the air compressor.

1. Capscrew
2. Steering Pump
3. Outlet Hose
4. Outlet Port
5. Inlet Hose
6. Air Compressor
7. Cross Plate
8. Inlet Port

Fig. 1, Power Steering Pump Mounting

Principles of Operation

The power steering pump driveshaft is driven by the air compressor, which is powered by the adaptor gear in the engine gear case. As the pump driveshaft turns the pump rotor, centrifugal force throws the vanes out against the surface of the cam ring. As fluid enters the cam ring through the inlet port, the rotor vanes force it out through the outlet port and into the system. The fluid enters the steering gear providing the gear with enough fluid to steer the vehicle. Eventually the fluid returns to the power steering reservoir and then back to the power steering pump. See **Fig. 2**.



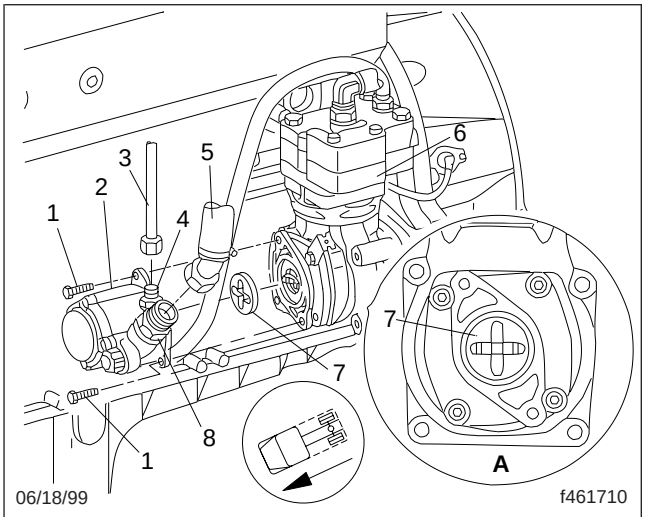
1. Low Pressure Area
2. Ring Contour
3. Rotor
4. Vane
5. High Pressure Area

Fig. 2, Power Steering Pump, Section View

If the system pressure gets too high, a poppet inside the control valve is forced off its seat shunting fluid into a relief passage connected to the inlet port. The fluid then recirculates inside the pump instead of going to the outlet port. When the system pressure drops to the correct level, the poppet seats, closing off the relief passage to the inlet port. The fluid flow returns to normal, flowing from the inlet port to the outlet port and then into the power steering system.

Replacement

1. Turn off the engine, apply the parking brakes, chock the tires, and open the hood.
2. Clean the dirt from around the inlet and outlet ports and from the hose connections. See **Fig. 1**.



A. Cross plate shown installed on the air compressor.

1. Capscrew	5. Inlet Hose
2. Steering Pump	6. Air Compressor
3. Outlet Hose	7. Cross Plate
4. Outlet Port	8. Inlet Port

Fig. 1, Power Steering Pump Mounting

3. Put a container under the steering pump. Disconnect the inlet hose and fitting and the outlet hose and fitting from the inlet and outlet ports. Drain the fluid. Plug the hoses to keep out dirt.
4. Remove the capscrews and washers that attach the steering pump to the air compressor. Remove the steering pump from the air compressor.
5. Remove the cross plate and inspect it for excess wear. See **Fig. 1**.
6. Before installing a new steering pump, make sure the cross plate aligns with the air compressor shaft. See **Fig. 1**.
7. Attach the steering pump to the air compressor using capscrews and washers. Tighten the capscrews 27 to 32 lbf·ft (37 to 43 N·m).
8. Connect the inlet and outlet hoses and fittings to the steering pump inlet and outlet ports.
9. Add fluid to the power steering reservoir. Start the engine and let it idle for two minutes. Do not turn the steering wheel; doing so can cause air to enter the system.

   Turn off the engine and check the fluid level in the reservoir.
10. Start the engine again. To remove air from the system, steer the vehicle from full left to full right several times.

    If necessary, add fluid to the full line on the reservoir dipstick.
11. If the steering gear does not have a manual bleed screw, turn the steering wheel from full lock to full lock two or three times with the engine running at idle. Repeat this step and add fluid as necessary until there are no bubbles in the reservoir.

    If the steering gear is equipped with a manual bleed screw, turn the steering wheel from full lock to full lock two or three times with the engine running at idle. Then loosen the manual bleed screw about one turn and look for clear fluid or fluid mixed with bubbles at the threaded area of the bleed screw. Repeat this step and add fluid as necessary until only clear fluid shows. Tighten the manual bleed screw 27 to 33 lbf·in (305 to 373 N·cm). Refill the reservoir if necessary to the full line on the dipstick.
12. Close the hood and remove the chocks from the tires.

Model Code Description*	
Model Code	**Description**
LF8	Power Steering Pump Series
0	Flange Type
25	Displacement (cubic cm/rev)
16	Control Flow (L/min)
150	Pressure Relief Valve Setting (bar)
L	Direction of Rotation
P	Inlet Port Size
U	Outlet (pressure) Port Size
MK1	Compressor Driven, Direct Drive
10	Design Number

* Model codes contain specifications in metric units.

Table 1, Model Code Description

Pump Port Specifications						
Code	**Size**	**Shaft Minor Diameter inches (mm)**	**Minimum Seal Diameter inches (mm)**	**Piping Inside Diameter inches (mm)**	**Piping Outside Diameter inches (mm)**	**O-Ring Chamfer**
Inlet Port						
M	M26 x 1.5	0.67 (17)	1.30 (33)	0.75 (19)	0.87 (22)	—
P	1-1/16–12		—			SAE J514
Outlet Port						
M	M16 x 1.5	0.55 (14)	0.98 (25)	0.39 (10)	0.47 (12)	—
N	M18 x 1.5			0.47 (12)	0.59 (15)	—
U	3/4–16		—			SAE J514

Table 2, Pump Port Specifications

Pump Specifications			
LuK Model Code	**Pump Displacement cubic inch/rev (cubic cm/rev)**	**Control Flow gpm (L/min)**	**Maximum Pressure psi (kPa)**
LF80-25-16-150-L-P-U-MK1-10	1.53 (25)	4.2 (16)	2205 (15 203)
LF80-25-16-163-L-P-U-MK1-10			2396 (16 520)
LF80-25-16-185-L-P-U-MK1-10			2683 (18 500)
LF80-21-16-150-L-P-U-MK1-10	1.28 (21)		2205 (15 203)
LF80-17-16-185-L-P-U-MK1-10	1.04 (17)		2683 (18 500)

Table 3, Pump Specifications

Specifications

Approved Power Steering Fluids	
Fluid Type	**Approved Fluid**
Automatic Transmission Fluid*	Dexron® II Dexron® III
Heavy-Duty Engine Oil* IMPORTANT: Do not use heavy-duty engine oil in vehicles built from November 4, 2002. **⚠ WARNING** **Do not use heavy-duty engine oil in vehicles equipped with a Hydro-Max® brake booster. Engine oil is not compatible with the seals in the brake booster. If the vehicle is equipped with a Hydro-Max® brake booster, use only automatic transmission fluid in the power steering system. Failure to follow this precaution could cause loss of hydraulic brake assist, possibly resulting in personal injury and property damage.**	15W–40

* Do not mix engine oil with automatic transmission fluid (ATF). Use the same lubricant for parts as is in the power steering system.

Table 4, Approved Power Steering Fluids

Pressure Settings		
Code	**Pressure psi (kPa)**	**Tolerance psi (kPa)**
81	1174.5 (8100)	58 (400)
90	1305 (9000)	
100	1450 (10 000)	
105	1522.5 (10 500)	
110	1595 (11 000)	
120	1740 (12 000)	
125	1812.5 (12 500)	
130	1885 (13 000)	
135	1957.5 (13 500)	
140	2030 (14 000)	
145	2102.5 (14 500)	
150	2175 (15 000)	
155	2247.5 (15 500)	
165	2392.5 (16 500)	
000	—	—

Table 5, Pressure Settings

General Information

A new Checklist for Troubleshooting Power Steering System Performance, form SD-94, has been developed to include the new high-pressure power steering gears as well as the power steering pumps. Use form SD-94, dated 9/17/04, and the following troubleshooting procedures when troubleshooting the power steering system.

You are required to fill out the applicable sections of form SD-94 when submitting a warranty claim on a power steering gear. It is recommended that you fill out the applicable sections of form SD-94 when submitting a warranty claim on a power steering pump. See **Fig. 1** and **Fig. 2** for a sample of form SD-94.

Form SD-94 can be downloaded from the internet through www.AccessFreightliner.com.

- Key in your user name and password.
- Click on Applications.
- Click on ServicePro®.
- Cancel the Vehicle Identification window.
- Click on Service Solutions.
- Click on Symptoms Search.
- At the bottom of the screen, enter 2005 in the Enter Solution Number field.
- Click on the SD-94 attachment.

Dealers can order form SD-94 through the TAO electronic mail system.

- At the TAO Mail Menu, key in B for bulletin boards.
- Tab down to Pub-Forms-FTL and key in L for list.
- At Freightliner Manuals Order Form, key in U.

If you don't have access to the TAO electronic mail system, contact Publishing Distribution at 503-745-7343.

Troubleshooting Procedures

Steps 1 through 3 are typically related to routine maintenance procedures. Some of these inspections and procedures can be found in the Pretrip Inspection and Daily Maintenance chapter in the *Business Class® Trucks Driver's Manual*; some of these inspections and procedures can be found in the *Business Class® Trucks Maintenance Manual*.

1. Check the tire pressure and load.

   1.1 Check that the front tires are inflated to the correct pressure, and the tire pressure is equal on both sides. Correct the pressure if needed.

   Low pressure causes increased steering effort due to friction with the road surface. Unequal tire pressure causes unequal friction between the tire and the road. This can cause pulling to one side. Check the tires for damage or abnormal wear.

   1.2 Check that the rear tires are inflated to the correct pressure, and the tire pressure is equal on both sides. Correct the pressure if needed.

   1.3 Check that the tire sizes are correctly matched, and whether duplex or oversized tires (that were not originally specified for the vehicle) have been installed.

   Extra tire width causes increased steering effort due to extra friction with the road surface. If the axle stops were turned out to reduce wheel cut due to a change in tires, the power steering gear poppets/plungers will need to be adjusted.

   1.4 Determine whether the vehicle is operated at or over the rated load.

   Increased load causes greater steering effort. Make sure the vehicle is being operated within rated capacities.

2. Check the lubrication and condition of the fifth wheel, if so equipped.

   Check to see if the fifth wheel is adequately lubricated. A dry fifth wheel plate makes it difficult to change direction. Check the plate surface for burrs, gouges, and irregularities.

3. Check for loose and binding components. Check whether any steering components need maintenance or adjustment.

   3.1 Check for proper lubrication of the drag link, tie rods, and knuckle pins. Apply lubrication as needed.

Troubleshooting Procedures

FREIGHTLINER® LLC
A DaimlerChrysler Company

Checklist for Troubleshooting Power Steering System Performance

To be used with the troubleshooting and diagnostic checks.

Date _____ Work order No. _____

Evaluation performed by _____ □ Dealership □ Fleet □ Independent

Vehicle Identification
Vehicle model _____ Serial No. _____ Date in service _____
Mileage _____ Mileage when steering complaint first occurred _____
Vehicle application _____ Normal steering axle load _____

Steering System Description
Steering pump mfr. _____ Model No. _____
Steering gear mfr. _____ Model No. _____ Date code _____
Slave steering gear mfr. (optional) _____ Model No. _____ Date code _____
Reservoir capacity: □ 2 quarts (1.9 liters) □ 4 quarts (3.8 liters) □ 9 quarts (8.5 liters)
Type of fluid: □ ATF □ 10 W □ 10W−30 □ 10W−40 □ Other:_____

List complaint: _____
_____
_____

The numbers below correspond to the steps in the troubleshooting procedures, Subject 300. Refer to Subject 300 for definitions, explanations, and instructions.

1. **Check tire pressure and load:**
   - Front tire pressure correct and even on both sides? □ Yes □ No
   - Rear tire pressure correct and even on both sides? □ Yes □ No
   - Oversized front tires? □ Yes □ No
   - Operated at excessive load? □ Yes □ No

2. **Check fifth wheel lube and condition:** □ N/A □ OK □ Not OK

3. **Check for loose and binding components:**
   - Lubrication of drag link, tie rods, and knuckle pins? □ Yes □ No
   - COE steering column bearings bind? □ N/A □ Yes □ No
   - Steering driveline U-joints bind? □ Yes □ No
   - Steering driveline phasing OK? □ Yes □ No
   - Sector shaft adjustment OK? □ Yes □ No
   - Front tire self−return OK? □ Yes □ No
   - Fasteners and components worn or loose? □ Yes □ No

4. **Power steering temperature and hydraulic checks:**
   - 4.2. Check for correct fluid level. □ Fluid OK □ Added fluid
   - 4.5. Record initial fluid temperature. □ °F □ °C _____

5. **Power steering hydraulic system:**

Install a Power Steering System Analyzer (PSSA) between the pump high-pressure line and the steering gear. Run the engine at idle and use the load valve to raise the fluid temperature to 180°F (82°C).

- 5.1. Record total system back pressure. □ psi □ kPa _____
  See troubleshooting and diagnostic checks if greater than 100 psi (689 kPa).

SD−94 (9/17/04)

10/14/2004 f020157

Fig. 1, Checklist for Troubleshooting Power Steering System Performance, Front Page

5.2. Check for erratic pump response while momentarily closing and opening the load valve. ◻ OK ◻ Not OK

5.3. Pump relief pressure. ◻ psi ◻ kPa _____

5.4. Pump relief valve operated correctly at idle. ◻ OK ◻ Not OK

5.5. Pump relief valve operated correctly at 1500 rpm. ◻ OK ◻ Not OK

5.6. Partially close the load valve until the pressure gauge reads approximately 1800 psi (12 410 kPa) or 2300 psi (15 858 kPa) for high-pressure steering gears. Record flow rate with engine at idle and with the appropriate load applied. ◻ gpm ◻ L/min ____

5.7. Record flow rate with engine at 1500 rpm and no load applied. ◻ gpm ◻ L/min ____

5.8. Run engine at governed speed until fluid temperature stabilizes. Record the maximum fluid temperature. Do not exceed 250°F (121°C). ◻ °F ◻ °C _____

5.9. Steering gear internal leakage:
Primary gear: 1.0 gpm (3.8 L/min) max ◻ gpm ◻ L/min Left _____ Right _____
(optional) Slave gear or ram: 1.0 gpm (3.8 L/min) max Left _____ Right _____
(optional) Slave gear or ram: 1.0 gpm (3.8 L/min) max Left _____ Right _____
(optional) Slave gear or ram: 1.0 gpm (3.8 L/min) max Left _____ Right _____

6. Steering gear poppet adjustment:
6.2. Poppet relief pressure. ◻ psi ◻ kPa Left _____ Right _____

7. Abnormal power steering noise:
7.1. If not already done, check for proper fluid level. ◻ Fluid OK ◻ Too low ◻ Too high
7.2. Check fluid condition. ◻ Fluid OK ◻ Discolored ◻ Foamy ◻ Other _____
7.3. Hissing at less than full turn. ◻ Yes ◻ No

8. Check for leaks and restrictions, and test the system back pressure:
8.1. Check for kinked or collapsed hoses. ◻ Yes ◻ No
8.1. Check for leaking fittings. ◻ Yes ◻ No
8.1. Check for leaking seals. ◻ Yes ◻ No

8.2. Install a low−pressure gauge− 200 to 300 psi (1379 to 2068 kPa)—in the appropriate locations within the power steering system to determine the following values.

8.3. Fill out the fields below using instructions found in substep 8.3 of the diagnostic checks.

Pump outlet	P2: _____	P2 max: 100 psi (689 kPa)	◻ OK	◻ Not OK
		140 psi* (965 kPa)	◻ OK	◻ Not OK
Gear inlet	G1: _____	P2 − G1 max: 12 psi	◻ OK	◻ Not OK
Gear outlet	G2: _____	G1 − G2 max 55 psi	◻ OK	◻ Not OK
Booster inlet*	B1: _____	G2* − B1 max: 12 psi	◻ OK	◻ Not OK
Booster outlet*	B2: _____	B1* − B2 max: 40 psi	◻ OK	◻ Not OK
Reservoir inlet	R1: _____	B2* − R1 max: 12 psi	◻ OK	◻ Not OK
Reservoir outlet	R2: _____	G2 − R1 max: 12 psi	◻ OK	◻ Not OK
Pump inlet	P1: _____	R1 − R2 max: 4 − 8 psi	◻ OK	◻ Not OK
		R2 − P1 max: 12 psi	◻ OK	◻ Not OK

*For vehicles with hydraulic brakes.

List repairs and add comments:_____

_____

_____

SD-94 (9/17/04)

10/14/2004 f020158

Fig. 2, Checklist for Troubleshooting Power Steering System Performance, Back Page

Troubleshooting Procedures

Chock the rearmost tires. With the engine shut down, turn the steering wheel and check for looseness or binding. Make sure all components are free to move, but are not excessively loose.

3.2 Check the COE steering column bearings for binding. Lubricate them if needed.

3.3 Check the steering driveline U-joints for looseness or binding. Lubricate them if needed.

3.4 Check for correct steering phasing where applicable. The U-joints should line up. Reset the phasing if needed.

NOTE: On older COEs, the steering U-joints do not line up.

3.5 Check the sector shaft adjustment.

- With the vehicle on the ground and the front tires pointed straight ahead, turn the steering wheel until slight motion is observed at the front wheels.
- Align a reference mark on the steering wheel to a rule, then slowly turn the steering wheel in the opposite direction until motion is again detected at the wheels.
- Measure the lash (free play) at the rim of the steering wheel.

  Excessive lash exists if steering wheel movement exceeds 2-1/2 inches (64 mm) with a 20-inch (508-mm) steering wheel, or 2-1/4 inches (57 mm) with an 18-inch (457-mm) steering wheel.

3.6 Check that the front wheels self-return without binding.

- With the engine off, chock the rearmost tires and place the front tires on radius plates (turntables).
- Disconnect the drag link from the steering arm.
- By hand, pull the tire to one axle stop and release. The tire should self-return to almost straight ahead.
- Repeat in the opposite direction.
- If the tire does not return to near straight ahead, check for binding or a lack of lubrication in the steering axle kingpin bushings or tie rod linkage.
- Connect the drag link and tighten the castle nut, then install a new cotter pin.

3.7 Inspect all suspension fasteners and components for wear and looseness.

4. Prepare the power steering system for temperature and hydraulic checks.

NOTE: The hydraulic power steering system is tested with a Power Steering System Analyzer (PSSA), and with the hydraulic fluid at operating temperature. The part number for the PSSA is J-26487. The part number for the adapter kit is J-28593. The PSSA and adapter kit are available from SPX Kent-Moore. See **Fig. 3**.

A PSSA is a combination of a flow meter, a shutoff valve, and a pressure gauge. The PSSA will allow you to measure flow and pressure, and provide a load on the pump in the hydraulic lines of the steering system.

4.1 Park the vehicle outside to reduce noise and exhaust in the shop.

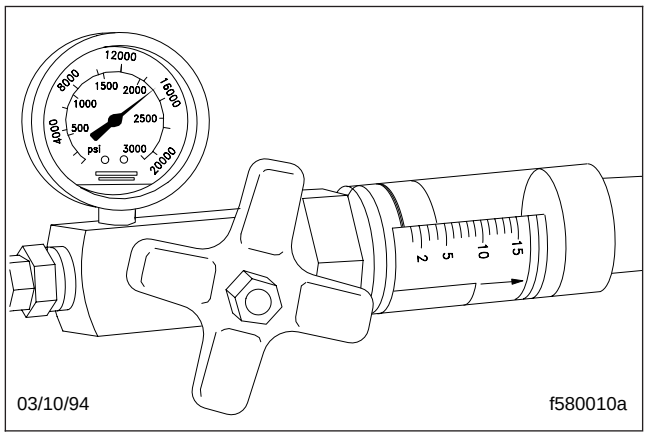


Fig. 3, Power Steering System Analyzer

4.2 Record on form SD-94 whether the fluid level was okay or if fluid was added.

4.3 Install the PSSA between the pump high-pressure line and the steering gear.

4.4 Fill and bleed the steering system as needed.

4.5 Determine the initial power steering fluid temperature.

- Place a temperature gauge in the fluid reservoir.
- Record the initial temperature on form SD-94, and leave the temperature gauge in the reservoir to monitor the fluid temperature throughout these tests.

NOTE: Power steering system checks must be done with the power steering fluid at operating temperature, approximately 180°F (82°C). Maintain this temperature throughout the following tests.

CAUTION

Do not leave the load valve fully closed for longer than five seconds. Doing so could damage the power steering system.

4.6 If not already done, raise the power steering fluid temperature to normal operating temperature.

- Run the engine at idle.
- Partially close the load valve on the PSSA until the pressure gauge reads 1000 psi (6895 kPa).
- Open the valve when the fluid temperature reaches about 180°F (82°C).

5. Test the power steering hydraulic system.

5.1 Check the total system back pressure.

- Run the engine at idle.
- Make sure the PSSA load valve is fully open.
- Read the pressure gauge on the PSSA.
- Record the total system back pressure on form SD-94.

NOTE: If the total system back pressure is greater than 100 psi (689 kPa) on a vehicle with air brakes, or 140 psi (965 kPa) on a vehicle with hydraulic brakes, back pressure is excessive. Go to step 8 to find the restriction in the system.

CAUTION

Do not leave the load valve closed for longer than five seconds during the following test. Doing so could damage the power steering system.

5.2 Check for erratic pump response.

- Slowly close the load valve.
- When the valve is completely closed, read the pressure gauge.
- Open the valve.

  If the pressure rises rapidly, appears to be uncontrolled, or rises above the typical relief pressure, open the load valve immediately. See **Table 1** or **Table 2** for relief pressures.
- Indicate on form SD-94 whether the pump response was erratic or not.

  If the response was erratic, replace the pressure relief valve in the pump or the power steering pump as required. For instructions, refer elsewhere in this group. After replacing the pressure relief valve, repeat substeps 5.1 and 5.2. Make sure the temperature is at about 180°F (82°C). If the pressure was consistent, go to substep 5.3.

5.3 Check the pump relief pressure.

- Slowly close the load valve.
- When the valve is completely closed, read the pressure gauge.
- Open the valve.

Troubleshooting Procedures

Minimum Measured Pump Flow and Relief Pressure at Engine Idle		
Gear Make and Model*	**Flow at 1800 psi (12 500 kPa)**	**Typical Relief Pressure**
TRW TAS40 or HFB52	1.8 gpm (6.8 L/min)	2175 ± 100 psi (15 000 ± 700 kPa)
TRW TAS55	2.2 gpm (8.3 L/min)	
TRW TAS65 or HFB64	2.6 gpm (9.8 L/min)	
TRW TAS85 or HFB70	3.2 gpm (12.1 L/min)	
TRW TAS65 With RCS65	5.6 gpm (21.1 L/min)	
TRW TAS65 With Linear Cylinder	6.1 gpm (23.1 L/min)	
TRW TAS85 With RCS65	6.6 gpm (25.0 L/min)	
TRW TAS85 With Linear Cylinder	6.1 gpm (23.1 L/min)	
HFB70 With RCB70	6.6 gpm (25.0 L/min)	
HFB70 With RCB64	6.1 gpm (23.1 L/min)	
HFB70 With Linear Cylinder	6.1 gpm (23.1 L/min)	
Sheppard MD83	2.1 gpm (8.1 L/min)	
Sheppard M100	3.0 gpm (11.4 L/min)	
Sheppard M110 With Slave 110 and Dual TRW Right-Side Rams	5.6 gpm (21.2 L/min)	

* On vehicles with TRW TAS steering gears and hydraulic brakes, the typical relief pressure is 2375 ± 100 psi (16 000 ± 700 kPa).

Table 1, Minimum Measured Pump Flow and Relief Pressure at Engine Idle

Minimum Measured Pump Flow and Relief Pressure for High-Pressure Gears at Engine Idle		
Gear Make and Model	**Flow at 2300 psi (16 000 kPa)**	**Typical Relief Pressure**
TRW THP45	1.5 gpm (5.7 L/min)	2683 ± 100 psi (15 000 ± 700 kPa)
TRW THP60 or PCF60	2.3 gpm (8.7 L/min)	
TRW THP60 With Linear Cylinder	5.8 gpm (22.0 L/min)	
TRW THP60 With RCH45	6.3 gpm (23.8 L/min)	

Table 2, Minimum Measured Pump Flow and Relief Pressure for High-Pressure Gears at Engine Idle

- Record the relief pressure on form SD-94.

If the pump relief pressure matches the relief pressure in **Table 1** or **Table 2**, it is acceptable. Go to the next substep.

If the pump relief pressure does not match the relief pressure in **Table 1** or **Table 2**, refer to the pump manufacturer's service literature to verify the exact relief pressure for the power steering pump being diagnosed.

If the pump relief pressure does not match the relief pressure in **Table 1** or **Table 2** or the pump manufacturer's specifications, replace the pressure valve if not done previously, or replace the power steering pump. After replacing the pressure relief valve in the pump, repeat substeps 5.1 and 5.2.

If the pump relief pressure does not match the relief pressure in **Table 1** or **Table 2** and the relief valve was previously replaced, replace the pump. For instructions, refer else-

where in this group. After replacing the pump, evaluate the pump's performance by repeating step 5.

5.4 Test the pump relief valve reaction at idle.

- Run the engine at idle.
- Note the flow rate with the load valve open.
- Close the load valve until the pump relief pressure is reached. The flow rate should drop to zero.
- Smoothly and quickly open the load valve and note the flow rate. Repeat this action three times. It should return to the flow rate noted above.
- Record on form SD-94 whether the relief valve operated correctly or not.

  If the flow rate returns smoothly and quickly, the relief valve is acceptable. Go to the next substep.

  If the flow rate does not return smoothly and quickly, the pump relief valve is not working correctly. Replace the relief valve if not done previously, or replace the power steering pump.

5.5 Test the pump relief valve reaction at 1500 rpm.

- Run the engine at 1500 rpm.
- Note the flow rate with the load valve open.
- Close the load valve until the pump relief pressure is reached.
- Smoothly and quickly open the load valve and note the flow rate. Repeat this action three times. It should return to the flow rate noted above.
- Record on form SD-94 whether the relief valve operated correctly at 1500 rpm.

  If the flow rate returns immediately, the relief valve is acceptable. Go to the next step.

  If the flow rate does not return immediately, the pump relief valve is not working correctly. Replace the relief valve if not done previously.

5.6 Test the flow of the pump at idle with a load applied.

- Run the engine at idle.
- Slowly close the load valve until the pressure gauge reads 1800 psi (12 410 kPa).
- Read the flow gauge and record the flow rate on form SD-94.

  NOTE: For high-pressure steering gears, use 2300 psi (15 858 kPa) as the test load pressure. See **Table 1** or **Table 2** for minimum flow rate.

- Open the load valve.

5.7 Test the maximum flow of the pump with no load applied.

- Run the engine at 1500 rpm.
- Read the flow gauge and record the maximum flow on form SD-94.

  If the flow rate is below the minimum as indicated in **Table 1** or **Table 2**, repair or replace the pump. For instructions, refer elsewhere in this group.

  If the flow rate is above 8 gpm (30 L/min), replace the flow control and relief valve in the pump, or replace the power steering pump as required. For instructions, refer elsewhere in this group.

CAUTION

Do not allow the temperature to exceed 250°F (121°C) during the following test. If this temperature is exceeded, stop the test and record the last noted temperature on form SD-94.

5.8 Record the maximum fluid temperature.

- Run the engine at governed speed.
- Observe the power steering fluid temperature until it stabilizes.
- Record on form SD-94 the maximum power steering fluid temperature.

Troubleshooting Procedures

If the temperature does not exceed 250°F (121°C) during the test, excessive system heat is probably not the cause of the complaint.

If at any time during the test the temperature exceeded 250°F (121°C), the system is operating at excessive temperature levels, and steering system performance and life may be affected. Damage to hoses, seals, and other components may result if the vehicle is operated at excessive steering system temperatures.

Excessive steering system backpressure or excessive pump flow may be the cause of the over temperature problem. Go to step 8 if you suspect a restriction in the system.

If excessive heat continues to be a problem, a cooler may need to be added to the system.

⚠ WARNING

Keep fingers clear of the stop bolt and spacer block during the following test. Make sure that the spacer block contacts the axle stop squarely. Contact that is not square could break the stop bolts or eject the spacer block, which could cause serious personal injury.

⚠ CAUTION

While running the following test, do not hold the steering wheel in the full-turn position for more than five seconds. Doing so could damage the pump.

NOTE: The following substeps check for excessive internal leakage in the steering gear(s). Make sure the fluid temperature is approximately 180°F (82°C) and the vehicle is stationary with the front wheels pointing forward.

5.9 Test the steering gear internal leakage.

- Run the engine at idle with the load valve open.
- Place an unhardened steel spacer, 1-inch (25-mm) thick, between the axle and the stop bolt at one side of the axle. See **Fig. 4**.

  The spacer should have an extension or handle long enough to keep fingers clear of the axle stop area. A brazing rod or welding rod works well for this purpose.

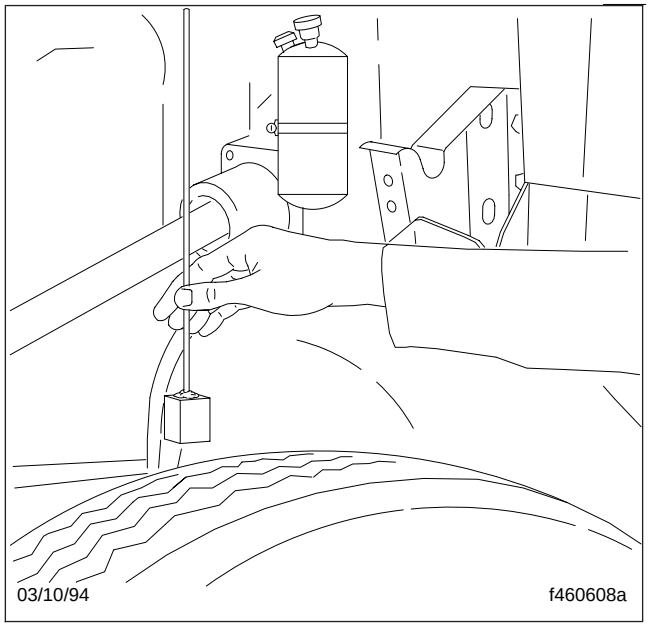


Fig. 4, Position the Steel Spacer

- Have someone turn the steering wheel until the stop bolt contacts the spacer block. See **Fig. 5**.
- Apply a 20-pound (89-newton) force on the steering wheel.
- Read the internal leakage rate on the flow meter. Record this value on form SD-94.
- Repeat substep 5.9 (beginning with placing the spacer between the axle and the axle stop) for the opposite turn.

  The maximum permissible internal leakage for a single gear is 1.0 gpm (3.8 L/min). If leakage is greater in either turning direction, replace the

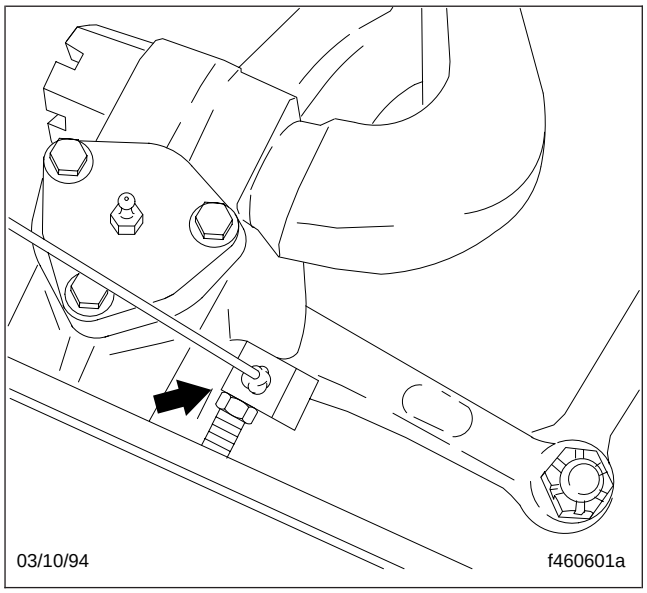


Fig. 5, Steel Spacer Contacting the Axle Stop

steering gear components as needed.

For systems with two or more steering gears and/or linear cylinders, the total acceptable internal leakage is 1.0 gpm (3.8 L/min) for each steering gear/ram in the system. For example, for a dual-gear system (two steering gears) the total acceptable internal leakage is 2.0 gpm (7.6 L/min).

If the leakage is more than 2.0 gpm (7.6 L/min) on a dual-gear system, isolate the auxiliary cylinder from the system.

- Disconnect the auxiliary cylinder hydraulic lines at the main gear auxiliary ports.
- Plug the main steering gear ports with suitable steel or high-pressure plugs or caps.
- Direct the disconnected lines into a drain pan.
- Repeat the internal leakage test.

If the internal leakage is less than 1 gpm (3.8 L/min), repair or replace the auxiliary gear or linear cylinder.

If the internal leakage is greater than 1 gpm (3.8 L/min), repair or replace the main gear.

- Remove the plugs and connect the hoses.
- Fill the power steering reservoir to the proper level.

6. Check the steering gear poppet relief valve and stop bolt adjustment.

   NOTE: Poppets limit the steering assist when the front wheels approach the stop bolts. Improper adjustment can apply excessive force to the steering linkage or loss of assist as the steering wheel approaches either full-left or full-right turns.

   6.1 Check the steering system for adequate turn angle.

   - Make sure the stop bolt settings limit the steering travel so there is 1/2-inch (13-mm) clearance from all stationary components, and 3/4-inch (19-mm) clearance from all moving components.
   - Make sure the pitman arm is situated on the steering gear sector shaft correctly.

⚠ CAUTION

If power steering pump relief pressure is reached while the steering wheel is at full lock, release the steering wheel from this position. Do not allow the pump relief pressure to be maintained for longer than five seconds or damage to the pump may result.

   6.2 Check the poppet relief pressure.

   - Set up a system for hydraulic checks as done in step 4.
   - Make sure the fluid temperature is at approximately 180°F (82°C) and the vehicle is stationary on the ground with the front wheels pointing forward.
   - Run the engine at idle with the load valve open.

Troubleshooting Procedures

- Turn the steering wheel to either full-lock position.
- Note the pressure gauge reading.
- Repeat the previous three instructions for the opposite turn.
- Record the poppet relief pressure on form SD-94 for both turns.

The pressure should drop slightly before the steering stops are contacted. If the pressure increases (from contact with the steering stops), the poppets/plungers must be manually reset. For poppet reset instructions, refer elsewhere in this group.

If the pressure is relieved and assist is lost when the wheel is too far from the axle stop, adjust the automatic poppet valve following the instructions in the next substep.

6.3 Adjust the poppet valves.

- Turn the steering wheel to the full-lock position.
- Apply a 20-pound (89-newton) force on the steering wheel while in the full-lock position.
- Repeat the previous two instructions for the opposite turn.

If the poppets (TRW gears only) have been adjusted or reset properly, and after subsequent vehicle operations loss of assist continues to occur when the wheel is too far from the axle stop, the poppets have become loose due to previous incorrect poppet adjustment and must be replaced. After poppet replacement and adjustment, test again for correct poppet relief function and record the pressure on form SD-94.

7. Check for abnormal power steering noise.

NOTE: Noise from the power steering system does not necessarily mean there is a problem. Some noises are normal and are the result of proper operation.

7.1 If not already done, check for proper fluid level. Record the results on form SD-94.

7.2 Check the condition of the power steering fluid and record the condition on form SD-94.

7.3 Check if a hissing sound is heard at less than full turn. If a hissing sound is heard, check the steering gear poppet and the axle stop adjustment and record the result on form SD-94. For adjustment instructions, see step 6.

See **Table 3** and **Table 4** for possible causes and remedies for common noises associated with the power steering system and power steering pump.

8. Check for leaks and restrictions, and test the system back pressure.

8.1 Check for leaks and restrictions.

- Run the engine at idle.
- Inspect all hoses and fittings for signs of kinked or collapsed hoses, or leaking fittings.
- Inspect all external seals.
- Repair all leaking fittings and replace parts as needed.
- Replace any leaking seals.
- Inspect the seal bores and sealing surfaces for scrapes or burrs. Make sure the seals are installed correctly using the recommended tools as found elsewhere in this group.
- Indicate on form SD-94 if there were any kinked or collapsed hoses, or leaking fittings or seals.

If you replaced the steering gear input shaft seal and found it to be excessively hard, test the system operating temperature, substep 5.8, if not already done.

Power Steering System Noise	
Possible Cause	**Remedy**
Growling or other abnormal steering noise	Check the fluid level. Check for air bubbles and foam. Check for hose and fitting leaks. Add fluid if needed. If there is air in the fluid, check for inlet tube and hose leaks. Correct all leaks.
A change from the usual pump sound	Check the power steering fluid reservoir. Check for air bubbles and foam in the fluid. If there is air in the fluid, check for inlet tube and hose leaks. Correct all leaks.
Clicking noise during a turn	Check for loose steering components. Check the front suspension for insufficient spring pin shims. Tighten any loose steering components. Add front spring pin shims if needed.
Hissing when the steering wheel is at or near full turn	Fluid flowing past a poppet valve makes a hissing noise. This is normal. No action is needed.

Table 3, Power Steering System Noise

Power Steering Pump Noise	
Possible Cause	**Remedy**
The intake line is plugged.	Drain the system. Clear the intake line if needed. Fill the system.
There is an air leak at the pump connections, the fittings, the reservoir connections, or the shaft seal.	Check all the connections by pouring power steering fluid over them, and listen for a reduction in sound. Tighten all the connections as needed. If the problem persists, remove the pump, disassemble it, and replace the shaft seal.
The pump input shaft is misaligned.	Remove and disassemble the pump. Replace the shaft seal and bearing.

Table 4, Power Steering Pump Noise

⚠ CAUTION

Do not move the steering wheel or allow the system pressure to exceed the rating of the gauge during the following test, or damage to the gauge could occur.

8.2 Test the system back pressure.

- Install a low-pressure gauge—200 to 300 psi (1379 to 2068 kPa) maximum—between the pressure line and the pump.
- Run the engine at idle and check for correct fluid level. If necessary, add fluid. If bubbles or foam appear in the reservoir, check the hose fittings for looseness or leaks.
- With the engine at idle, read the total system back pressure on the pressure gauge. Record the value on form SD-94.
- If the total system back pressure is greater than 100 psi (689 kPa), or 140 psi (965 kPa) for a vehicle with hydraulic brakes, go to the next substep. If the pressure between the pressure line and pump is less, restriction is not a problem.

8.3 Determine the restriction of the individual components by subtracting the values shown in **Table 5**. Record the values on form SD-94.

The component at fault can be identified by checking pressure at key locations in the steering system. With the engine at idle, use the low-pressure gauge and hose connection adaptors necessary to measure pressure at all locations identified in **Fig. 6**. Each time the gauge moves to a new location, make sure that the fluid

Troubleshooting Procedures

level is correct and air is removed from the system by running the engine at idle and checking the fluid level.

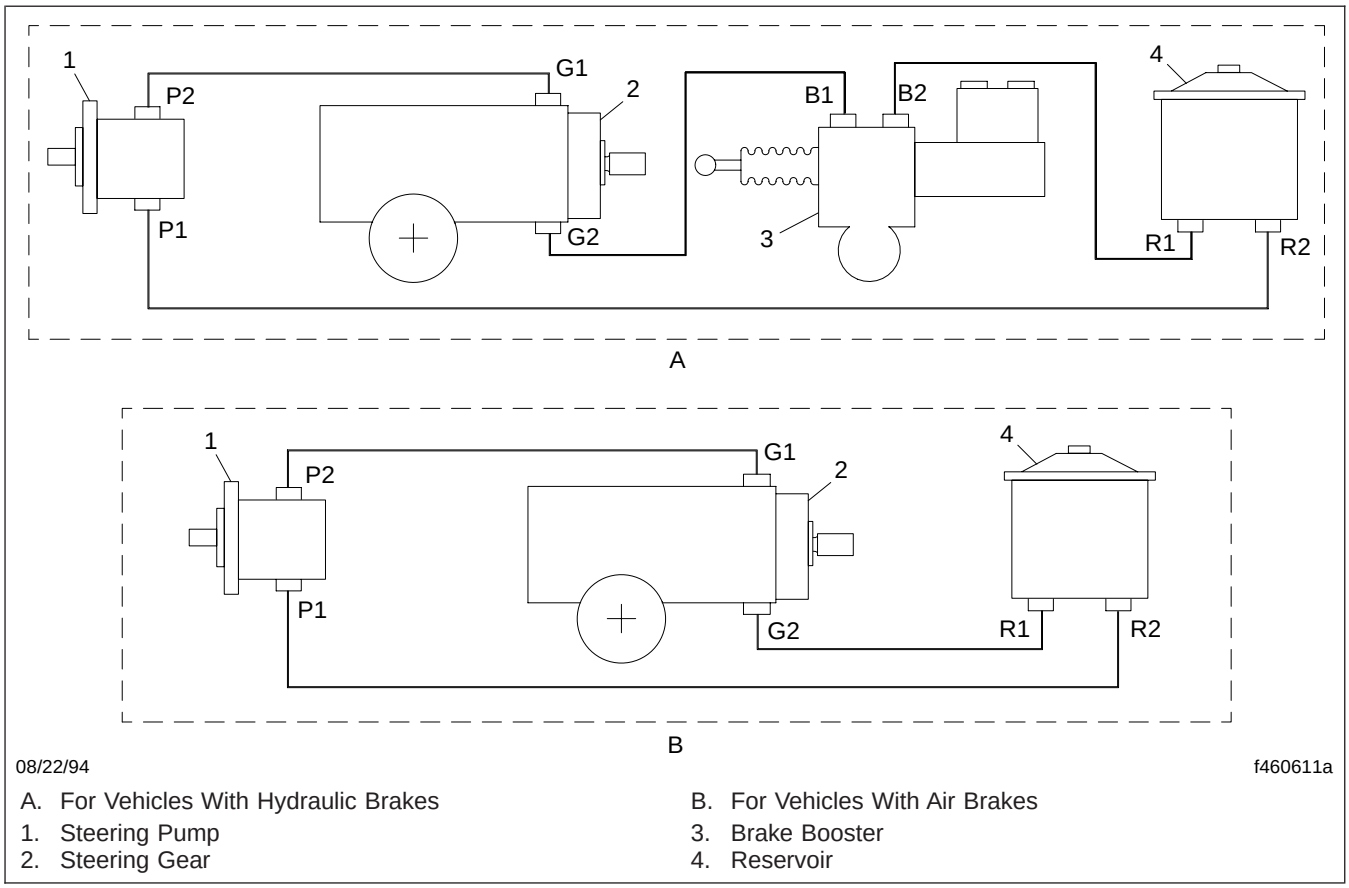
- Install the low-pressure gauge between the pump outlet and the pump-to-gear hose. Record this value as P2.
- Install the low-pressure gauge between the pump-to-gear hose and the steering gear inlet port. Record this value as G1.
- Install the low-pressure gauge between the steering gear outlet port and the gear-to-reservoir hose. Record this value as G2.
- Install the low-pressure gauge between the gear-to-reservoir hose and the reservoir inlet port. Record this value as R1.
- Install the low-pressure gauge between the reservoir outlet port and the reservoir-to-pump hose. Record this value as R2.
- Record the total system back pressure as determined in substep 8.2 as P1.

NOTE: For a vehicle with hydraulic brakes, perform similar procedures as those in substep 8.3. Record the pressure at the booster inlet as B1, and at the booster outlet as B2.

If any component exceeds the maximum allowable restriction listed for each component, refer to the applicable action to take in **Table 5**.

Total System and Component Restrictions		
Total System and Component Pressure-Check Location	**Maximum Allowable Restriction**	**Action to Take**
P2 = total system (pump outlet)	Hydraulic brakes: 140 psi (965 kPa) Air brakes: 100 psi (689 kPa)	Check pressure at the key locations.
P2–G1 = hose: pump-to-gear	12 psi (83 kPa)	Check for a kinked or plugged hose. Replace the hose if necessary.
G1–G2 = steering gear	55 psi (379 kPa)	The gear rotary valve is damaged. Replace the gear. See instructions elsewhere in this group.
G2–B1 = hose: gear-to-booster	12 psi (83 kPa)	Check for a kinked or plugged hose. Replace the hose if necessary.
G2–R1 = hose: gear-to-reservoir	12 psi (83 kPa)	Check for a kinked or plugged hose. Replace the hose if necessary.
B1–B2 = booster	40 psi (276 kPa)	Check the internal booster filter for contaminants. Check for contaminants causing binding or blockage of poppet and check valves within the booster.
B2–R1 = hose: booster-to-reservoir	12 psi (83 kPa)	Check for a kinked, collapsed, or plugged hose. Replace the hose if necessary.
R1–R2 = reservoir	2 qt: 4 psi (28 kPa)	Replace the filter. Check for internal blockage.
R2–P1 = hose: pump supply	12 psi (83 kPa)	Check for a kinked, collapsed, or plugged hose. Replace the hose if necessary.

Table 5, Total System and Component Restrictions



A. For Vehicles With Hydraulic Brakes
1. Steering Pump
2. Steering Gear

B. For Vehicles With Air Brakes
3. Brake Booster
4. Reservoir

Fig. 6, Plumbing Diagrams

General Information

The fuel system delivers fuel from the fuel tanks to the engine. It consists of the engine fuel system components, the fuel tank(s) and tank mounting components, and the fuel lines and (if so equipped) shutoff valve.

The engine fuel system components include fuel filters, injectors, fuel transfer pumps, and a fuel governor. For service and maintenance procedures, refer to the applicable engine manufacturer's service and maintenance manuals.

The fuel tanks are held in place by metal straps and brackets that transfer the load to the vehicle frame. On some installations, cab-access and chassis-access step assemblies attach to the fuel tanks and tank brackets.

In diesel engine installations, fuel suction and return lines made of polyester-braid-reinforced nylon tubing bring fuel from the tank to the engine, and return surplus fuel from the engine to the tank. Dual-tank installations have single suction and return lines with a crossover fuel line (a flexible, wire-braid-reinforced hose) to equalize the level of fuel in the tanks. A shutoff valve in the crossover line attaches to the bottom fitting of the primary tank, and shuts off fuel flow to or from the secondary tank.

A dual suction/dual return fuel system has been added to late model vehicles. This system provides equal fuel levels in both fuel tanks without the need of a low crossover line. This system also reduces the tendency for fuel to gel in cold weather.

NOTE: EquiFlo fuel systems are not available on vehicles equipped with the Chrysler gasoline engine.

⚠ WARNING

On gasoline engines, release the fuel system pressure before servicing the fuel system. Otherwise fuel could spray out, possibly resulting in severe personal injury and property damage, including fire.

Gasoline engines are equipped with a returnless fuel system in which the fuel is held under constant pressure, even when the engine is shut down. While this eliminates the need for a return line, it makes it necessary to drain the fuel system pressure before servicing the fuel system.

The returnless fuel system also requires special high-pressure lines, tubes and fittings, which cannot be interchanged with diesel fuel lines, tubes or fittings.

Standard equipment for diesel engines includes a fuel level gauge sender in the primary tank, with an electric fuel level gauge mounted in the cab instrument panel. For gasoline engines, a float and sensing unit on the fuel pump module send data to the electric fuel gauge.

Tank-Mounted Step Assembly Removal and Installation

Removal

CAB-ACCESS STEP (Refer to Fig. 1)

To remove a *single-level* step, or the *lower step* of a *dual-level* installation (Ref. 5), remove the locknuts, bearing washers, and capscrews (Refs. 6 and 7) that attach the bottom of the step brackets to the fuel tank brackets (Ref. 1). Also, to remove the lower step from a 45-gallon *long* fuel tank, remove the *inboard* button-head capscrews, bearing washers, and locknuts (Refs. 8 and 9) that attach the step and step brackets to the fuel tank brackets. Don't remove the outboard fasteners (Ref. 10) that attach the step to the step brackets. Remove the step.

To remove the *upper step* of a *dual-level* installation (Ref. 4), remove the capscrews and bearing washers (Ref. 2) that attach the step brackets to the sealed weldnuts (Ref. 3) on the fuel tank. Remove the step.

CHASSIS-ACCESS STEP

(Refer to Fig. 2)

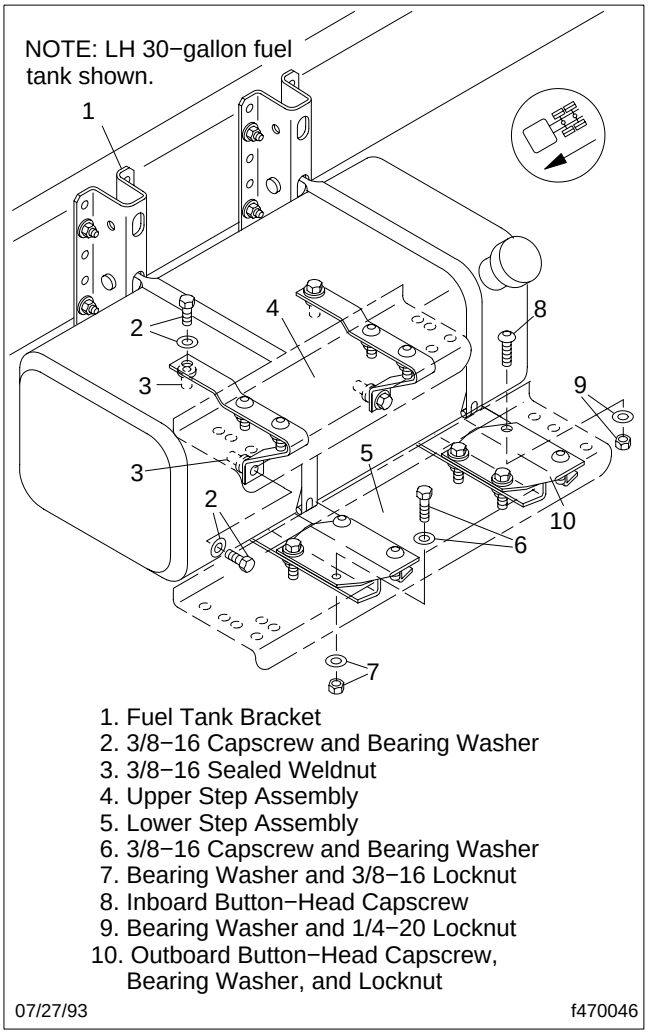
1. Remove the capscrews and bearing washers (Ref. 2) that attach the step clamps (Ref. 3) to the top of the fuel tank.
2. Remove the step. Remove the step clamps and fasteners from the step.

Installation

CAB-ACCESS STEP (Refer to Fig. 1)

NOTE: The procedures below are for step *assemblies* ; if the step and its brackets have been disassembled, use the procedures below to install the brackets, then **refer to Fig. 3,** or **Fig. 4** to position the step on the brackets.

To install a *single-level* step, or the *lower step* of a *dual-level* installation (Ref. 5), on the right-hand side of the vehicle, position the step brackets against the rear flanges of the outboard ends of the fuel tank brackets; on the left-hand side of the vehicle, position the step brackets against the front flanges of the fuel tank brackets. Install the capscrews, bearing washers, and locknuts (Refs. 6 and 7) that attach the step brackets to the tank brackets. Tighten the locknuts 38 N·m (28 lbf·ft). Also, for a lower step on a 45-gallon long fuel tank, install the inboard button-head capscrews, bearing washers, and locknuts (Refs. 8 and 9). Tighten the locknuts 10 N·m (7 lbf·ft).



1. Fuel Tank Bracket
2. 3/8−16 Capscrew and Bearing Washer
3. 3/8−16 Sealed Weldnut
4. Upper Step Assembly
5. Lower Step Assembly
6. 3/8−16 Capscrew and Bearing Washer
7. Bearing Washer and 3/8−16 Locknut
8. Inboard Button−Head Capscrew
9. Bearing Washer and 1/4−20 Locknut
10. Outboard Button−Head Capscrew, Bearing Washer, and Locknut

Fig. 1, Tank-Mounted Cab-Access Step Installation (dual-level steps shown)

To install the *upper step* of a *dual-level* installation (Ref. 4), align the fastener holes of the upper step brackets with the sealed weldnuts (Ref. 3) on the top and outboard side of the fuel tank. Install the capscrews and bearing washers (Ref. 2) that attach the step brackets to the fuel tank. Tighten the capscrews 35 N·m (26 lbf·ft).

Tank-Mounted Step Assembly Removal and Installation

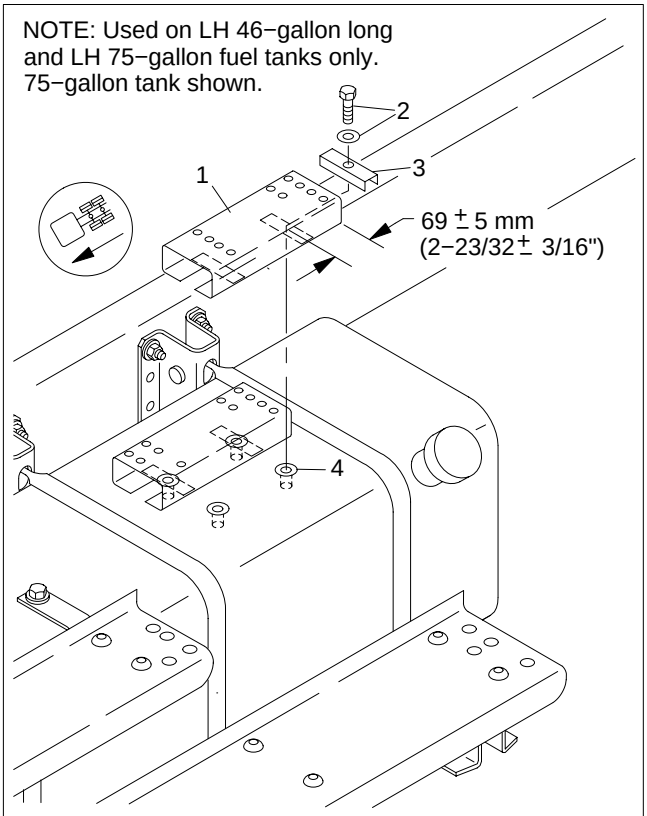


Fig. 2, Tank-Mounted Chassis-Access Step Installation

CHASSIS-ACCESS STEP

(Refer to Fig. 2)

1. Install the step clamps, capscrews, and bearing washers (Refs. 3 and 2) on the fuel tank; leave the fasteners loose. Turn the step clamps so they point to the front and rear of the truck (parallel to the frame rail).
2. Install the step on the fuel tank so the distance from the rear of the step to the center of the step clamp is 69 ± 5 mm (2-23/32 ± 3/16 inches).
3. Turn the step clamps so they point from side to side, and the ends are positioned over both bottom flanges of the step.
4. Tighten the step clamp capscrews 35 N·m (26 lbf·ft).

Tank-Mounted Step Assembly Removal and Installation

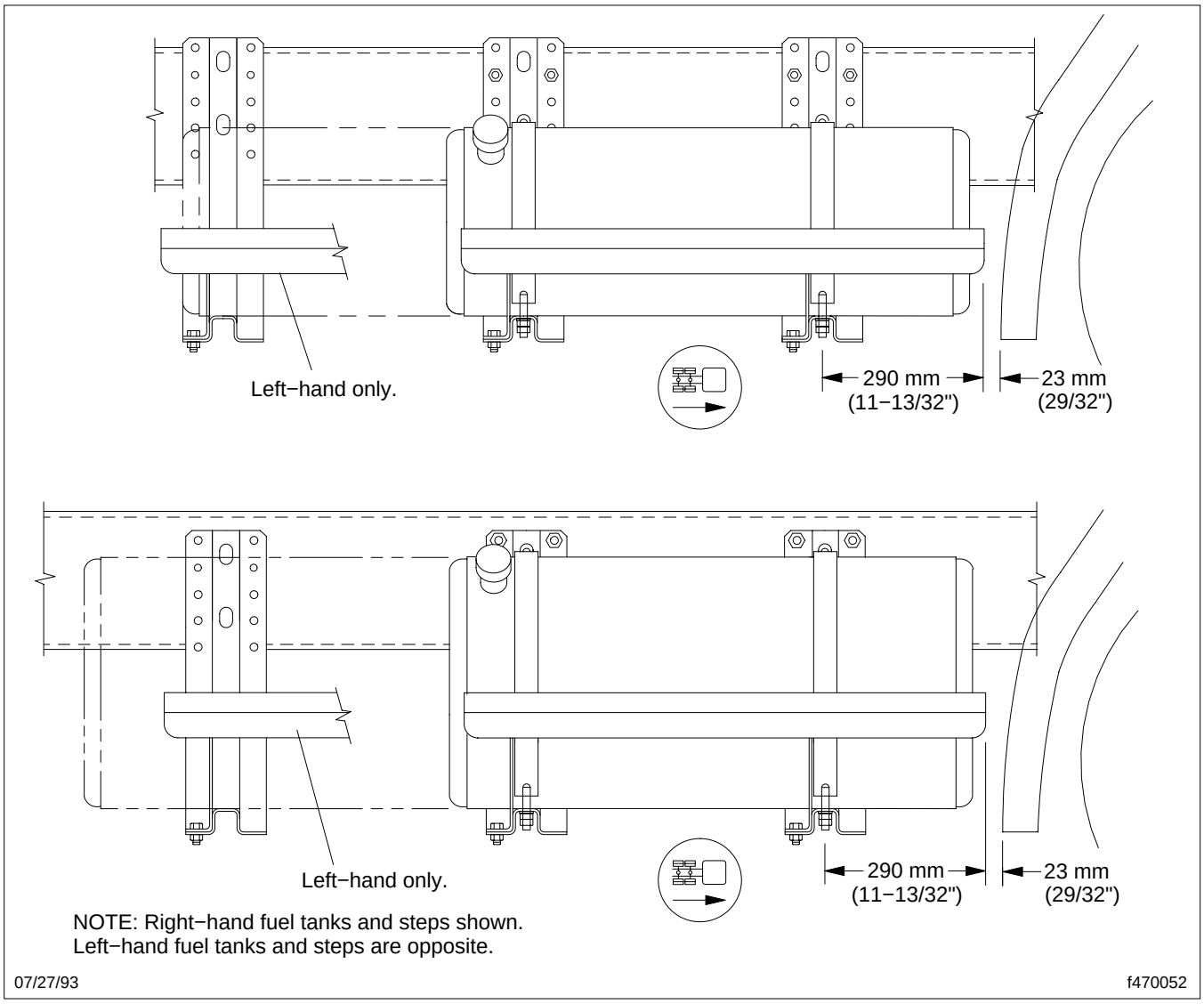


Fig. 3, Single-Level Cab-Access Step Positioning

Tank-Mounted Step Assembly Removal and Installation

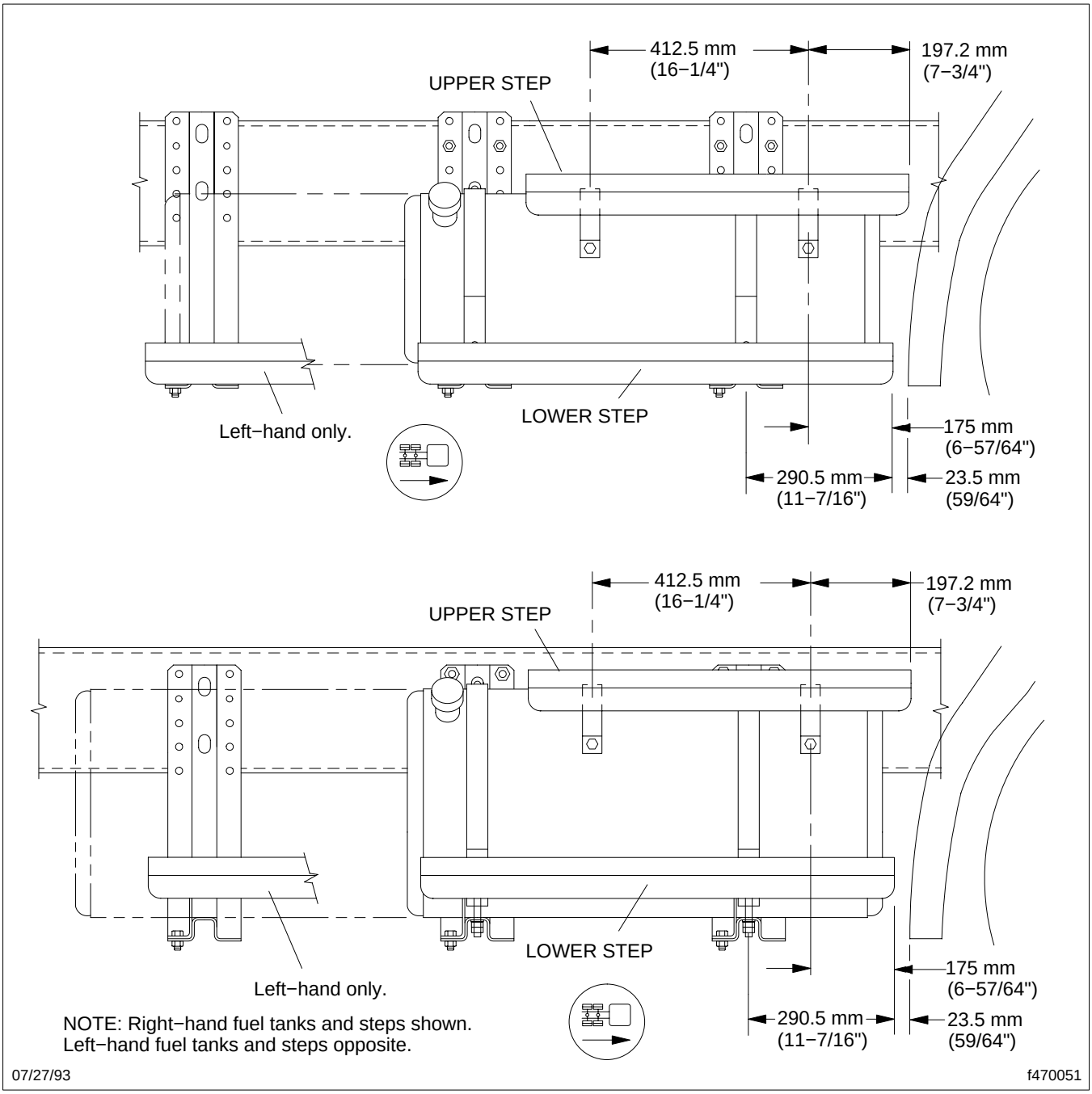


Fig. 4, Dual-Level Cab-Access Step Positioning

Removal (See Fig. 1, Fig. 2, Fig. 3, Fig. 4, or Fig. 5)

⚠ WARNING

Damaged fuel tanks must be replaced. A repaired fuel tank may not meet U.S. Federal strength, leakage, and venting standards required for all fuel tanks. A repaired fuel tank may be more likely to spill fuel or be ruptured in a vehicle accident, which could lead to personal injury or property damage.

If a damaged tank is found, use the following procedure:

1. Park the vehicle on level ground. Apply the parking brakes and chock the tires.
2. Remove the cab-access step(s); see **Subject 100**.

⚠ WARNING

Do not drain fuel near, or allow fuel vapor near, open flame or intense heat. Doing so is a dangerous practice, and creates a severe fire hazard. This could lead to personal injury, or property damage.

NOTE: Dual suction/dual return fuel systems on Business Class vehicles are not equipped with shut-off valves.

3. On a single-tank installation or a dual suction/dual return fuel system, place a suitable container under the fuel tank and remove the drain plug.

   On a dual-tank installation with a shut-off valve, place a suitable container under the fuel tank, close the fuel shutoff valve located on the primary fuel tank, then remove the drain plug.

   If the fuel is to be re-used, store it in a clean container to protect it from contaminants.
4. Disconnect the fuel return and suction lines from the tank; then cap the lines to prevent fuel spillage.

   On a dual-tank installation with a fuel crossover line, disconnect the fuel crossover line from the bottom of the tank that is to be removed; then cap the line.
5. If removing a single or primary tank, disconnect the wires from the fuel level gauge sender. See **Fig. 6.**
6. Remove the tank straps and isolators. See **Fig. 7.**

   6.1 Remove the nuts and washers from the tank strap T-bolts at the outboard end of the tank brackets.

   6.2 Remove the cotter pins and clevis pins from the inboard end of the tank straps. Remove the tank straps and isolators.
7. Using a fork lift, remove the fuel tank.
8. Inspect the tank straps, isolators, and brackets for wear and damage. Replace worn or damaged parts with new parts.

⚠ WARNING

Failure to replace worn or damaged parts could result in loss of a fuel tank and spilling of fuel, which could cause property damage or personal injury.

9. When replacing a fuel tank, remove all parts necessary to install the new fuel tank. Inspect the parts, and replace them as needed. Install all necessary components on the new fuel tank before installation.

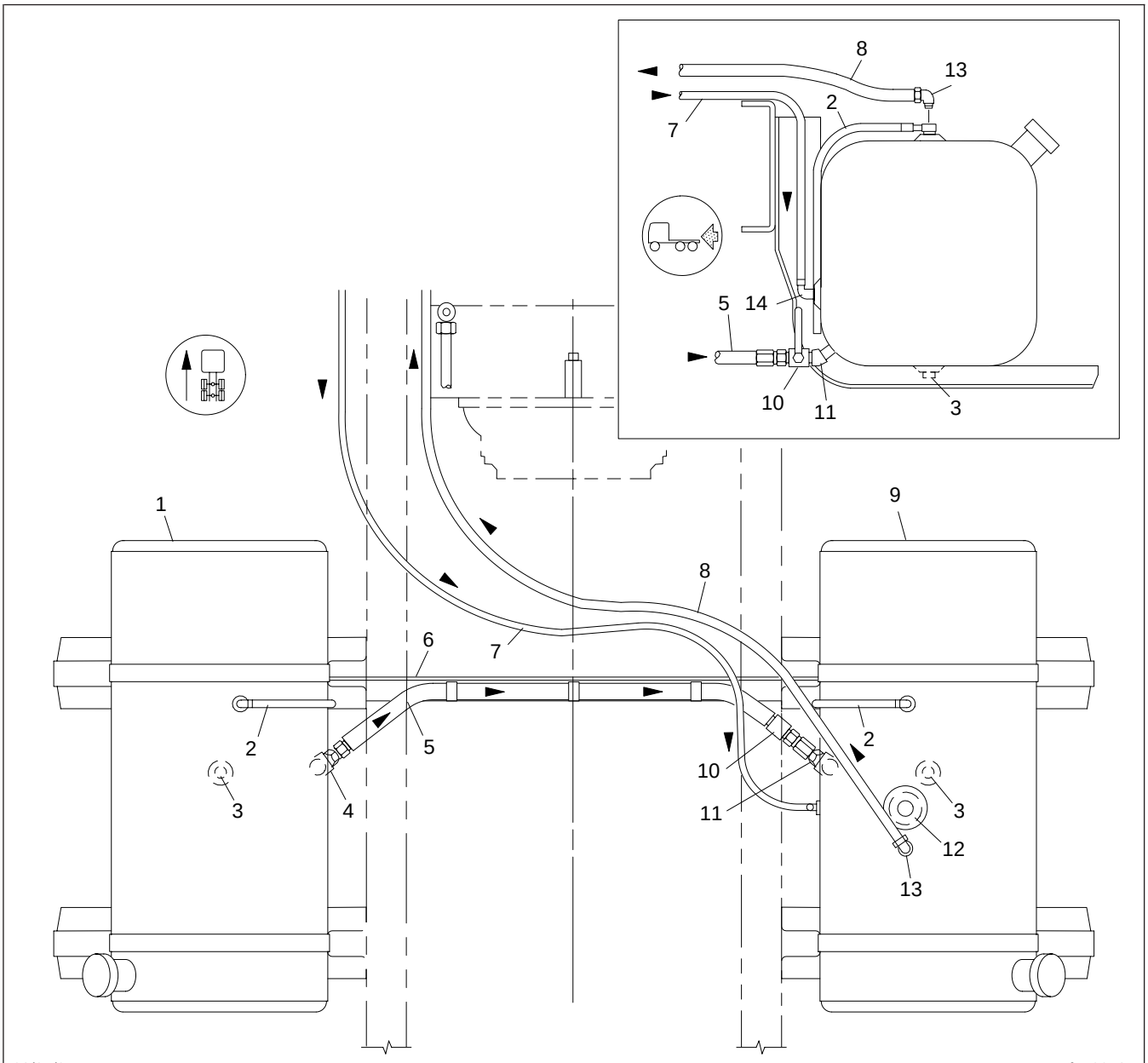
   9.1 Remove and clean all pipe plugs, fittings and lines, then transfer the components to the new fuel tank. Coat all tapered pipe plug and fitting threads with Loctite® 592, or an equivalent sealer.

   9.2 Inspect the vent line, then transfer it to the new fuel tank.

   9.3 Transfer the chassis-access steps to the new tank, if so equipped; see **Subject 100.**

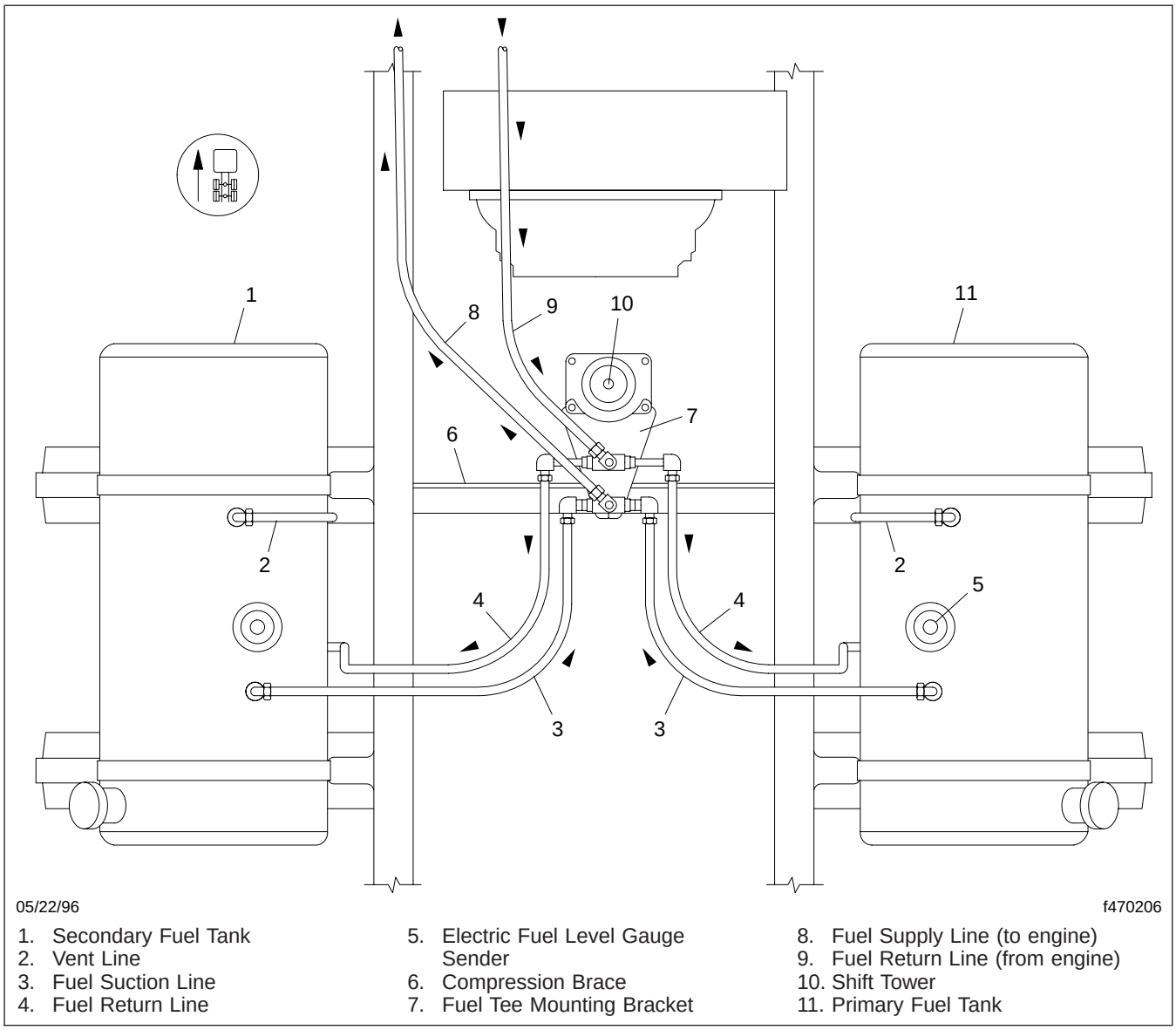
   9.4 If a single or primary fuel tank is being replaced, transfer the fuel level gauge sender and gasket to the new fuel tank. Install the machine screws until contact is made with the sender unit. Use a star pattern (see **Fig. 8**) to distribute the torque evenly around the sender unit.

Fuel Tank Removal and Installation



1. Secondary Fuel Tank
2. Vent Line
3. Drain
4. 45-Degree Elbow
5. Fuel Crossover Line
6. Compression Brace
7. Fuel Return Line
8. Fuel Suction (Supply) Line
9. Primary Fuel Tank
10. Fuel Shutoff Valve
11. 45-Degree Elbow
12. Electric Fuel Level Gauge Sender
13. 90-Degree Elbow (08 nylon x 06 MPT)
14. 90-Degree Elbow (06 nylon x 04 MPT)

Fig. 1, Fuel Tank Installation with Early-Style Single Suction/Single Return Fuel System



1. Secondary Fuel Tank
2. Vent Line
3. Fuel Suction Line
4. Fuel Return Line
5. Electric Fuel Level Gauge Sender
6. Compression Brace
7. Fuel Tee Mounting Bracket
8. Fuel Supply Line (to engine)
9. Fuel Return Line (from engine)
10. Shift Tower
11. Primary Fuel Tank

Fig. 2, Fuel Tank Installation with Early-Style Dual Suction/Dual Return Fuel System (Typical)

Installation (See Fig. 9)

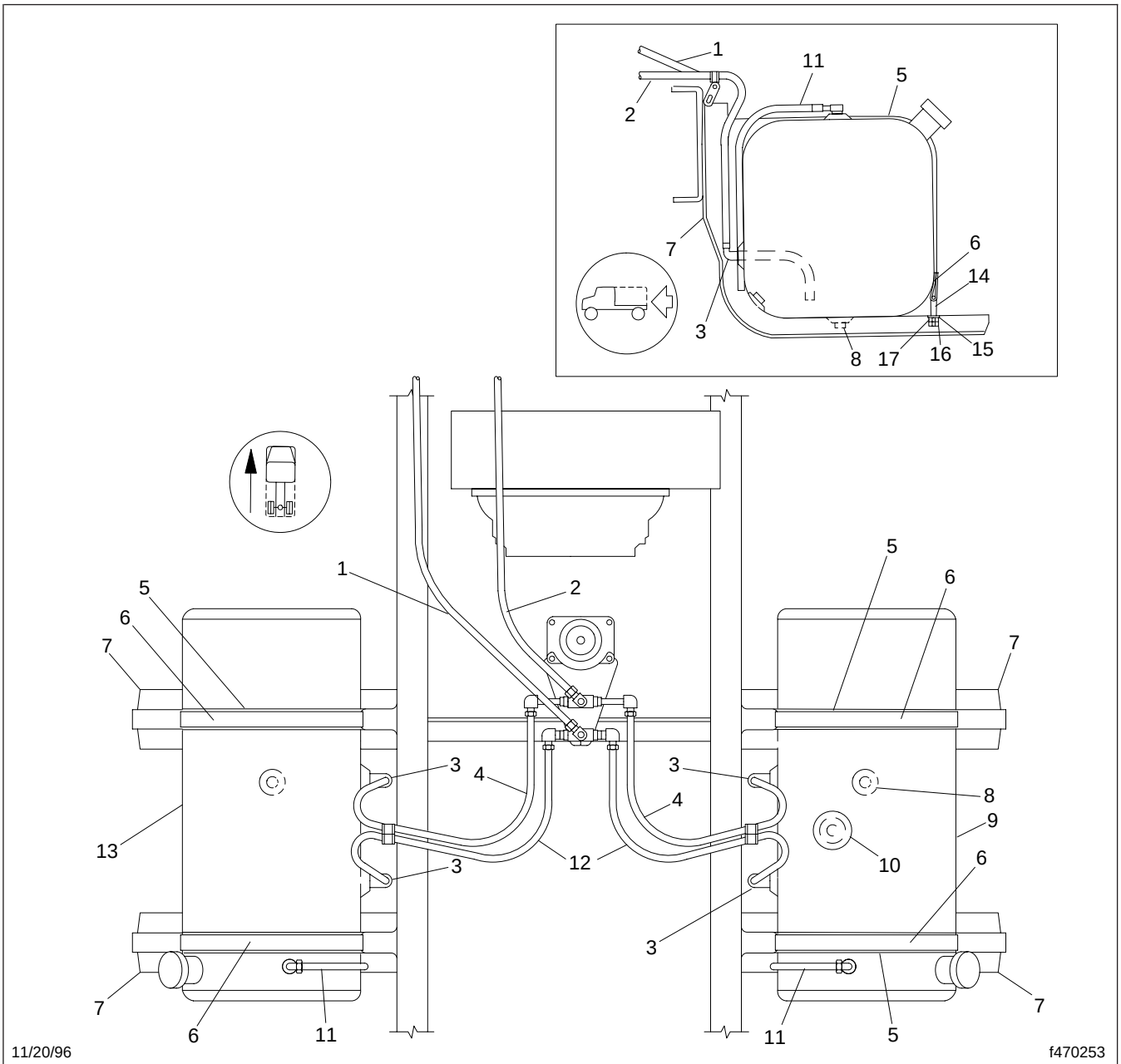
1. Using a fork lift, or other approved lifting device, and place the fuel tank in its approximate installed position. Make sure the fuel filler neck is outboard.

   Move the tank fore or aft until the distance from the front of the tank to the centerline of the forward tank bracket (Ref. B) is 10-13/16 ± 3/16 inches (275 ± 5 mm).

2. Install the isolators and tank straps. See **Fig. 7 .**

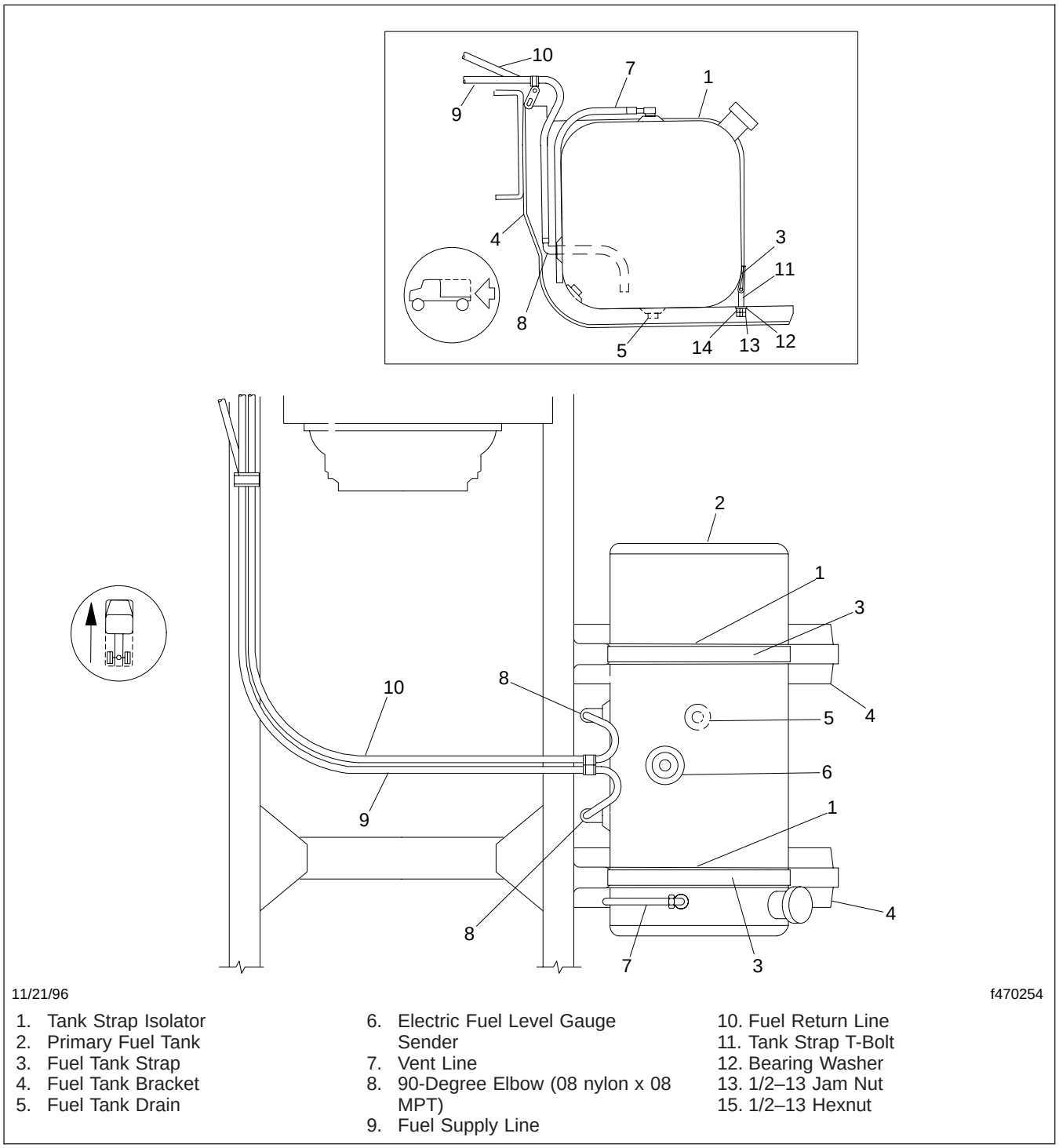
   2.1 Install the clevis pins through the inboard end of the tank brackets and tank straps. Install and lock new cotter pins in the clevis pins.

Fuel Tank Removal and Installation



1. Fuel Supply Line (to engine)
2. Fuel Return Line (from engine)
3. 90-Degree Elbow (08 nylon x 08 MPT)
4. Fuel Return Line
5. Tank Strap Isolator
6. Fuel Tank Strap
7. Fuel Tank Bracket
8. Fuel Tank Drain
9. Primary Fuel Tank
10. Electric Fuel Level Gauge Sender
11. Vent Line
12. Fuel Supply Line
13. Secondary Fuel Tank
14. Tank Strap T-Bolt
15. Bearing Washer
16. 1/2–13 Jam Nut
17. 1/2–13 Hexnut

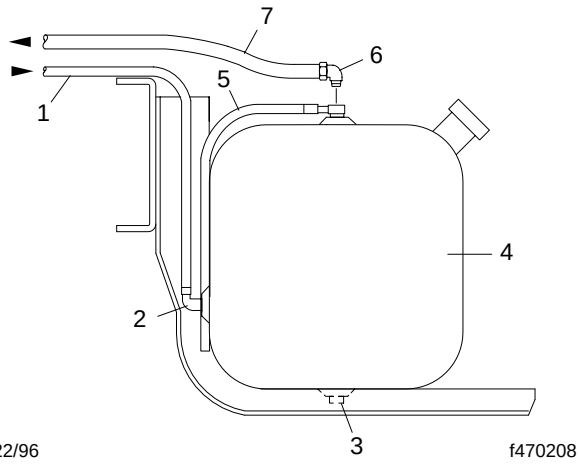
Fig. 3, Fuel Tank Installation with Later-Style Dual Suction/Dual Return Fuel System, (Typical)



1. Tank Strap Isolator
2. Primary Fuel Tank
3. Fuel Tank Strap
4. Fuel Tank Bracket
5. Fuel Tank Drain
6. Electric Fuel Level Gauge Sender
7. Vent Line
8. 90-Degree Elbow (08 nylon x 08 MPT)
9. Fuel Supply Line
10. Fuel Return Line
11. Tank Strap T-Bolt
12. Bearing Washer
13. 1/2–13 Jam Nut
15. 1/2–13 Hexnut

Fig. 4, Later-Style Fuel Tank Installation with Single Suction/Single Return Fuel System, (Typical)

Fuel Tank Removal and Installation



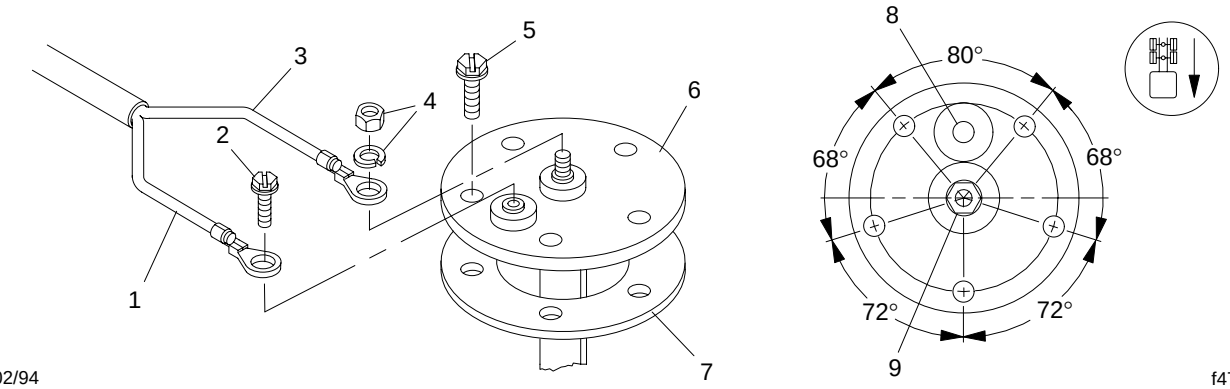
1. Fuel Return Line
2. 90-Degree Fitting
3. Fuel Tank Drain
4. Fuel Tank
5. Vent Line
6. 90-Degree Fitting
7. Fuel Suction Line

Fig. 5, Early-Style Fuel Tank Line Routing with Dual Suction/Dual Return Fuel System

2.2 Install a bearing washer and two nuts on each tank strap T-bolt. Tighten the first nuts 15 lbf·ft (20 N·m).

2.3 While holding the first nut stationary with a wrench, tighten each jam nut 30 lbf·ft (41 N·m).

3. Attach the wires to the fuel level gauge sender. Securely tighten the machine screw and hexnut.
4. Make certain the fuel lines are clean, then install them on their fittings on the fuel tank; see **Subject 150** for general guidelines. Coat all tapered pipe plug and fitting threads with Loctite 592, or an equivalent sealer. Install pipe plugs in any remaining open threaded holes.
5. Install the cab-access step(s); see **Subject 100**.
6. Add clean fuel to the fuel tank.
7. On a single suction/single return fuel system with dual fuel tanks, open the fuel shutoff valve.



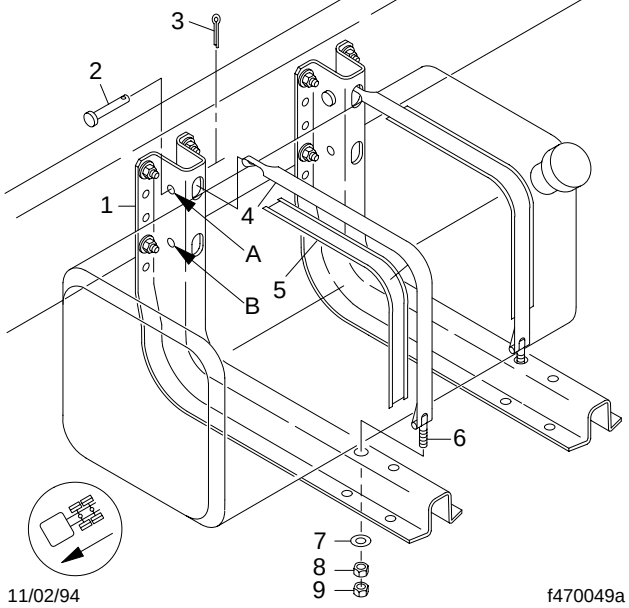
1. Ground Wire
2. 10–24 Machine Screw
3. Circuit 47 Wire
4. 10–32 Hexnut and Split Lockwasher
5. 10–32 Machine Screw
6. Electric Fuel Level Gauge Sender
7. Fuel Tank Gasket
8. 10–24 UNC–2B Threaded Hole (GND)
9. 10–32 UNF–2A Stud (sender)

Fig. 6, Fuel Level Gauge Sender Installation

CAUTION

Do not overtighten the fuel tank straps. To do so could damage the fuel tanks.

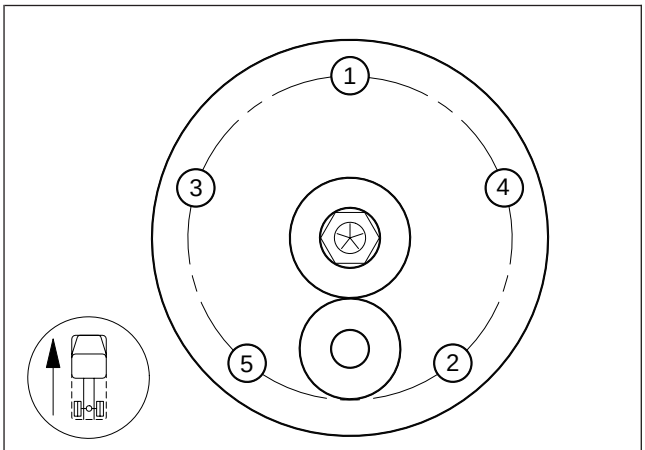
8. Prime the engine fuel pump; see **Subject 160**.
9. Remove the tire chocks.



A. Use for 45-gallon short tank (shown) or 75-gallon tank.
B. Use for 45-gallon long tank or 30-gallon tank.

1. Fuel Tank Bracket
2. Tank Strap Clevis Pin
3. Clevis Pin, Cotter Pin
4. Fuel Tank Strap
5. Tank Strap Isolator
6. Tank Strap T-Bolt
7. Bearing Washer
8. 1/2–13 Hexnut
9. 1/2–13 Jam Nut

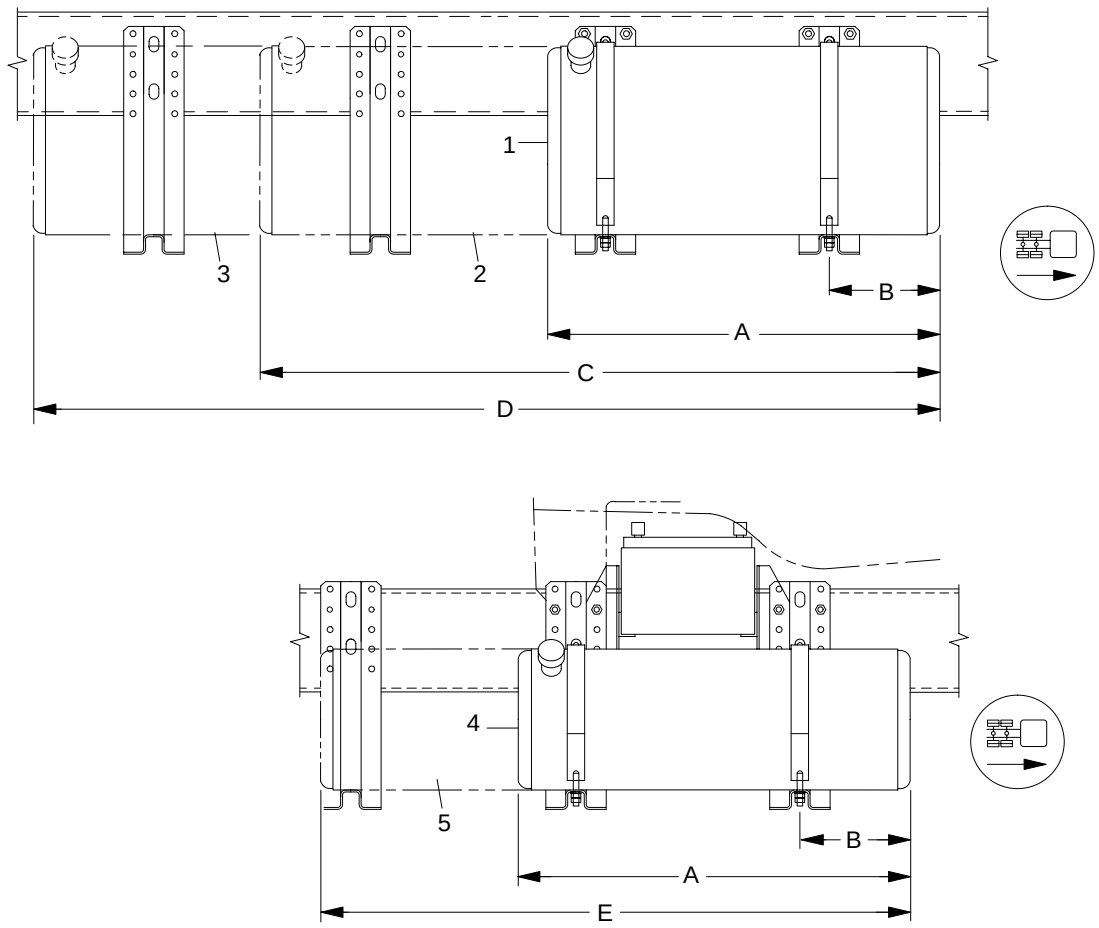
Fig. 7, Fuel Tank Brackets and Straps



NOTE: Tighten fuel level gauge sender as shown.

Fig. 8, Electric Fuel Level Gauge Sender Tightening Sequence

Fuel Tank Removal and Installation



11/19/96 f470050b

A. 38 inches (965 mm)
B. 10-13/16 ± 3/16 inches (275 ± 5 mm)
C. 64 inches (1626 mm)
D. 85 inches (2166 mm)
E. 57 inches (1448 mm)

1. 45 Gallon Short Tank
2. 75 Gallon Tank
3. 100 Gallon Tank
4. 30 Gallon
5. 45 Gallon Long Tank

Fig. 9, Fuel Tank Positioning

Fuel Tank Strap Replacement

Replacement (Refer to Fig. 1)

1. Apply the vehicle parking brakes and chock the tires.
2. Remove the cab-access step(s); **refer to Subject 100.**
3. Remove the fuel tank strap and isolator (Refs. 4 and 5).
   - 3.1 Remove the nuts and washer (Refs. 9, 8, and 7) from the tank strap T-bolt (Ref. 6) at the outboard end of the tank bracket.
   - 3.2 Remove the cotter pin and clevis pin (Refs. 3 and 2) from the tank strap eye at the inboard end of the tank bracket.
4. Inspect the isolator and clevis pin for wear or damage; replace if needed.

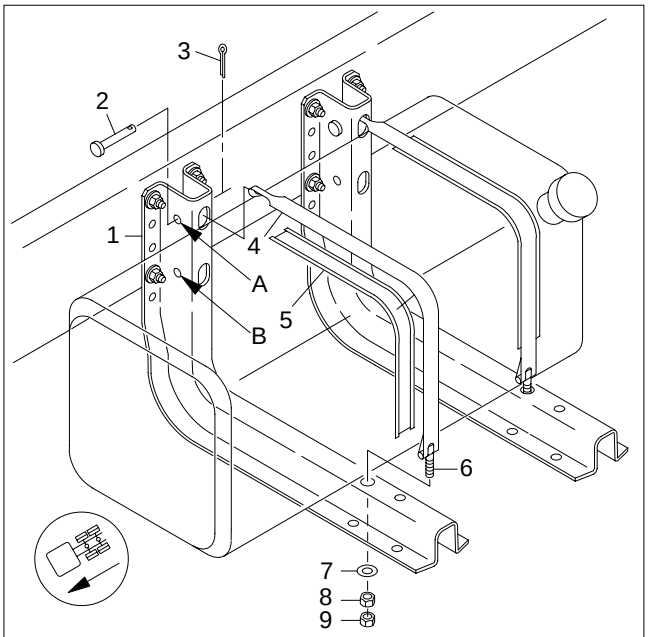
WARNING

WARNING: Failure to replace worn or damaged parts could result in loss of a fuel tank and spilling of fuel, which could cause property damage or personal injury.

5. Install the isolator and the new tank strap on the tank.
   - 5.1 Install the clevis pin (Ref. 2) through the inboard end of the tank bracket and tank strap. Install and lock a new cotter pin (Ref. 3) in the clevis pin.

   IMPORTANT: Fuel tanks can be damaged by overtightening the fuel tank straps.

   - 5.2 Install a bearing washer and two nuts on the tank strap T-bolt. Tighten the first nut 20 N·m (15 lbf·ft).
   - 5.3 While holding the first nut stationary with a wrench, tighten the jam nut 41 N·m (30 lbf·ft).
6. Install the cab-access step(s); **refer to Subject 100.**
7. Remove the tire chocks.



1. Fuel Tank Bracket
2. Tank Strap Clevis Pin
3. Clevis Pin Cotter Pin
4. Fuel Tank Strap
5. Tank Strap Isolator
6. Tank Strap T−Bolt
7. Bearing Washer
8. 1/2−13 Hexnut
9. 1/2−13 Jam Nut

A. Use for 45−gallon short tank (shown) or 75−gallon tank.

B. Use for 45−gallon long tank or 30−gallon tank.

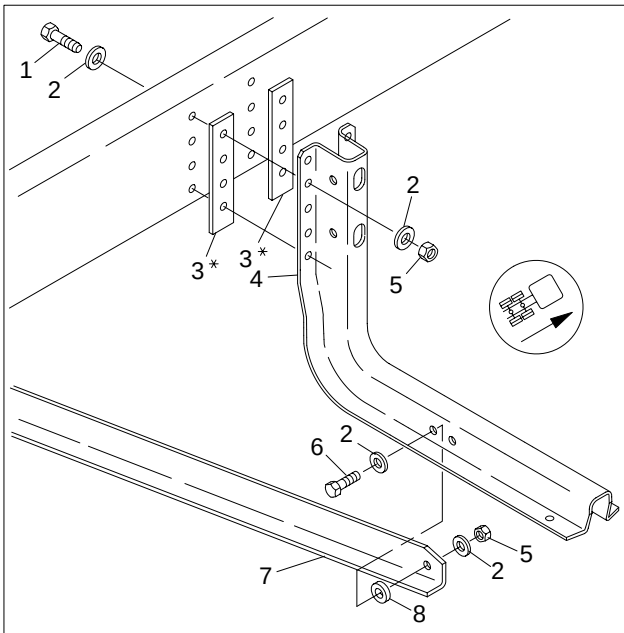
07/27/93 f470049

Fig. 1

Fuel Tank Bracket Replacement

Replacement (Refer to Fig. 1)

1. Remove the fuel tank; **refer to Subject 110.**
2. If the fuel tank bracket has a compression brace (Ref. 7) attached, remove the locknut, washers, spacer (Ref. 8), and capscrew that attach the brace to the bracket.
3. Remove the locknuts, hardened washers, and capscrews that attach the fuel tank bracket to the frame rail. Remove the bracket, and if so equipped, the fuel tank bracket spacers (Ref. 3).
4. From inside the frame rail, install the two upper capscrews and hardened washers. If so equipped, install the fuel tank bracket spacers onto the outboard ends of the capscrews. Position the new tank bracket on the capscrews, then install the two upper hardened washers and locknuts, finger-tight.
5. Install the two lower sets of fasteners. Tighten all of the locknuts 92 N·m (68 lbf·ft).
6. If a compression brace (Ref. 7) was attached to the bracket, install the capscrew, hardened washers, spacer (Ref. 8), compression brace, and locknut, **as shown in Fig. 1 .** Tighten the locknut 92 N·m (68 lbf·ft).
7. Install the fuel tank; **refer to Subject 110.**



1. 1/2−13 Capscrew
2. Bearing Washer
3. Fuel Tank Bracket Spacer *
4. Fuel Tank Bracket
5. 1/2−13 Locknut
6. 1/2−13 Capscrew
7. Compression Brace
8. Compression Brace Spacer

* Used with 14,000 and 16,000 lb front suspension when frame reinforcement isn't used.

07/27/93 f470057

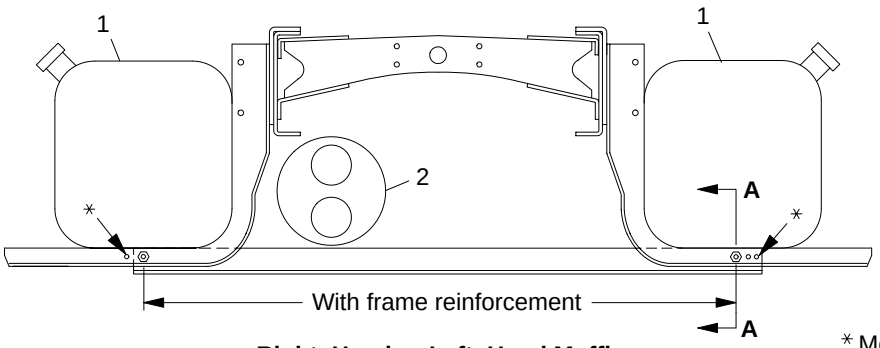
Fig. 1

Compression Brace Replacement

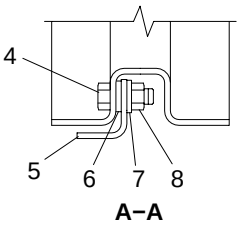
Replacement (Refer to Fig. 1)

1. Apply the vehicle parking brakes and chock the tires.
2. Remove the fasteners and clamps that attach the fuel crossover line to the compression brace.
3. Remove the locknuts, bearing washers, spacers (Ref. 6), and capscrews that attach the compression brace to the fuel tank brackets. Remove the compression brace.
4. Position the new compression brace, **as shown in Fig. 1 .** Install the capscrews, bearing washers, spacers, and locknuts, in the indicated mounting holes.
5. Tighten the locknuts 92 N·m (68 lbf·ft).
6. Install the clamps and fasteners that attach the fuel crossover line to the compression brace. Tighten the fasteners snugly.
7. Remove the chocks.

Compression Brace Replacement

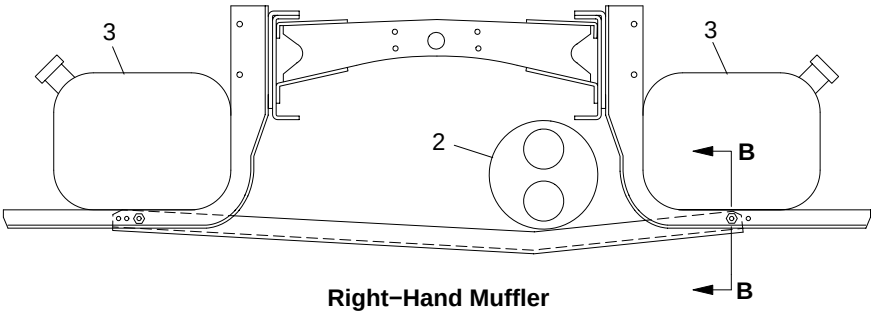


Right−Hand or Left−Hand Muffler

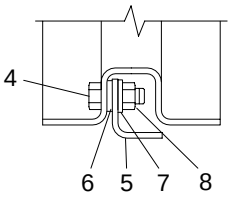


A−A

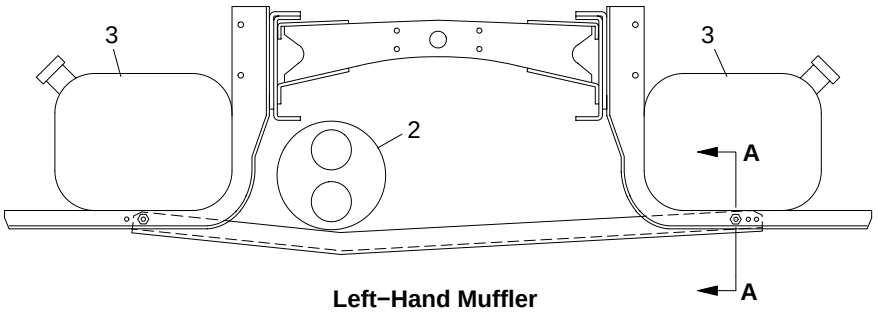
* Mounting location without frame reinforcement.



Right−Hand Muffler



B−B



Left−Hand Muffler

1. 45−Gallon Short or 75−Gallon Fuel Tank
2. Muffler
3. 45−Gallon Long or 30−Gallon Fuel Tank
4. 1/2−13 Capscrew
5. Compression Brace
6. Compression Brace Spacer
7. Bearing Washer
8. 1/2−13 Locknut

07/27/93 pf470054

Fig. 1

Diesel Fuel Lines

GENERAL GUIDELINES

If diesel fuel lines are worn, damaged, or deteriorated, replace them. Use the following guidelines for installing and routing them.

- Fuel lines must be free of droops, sharp bends, and kinks in the lines.
- Fuel lines must not extend more than 2 inches (5 cm) below the fuel tank unless they are completely enclosed in a protective housing.
- Fuel lines must be routed in a continuous upward slope from the fuel tank to prevent high and low spots in the hoses.
- Fuel lines must be routed at least six inches (15 cm) from exhaust pipes
- Heat shields and/or hose insulation must be used to protect any section of fuel line that is less than six inches (15 cm) from a heat source.
- Fuel lines must be routed to allow routinely serviceable components such as dipsticks, filters, and water separators to be readily accessed without the need to disconnect the fuel lines.
- Fuel lines must be secured to prevent chafing, kinking, or other damage.
- Fuel lines must be long enough to allow movement of the parts to which they are attached.
- Coat all pipe threads (tapered threads) with Loctite® 592, or an equivalent.
- Finger-tighten pipe fittings; then tighten one and one half turns. Tighten more if necessary to seal.
- Fuel lines and fittings must be free of leaks, to prevent fuel loss or entry of air into the line, which may result in a loss of prime by the engine fuel system.
- Drains or other bottom fittings must not extend more than 3/4 inch (19 mm) below the lowest part of the fuel tank or sump.

Gasoline Fuel Lines and Clamps

GENERAL GUIDELINES FOR LINES AND CLAMPS

The gasoline-powered engines used on Freightliner vehicles use a fuel injection system. This system requires fuel lines, tubes and clamps of special construction.

The fuel lines and tubes must withstand higher fuel pressures and the possibility of contaminated fuel in this system. Only lines and tubes marked EFM/EFI may be used.

The hose clamps on fuel-injected vehicles are of a special rolled-edge construction. This prevents the edge of the clamp from cutting into the hose and causing leaks. Do not use other types of clamps.

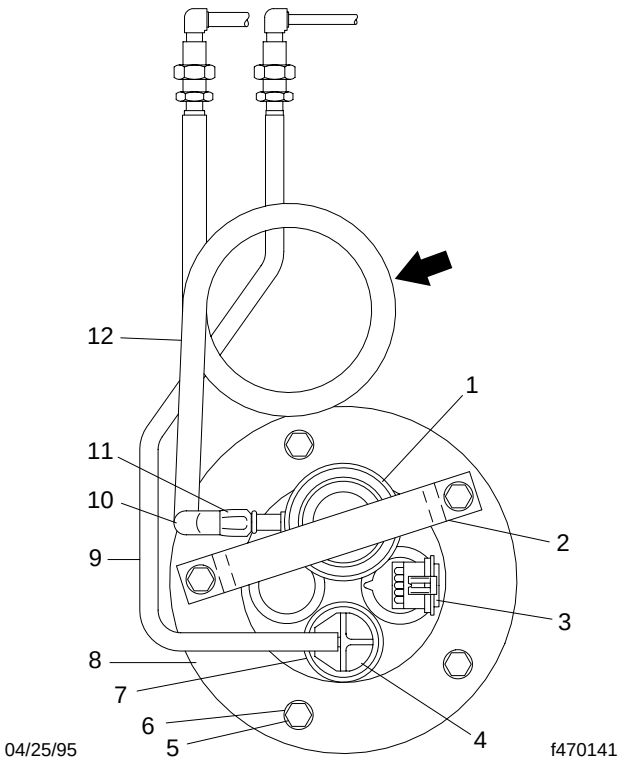
Inspect the fuel system using the following guidelines.

⚠ WARNING

WARNING: Release the fuel system pressure before servicing any fuel system lines, tubes, or fittings. Otherwise fuel could spray out, possibly resulting in severe personal injury and property damage, including fire.

1. Release the fuel system pressure. For instructions, refer to **Subject 170**.
2. Inspect all fuel lines to be sure they are free from sharp bends or kinks, and are not in contact with other vehicle components so as to cause scuffing or abrasion. Replace any bent or kinked lines.
3. Secure all fuel lines to prevent chafing, kinking, or other damage.
4. Check the length of all fuel lines. They must be long enough to allow movement of the parts to which they attach. Check that the fuel supply line is looped correctly where it attaches to the fuel pump module. See **Fig. 1.**
5. Inspect all fuel lines, clamps, couplings, and fittings for leaks. Inspect all clamps, couplings, and fittings for security. Immediately replace any component that shows signs of failure, or damage that could lead to failure. Tighten new clamps 15 lbf·in (170 N·cm).

Fuel Line Routing



Loop the fuel supply line as shown.

1. Fuel Filter/Pressure Regulator
2. Fuel Pump Guard Bracket
3. Pump/Gauge Electrical Connector
4. Pressure Relief/Rollover Valve
5. 5/16–18 Clamp Ring Mounting Capscrew (Grade 8)
6. Hardened Flatwasher
7. Rollover Valve Grommet
8. Fuel Pump Mounting Clamp Ring
9. Evaporative Canister Line
10. 90° Elbow
11. Fuel Supply Line Fitting
12. Fuel Supply Line

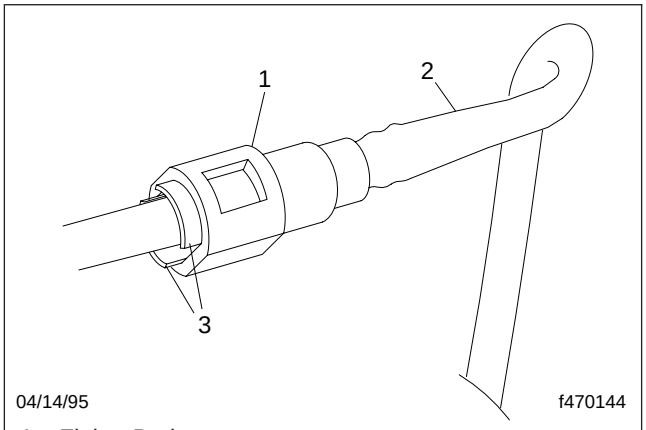
Fig. 1, Fuel Supply Line

6. Be sure that all nylon fuel tubes are properly routed, not pinched, and far enough away from sources of heat. Replace as necessary.

IMPORTANT: Never attempt to repair a nylon fuel tube.

QUICK-DISCONNECT FITTINGS

Gasoline fuel lines are equipped with quick-disconnect fittings to allow easy and fast connections. These fittings contain a plastic retainer with two external tabs, one on each side of the fitting. See **Fig. 2.**



1. Fitting Body
2. Fuel Line
3. Plastic Retainer Tab

Fig. 2, Quick-Disconnect Fitting

1. Disconnect the batteries.

WARNING

WARNING: Release the fuel system pressure before servicing any fuel system quick-disconnect fittings. Otherwise fuel could spray out, possibly resulting in severe personal injury and property damage, including fire.

2. Release the fuel system pressure. For instructions, refer to **Subject 170**
3. Clean the fitting of any foreign material such as grease or oil.
4. To disconnect the line at the fuel rail, squeeze the two tabs on the plastic retainer against the sides of the fitting, using finger pressure only. Remove the line and fitting body, leaving the retainer on the fuel rail.

NOTE: To remove the plastic retainer, if necessary, very carefully release it from the component using two small screwdrivers. Inspect the retainer after removal for cracks or damage.

5. Inspect the plastic retainer and the body of the quick-connect fitting for damage. Replace if necessary.

IMPORTANT: Do not attempt to replace any interior components (O-rings, spacers) of the quick-disconnect fitting. If repair is needed, replace the complete fitting.

6. Check the condition of the fitting and the component. Clean all parts with a lint-free cloth. Lubricate them with clean engine oil.
7. To connect, insert the fitting into the component and into the plastic retainer. When you hear a click, the connection has been made. Pull firmly on the fuel tube to make sure the connection is locked.

NOTE: A locked fitting should resist a pull of approximately 15 to 30 lbf (65 to 130 N).

8. Connect the batteries.
9. Start the engine and check for leaks.

Priming

Before priming the system, make sure there is enough fuel in the tank(s). Don't fill them to more than 95 percent of capacity.

⚠ WARNING

WARNING: Federal regulations prohibit filling a fuel tank to more than 95 percent of its capacity. A tank with air space is much less likely to rupture in an accident than one that has little or no air space. Fuel tank rupture could result in fuel spillage and a hazardous condition.

Don't crank the starter more than 30 seconds at a time during any of the following procedures; wait 2 minutes after each try to allow the starter to cool, or starter damage may occur.

1. If the engine is equipped with a priming pump, use it to prime the fuel transfer pump.
   - 1.1 Operate the priming pump plunger until there is resistance.
   - 1.2 Push the plunger in and tighten it by hand.
   - 1.3 Start the engine; if it doesn't start, more priming is needed. Once the engine has started, it may run rough; if so, run the engine at low idle until it runs smoothly.
2. If the engine isn't equipped with a priming pump, pressurize the fuel in the fuel tank, to prime the fuel transfer pump.
   - 2.1 Remove the fuel tank cap from the primary tank.
   - 2.2 Loosen the fuel supply line at the fuel transfer pump.
   - 2.3 While someone else looks for a constant fuel flow at the loosened fuel supply line, partially block the fuel tank opening with a clean rag, and use an air hose to apply no more than 35 kPa (5 psi) air pressure to the fuel tank.
   - 2.4 When the fuel flow is constant, remove the air hose and rag, and tighten the fuel supply line.

IMPORTANT: To prevent fuel loss or entry of air into a fuel line, make sure that all fuel line connections are tight.

- 2.5 Start the engine. Once the engine has started, it may run rough. If this occurs, run the engine at low idle until it runs smoothly.

Gasoline Fuel Tank Removal and Installation

Removal

If there is any damage to the fuel tank, *replace* it; *do not repair* fuel tanks.

⚠ WARNING

WARNING: Damaged fuel tanks must be replaced. A repaired fuel tank will not meet the strength, leakage, and venting standards required by U.S. Federal regulations for original and replacement fuel tanks. A repaired fuel tank may be more likely to rupture from impact, possibly causing fire and resulting in personal injury or property damage.

1. Apply the vehicle parking brakes and chock the tires.

IMPORTANT: The gasoline-powered engine uses a returnless fuel system. Even when the engine is shut down, the fuel system is under constant pressure.

2. Release the pressure on the fuel system.

   2.1 Disconnect the batteries.

   2.2 Remove the fuel tank filler cap. This releases fuel tank pressure.

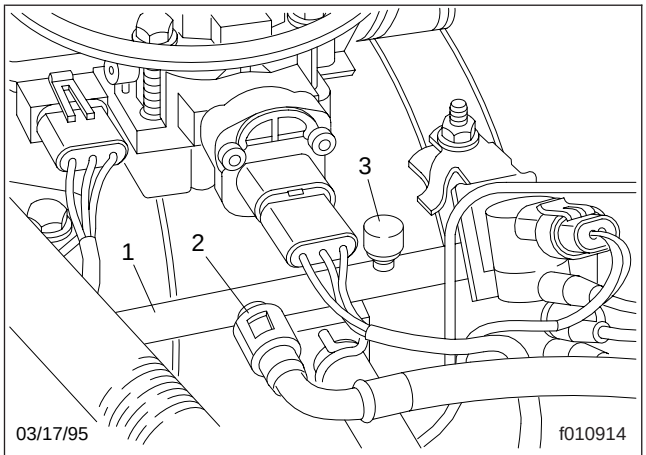
   IMPORTANT: Do not allow gasoline to spill onto the engine intake or exhaust manifolds. To absorb the gasoline, place shop towels under and around the pressure port when the pressure is released from the fuel rail.

   2.3 Unscrew the protective plastic cap from the pressure test port on the fuel rail (**see Fig.1**).

⚠ WARNING

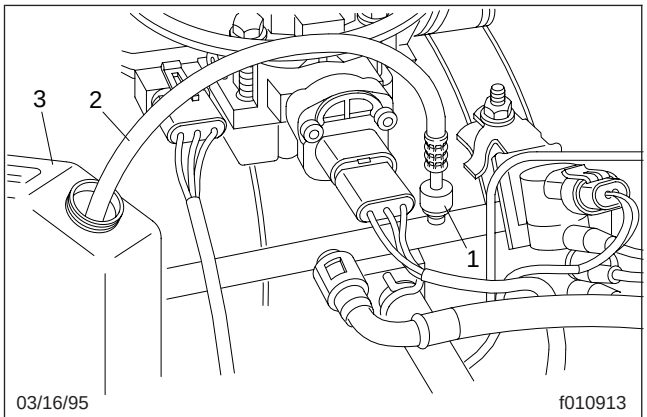
WARNING: Always wear proper eye protection when releasing fuel system pressure. Fuel squirted or splashed into the eyes can cause injury.

   2.4 Obtain fuel pressure gauge tool set #5069. To order this tool set, call the Kent-Moore Tool Company at 1-800-328-6657. Remove the gauge from the hose. Place one end of the hose into an approved gasoline container. Place a shop towel under the test port. **See Fig.2.**



1. Fuel Rail
2. Fuel Line
3. Test Port Protective Cap

Fig. 1, Pressure Test Port



1. Test Port
2. Test Hose
3. Vented Gasoline Can

Fig. 2, Release Fuel System Pressure

   2.5 Screw the other end of the hose onto the fuel pressure test port and allow the gasoline to run into the container until the pressure is fully released.

   2.6 Remove the hose from the test port and return it to tool set #5069.

   2.7 Install the protective cap on the test port.

Gasoline Fuel Tank Removal and Installation

WARNING

WARNING: Gasoline is highly flammable. Do not drain gasoline near, or expose gasoline vapor to, open flame or intense heat. This could lead to personal injury or property damage by fire.

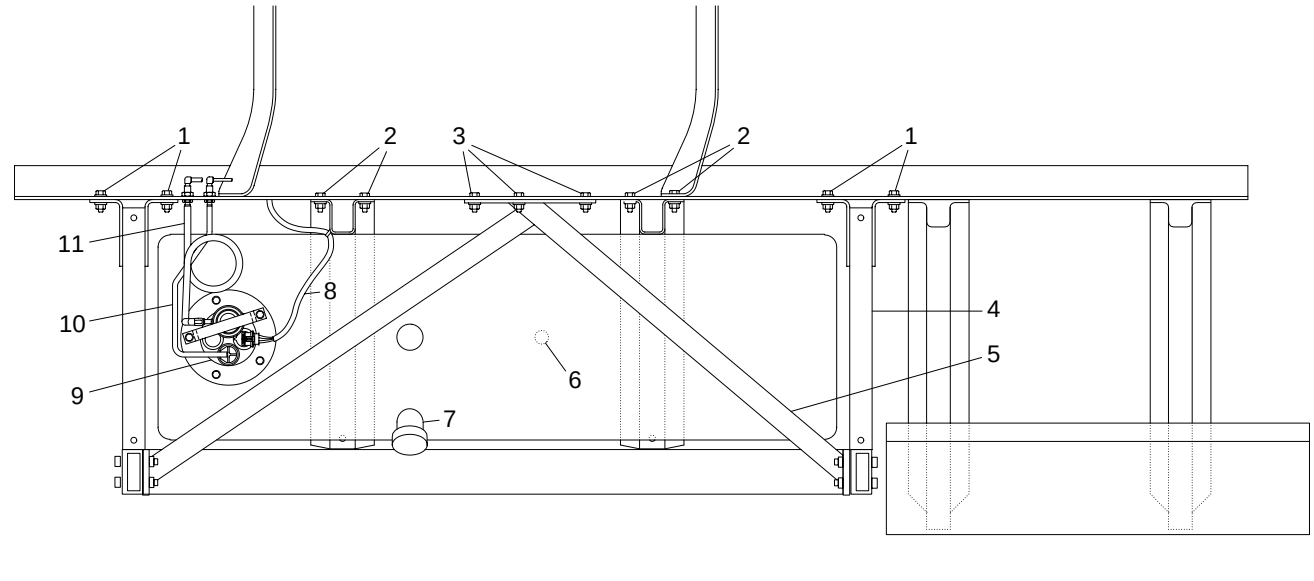
3. Remove the drain plug (**see Fig.3**, Ref. 6). Drain the fuel tank.

   If the gasoline is to be saved, store it in a clean container, and protect it from contaminants. Move the container away from the work area.

First determine the vehicle's configuration, and then refer to the appropriate removal method below.

Vehicles with Open Frame

1. Disconnect the electrical connector and fuel lines from the fuel pump module. Then, remove the fuel pump module from the tank. For a detailed removal procedure, refer to **Subject 100** in the Chrysler fuel pump module section.
2. Remove the mounting locknuts and capscrews.



05/04/95 f470143

1. End Bracket Bolts
2. Fuel Tank Bracket Bolts
3. Top Brace Bolts
4. End Bracket
5. Top Brace
6. Drain Plug
7. Fuel Filler Neck
8. Electrical Cable
9. Fuel Pump Module
10. Evaporative Canister Line
11. Fuel Supply Line

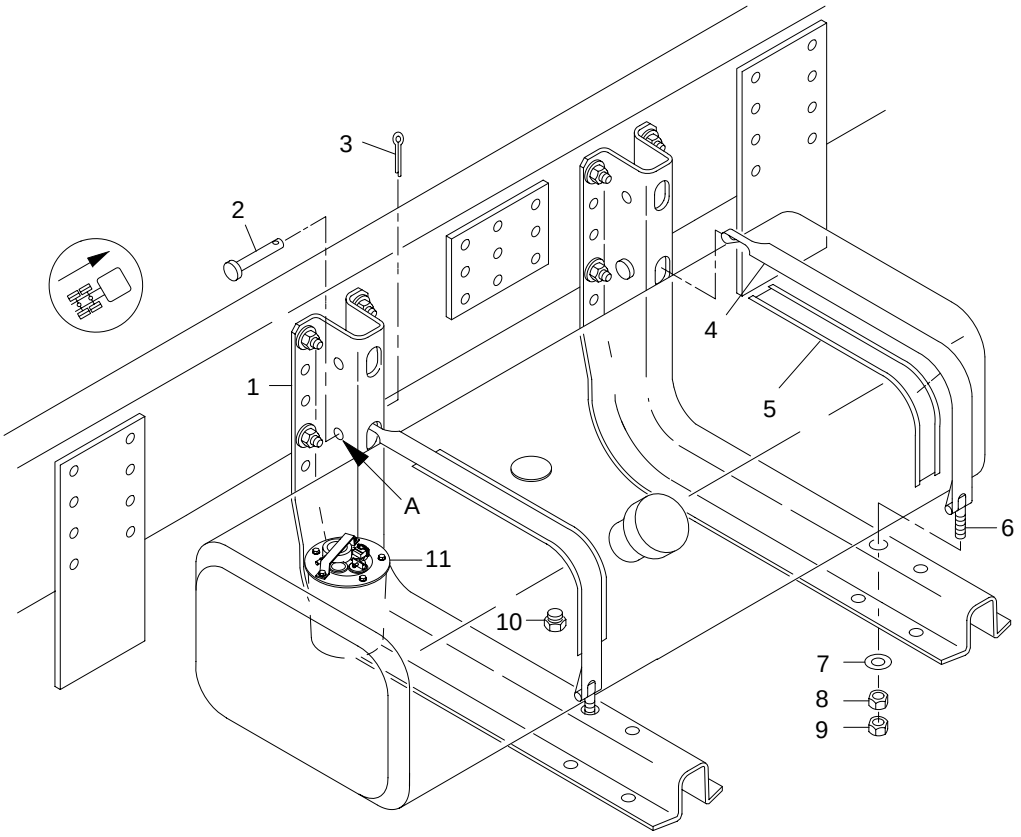
Fig. 3, Rectangular Fuel Tank (installed)

IMPORTANT: The removal of the fuel tank is affected by the configuration of the vehicle. The three configurations are:

- open frame;
- box with a bolted tank assembly;
- box with Huckbolted tank assembly.

3. Remove the top brace bolts from the top brace bracket and the outboard end of each end bracket. Remove the top braces (upper cage assembly) from the vehicle.
4. Remove the tank straps and isolators. **See Fig.4.**

   4.1 From each tank strap T-bolt (Ref. 6), fastened to the outboard end of the tank brackets, remove the nuts and bearing washers (Refs. 9, 8, and 7).



09/18/95 f470142

NOTE: Lower cage assembly removed for clarity.

A. Use the lower set of holes in the tank bracket for attaching the fuel tank straps.

1. Fuel Tank Bracket
2. Tank Strap Clevis Pin
3. Tank Strap Cotter Pin
4. Fuel Tank Strap
5. Tank Strap Isolator
6. Tank Strap T-Bolt
7. Bearing Washer
8. 1/2–13 Hexnut
9. 1/2–13 Jam Nut
10. Drain Plug
11. Fuel Pump Module

Fig. 4, Fuel Tank Removal and Installation

4.2 Remove the cotter pins and clevis pins (Refs. 3 and 2) from the inboard end of each tank strap. Remove the tank straps and isolators.

5. Lift the fuel tank out of the fuel tank cage.

6. Inspect the tank straps, isolators, and brackets for wear and damage.

⚠ WARNING

WARNING: Replace worn or damaged parts. Failure to replace worn or damaged parts could result in loss of a fuel tank and spilling of fuel, which could cause personal injury or property damage.

7. If a fuel tank is being replaced, remove parts from the old tank that will be needed on the new tank. Inspect the parts, and replace them if necessary. Install them on the new tank. If neces-

Gasoline Fuel Tank Removal and Installation

sary, install near the fuel filler neck a new decal reading "unleaded fuel only."

7.1 Remove and clean all pipe plugs and fittings, and transfer them to the new tank. Clean all parts with a lint-free cloth. Lubricate them with clean engine oil.

IMPORTANT: Loop the fuel supply line during the next step in the installation procedure. **See Fig.5.**

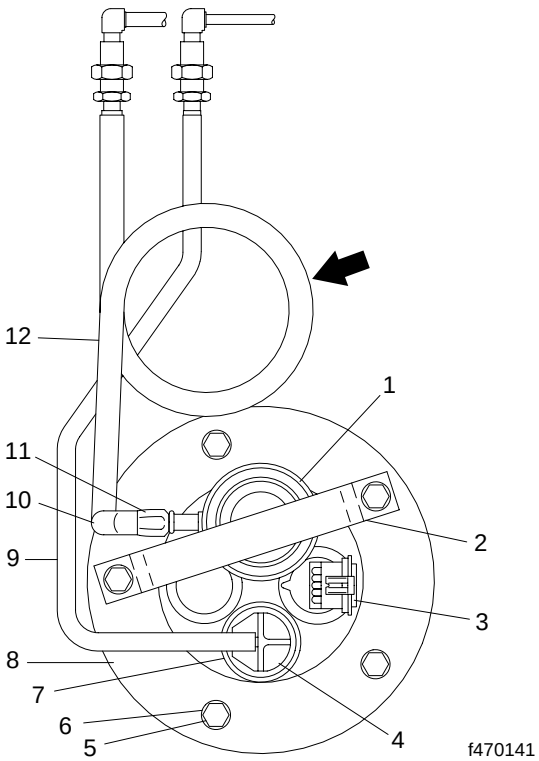
7.2 Install the fuel pump module to the new tank. **See Fig.5.** For a detailed installation procedure, refer to **Subject 100** in the Chrysler fuel pump module section. Securely and evenly tighten the clamp ring mounting capscrews 20 N·m (15 lbf·ft).

Vehicles With Box and Bolted Fuel Tank Assemblies Installed

1. Disconnect the electrical connector and fuel lines from the fuel pump module. Then, remove the fuel pump module from the tank. For a detailed removal procedure, refer to **Subject 100** in the Chrysler fuel pump module section.
2. Remove the fuel tank cage. To do so, use the following instructions:
   - 2.1 Support the cage assembly with a forklift or other lifting device;
   - 2.2 Unbolt the cage assembly from the frame rail;
   - 2.3 Remove the cage from the vehicle.
3. Remove the tank straps and isolators. **See Fig.4.**
   - 3.1 From each tank strap T-bolt (Ref. 6), fastened to the outboard end of the tank brackets, remove the nuts and bearing washers (Refs. 9, 8, and 7).
   - 3.2 Remove the cotter pins and clevis pins (Refs. 3 and 2) from the inboard end of each tank strap. Remove the tank straps and isolators.

NOTE: Do not remove the fuel tank brackets.

4. Remove the fuel tank from the vehicle.
5. Inspect the tank straps, isolators, and brackets for wear and damage.



NOTE: It is important to loop the fuel supply line as shown.

1. Fuel Filter/Pressure Regulator
2. Fuel Pump Guard Bracket
3. Pump/Gauge Electrical Connector
4. Pressure Relief/Rollover Valve
5. 5/16–18 Clamp Ring Mounting Capscrew (Grade 8)
6. Hardened Flatwasher
7. Rollover Valve Grommet
8. Fuel Pump Mounting Clamp Ring
9. Evaporative Canister Line
10. 90° Elbow
11. Fuel Supply Line Fitting
12. Fuel Supply Line

Fig. 5, Fuel Pump Module (Top View)

WARNING

WARNING: Replace worn or damaged parts. Failure to replace worn or damaged parts could result in loss of a fuel tank and spilling of fuel, which could cause personal injury or property damage.

6. If a fuel tank is being replaced, remove parts from the old tank that will be needed on the new tank. Inspect the parts, and replace them if necessary. Install them on the new tank. If necessary, install near the fuel filler neck a new decal reading "unleaded fuel only."

    6.1 Remove and clean all pipe plugs and fittings, and transfer them to the new tank. Clean all parts with a lint-free cloth. Lubricate them with clean engine oil.

    6.2 Install the fuel pump module to the new tank. **See Fig.5.** For a detailed installation procedure, refer to **Subject 100** in the Chrysler fuel pump module section. Securely and evenly tighten the clamp ring mounting capscrews 20 N·m (15 lbf·ft).

Vehicles With Box and Huckbolted Fuel Tank Assemblies Installed

1. Disconnect the electrical connector and fuel lines from the fuel pump module. Then, remove the fuel pump module from the tank. For a detailed removal procedure, refer to **Subject 100** in the Chrysler fuel pump module section.

NOTE: Use a gas cutting torch and a grinder to remove the Huckbolts.

2. To prepare the fuel tank and the vehicle for removal of the Huckbolts, use the following instructions:

    2.1 Flush the fuel tank with water for several minutes;

    2.2 Fill the fuel tank with water;

    2.3 Flush the adjacent portion of the vehicle and the surrounding area with water;

    2.4 Allow the water on the vehicle and the work area to dry.

⚠ WARNING

WARNING: Do not use a flame or a grinder near a gasoline tank unless the tank has been flushed and filled with water, and the surrounding area has been flushed with water. Otherwise, an explosion or fire could result, causing serious person injury or death.

    2.5 Burn and grind seven of the nine Huckbolts attaching the fuel tank brackets. (Leave one Huckbolt holding each bracket). Work on either side of the frame rail, whichever offers the best access;

    2.6 Install a nut and bolt to hold each bracket before removing the last Huckbolts;

    2.7 Remove the last Huckbolts with the torch and grinder;

    2.8 Drain the water from the tank, and position a forklift or other lifting device under the tank.

3. Remove the tank straps and isolators. **See Fig.4.**

    3.1 From each tank strap T-bolt (Ref. 6), connected to the outboard end of the tank brackets, remove the nuts and bearing washers (Refs. 9, 8, and 7).

    3.2 Remove the cotter pins and clevis pins (Refs. 3 and 2) from the inboard end of each tank strap. Remove the tank straps and isolators.

    3.3 Remove the temporary bolts holding the brackets.

4. Lower the fuel tank out of the fuel tank cage. Remove the fuel tank from the vehicle.

NOTE: During the lowering procedure, the fuel tank may need to be rotated slightly so that the filler tube clears the cage assembly.

5. Inspect the tank straps, isolators, and brackets for wear and damage.

⚠ WARNING

WARNING: Replace worn or damaged parts. Failure to replace worn or damaged parts could result in loss of a fuel tank and spilling of fuel, which could cause personal injury or property damage.

6. If a fuel tank is being replaced, remove parts from the old tank that will be needed on the new tank. Inspect the parts, and replace them if necessary. Install them on the new tank. If necessary, install near the fuel filler neck a new decal reading "unleaded fuel only."

Gasoline Fuel Tank Removal and Installation

6.1 Remove and clean all pipe plugs and fittings, and transfer them to the new tank. Clean all parts with a lint-free cloth. Lubricate them with clean engine oil.

6.2 Transfer the fuel pump module to the new tank. **See Fig.5.** For a detailed installation procedure, refer to **Subject 100** in the Chrysler fuel pump module section. Securely and evenly tighten the clamp ring mounting capscrews 20 N·m (15 lbf·ft).

7. If the old tank, which was filled with water, is to be installed, ensure that it is dry before installation. Mop out the interior of the tank with shop towels, and then direct shop air into the tank until dry.

Installation

1. Depending on the vehicle's configuration, lower or lift the fuel tank into its approximate installed position. **See Fig.3.**

   Make sure the fuel filler neck is outboard.

   On vehicles where the Huckbolts and the brackets were removed, install the brackets along with the fuel tank. Replace the Huckbolts with fuel tank bracket mounting locknuts and Grade 8 capscrews. Tighten each nut 68 lbf·ft (92 N·m).

2. Install the isolators and tank straps. **See Fig.4.**

   2.1 Install a clevis pin (Ref. 2) through the inboard end of each tank bracket and tank strap. Use the lower hole in the tank bracket. Install and lock a new cotter pin (Ref. 3) in each clevis pin.

   IMPORTANT: Fuel tanks can be damaged by overtightening the fuel tank straps.

   2.2 Install a bearing washer and two nuts on each tank strap T-bolt. Tighten the first nuts 20 N·m (15 lbf·ft).

   2.3 While holding the first nut stationary with a wrench, tighten each jam nut 41 N·m (30 lbf·ft).

3. On open-framed vehicles, install the top braces onto the fuel tank cage end brackets and the frame rail. Install all bolts with the nuts facing toward the fuel filler cap. Tighten the bolts 68 lbf·ft (92 N·m). **See Fig.3.**

   On vehicles with a box or container (bolted cage), install the fuel tank cage to the frame rail. Use a forklift or other lifting device to support the cage during installation. Tighten the bolts 68 lbf·ft (92 N·m).

4. Attach the wires to the electrical connector on the fuel pump module. Check the connector for tightness.

5. Make certain the fuel lines are clean. Loop the fuel supply line as shown **in Fig.5**. Then connect the fuel lines to their fittings on the fuel tank. For general guidelines, refer to **Subject 150**.

6. Add clean unleaded gasoline to the fuel tank. Be sure the fuel tank has a decal reading "Unleaded fuel only" located near the fuel filler neck. Replace the filler cap.

7. Remove the tire chocks.

Specifications

This subject contains the following table:

•Fastener Torques

Refer to Fig. 1 for fuel tank positioning. Refer to Fig. 2 for single-level cab-access step positioning. Refer to Fig. 3 for dual-level cab-access step positioning.

Description	Size	Grade	Torque N·m (lbf·ft)
Cab-Access Step Bracket-to-Fuel Tank Bracket Locknut	3/8–16	C	38 (28)
Cab-Access Step Bracket-to-Fuel Tank Weldnut Capscrew	3/8–16	5	35 (26)
Cab-Access Step-to-Step Bracket Locknut	1/4–20	B	10 (7)
Chassis-Access Step Clamp Capscrew	3/8–16	5	35 (26)
Fuel Tank Strap T-Bolt:			
Hexnut	1/2–13	B	20 (15)
Jam Nut	1/2–13	B	41 (30)
Fuel Tank Bracket Mounting Locknut	1/2–13	C	92 (68)
Compression Brace Mounting Locknut	1/2–13	C	92 (68)

Table 1, Fastener Torques

Specifications

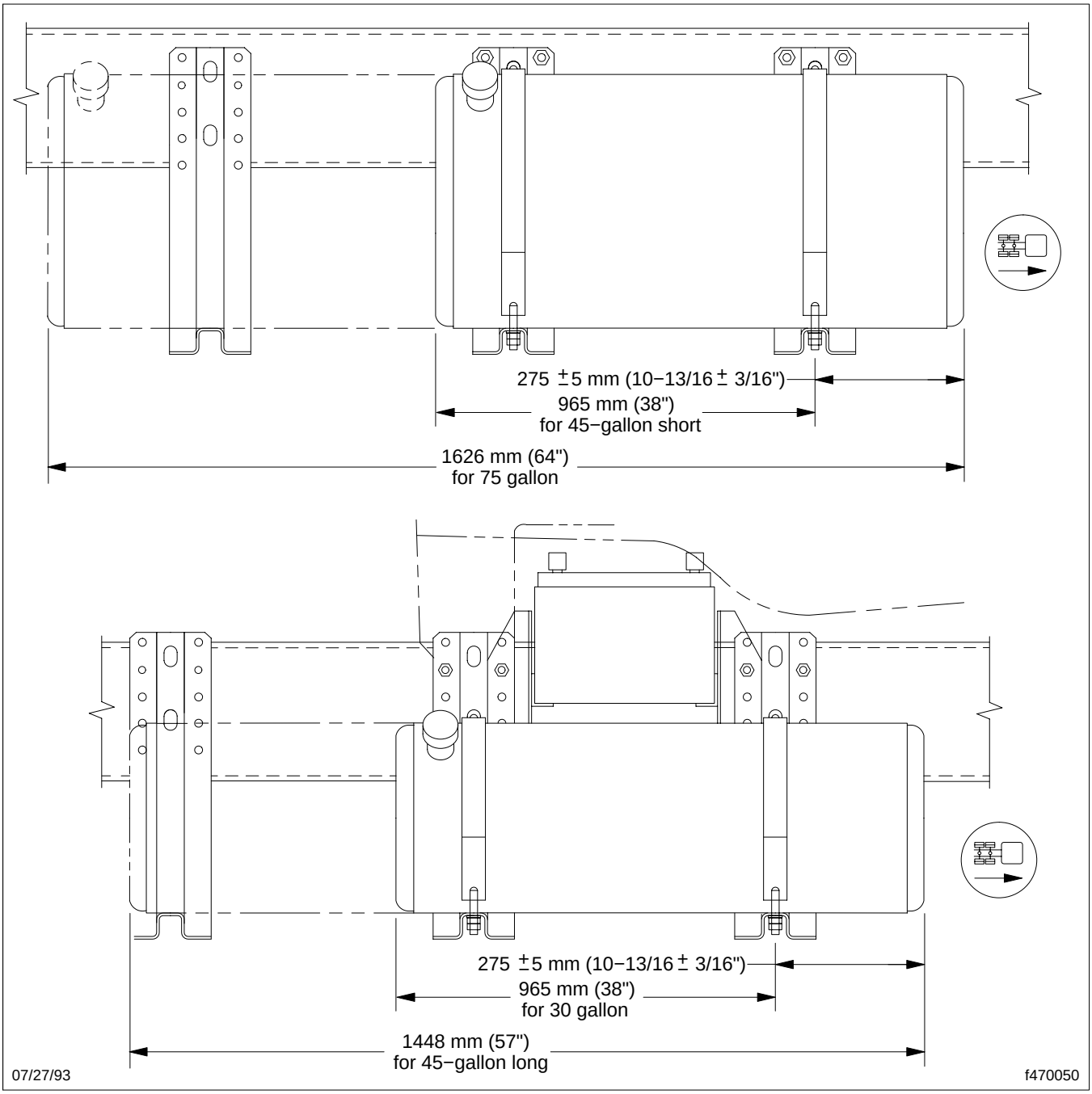


Fig. 1, Fuel Tank Positioning

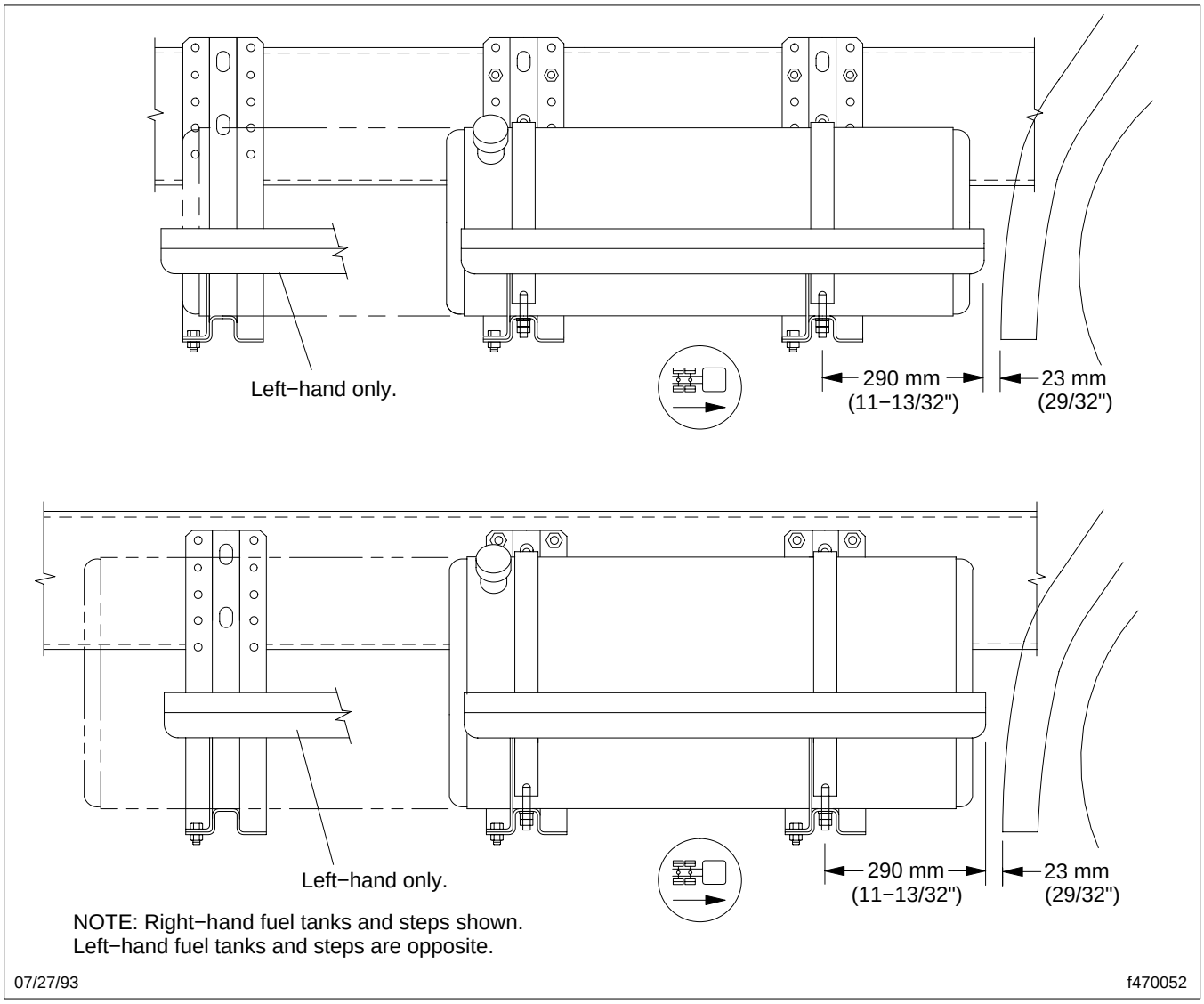


Fig. 2, Single-Level Cab-Access Step Positioning

Specifications

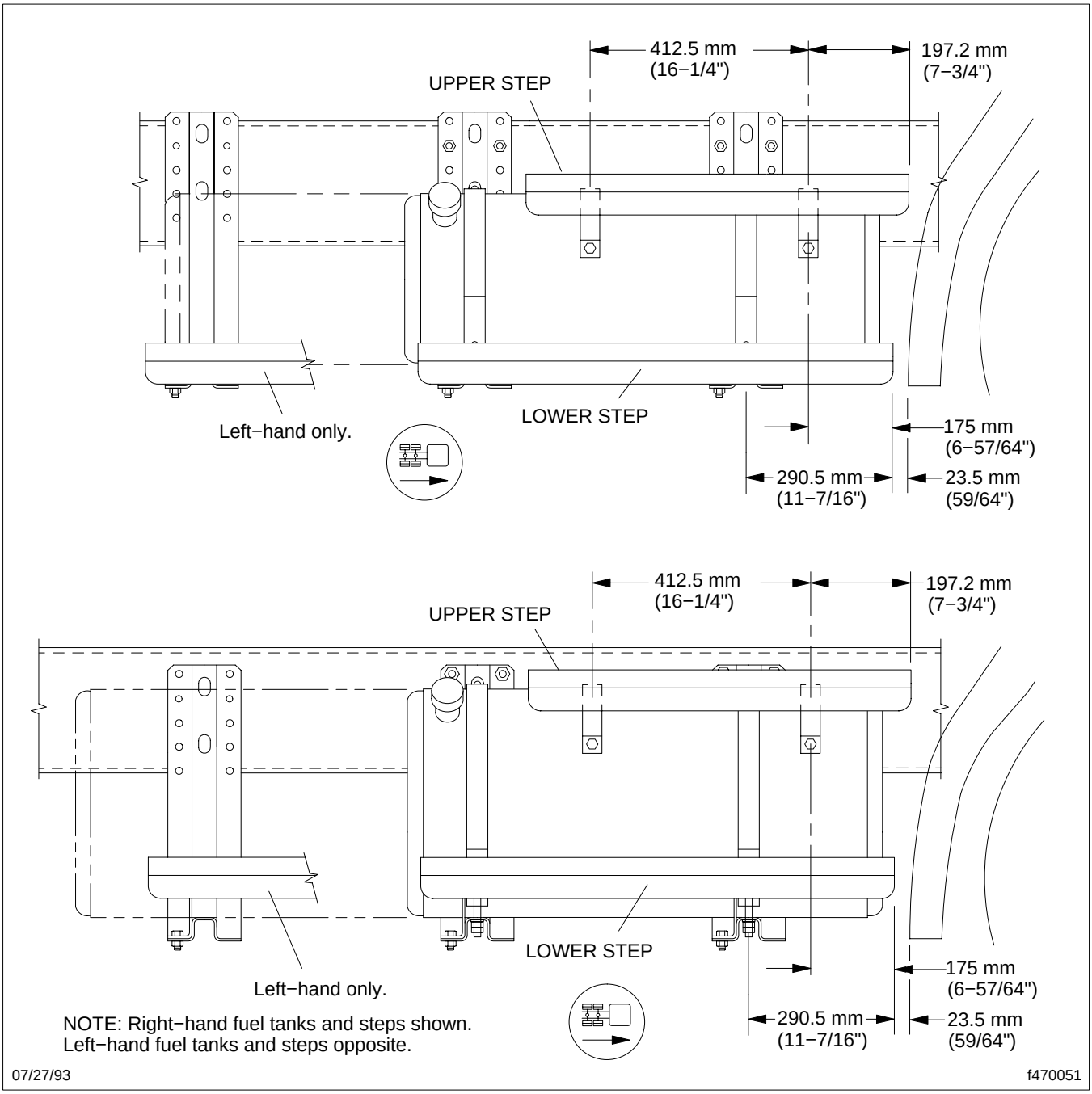
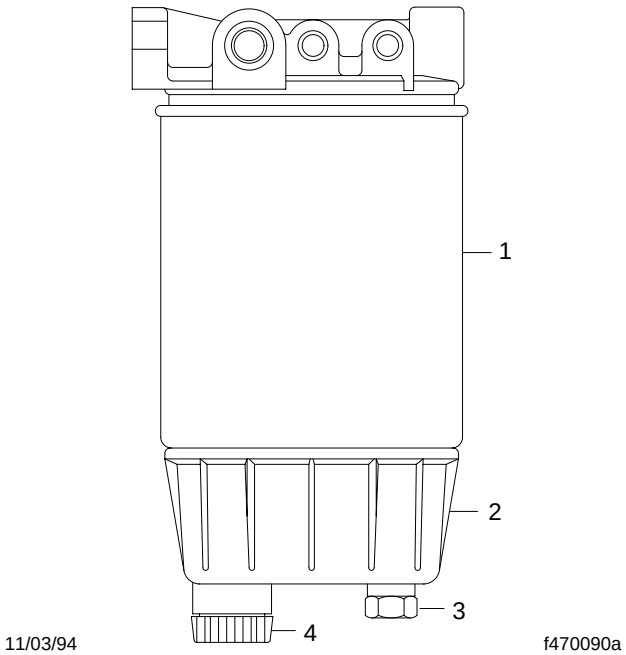


Fig. 3, Dual-Level Cab-Access Step Positioning

General Description

The Freightliner/Racor fuel/water separator (**Fig. 1**) removes water and solid contaminants from diesel fuel. Installed between the fuel tank and the fuel transfer pump, the separator has an optional ignition-controlled fuel heater to prevent ice and wax in the diesel from clogging fuel filters.



1. Fuel Filter
2. Collection Bowl
3. Water Sensor Probe
4. Drain

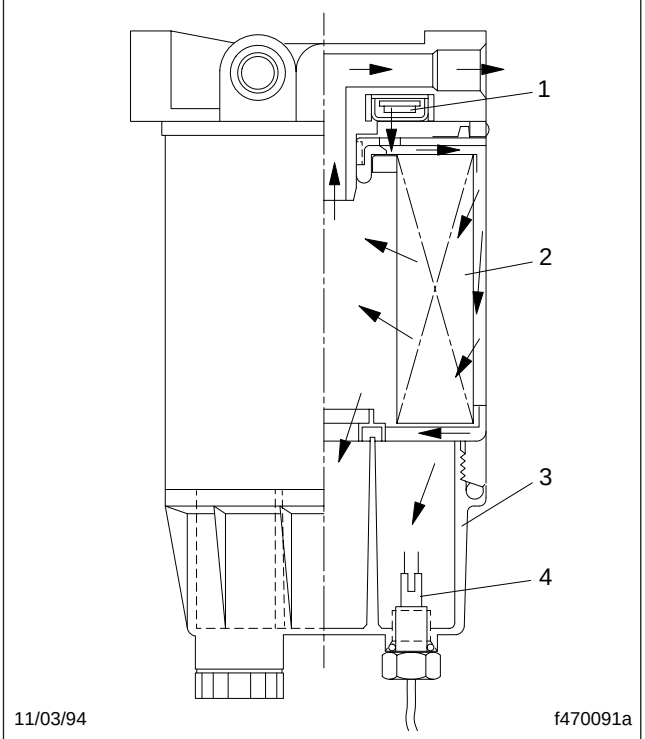
Fig. 1, Fuel/Water Separator

The separator is mounted on the frame rail.

Principles of Operation

Diesel fuel enters at the top of the separator (**Fig. 2**), flowing down past the heater element (if so equipped), and on to the top of the filter element. As the fuel flows down the sides of the element, the heavier contaminants and some water fall directly to the collection bowl below the element. The filter element itself contains a resin that repels water, forcing any remaining water to bead against or within the element and fall to the collection bowl. As the fuel passes from the outside to the inside of the filter element, the last traces of water collect on the inner surface of the element and fall to the collection bowl.

The filtered fuel is drawn out through the top of the separator, and the water and solid contaminants remain in the collection bowl. As the water collects, it completes the circuit between the two prongs of the water sensor probe. A warning light in the cab alerts the operator to drain the bowl.



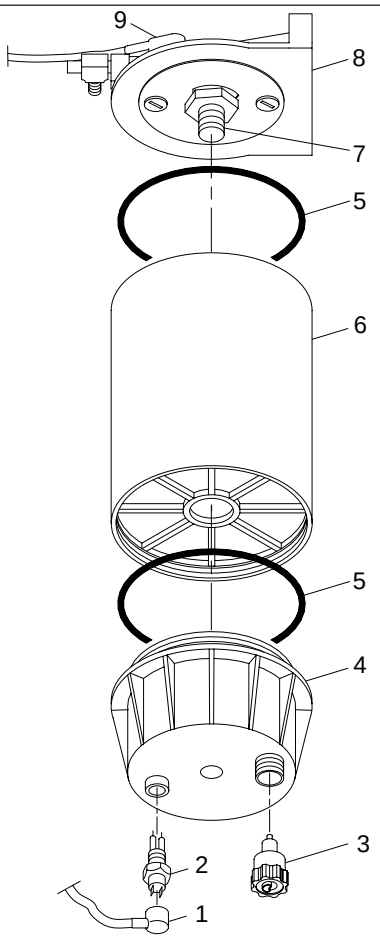
1. Heater Element
2. Filter Element
3. Collection Bowl
4. Water Sensor Probe

Fig. 2, Fuel Flow Through the Separator

Replacement (See Fig. 1)

1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Drain the fuel/water separator.
   - 2.1 Place a suitable container under the separator.
   - 2.2 Turn the drain counterclockwise to remove it.

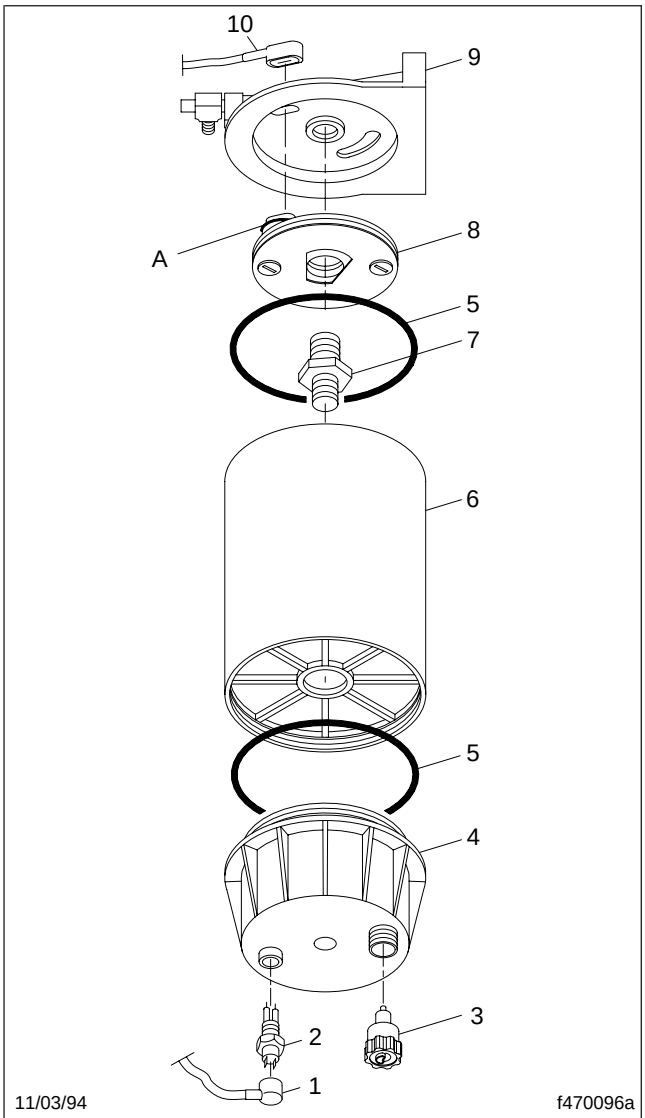
   IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel/water separators onto the ground. On all types of separators, stop draining fluid when you see fuel come out of the separator drain valve.
3. Disconnect the wiring connector from the water sensor probe.
4. Remove the bowl from the element.
5. Remove the element from the adapter fitting and the mounting head.
6. Install the bowl on the bottom of the new filter element.
7. Install the drain by turning it clockwise into the bottom of the bowl.
8. Lubricate the O-ring in the top of the filter element with clean motor oil or diesel fuel.
9. Fill the element and bowl assembly with clean fuel.
10. Install the new filter element on the mounting head. Tighten the element 72 lbf·in (820 N·cm).
11. Connect the wiring connector to the water sensor probe.
12. Start the engine and check for leaks. Repair any leaks.
13. Lower the hood, and remove the chocks from the tires.



1. Wiring Connector
2. Water Sensor Probe
3. Self-Venting Drain
4. Bowl
5. Filter Element O-Ring
6. Filter Element
7. Adaptor Fitting
8. Mounting Head
9. Wiring Connector

Fig. 1, Fuel/Water Separator Assembly

Replacement (See Fig. 1)



A. Install the heater element O-ring here.

1. Wiring Connector
2. Water Sensor Probe
3. Self-Venting Drain
4. Bowl
5. Filter Element O-Ring
6. Filter Element
7. Adaptor Fitting
8. Heater Element
9. Mounting Head
10. Wiring Connector

Fig. 1, Fuel/Water Separator Assembly With Heater

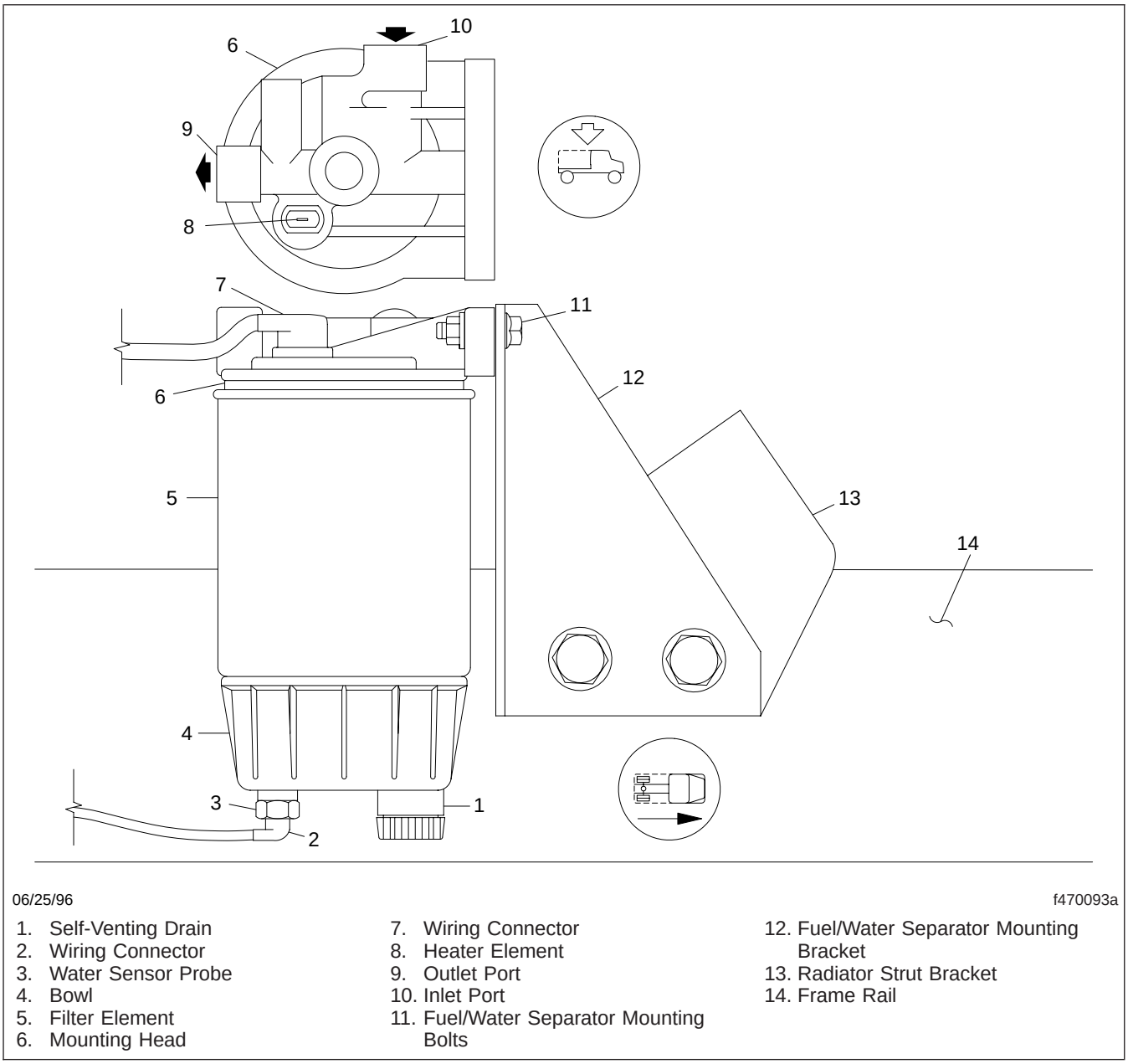
1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Drain the fuel/water separator.
   - 2.1 Place a suitable container under the separator.
   - 2.2 Turn the drain counterclockwise to remove it.

   IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel/water separators onto the ground. On all types of separators, stop draining fluid when you see fuel come out of the separator drain valve.
3. Disconnect the wiring connector from the water sensor probe.
4. Remove the bowl from the element.
5. Remove the element from the adapter fitting and the mounting head.
6. Remove the brass adapter fitting from the mounting head.
7. Disconnect the wiring connector from the heater element.
8. Remove the heater element from the mounting head.
9. Clean the inside surface of the mounting head, and install the new heater element with a new, lubricated element O-ring.
10. Apply Loctite 271 (or equivalent) to the adapter fitting threads, and install the adapter on the mounting head. Tighten the adapter 30 lbf·ft (40 N·m).
11. Connect the wiring connector to the element.
12. Install the bowl on the bottom of the replacement filter element.
13. Screw the drain into the bottom of the bowl.
14. Lubricate the O-ring in the top of the filter element with clean motor oil or diesel fuel.
15. Fill the element and bowl assembly with clean fuel.
16. Install the replacement filter element on the adaptor fitting. Tighten the element 72 lbf·in (820 N·cm).

Heater Element Replacement

17. Connect the wiring connector to the water sensor probe.
18. Start the engine and check for leaks. Repair any leaks.
19. Lower the hood, and remove the chocks from the tires.

Replacement (See Fig. 1)



1. Self-Venting Drain
2. Wiring Connector
3. Water Sensor Probe
4. Bowl
5. Filter Element
6. Mounting Head
7. Wiring Connector
8. Heater Element
9. Outlet Port
10. Inlet Port
11. Fuel/Water Separator Mounting Bolts
12. Fuel/Water Separator Mounting Bracket
13. Radiator Strut Bracket
14. Frame Rail

Fig. 1, Fuel/Water Separator Mounting

1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Drain the fuel/water separator.

2.1 Disconnect the fuel lines from the separator, and mark the lines for reassembly.

Fuel/Water Separator Replacement

2.2 Place a suitable container under the separator.

2.3 Turn the drain counterclockwise to remove it.

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel/water separators onto the ground. On all types of separators, stop draining fluid when you see fuel come out of the separator drain valve.

3. Remove the wiring connectors from the water sensor probe and the heater element.
4. Remove the fuel/water separator mounting bolts, and remove the separator from its mounting bracket.
5. Place the new separator against the mounting bracket, and secure it with the mounting bolts. Tighten the bolts 40 lbf·ft (55 N·m).
6. Remove the bowl and the filter element, as a unit, from the new separator.
7. Using clean motor oil or diesel fuel, lubricate the O-ring in the top of the filter element.
8. Make sure the drain in the bowl is closed, then fill the filter element and bowl assembly with clean fuel.
9. Install the element on the mounting head, and tighten the element 72 lbf·in (820 N·cm).
10. Connect the fuel lines to the separator.
11. Connect the wiring connectors to the water sensor probe and the heater element.
12. Prime the fuel system. With the filter element and bowl assembly full of clean fuel, crank the engine until it starts. This serves to prime the fuel system.
13. Start the engine and check for leaks. Repair any leaks.
14. Lower the hood, and remove the chocks from the tires.

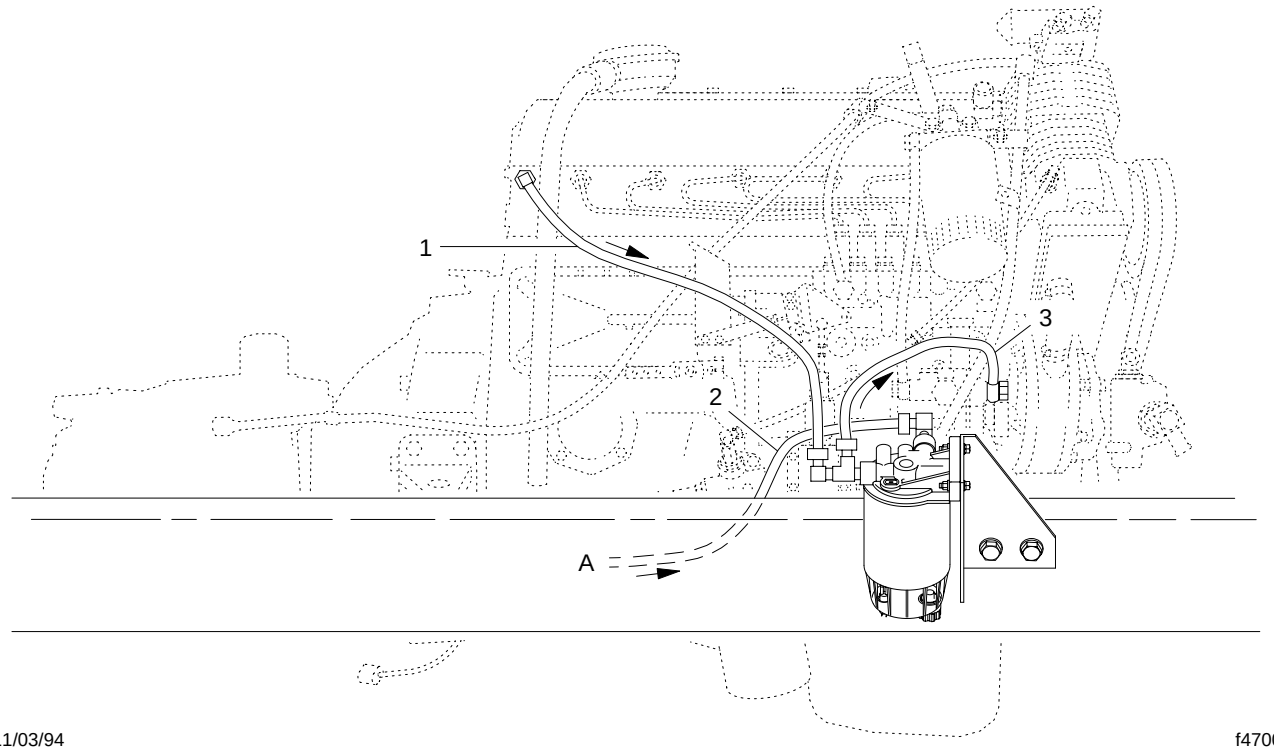
Troubleshooting

1. Turn the ignition to "Accessory." The high water light should come on for 2 to 5 seconds, then go off.
2. With the ignition still on, disconnect the wiring connector from the water sensor probe, and run a jumper wire from one connector terminal to the other. The high water light should come on. If it does not, check all wiring connections. Check that power is on, and that the separator is grounded. Check for damaged wiring in the sensor probe circuit. For a diagram of the sensor circuit, see **Specifications, 400**. If the circuit is intact and undamaged, replace the sensor probe.
3. Repeat the above steps to test the new sensor probe.
4. Connect the wiring connector to the sensor probe.

Specifications

Fastener Torques				
Description	**Grade**	**Size**	**Torque**	
			lbf·ft (N·m)	**lbf·in (N·cm)**
Adaptor Fitting	—	—	30 (40)	—
Filter Element	—	—	—	72 (820)
Separator Mounting Bolts	8	3/8-16	40 (55)	—

Table 1, Fastener Torques



11/03/94 f470094a

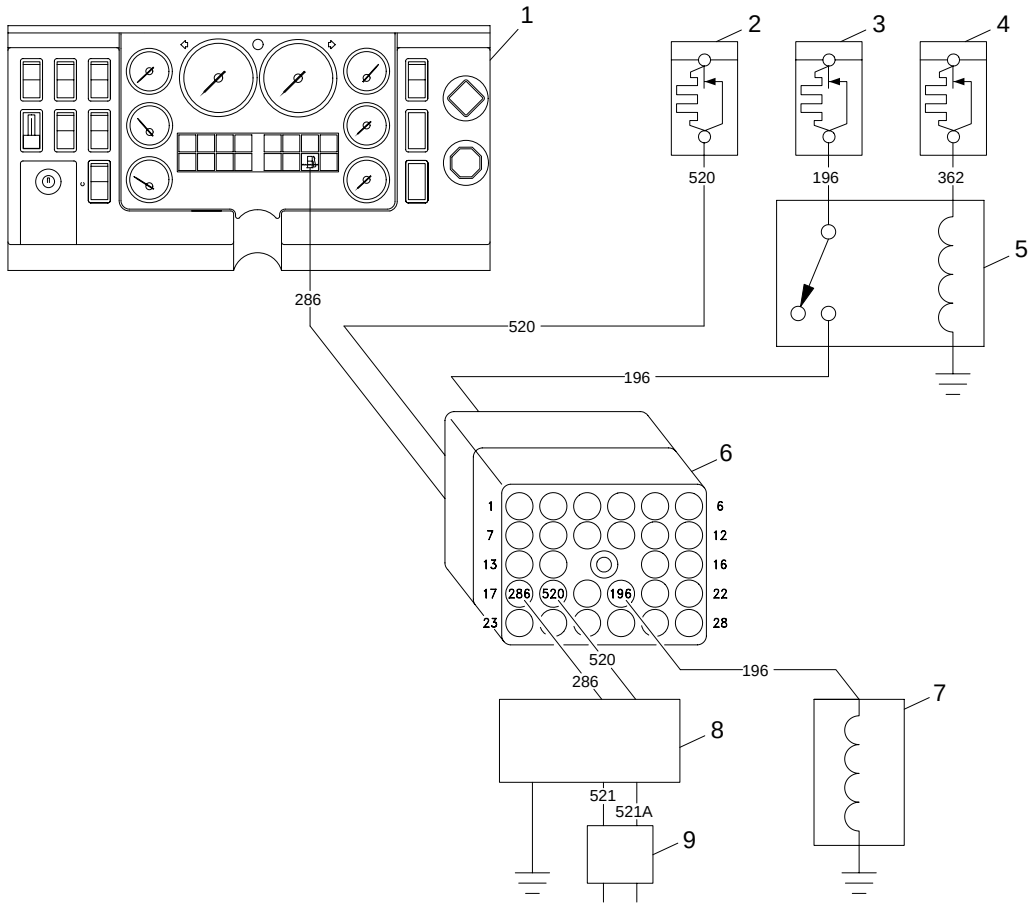
NOTE: On Cummins B or C Series engines, no fuel injector bleed line is used.

A. From the fuel tank

1. Fuel Injector Bleed Line
2. Fuel Inlet Line
3. Fuel Outlet Line

Fig. 1, Fuel Line Routing (Mercedes-Benz OM 366LA engine shown)

Specifications

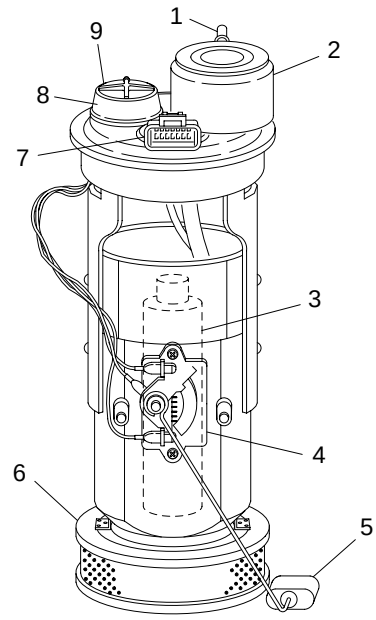


1. Instrument Panel
2. 3-Amp Circuit Breaker (in electrical center)
3. 20-Amp Circuit Breaker (in electrical center)
4. 5-Amp Circuit Breaker (in electrical center)
5. Heater Relay (in electrical center)
6. Bulkhead Connector
7. Heater Element
8. Fuel/Water Separator Module (on the engine side of the bulkhead, below the bulkhead wiring connector)
9. Water Sensor

Fig. 2, Fuel/Water Separator Wiring Diagram

General Information

On all gas-powered engines, the fuel pump module is installed in the top of the fuel tank. **See Fig. 1.**



1. Fuel Supply Line Connection
2. Fuel Filter/Pressure Regulator
3. Electric Fuel Pump
4. Sensing Unit
5. Float
6. In-Tank Fuel Filter
7. Electrical Connector
8. Pressure Relief/ Rollover Valve
9. Ribbed Cover

Fig. 1, Fuel Pump Module

The fuel pump module contains the following:

- A combination fuel filter and pressure regulator
- An electric fuel pump
- A separate in-tank fuel filter
- A fuel gauge sensing unit and float
- A fuel supply line connection

Also mounted in the fuel pump module is a pressure relief/rollover valve that is designed to prevent fuel leakage during a rollover. Molded on the ribbed cover of this valve is a barbed connection. A flexible line attaches this barb to the evaporative canister.

The fuel pump module is suspended in fuel inside the fuel tank. Fuel is drawn in through the separate in-tank filter in the base of the module.

The electric fuel pump is located inside the fuel pump module. It is equipped with a permanent magnet electric motor which pushes the fuel into the filter/pressure regulator.

The fuel pump is located inside a 1-liter (1.1-quart) plastic reservoir that remains full while the engine is running. In the bottom of the reservoir, there is a valve that closes whenever the fuel level in the tank drops below approximately 25 mm (1 inch). This will supply fuel from the reservoir to prevent cavitation of the pump.

A check valve installed in the fuel outlet prevents pressure drain-back through the pump. This maintains constant fuel pressure even when the engine is not running and helps to start the engine more easily.

IMPORTANT: The fuel system is under constant pressure. Before performing any service on the fuel pump module, be sure to release the fuel system pressure. For procedures, refer to **Subject 130**.

The electric fuel pump is not serviceable. If the fuel pump needs replacement, replace the entire fuel pump module. For procedures, refer to **Subject 100**.

The fuel filter/pressure regulator is a mechanical device not controlled by the Powertrain Control Module. It is calibrated to maintain fuel system pressure at approximately 240 to 310 kPa (35 to 45 psi) and contains an internal diaphragm, calibrated springs, a fuel return valve, and an internal fuel filter.

The electric fuel pump supplies fuel through a fuel inlet in the base of the pressure regulator. If fuel pressure exceeds 310 kPa (45 psi), the internal diaphragm closes, forcing the excess fuel back into the tank. No separate fuel return line is needed.

The fuel filter/pressure regulator and the pressure relief/rollover valve can be replaced without removing the fuel pump module. For procedures, refer to **Subject 110** and **Subject 120**. If the fuel pump module has to be removed for any reason, replace the entire module. Do not attempt to disassemble the sensing unit, float, or in-tank fuel filter.

Fuel Pump Module Removal and Installation and In-Tank Fuel Filter Replacement

Removal

1. Apply the parking brakes and chock the tires. Disconnect the batteries.

⚠ WARNING

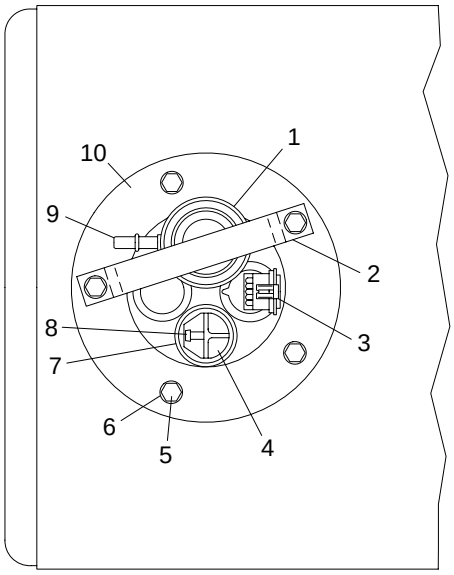
WARNING: Release the fuel system pressure before removing the fuel pump module. Otherwise fuel could spray out, possibly resulting in severe personal injury and property damage, including fire. Always wear proper eye protection when releasing the fuel system pressure. Fuel squirted into the eyes can cause serious injury, including blindness.

2. Release the fuel system pressure and drain the fuel tank. For instructions, see **Subject 130**.

⚠ WARNING

WARNING: Gasoline is flammable and can ignite if exposed to open flame, intense heat, or other ignition source. Do not drain fuel near, or expose fuel vapor to open flame or intense heat. Exposure to open flame, intense heat, or other ignition source could start a fire, possibly resulting in personal injury or property damage. When working on a fuel system, have a fire extinguisher within easy reach.

3. Disconnect the fuel supply line from the filter/pressure regulator, and the evaporative canister line from the rollover valve. Disconnect the electrical connector. See **Fig. 1**.
4. Remove the fuel pump module from the fuel tank.
   - 4.1 Clean the top of the fuel pump module to prevent dirt from falling into the fuel tank.
   - 4.2 Remove the two 5/16–18 grade 8 capscrews holding the fuel pump guard bracket in place. Remove the guard bracket, capscrews and hardened flatwashers.
   - 4.3 Remove the other three 5/16–18 grade 8 capscrews holding the fuel pump clamp ring in place. Remove the capscrews and hardened flatwashers.



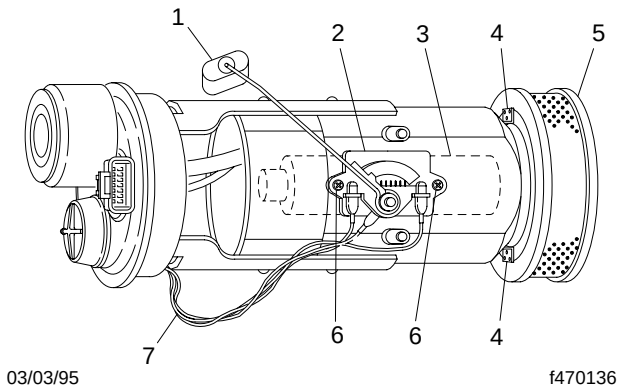
03/17/95 f470135

1. Fuel Filter/Pressure Regulator
2. Fuel Pump Guard Bracket
3. Pump/Gauge Electrical Connector
4. Pressure Relief/Rollover Valve
5. 5/16–18 Clamp Ring Mounting Capscrew (Grade 8)
6. Hardened Flatwasher
7. Rollover Valve Grommet
8. EVAP Canister Connection
9. Fuel Supply Line Connection
10. Fuel Pump Mounting Clamp Ring

Fig. 1, Fuel Pump Module (top view)

   - 4.4 Remove the fuel pump module from the fuel tank. See **Fig. 2**.
   - 4.5 Remove the fuel pump module gasket from the fuel tank. See **Fig. 3**. Discard the old gasket.
5. Replace the in-tank fuel filter on the fuel pump module. See **Fig. 2**.
   - 5.1 Use an appropriate tool to pry back the retaining tabs.
   - 5.2 Remove the in-tank fuel filter.
   - 5.3 Install the new filter into the retaining tabs until the filter is firmly seated.

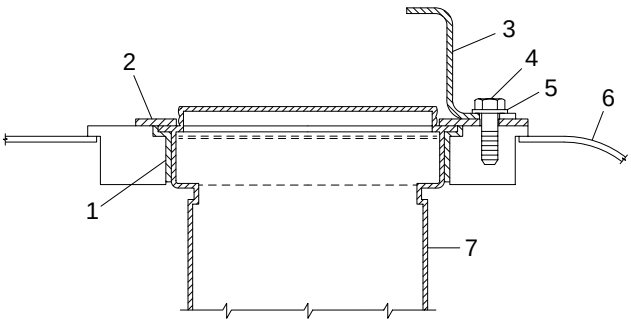
Fuel Pump Module Removal and Installation and In-Tank Fuel Filter Replacement



03/03/95 f470136

1. Float
2. Fuel Gauge Sensing Unit
3. Electric Fuel Pump
4. Retaining Tab
5. In-Tank Fuel Filter
6. Mounting Screw
7. Electrical Wiring

Fig. 2, Fuel Pump Module (side view)



03/03/95 f470137

1. Fuel Pump Module Gasket
2. Fuel Pump Mounting Clamp Ring
3. Fuel Pump Guard Bracket
4. 5/16–18 Clamp Ring Mounting Capscrew (Grade 8)
5. Hardened Flatwasher
6. Fuel Tank
7. Fuel Pump Module

Fig. 3, Fuel Pump Module Mounting (cutaway view)

Installation

1. Check that the sensing unit, the electrical wires, the float, and the in-tank fuel filter are properly installed. See **Fig. 2**.
2. Install a new fuel pump module gasket in the opening in the fuel tank. See **Fig. 3**.
3. Position the fuel pump module in the opening in the fuel tank. Make sure the filter/pressure regulator is on the side facing the frame rail (see **Fig. 1**). Apply a light coat of silicone spray to the gasket, if necessary to ease installation.

NOTE: Using silicone spray on the mounting gasket will prevent the gasket from bunching, or deforming. The spray will evaporate and not affect the fuel.

4. Secure the fuel pump module in the fuel tank.

   IMPORTANT: Use only grade 8 capscrews.

   4.1 Install the fuel pump clamp ring over the fuel pump module. To hold it in place, install three capscrews with hardened flatwashers. Use the holes not intended for the guard bracket. Do not tighten the capscrews yet.

   4.2 Install the fuel pump guard bracket over the filter/pressure regulator. Fasten it in place with the remaining two capscrews and hardened flatwashers.

   4.3 Tighten all five capscrews 15 lbf·ft (20 N·m).

5. Connect the fuel lines to the fittings on the filter/pressure regulator and the rollover valve. Attach the electrical connector. See **Fig. 1**.
6. Return clean unleaded gasoline to the fuel tank.
7. Connect the battery, start the engine, and check for fuel leaks. Also check that the fuel gauge is working properly. Correct any fuel leaks with the engine OFF.
8. Remove the chocks from the tires.

Fuel Filter/Pressure Regulator Removal and Installation

Removal

It is not necessary to remove the fuel pump module to replace the fuel filter/pressure regulator.

1. Apply the parking brakes and chock the tires. Disconnect the batteries.

⚠ WARNING

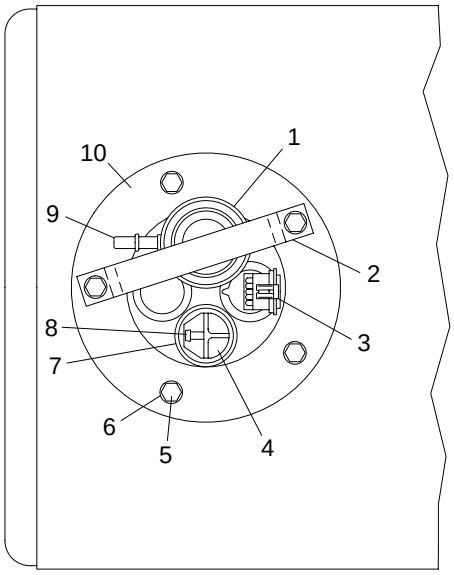
WARNING: Release the fuel system pressure before removing the fuel filter/pressure regulator. Otherwise fuel could spray out, possibly resulting in severe personal injury and property damage, including fire.

2. Release the fuel system pressure. For instructions, refer to **Subject 130**.
3. Remove the fuel supply line from the fuel filter/pressure regulator. If necessary for convenient access, remove the evaporative canister line from the rollover valve and disconnect the electrical connector. **See Fig. 1.**
4. Remove the fuel pump guard bracket.
   - 4.1 Unscrew the two 5/16–18 grade 8 capscrews holding the fuel pump guard bracket in place.
   - 4.2 Remove the guard bracket, the two capscrews, and the two hardened flatwashers.
5. Remove the filter/pressure regulator from the fuel pump module.

⚠ CAUTION

CAUTION: Do not pull up the filter/regulator more than 7.5 centimeters (3 inches) from the fuel pump module. Pulling it any further could cause damage to the coiled fuel tube.

- 5.1 Twist the filter/regulator and pull straight up to free it from the rubber grommet attaching it to the fuel pump module. **See Fig. 2.**
- 5.2 Release the snap ring holding the convoluted fuel tube cover. Slide the fuel tube cover away from the plastic fuel tube until the fuel tube clamp is exposed. **See Fig. 3.**



03/17/95 f470135

1. Fuel Filter/Pressure Regulator
2. Fuel Pump Guard Bracket
3. Pump/Gauge Electrical Connector
4. Pressure Relief/Rollover Valve
5. 5/16–18 Clamp Ring Mounting Capscrew (Grade 8)
6. Hardened Flatwasher
7. Rollover Valve Grommet
8. Evaporative Canister Barb
9. Fuel Supply Line Connection
10. Fuel Pump Mounting Clamp Ring

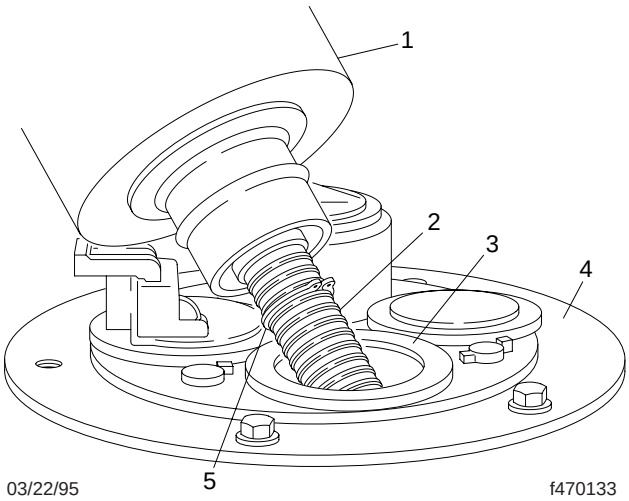
Fig. 1, Fuel Pump Module (Top View)

- 5.3 Gently cut the fuel tube clamp, taking care not to damage the fuel tube. Discard the fuel tube clamp.
- 5.4 Pull downward gently on the fuel tube to remove it from the filter/regulator. Remove the filter/regulator unit from the fuel pump module.

Installation

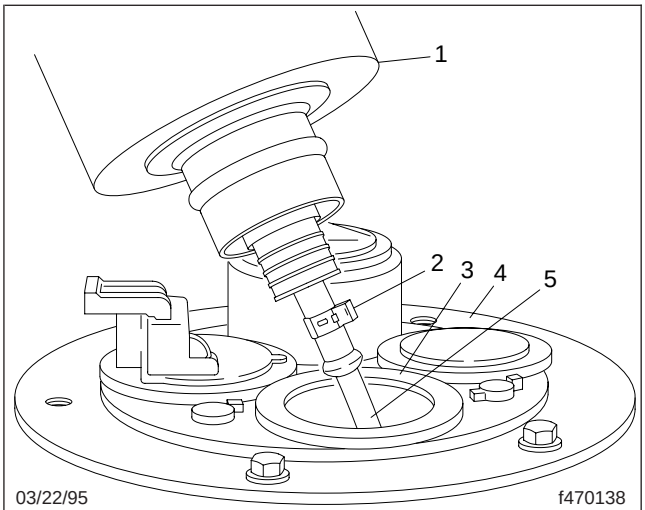
1. Slide a new clamp onto the plastic fuel tube.
2. Attach the filter/regulator to the fuel tube. Be sure the fuel supply line fitting near the top of the filter unit is positioned to allow easy attachment of the fuel supply line.

Fuel Filter/Pressure Regulator Removal and Installation



1. Fuel Filter/Pressure Regulator
2. Fuel Tube Cover
3. Rubber Grommet
4. Fuel Pump Mounting Clamp Ring
5. Snap Ring

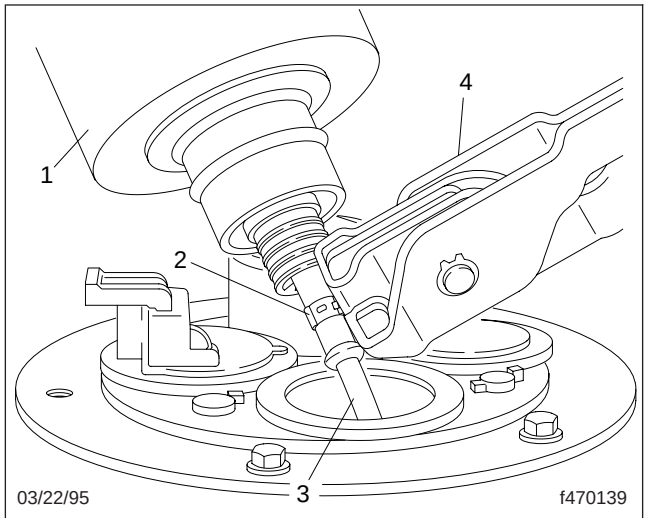
Fig. 2, Snap Ring and Fuel Tube Cover



1. Fuel Filter/Pressure Regulator
2. Fuel Tube Clamp
3. Rubber Grommet
4. Fuel Pump Mounting Clamp Ring
5. Nylon Fuel Tube

Fig. 3, Fuel Tube and Clamp

3. Tighten the fuel tube clamp using the special hose clamp pliers, Kent Moore tool number C-4124, or equivalent. To order this tool, call the Kent-Moore Tool Company at 1-800-328-6657. **See Fig. 4.** Do not use conventional side cutters to tighten this type of clamp.



1. Fuel Filter/Pressure Regulator
2. Fuel Tube Clamp
3. Nylon Fuel Tube
4. Hose Clamp Pliers, Tool C-4124

Fig. 4, Tightening the Fuel Tube Clamp

4. Slide the fuel tube cover into place and install the snap ring.
5. Press the filter/regulator by hand into the rubber grommet. As you do, check the positioning of the fuel supply fitting.
6. Connect the fuel lines to the fittings on the fuel filter/pressure regulator and the rollover valve. Attach the electrical connector. **See Fig. 1.**
7. Install the fuel pump guard bracket.

   IMPORTANT: Use only grade 8 capscrews.

   7.1 Install the fuel pump guard bracket over the filter/pressure regulator. Fasten it in place with two 5/16–18 grade 8 capscrews and hardened flatwashers.

   7.2 Tighten both capscrews 15 lbf·ft (20 N·m).
8. Fill the fuel tank with unleaded gasoline.
9. Connect the batteries. Then remove the chocks from the tires and release the parking brake.

Pressure Relief/Rollover Valve Removal and Installation

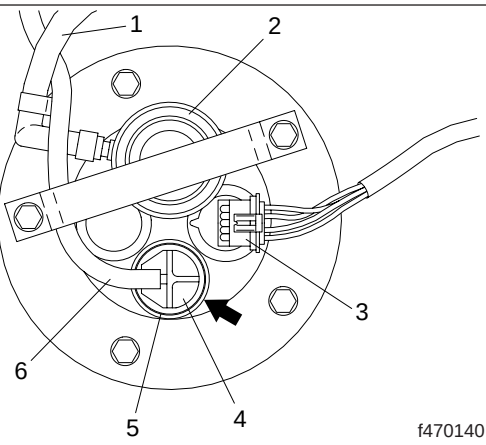
Removal

1. Apply the parking brakes and chock the tires. Disconnect the batteries.

⚠ WARNING

WARNING: Release the fuel system pressure before removing the pressure relief/rollover valve. Otherwise fuel could spray out, possibly resulting in severe personal injury and property damage, including fire.

2. Release the fuel system pressure. For instructions, refer to **Subject 130**.
3. Remove the evaporative canister line from the rollover valve. **See Fig. 1.**



Remove the evaporative canister line. Wedge a screwdriver at the arrow, between the fuel pump module and the grommet. Do not wedge anything between the rollover valve and the grommet.

1. Fuel Supply LIne
2. Fuel Filter/Pressure Regulator
3. Electrical Connector
4. Pressure Relief/Rollover Valve
5. Rollover Valve Grommet
6. Evaporative Canister LIne

Fig. 1, Fuel Pump Module, Top View

4. Remove the pressure relief/rollover valve from the fuel pump module.

⚠ CAUTION

CAUTION: Do not wedge anything between the rollover valve and the grommet. This may cause damage to the valve unit.

4.1 Wedge the blade of a standard screwdriver between the rubber rollover valve grommet and the surface of the fuel pump module. **See Fig. 1.**

4.2 Using a second screwdriver as a support, pry both the valve and the grommet out of the fuel pump module.

5. Remove the grommet from the rollover valve.

5.1 Place the valve upright on a flat surface. Push down on the grommet.

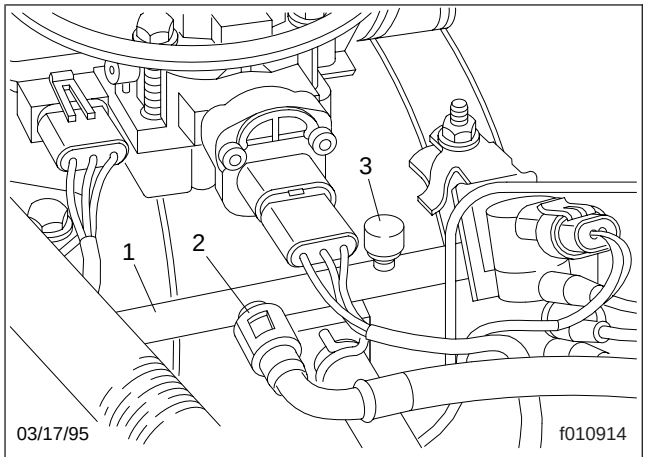
5.2 Peel the grommet off the valve. Discard the old grommet.

Installation

1. Install a new rollover valve grommet in the fuel pump module. Work it around the curled lip on the surface of the module.
2. Lubricate the grommet, using power steering fluid.
3. Push the valve downward through the grommet and into the fuel pump module.
4. Be sure the evaporative canister line fitting on the rollover valve is positioned to allow easy attachment of the evaporative canister line. If necessary, twist the valve into a better position.
5. Connect the fuel supply line to the fitting on the fuel filter/pressure regulator and the evaporative canister line to the fitting on the rollover valve. Connect the electrical connector. **See Fig. 1.**
6. Fill the fuel tank with unleaded gasoline.
7. Connect the batteries. Remove the chocks from the tires and release the parking brake.

Release

1. Disconnect the batteries.
2. Remove the fuel tank filler cap. This releases fuel tank pressure.
3. Unscrew the protective plastic cap from the pressure test port on the fuel rail (**see Fig. 1**).



1. Fuel Rail
2. Fuel Supply Line
3. Test Port Protective Cap

Fig. 1

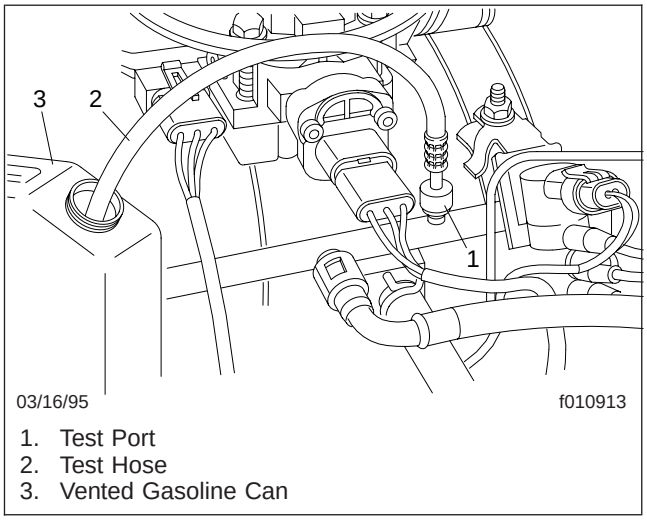
WARNING

WARNING: Always wear proper eye protection when releasing the fuel system pressure. Fuel squirted or splashed into the eyes can cause injury.

4. Obtain Kent-Moore fuel pressure gauge tool set #5069. To order this tool set, call the Kent-Moore Tool Company at 1-800-328-6657. Remove the gauge from the hose. Place one end of the hose into an approved gasoline container. Place a shop towel under the test port. **See Fig. 2.**

IMPORTANT: Do not allow fuel to spill onto the engine intake or exhaust manifolds. To absorb fuel, place shop towels under and around the pressure port when the pressure is released from the fuel rail.

5. Screw the other end of the hose onto the fuel pressure test port and allow the fuel to run into the container until the pressure is fully released.



1. Test Port
2. Test Hose
3. Vented Gasoline Can

Fig. 2

6. Remove the hose from the test port and return it to tool set #5069.
7. Install the protective cap on the test port.
8. Install the filler cap on the fuel tank.

Troubleshooting Tests

To test fuel system pressure, do tests NTC-3A and -B in the Chrysler Powertrain Diagnostic Procedures Manual.

For additional fuel pump module troubleshooting procedures, see tests NS-4A through -C and NS-5A and -B in the Chrysler Powertrain Diagnostic Procedures Manual.

FUEL PUMP CAPACITY TEST

NOTE: Before running this test, verify fuel pump pressure by doing fuel system pressure test NTC-3A in the Chrysler Powertrain Diagnostic Procedures Manual.

⚠ WARNING

WARNING: Release the fuel system pressure before testing the fuel pump capacity. Otherwise fuel could spray out, possibly resulting in severe personal injury and property damage, including fire.

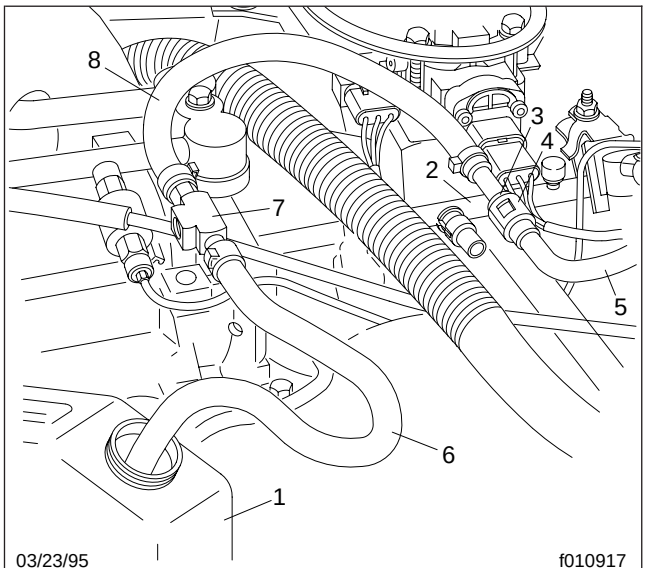
1. Release the fuel system pressure. For instructions, refer to **Subject 130**. Do not drain the fuel tank.
2. Connect Kent-Moore special tool part #6631, the fuel line pressure test adapter. **See Fig. 1.** To order this tool, call the Kent-Moore Tool Company at 1-800-328-6657.

   NOTE: Use Kent-Moore special tool part #6631 only with 3/8-inch i. d. hose.

   2.1 Disconnect the fuel supply line at the fuel rail. Squeeze the plastic retainer tabs against the sides of the quick-connect fitting, using fingers only.

   2.2 Into the disconnected end of the fuel supply line, insert the hose attached to one end of Kent-Moore special tool part #6631, the fuel line pressure test adapter. Insert the hose attached to the other end of special tool #6631 into an approved vented gasoline container, at least 7.5 liters (two gallons) in capacity.

   NOTE: Be sure the "T" end of special tool #6631 is capped.



1. Vented Gasoline Can
2. Fuel Rail
3. Plastic Retainer Tab
4. Quick-Connect Fitting
5. Fuel Supply Line
6. Test Hose (to Vented Gas Can)
7. Kent-Moore Special Tool Part #6631
8. Test Hose (to Fuel Supply Line)

Fig. 1, Fuel Pump Capacity Test

3. Activate the fuel pump and pressurize the system using the DRB scan tool. For procedures, refer to the Chrysler Powertrain Diagnostic Procedures manual.
4. Check that the fuel pump delivers at least 2 liters (2.1 quarts) per minute.

FUEL PRESSURE LEAKDOWN TEST

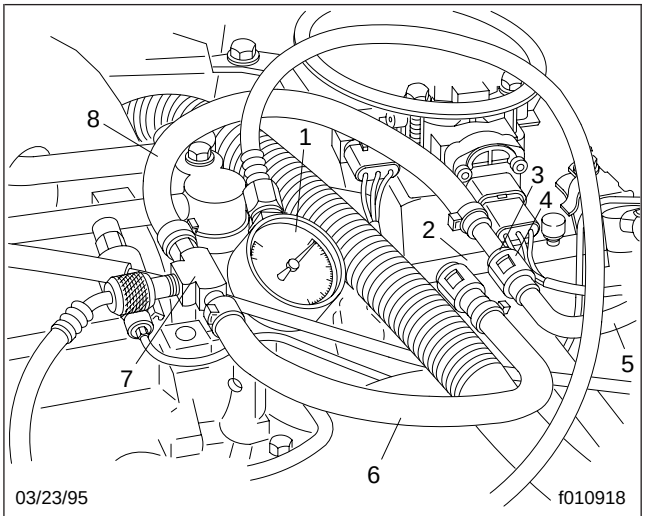
Use this test to diagnose low fuel pressure when a hot engine that has been shut down only a short time requires an abnormally long period of cranking to restart it. Low fuel pressure may be caused by leaks in the fuel injectors or fuel rail, fuel lines, or the check valve in the fuel pump module.

Troubleshooting

WARNING

WARNING: Release the fuel system pressure before testing fuel pressure leakdown. Otherwise fuel could spray out, possibly resulting in severe personal injury and property damage, including fire.

1. Release the fuel system pressure. For instructions, refer to **Subject 130**. Do not drain the fuel tank.
2. Connect Kent-Moore special tool part #6631, the fuel line pressure test adapter. **See Fig. 2.**



1. Fuel Pressure Test Gauge (from Gauge Set #5069)
2. Fuel Rail
3. Plastic Retainer Tab
4. Quick-Connect Fitting
5. Fuel Supply Line
6. Test Hose (to Fuel Rail)
7. Kent-Moore Special tool part #6631
8. Test Hose (to Fuel Supply Line)

Fig. 2, Fuel Pressure Leakdown Test

NOTE: Use special tool #6631 only with 3/8-inch i. d. hose.

2.1 Disconnect the fuel supply line at the fuel rail. Squeeze the plastic retainer tabs against the sides of the quick-connect fitting, using fingers only.

2.2 Into the disconnected end of the fuel supply line, insert the hose attached to one end of Kent-Moore special tool part #6631. Insert the hose attached to the other end of special tool #6631 into the fuel rail.

3. Connect the fuel pressure test gauge from Kent-Moore gauge set, part #5069, to the test port on Kent-Moore special tool part #6631.

IMPORTANT: To ensure the accuracy of the test results, check that the fittings on special tool #6631 and gauge set #5069 are in good condition and do not leak.

4. Check the fuel system for pressure leakdown.

4.1 Start the engine and bring it to the normal operating temperature of 82°C (180°F).

4.2 Check that the test gauge climbs to normal operating pressure of 240-310 kPa (35-45 psi).

4.3 Shut down the engine.

4.4 Check the test gauge. If the pressure falls below 165 kPa (24 psi) in less than five minutes, go to the next step.

5. Check the fuel injectors and fuel rail for leakage.

5.1 Again, start the engine and bring it to the normal operating temperature of 82°C (180°F).

5.2 Shut down the engine.

5.3 Clamp off the rubber hose leading from special tool #6631 to the fuel rail. If the pressure now holds at or above 165 kPa (24 psi), check the fuel injectors and the fuel rail for leaks. If the pressure continues to fall, go to the next step.

6. Check the fuel lines and the fuel pump module for leakage.

6.1 Now clamp off the rubber hose leading from the fuel supply line to special tool #6631. If the pressure now holds at or above 165 kPa (24 psi), check the fuel lines for leaks.

6.2 If no leaks are found in the fuel lines, replace the fuel pump module.

Specifications

Description	Torque N·m (lbf·ft)
Clamp Ring Mounting Capscrews	20 (15)

Table 1, Fastener Torques

Description	Pressure kPa (psi)
Operating Pressure	240–310 (35–45)
Bypass Pressure	620 (90)

Table 2, Fuel System Pressures

General Description

(See Fig.1or Fig.2)

The exhaust system routes hot exhaust gas away from the cab, and reduces engine exhaust noise. Vehicles (except FL112s) have a horizontally mounted muffler on either the left or right side of the vehicle, and are available with either a horizontal outlet or vertical exhaust stack.

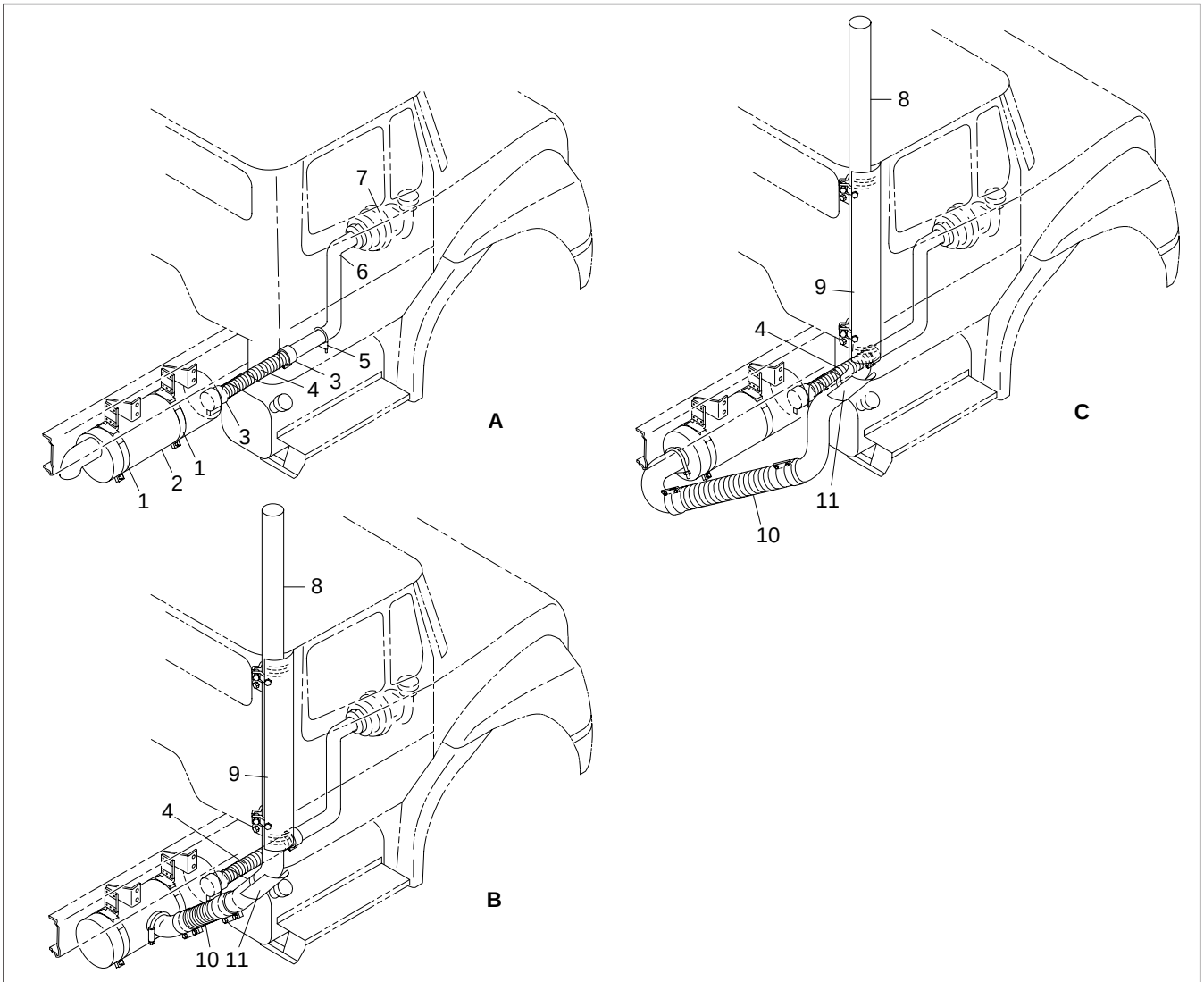
FL112 vehicles have either a horizontally mounted muffler with a horizontal outlet, (see **Fig.3** and **Fig.4**), or a vertical muffler with a stack (see **Fig.2**).

System components include the engine outlet exhaust pipe, muffler, muffler mounting components, saddle clamps, wide-band exhaust clamps, flex pipe, exhaust stack, and exhaust system heat shields.

Most exhaust installations consist of an engine exhaust pipe, sometimes called the turbo pipe, mounted to the rear of the turbocharger and secured with a V-clamp. On Cummins M11 and C8.3 engines, Detroit Diesel Series 50, Caterpillar 3126, and OM 366LA engines, a section of this pipe is flex pipe. On Cummins M11 engines, a bracket attached to the frame rail uses a saddle clamp to hold and support the engine exhaust pipe as it runs to the muffler. See **Fig.3**. A wide-band clamp holds the exhaust pipe to the muffler.

A horizontal muffler hangs from brackets mounted inside the frame rail web. See **Fig.1** or **Fig.5**. A vertical muffler bolts to an upright. See **Fig.2**. All exhaust components attach to either the engine or the chassis frame rails, so there is no need to allow for movement between the cab and chassis.

General Description

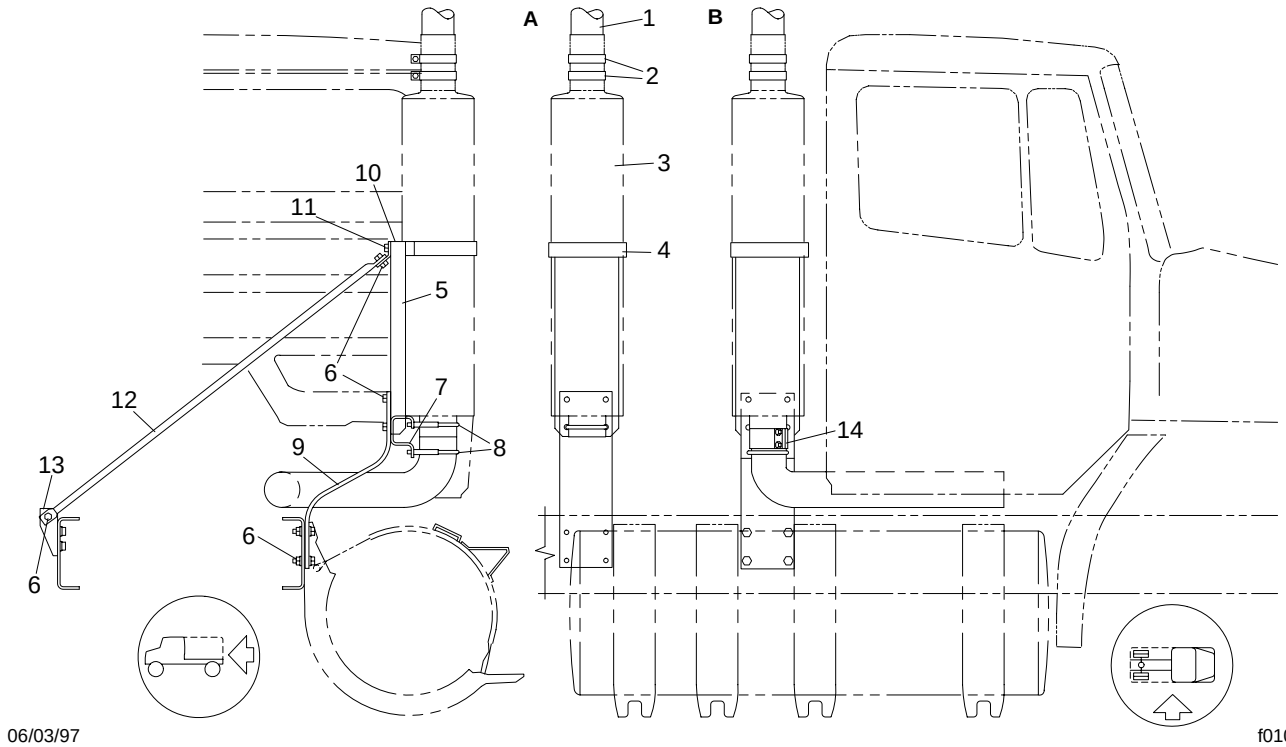


08/18/97 f490030b

A. Exhaust System Without a Stack
B. Exhaust System With a Stack, Vehicles Built To August 2, 1996
C. Exhaust System with a Stack, Vehicles Built From August 2, 1996

1. Muffler Mounting Band
2. Muffler
3. Wide-Band Exhaust Clamp
4. Flex Pipe (except Cummins B 5.9 engines)
5. Saddle Clamp
6. Engine Outlet Exhaust Pipe
7. Turbocharger
8. Exhaust Stack
9. Exhaust Stack Shield
10. Flex Pipe
11. Exhaust Pipe Shield

Fig. 1, Exhaust Mounting, All Models Except FL112



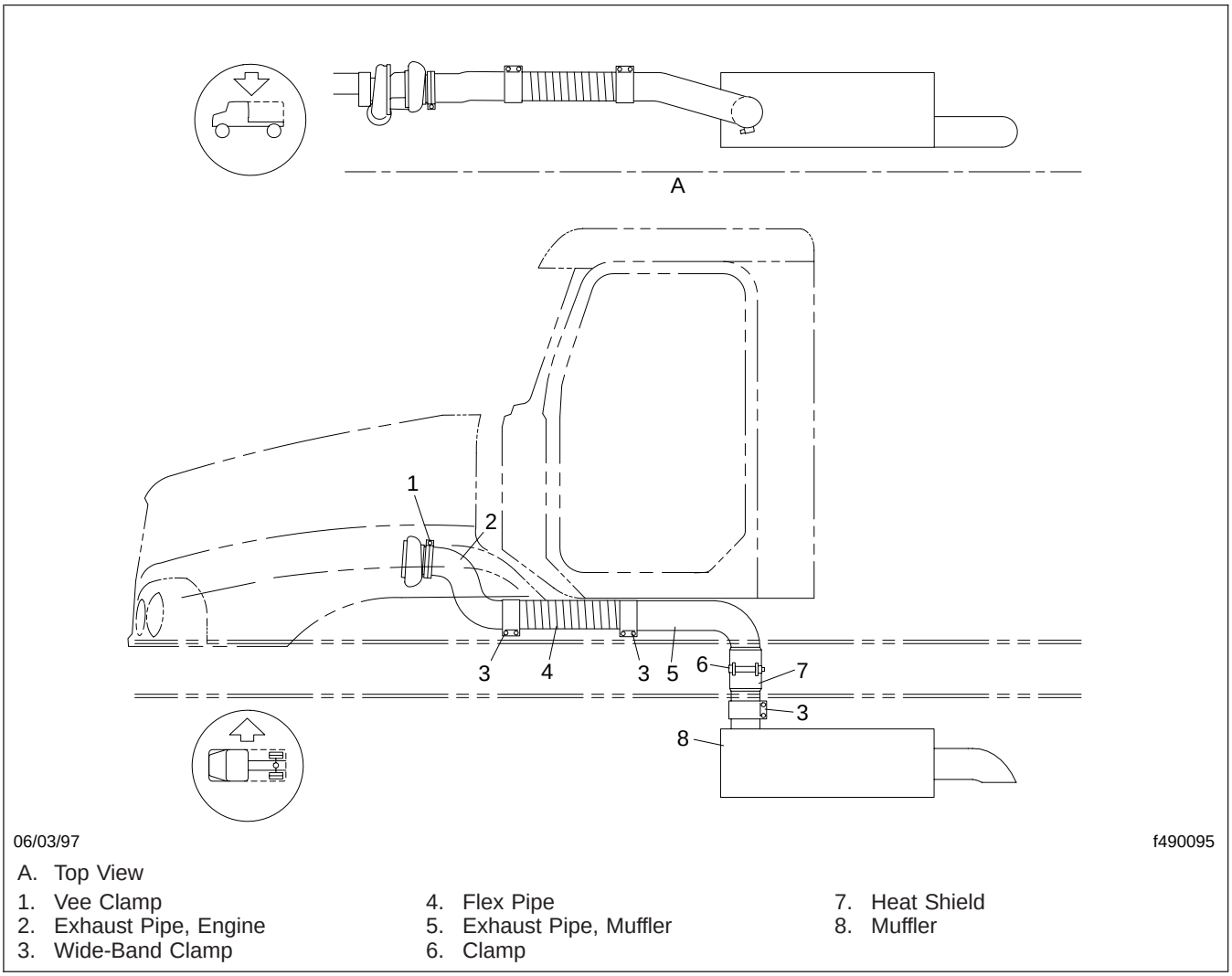
A. Muffler Position, FL112 Conventional with Extended Cab

B. Muffler Position, FL112 Conventional with Day Cab

1. Exhaust Stack
2. Narrow-Band Clamp (2 qty.)
3. Muffler
4. Muffler Mounting Band
5. Support Channel
6. Nut, Washer, and Capscrew, 5/8–11, Grade 8
7. Lower Muffler Mounting Bracket
8. Saddle Clamp, 5-Inch
9. Upright Muffler Mounting Bracket
10. Upper Brace Bracket
11. Nut, Washer, and Capscrew, 1/2–13
12. Brace
13. Lower Brace Bracket
14. Wide-Band Clamp

Fig. 2, Vertical Exhaust Mounting, FL112

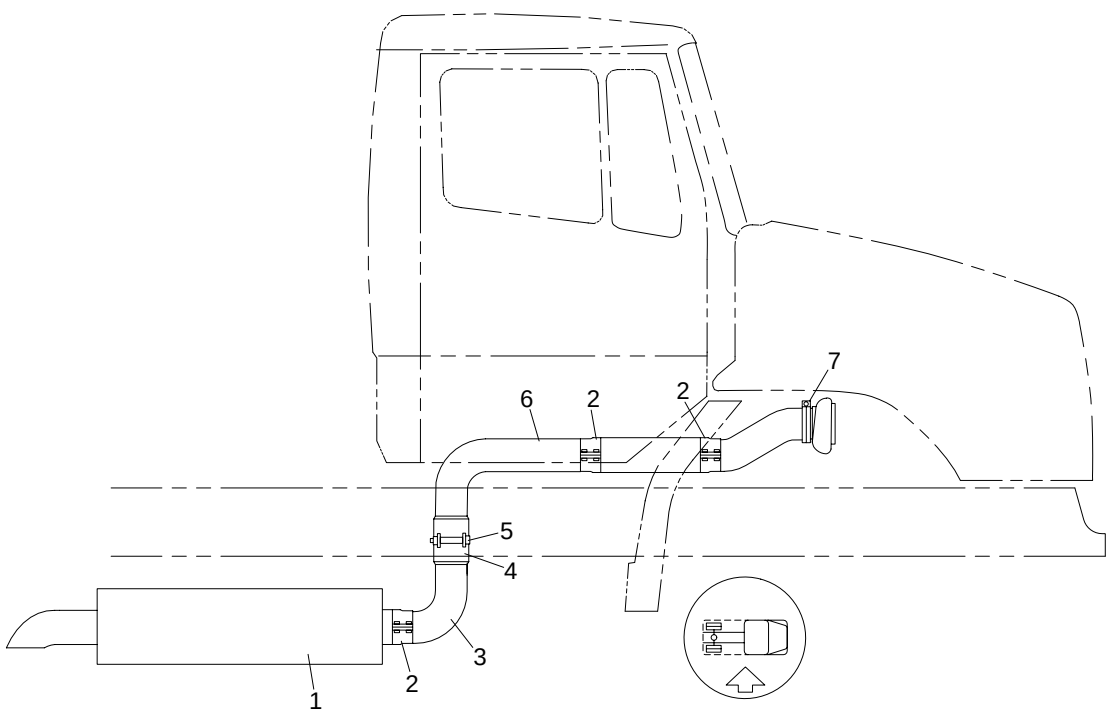
General Description



A. Top View

1. Vee Clamp
2. Exhaust Pipe, Engine
3. Wide-Band Clamp
4. Flex Pipe
5. Exhaust Pipe, Muffler
6. Clamp
7. Heat Shield
8. Muffler

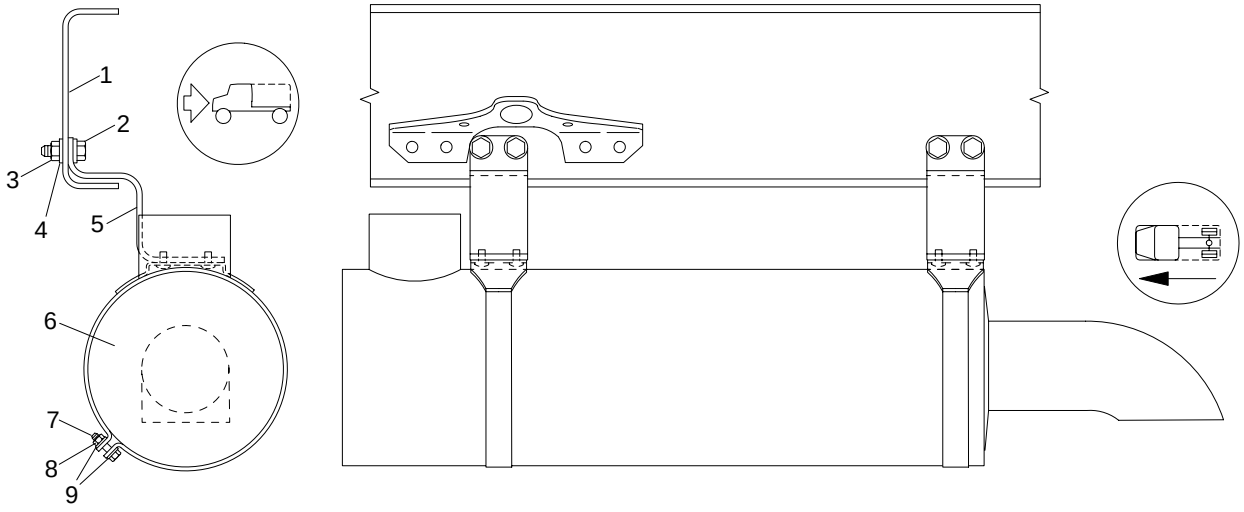
Fig. 3, Horizontal Exhaust System, FL112, Equipped with Cummins or Caterpillar Engine



1. Muffler
2. Wide-Band Clamp
3. Exhaust Pipe, Muffler
4. Heat Shield
5. Clamp
6. Exhaust Pipe, Engine
7. Vee Clamp

Fig. 4, Horizontal Exhaust System, FL112, Equipped with a Detroit Diesel Series 55 Engine

General Description



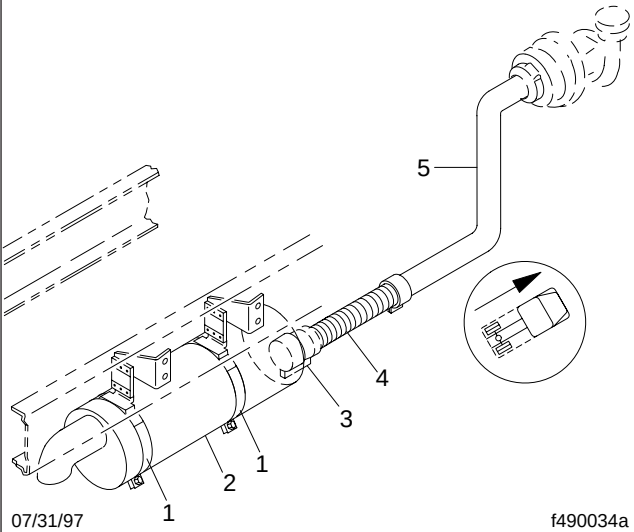
1. Frame Rail
2. Capscrew, 5/8–11 x 1.75 Inch, Grade 8
3. Hexnut, 5/8–11
4. Washer
5. Horizontal Muffler Mounting Bracket
6. Muffler
7. Capscrew, 5/16–18 x 1.75 Inch, Grade 8
8. Hexnut, 5/16–18
9. Washer

Fig. 5, Horizontal Muffler Mounting, FL112

Replacement

NOTE: The mufflers on Freightliner Business Class vehicles can be mounted either horizontally or vertically. Use the following replacement procedure that applies to your vehicle.

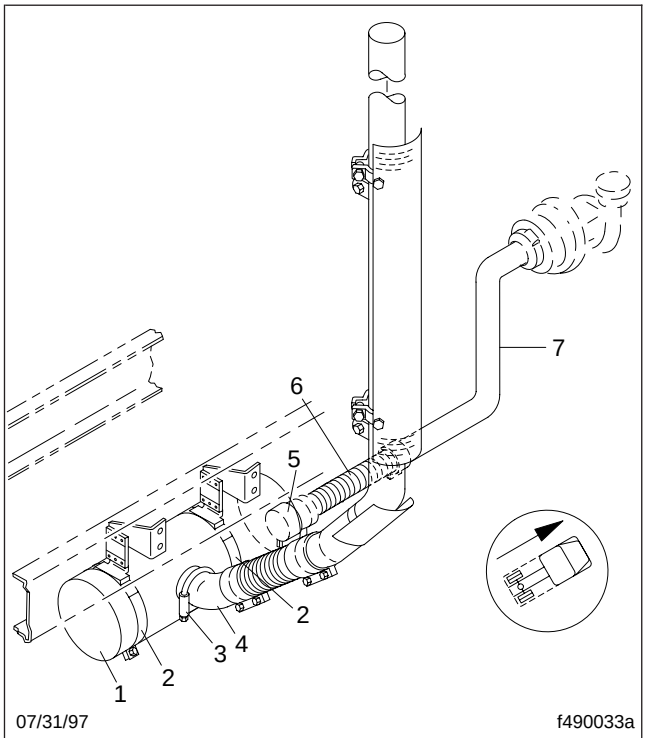
HORIZONTALLY MOUNTED MUFFLERS (See Fig. 1, Fig. 2 , and Fig. 3)



NOTE: The exhaust flex pipe (Ref. 4) may not be present on early model vehicles.

1. Muffler Mounting Band
2. Muffler
3. Wide-Band Exhaust Clamp
4. Exhaust Flex Pipe (except Cummins B 5.9 engines)
5. Muffler Inlet Exhaust Pipe

Fig. 1, Exhaust System Without a Stack, All Models Except FL112



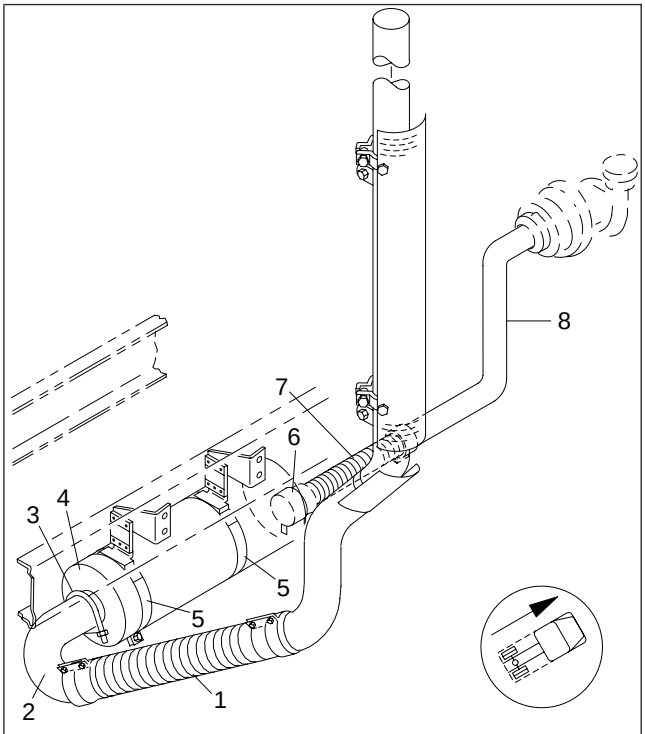
NOTE: This configuration is on vehicles built to August 2, 1996. The exhaust flex pipe (Ref. 6) may not be present on early model vehicles.

1. Muffler
2. Muffler Mounting Band
3. Saddle Clamp
4. Muffler Outlet Exhaust Pipe
5. Wide-Band Exhaust Clamp
6. Exhaust Flex Pipe (except Cummins B 5.9 engines)
7. Muffler Inlet Exhaust Pipe

Fig. 2, Exhaust System With a Stack, Side Outlet, All Models Except FL112

1. Remove the muffler.
   - 1.1 Remove and discard the wide-band exhaust clamp from the muffler inlet connection.
   - 1.2 On vehicles with a vertical exhaust stack, remove the saddle clamp from the muffler outlet connection. Pull the muffler outlet exhaust pipe out of the muffler outlet tube.
   - 1.3 Remove the bolts and locknuts on the front and rear muffler mounting bands. Remove the mounting bands. Remove the muffler.
2. Install the muffler.
   - 2.1 Slide the new muffler's inlet tube over the muffler inlet exhaust pipe.
   - 2.2 Install the front and rear muffler mounting bands. Install the bolts and locknuts on the mounting bands, but do not tighten them at this time.

Muffler Replacement



07/31/97 f490143

NOTE: This configuration is on vehicles built from August 2, 1996. The exhaust flex pipe (Ref. 7) may not be present on early model vehicles.

1. Flex Pipe
2. Rear Exhaust Outlet
3. Saddle Clamp
4. Muffler (catalytic converter on some engine models)
5. Muffler Mounting Band Muffler
6. Wide-Band Exhaust Clamp
7. Exhaust Flex Pipe (except Cummins B 5.9 engines)
8. Muffler Inlet Exhaust Pipe

Fig. 3, Exhaust System, Rear Outlet, All Models Except FL112

2.3 On vehicles with a vertical exhaust stack, slide the muffler outlet exhaust pipe into the muffler outlet tube.

2.4 Coat the lap joint area with chassis grease, so the clamp will slide freely without scratching the surface of the pipe.

2.5 Wrap a new wide-band exhaust clamp by hand around the lap joint. Place the large end of the clamp around the muffler inlet tube, and the small end around the inlet exhaust pipe.

2.6 Install the fasteners in the clamp. Starting from the larger end of the clamp, alternately tighten the fastener in three increments to a final torque of 50 to 60 lbf·ft (68 to 81 N·m).

Clean any excess chassis grease from around the clamp.

2.7 Install the saddle clamp U-bolt on the muffler outlet tube (where applicable). Tighten the saddle clamp flanged nuts alternately in three increments to a final torque of 24 lbf·ft (33 N·m).

2.8 Tighten the muffler mounting band fasteners until the band ears touch; then, tighten the fasteners two full turns or until the ears are in full contact, whichever occurs first.

2.9 Run the engine, and check for exhaust leakage at the exhaust clamp joints. Replace the wide-band exhaust clamps if they leak.

VERTICALLY MOUNTED MUFFLERS

(See Fig. 4)

1. Remove the muffler.

1.1 Loosen the saddle clamp that holds the stack on the muffler, and remove the stack.

1.2 Loosen the saddle clamp that holds the base of the muffler to the support channel.

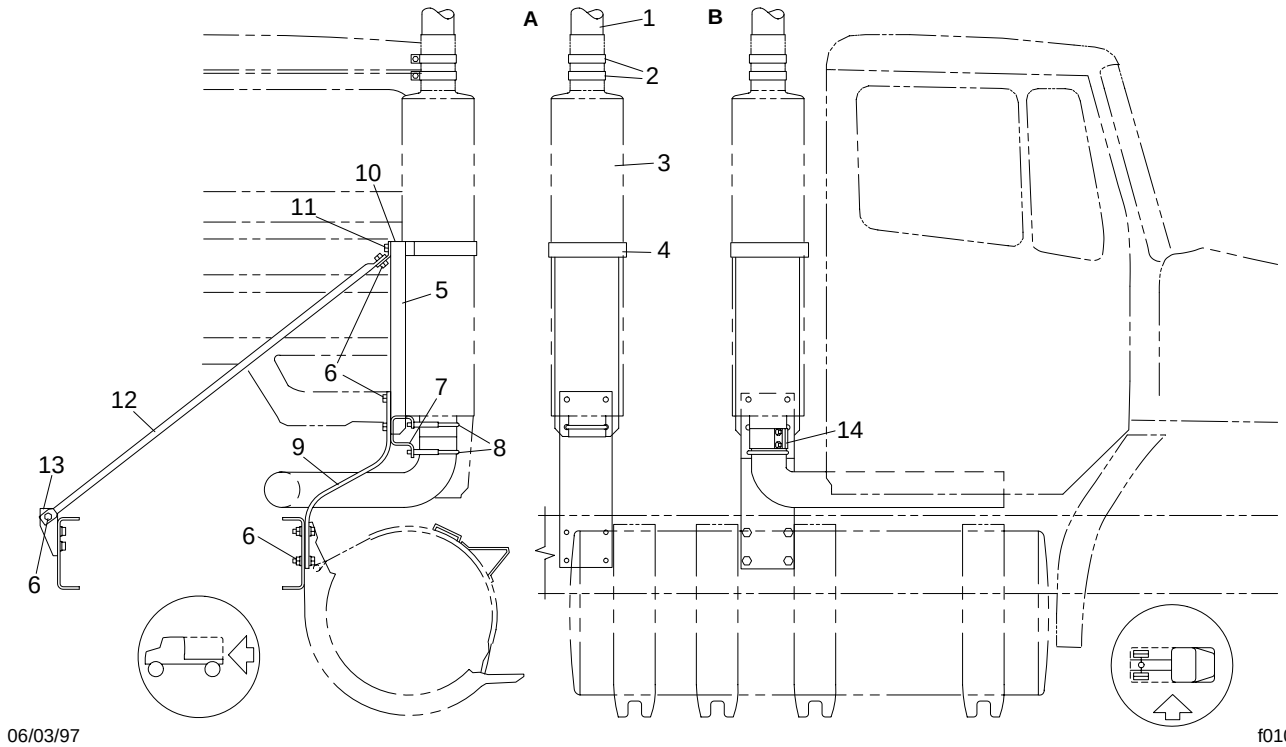
1.3 Loosen the wide-band clamp that connects the muffler to the exhaust pipe.

1.4 Remove the two bolts that hold the muffler mounting band to the muffler support channel.

1.5 Lift the muffler out of the lower saddle clamp.

2. Install the muffler.

2.1 Place the muffler in the support channel, and hold it in place while installing a new wide-band clamp to connect the muffler with the exhaust pipe.



A. Muffler Position, FL112 Conventional with Extended Cab

B. Muffler Position, FL112 Conventional with Day Cab

1. Exhaust Stack
2. Narrow-Band Clamp (2 qty.)
3. Muffler
4. Muffler Mounting Band
5. Support Channel
6. Nut, Washer, and Capscrew, 5/8–11, Grade 8
7. Lower Muffler Mounting Bracket
8. Saddle Clamp, 5-Inch
9. Upright Muffler Mounting Bracket
10. Upper Brace Bracket
11. Nut, Washer, and Capscrew, 1/2–13
12. Brace
13. Lower Brace Bracket
14. Wide-Band Clamp

Fig. 4, Vertical Exhaust Mounting, FL112

2.2 Coat the lap joint area with chassis grease, so the clamp will slide freely without scratching the surface of the pipe.

2.3 Wrap a new wide-band exhaust clamp by hand around the lap joint. Place the large end of the clamp around the muffler inlet, and the small end around the exhaust pipe.

2.4 Install the fasteners in the clamp. Starting from the larger end of the clamp, alternately tighten the fastener in three increments to a final torque of 50 to 60 lbf·ft (68 to 81 N·m).

Clean any excess chassis grease from around the clamp.

2.5 Install the saddle clamp at the bottom of the muffler, and tighten the clamp 24 lbf·ft (33 N·m).

2.6 Install the capscrews, washers and nuts that hold the muffler mounting band to the support channel, and tighten the capscrews 68 lbf·ft (92 N·m).

2.7 Install the stack, and secure it with two narrow-band clamps. Tighten the clamps 50 lbf·ft (68 N·m).

Muffler Replacement

2.8 Run the engine, and check for exhaust leakage at the exhaust clamp joints. Replace the wide-band exhaust clamps if they leak.

Wide-Band Exhaust Clamp Replacement

Replacement

1. Remove and discard the leaking or damaged wide-band exhaust clamp.
2. Grease the lap joint area.
3. Hand-form a new wide-band exhaust clamp around the lap joint, with the larger end of the clamp around the larger diameter tubing, and the smaller end of the clamp around the smaller diameter tubing. Position one third to one half of the exhaust clamp width onto the larger diameter tubing, or completely cover the slots in the larger tubing.
4. Install the fasteners in the clamp. Starting from the larger end of the clamp, alternately tighten the fasteners in three increments to a final torque of 68 to 81 N·m (50 to 60 lbf·ft).
5. Run the engine, and check for exhaust leakage at the exhaust clamp joint. Replace the wide-band exhaust clamp if it leaks.

Exhaust Stack Shield Replacement

Replacement

1. Remove the four capscrews that attach the exhaust shield to the exhaust shield clamps, and remove the exhaust shield.
2. Position the new exhaust shield against the clamps, and install all four capscrews. Tighten the capscrews to 18 N·m (13 lbf·ft).

Specifications

Description	Grade	Size	Torque N·m (lbf·ft)
Wide-Band Exhaust Clamp	—	—	68-81 (50-60)
Saddle Clamp U-Bolt	—	3/8-16	33 (24)
Exhaust Stack Shield Capscrews	302 SS	5/16-18	18 (13)

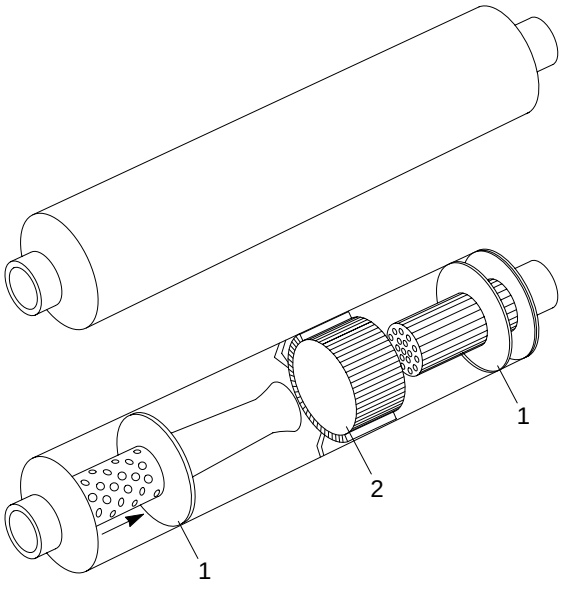
Table 1, Fastener Torques

General Information

To clean vehicle exhaust and reduce exhaust noise, Freightliner uses mufflers and catalytic converters with some engines. On diesel engines, including the Cummins B and C series, and the Mercedes Benz 210 and 230 horsepower OM 366LA, Freightliner uses a combined catalytic converter and muffler in the same housing (can). On gasoline engines, Freightliner uses a separate catalytic converter and muffler.

Exhaust pipes route the exhaust from the engine to the catalytic converter.

Diesel engines use a combined catalytic converter and muffler. The converter consists of three sections: a muffler section, the catalytic converter, another muffler section. **See Fig. 1.**



01/27/94 f490058

NOTE: This combined muffler and catalytic converter is used with diesel engines.

1. Baffle
2. Substrate

Fig. 1, Typical Catalytic Converter Muffler

Inside the converter, a series of baffles dampens the noise of the exhaust by breaking the sound waves into shorter lengths. Then the exhaust is channeled through the catalytic converter, a section of fine ceramic honeycomb called the substrate. The substrate is coated with gold, and the heat of the exhaust heats the gold plate. Once the catalytic converter is warmed to operating temperature, the hot gold plate ignites any unburned fuel and oil in the exhaust. The remaining fuel and oil burn, and the cleaned exhaust passes through another section of baffles that further muffle any noise. After the second muffler section, the exhaust vents to the atmosphere.

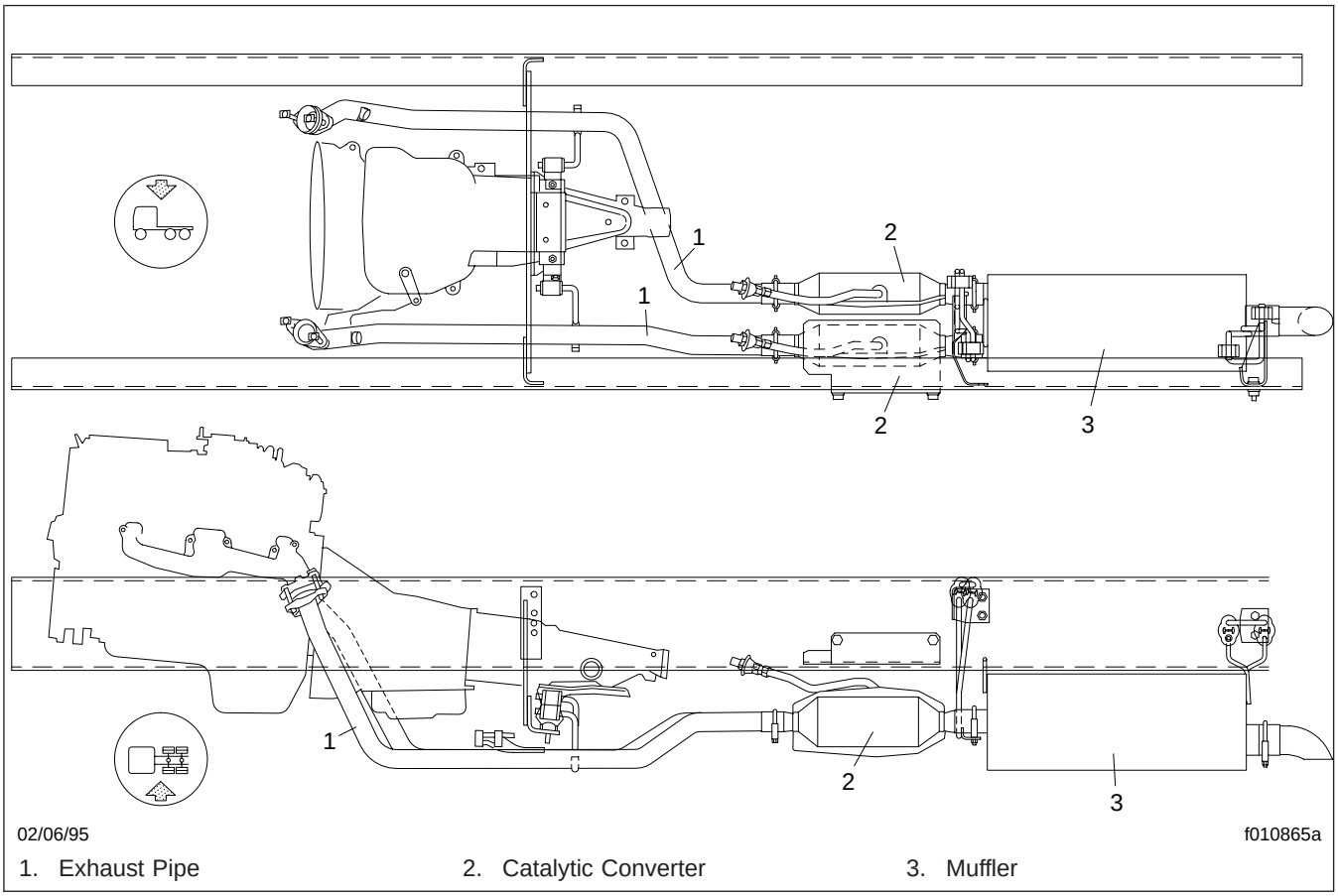
Although the catalytic converter muffler is the same size as a standard muffler assembly, the converter muffler weighs about 50 percent more. A standard muffler may weigh about 9 kg (20 lbs), while a converter muffler the same size will weigh 15 kg (33 lbs). To be fully effective, the gold plate on the ceramic honeycomb of the substrate must stay clean so that it can contact and burn any fuel and oil in the exhaust. A layer of pollutants on the gold plate will insulate it and allow unburned fuel and oil to pass through the catalytic converter muffler. To prevent pollution build-up on the gold plate, the muffler is built with aluminized stainless steel which is thicker and heavier than the aluminized steel used in standard mufflers.

Gasoline engines use separate catalytic converters and mufflers. Engine exhaust is routed from each exhaust manifold, back, to two separate catalytic converters on the forward end of the muffler. **See Fig. 2.**

To help the converters burn any residual oil and fuel, an air injection pump on the engine pumps air through lines to the catalytic converters. **See Fig. 3.** A pressure relief valve on the air injection line will open if pressure in the injection line is too high. Check valves at the catalytic converters keep hot exhaust from backing up the air injection lines into the injection pump and engine. After passing through the converters, the exhaust passes through the muffler. The catalytic converters, muffler, and exhaust pipes are suspended from the frame rails and transmission by rubber isolators (**see Fig. 4**) or straps (**Fig. 5**) that allow the exhaust system to move as necessary under normal vehicle operation.

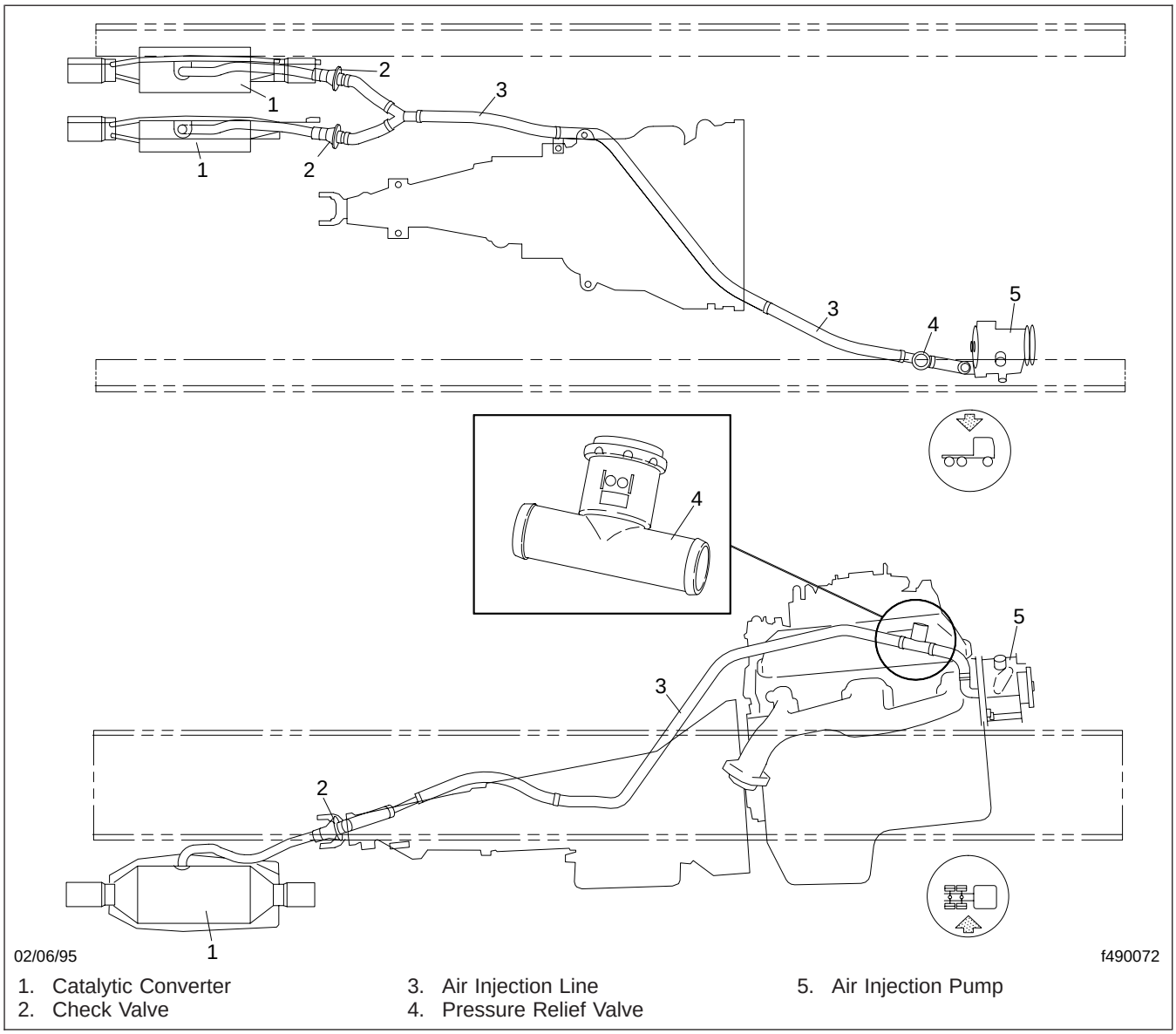
All catalyst muffer installations are certified to be in compliance with 1994 EPA standards. Use parts specified by PartsPro® when replacing any of the exhaust system components.

General Description



1. Exhaust Pipe 2. Catalytic Converter 3. Muffler

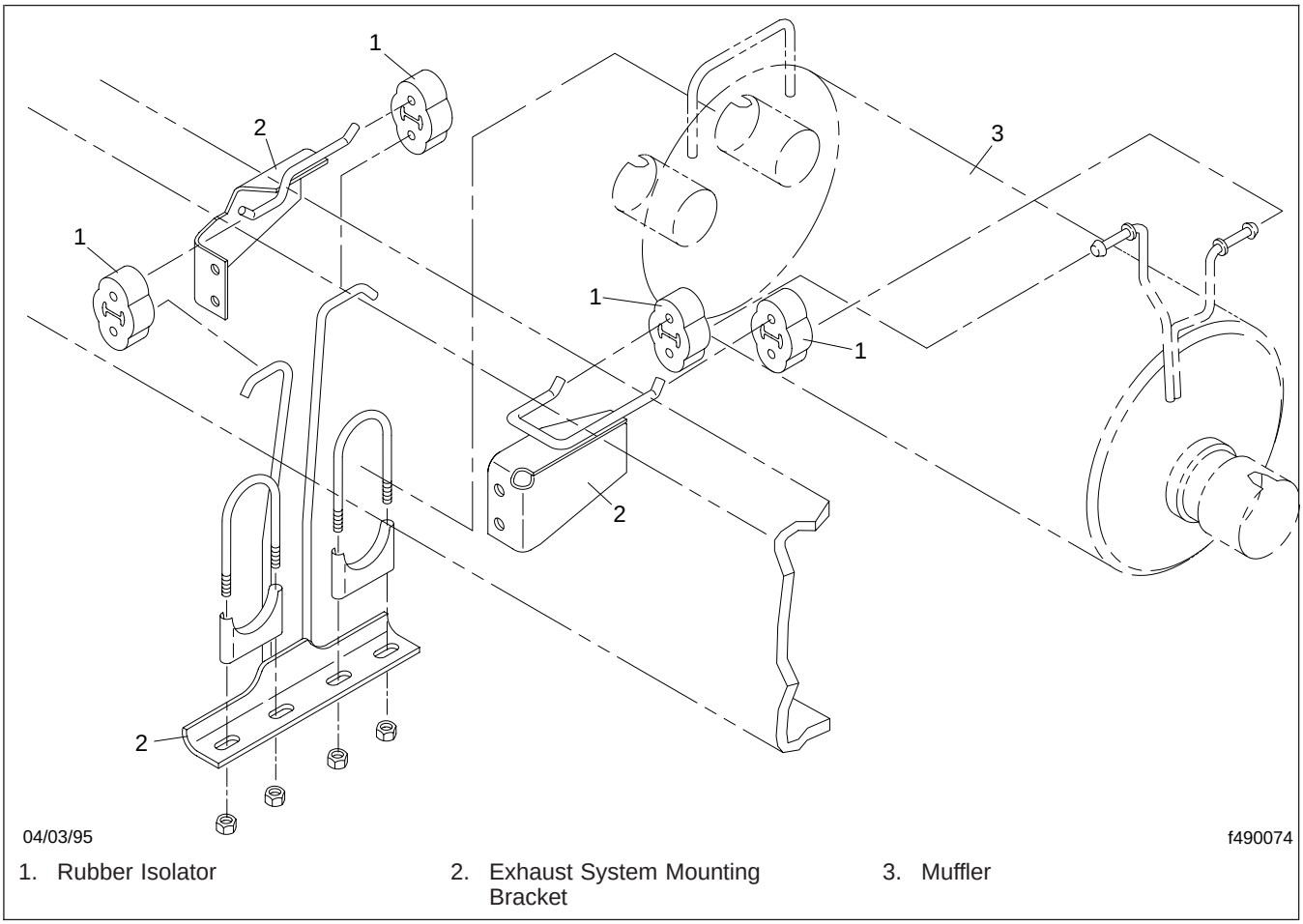
Fig. 2, Exhaust Routing, Dodge Magnum Engine



1. Catalytic Converter
2. Check Valve
3. Air Injection Line
4. Pressure Relief Valve
5. Air Injection Pump

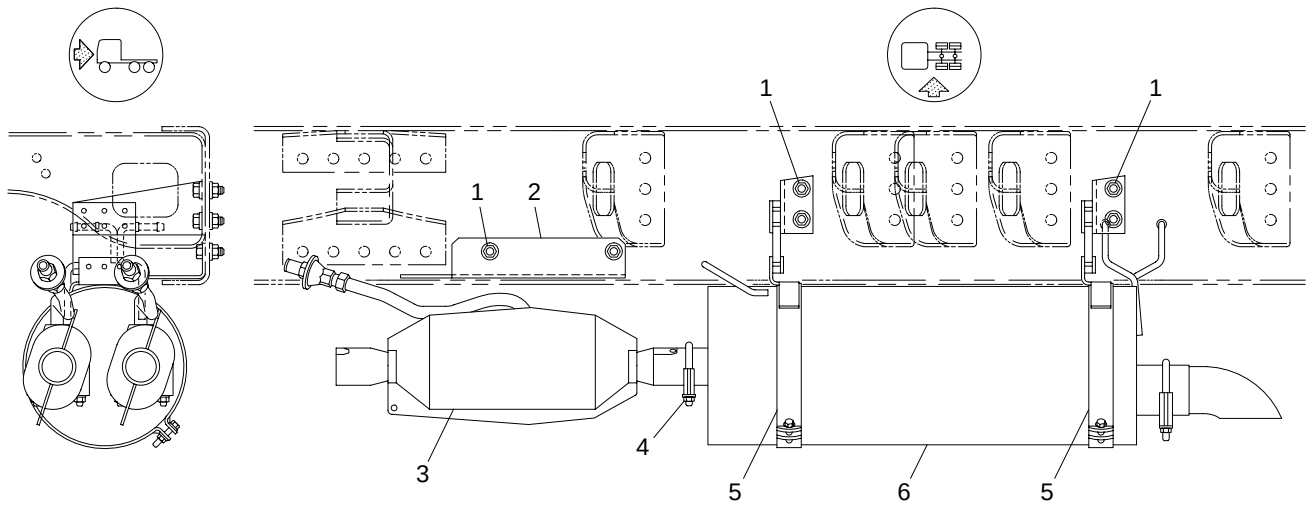
Fig. 3, Air Injection System, Dodge Magnum Engine

General Description



1. Rubber Isolator
2. Exhaust System Mounting Bracket
3. Muffler

Fig. 4, Muffler Mounting with Rubber Isolators, Dodge Magnum Engine



01/09/96 f490129

1. Capscrew, 1/2–13 x 1.75 inch, grade 8; Washer; Hexnut, 1/2–13
2. Heat Shield
3. Catalytic Converter
4. U-Bolt Clamp, 57.15 mm diameter
5. Muffler Support Assembly
6. Muffler

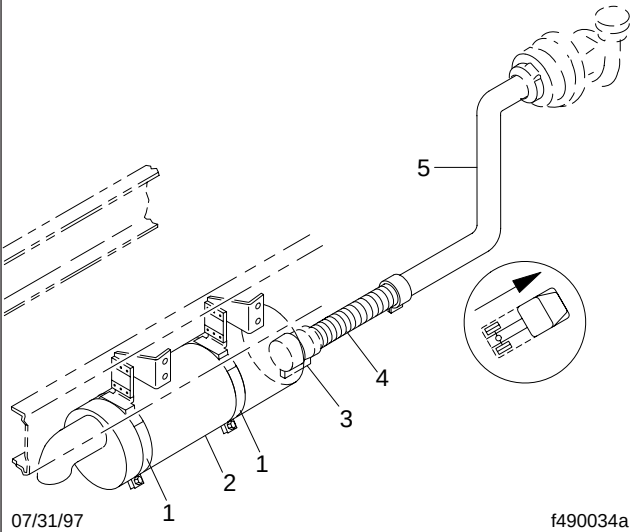
Fig. 5, Muffler Mounting with Straps, Dodge Magnum Engine

Replacement

NOTE: The mufflers on Freightliner Business Class vehicles can be mounted either horizontally or vertically. Use the following replacement procedure that applies to your vehicle.

Horizontally Mounted Mufflers

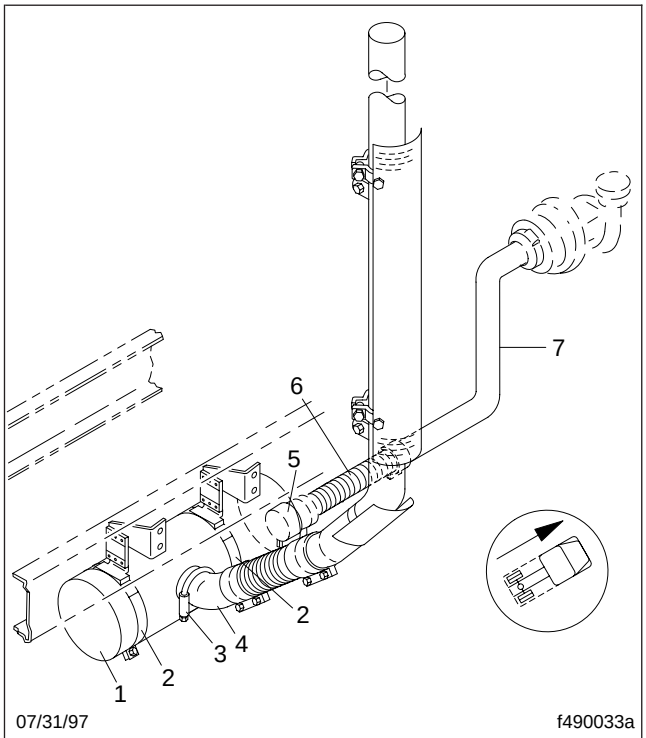
(See Fig. 1, Fig. 2 , and Fig. 3)



NOTE: The exhaust flex pipe (Ref. 4) may not be present on early model vehicles.

1. Muffler Mounting Band
2. Muffler
3. Wide-Band Exhaust Clamp
4. Exhaust Flex Pipe (except Cummins B 5.9 engines)
5. Muffler Inlet Exhaust Pipe

Fig. 1, Exhaust System Without a Stack, All Models Except FL112



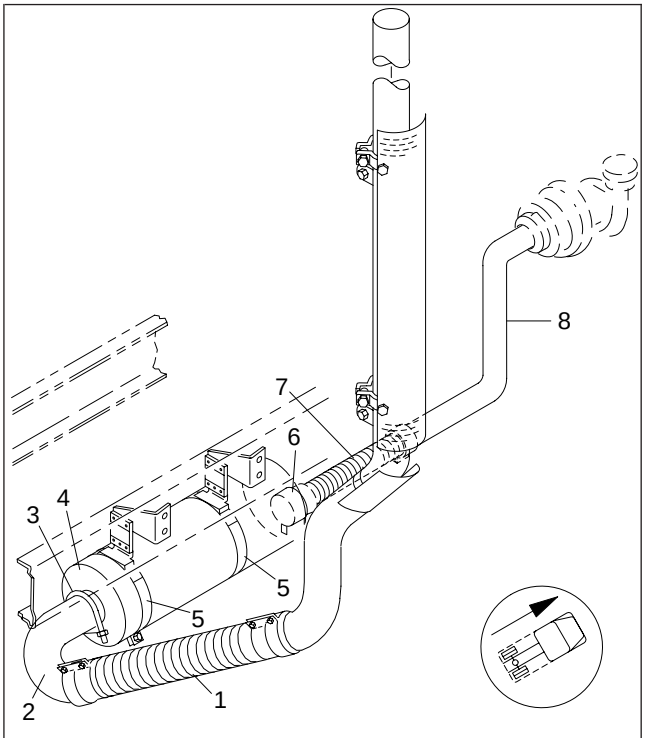
NOTE: This configuration is on vehicles built to August 2, 1996. The exhaust flex pipe (Ref. 6) may not be present on early model vehicles.

1. Muffler
2. Muffler Mounting Band
3. Saddle Clamp
4. Muffler Outlet Exhaust Pipe
5. Wide-Band Exhaust Clamp
6. Exhaust Flex Pipe (except Cummins B 5.9 engines)
7. Muffler Inlet Exhaust Pipe

Fig. 2, Exhaust System With a Stack, Side Outlet, All Models Except FL112

1. Remove the muffler.
   - 1.1 Remove and discard the wide-band exhaust clamp from the muffler inlet connection.
   - 1.2 On vehicles with a vertical exhaust stack, remove the saddle clamp from the muffler outlet connection. Pull the muffler outlet exhaust pipe out of the muffler outlet tube.
   - 1.3 Remove the bolts and locknuts on the front and rear muffler mounting bands. Remove the mounting bands. Remove the muffler.
2. Install the muffler.
   - 2.1 Slide the new muffler's inlet tube over the muffler inlet exhaust pipe.
   - 2.2 Install the front and rear muffler mounting bands. Install the bolts and locknuts on the mounting bands, but do not tighten them at this time.

Muffler Replacement



07/31/97 f490143

NOTE: This configuration is on vehicles built from August 2, 1996. The exhaust flex pipe (Ref. 7) may not be present on early model vehicles.

1. Flex Pipe
2. Rear Exhaust Outlet
3. Saddle Clamp
4. Muffler (catalytic converter on some engine models)
5. Muffler Mounting Band Muffler
6. Wide-Band Exhaust Clamp
7. Exhaust Flex Pipe (except Cummins B 5.9 engines)
8. Muffler Inlet Exhaust Pipe

Fig. 3, Exhaust System, Rear Outlet, All Models Except FL112

2.3 On vehicles with a vertical exhaust stack, slide the muffler outlet exhaust pipe into the muffler outlet tube.

2.4 Coat the lap joint area with chassis grease, so the clamp will slide freely without scratching the surface of the pipe.

2.5 Wrap a new wide-band exhaust clamp by hand around the lap joint. Place the large end of the clamp around the muffler inlet tube, and the small end around the inlet exhaust pipe.

2.6 Install the fasteners in the clamp. Starting from the larger end of the clamp, alternately tighten the fastener in three increments to a final torque of 50 to 60 lbf·ft (68 to 81 N·m).

Clean any excess chassis grease from around the clamp.

2.7 Install the saddle clamp U-bolt on the muffler outlet tube (where applicable). Tighten the saddle clamp flanged nuts alternately in three increments to a final torque of 24 lbf·ft (33 N·m).

2.8 Tighten the muffler mounting band fasteners until the band ears touch; then, tighten the fasteners two full turns or until the ears are in full contact, whichever occurs first.

2.9 Run the engine, and check for exhaust leakage at the exhaust clamp joints. Replace the wide-band exhaust clamps if they leak.

Vertically Mounted Mufflers (See Fig. 4)

1. Remove the muffler.

1.1 Loosen the narrow-band clamps that hold the stack on the muffler, and remove the stack.

1.2 Loosen the saddle clamp that holds the base of the muffler to the support channel.

1.3 Loosen the wide-band clamp that connects the muffler to the exhaust pipe.

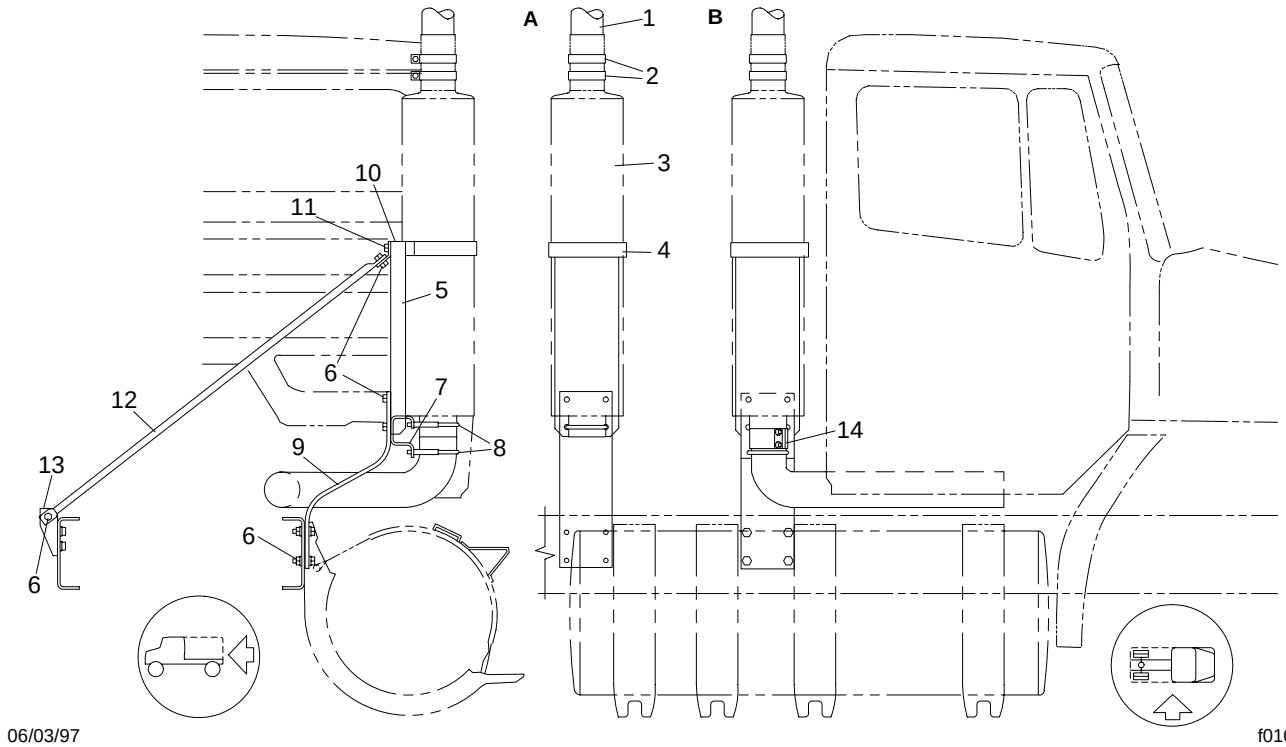
1.4 Remove the two bolts that hold the muffler mounting band to the muffler support channel.

1.5 Lift the muffler out of the lower saddle clamp.

2. Install the muffler.

2.1 Place the muffler in the support channel, and hold it in place while installing a new wide-band clamp to connect the muffler with the exhaust pipe.

2.2 Coat the lap joint area with chassis grease, so the clamp will slide freely without scratching the surface of the pipe.



A. Muffler Position, FL112 Conventional with Extended Cab

B. Muffler Position, FL112 Conventional with Day Cab

1. Exhaust Stack
2. Narrow-Band Clamp (2 qty.)
3. Muffler
4. Muffler Mounting Band
5. Support Channel
6. Nut, Washer, and Capscrew, 5/8–11, Grade 8
7. Lower Muffler Mounting Bracket
8. Saddle Clamp, 5-Inch
9. Upright Muffler Mounting Bracket
10. Upper Brace Bracket
11. Nut, Washer, and Capscrew, 1/2–13
12. Brace
13. Lower Brace Bracket
14. Wide-Band Clamp

Fig. 4, Vertical Exhaust Mounting, FL112

2.3 Wrap a new wide-band exhaust clamp by hand around the lap joint. Place the large end of the clamp around the muffler inlet, and the small end around the exhaust pipe.

2.4 Install the fasteners in the clamp. Starting from the larger end of the clamp, alternately tighten the fastener in three increments to a final torque of 50 to 60 lbf·ft (68 to 81 N·m).

Clean any excess chassis grease from around the clamp.

2.5 Install the saddle clamp at the bottom of the muffler, and tighten the clamp 24 lbf·ft (33 N·m).

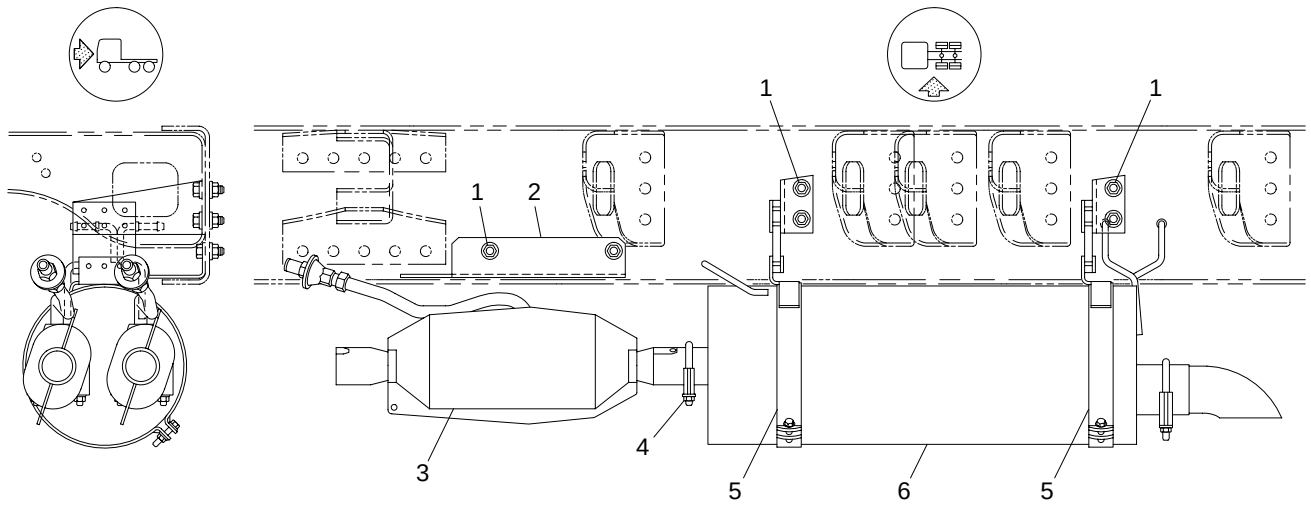
2.6 Install the capscrews, washers and nuts that hold the muffler mounting band to the support channel, and tighten the capscrews 68 lbf·ft (92 N·m).

2.7 Install the stack, and secure it with two narrow-band clamps. Tighten the clamps 50 lbf·ft (68 N·m).

2.8 Run the engine, and check for exhaust leakage at the exhaust clamp joints. Replace the wide-band exhaust clamps if they leak.

Muffler Removal and Installation, Gasoline Engines

Removal (See Fig.1 or Fig.2)



01/09/96 f490129

1. Capscrew, 1/2–13 x 1.75 inch, grade 8; Washer; Hexnut, 1/2–13
2. Heat Shield
3. Catalytic Converter
4. U-Bolt Clamp, 57.15 mm diameter
5. Muffler Support Assembly
6. Muffler

Fig. 1, Muffler Mounting with Straps, Dodge Magnum Engine

1. Park the vehicle, apply the parking brakes, and shut down the engine.
2. Loosen the two saddle clamps that hold the catalytic converters to the front of the muffler.
3. *If removing a muffler supported by straps (* **Fig.1***) do this step, if removing a muffler supported by rubber isolators (* **Fig.2***) go to the next step.*

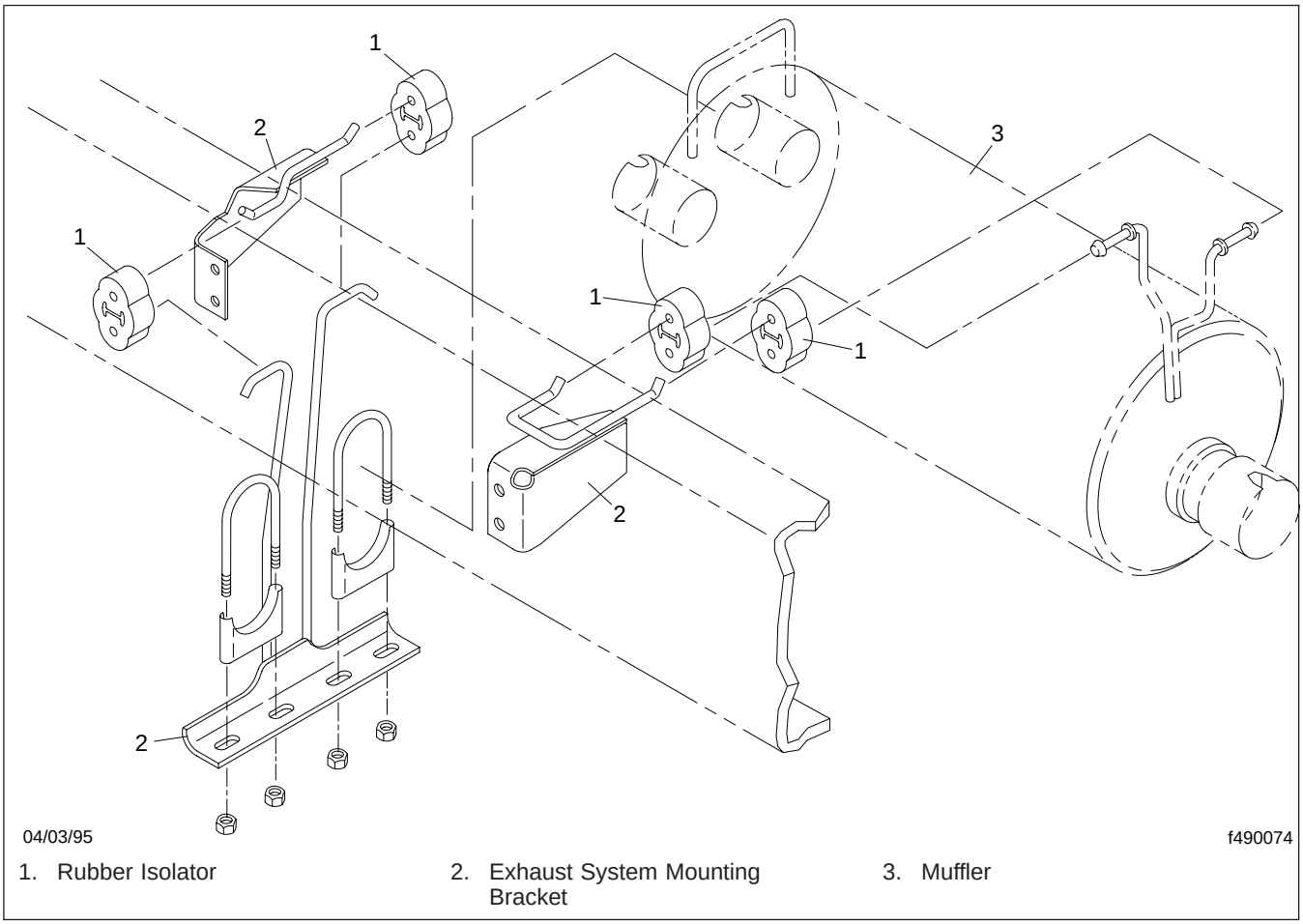
   Remove the capscrews that hold the bands of the muffler support assemblies together. Then lower and remove the muffler.
4. To remove a muffler supported by rubber isolators, support the muffler, and remove the two bolts that hold the rear exhaust system mounting bracket to the frame rail.
5. Pull the muffler back, away from the catalytic converters, and remove it.
6. If replacing the muffler, remove the rubber isolators and the rear exhaust system mounting bracket from the old muffler.

Installation

1. *If installing a muffler supported by straps (* **Fig.1***) do this step, if installing a muffler supported by rubber isolators (* **Fig.2***) go to the next step.*

   To install a muffler supported by straps, position the muffler in the bands of the support assemblies, then close the bands with capscrews and tighten the capscrews 13 N·m (10 lbf·ft). Now, go to the last step in this procedure.
2. To install a muffler supported by rubber isolators, first install the rubber isolators and the rear exhaust system mounting bracket on the new muffler.
3. Position the muffler in the vehicle so that it mates with the catalytic converters.
4. Install the two bolts that hold the rear exhaust system mounting bracket to the frame rail, and tighten the bolts firmly.

Muffler Removal and Installation, Gasoline Engines



1. Rubber Isolator
2. Exhaust System Mounting Bracket
3. Muffler

Fig. 2, Muffler Mounting with Rubber Isolators, Dodge Magnum Engine

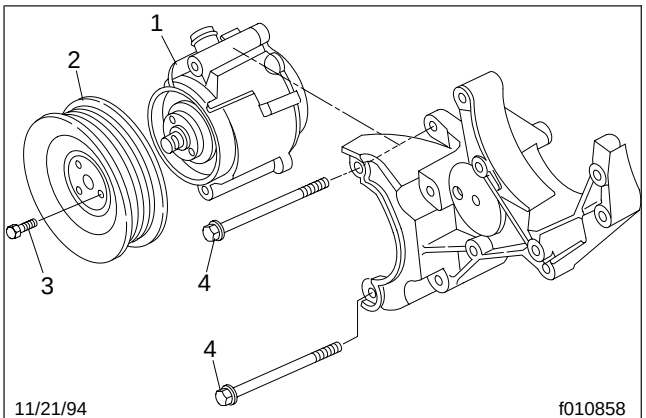
5. Tighten the saddle clamps to seal the muffler-catalytic converter joints.

Air Injection Pump Removal and Installation, Gasoline Engines

Removal

NOTE: The air injection pump does not have any internal serviceable parts.

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the hood.
3. Disconnect both the hoses at the air injection pump.
4. Loosen (but do not remove at this time) the three 10 mm air pump pulley mounting bolts. **See Fig. 1.**



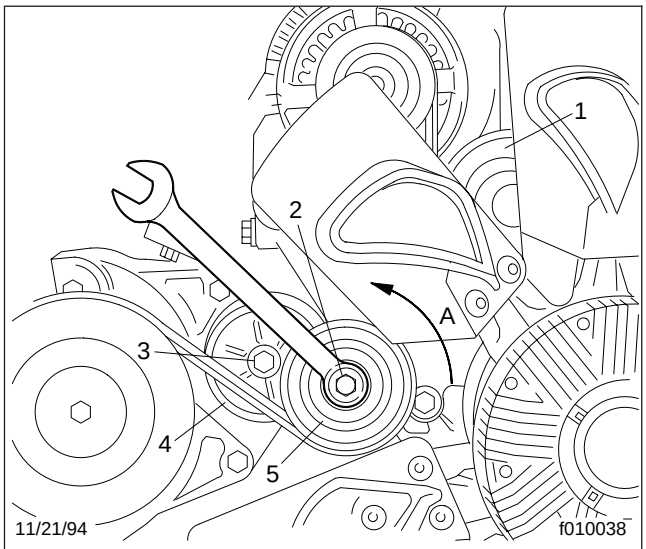
1. Air Injection Pump
2. Pump Pulley
3. Pulley Mounting Bolt
4. Pump Mounting Bolt

Fig. 1, Pump Mounting

5. Place a 5/8-inch wrench over the pulley bolt on the automatic belt tensioner, and turn the wrench counterclockwise to relax the belt tensioner and remove the engine accessory drive belt. **See Fig. 2.**
6. Remove the three air pump pulley bolts and remove the pulley from the pump.
7. Remove the two 14 mm air pump mounting bolts, and remove the pump from the mounting bracket. **See Fig. 1.**

Installation

1. Position the air injection pump on the mounting bracket.



A. Turn counterclockwise to remove the belt.

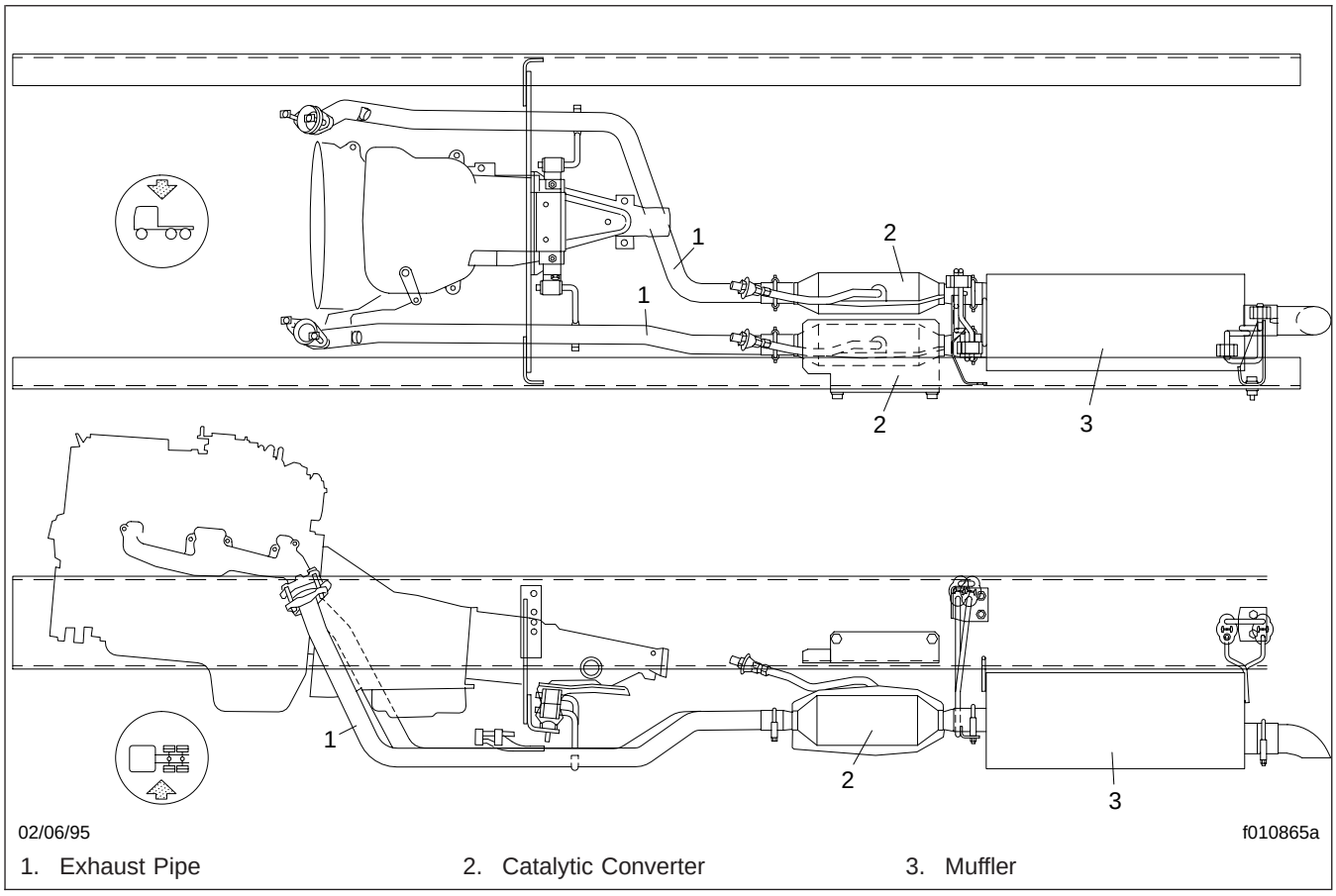
1. Idler Pulley
2. Tensioner Pulley Bolt
3. Tensioner Mounting Bolt
4. Tensioner
5. Tensioner Pulley

Fig. 2, Relieving Belt Tension

2. Install the two 14 mm pump mounting bolts. **See Fig. 1.** Tighten the mounting bolts 40 N·m (30 lbf·ft).
3. Install the pump pulley and three 10 mm pulley mounting bolts. Tighten the bolts finger tight.
4. Place a 5/8-inch wrench over the pulley bolt on the automatic belt tensioner, and turn the wrench counterclockwise to relax the belt tensioner. Install the engine accessory drive belt. **See Fig. 2.**
5. Tighten the pump pulley mounting bolts 1180 N·cm (105 lbf·in).
6. Connect the two hoses to the air pump.
7. Lower the hood, and remove the chocks from the tires.

Catalytic Converter Removal and Installation, Gasoline Engines

Removal (See Fig.1 or Fig.2)



1. Exhaust Pipe 2. Catalytic Converter 3. Muffler

Fig. 1, Muffler Mounting with Rubber Isolators, Dodge Magnum Engine

1. Park the vehicle, apply the parking brakes, and shut down the engine.
2. *If the muffler is mounted with rubber isolators (* **Fig.1***), remove the muffler. For instructions, refer to* **Subject 105***.*

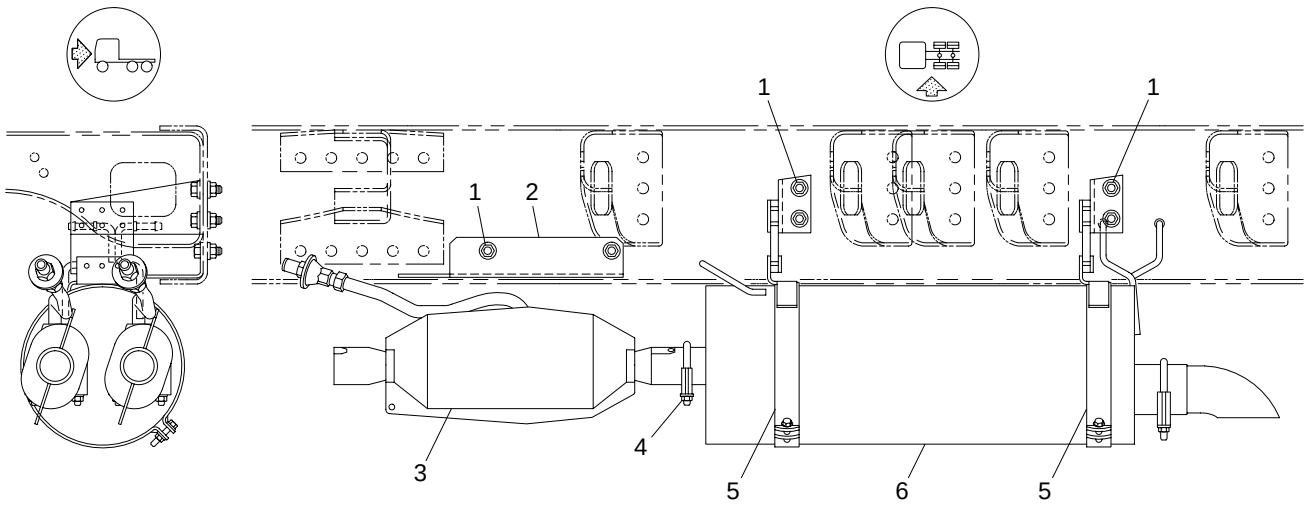
   If the muffler is mounted with straps (**Fig.2***), loosen the U-bolt clamps that hold the catalytic converters to the muffler.*
3. Loosen the clamps that hold the air injection lines to the catalytic converters. Then, disconnect the lines from the converters.
4. Loosen the saddle clamps that hold the catalytic converters to the exhaust pipes, then pull the converters back and remove them.

Installation

1. Position the catalytic converters on the exhaust pipes, but don't tighten the saddle clamps yet.
2. *If the muffler is mounted with rubber isolators (* **Fig.1***), install the muffler. For instructions, refer to* **Subject 105***.*

   If the muffler is mounted with straps (**Fig.2***), connect the catalytic converters to the muffler, and tighten the U-bolt clamps to seal the connection.*
3. Tighten the saddle clamps to seal the joint between the exhaust piping and each catalytic converter.

Catalytic Converter Removal and Installation, Gasoline Engines



01/09/96 f490129

1. Capscrew, 1/2–13 x 1.75 inch, grade 8; Washer; Hexnut, 1/2–13
2. Heat Shield
3. Catalytic Converter
4. U-Bolt Clamp, 57.15 mm diameter
5. Muffler Support Assembly
6. Muffler

Fig. 2, Muffler Mounting with Straps, Dodge Magnum Engine

4. Connect the air injection lines to the catalytic converters, and tighten the hose clamps.

Specifications

Description	Grade	Size	Torque N·m (lbf·ft)
Wide-Band Exhaust Clamp	—	—	68-81 (50-60)
Saddle Clamp U-Bolt	—	3/8–16	33 (24)
Exhaust Stack Shield Capscrews	302 SS	5/16–18	18 (13)
Mounting Band Fasteners	—	—	14 (10)

Table 1, Fastener Torques

General Information and Principles of Operation

The Freightliner engine warning system is an optional system that alerts the driver to any problem associated with low oil pressure, high coolant temperature, and low coolant level. If a problem occurs in one of these systems, an indicator light will illuminate on the dashboard and a buzzer will sound.

The warning light and buzzer for the low oil pressure and high coolant temperature are activated by switches. The warning light and buzzer for the low coolant level are activated by a probe and a module.

NOTE: The low oil pressure switch and the high coolant temperature switch activate the same warning light.

- If the engine oil pressure drops below a predetermined level, the warning light comes on and the buzzer sounds. The pressure that triggers the warning light and buzzer is given in **Table 1.**

Engine Model	Switching Pressure bar (psi)	Switch Position	
		Engine Off (Ignition Off)	Engine Running
MB OM 366LA	0.7 (10)	NC *	Open
Cummins B5.9	0.7 (10)	NC *	Open

* NO = normally open; NC = normally closed. A normally open switch is open; a normally closed switch is closed when the engine is shut down and all electrical power is off.

Table 1, Low Oil Pressure Switch

- If the engine overheats, the warning light comes on and the buzzer sounds. The temperature that triggers the warning light and buzzer varies with engine type. **See Table 2.**

Engine Model	Switching Temperature°C (°F)	Switch Position	
		Ignition Off	Ignition On
MB OM 366LA	96 (205)	NO *	Open
Cummins B5.9	99 (210)	NO *.	Open

* NO = normally open; NC = normally closed. A normally open switch is open; a normally closed switch is closed when the engine is shut down and all electrical power is off.

Table 2, High Coolant Temperature Switch

- If the coolant level drops below a probe in the cooling system, the low coolant light comes on and the buzzer sounds. As an antislosh feature, the probe must be exposed for more than five seconds before the warnings are activated.

Because power is supplied to these circuits through the ignition switch, turning the ignition switch off also shuts off the warning system.

ENGINE FUNCTIONS

The low oil pressure switch controls a ground activated circuit: The switch is normally closed (NC). [1] During normal operation, the switch is held open by the engine oil pressure. If the oil pressure drops below a predetermined point **(see Table 1),** the switch closes and connects wire 34 to ground. This completes the circuit, activating the warning light and buzzer.

The coolant temperature switch also controls a ground activated circuit, but the switch is normally open (NO). [1] If the coolant temperature rises above a predetermined point **(see Table 2),** the switch closes and connects wire 18C to ground. This completes the circuit, activating the warning light and buzzer.

The coolant level warning system consists of a probe and a module. The probe is located in the surge tank and uses the coolant as a conductor to ground. If the coolant level drops below the probe for longer than 5 seconds, the module, which controls a normally open (NO) [1] switch, will close the switch and connect wire 150G to ground. This completes the circuit, activating the low coolant level warning light and the buzzer.

[1] NO = normally open; NC = normally closed. A normally open switch is open; a normally closed switch is closed when the engine is shut down and all electrical power is off.

Low Coolant Level Control Module Replacement

Replacement

1. The control module is located behind the right-side upper dashboard panel, above the electrical center. Access it by removing the rubber trim piece on the right side of the dashboard and the two screws that connect the dashboard cover to the dashboard.
2. Disconnect the vehicle harness 5-pin connector from the module (only 4 pins are used), then remove the low coolant level module from the mounting bracket.
3. Install the new low coolant level module and connect the 5-pin connector.
4. Install the dashboard cover and tighten the screws securely; then install the trim piece.

Replacement

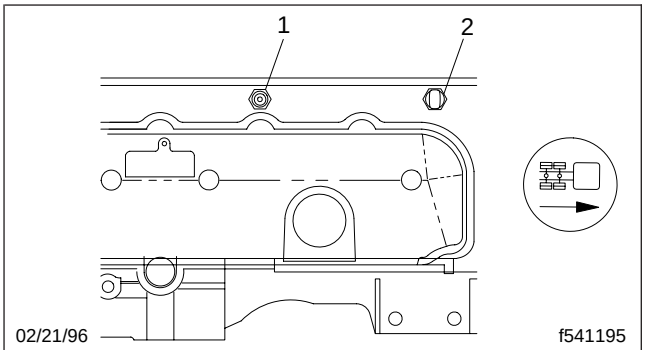
HIGH COOLANT TEMPERATURE SWITCH

1. Turn off the ignition switch and let the engine cool. Remove the surge tank cap to release the system pressure.

⚠ WARNING

Do not drain coolant from a hot engine. Opening the cooling system when the engine and coolant are hot can cause severe personal injury due to scalding by the hot, pressurized coolant.

2. Drain the coolant from the engine.
3. Disconnect wire 18C from the high coolant temperature switch (see **Fig. 1**, **Fig. 2**, **Fig. 3**, **Fig. 4**, **Fig. 5,** , **Fig. 6**, **Fig. 7**, and **Fig. 8**); then remove the switch.



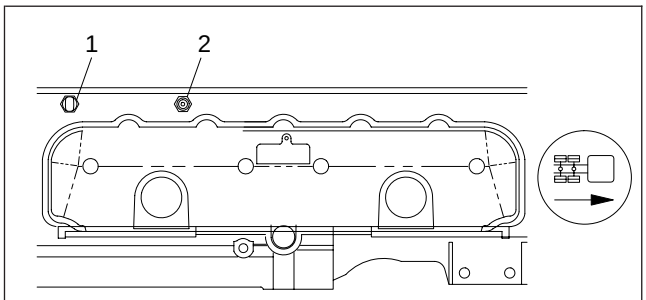
1. Coolant Temperature Sender
2. High Coolant Temperature Switch

Fig. 1, OM 366LA, Forward Mounted Coolant Temperature Sender and High Coolant Temperature Switch

4. Install the new switch and tighten it one-half turn past finger-tight. Connect wire 18C to the switch.
5. Add coolant to the system as needed; then install the cap. Start the engine and check the system to be sure there are no coolant leaks.

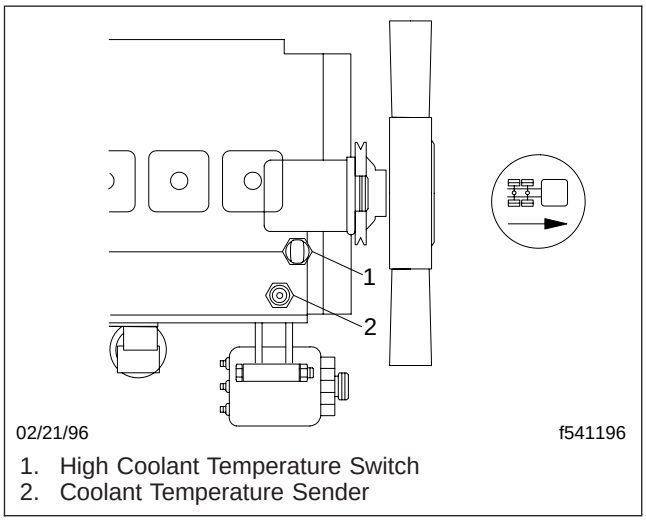
LOW COOLANT LEVEL PROBE

1. Turn off the ignition switch and let the engine cool. Remove the surge tank cap to release the system pressure.



1. High Coolant Temperature Switch
2. Coolant Temperature Sender

Fig. 2, OM 366LA, Rear Mounted Coolant Temperature Sender and High Coolant Temperature Switch



1. High Coolant Temperature Switch
2. Coolant Temperature Sender

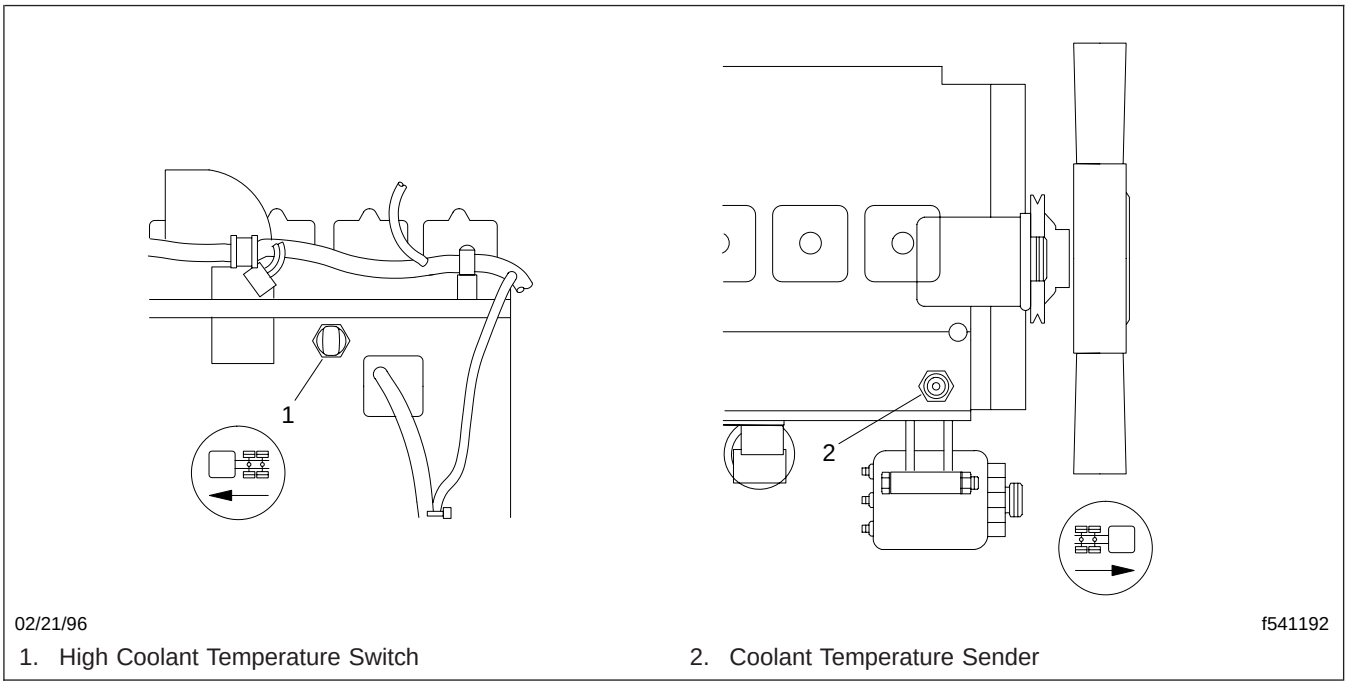
Fig. 3, Cummins B Series with Top Mounted Coolant Temperature Sender and High Coolant Temperature Switch

⚠ WARNING

WARNING: Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

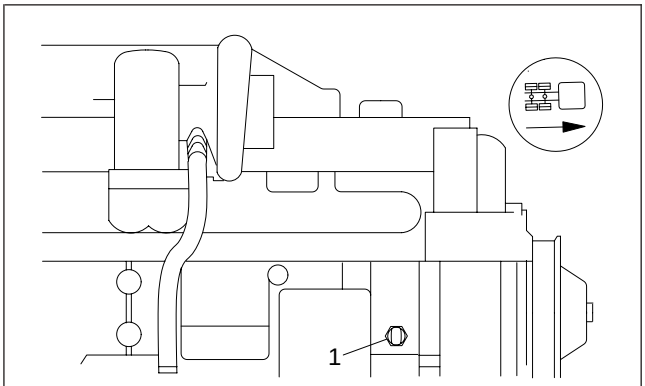
2. Drain the coolant from the surge tank.
3. Disconnect wire 173 and the ground wire (if equipped) from the low coolant level probe, located in the inboard side of the surge tank (see **Fig. 9**); then remove the probe.

Switch (Sensor) Replacement



1. High Coolant Temperature Switch
2. Coolant Temperature Sender

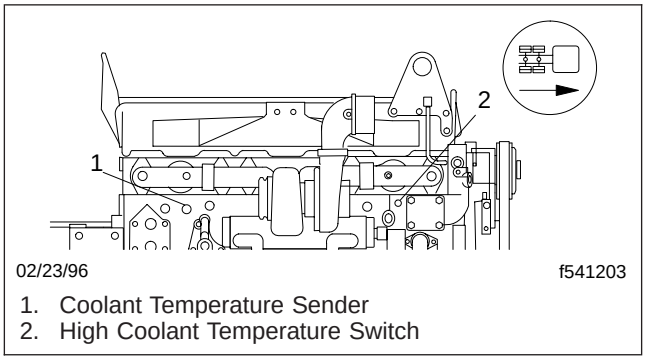
Fig. 4, Cummins B Series with Side Mounted Coolant Temperature Sender and Top Mounted High Coolant Temperature Switch



1. Coolant Temperature Sender, and High Coolant Temperature Switch

Fig. 5, Cummins C Series

4. Install the new probe and tighten it one-half turn past finger-tight. Connect wire 173 to the probe.
5. Add coolant to the system as needed; then install the cap.



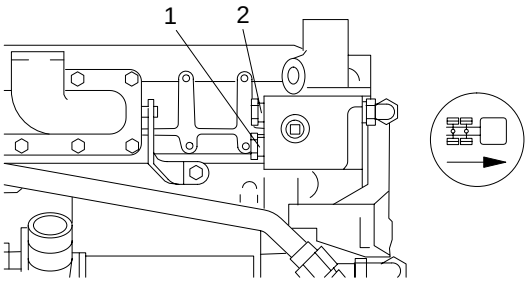
1. Coolant Temperature Sender
2. High Coolant Temperature Switch

Fig. 6, Cummins M11

6. Start the engine and check that the low coolant level warning light and buzzer do not come on. Check the system to be sure there are no coolant leaks.

LOW OIL PRESSURE SWITCH

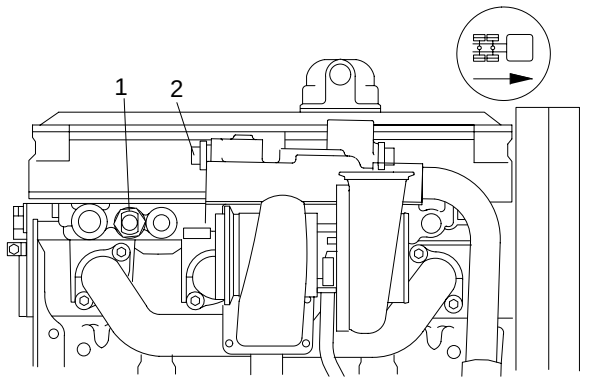
NOTE: The low oil pressure warning switch is located on a tee on the air-oil manifold located behind the left side of the dash panel. Access it by removing the rubber trim piece and the two



02/20/96 f541190

1. Coolant Temperature Sender
2. High Coolant Temperature Switch

Fig. 7, Caterpillar 3126



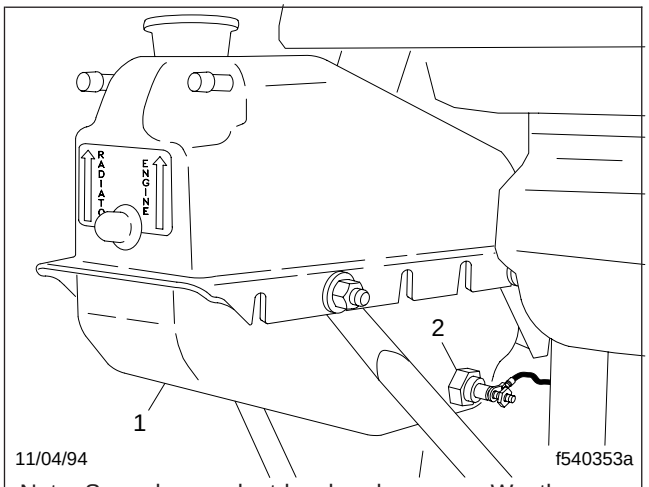
10/01/96 f541194

1. High Coolant Temperature Switch
2. Coolant Temperature Sender

Fig. 8, Detroit Diesel 50 Series

screws that connect the dashboard cover to the dashboard.

1. Turn off the ignition switch.
2. Disconnect wire 34 from the switch. (see **Fig. 10**, Ref. 2),. then remove the switch.
3. Install the new switch and tighten it one-half turn past finger-tight. Connect wire 34 to the switch.
4. Start the engine and check that the warning light and buzzer shut off when the oil pressure reaches approximately 10 psi (69 kPa). Check the system to be sure there is no oil leakage.



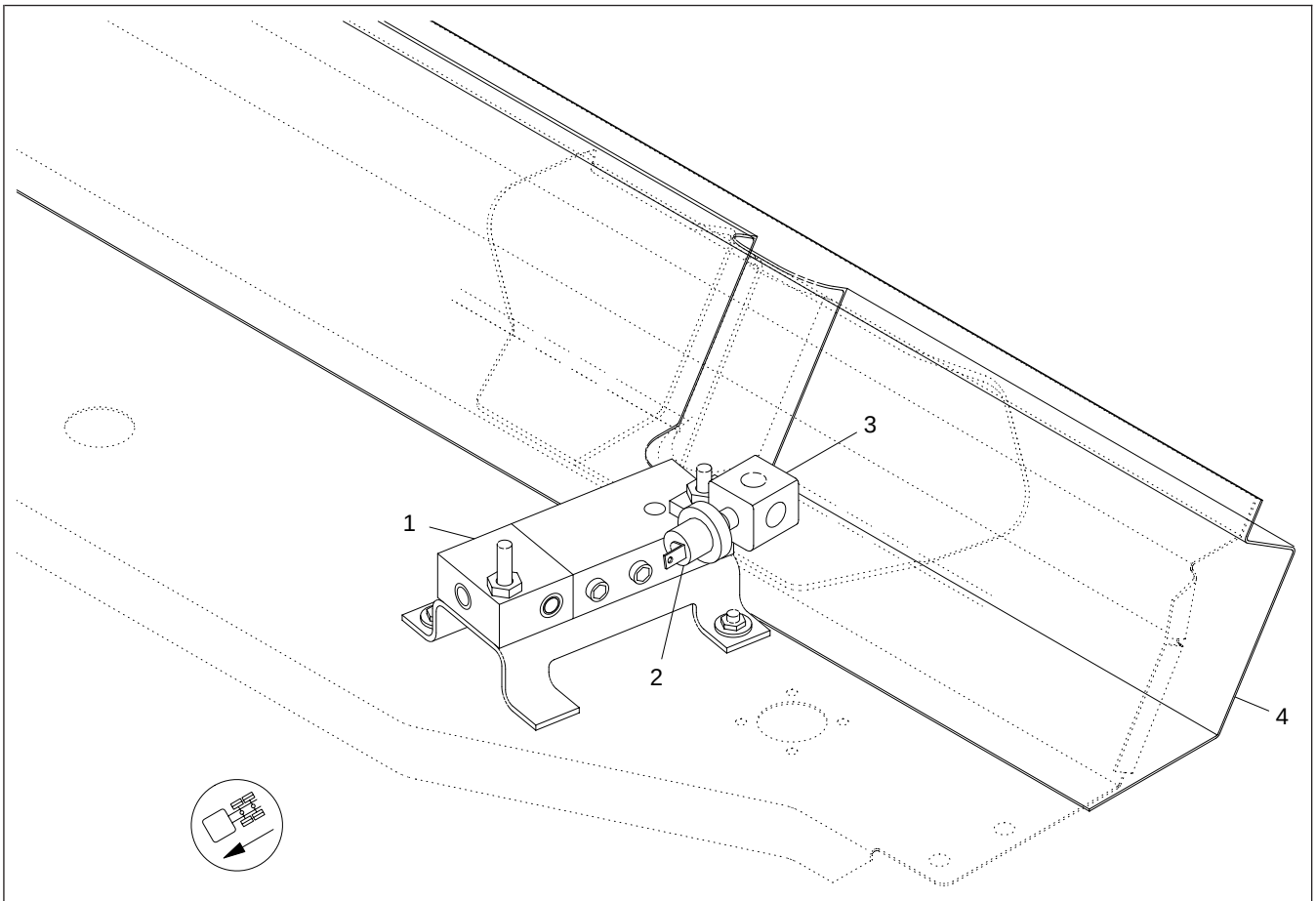
11/04/94 f540353a

Note: Some low coolant level probes use a Weather Pack® connector. The low coolant level probe may also have a ground wire attached to its body.

1. Surge Tank
2. Low Coolant Level Probe

Fig. 9, Low Coolant Level Probe

Switch (Sensor) Replacement



11/07/94 f540351a

NOTE: For clarity, other air/oil fittings, lines, and switches are not shown.

1. Air/Oil Manifold
2. Low Oil Pressure Switch
3. Tee
4. Lower Dash Panel

Fig. 10, Low Oil Pressure Switch

Troubleshooting

This subject contains the following troubleshooting tables:

- Warning Light Comes On But the Buzzer Does Not Sound
- Buzzer Sounds But the Warning Light Does Not Come On
- Buzzer Does Not Sound and Light Does Not Come On When the Systems Are Known to Be Operating Incorrectly
- Warning Light or Buzzer or Both Stay On When the Systems Are Known to Be Operating Correctly

Problem—Warning Light Comes On But the Buzzer Does Not Sound

Possible Cause	Remedy
The buzzer assembly is damaged.	Replace the buzzer assembly.
There is a break in the wiring between the fuse and the buzzer assembly, or between the buzzer assembly and the switch (or low coolant level module, if equipped).	Repair or replace the wiring as needed.

Problem—Buzzer Sounds But the Warning Light Does Not Come On

Possible Cause	Remedy
One or more of the warning lights is loose or damaged.	Check each bulb and replace as needed.
There is a break in the wiring between the fuse and the warning lights, or between the warning lights and the switch (or low coolant level module, if equipped).	Repair or replace the wiring as needed.

Problem—Buzzer Does Not Sound and Light Does Not Come On When the Systems Are Known to Be Operating Incorrectly

Possible Cause	Remedy
The fuse is damaged.	Replace the fuse.
A switch (or the low coolant level module, and/or probe, if equipped) is damaged.	Replace the damaged switch, module, or probe, as needed.
There is a short or break in the wiring from the fuse to both the buzzer assembly and the warning light.	Repair or replace the wiring as needed.

Problem—Warning Light or Buzzer or Both Stay On When the Systems Are Known to Be Operating Correctly

Possible Cause	Remedy
A switch (or the low coolant level module, and/or probe, if equipped) is damaged.	Replace the damaged switch, module, or probe, as needed.
The circuits are closing to ground due to a short in the wiring from the warning lights or the buzzer assembly to the switches (or low coolant control module and/or probe, if equipped).	Repair or replace the wiring as needed.

Specifications

This subject contains the following tables:

- Low Oil Pressure Switch
- High Coolant Temperature Switch

For the Freightliner warning system wiring diagram, see **Fig. 1** .

Engine Model	Switching Pressure psi (bar)	Switch Position	
		Engine Off (Ignition Off)	Engine Running
All Engines	10 (0.7)	NC *	Open

* NO = normally open; NC = normally closed. A normally open switch is open when the engine is shut down. A normally closed switch is closed when the engine is shut down.

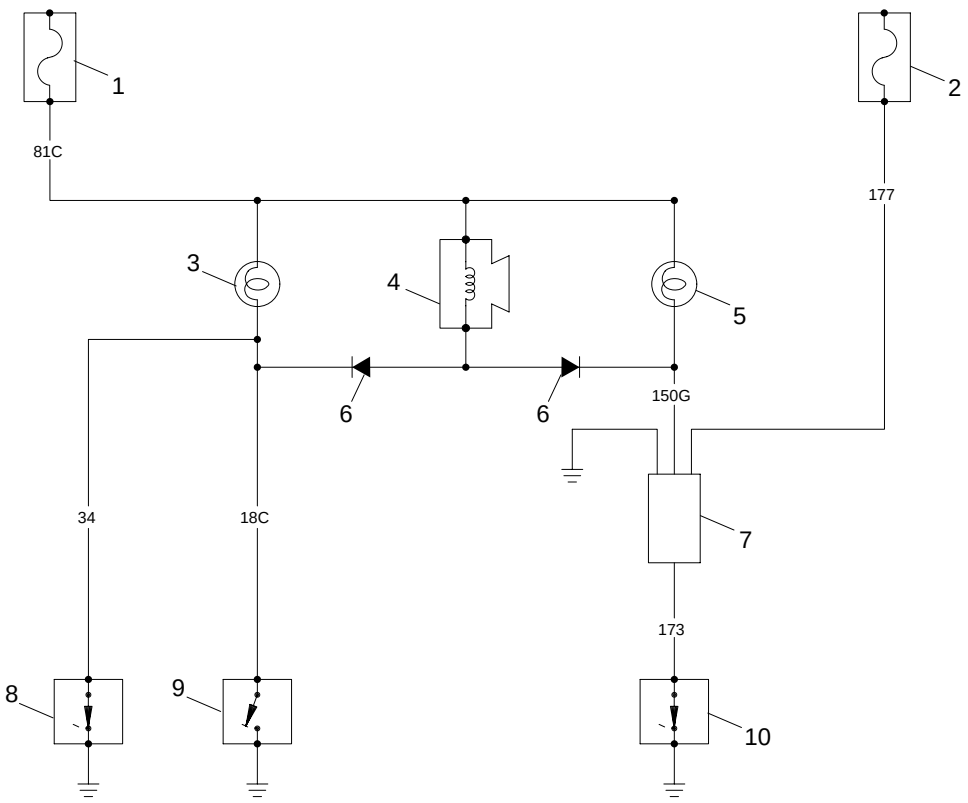
Table 1, Low Oil Pressure Switch

Engine Model	Switching Temperature°F (°C)	Switch Position	
		Ignition Off	Ignition On
MB OM 366LA	205 (96)	NO *	Open
Cummins B5.9	215 (101)	NO *	Open
Cummins C Series	215 (101)	NO *	Open
Cummins M11	220 (104)	NO *	Open
Caterpillar 3126	225 (107)	NO *	Open
DDEC 50 Series	215 (101)	NO *	Open

* NO = normally open; NC = normally closed. A normally open switch is open when the engine is shut down. A normally closed switch is closed when the engine is shut down. Also, see **Fig. 1**.

Table 2, High Coolant Temperature Switch

Specifications



1. 10 Amp Fuse (ignition controlled)
2. 15 Amp Fuse (accessory controlled)
3. Low Oil Pressure/High Coolant Temperature Light
4. Warning Buzzer
5. Low Coolant Level Light
6. Diode
7. Low Coolant Level Module
8. Low Oil Pressure Switch
9. High Coolant Temperature Switch
10. Low Coolant Level Probe

Fig. 1, Freightliner Warning System Wiring Diagram (key off)

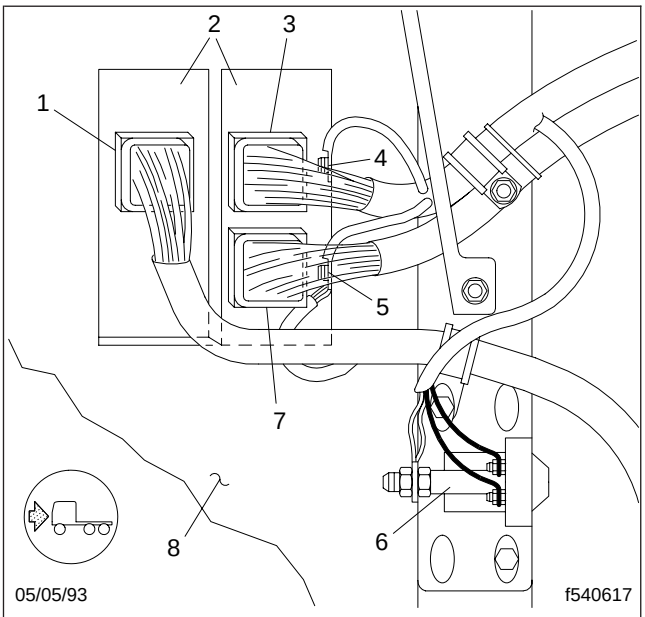
General Information

A 21.5 by 28 cm (8-1/2 by 11 inch) clear-coated white vinyl card, with the standard vehicle wiring diagram printed on one side, and the wire number code identification printed on the other, is placed in the storage console of each vehicle. This standard vehicle wiring diagram is shown in **Specifications, 400**. It shows the wiring circuits for all standard and standard-option electrical components and systems. Wiring diagrams that cover specific systems are included in Specifications, 400, of the applicable sections throughout this service manual.

The wire number code identification is shown in a table in **Specifications, 400**. It is a listing by circuit number of the vehicles' standard and standard-option electrical components and systems, with a brief circuit description for each.

Most of the vehicle wiring is included in just three major wiring harnesses: the engine harness (varies by engine), the chassis harness, and the main cab harness. A fourth major wiring harness is used with vehicles having an electronic engine. The main cab harness is joined to the engine harness(es) and the chassis harness at two (or, three for electronic engines) 28-pin bulkhead connectors attached to a junction plate on the passenger's side of the firewall. See **Fig. 1**. Additional harnesses are used for variable and optional components. The insulation on each wire is marked every two to three inches with its circuit number. All exterior wiring connections use weather-proof Metri-Pack® connectors.

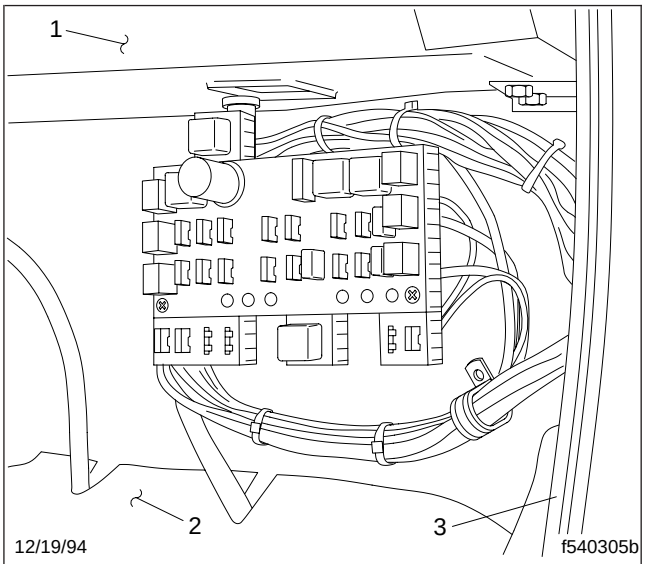
On vehicles with left-hand drive, the electrical power center, containing the relays and fuses or circuit breakers, is located on an expandable panel under the passenger-side of the dash, near the 28-pin frontwall harness connectors. On vehicles with right-hand drive, the electrical power center is located under the center dash skirt panel. See **Fig. 2** for a typical electrical power center. Standard protection for circuits is provided by plug-in blade-type fuses; optional protection is by automatic-reset circuit breakers. For identification of all fuses, circuit breakers, and relays, see **Specifications 400**.



1. 28-pin Chassis Connector (to main cab harness connector inside cab)
2. Junction Plate
3. 28-pin Engine Connector (to main cab harness connector inside cab)
4. Power (positive) Stud
5. Ground Stud
6. Magnetic Switch
7. 28-pin Electronic Engine Connector (to main cab harness connector inside cab)
8. Bulkhead (passenger-side of engine compartment)

Fig. 1, Junction Plate and Electrical Connectors

General Information



1. Passenger-Side Lower Dash
2. Floor Mat
3. Passenger's Door-Opening Frame

Fig. 2, Expandable Electrical Power Center

Repair and Replacement

IMPORTANT: Before you repair or replace any damaged electrical system parts, find and correct the cause of the damage; otherwise it could occur again.

Wiring insulation can be damaged from heat (internal or external), chafing, kinking, breaking, cracking, or saturation with oil or grease.

Discolored wire insulation (brown) is caused by long-term overheating of the wire itself. Melted insulation is usually caused by an external heat source.

Repair or replace damaged wiring. The choice depends on the type of damage and the wire size. **See Table 1 .** If the wire is 12 gauge or larger, replace it.

Type of Damage	Remedy
Broken wire	Repair or replace *
Kinked wire	Replace
Oil-soaked insulation	Replace
Cracked insulation	Repair if minor, otherwise replace
Melted insulation	Replace
Worn or missing insulation	Repair or replace †
Discolored insulation	Replace

* Repair the break by soldering the two broken ends together, if there is enough slack in the wire; otherwise solder in a new section of wire. See "Repairing Broken Wire" for instructions.
† Repair the damage if the area is two inches (51 mm) or less in length; otherwise, replace the section of wiring.

Table 1

REPAIRING DAMAGED WIRE INSULATION

1. Using shrink tubing, cover the damaged area. Overlap the damaged area at least 3/4 inch (20 mm) on both sides.

IMPORTANT: Don't repair the insulation if the wire underneath is also damaged. Remove and replace the damaged section.

2. If the insulation is chafed, find the source of chafing, and reroute the wiring away from it. If this isn't possible, either cover the sharp edge with protective vinyl trim 48–02188–001, or use convoluted tubing to protect the insulation.
3. Cover the repaired section of wiring with plastic convoluted tubing.

REPLACING DAMAGED WIRE

⚠ CAUTION

CAUTION: Never replace a wire with a smaller gauge wire. Wire gauge is selected by electrical load and current capabilities, and overheating may occur if a wrong gauge wire is used.

1. Replace damaged wire using a solder splice. See "Repairing Broken Wire" for instructions. Use only solder splices. If the damaged wire is 12 gauge or larger, replace the entire section of wire.
2. If the insulation has been discolored, find out what is causing the wire to overheat, and correct it.
3. If the insulation has been melted, check the routing of the wiring and find the problem. Reroute the wiring if possible, and secure it with clamps. If rerouting is not possible, use a heat shield to protect the wire.

REPAIRING ELECTRICAL CONNECTIONS

1. Find the cause of the damage or corrosion, and correct the problem.
2. Clean corroded connectors with a wire brush, using a solution of baking soda and water. Replace any damaged connectors.
3. Spray any exposed connectors (such as ground terminals) with dielectric red enamel. **See Table 2** for approved brands.

Material	Approved Brand(s)
Dielectric Red Enamel Spray	3-M® 1602
	IVI® Spray-Sealer
	Spray-On® B-6-665

Table 2

Wiring Repair and Replacement

REPAIRING BROKEN WIRE

IMPORTANT: The following procedure is the only approved method of repairing broken wires on Freightliner vehicles. This procedure (solder splicing) is done using solder repair kit ESYES66 404, and is for 14-or 16-gauge wire. Don't repair wire that is 12 gauge or larger; replace it.

1. Strip the ends of the wire to be repaired. Make sure the stripped ends are 3/8-to 1/2-inch (10-to 13-mm) long.
2. If repairing an exterior wire, slip a 3-inch (75-mm) long piece of shrink tube over one end of the wire. **See Fig. 1** , Ref. 4.
3. Slip a solder sleeve from kit ESYES66 404 over one end of the wire. **See Fig. 1** , Ref. 3.
4. Using a suitable crimp tool and a crimp splice from the kit, crimp the ends of the wire as follows **(see Fig. 2):**
   - 4.1 Insert a stripped wire end into the crimp splice until it touches the wire stop (Ref. 1) in the middle of the crimp splice.
   - 4.2 Center the crimping tool between the wire stop and the end of the crimp splice, then crimp the wire.
   - 4.3 Repeat steps for crimping the other wire end.
5. Check the crimp, making sure the crimping tool impression is on both ends of the crimp splice.
6. Slide the solder sleeve over the crimp splice so the solder ring is over the center of the crimp splice **(see Fig. 3),** then apply 250°F (121°C) heat until the solder flows into the splice crimp, and the plastic sleeve has shrunk completely against the wire.
7. If shrink tubing was installed to repair an exterior wire, slide it over the splice; then apply 250°F (121°C) heat to it until it's completely shrunk against the wire insulation. Some of the sealant material should be bubbling out from the ends of the shrink tube.

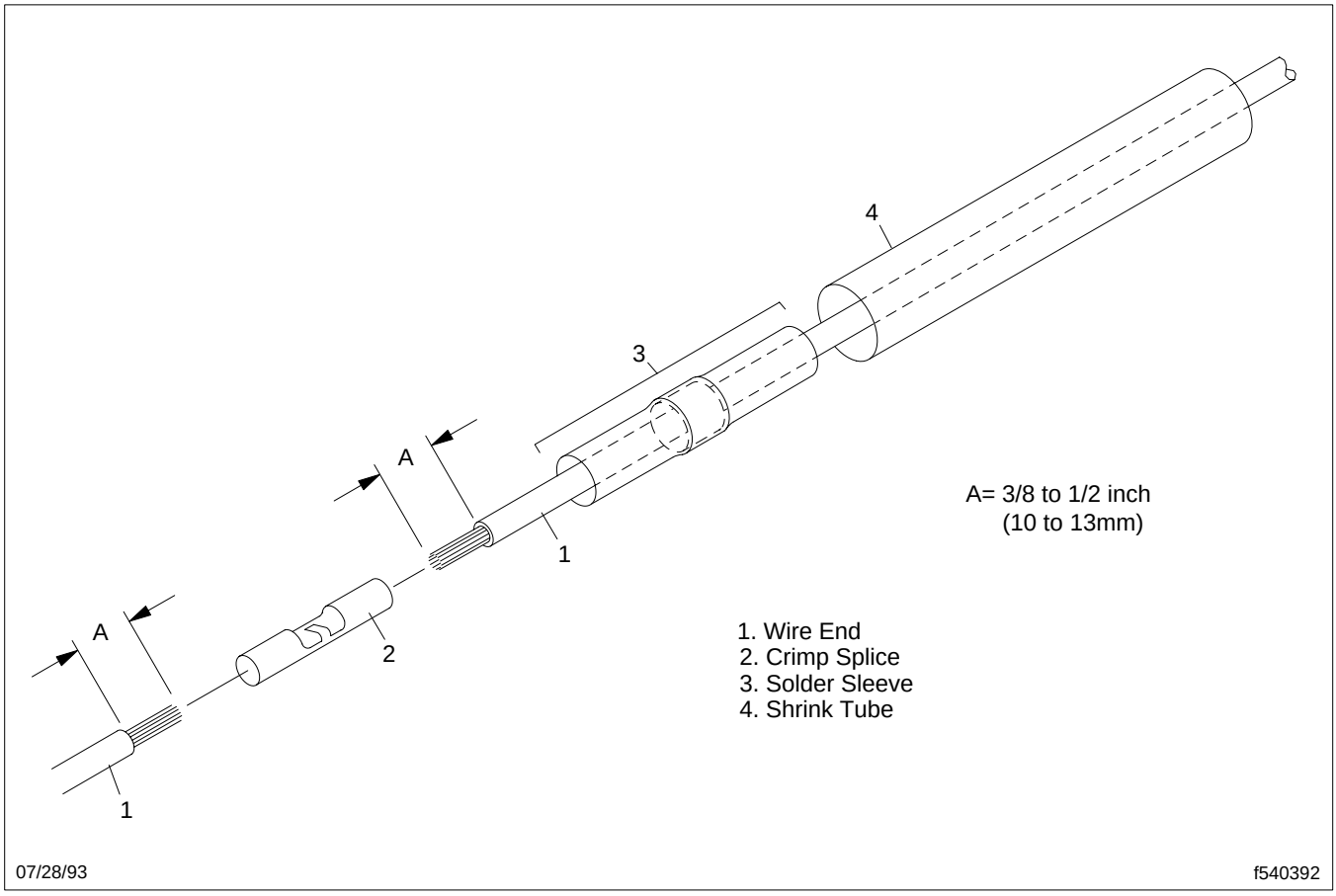


Fig. 1

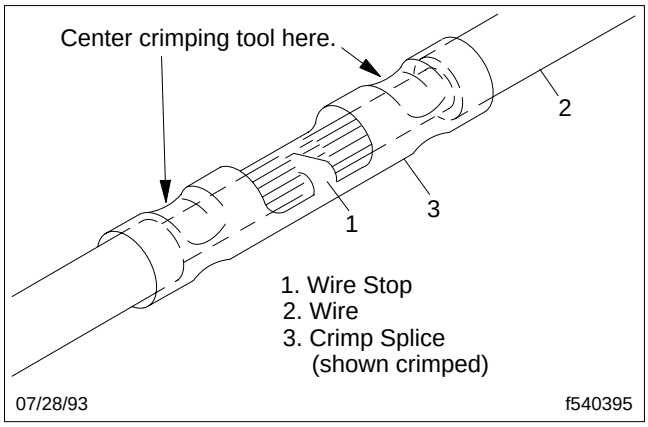


Fig. 2

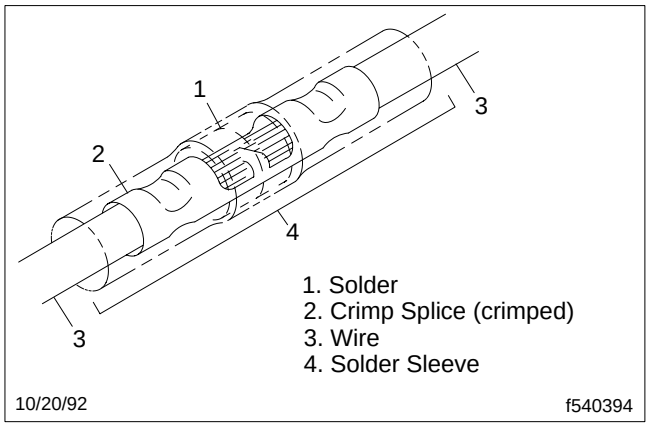


Fig. 3

A Vehicle Electrical System – The Basics

NOTE: This subject is intended to provide a brief review of the electrical symbols and theory necessary for basic troubleshooting. For comprehensive coverage of electrical theory and practice as it applies to motor vehicles, refer to Freightliner Self-Paced Training Basic Electricity Units SDF–006 (Volts, Ohms & Amps), SDF–007 (Magnetism), SDF–008 (Symbols & Diagrams) & SDF–009 (Terms).

The vehicle electrical system can be divided into four basic categories: power suppliers, power controllers, directional controllers, and appliances. Every system has these four categories, in one form or another.

Power Suppliers

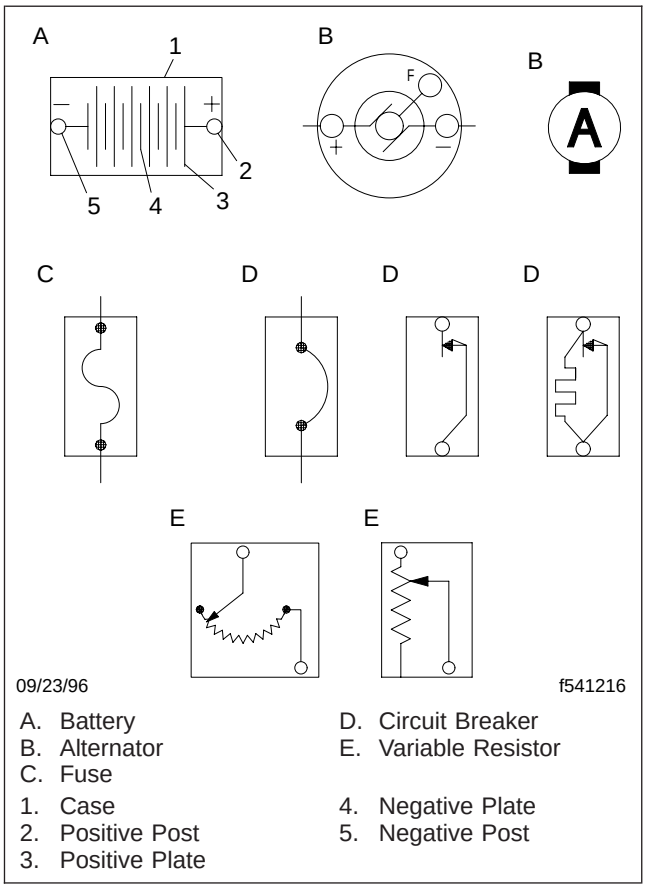
Everyone knows that the battery (see **Fig. 1**, Ref. A for symbol) is a very important source of electrical power in a motor vehicle. A typical battery (wet cell) is an electro-chemical device consisting of metal plates (usually lead) and an acid-water solution (sulfuric acid). The battery has both positive and negative plates, which are stacked together like a deck of cards, but not allowed to touch each other. The chemical reaction that takes place inside the battery results in an electron build-up on one set of plates, and an electron deficit on the other set of plates. The electrons will follow any available pathway to get from one set of plates to the other.

The alternator (Ref. B), on the other hand, converts mechanical power supplied by the engine into electrical power. The alternator produces power whenever the engine is running, to operate lights, motors, etc., and also to keep the battery fully charged.

There may be other "power suppliers" in the vehicle electrical system, too, but they are something different and we won't discuss them here. Basically, they take power supplied by the battery/alternator and modify it somehow (usually reduce the voltage) for use in an electronic subsystem (like engine control or ABS).

Power Controllers

Power controllers such as fuses and circuit breakers (Refs. C and D) are the "safety valves" in an electrical system. If too many electrons flow through the



A. Battery
B. Alternator
C. Fuse
D. Circuit Breaker
E. Variable Resistor

1. Case
2. Positive Post
3. Positive Plate
4. Negative Plate
5. Negative Post

Fig. 1, Symbols, Power Suppliers and Controllers

fuse or circuit breaker, it gets hot and either melts (fuse) or its contacts open (circuit breaker) to open the power pathway in a controlled manner. The fuse or circuit breaker is the built-in "weak link" in a circuit; it is supposed to interrupt the flow of electrons before other parts of the circuit are damaged.

The rheostat or variable resistor (Ref. E) is also a power controller. A rheostat is a device that is specifically designed to reduce electron flow (current) in a circuit. A good example of a common rheostat is the instrument panel illumination bulb dimmer (I/P dimmer, for short). The I/P dimmer takes battery voltage and, by restricting the flow of electrons, reduces the voltage available "downstream" of the rheostat. So, as you increase rheostat resistance by twisting the I/P dimmer knob, you lower voltage to the illumination bulbs and they burn less brightly.

Troubleshooting

Directional Controllers

The electrons stored on the battery plates need pathways to complete their circuit. The vehicle electrical system provides pathways in the form of wires, terminals, the cab, the frame, component cases or housings, and even fasteners (screws, bolts, washers). The important thing about pathways is that they provide very easy routes for the electrons to take; very little energy is lost or consumed as the electrons travel along. The materials most commonly used as power pathways are copper (wiring), aluminum (cab structure, frame rails, component housings), steel (cab structure, frame rails), and cast iron (engine block, transmission case).

It's not desirable or practical to operate all electrical equipment at the same time. For instance, you want the starting motor to operate only when starting the engine, and you want to be able to turn off the headlights. Switches and relays (see **Fig. 2**, Refs. A and B for symbols) work like drawbridges, closing and opening to allow and interrupt the flow of electrons in a circuit. Typically, switches are used in low power circuits, and relays are used in moderate to high power circuits.

Appliances

Appliances are the reason we create power sources, power controllers, and directional controllers — we want electrons to go somewhere and do something for us. Electric motors, light bulbs, heating elements (for mirrors), solenoids, solid-state devices (like radios and control modules), and gauges (see Refs. C to H for symbols) all do something for us when they use those electrons. Electric motors turn shafts, light bulbs provide illumination, heating elements melt ice or evaporate condensation, solenoids provide linear motion, etc. From an electrical standpoint, appliances fit into our discussion here because a large voltage drop occurs as the electrons travel through the appliance.

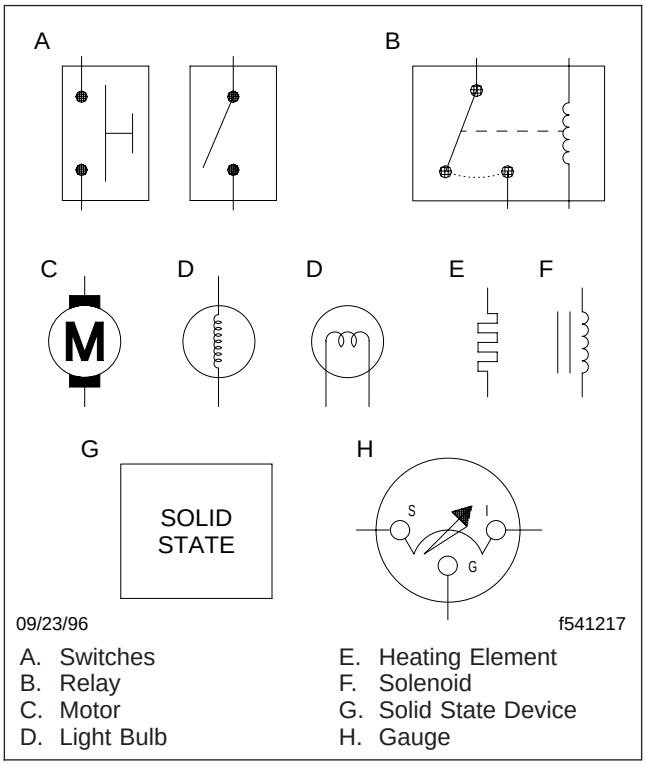


Fig. 2, Symbols, Directional Controllers and Appliances

Troubleshooting Tools

Here are some of the tools used during electrical troubleshooting:

Voltmeter

A DC voltmeter (see **Fig. 3**) is used to measure circuit voltage. Connect the black (–) lead to ground and the red (+) lead to the place where you want to measure voltage.

Ohmmeter

An ohmmeter (see **Fig. 4**) is used to measure circuit resistance and check continuity. When checking circuit resistance, the circuit's normal power source must be removed by disconnecting the battery or pulling a fuse or circuit breaker. If this isn't done, there's a good chance that the ohmmeter will be damaged.

A battery inside the ohmmeter supplies the voltage necessary to make resistance measurements.

Volt-Ohm-Milliammeter (VOM)

The VOM is simply three separate devices combined into one. It's a voltmeter, an ohmmeter, and an ammeter. Typically, you operate a rotary switch on the VOM to select the type of measurement you want to make; when measuring current flow (ammeter function) you often have to connect the positive (+) lead to a different port on the VOM.

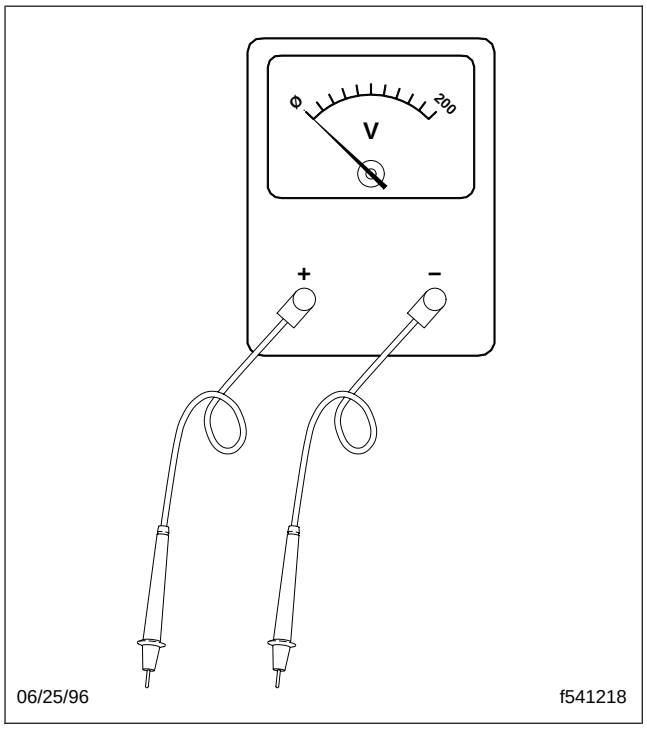


Fig. 3, Voltmeter

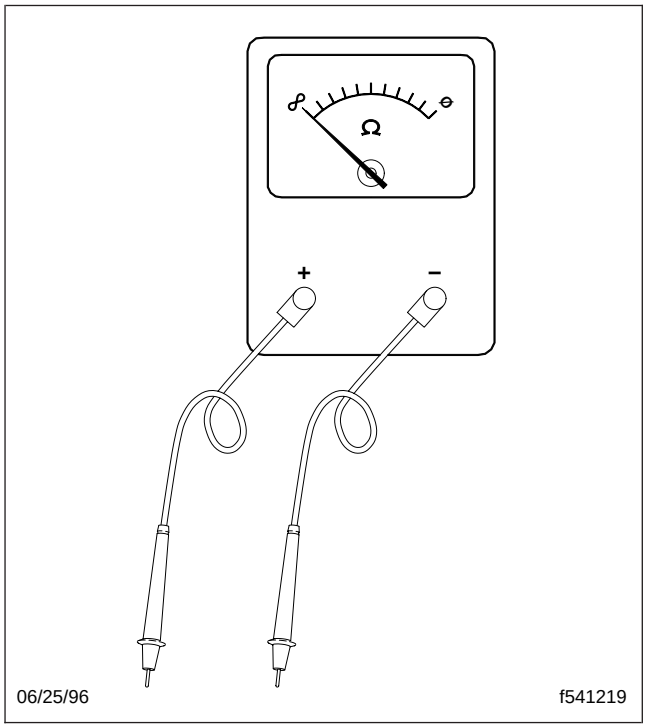


Fig. 4, Ohmmeter

A very common modern alternative to the VOM is the Digital Volt-Ohm Millammeter or DVOM. See **Fig. 5**. This tool is a solid-state version of the VOM and usually has a large, easy to read, digital LCD display instead of a needle.

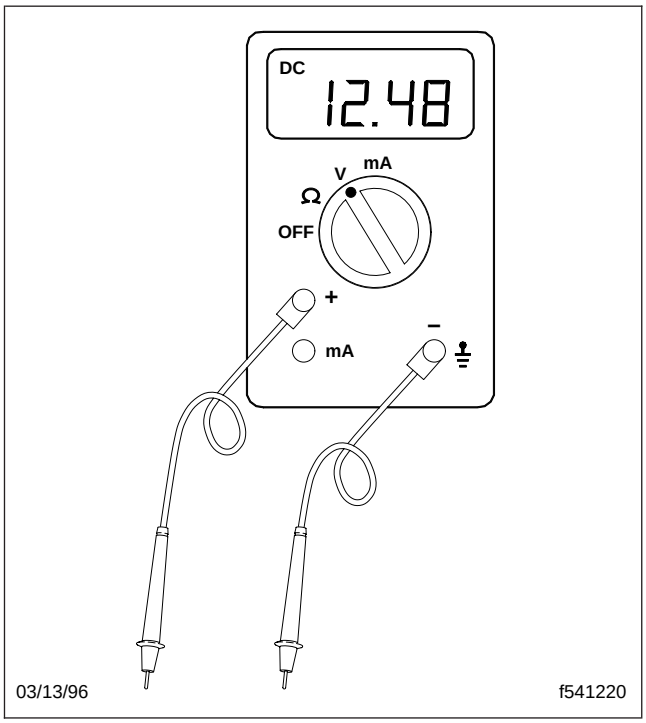


Fig. 5, Digital Volt-Ohm-Milliammeter (DVOM)

Jumper Wire

A jumper wire (see **Fig. 6**, Ref. A) is simply a length of wire with an alligator clip or test probe at each end. You can use a jumper wire to connect two points of a circuit, bypassing (or jumping over) fuses, switches, etc.

NOTE: Never connect a jumper wire across an appliance! This would be a short circuit from battery to ground and could cause an injury or a fire.

Actually, it's a good idea to use a fused jumper wire (Ref. B) at all times. That way an accidental short will blow the fuse, protecting both you and the rest of the circuit.

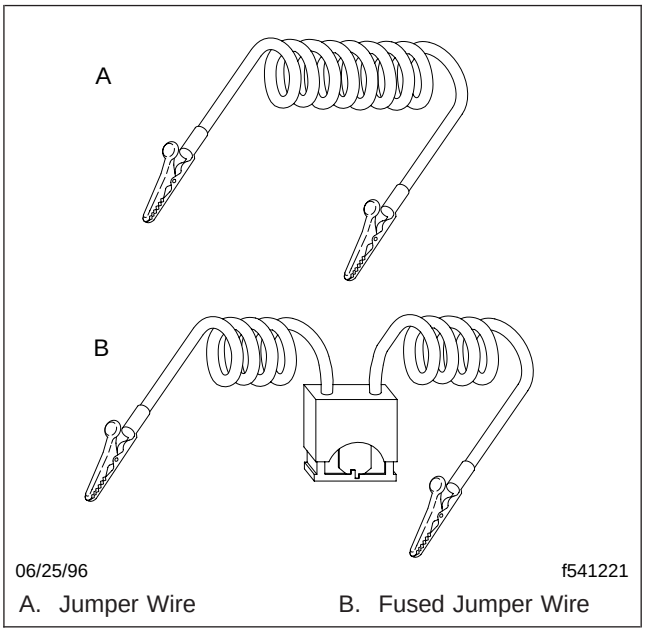


Fig. 6, Jumper Wires

Test Lamp

A test lamp (see **Fig. 7**) is a 12V (or 24V, if appropriate) light bulb with a length of wire attached to each terminal. The test lamp can be used for quick, but imprecise, voltage checks.

Typically, the bulb is enclosed in a clear plastic handle (screwdriver-like) with a pointed metal probe coming out one end and a wire coming out the other end. Clamp the wire to a good ground and touch the metal probe to the desired test point. If enough voltage is present, the bulb will illuminate.

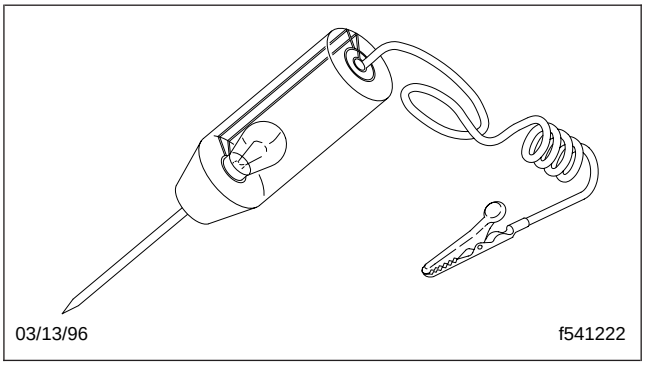


Fig. 7, Test Lamp

A Sample Circuit

See **Fig. 8** for a sample circuit. Notice that every one of the categories discussed previously is present: power supplier (the battery, Ref. A), power controller (the circuit breaker, Ref. B), directional controllers (wiring and switch, Ref. C), and appliance (electric motor, Ref. D). This kind of circuit is called a series circuit; all the parts are arranged, one after the other, in series. There's only one possible path the electrons can take. This is a simple circuit, but it is also typical.

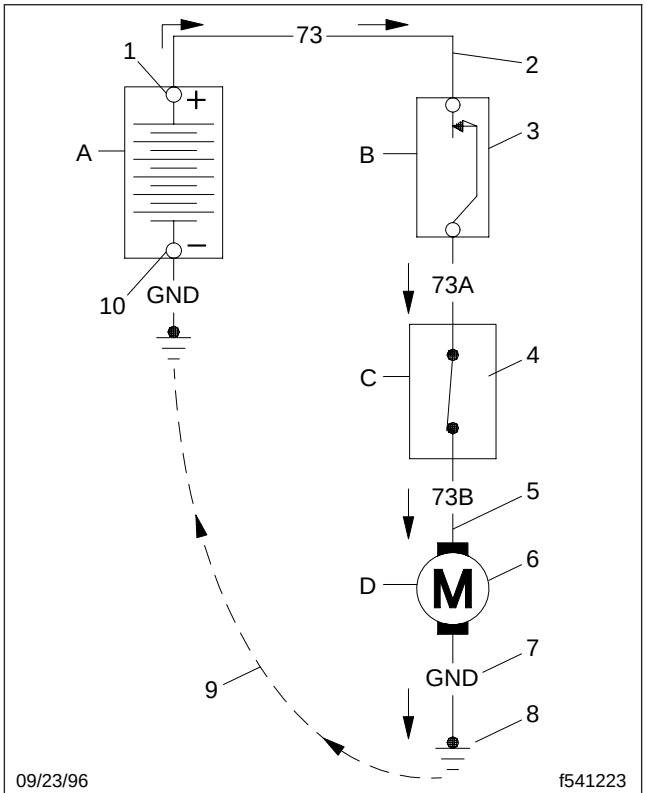


Fig. 8, Sample Circuit Number One

The circuit starts at the battery positive terminal (Ref. 1) follows wire 73 (Ref. 2) to the circuit breaker (Ref.

3), and continues on to the switch (Ref. 4). When the switch contacts are closed, the circuit continues through the switch and wire 73B (Ref. 5) to the electric motor (Ref. 6). So long as the motor is operative (isn't damaged or burned-out) the circuit continues through the motor to the GND wire (Ref. 7) and on to the chassis ground point (Ref. 8). Although it isn't usually shown on a schematic, the circuit actually continues through chassis metal (Ref. 9) back to the battery negative terminal (Ref. 10).

Troubleshooting the Sample Circuit

To find out what's wrong if the switch is closed, but the motor doesn't run, work around the circuit, checking for voltage at key points. If voltage is present, keep going; if voltage isn't present, find out why:

Is the battery dead? Check battery voltage using a voltmeter. See **Fig. 9**. Connect the voltmeter red (+) lead to the battery (+) terminal and the voltmeter black (–) lead to the battery (–) terminal. Voltage should be at least 12 volts. Low or no voltage could mean that there is corrosion between the battery post and terminal. If the battery terminals are loose or obviously corroded, fix them. If not, loosen the clamp bolts and disconnect the terminals. Soft, shiny or greyish metal should be present on both the battery post and the inside of the terminal, not hard, dark and scaly metal. Clean the battery posts and the terminals, if necessary. If the terminal connections seem to be okay, the battery needs to be charged, or the battery should be replaced.

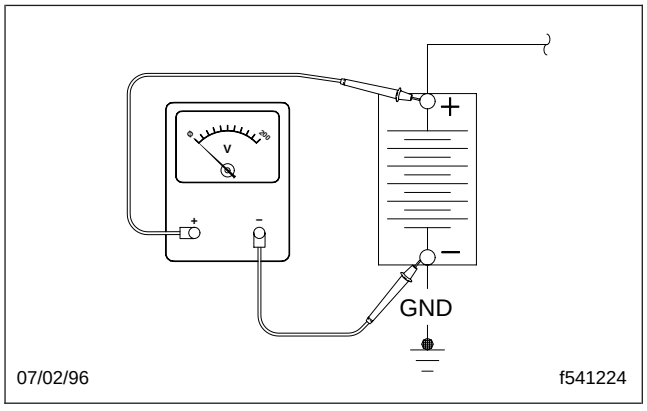


Fig. 9, Checking Battery Voltage

Is battery voltage present at the circuit breaker? Check, using a voltmeter. See **Fig. 10**. Connect the voltmeter red (+) lead to the circuit breaker (the side fed by the battery) and the voltmeter black (–) lead to the battery (–) terminal. Again, voltage should be at least 12 volts. If it isn't, the problem may be a broken wire 73, or an inadequate or damaged crimp where a wire terminal is connected to wire 73 (see **Fig. 11**).

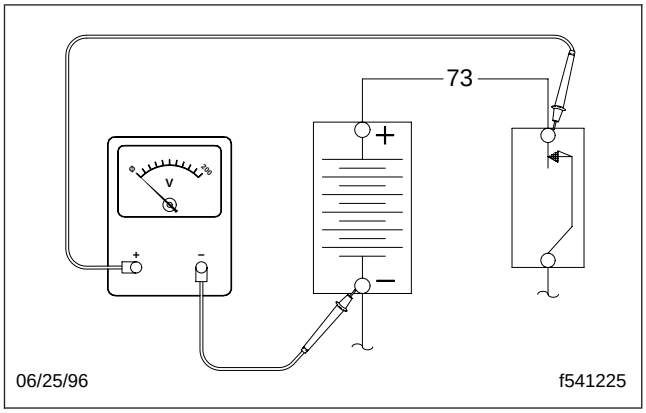
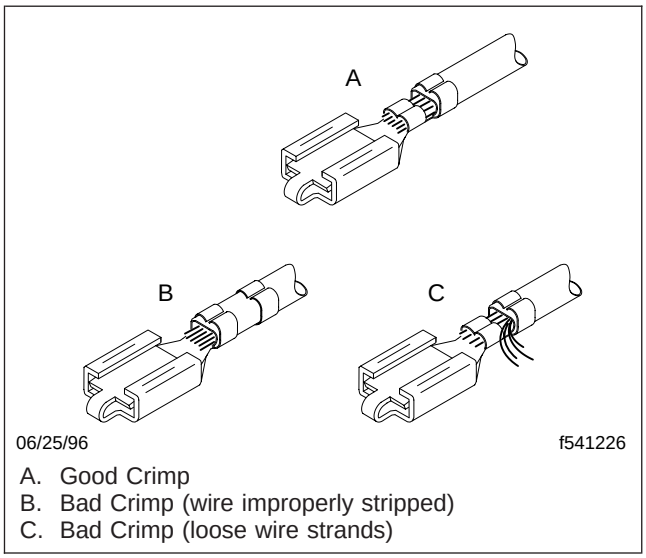


Fig. 10, Voltage Check at Circuit Breaker



A. Good Crimp
B. Bad Crimp (wire improperly stripped)
C. Bad Crimp (loose wire strands)

Fig. 11, Good and Bad Crimps

Is battery voltage present at the other end of the circuit breaker? See **Fig. 12**. If not, the circuit breaker is faulty and should be replaced.

Is battery voltage present at the switch? See **Fig. 13**. If it isn't, possible causes again include a broken wire or inadequate/damaged terminal crimps.

Is battery voltage present at the switch outlet when the switch is closed? See **Fig. 14**. If not, the switch is faulty and should be replaced.

Troubleshooting

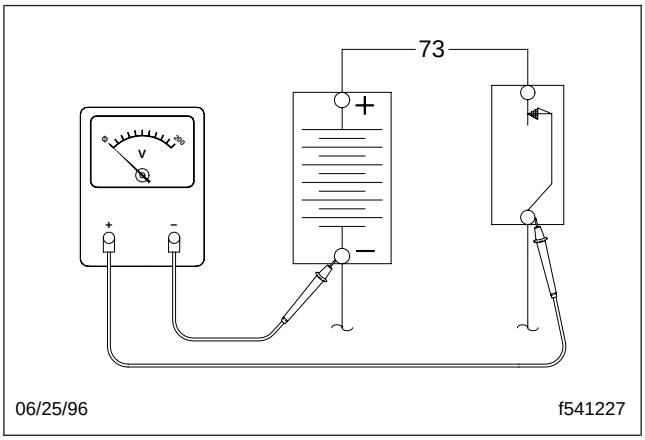


Fig. 12, Voltage Check after Circuit Breaker

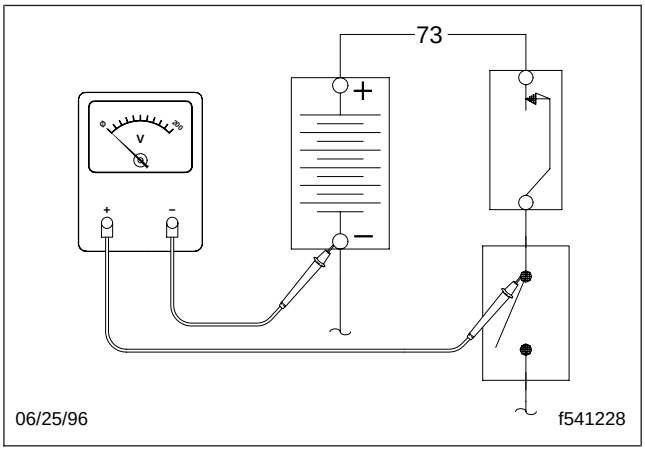


Fig. 13, Voltage Check at the Switch

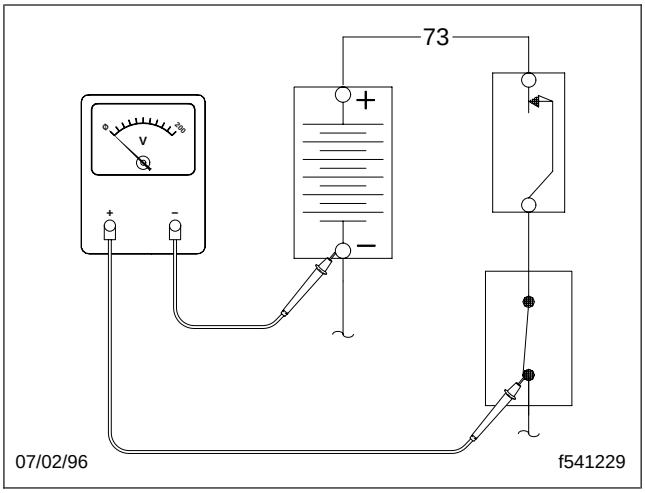


Fig. 14, Voltage Check after the Switch

Is battery voltage present at the motor? See **Fig. 15**. If not, wire 73B could be broken or an inadequate/ damaged terminal crimp could be the cause.

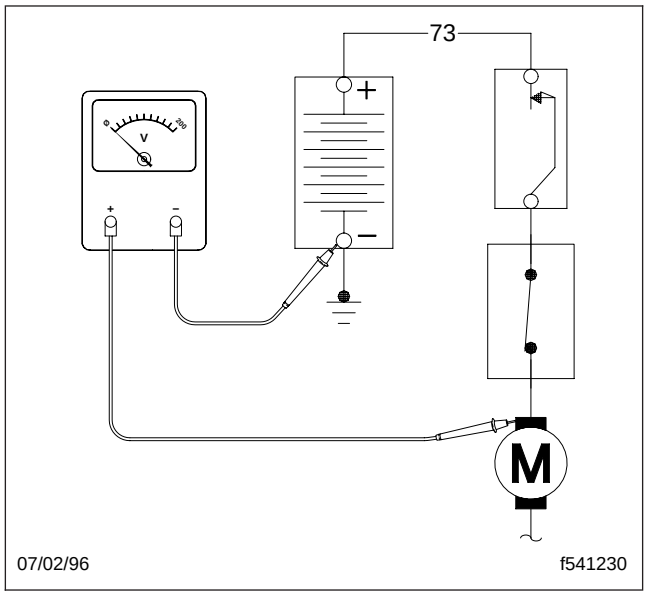


Fig. 15, Voltage Check at the Motor

Is the motor obviously damaged or burned-out? If it is, replace it. If it doesn't appear to be, continue troubleshooting.

If voltage is present at all the points mentioned above, perhaps the ground circuit is faulty. Note that voltage tests are performed only on parts of the circuit that appear before the appliance. This is because a large voltage drop occurs across the appliance and, unless you know exactly what voltage should be present after the appliance, a voltage measurement won't be very meaningful.

The most commonly used method for troubleshooting ground circuits is checking circuit resistance with an ohmmeter.

NOTE: One very important thing to remember when checking circuit resistance with an ohmmeter is that voltage must not be present in the circuit being tested, or the ohmmeter will be damaged. A battery inside the ohmmeter provides all the voltage necessary to make the resistance measurement. Make sure the appropriate power switch for the circuit being tested is off. For circuits receiving battery voltage all the

time, shut off power using the main disconnect switch or, if necessary, disconnect the batteries.

Check circuit resistance between the GND wire terminal and the vehicle frame or body. See **Fig. 16**. Resistance should be very low; usually less than one ohm for this type of connection. If resistance is more than five ohms, there is a problem that needs to be corrected. The cause could be a loose screw securing the terminal to the frame or body, or corrosion between the terminal and the frame or body. Make sure that the bare metal of the frame or body is exposed at the ground point — paint, rust, grease, and dirt can act as an insulator, causing high resistance.

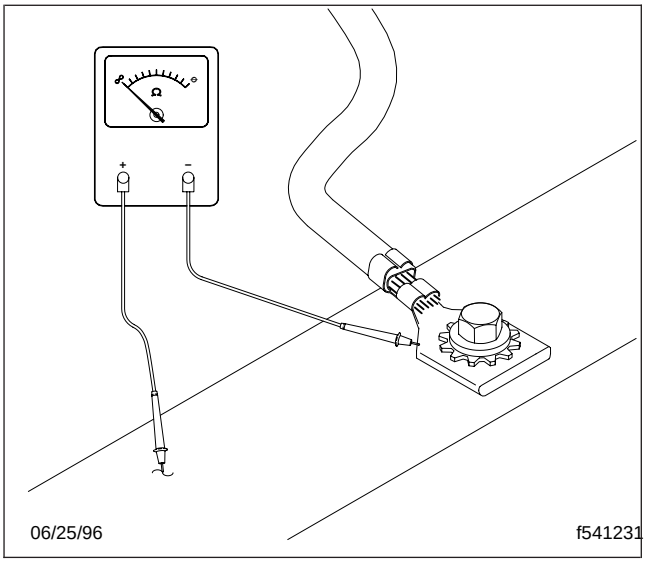


Fig. 16, Resistance Check at the Ground Point

Check circuit resistance between the motor ground terminal and the vehicle frame or body. See **Fig. 17**. Again, resistance should be very low — if it is more than 5 ohms, there's a problem. Inspect for damaged or inadequate crimps where a wire is connected to a terminal. See **Fig. 11**. Check for corrosion at connections and check for a damaged wire.

At some point during the steps outlined above, you should have discovered the cause of the problem. If you didn't, the motor may be malfunctioning; replace it. If the new motor doesn't work, go back to the beginning, checking voltage and resistance readings again.

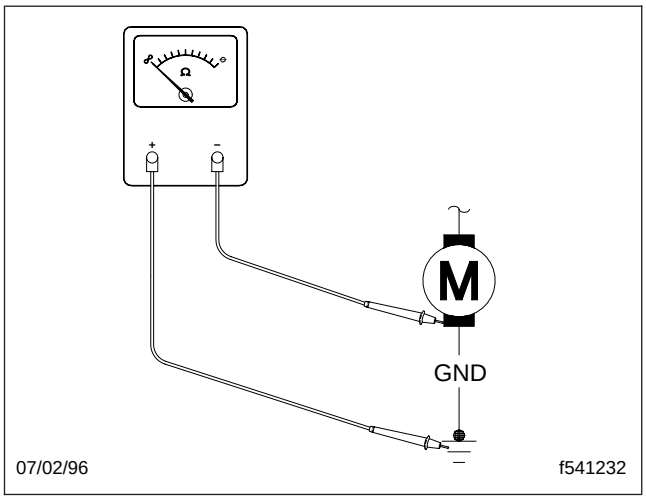


Fig. 17, Resistance Check of Ground Circuit

Short Cuts

Sometimes, it may be very difficult to access voltage measurement points in the circuit. In those cases, it makes sense to check the easy-to-access points first, regardless of their position in the circuit; check the battery terminals, fuse, and motor.

Or, check voltage at the motor first with the switch turned on; if voltage is present at the motor, it must be present at the battery, circuit breaker, and switch, so you can skip those voltage tests.

The same strategy applies to the resistance tests; if low resistance is measured between the motor and the frame, there's no point in measuring resistance between the GND wire terminal and the frame. Use short cuts whenever it makes sense, not just when access to a component is a problem.

Troubleshooting Steps

Take an orderly approach to electrical troubleshooting. Follow the same set of steps every time to improve your chances of a quick, accurate diagnosis:

Step 1 – Verify that the problem exists.

Using information provided by the owner/operator of the vehicle, operate the system and see all the symptoms for yourself. The owner/operator complaint may be inaccurate or misleading. Also, you may no-

tice symptoms that the owner/operator didn't notice or didn't think were important enough to report.

Step 2 – Narrow down the possible causes of the problem.

Perform basic checks to quickly eliminate possible causes. Are the battery terminals loose or corroded? Is the alternator belt loose? Any obvious damage to the vehicle? Blown fuses? Loose or corroded ground wires? Lenses showing that moisture is trapped inside a lamp?

If you don't find anything, check the wiring schematics or service bulletins for clues. What other component/system shares a fuse/circuit breaker or ground point with the faulty component/system? Is that component/system operating properly?

Step 3 – Test for the cause of the problem.

Use the appropriate test equipment and procedures to zero in on the cause of the problem. Check for voltage. Check for continuity. Check for appropriate resistance values. Check for appropriate current flow.

Step 4 – Verify that you have located the cause of the problem.

If you think a switch is faulty, use jumper wires to bypass the switch and verify that the component now operates. Likewise for a suspected bad ground - run a jumper directly from the component to the frame or cab. If you think that one shorted lamp is blowing a fuse or tripping a breaker, disconnect that lamp and verify that the rest now operate normally. Connect a known good component without actually removing the old one, if possible — does the component operate?

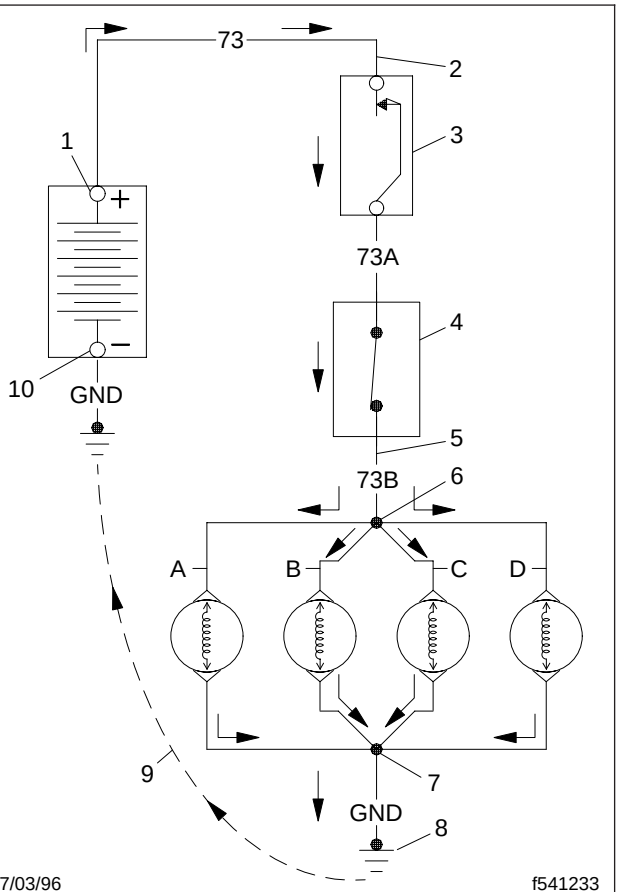
Step 5 – Make the necessary repairs.

Perform any repairs or parts replacement necessary.

Step 6 – Verify that the problem is gone.

Operate the system to make sure that all symptoms are gone. Just as important, make sure that no new symptoms have appeared.

Another Sample Circuit



A. Path "A"
B. Path "B"
C. Path "C"
D. Path "D"
1. Battery (+)
2. Circuit #73
3. Circuit Breaker
4. Switch
5. Circuit #73B
6. Power Circuit Splice
7. Ground Circuit Splice
8. Ground Point
9. Path Through Chassis
10. Battery (–)

Fig. 18, Sample Circuit Number Two

The following circuit (see **Fig. 18**) is a little more complicated than the first one. This one includes parallel circuits. Most of the parts in the circuit are arranged, one after the other, just like the parts in the series circuit we looked at earlier. The light bulbs, however, aren't arranged one after the other; they appear side by side or "in parallel."

In parallel circuits, the electrons are not limited to following just one path back to the battery — they

can follow any of several parallel paths. Many vehicle illumination circuits are parallel circuits where several bulbs come on at the same time.

So, the circuit starts at the battery positive terminal (Ref. 1) follows wire 73 (Ref. 2) to the circuit breaker (Ref. 3), and continues on to the switch (Ref. 4). When the switch contacts are closed, the circuit continues through the switch and wire 73B (Ref. 5) to the splice (Ref. 6). Up to this point we've been tracing a series circuit.

Assuming that resistance in each of the bulb circuits is equal, an equal number of electrons will travel down each of the four bulb circuits (Refs. A, B, C, & D). If all the light bulb filaments are intact (none of the bulbs are burned-out), electrons travel through the bulbs and their individual GND wires to the ground splice (Ref. 7) and on to the chassis ground point (Ref. 8). Although it isn't usually shown, the circuit actually continues through chassis metal (Ref. 9) back to the battery negative terminal (Ref. 10).

Troubleshooting the Sample Circuit

Let's look at two possible circuit failures — none of the bulbs illuminate when the switch is closed, and some, but not all, of the bulbs illuminate when the switch is closed.

None of the Bulbs Operate — if none of the bulbs illuminate, it's very possible that the problem is in the series part of the circuit — the part of the circuit that is just like the circuit we looked at earlier. So, the troubleshooting steps are exactly the same. Work around the circuit, checking for voltage at key points. If voltage is present, keep going; if voltage isn't present, find out why. Review "A Sample Circuit" if necessary.

Unlike the first sample circuit in which we checked for voltage at the electric motor, this sample circuit has an extra "component" — the splice which feed the individual bulb circuits. Check for battery voltage at the splice. See **Fig. 19**. If battery voltage isn't present, wire 73B could be broken or an inadequate/ damaged terminal crimp could be the cause.

If voltage is present at the splice, lack of voltage is not likely to be the cause of the problem, since the splice is the transition point between the series circuit and the parallel circuit. If voltage is present at the splice, that would mean that all four circuits leading to the bulbs would have to be faulty or all four bulbs would have to be burned out and that's unlikely.

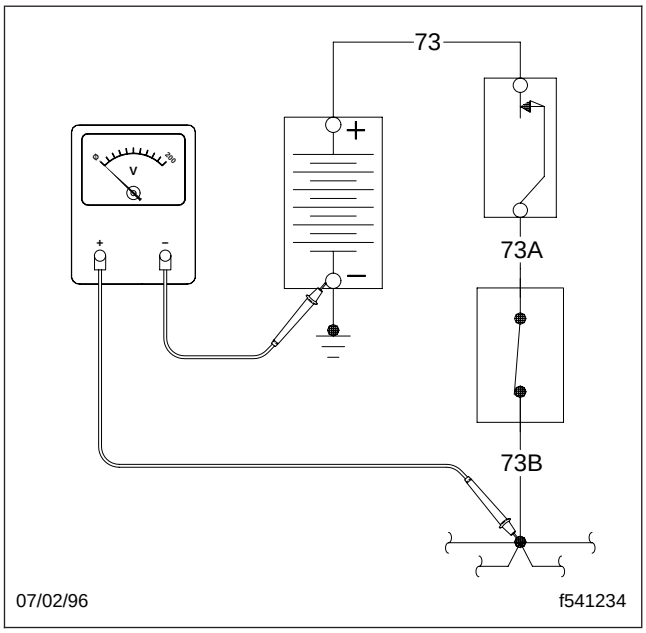


Fig. 19, Checking for Power at the Splice

Check the ground circuit instead. Review "A Sample Circuit" if necessary.

NOTE: Remember, when checking circuit resistance with an ohmmeter, voltage must not be present in the circuit being tested, or the ohmmeter will be damaged. A battery inside the ohmmeter provides all the voltage necessary to make the resistance measurement. Make sure the appropriate power switch for the circuit being tested is off. For circuits receiving battery voltage all the time, shut off power using the main disconnect switch or, if necessary, disconnect the batteries.

The ground circuit of this sample circuit, like the power circuit, has an extra "component," and it's the ground splice. Check circuit resistance between this ground splice and the vehicle frame or body. See **Fig. 20**. Again, resistance should be very low — if it is more than 5 ohms, there's a problem. Inspect for damaged or inadequate crimps where a wire is connected to a terminal and check for a damaged wire.

If you still haven't found the cause, check the individual bulb ground circuits that run between each bulb and the ground splice. But if none of the bulbs are working, it means that all four of the circuits are faulty (which is very unlikely).

Troubleshooting

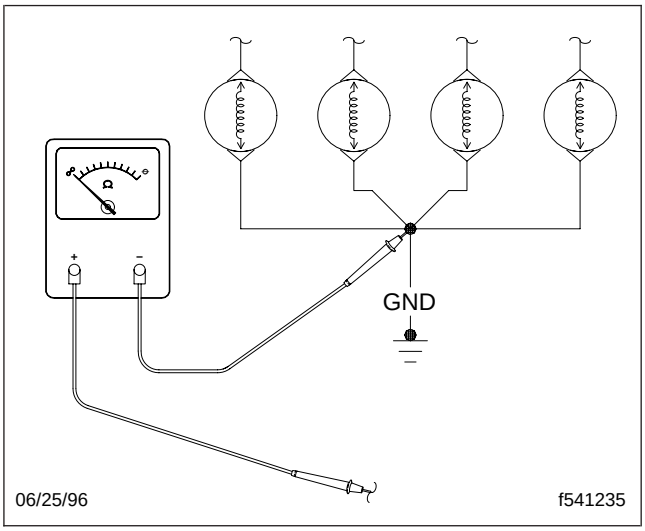


Fig. 20, Checking the Shared Ground Circuit

Check resistance between each bulb socket ground terminal and the ground splice. See **Fig. 21**. Resistance between each terminal and the splice should be very low.

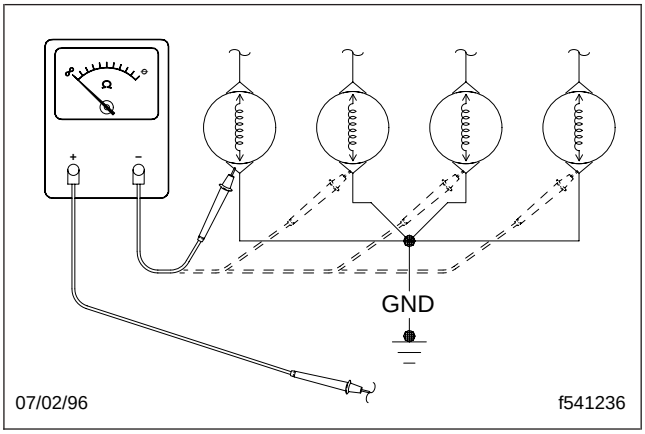


Fig. 21, Checking the Individual Ground Circuits

Some, But Not All of the Bulbs Operate — This kind of failure is a lot easier to troubleshoot since most of the possible circuit faults are immediately eliminated.

If even just one of the bulbs is operating, you can skip voltage tests all the way up to the circuit 73B splice; if one of the bulbs is operating, voltage must be reaching the splice. And, you can assume that the shared ground circuit between the ground splice and the actual ground point is also intact for the same reason.

The problem, then, must be in the individual power or ground circuits for each non-functioning bulb, or the bulb itself.

So, check for battery voltage at the circuit 73B terminal for each of the non-functioning bulbs. If battery voltage is present, use the DVOM to check resistance between the bulb socket ground terminal and the ground splice.

Specifications

To identify circuit numbers, see **Table 1** for circuits 1 through 61A. See **Table 2** for circuits 71 through 319, and see **Table 3** for circuits 320 through 503.

To identify fuses, relays, and circuit breakers on vehicles with left-hand drive (LH DR), see **Table 4** for positions 1 through 25 and **Table 5** for positions 26 through 50.

To identify relays and circuit breakers on vehicles with right-hand drive (RH DR), see **Table 6** for positions 1 through 29 and **Table 7** for positions 30 through 55.

See **Fig. 1** for a standard vehicle wiring diagram. For detailed (partial) views of the standard vehicle wiring diagram, see **Fig. 2** or **Fig. 3**.

See **Fig. 4** for the revised (as of April 3, 1998) standard left-hand-drive (LH DR) vehicle wiring diagram. For detailed (partial) views of the revised (as of April 3, 1998) standard (LH DR) vehicle wiring diagram, see **Fig. 5** or **Fig. 6**. See **Fig. 7** for the revised (as of April 3, 1998) standard (LH DR) vehicle wiring diagram wire code numbers.

See **Fig. 8** for the right-hand-drive (RH DR) vehicle wiring diagram. For detailed (partial) views of the RH DR vehicle wiring diagram, see **Fig. 9** or **Fig. 10**. See **Fig. 11** for the RH DR vehicle wiring diagram wire code numbers.

Circuit Number Identification, Circuits 1 through 61A	
Circuit	**Description**
14	Main Cab Feed
15	Starter Magnetic Switch Coil Feed
16	Alternator Output
18B	Low Air Pressure Indicator Feed
18C	High Coolant Temperature Indicator Feed
20	Left Headlight Switch Supply
20A	Right Headlight Switch Supply
20L	Left Headlight Relay Feed
20R	Right Headlight Relay Feed
21	Left Headlight High Beam
21B	High Beam Indicator Feed
21D	Right Headlight High Beam
22	Left Headlight Low Beam
22D	Right Headlight Low Beam

Circuit Number Identification, Circuits 1 through 61A	
Circuit	**Description**
23	Trailer Marker and Taillight Feed
23A	Vehicle Taillight Feed
23D	Tractor Marker Light Control
23F	Tractor Marker Light Relay (NC)
23T	Trailer Taillight Control
25	Horn Button Feed
26	Horn Feed
27	Road Light Feed
28	Road Light Feed
29	Instrument Light Switch Feed
29A	Instrument Light Feed
29D	Panel Light Control
29F	Panel Light Relay (NC)
30	Main Transmission Fluid Temperature Gauge Feed
34	Low Oil Pressure Indicator Feed
35	Engine Oil Temperature Gauge Feed
36	Brake Light Switch Feed
36B	Trailer Brake Light Feed
36C	Turn Signal Switch Brake Light Feed
36F	Pressure Differential Switch
36G	Brake Light Relay Coil
38	Trailer Left Turn Signal Feed
38B	Left Brake Light and Turn Signal Feed
39	Trailer Right Turn Signal Feed
39B	Right Brake Light and Turn Signal Feed
41	Cab Dome Light Switch Feed
45	Auxiliary Trailer Feed
46	Cab Marker Light Feed
46E	Left Side Marker Light Feed
46F	Right Side Marker Light Feed
46T	Trailer Marker Relay Coil
47	Fuel Level Gauge Feed
52	Ignition Switch Feed (Battery)
57	Cigarette Lighter Feed
60	Left Front Turn Signal Light Feed

Specifications

Circuit Number Identification, Circuits 1 through 61A	
Circuit	**Description**
60A	Left Turn Signal Indicator Feed
61	Right Front Turn Signal Light Feed
61A	Right Turn Signal Indicator Feed

Table 1, Circuit Number Identification, Circuits 1 through 61A

Circuit Number Identification, Circuits 71 through 319	
Circuit	**Description**
71	Ignition-Controlled Relays and Alternator Excitation
73	Utility/Auxiliary Dome Light
73B	Utility/Auxiliary Dome Light
74	Starter Solenoid Feed
76	Left Heated Mirror Feed
77	Right Heated Mirror Feed
80	Heated Mirror Switch Feed
81C	Instrument Feed
82	Starter Control Solenoid Feed
84	Flamestart Solenoid Feed
87	Axle Lock Indicator Feed
98	Heater/AC Feed
98A	A/C Compressor Clutch Feed and Receiver-Dryer Feed
98E	Blower Motor (Medium)
98L	High Speed Fan Relay Control
98R	High Speed Fan Relay (NC)
98T	Blower Motor
98Y	Blower Motor (Low)
98Z	A/C Clutch Control and Shutter Control
99	Fuel Solenoid Feed
117	Speedometer Sensor (+ Signal)
118	Speedometer Sensor (– Signal)
119	Coolant Temperature Gauge Feed
119B	Ground, Coolant Temperature Sending Unit
120	Back-Up Light Switch Feed
120B	Back-Up Light Switch Feed
137	Alternator No Charge

Circuit Number Identification, Circuits 71 through 319	
Circuit	**Description**
150D	Shutdown Indicator Light
150F	Alarmstat (NC) Shutdown Terminal Feed
150G	Shutdown Module Feed
150M	Alarmstat to Pressurestat or Temperature Switch Ground
150R	Shutdown Module Start Indicator
162	Tachometer Sensor (+ Signal)
163	Tachometer Sensor (– Signal)
166	Ether Injector Pushbutton Feed
166A	Ether Injector Solenoid Feed
166B	Ether Injector Thermostat Feed
173	Low Coolant Level Probe
177	Low Coolant Probe Light Feed
183A	Air Restriction Sensor
222	Headlight Dimmer Switch Feed
223	Do-Not-Shift Warning Light
234	Fan Clutch Thermostat Control Feed
234A	Fan Clutch Solenoid Feed
261	Traction Equalizer Differential Lock
274	Transmission Fluid Temperature Indicator Light
286	Water in Fuel
300	Radio Feed
303	Low Air Switch Jumper
304	Back-Up Light Feed
305	Accessory—Breaker Feed
306	Ignition—Breaker Feed
309	Parking Brake Switch Feed
310	Axle Lock Switch Feed
311	Option Block Feed—Accessory
312	Radio Power—Battery
313	Turn Signal Flasher Feed
314	Turn Signal Switch Feed
315	Wiper Switch Feed
316	Wiper Motor—Low Speed
317	Wiper Motor—Park
318	Wiper Motor—High Speed

Circuit Number Identification, Circuits 71 through 319	
Circuit	**Description**
319	Wiper Motor Park—Battery

Table 2, Circuit Number Identification, Circuits 71 through 319

Circuit Number Identification, Circuits 320 through 503	
Circuit	**Description**
320	Wiper-Washer Motor
324	High Coolant Temperature Shutdown
325	Low Oil Pressure Shutdown
329	Pyrometer Transducer—Positive
330	Pyrometer Transducer—Negative
331	Positive Data Link
332	Negative Data Link
333	Air Dryer Feed
334	Dome Light Feed
337	Road Light Switch Feed
339	Light Bar Feed—Battery
342	Ammeter Feed
343	Glow Plug Switch Feed
344	Glow Plug Pressure Switch Feed
345	Glow Plug Solenoid to Glow Plugs
346	Speaker Ground Circuit
347	Shutter to Relay
348	Trinary Switch to Dual Temperature Switch (Shutters)
349	Shutter Solenoid to Dual Temperature Switch
354	Shutter Solenoid to Transmission Temperature Switch
355	Fan Switch to Transmission Temperature Switch
362	Fuel/Water Separator Relay Coil Power
363	Power Window Feed
364	Power Window Up
365	Power Window Down
373	Fuel Solenoid Relay
374	Starter Lockout Relay
375	Neutral—DRL

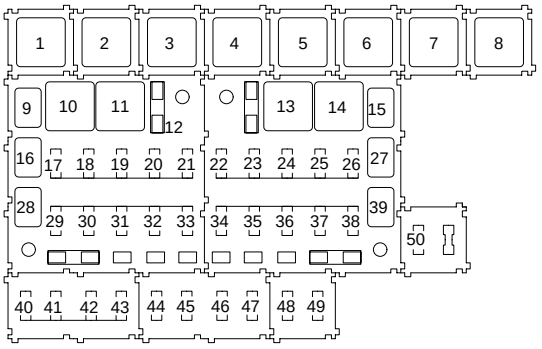
Circuit Number Identification, Circuits 320 through 503	
Circuit	**Description**
376	Antilock Power—Meritor (Rockwell)
377	Antilock Indicator—Meritor (Rockwell)
378	Antilock Solenoid—Meritor (Rockwell)
379	Park Brake Input—DRL
380	DRL Breaker Feed
381	DRL Module—B+
382	Left Headlight Relay—Common, DRL
383	Right Headlight—DRL
386	DRL—Left
387	DRL—Right
388	Ignition On
389	Relay Coil Feed
390	Warning Light Indicator Park
393	Flow Switch and Relay Coil Ground
394	Warning Light
395	Low Fluid Indicator
396	Audible Alarm
396A	Audible Alarm
397	Door Open Switch
398	Motor Pump Coil Sensing Signal
500	Hydraulic Brake Switch Sensing Signal
502	Oil Level Sensor
503	Flame Start Temperature Sensor

Table 3, Circuit Number Identification, Circuits 320 through 503

Specifications

Fuse/Relay/Circuit Breaker Identification, LH DR, Positions 1 through 25

PDM Layout *

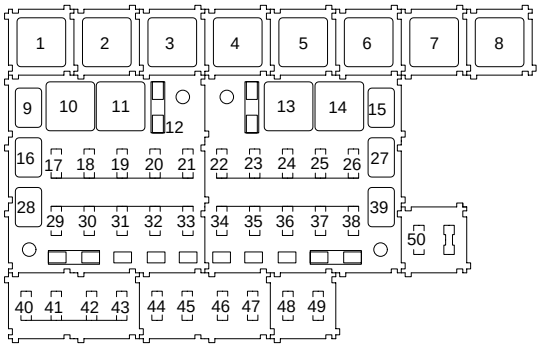


06/01/95 f540350a

Pos. No.	Description	Part Number	Rating
1	Hazard-Warning Flasher		
	Thermal	681 822 00 21	—
	Solid-State	680 822 00 21	15A
2	Trailer Marker Light Relay	23–11276–011	—
3 *	Trailer Taillight Relay	23–11276–011	—
4 *	2-Speed Axle Relay	23–11276–011	—
5 *	Fuel/Water Separator Heater Relay	23–11276–011	—
6 *	Engine Shutdown Warning Relay	23–11276–011	—
7 *	Engine Shutdown Warning Relay	23–11276–011	—
8 *	Fog Light Relay	23–11276–011	—
9	AC Compressor/ Clutch Relay	680 545 00 05	—
10	Brake Light Relay	23–11276–011	—
11	Blower Motor Relay	23–11276–011	—
12	Heater Blower Motor	680 545 02 34	40A Fuse
		680 545 23 66	40A C.B.
13	Heater/AC Switch Relay	23–11276–011	—
14	Tail and Marker Light Relay	23–11276–011	—
15	Panel Light Relay	680 545 00 05	—

Fuse/Relay/Circuit Breaker Identification, LH DR, Positions 1 through 25

PDM Layout *



06/01/95 f540350a

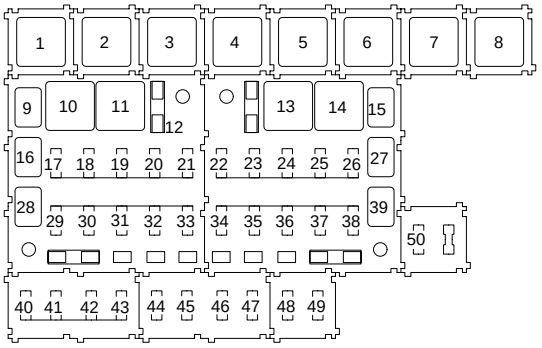
Pos. No.	Description	Part Number	Rating
16	Parking Brake Relay	680 545 00 05	—
17	Windshield Wiper and Washer	680 545 16 66	15A C.B.
18	Back-Up Light Switch and Radio	LF 257 010	10A Fuse
		680 545 19 66	10A C.B.
19	Low Coolant/Heated Mirror	LF 257 015	15A Fuse
		680 545 20 66	15A C.B.
20	Heater/AC Switch	LF 257 020	20A Fuse
		680 545 20 66	20A C.B.
21	Ether Start	LF 257 010	10A Fuse
		680 545 19 66	10A C.B.
22	Taillight	LF 257 015	15A Fuse
		680 545 20 66	15A C.B.
23	Cigarette Lighter	LF 257 015	15A Fuse
		680 545 20 66	15A C.B.
24	A/C Compressor	LF 257 010	10A Fuse
		680 545 19 66	10A C.B.
25	Turn Signal Flasher	LF 257 020	30A Fuse

* If one of the optional circuits listed (in PDM Positions 3 through 8) is not installed on the vehicle, its relay and mounting pad are not installed and all the remaining relays are shifted to the left.

Table 4, Fuse/Relay/Circuit Breaker Identification, LH DR, Positions 1 through 25

Fuse/Relay/Circuit Breaker Identification, LH DR, Positions 26 through 50

PDM Layout

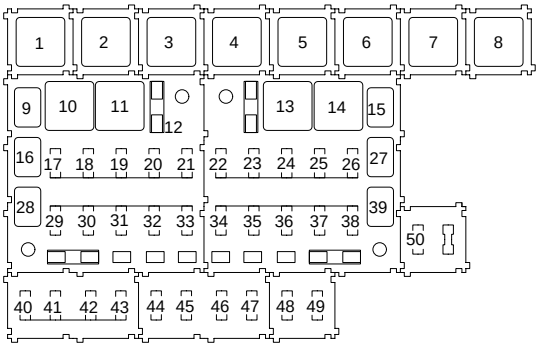


06/01/95 f540350a

Pos. No.	Description	Part Number	Rating
26	Headlight, Right	LF 257 015 680 545 16 66	15A Fuse 15A C.B.
27	Headlight Relay, Right	680 545 00 05	—
28	Auxiliary Feed Relay	680 545 00 05	—
29	Fuel Solenoid	LF 257 010 680 545 19 66	10A Fuse 10A C.B.
30	Flame Start/Fan Clutch	LF 257 025 680 545 22 66	25A Fuse 25A C.B.
31	Instruments/Gauges	LF 257 010 680 545 15 66	10A Fuse 10A C.B.
32	Hydraulic Brakes	231284 000005	5A Fuse
33	Relay Coil Feeds	231284 000005	5A Fuse
34	Panel Lights	LF 257 015 680 545 20 66	15A Fuse 15A C.B.
35	Brake Light Switch	LF 257 015 680 545 16 66	15A Fuse 15A C.B.
36	Horn/Dome Light	LF 257 015 680 545 20 66	15A Fuse 15A C.B.
37	Accessory Feed	LF 257 010 680 545 19 66	10A Fuse 10A C.B.
38	Headlight, Left	LF 257 015 680 545 16 66	15A Fuse 15A C.B.
39	Headlight Relay, Left	680 545 00 05	—

Fuse/Relay/Circuit Breaker Identification, LH DR, Positions 26 through 50

PDM Layout



06/01/95 f540350a

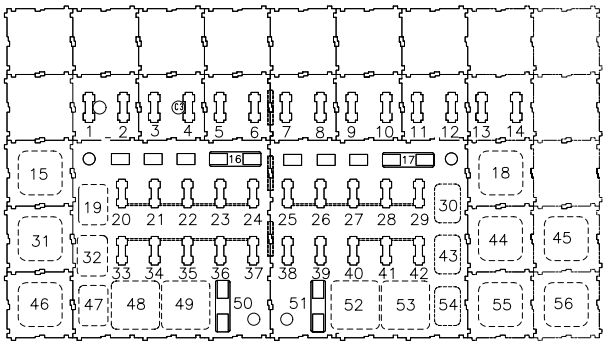
Pos. No.	Description	Part Number	Rating
40	Flame Start	LF 257 025 680 545 22 66	25A Fuse 25A C.B.
41	Utility Light	LF 257 020 680 545 21 66	20A Fuse 20A C.B.
42	Road Light Switch	LF 257 020 680 545 21 66	20A Fuse 20A C.B.
43	Daytime Running Lights	LF 257 020 680 545 17 66	20A Fuse 20A C.B.
44	2-Speed Axle Shift	LF 257 020 680 545 21 66	20A Fuse 20A C.B.
45	Auxiliary Trailer Feed	LF 257 015 680 545 20 66	15A Fuse 15A C.B.
46	Trailer Marker Lights	LF 257 020 680 545 21 66	20A Fuse 20A C.B.
47	Trailer/Marker/ Taillights	LF 257 020 680 545 21 66	20A Fuse 20A C.B.
48	Fuel/Water Separator Heater	LF 257 020 680 545 21 66	20A Fuse 20A C.B.
49	Fuel/Water Separator	231284 000005	5A Fuse
50	Air Dryer	LF 257 015 680 545 20 66	15A Fuse 15A C.B.

Table 5, Fuse/Relay/Circuit Breaker Identification, LH DR, Positions 26 through 50

Specifications

Fuse/Relay/Circuit Breaker Identification, RH DR, Positions 1 through 29

PDM Layout

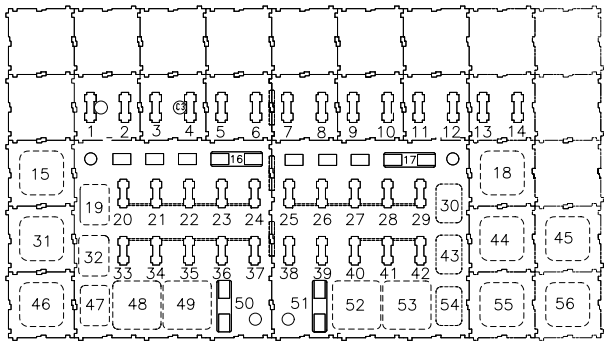


11/07/97 f541799

Pos. No.	Description	Part Number	Rating
1	Moto Mirrors	23284 000015	15A
2	Spare	—	—
3	IGN Power, Electronic Engine	23284 000015	15A
4	Engine Diagnostic	23284 000005	5A
5	Trailer Marker Lights	LF 257 020	20A
6	Trailer/Marker/ Taillights	LF 257 020	20A
7	Auxiliary Trailer Feed	231284 000015	15A
8	Spare	—	—
9	IGN Power Options	—	—
10	IGN Power Options	—	—
11	Utility Light	LF 257 020	20A
12	Air Dryer	231284 000015	15A
13	Power Feed (A/T) *	23284 000015	15A
14	IGN Feed (A/T) *	23284 000015	15A
15	Trailer Taillight Relay	23–11276–011	—
16	Spare	—	—
17	Spare	—	—
18	Neutral Start Relay (A/T) *	23–11276–011	—
19	Headlight Relay, Left	680 545 00 05	—
20	Headlight, Left	231284 000015	15A
21	Accessory Feed	231284 000010	10A

Fuse/Relay/Circuit Breaker Identification, RH DR, Positions 1 through 29

PDM Layout



11/07/97 f541799

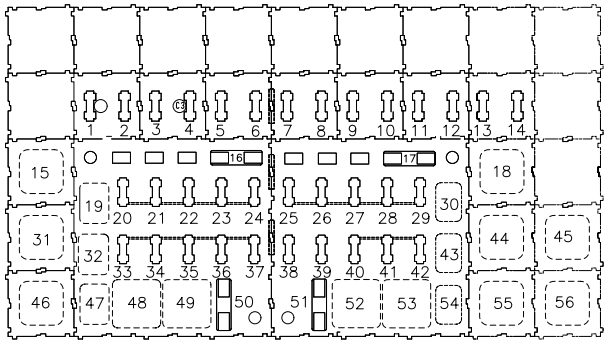
Pos. No.	Description	Part Number	Rating
22	Horn/Dome Light	231284 000015	15A
23	Brake Light Switch	231284 000015	15A
24	Instrument Lights	231284 000015	15A
25	Relay Coil Feeds	231284 000005	5A
26	Parking Brake Indicator Light	231284 000005	5A
27	Low Coolant/ Instrument Feed	231284 000010	10A
28	Fan Clutch	231284 000010	10A
29	Fuel Solenoid	231284 000010	10A

* Optional—available on vehicles with automatic transmission only

Table 6, Fuse/Relay/Circuit Breaker Identification, RH DR, Positions 1 through 29

Fuse/Relay/Circuit Breaker Identification, RH DR, Positions 30 through 56

PDM Layout

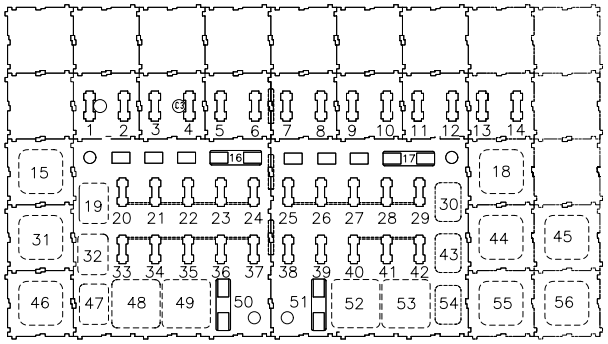


11/07/97 f541799

Pos. No.	Description	Part Number	Rating
30	Auxiliary Feed Relay	680 545 00 05	—
31	Trailer Marker Light Relay	23–11276–011	—
32	Headlight Relay, Right	680 545 00 05	—
33	Headlight, Right	231284 000015	15A
34	Turn Signal Flasher	LF 257 020	20A
35	A/C Compressor	231284 000010	10A
36	Cigar Lighter	231284 000015	15A
37	Taillight	231284 000015	15A
38	Ether Start	231284 000010	10A
39	Heater/AC Switch	231284 000015	15A
40	Heated Mirror	231284 000015	15A
41	Back-Up Light Switch and Radio	231284 000010	10A
42	Windshield Wiper and Washer	680 545 16 66 (Type 1)	15A
43	Spare	—	—
44	Back-Up Light Relay (A/T) *	680 545 00 05	—
45	Engine Shutdown Warning Relay	23–11276–011	—
47	Panel Light Relay	680 545 00 05	—
48	Tail and Marker Light Relay	23–11276–011	—

Fuse/Relay/Circuit Breaker Identification, RH DR, Positions 30 through 56

PDM Layout



11/07/97 f541799

Pos. No.	Description	Part Number	Rating
49	Heater/AC Switch Relay	23–11276–011	—
50	Spare	—	—
51	Heater Blower Motor	680 545 02 34	40A
52	Blower Motor Relay	23–11276–011	—
53	Brake Light Relay	23–11276–011	—
54	AC Compressor/ Clutch Relay	680 545 00 05	—
55	Hazard-Warning Flasher	HAL3016	—
56	Engine Shutdown Warning Relay	23–11276–011	—

* Optional—available on vehicles with automatic transmission only

Table 7, Fuse/Relay/Circuit Breaker Identification, RH DR, Positions 30 through 56

Specifications

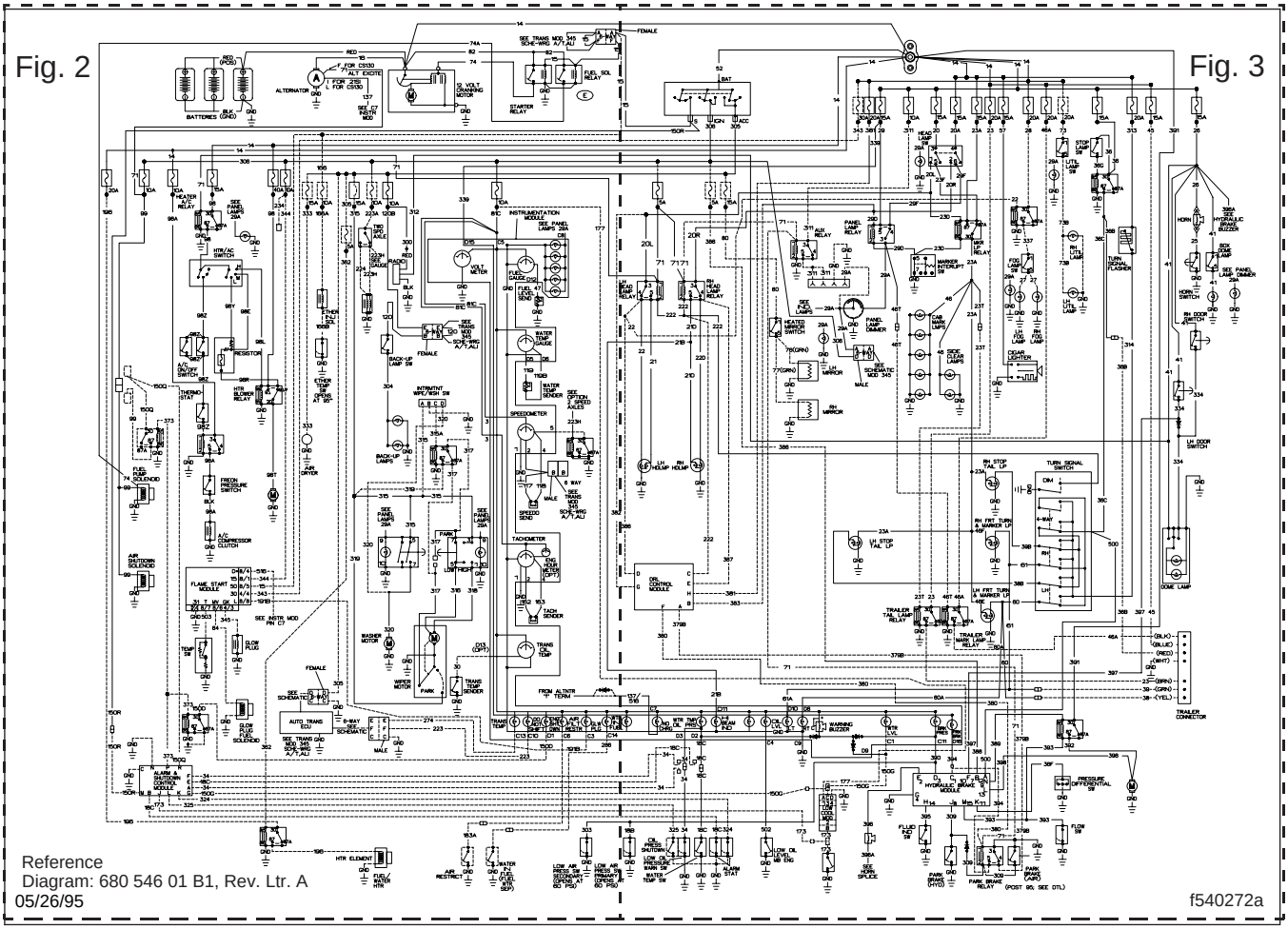


Fig. 1, Standard Vehicle Wiring Diagram

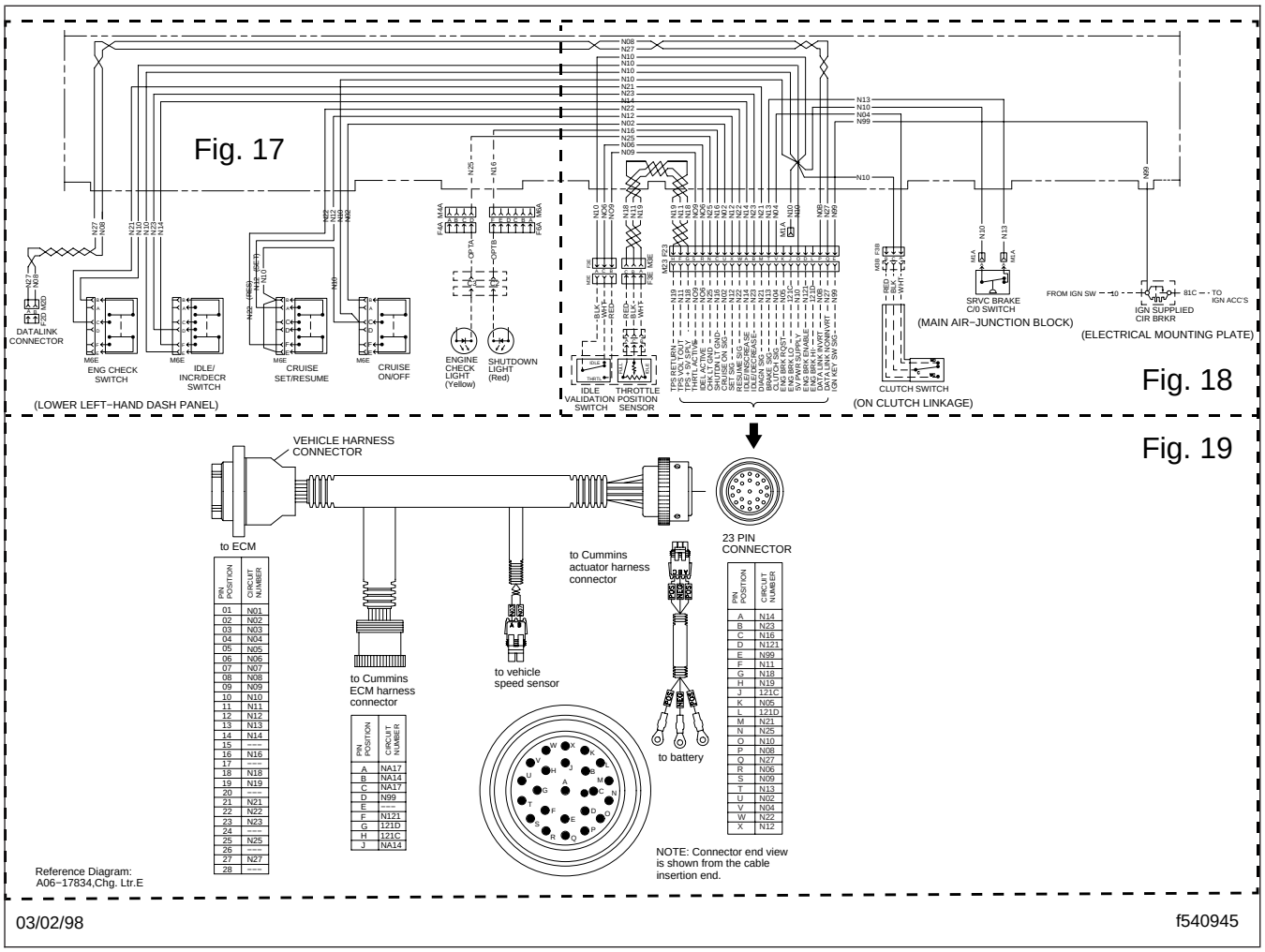


Fig. 2, Standard Vehicle Wiring Diagram (partial view)

Specifications

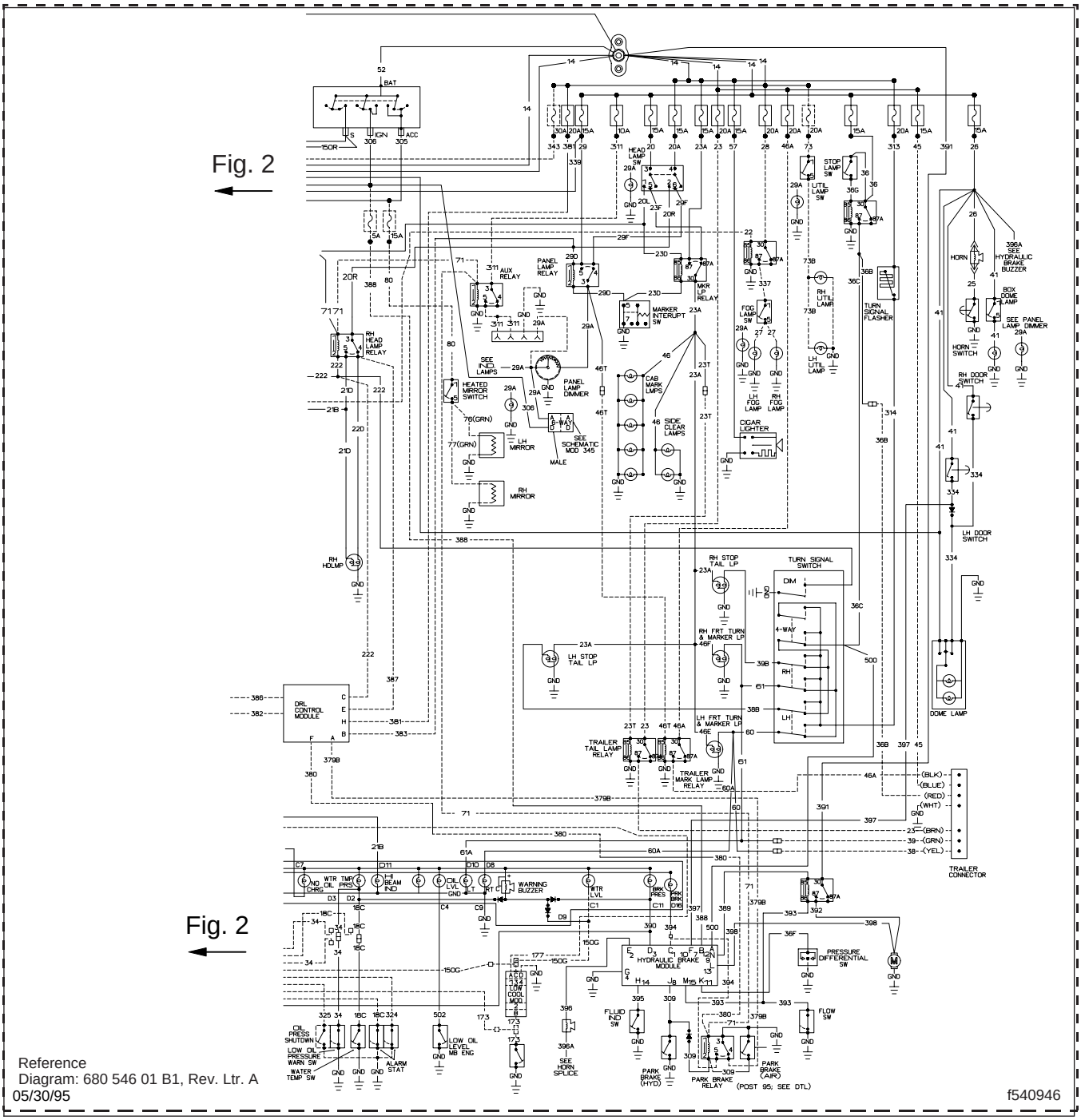


Fig. 3, Standard Vehicle Wiring Diagram (partial view)

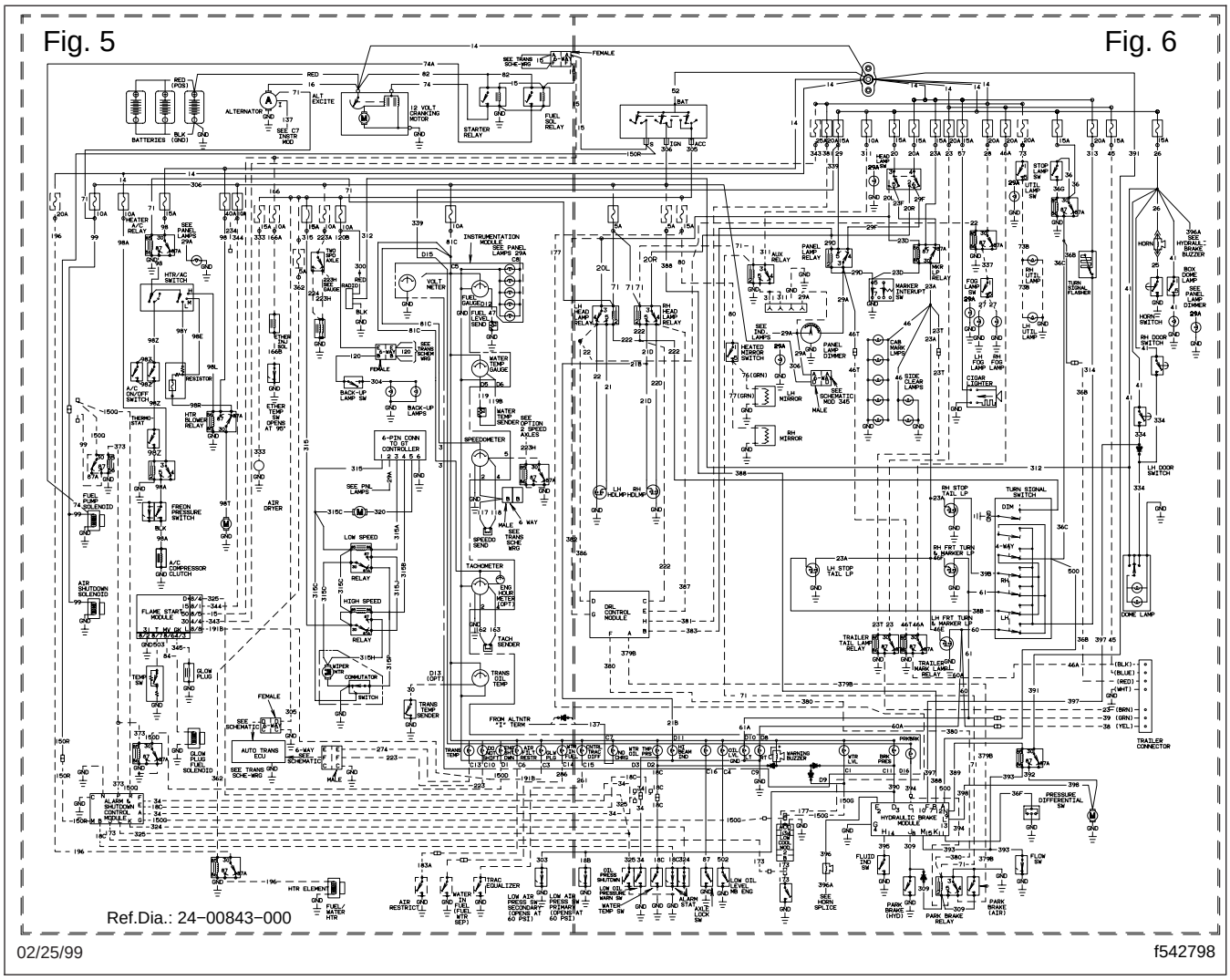


Fig. 4, Revised (as of April 3, 1998) Standard (LH DR) Vehicle Wiring Diagram

Specifications

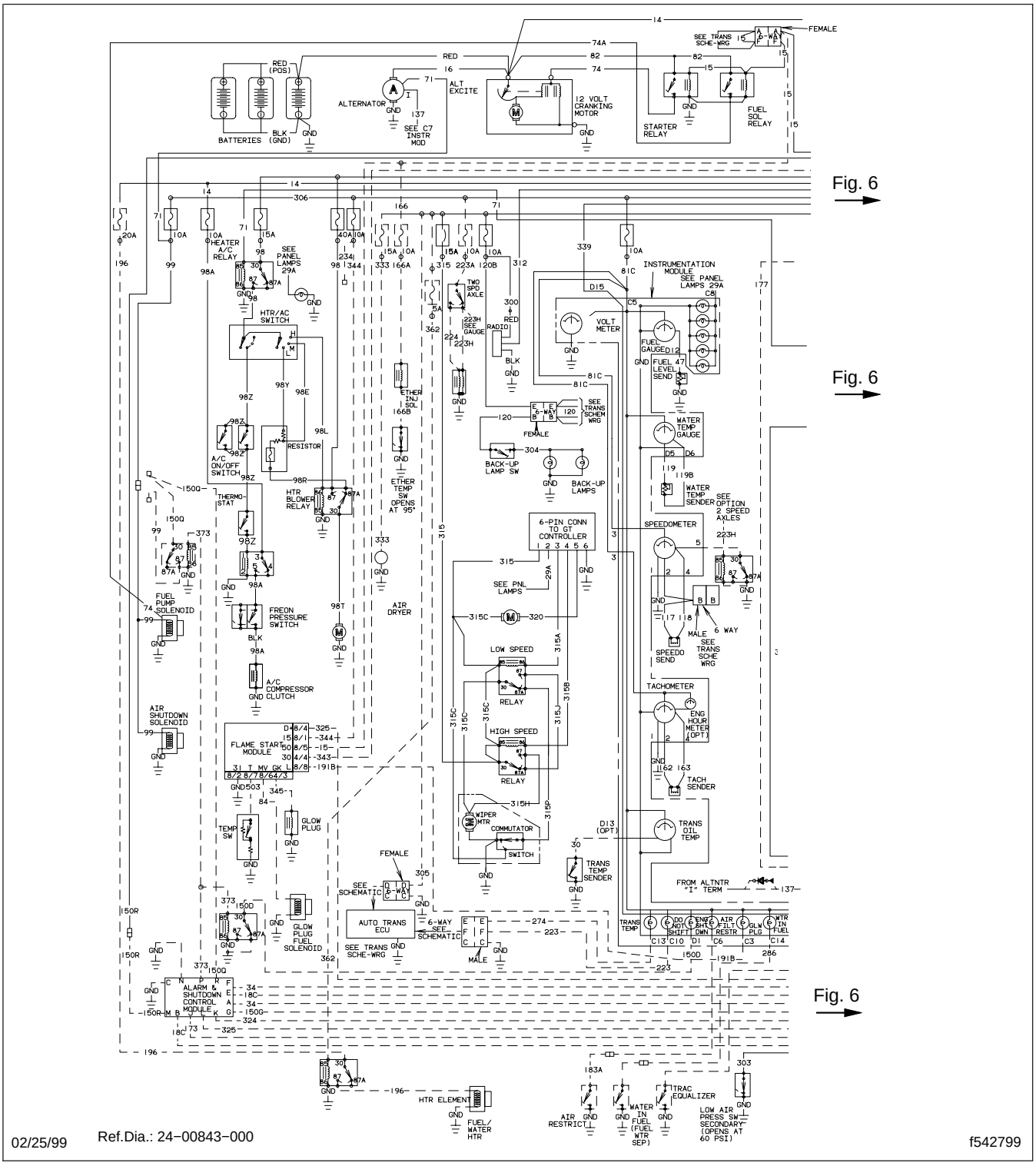


Fig. 5, Revised (as of April 3, 1998) Standard (LH DR) Vehicle Wiring Diagram (partial view)

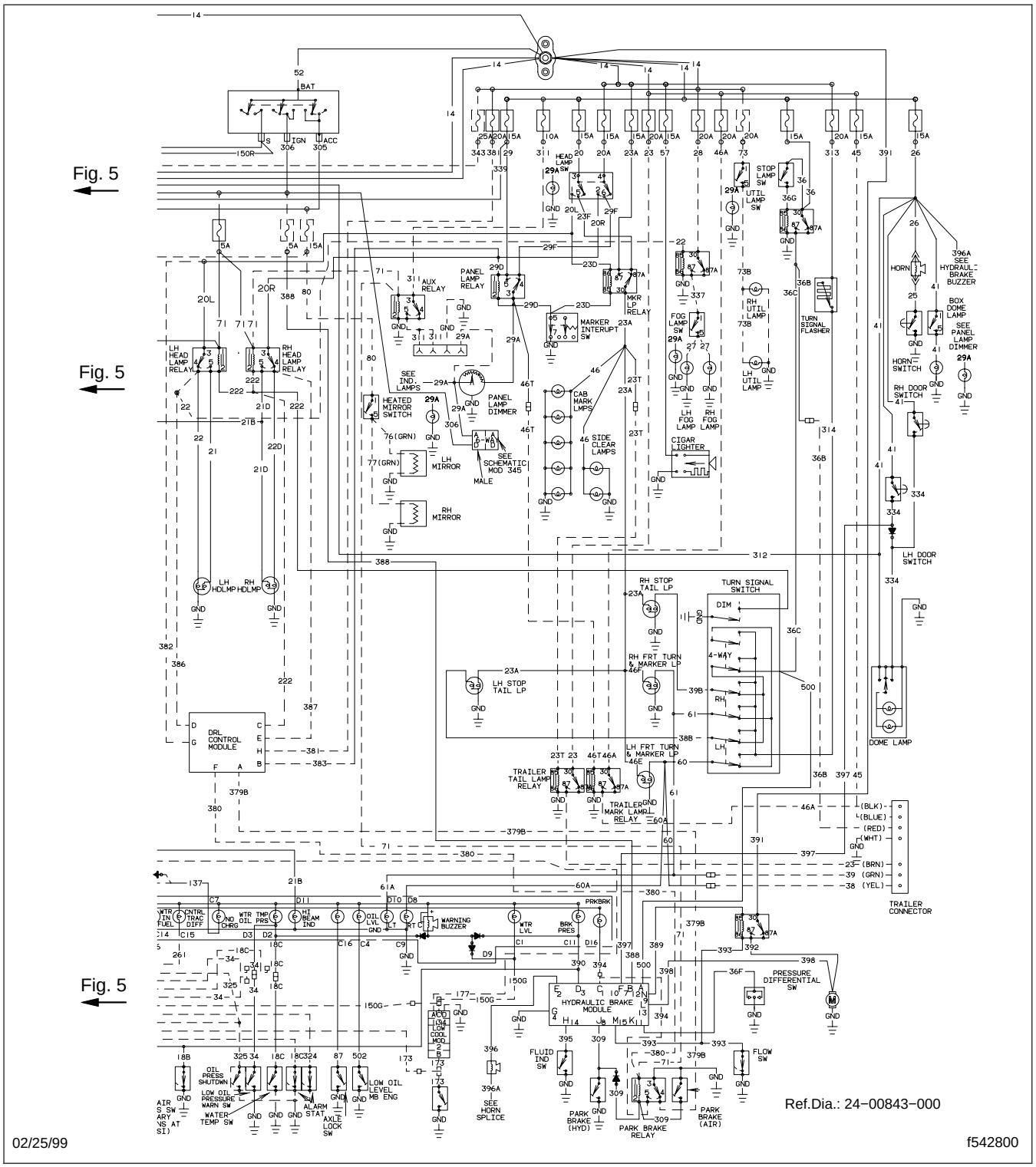


Fig. 6, Revised (as of April 3, 1998) Standard (LH DR) Vehicle Wiring Diagram (partial view)

Specifications

WIRE NUMBER CODE IDENTIFICATION

CIRC.	DESCRIPTION
14	MAIN CAB FEED
15	STARTER SOLENOID COIL FEED
16	ALTERNATOR OUTPUT
18B	LOW AIR PRESSURE INDICATOR FEED
18C	HIGH WATER TEMP INDICATOR FEED
20	HEADLAMP SWITCH SUPPLY (L)
20A	HEADLAMP SWITCH SUPPLY (R)
20L	L/H HEADLAMP RELAY FEED
20R	R/H HEADLAMP RELAY FEED
21	HEADLAMP HIGH BEAM - LH
21B	HIGH BEAM INDICATOR FEED
21D	HEADLAMP HIGH BEAM - RH
22	HEADLAMP LOW BEAM - LH
22D	HEADLAMP LOW BEAM - RH
23	TRAILER MARKER & TAIL LAMP FEED
23A	VEHICLE TAIL LAMP FEED
23D	TRACTOR MARKER LAMP CONTROL
23F	TRACTOR MARKER LAMP RELAY (NC)
23T	TRAILER TAIL LAMP CONTROL
25	HORN BUTTON FEED
26	HORN FEED
27	ROADLAMP FEED
28	ROADLAMP FEED
29	INSTRUMENT LAMP SWITCH FEED
29A	INSTRUMENT LAMP FEED
29D	PANEL LAMP CONTROL
29F	PANEL LAMP RELAY (NC)
30	MAIN TRANSMISSION OIL TEMP GAUGE FEED
34	LOW OIL PRESSURE INDICATOR FEED
35	ENGINE OIL TEMP GAUGE FEED
36	STOP LAMP SWITCH FEED
36B	TRAILER STOP LAMP FEED
36C	TURN SIGNAL SWITCH STOP LAMP FEED
36F	PRESSURE DIFF SWITCH
36G	STOP LAMP RELAY COIL
38	TRAILER TURN SIGNAL LAMP FEED - LH
38B	LH STOP & TURN LAMP FEED
39	TRAILER TURN SIGNAL LAMP FEED - RH
39B	RH STOP & TURN LAMP FEED
41	CAB DOME LAMP SWITCH FEED
45	AUXILIARY TRAILER FEED
46	CAB MARKER LAMP FEED
46E	SIDE MARKER LAMP FEED - LH
46F	SIDE MARKER LAMP FEED - RH
46T	TRLR MARKER RELAY COIL
47	FUEL LEVEL GAUGE FEED
52	IGNITION SWITCH FEED (BATT)
57	CIGAR LIGHTER FEED
60	FRONT TURN SIGNAL LAMP FEED - LH
60A	TURN SIGNAL INDICATOR FEED - LH
61	FRONT TURN SIGNAL LAMP FEED - RH
61A	TURN SIGNAL INDICATOR FEED - RH
71	HEATER/AC CONTROL; H/L RELAY CONTROL
73	UTILITY/AUX DOME LAMP
73B	UTILITY/AUX DOME LAMP
74	STARTER SOLENOID FEED
74A	FUEL SOLENOID RELAY
76	HEATED MIRROR FEED - LH
77	HEATED MIRROR FEED - RH
80	HEATED MIRROR SWITCH FEED
81C	INSTRUMENT FEED
82	STARTER CONTROL SOLENOID FEED
84	FLAMESTART SOL. FEED
87	AXLE LOCK INDICATOR FEED
98	HEATER/AC FEED
98A	A/C COMPRESSOR CLUTCH FD & DRYER REC FD
98E	BLOWER MOTOR (MED-I)
98L	HIGH SPEED FAN RELAY CONTROL
98R	HIGH SPEED FAN RELAY (NC)
98T	BLOWER MOTOR
98Y	BLOWER MOTOR LOW
98Z	A/C CLUTCH CONTROL; SHUTTER CONTROL
99	FUEL SOLENOID FEED
117	SPEEDOMETER (SENDER SIGNAL +)
118	SPEEDOMETER (SENDER SIGNAL -)
119	WATER TEMP GAUGE FEED
119B	GND-WTR TEMP SEND UNIT
120	BACKUP LAMP SWITCH FEED
120B	BACKUP LAMP SWITCH FEED
137	ALT.NO CHARGE
150D	SHUTDOWN IND. LAMP
150F	ALARMSTAT (N.C.) SHUTDOWN TERMINAL FEED
150G	SHUTDOWN MOD. FEED
150M	ALARMSTAT TO PRESSURESTAT OR TEMP SW GND
150R	SHUTDOWN MODULE START IND.
162	TACHOMETER (SENDER SIGNAL +)
163	TACHOMETER (SENDER SIGNAL -)
166	ETHER INJECTOR PUSHBUTTON FEED
166A	ETHER INJECTOR SOLENOID FEED
166B	ETHER INJECTOR THERMOSTAT FEED
173	LOW WATER LEVEL PROBE
177	LOW COOLANT PROBE LAMP FEED
183A	AIR RESTRICT SENDER
222	HEADLAMP DIMMER SW FEED
223	WARN LAMP DO NOT SHIFT
234	FAN CLUTCH THERMOSTAT CONTROL FEED
234A	FAN CLUTCH SOLENOID FEED
261	TRAC. EQUAL DIFF. LOCK
274	TRANS TEMP OIL IND. LAMP
286	WATER IN FUEL
300	RADIO FEED
303	LOW AIR SWITCH JUMPER
304	BACKUP LAMP FEED
305	ACCESSORY-BREAKER FEED
306	IGNITION-BREAKER FEED
309	PARK BRAKE SIG
310	AXLE LOCK SWITCH FEED
311	OPTION BLOCK FEED-ACCESSORY
312	RADIO POWER-BATT
313	TURN SIGNAL FLASHER FEED
314	TURN SIGNAL SWITCH FEED
315	WIPER SWITCH POWER
315A	WIPER RELAY COIL-LOW
315B	WIPER RELAY COIL-HIGH
315C	WIPER/WASHER POWER
315H	WASHER-HIGH SPEED
315J	JUMPER
315L	WASHER-LOW SPEED
315P	PARK MODE
---	---
320	WIPER-WASHER MOTOR
324	HIGH WATER TEMPERATURE SHUTDOWN
325	LOW OIL PRESSURE SHUTDOWN
329	PYROMETER TRANSDUCER-POS
330	PYROMETER TRANSDUCER-NEG
331	POSITIVE DATA LINK
332	NEGATIVE DATA LINK
333	AIR DRYER FEED
334	DOME LAMP FEED
337	ROADLAMP SWITCH FEED
339	LIGHT BAR FEED-BATT
342	AMMETER FEED
343	GLOW PLUG SWITCH FEED
344	GLOW PLUG PRESSURE SWITCH FEED
345	GLOW PLUG SOLENOID TO GLOW PLUGS
346	SPEAKER GROUND CIRCUIT
347	SHUTTER TO RELAY
348	TRINARY SW TO DUAL TEMP SW (SHUTTERS)
349	SHUTTER SOLENOID TO DUAL TEMP SWITCH
354	SHUTTER SOLENOID TO TRANS TEMP SWITCH
355	FAN SWITCH TO TRANS TEMP SWITCH
362	FUEL WATER SEPERATOR RELAY COIL POWER
363	POWER WINDOW FEED
364	POWER WINDOW UP
365	POWER WINDOW DOWN
373	FUEL SOLENOID RELAY
374	STARTER LOCKOUT RELAY
375	NEUTRAL-DRL
376	ANTILOCK POWER-ROCKWELL
377	ANTILOCK INDICATOR-ROCKWELL
378	ANTILOCK SOLENOID-ROCKWELL
379B	PARK BRAKE GND SIG TO DRL
380	DRL IGN FEED
381	DRL MODULE-B+
382	LH HEADLAMP RELAY-COMMON,DRL
383	RH HEADLAMP-DRL
386	DRL-LH
387	DRL-RH
388	IGN. ON
389	RELAY COIL FD.
390	BRAKE PRESS WARN IND LT
393	FLOW SW & RELAY COIL GND
394	PARK BRK IND LT
395	LOW FLUID IND.
396	AUDIBLE ALARM
396A	AUDIBLE ALARM
397	DOOR OPEN SW.
398	MOTOR PUMP COIL SENSE
500	HYD BRAKE SW SENSE
502	OIL LEVEL SENSOR
503	FLAMESTART TEMP SENSOR

02/24/99

Ref. Dia.: 24−00843−000

f542801

Fig. 7, Revised (as of April 3, 1998) Standard (LH DR) Vehicle Wiring Diagram Wire Number Codes

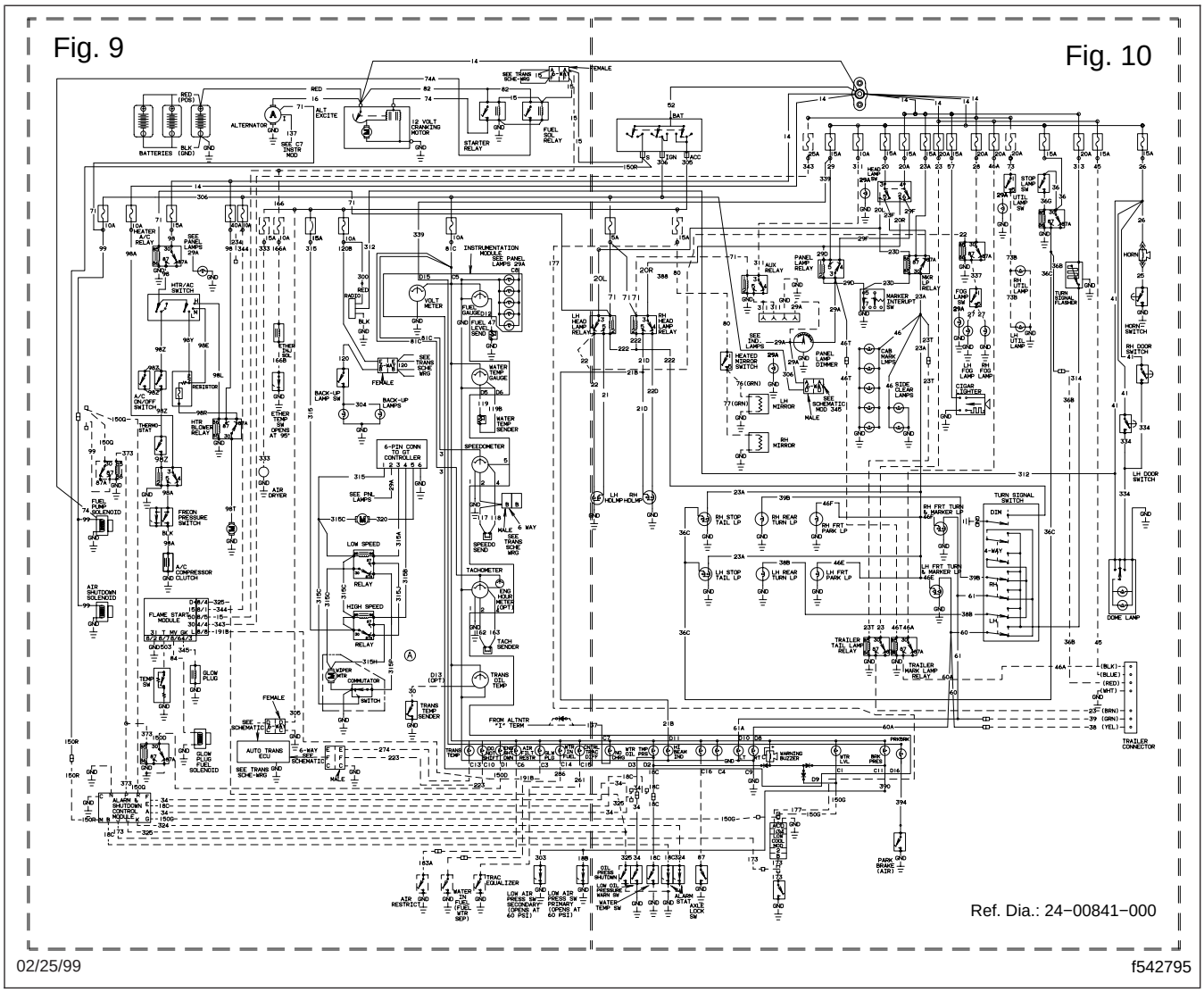


Fig. 8, RH DR Vehicle Wiring Diagram

Specifications

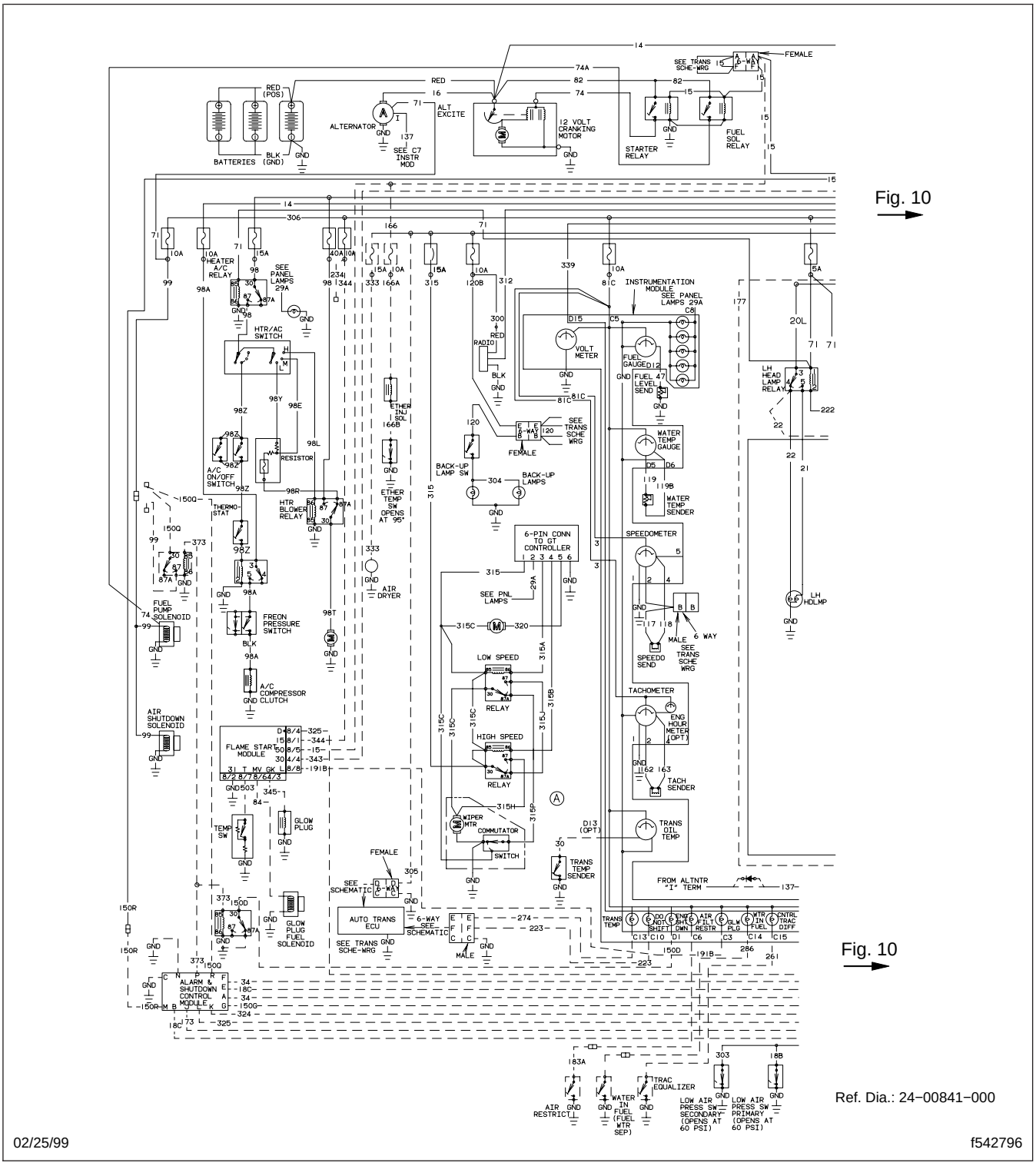


Fig. 9, RH DR Vehicle Wiring Diagram (partial view)

Fig. 9

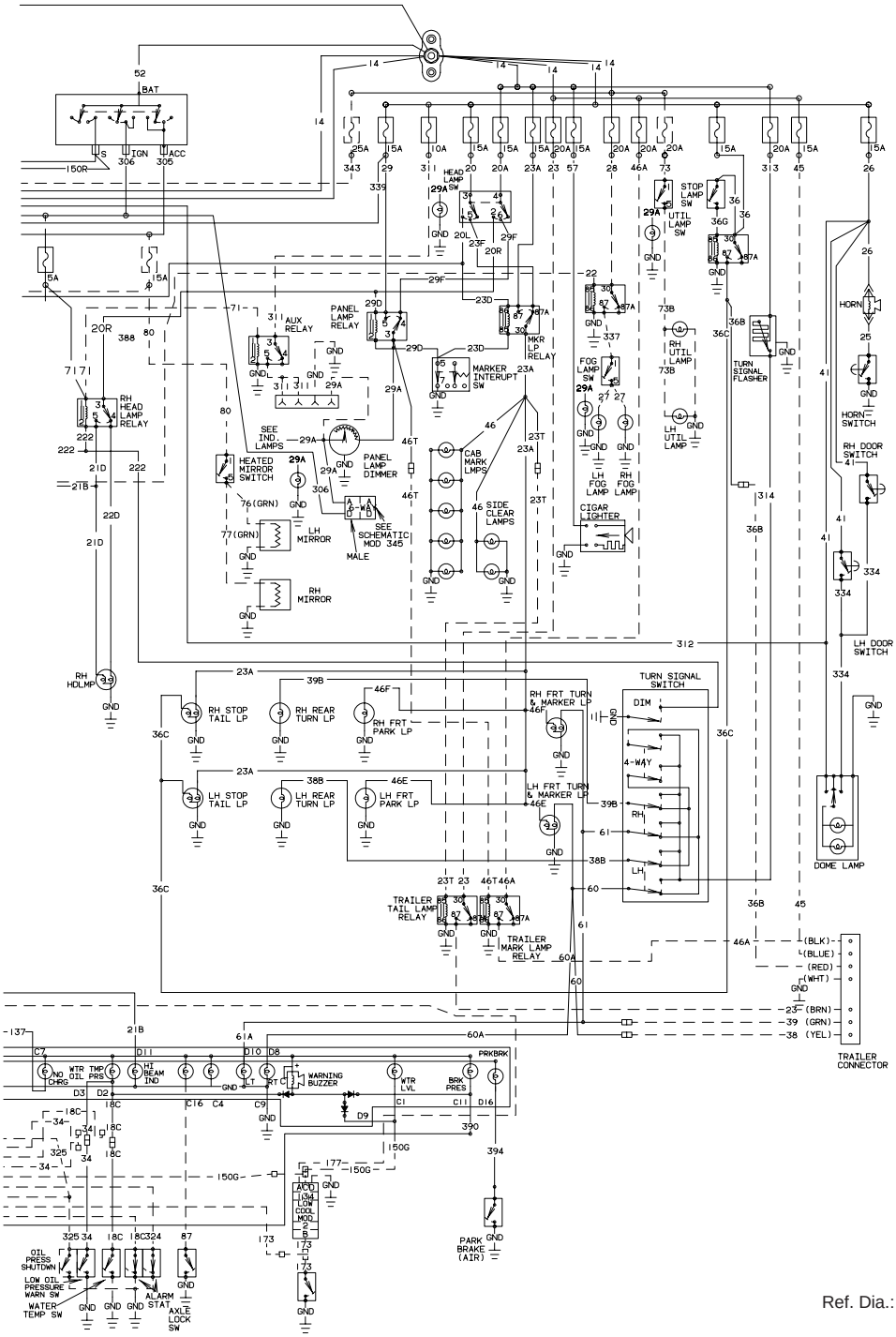


Fig. 9

Ref. Dia.: 24−00841−000

02/25/99 f542797

Fig. 10, RH DR Vehicle Wiring Diagram (partial view)

Specifications

WIRE NUMBER CODE IDENTIFICATION

CIRC.	DESCRIPTION
14	MAIN CAB FEED
15	STARTER SOLENOID COIL FEED
16	ALTERNATOR OUTPUT
18B	LOW AIR PRESSURE INDICATOR FEED
18C	HIGH WATER TEMP INDICATOR FEED
20	HEADLAMP SWITCH SUPPLY (L)
20A	HEADLAMP SWITCH SUPPLY (R)
20L	L/H HEADLAMP RELAY FEED
20R	R/H HEADLAMP RELAY FEED
21	HEADLAMP HIGH BEAM - LH
21B	HIGH BEAM INDICATOR FEED
21D	HEADLAMP HIGH BEAM - RH
22	HEADLAMP LOW BEAM - LH
22D	HEADLAMP LOW BEAM - RH
23	TRAILER MARKER & TAIL LAMP FEED
23A	VEHICLE TAIL LAMP FEED
23D	TRACTOR MARKER LAMP CONTROL
23F	TRACTOR MARKER LAMP RELAY (NC)
23T	TRAILER TAIL LAMP CONTROL
25	HORN BUTTON FEED
26	HORN FEED
27	ROADLAMP FEED
28	ROADLAMP FEED
29	INSTRUMENT LAMP SWITCH FEED
29A	INSTRUMENT LAMP FEED
29D	PANEL LAMP CONTROL
29F	PANEL LAMP RELAY (NC)
30	MAIN TRANSMISSION OIL TEMP GAUGE FEED
34	LOW OIL PRESSURE INDICATOR FEED
35	ENGINE OIL TEMP GAUGE FEED
36	STOP LAMP SWITCH FEED
36B	TRAILER STOP LAMP FEED
36C	TURN SIGNAL SWITCH STOP LAMP FEED
36F	PRESSURE DIFF SWITCH
36G	STOP LAMP RELAY COIL
38	TRAILER TURN SIGNAL LAMP FEED - LH
38B	LH STOP & TURN LAMP FEED
39	TRAILER TURN SIGNAL LAMP FEED - RH
39B	RH STOP & TURN LAMP FEED
41	CAB DOME LAMP SWITCH FEED
45	AUXILIARY TRAILER FEED
46	CAB MARKER LAMP FEED
46E	SIDE MARKER LAMP FEED - LH
46F	SIDE MARKER LAMP FEED - RH
46T	TRLR MARKER RELAY COIL
47	FUEL LEVEL GAUGE FEED
52	IGNITION SWITCH FEED (BATT)
57	CIGAR LIGHTER FEED
60	FRONT TURN SIGNAL LAMP FEED - LH
60A	TURN SIGNAL INDICATOR FEED - LH
61	FRONT TURN SIGNAL LAMP FEED - RH
61A	TURN SIGNAL INDICATOR FEED - RH
71	HEATER/AC CONTROL; H/L RELAY CONTROL
73	UTILITY/AUX DOME LAMP
73B	UTILITY/AUX DOME LAMP
74	STARTER SOLENOID FEED
74A	FUEL SOL RELAY
76	HEATED MIRROR FEED - LH
77	HEATED MIRROR FEED - RH
80	HEATED MIRROR SWITCH FEED
81C	INSTRUMENT FEED
82	STARTER CONTROL SOLENOID FEED
84	FLAMESTART SOL. FEED
87	AXLE LOCK INDICATOR FEED
98	HEATER/AC FEED
98A	A/C COMPRESSOR CLUTCH FEED & DRIER REC FEED
98E	BLOWER MOTOR (MED-I)
98L	HIGH SPEED FAN RELAY CONTROL
98R	HIGH SPEED FAN RELAY (NC)
98T	BLOWER MOTOR
98Y	BLOWER MOTOR LOW
98Z	A/C CLUTCH CONTROL; SHUTTER CONTROL
99	FUEL SOLENOID FEED
117	SPEEDOMETER (SENDER SIGNAL +)
118	SPEEDOMETER (SENDER SIGNAL -)
119	WATER TEMP GAUGE FEED
119B	GND-WTR TEMP SEND UNIT
120	BACKUP LAMP SWITCH FEED
120B	BACKUP LAMP SWITCH FEED
137	ALT.NO CHARGE
150D	SHUTDOWN IND. LAMP
150F	ALARMSTAT (N.C.) SHUTDOWN TERMINAL FEED
150G	SHUTDOWN MOD. FEED
150M	ALARMSTAT TO PRESSURESTAT OR TEMP SW GROUND
150R	SHUTDOWN MODULE START IND.
162	TACHOMETER (SENDER SIGNAL +)
163	TACHOMETER (SENDER SIGNAL -)
166	ETHER INJECTOR PUSHBUTTON FEED
166A	ETHER INJECTOR SOLENOID FEED
166B	ETHER INJECTOR THERMOSTAT FEED
173	LOW WATER LEVEL PROBE
177	LOW COOLANT PROBE LAMP FEED
183A	AIR RESTRICT SENDER
222	HEADLAMP DIMMER SW FEED
223	WARN LAMP DO NOT SHIFT
234	FAN CLUTCH THERMOSTAT CONTROL FEED
234A	FAN CLUTCH SOLENOID FEED
261	TRAC. EQUAL DIFF. LOCK
274	TRANS TEMP OIL IND. LAMP
286	WATER IN FUEL
300	RADIO FEED
303	LOW AIR SWITCH JUMPER
304	BACKUP LAMP FEED
305	ACCESSORY-BREAKER FEED
306	IGNITION-BREAKER FEED
309	PARK BRAKE INDICATE
310	AXLE LOCK SWITCH FEED
311	OPTION BLOCK FEED-ACCESSORY
312	RADIO POWER-BATT
313	TURN SIGNAL FLASHER FEED
314	TURN SIGNAL SWITCH FEED
315	WIPER SWITCH POWER
315A	WIPER RELAY COIL-LOW
315B	WIPER RELAY COIL-HIGH
315C	WIPER/WASHER POWER
315H	WASHER-HIGH SPEED
315J	JUMPER
315L	WASHER-LOW SPEED
315P	PARK MODE
319	WIPER MOTOR PARK-BATT
320	WIPER-WASHER MOTOR
324	HIGH WATER TEMPERATURE SHUTDOWN
325	LOW OIL PRESSURE SHUTDOWN
329	PYROMETER TRANSDUCER-POS
330	PYROMETER TRANSDUCER-NEG
331	POSITIVE DATA LINK
332	NEGATIVE DATA LINK
333	AIR DRYER FEED
334	DOME LAMP FEED
337	ROADLAMP SWITCH FEED
339	LIGHT BAR FEED-BATT
342	AMMETER FEED
343	GLOW PLUG SWITCH FEED
344	GLOW PLUG PRESSURE SWITCH FEED
345	GLOW PLUG SOLENOID TO GLOW PLUGS
346	SPEAKER GROUND CIRCUIT
362	FUEL WATER SEPERATOR RELAY COIL POWER
363	POWER WINDOW FEED
364	POWER WINDOW UP
365	POWER WINDOW DOWN
373	FUEL SOLENOID RELAY
374	STARTER LOCKOUT RELAY
390	BRAKE PRESSURE WARN LT
394	PARK BRAKE IND LT
502	OIL LEVEL SENSOR
503	FLAMESTART TEMP SENSOR
516	FLAMESTART ALTERNATOR INDICATOR

Ref.Dia.: 24-00841-000

02/24/99

f542802

Fig. 11, RH DR Vehicle Wiring Diagram Wire Number Codes

General Description and Principles of Operation

The Kysor warning and engine shutdown system electronically monitors engine oil pressure, coolant temperature, and coolant level. If the oil pressure drops below a preset level, the low oil pressure light comes on, and a warning buzzer sounds. If the oil pressure drops to a preset critical level, the engine shutdown light comes on, and the voltage to the fuel control circuit is interrupted, shutting down the engine.

If engine coolant temperature rises above a preset level, a warning light comes on, and a buzzer sounds. The temperature that triggers the warning light and buzzer varies with engine type. If the temperature continues to rise to critical levels, the engine shutdown light comes on, and the voltage to the fuel control circuit is interrupted, shutting down the engine.

If the coolant level drops below the level of a sensor in the cooling system, the low water level light comes on, and a buzzer sounds. After 30 seconds the system shuts down the engine.

All shutdown features have an automatic override: if it is necessary to move the vehicle to a safe location after a shutdown, just crank the engine— it will run for about 30 seconds and then shut down again.

The Kysor warning and engine shutdown system provides a driver circuit for the temperature gauge. This circuit uses the same temperature sensor as the alarm and shutdown functions.

When the ignition switch is turned on, the engine function light will turn on and the buzzer will sound momentarily.

The warning buzzer is triggered by the start circuit. After the engine is cranked, releasing the start switch activates the buzzer. Therefore, during a normal start, the buzzer sounds after releasing the starter until the engine oil pressure and the air pressure reach normal operating values.

Circuit overload protection is built into the Kysor warning and engine shutdown system. If an overload is detected on an output circuit, that par-ticular circuit shuts down. To restore full function, remove the overload; turn the ignition switch off, then on again. Intermittent shorts in the output circuits will cause intermittent false engine shutdown.

Replacement

1. The warning and shutdown control module is located behind the right-side upper dashboard panel, above the electrical center. Access it by removing the rubber trim piece on the right side of the dashboard and the two screws that connect the dashboard cover to the dashboard.
2. Replace the control module.
   - 2.1 Disconnect the 15-pin wiring connector from the warning and shutdown control module.
   - 2.2 Remove the two mounting bolts and the module.
   - 2.3 Position the new module on the mounting bracket then install the two mounting bolts.
   - 2.4 Connect the 15-pin wiring connector.
3. Install the dashboard cover and tighten the screws securely; then install the trim piece.

Replacement

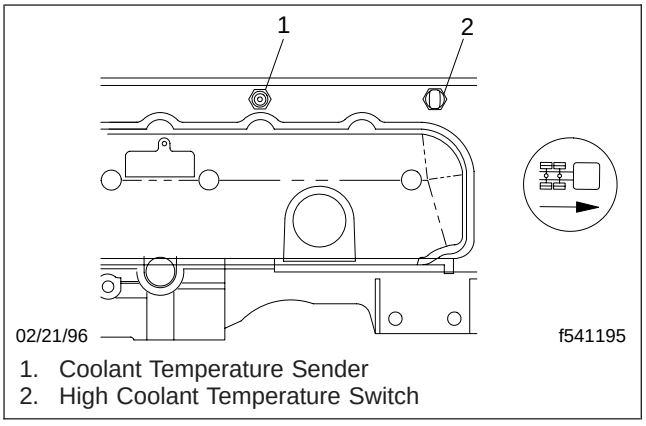
HIGH COOLANT TEMPERATURE SWITCH

1. Turn off the ignition switch and let the engine cool. Remove the surge tank cap to release the system pressure.

⚠ WARNING

Do not drain coolant from a hot engine. Opening the cooling system when the engine and coolant are hot can cause severe personal injury due to scalding by the hot, pressurized coolant.

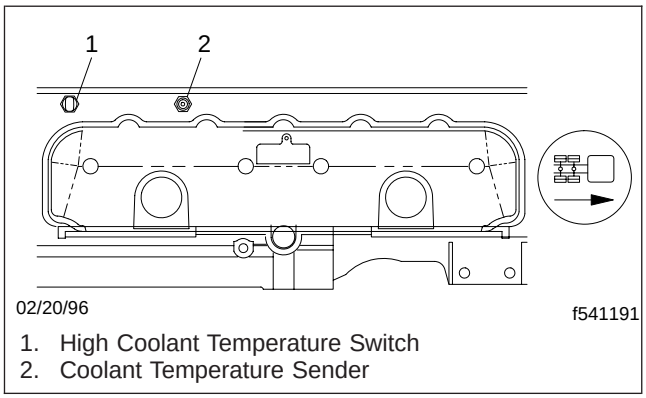
2. Drain the coolant from the engine.
3. Disconnect wires 18C and 324 from the high coolant temperature switch (see **Fig. 1**, **Fig. 2**, **Fig. 3**, **Fig. 4**, **Fig. 5**, **Fig. 6**, **Fig. 7**, or **Fig. 8**); then remove the switch.



1. Coolant Temperature Sender
2. High Coolant Temperature Switch

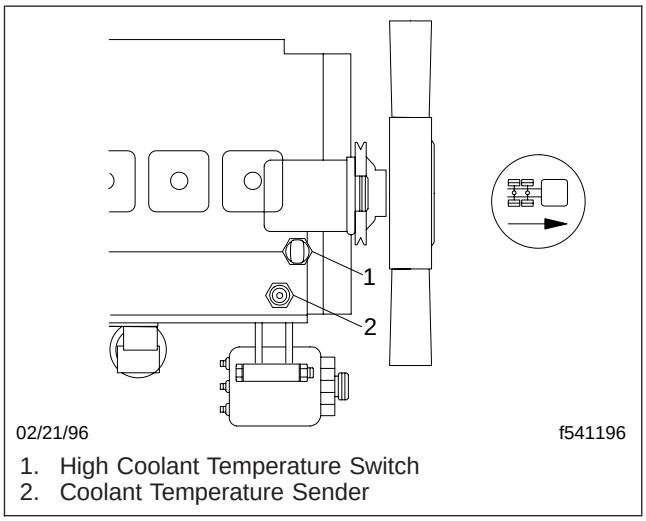
Fig. 1, OM 366LA, Forward-Mounted Coolant Temperature Sender and High Coolant Temperature Switch

4. Install the new switch and tighten it one-half turn past finger-tight. Connect wires 18C and 324 to the switch.
5. Add coolant to the system as needed; then install the cap. Start the engine and check the system to be sure there are no coolant leaks.



1. High Coolant Temperature Switch
2. Coolant Temperature Sender

Fig. 2, OM 366LA, Rear-Mounted Coolant Temperature Sender and High Coolant Temperature Switch



1. High Coolant Temperature Switch
2. Coolant Temperature Sender

Fig. 3, Cummins B Series with Top-Mounted Coolant Temperature Sender and High Coolant Temperature Switch

LOW COOLANT LEVEL PROBE

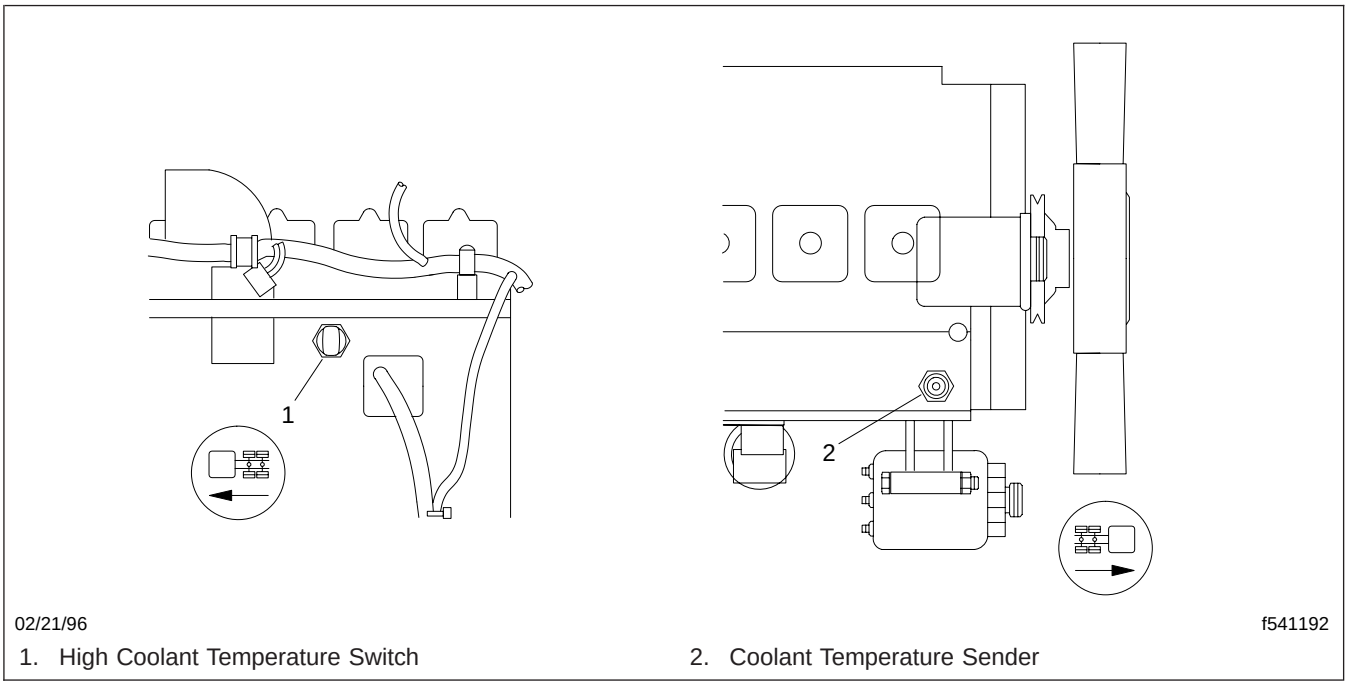
1. Turn off the ignition switch and let the engine cool. Remove the surge tank cap to release the system pressure.

⚠ WARNING

Do not drain coolant from a hot engine. Opening the cooling system when the engine and coolant are hot can cause severe personal injury due to scalding by the hot, pressurized coolant.

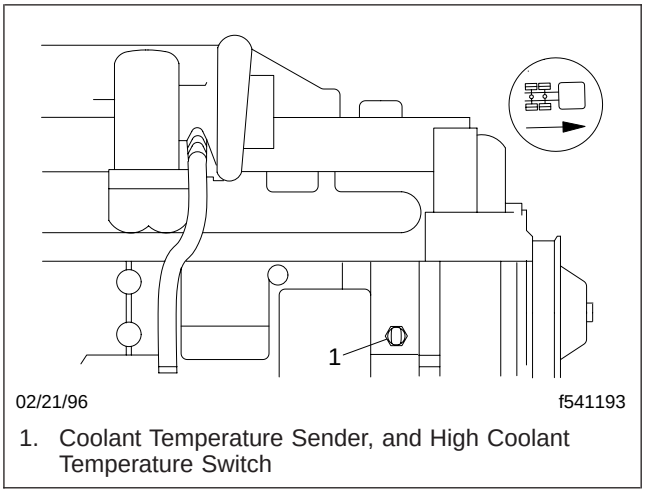
2. Drain the coolant from the surge tank.

Switch (Sensor) Replacement



1. High Coolant Temperature Switch
2. Coolant Temperature Sender

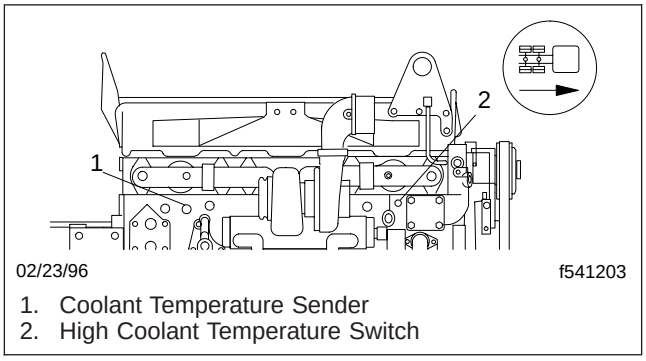
Fig. 4, Cummins B Series with Side-Mounted Coolant Temperature Sender and Top-Mounted High Coolant Temperature Switch



1. Coolant Temperature Sender, and High Coolant Temperature Switch

Fig. 5, Cummins C Series

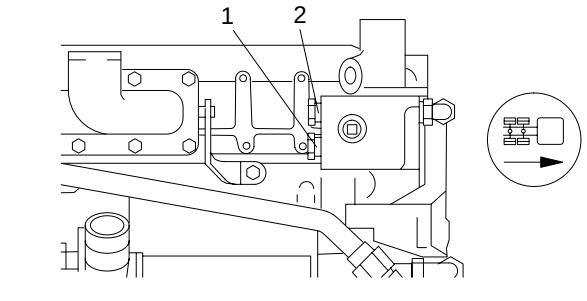
3. Disconnect wire 173 and the ground wire (if equipped) from the low coolant level probe, located in the inboard side of the surge tank (see **Fig. 9**), then remove the probe.
4. Install the new probe and tighten it one-half turn past finger-tight. Connect wire 173 and the ground wire (if equipped) to the probe.



1. Coolant Temperature Sender
2. High Coolant Temperature Switch

Fig. 6, Cummins M11

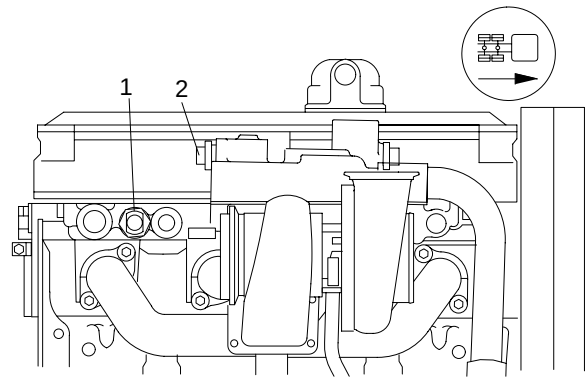
5. Add coolant to the system as needed; then install the cap.
6. Start the engine and check that the low coolant level warning light and buzzer do not come on. Check the system to be sure there are no coolant leaks.



02/20/96 f541190

1. Coolant Temperature Sender
2. High Coolant Temperature Switch

Fig. 7, Caterpillar CFE



10/01/96 f541194

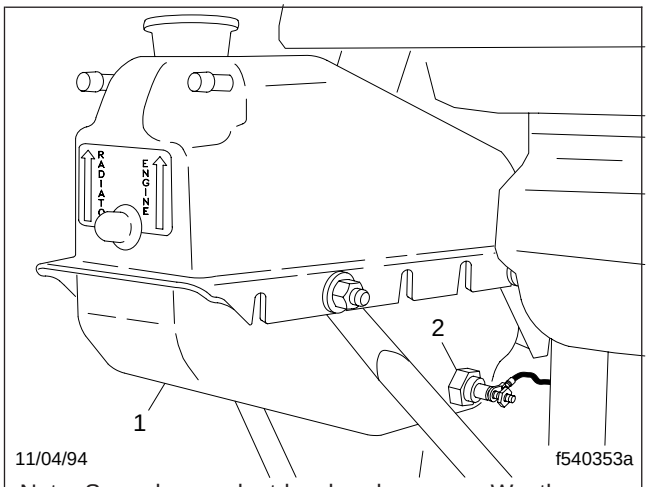
1. High Coolant Temperature Switch
2. Coolant Temperature Sender

Fig. 8, Detroit Diesel Series 50

LOW OIL PRESSURE WARNING SWITCH

NOTE: The low oil pressure warning switch is located on a tee on the air-oil manifold located behind the left side of the dash panel. Access it by removing the rubber trim piece and the two screws that connect the dashboard cover to the dashboard.

1. Turn off the ignition switch.
2. Disconnect wire 34 from the switch (see **Fig. 10**, Ref. 2), then remove the switch.
3. Install the new switch and tighten it one-half turn past finger-tight. Connect wire 34 to the switch.



11/04/94 f540353a

Note: Some low coolant level probes use a Weather Pack® connector. The low coolant level probe may also have a ground wire attached to its body.

1. Surge Tank
2. Low Coolant Level Probe

Fig. 9, Low Coolant Level Probe

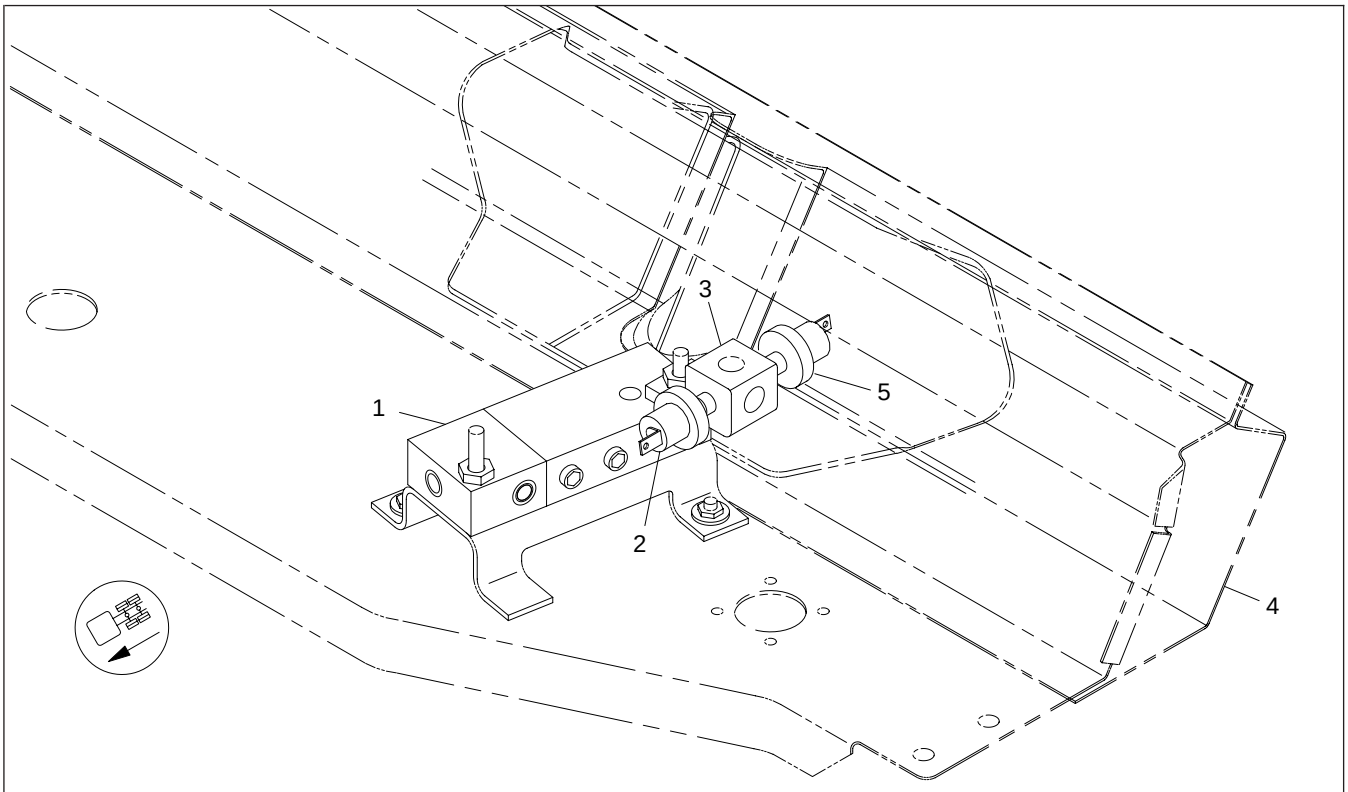
4. Start the engine and check that the warning light and buzzer shut off when the oil pressure reaches approximately 10 psi (69 kPa). Check the system to be sure there is no oil leakage.
5. Install the dash panel.

LOW OIL PRESSURE SHUTDOWN SWITCH

NOTE: The low oil pressure shutdown switch is located on a tee on the air-oil manifold located behind the left side of the dash panel. Access it by removing the rubber trim piece and the two screws that connect the dashboard cover to the dashboard.

1. Turn off the ignition switch.
2. Disconnect wire 325 from the switch (see **Fig. 10**, Ref. 5). Remove the switch.
3. Install the new switch and tighten it one-half turn past finger-tight. Connect wire 325 to the switch.
4. Start the engine and check that the warning light and buzzer shut off when the oil pressure reaches approximately 10 psi (69 kPa). Check the system to be sure there is no oil leakage.

Switch (Sensor) Replacement



04/24/96 f540356a

1. Air/Oil Manifold
2. Low Oil Pressure Warning Switch
3. Tee
4. Lower Dash Panel
5. Low Oil Pressure Shutdown Switch

Fig. 10, Low Oil Pressure Warning and Shutdown Switch

5. Install the dash panel.

Troubleshooting Procedures

ENGINE PROTECTION FEATURES

The Engine Run switch must be on for the fuel solenoid (or other fuel control) to turn on. The Engine Run switch is controlled by five separate inputs to the Kysor warning and engine shutdown system. The test procedure for each input and an explanation of how each one functions are presented below.

1. *Ignition Switch On*—Connect a voltmeter to the fuel solenoid wire 99, and turn on the ignition switch. The voltmeter should register at least 12 volts for 25 to 35 seconds; then, the voltage should drop to zero.

2. *Starter Engage*—Turn on the ignition switch and measure the voltage as above. After the voltage drops to zero, briefly engage the starter. There should be 12 volts at the fuel solenoid again for 25 to 35 seconds. Then, the voltage should drop to zero. This feature is operated by voltage in wire 150R, which has voltage only when the engine is being cranked.

3. *Coolant Level Sensing*—Disconnect wire 173 from the coolant level sensor in the surge tank. Start the engine. The LOW WTR light and the warning buzzer should be on. The engine should shut down 30 seconds after it starts, and the SHUTDOWN light should come on at the same time.

   Reconnect wire 173 to the coolant level sensor.

   This circuit sends a current through wire 173 to the low coolant sensor. When the circuit is grounded through the coolant, the system interprets this as a normal condition. Excessive coolant loss uncovers the sensor and breaks the circuit to ground. This causes the warning and shutdown control module to turn on the low coolant warning and to shut down the engine. An open circuit in wire 173 causes a false low coolant warning and shutdown. If wire 173 shorts to ground, the protection feature doesn't operate.

4. *Temperature Sensing*—Disconnect wires 18C and 324 from the temperature switch. Start the engine. The overheat indicator light should be on and the warning buzzer should sound. The engine should shut down 20 to 40 seconds after starting, and the SHUTDOWN light should come on at the same time.

   This circuit monitors the temperature switch continuity through wires 324 and 18C. If wire 18C or 324 shorts to ground, the high temperature alarm and shutdown features won't work. The engine could overheat and would probably be damaged.

IMPORTANT: Perform the temperature sensing test at every scheduled vehicle service to ensure that there are no problems with circuit 18C or 324. Reconnect wires 18C and 324 to the temperature switch.

5. *Low Oil Pressure Sensing*

   5.1 Warning Light

   Disconnect wire 34 from the low oil pressure warning sensor. Start the engine. The low oil pressure light should come on and the warning buzzer should sound. Circuit 34 is ground-seeking at the warning switch, which is normally open. The warning switch opens and interrupts the ground to wire 34 if oil pressure falls below the switch setpoint. When wire 34 loses ground, the oil pressure warning turns on, so an open circuit in wire 34 would cause a false low oil pressure warning. A short to ground in wire 34 would prevent the low oil pressure warning from working. This would occur when the ignition switch is first turned on: the low oil pressure symbol would not light until the starter is engaged. During normal start up, the low oil pressure indicator should light and the buzzer should sound when the key is turned on.

   5.2 Engine Shutdown

   Leave wire 34 disconnected from the low oil pressure warning switch. Disconnect wire 325 from the low oil pressure shutdown switch. Start the engine. The low oil pressure symbol and the buzzer should be on. The SHUTDOWN light should come on 20 to 40 seconds after start up, and the engine should shut down at the same time. Circuit 325 is similar to 34 in that it seeks ground through the normally open shutdown switch; if that ground is lost due to low oil pressure or an open circuit, the Kysor warning and shutdown control module shuts down the engine. If

Troubleshooting

circuit 325 shorts to ground, the low oil pressure shutdown feature will not work.

Troubleshooting Table

ENGINE PROTECTION FEATURES

For troubleshooting of the Kysor warning and engine shutdown system, see the following table.

Kysor Warning and Engine Shutdown System Troubleshooting

Kysor Warning and Engine Shutdown System Troubleshooting	
Problem	**Remedy**
The water temperature/oil pressure indicator does not light when engine coolant temperature is high.	Check the indicator bulb, the water temperature switch and wire 18C. See **Fig. 1**.
The water temperature/oil pressure indicator does not light when oil pressure is low.	Check the indicator bulb, the low oil pressure switch and wire 34. See **Fig. 2**.
The water temperature/oil pressure indicator is on when the oil pressure and coolant temperature are normal.	Check the low oil pressure switch, the water temperature switch, wire 34 and wire 18C. See **Fig. 3**.
The engine cranks but will not start. The engine shutdown indicator is on while the starter is cranking.	Check wire 150R, wire 150Q, and wire 373. See **Fig. 4**.
The engine shuts down; the engine shutdown indicator is not on as the engine begins to lose rpm.	Check the fuel solenoid relay, fuel pump and wire 373. See **Fig. 5**.
The engine shuts down with the water level and engine shutdown indicators on.	Check the coolant level switch and wire 173. See **Fig. 6**.
The water level indicator does not come on when the coolant level is low.	Check the coolant level switch and wire 173. See **Fig. 7**.
The engine starts, but the engine shuts down after 20 to 40 seconds.	Check the alarmstat, the oil pressure shutdown switch, wire 324 and wire 325. See **Fig. 8**.
The engine shutdown indictor does not come on when the engine shuts down.	Check the engine shutdown indicator relay. See **Fig. 9**.
The engine shutdown indicator is on, but the engine does not shut down.	Check the engine shutdown relay and wire 373. See **Fig. 10**.
The warning buzzer does not sound with high water temperature, but the water temperature/oil pressure indicator does light.	Check the warning buzzer and warning buzzer wiring. See **Fig. 11**.
The warning buzzer does not sound with low oil pressure, but the water temperature/oil pressure indicator does light.	Check the warning buzzer and warning buzzer wiring. See **Fig. 12**.

Troubleshooting

Kysor Warning and Engine Shutdown System Troubleshooting	
Problem	**Remedy**
The warning buzzer sounds without the water temperature/oil pressure indicator or the water level indicator lighting.	Check the warning buzzer and warning buzzer wiring. See **Fig. 13**.
The warning buzzer does not sound and the water temperature/oil pressure indicator does not light briefly after the starter is disengaged.	Check wire 81C. See **Fig. 14**.
The warning buzzer does not sound, but the water temperature/oil pressure indicator lights briefly after the starter is disengaged.	Check the warning buzzer and associated wiring. See **Fig. 15**.

Troubleshooting

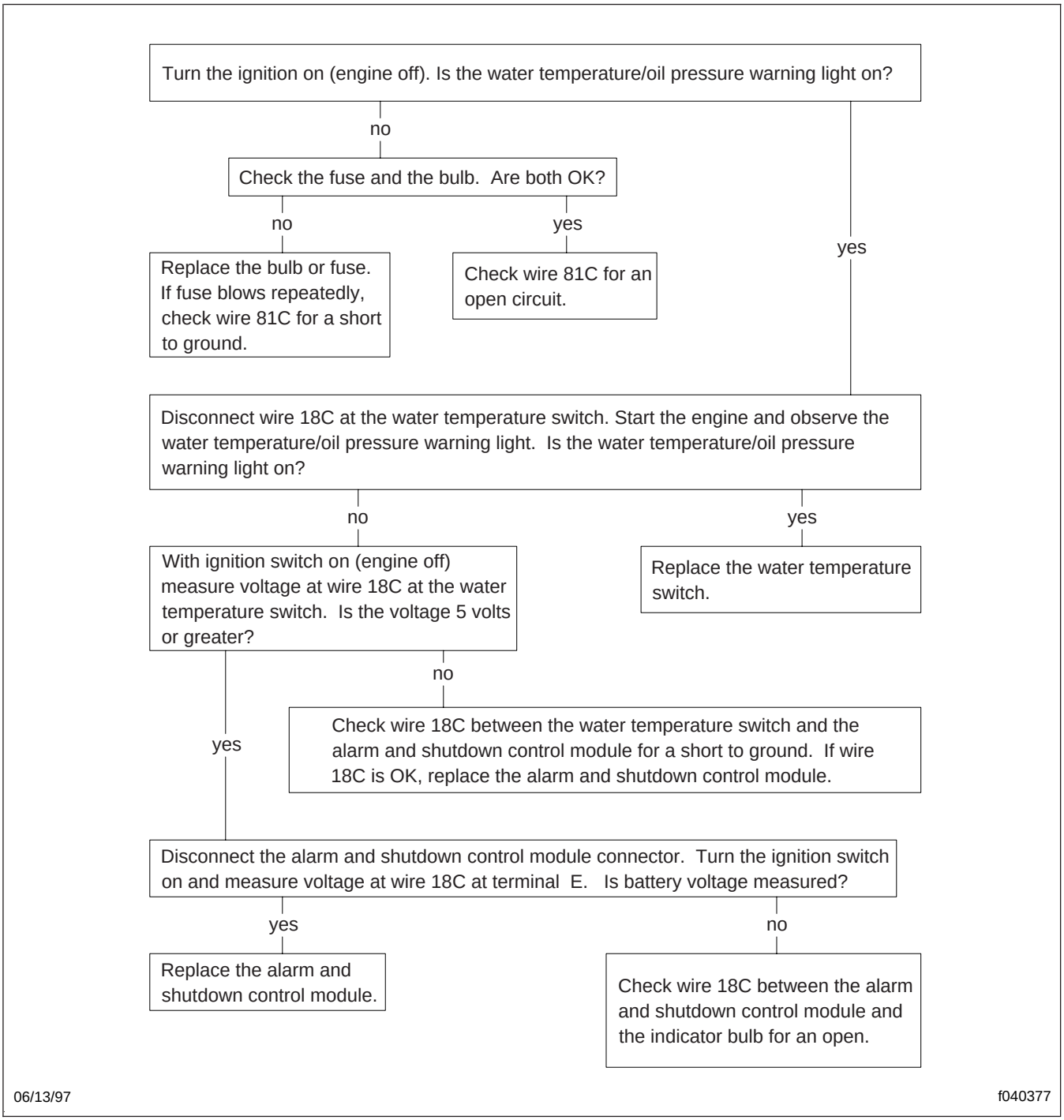


Fig. 1, The Water Temperature/Oil Pressure Indicator Does Not Light When Engine Water Temperature is High

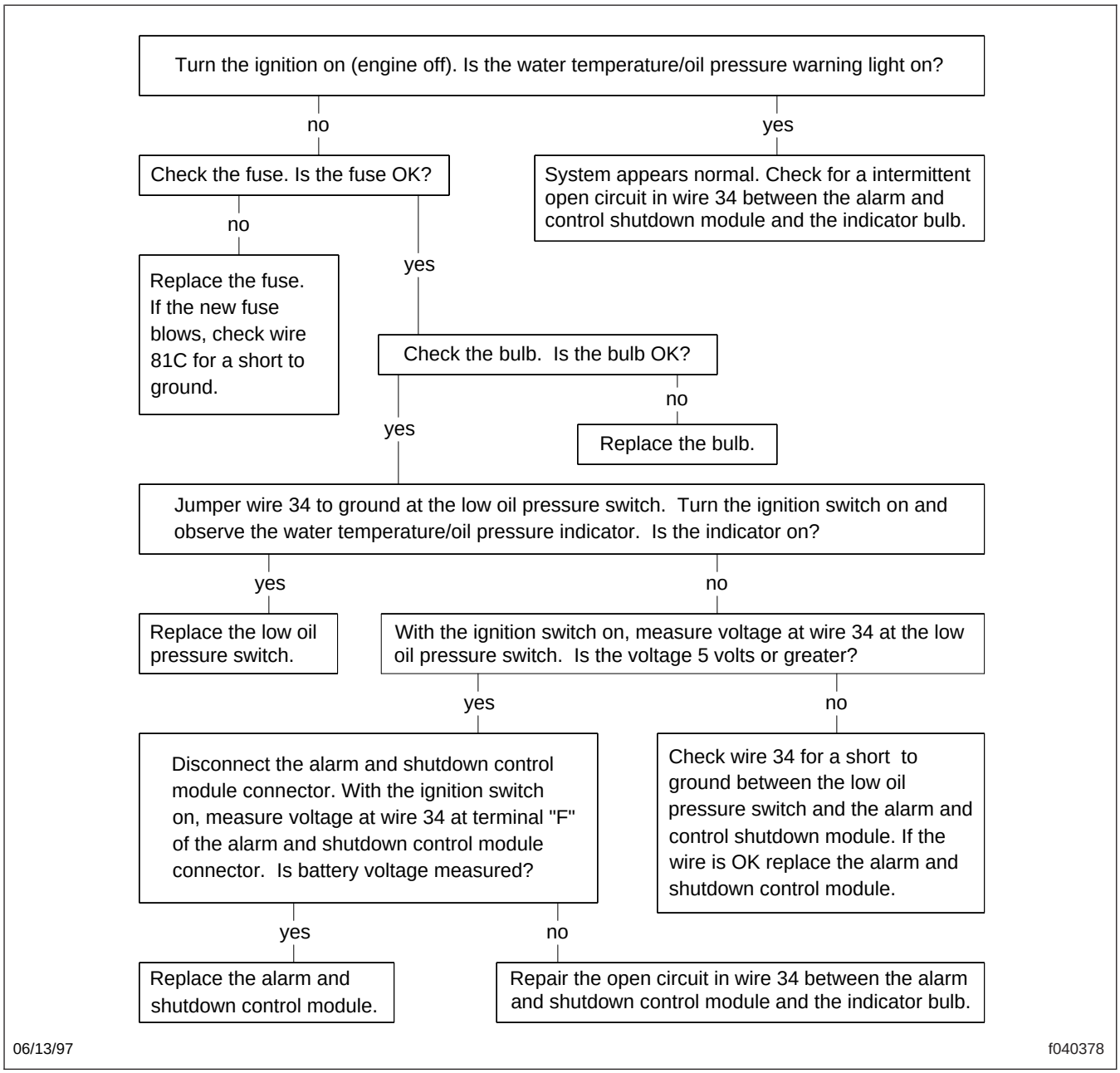


Fig. 2, The Water Temperature/Oil Pressure Indicator Does Not Light When Oil Pressure is Low

Troubleshooting

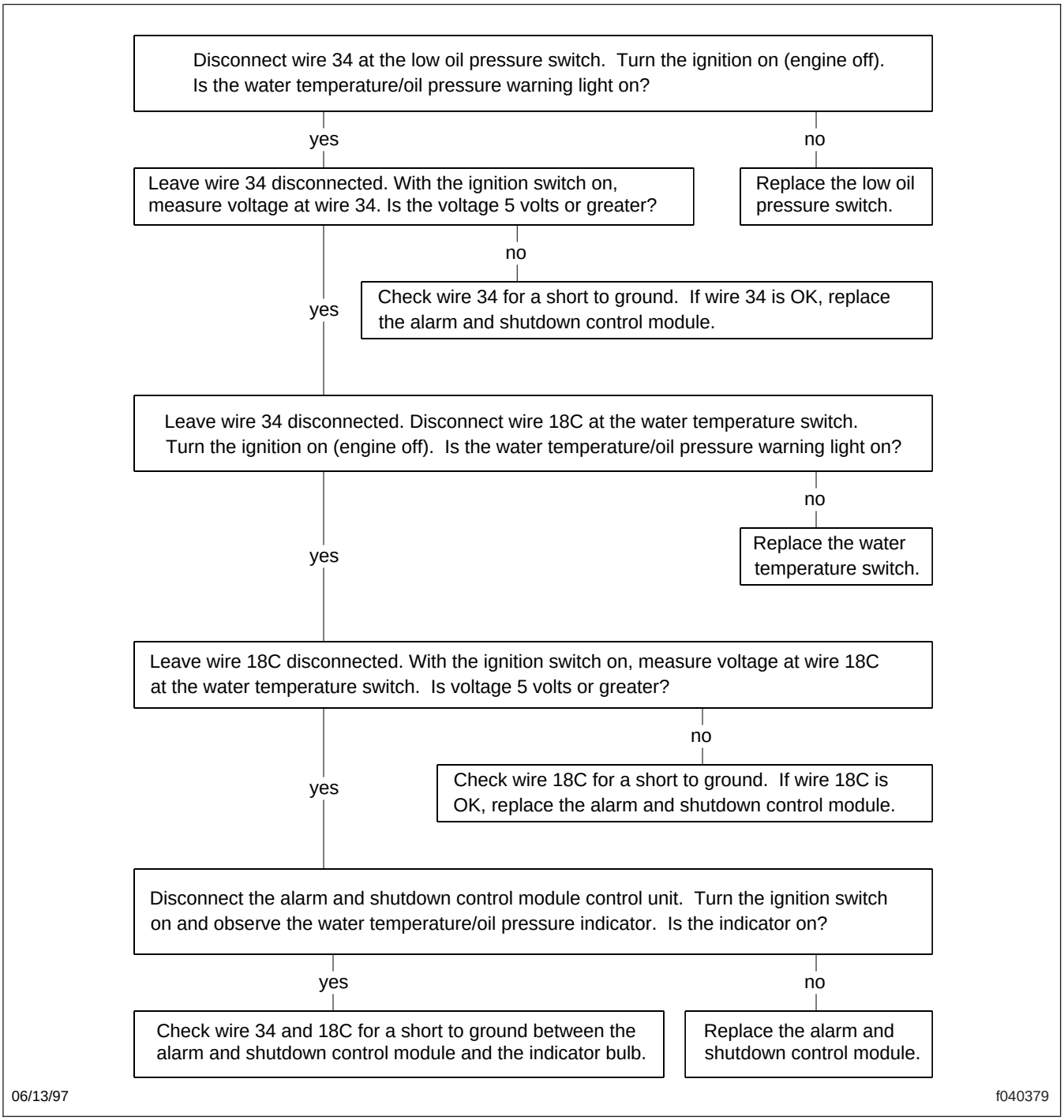


Fig. 3, The Water Temperature/Oil Pressure Indicator is On When the Oil Pressure and Water Temperature are Normal

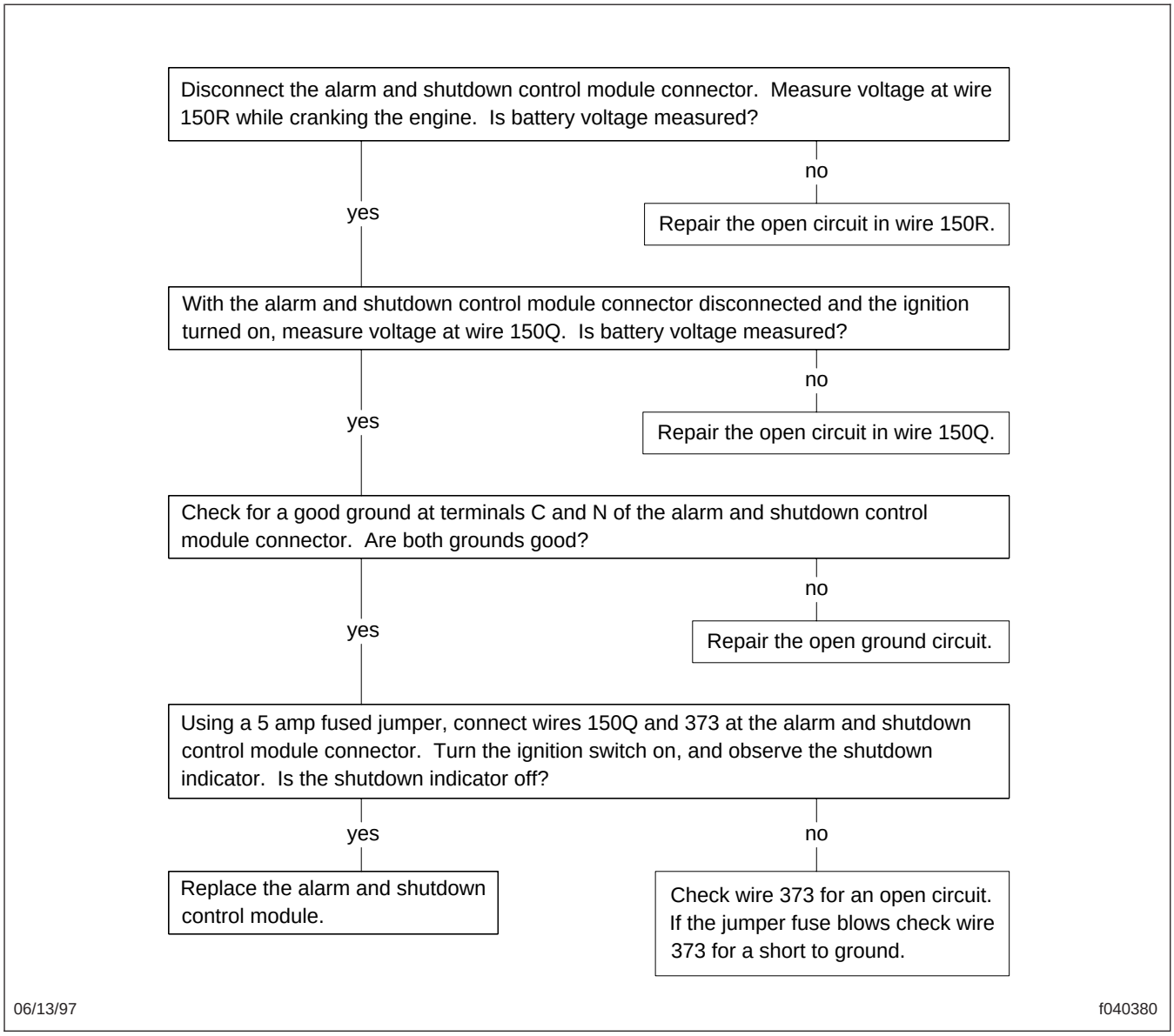


Fig. 4, The Engine Cranks But Will Not Start. The Engine Shutdown Indicator is On While the Starter is Cranking

Troubleshooting

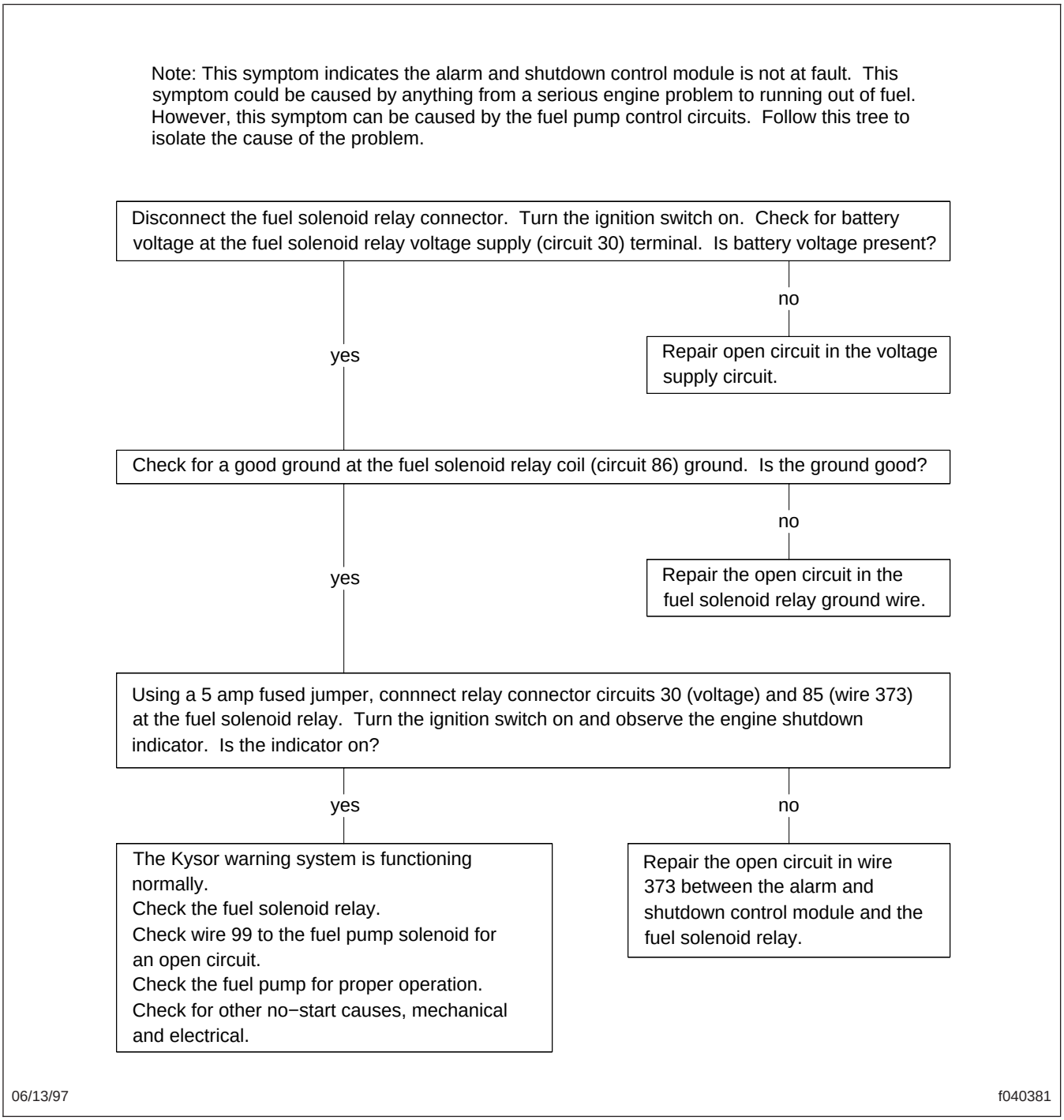


Fig. 5, The Engine Shuts Down; The Engine Shutdown Indicator is Not On as the Engine Begins to Lose RPM

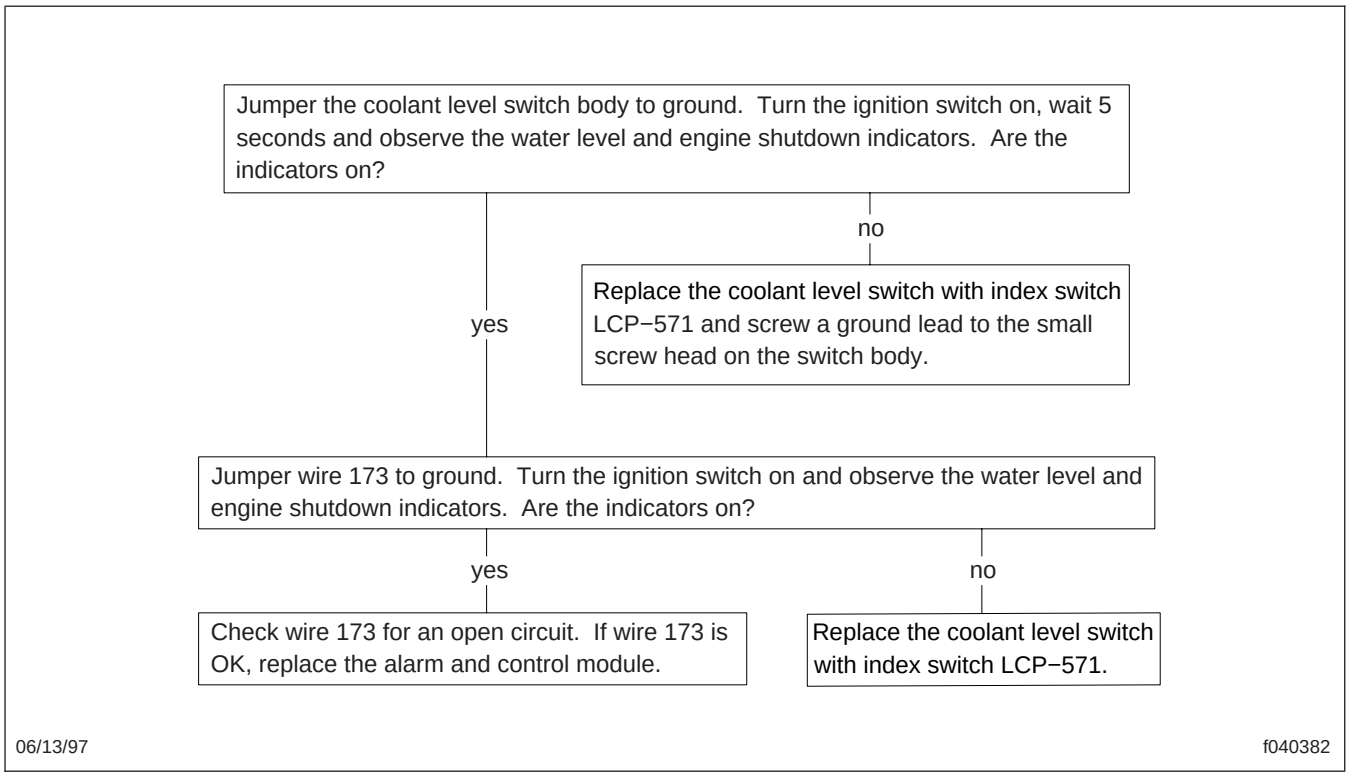


Fig. 6, The Engine Shuts Down With the Water Level and Engine Shutdown Indicators On

Troubleshooting

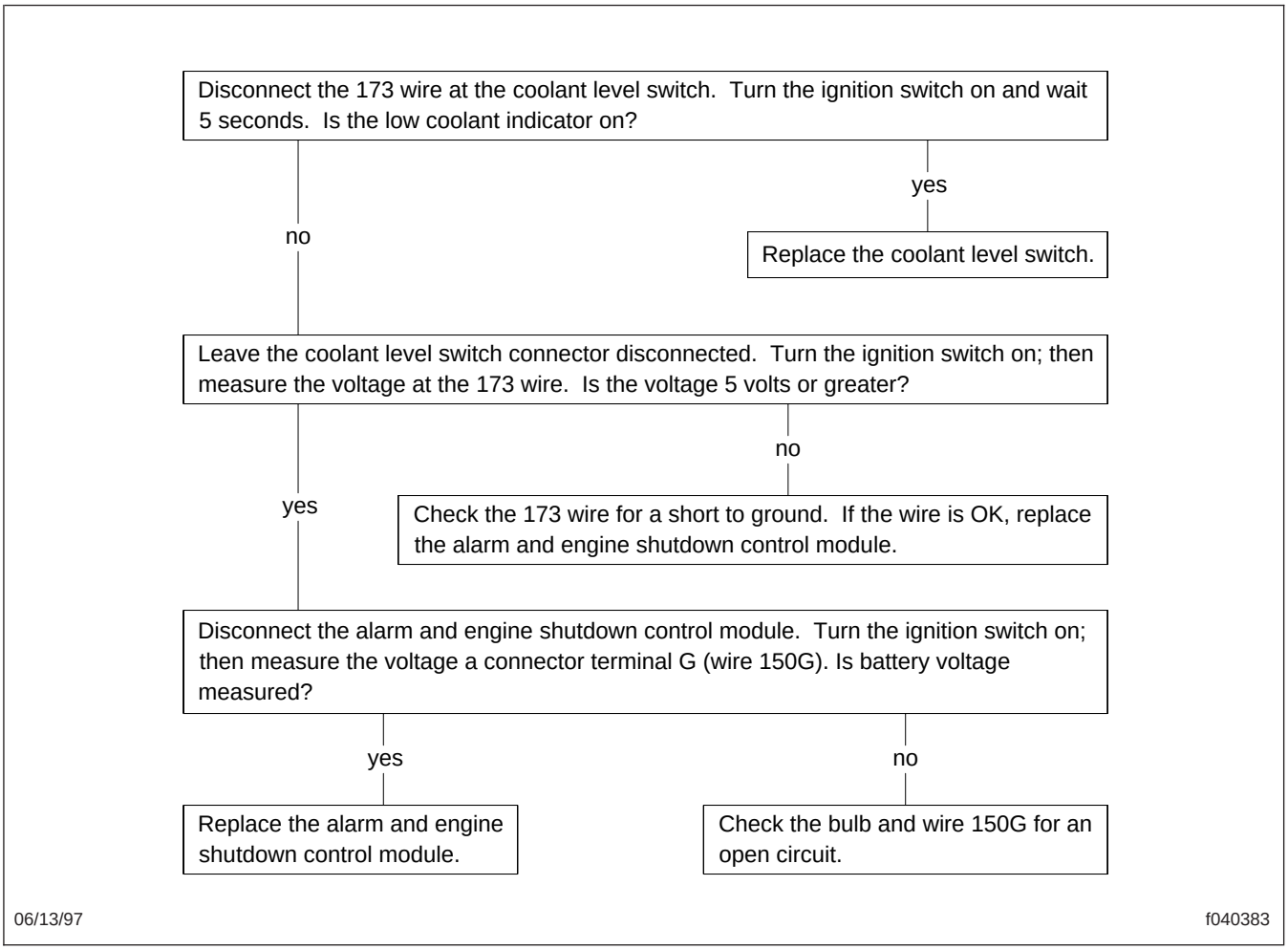


Fig. 7, The Water Level Indicator Does Not Come On When the Coolant Level is Low

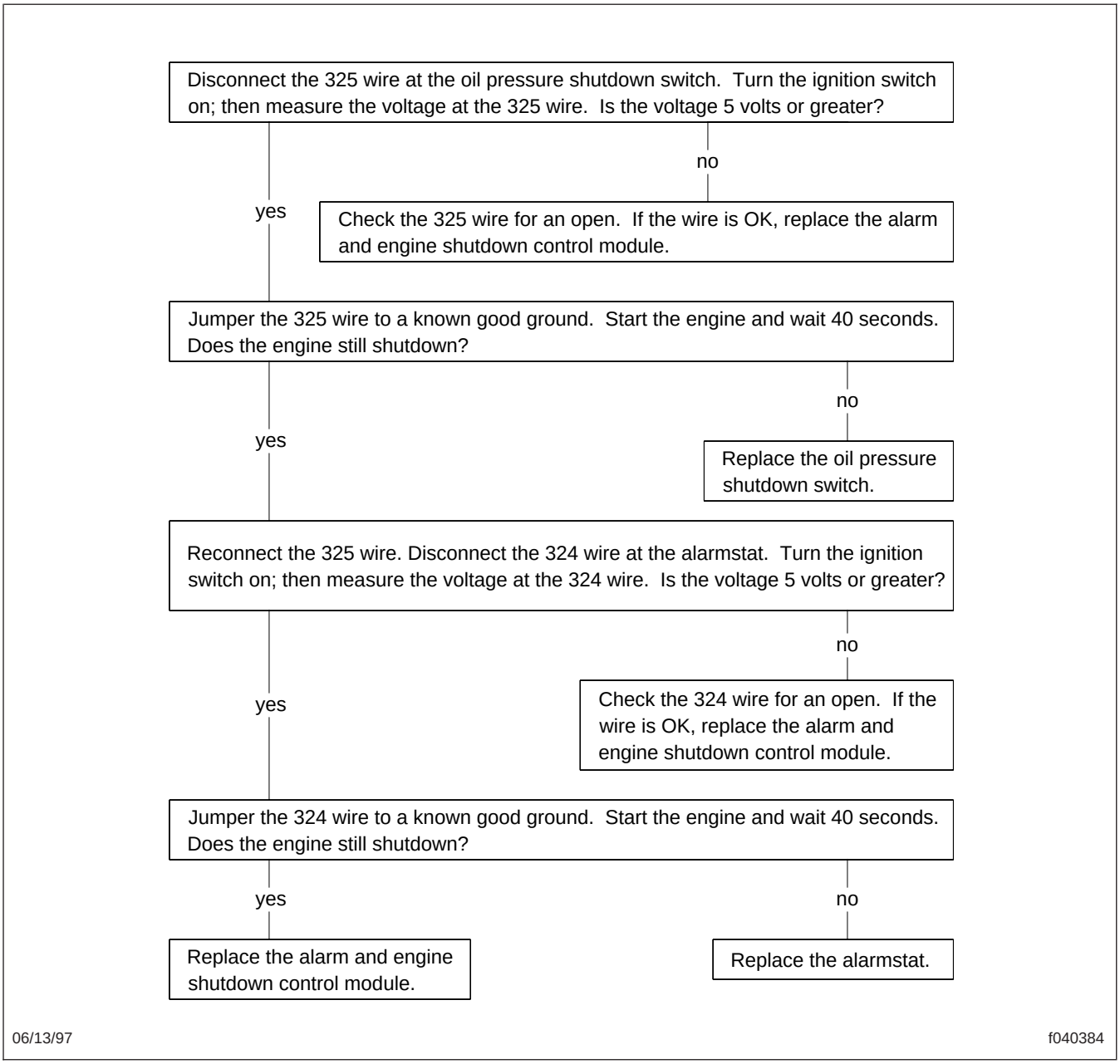


Fig. 8, The Engine Starts, But the Engine Shuts Down After 20 to 40 Seconds

Troubleshooting

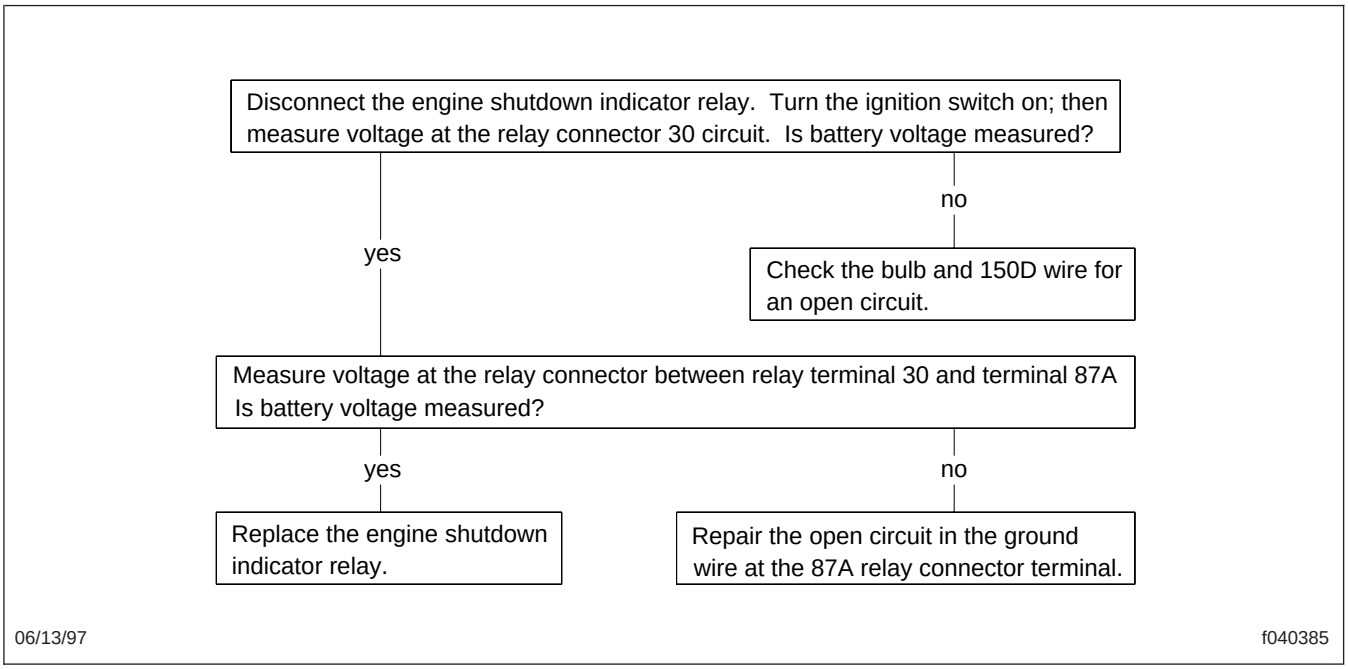


Fig. 9, The Engine Shutdown Indictor Does Not Come On When the Engine Shuts Down

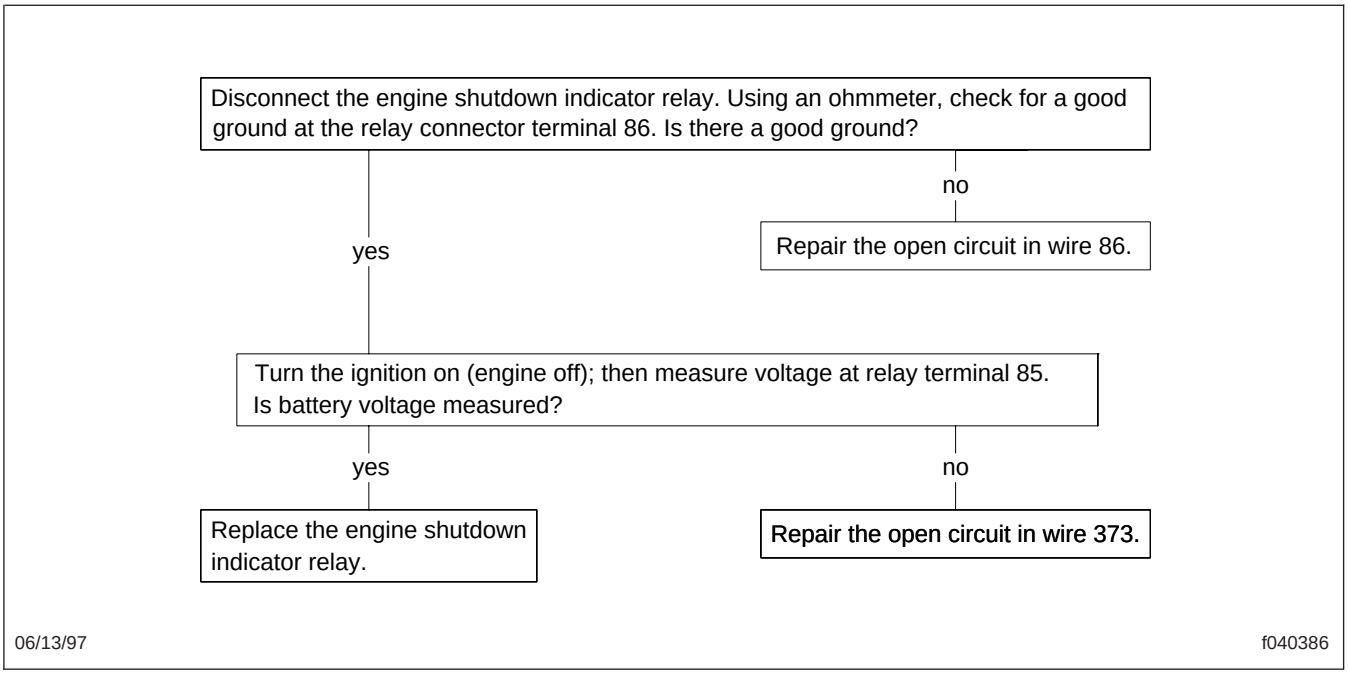


Fig. 10, The Engine Shutdown Indicator is On, But the Engine Does Not Shut Down

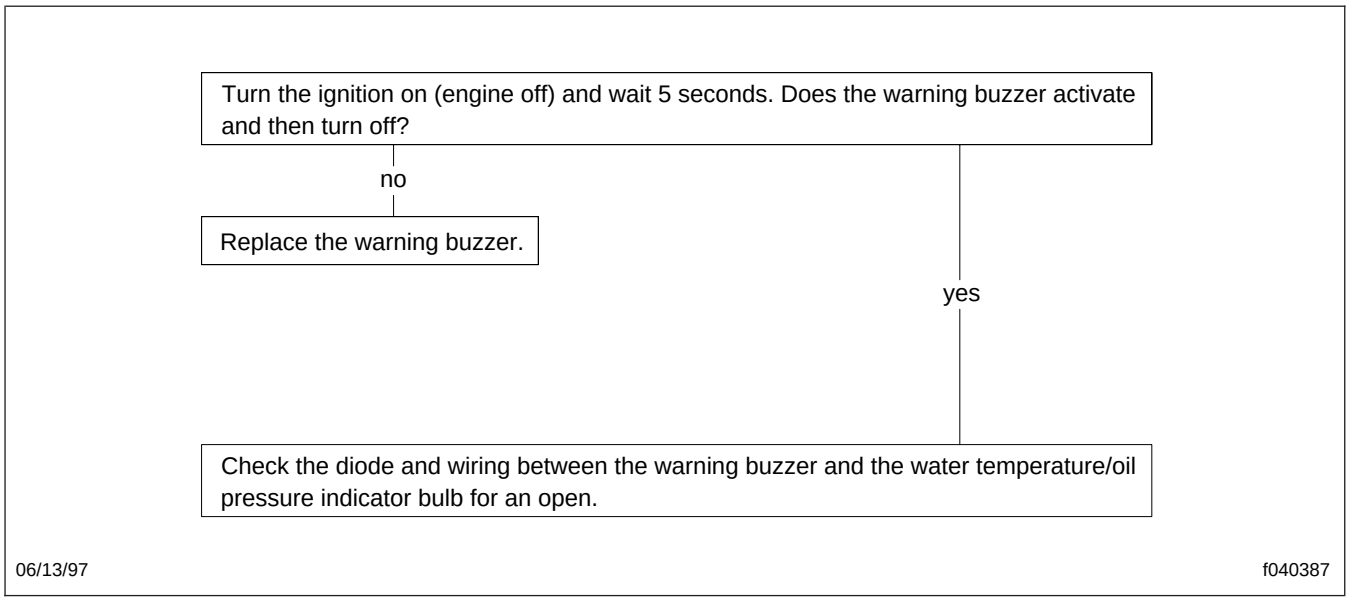


Fig. 11, The Warning Buzzer Does Not Sound With High Water Temperature, But the Water Temperature/Oil Pressure Indicator Does Light

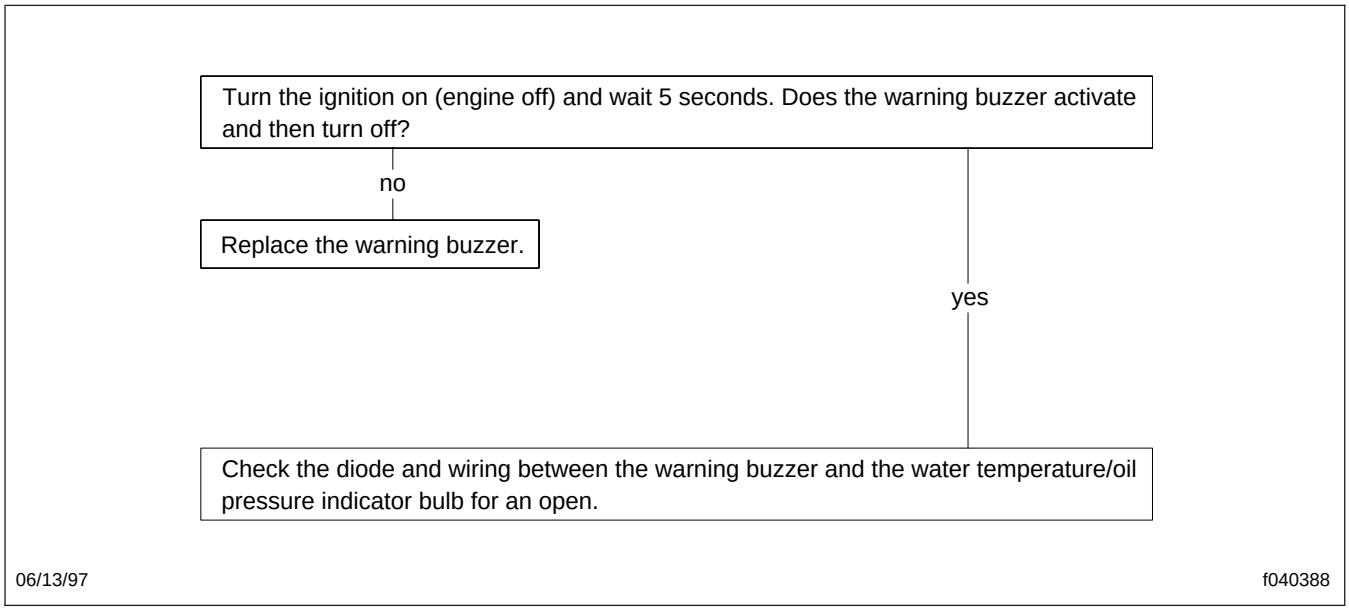


Fig. 12, The Warning Buzzer Does Not Sound With Low Oil Pressure, But the Water Temperature/Oil Pressure Indicator Does Light

Troubleshooting

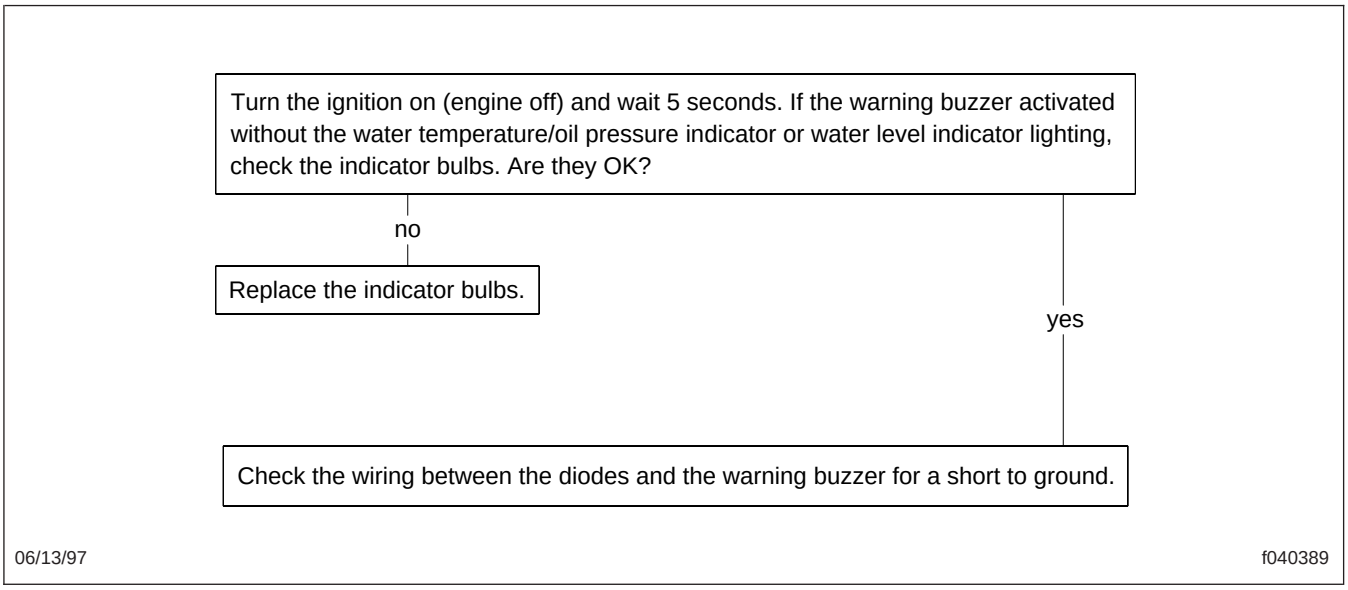


Fig. 13, The Warning Buzzer Sounds Without the Water Temperature/Oil Pressure or the Water Level Indicator Lighting

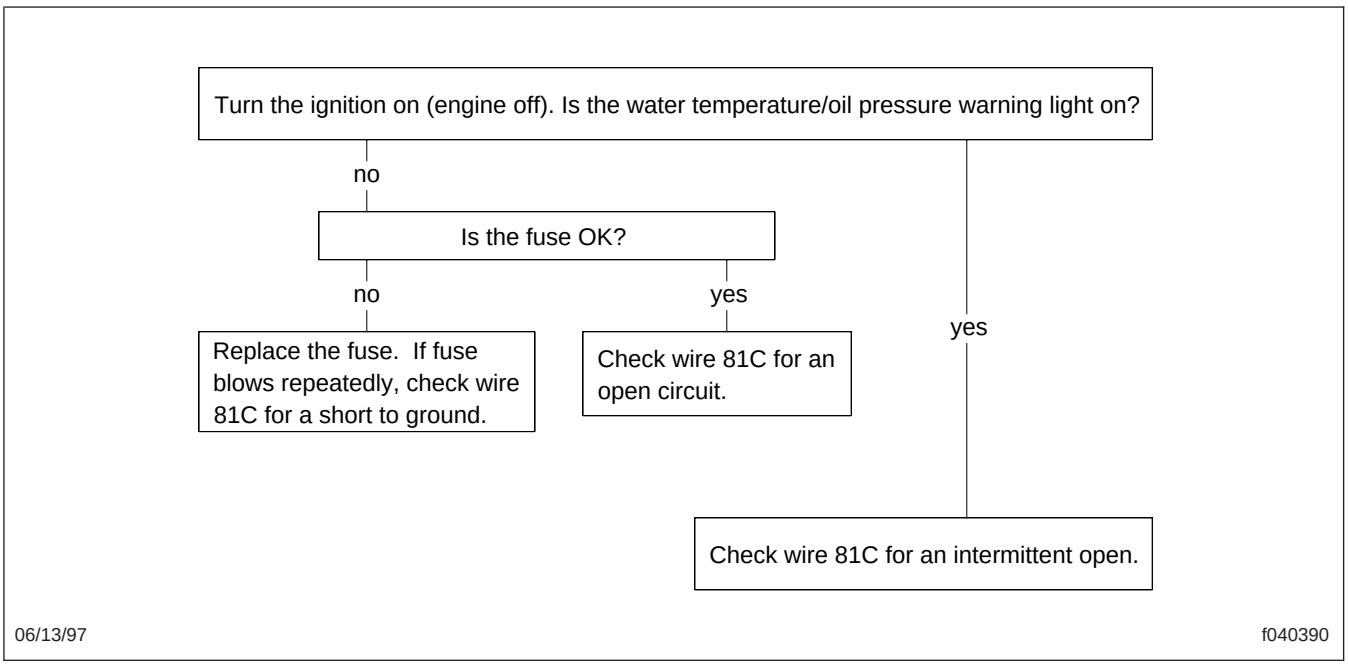


Fig. 14, The Warning Buzzer Does Not Sound and the Water Temperature/Oil Pressure Indicator Does Not Light Briefly After the Starter is Disengaged

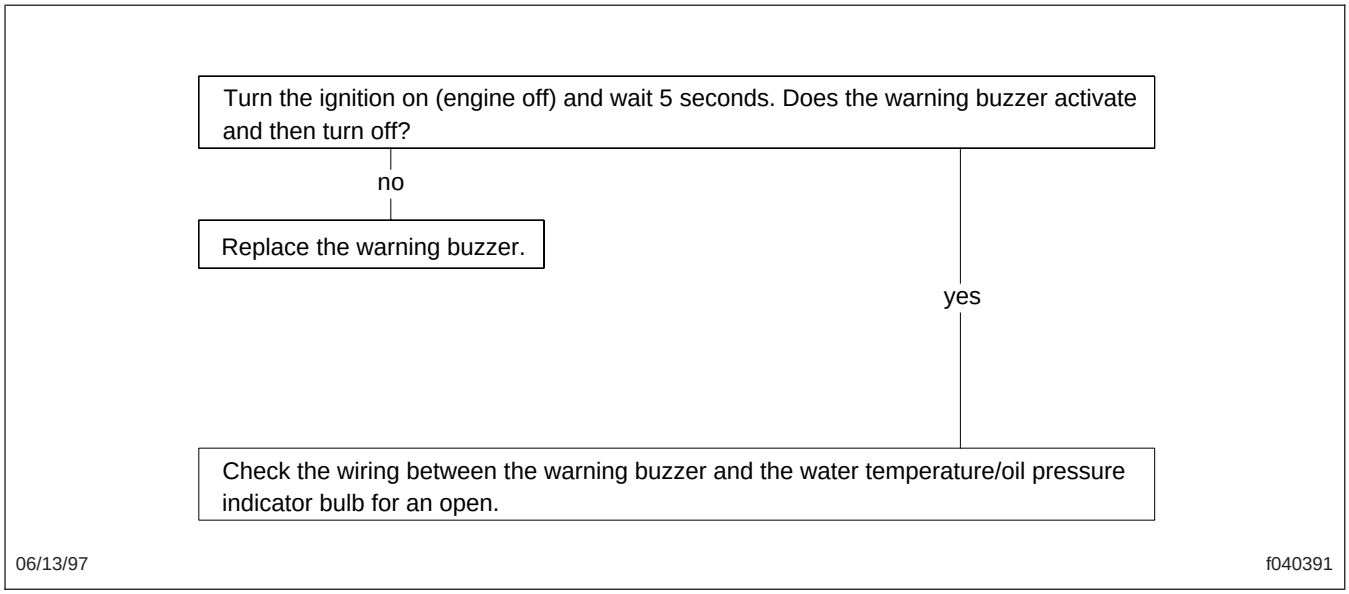


Fig. 15, The Warning Buzzer Does Not Sound, But the Water Temperature/Oil Pressure Indicator Lights Briefly After the Starter is Disengaged

For a wiring diagram of the Kysor warning and engine shutdown system, see **Fig. 1**.

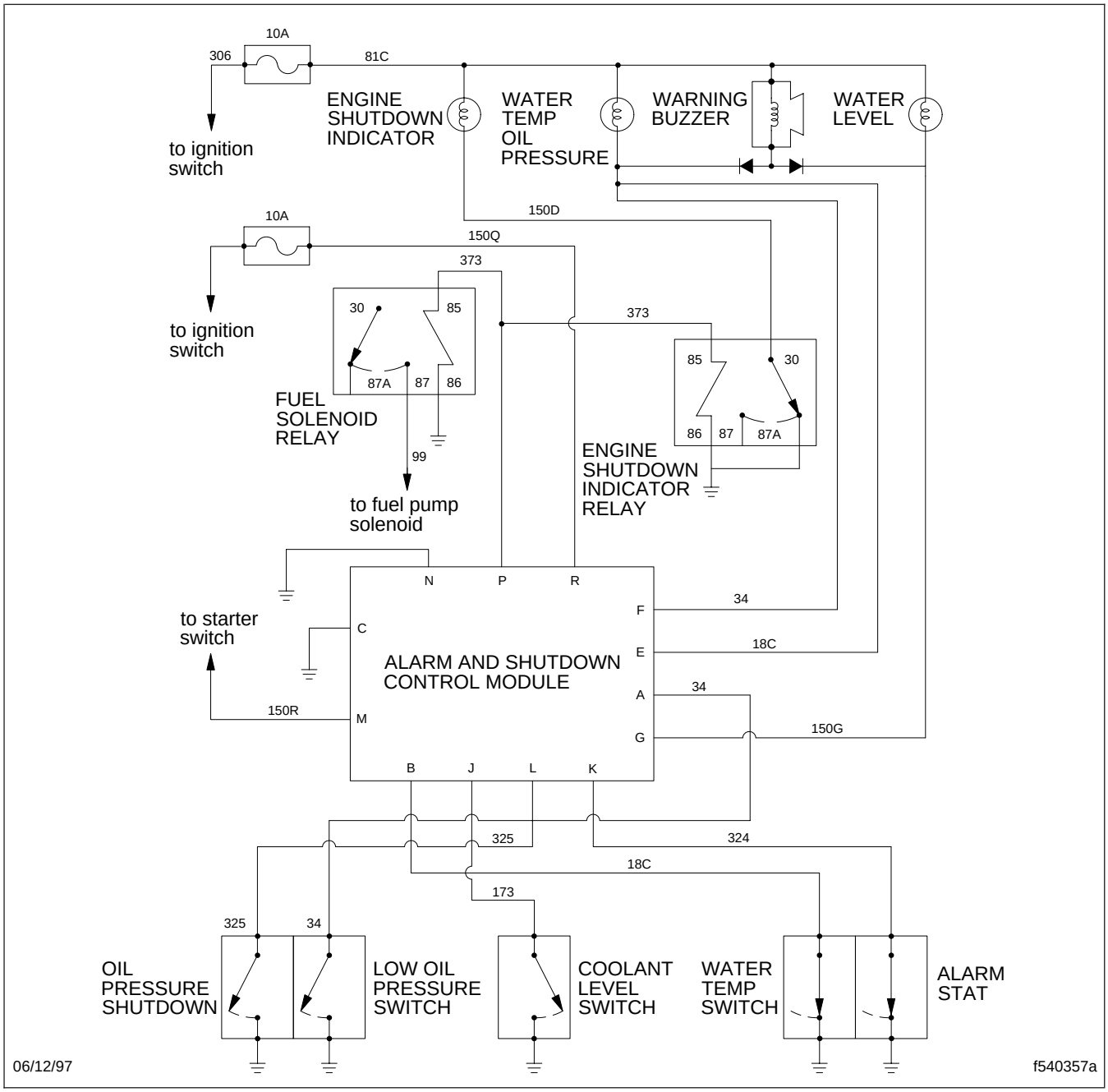


Fig. 1, Wiring Diagram, Kysor Warning and Engine Shutdown System

General Information

ALL LEAD-ACID BATTERIES

Maintenance-free lead-acid batteries, both liquid-electrolyte batteries and gel cells, are electrochemical devices which store chemical energy. When the battery is connected to an external load, such as a starter, the chemical energy is converted into electrical energy and current flows through the circuit.

The modern automotive battery has three functions:

- To supply power to the starter and ignition system so the engine can be cranked and started.
- To stabilize the voltage in the electrical system by reducing temporary high voltages in the electrical system. These high transient voltages could damage other electrical components if they were not protected by the battery.
- To supply extra power when the vehicle's electrical load requirements go beyond what the charging system can supply, or when the engine is not running.

All lead-acid batteries use plates made of two unlike metals held apart by separators. One of the metals becomes the positive plate, the other the negative plate. These plates are then grouped in pairs, alternating negative and positive. The groups are connected in series, and each plate group (cell) produces about two volts. Thus, a battery with six cells is a 12-volt battery. See **Fig. 1**.

In conventional liquid-electrolyte batteries (wet cells), each battery contains a group of plates immersed in a solution of electrolyte (dilute sulfuric acid). In a gel cell battery, the electrolyte is a solid gel, not a liquid.

Maintenance-free wet cells use calcium rather than antimony to improve grid strength. Calcium reduces the tendency for the battery to produce gas at normal charging voltages. Therefore, little water is lost, unless the battery has been charged at a very high rate. There are no filler caps in the cover. The battery is sealed, except for small vent holes in the cover. The vents allow the escape of gases produced in the battery.

Electrical energy is produced in each cell by chemical changes in the plates (and in the electrolyte whenever a battery is discharged). See **Fig. 2**. A battery produces maximum electrical energy only when the cells are fully charged. As the cells discharge, chemical changes in the plates gradually reduce the potential electrical energy available. Recharging the battery with an opposite flow of direct current reverses the chemical changes within the cells and restores them to their active state. See **Fig. 3**.

NOTE: Liquid-electrolyte batteries must be kept in an upright position to prevent electrolyte leakage. Tipping a wet cell beyond a 45-degree angle in any direction can allow a small amount of electrolyte to leak out the vent holes.

In standard installations, the batteries are contained in a carrier below the left-hand door. See **Fig. 4**.

Only good care can ensure long battery life. Proper testing will indicate the battery condition. For more information, see **Subject 140**.

GEL CELLS (ISOLATED BATTERY SYSTEM)

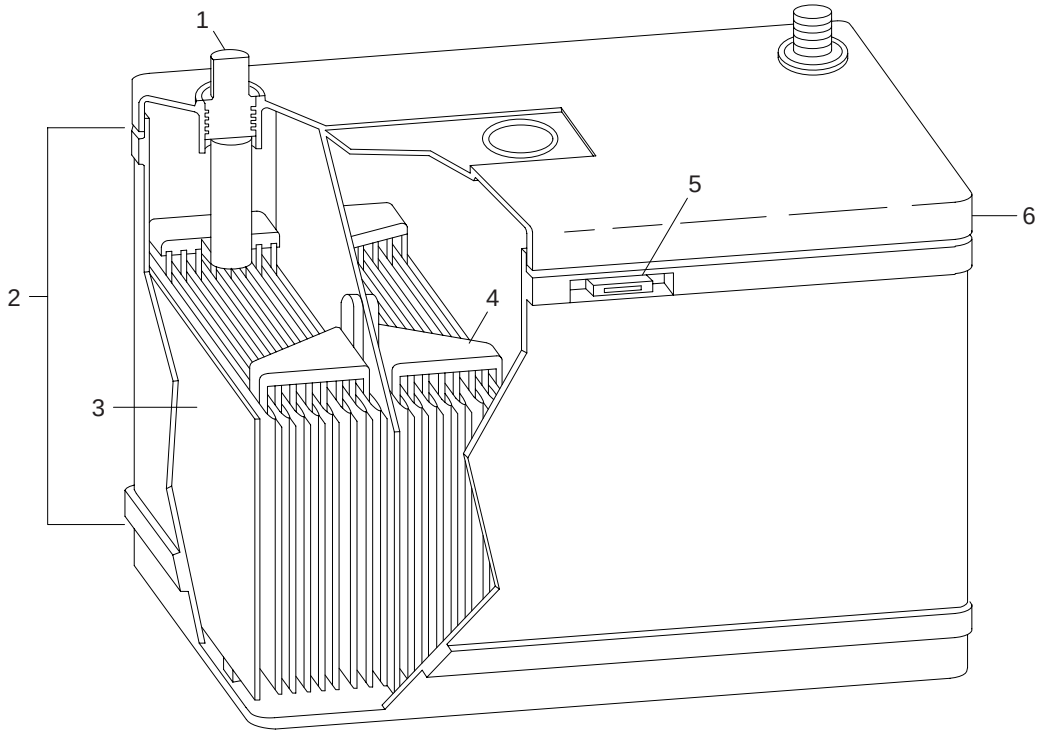
The purpose of an isolated battery system is to prevent the starting batteries from becoming discharged by overuse of accessories when the vehicle is not operating. When the engine is running, the isolated battery is charged like the starting batteries. When the engine is shut down, the isolator relay disconnects the starting batteries from the accessory power circuits, directing the entire load to the isolated battery. The starting batteries can start the vehicle even if the isolated battery is completely drained.

Since March 1, 1996, vehicles with battery isolator systems are equipped with the Freightliner gel cell as the isolated battery.

A gel cell is a lead-acid electric storage battery with the following features:

- It is pressurized and sealed using special vents, and therefore *it should never be opened*.
- The only maintenance it needs is periodic cleaning of the terminals and tightening of the cable connectors.
- It uses a thixotropic gelled electrolyte that liquefies when stirred or shaken, but returns to a solid state when allowed to rest.
- It never needs filling, because it uses a special recombination technique to replace the oxygen and hydrogen normally lost in a standard wet

General Information



1. Terminal
2. Electrolyte Reservoir
3. Positive Plate Envelope
4. Intercell Connection
5. Vent Hole
6. Plastic Cover

Fig. 1, Typical Maintenance-Free 12-Volt Battery

cell, particularly when used in deep-cycle applications.

- It is non-spillable, and can be operated in virtually any position (upside-down installation is not recommended).

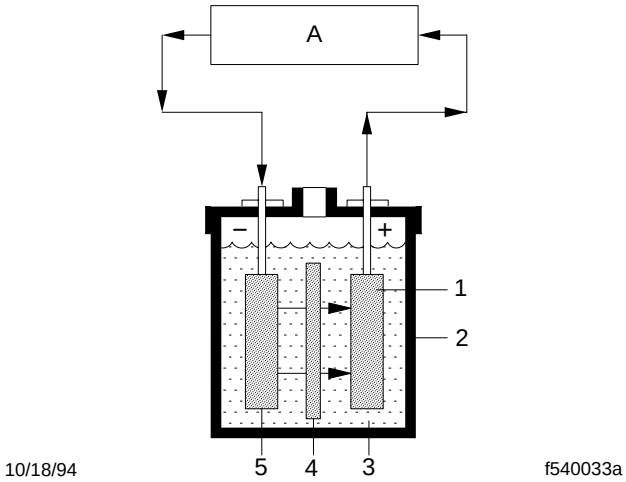
At 14 volts, a gel cell has a very high charge acceptance rate. Because a truck charging system operates at approximately 14 volts, under normal conditions a gel cell should never need to be recharged with an external charger.

CAUTION

Do not attempt to charge a gel cell with a standard battery charger. All standard battery chargers supply at least 16 volts to the battery. This will damage the gel cell.

Neither type of maintenance-free battery (see **Fig. 1**) needs additional water during normal service life.

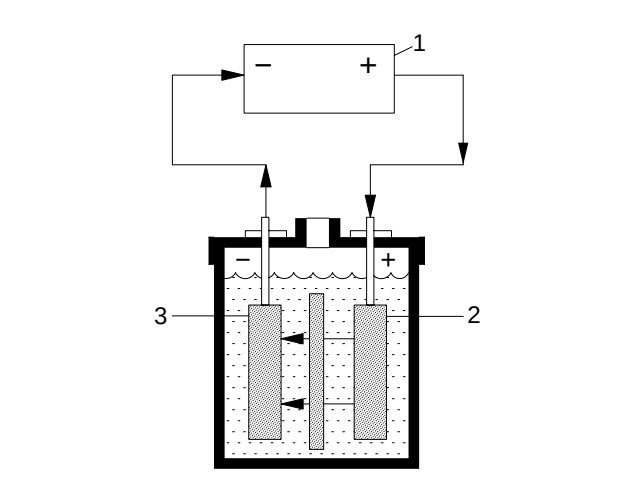
A gel cell is a "recombinant" battery. The oxygen that is normally produced at the positive plate (in all lead-acid batteries) recombines (in a gel cell) with the hydrogen given off at the negative plate. The recombination of hydrogen and oxygen produces water (H_2O), which replenishes the moisture in the battery. Therefore, the gel cell is maintenance-free, as it never needs added water.



A. External Electrical Load (such as a starter)

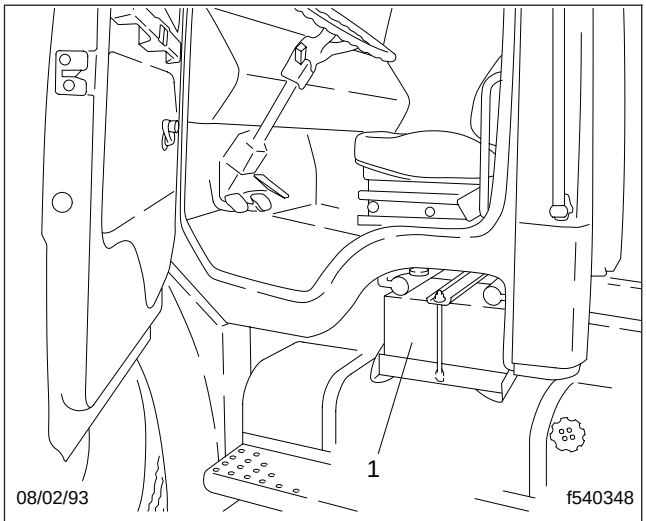
1. Positive Plate
2. Battery Case
3. Electrolyte
4. Separator
5. Negative Plate

Fig. 2, Discharging the Battery



1. Charger
2. Positive Plate
3. Negative Plate

Fig. 3, Charging the Battery



1. Batteries

Fig. 4, Typical Battery Installation

Selecting a Replacement

Long and trouble-free service is assured when the reserve capacity of the battery is equal to or exceeds 160 minutes and the cold cranking amp (CCA) rating of each replacement battery is at least 625 amperes. The CCA rating of the battery is a measure of its ability to supply high cranking power to the cranking motor at 0°F (–18°C).

The use of an undersized battery may cause poor performance and early failure. It may also cause damage to or reduced life of the starter. With falling temperatures, battery power decreases while the need for engine cranking power increases. Subzero temperatures reduce the capacity of a fully charged battery to 45 percent of the normal power, and at the same time, increase cranking load to 3-1/2 times the normal warm-weather load.

Batteries of a greater capacity should be considered if the electrical load has been increased through the addition of accessories, or if driving conditions are such that the charging system cannot keep the batteries charged.

IMPORTANT: Don’t replace a battery with one designed for automobiles and light trucks. The cold cranking amp (CCA) rating may be the same or higher, but the plates are lighter, and the battery won’t provide the reserve life that is needed. Also, these batteries don’t have the extra vibration protection or temperature resistance required on a heavy-duty vehicle.

Storage

Always store batteries in an upright position. Don't store liquid-electrolyte type batteries on their sides, as electrolyte may escape through the vent holes.

Maintain inventory levels in balance with demand and always rotate battery stock on a strict first-in, first-out basis. To protect against self-discharge, check the date codes stamped on the battery cartons and on the batteries themselves.

IMPORTANT: One of the major causes of problems with replacement batteries is failure to follow the first-in, first-out stock procedure.

Roller racks provide the best way to store batteries. If loaded properly from the back, they insure that the oldest battery of a particular type will always appear in the front.

Mark the racks clearly, both front and back, to ensure that the same battery type will go in the same rack every time.

If roller racks are not available, use wooden shelving reachable from both the front and the back. Otherwise, old batteries must be removed, to put new batteries in the back.

Never stack batteries on top of one another. If nothing else is available, simple battery storage racks can be made from loose, flat boards.

Maintenance-free batteries can have a shelf life of up to twelve months or more, depending upon storage temperatures, before charging is needed.

NOTE: Batteries in vehicles that are not in service are considered to be in storage. When a vehicle is to be out of service for 30 days or more, disconnect the negative ground terminal of each battery to prevent self-discharge caused by various components.

To minimize self-discharge, store batteries in as cool a place as possible, away from heat ducts in winter, and shielded from direct sunlight in summer.

The best storage conditions are in clean, dry areas where ambient temperatures are stable between 32° and 80°F (0° and 27°C). Storage in temperatures above 80°F (27°C) is not recommended, as this increases the rate of self-discharge. Avoid temperatures below 32°F (0°C) to prevent freezing if a battery becomes discharged.

General Safety Precautions

⚠ WARNING

Keep sparks, flames, burning cigarettes, etc. away from batteries. Batteries generate explosive gases, which could cause a battery to explode, causing serious personal injury, including blindness.

When charging the batteries, gas forms in each cell and escapes through the vent holes. In poorly ventilated areas, the gas lingers around the battery several hours after it has been charged. The gas is explosive around sparks, flame, or other intense heat; if ignited, it could cause the battery to explode. Follow these precautions when charging the batteries:

1. Wear safety glasses or a face shield when working with batteries. When many batteries are handled, wear rubber gloves and an apron to protect clothing.
2. Make sure that the area is well ventilated.

⚠ WARNING

Do not install any lead-acid battery in a sealed container or enclosure. Allow hydrogen gas caused by overcharging to escape. Exploding hydrogen gas can cause blindness or other bodily injury.

3. Make certain that the charger cable leads are clean and making good connections. A poor connection could cause an electrical arc which could ignite the gas mixture and explode the battery.
4. Do not break live circuits at the terminals because a spark usually occurs at the point where a live circuit is broken. Use care when connecting or disconnecting booster leads or cable clamps on chargers.
5. Don't smoke near batteries that are being charged or have recently been charged. Keep the batteries away from open flames or sparks.
6. If the battery is frozen, let it reach room temperature before trying to charge it. Check for leaks and cracks before charging the battery. Replace the battery if leaks or cracks are seen.
7. Take care that tools or metal objects do not fall across the battery terminals.

⚠ CAUTION

If a metal object connects an ungrounded battery terminal to a nearby metal part of the vehicle which is grounded, it could short out the batteries, causing sparks and possible property damage.

Battery Electrolyte Safety Precautions

⚠ WARNING

Protect skin and eyes from battery electrolyte (acid). Electrolyte is corrosive and could result in serious personal injury if splashed on your skin or in your eyes.

If electrolyte is splashed on your skin or in your eye, force the eye open, rinse it with cool, clean water for about five minutes, and call a doctor immediately. Do not add eye drops or other medication unless advised by the doctor.

If electrolyte is swallowed, drink several large glasses of milk or water. Follow with milk of magnesia, a beaten raw egg, or vegetable oil. Call a doctor immediately.

Use extreme care to avoid spilling or splashing electrolyte. Electrolyte spilled or splashed on your body or clothing should be neutralized with baking soda or household ammonia and then rinsed with clean water.

Electrolyte can also damage painted or unpainted metal vehicle parts. If electrolyte is spilled or splashed on any metal surface, neutralize and rinse it with clean water.

To prevent possible skin burns, do not wear watches, rings, or other jewelry while performing maintenance work on the batteries.

Battery Safety Precautions

⚠ WARNING

Do not apply pressure to the end walls of a plastic-case battery. This could cause electrolyte to squirt from the vents, possibly resulting in serious injury to skin or eyes.

When handling plastic-case batteries, use a battery carrier. If one is not available, lift these batteries with your hands placed at opposite corners of the battery.

Gel Cell Charging Precautions

GEL CELLS ARE SENSITIVE TO OVERCHARGING

⚠ CAUTION

To avoid shortening the life of a gel cell, carefully regulate the charging voltage—between 13.8 and 14.1 volts. Use only a reliable, automatic, temperature-sensing, voltage-regulated charger. Use only the gel cell charging procedures in Subject 150. *Never* use a constant current charger. *Never* leave any battery, including a gel cell, on a trickle charger.

Because gel cells normally give off little or no hydrogen gas, they do not cause explosions unless extremely overcharged. This is why they are safe around sensitive electronic equipment, and do not cause surrounding metals to corrode.

However, gel cells are very sensitive to overcharging. If overcharged, the oxygen and hydrogen are produced too rapidly and are vented away. Since they are no longer present inside the battery, they cannot recombine to form water. The water loss to the battery is permanent.

⚠ CAUTION

Never overcharge a gel cell. If a gel cell is charged to more than 14.1 volts, it will dry out and be unable to perform.

CONTINUAL UNDERCHARGING CAN DAMAGE GEL CELLS

In many respects, undercharging is as harmful as overcharging. In an undercharged state, the positive grids corrode and the plates shed, dramatically shortening battery life.

Furthermore, an undercharged battery works harder (is more heavily loaded) than a fully-charged battery. This also shortens its life.

IMPORTANT: The warranty is void if the battery is improperly charged. Use only a charger that limits voltage to no more than 14.1 volts and no less than 13.8 volts at 68°F (20°C). The charger must be temperature-sensing to prevent over- or undercharging caused by temperature changes.

CHECK FOR VENT BLOCKAGE

Because the gel cell operates under internal pressure, it is normal for it to bulge slightly, particularly at higher temperatures, which make the polypropylene case more pliable. Severe bulging indicates a battery with a blocked vent. Bulging (swollen) gel cells should be taken out of service.

DO NOT CHARGE GEL CELLS ON THE VEHICLE

Because the gel cell is an isolated battery, it needs to be connected directly to the charger. To properly charge the gel cell, it must be removed from all electrical loads. The best way to accomplish this is to remove it from the vehicle.

Emergency (Jump) Starting

⚠ WARNING

Before jump starting a vehicle, read the instructions in Subject 120. Failure to follow the safety precautions could result in personal injury.

⚠ CAUTION

Do not attempt to charge gel cells (isolated batteries) with jumper cables. The gel cell requires a special charger and should be removed from the vehicle before charging. To avoid damage, follow the manufacturer's instructions.

Handle both the charged and the discharged batteries carefully when using jumper cables. Follow the procedure below, being careful not to cause sparks.

⚠ CAUTION

Make sure the starting systems on both vehicles have the same voltage outputs, and make connections as described below. Otherwise, the starter or the charging system could be damaged.

IMPORTANT: At no time during this operation should the vehicles touch each other, as this could establish a ground connection and offset the benefits of this procedure.

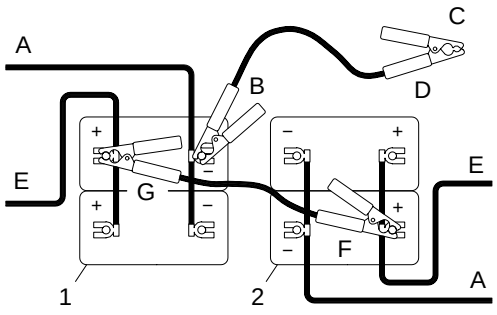
⚠ WARNING

Use the following procedure when jump starting. Incorrect battery handling procedures could result in battery explosion and severe personal injury, including blindness.

1. Apply the parking brakes. Turn off the lights, heater, and all other electrical loads.

IMPORTANT: If the vehicles are exposed to traffic, activate the warning flashers on the booster vehicle.

2. For your first connection, attach one end of the jumper cable to the positive terminal of the booster battery. For your second connection, attach the opposite end of the same cable to the positive terminal of the discharged battery. See Fig. 1 and Fig. 2.



10/18/94 f540303a

If the vehicle is equipped with an isolated battery system, make sure that the connections are made to the starting set of batteries, not to the gel cell(s).

NOTE: This procedure is for negative-ground vehicles only.

A. To Ground
B. Third Connection
C. To Frame
D. Fourth Connection
E. To Starter
F. Second Connection
G. First Connection
1. Booster Battery
2. Discharged Starting Battery

Fig. 1, Jumper Connections, Two-Battery System

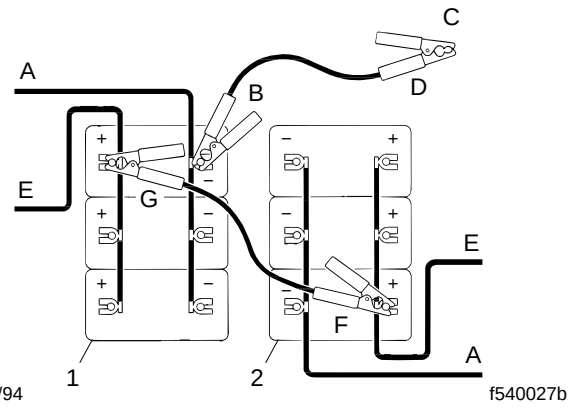
3. For your third connection, attach one end of the other jumper cable to the negative terminal of the booster battery. For the fourth connection, attach the opposite end of that cable to a ground at least 12 inches (300 mm) from the battery of the vehicle being started. See Fig. 1 and Fig. 2. The vehicle frame is usually a good ground.

IMPORTANT: The final ground connection must provide good electrical conductivity and current-carrying capacity. To prevent sparks and explosions of hydrogen gas, don't connect directly to the negative post of the discharged battery.

4. Make sure that the clamps from one cable do not touch the clamps on the other cable. Don't lean over the batteries when making connections.

5. Make sure that everyone is standing away from the vehicles. Start the engine of the vehicle with the booster batteries. Wait a few minutes, then attempt to start the engine of the vehicle with the discharged batteries.

Emergency (Jump) Starting a Battery



If the vehicle is equipped with an isolated battery system, make sure that the connections are made to the starting set of batteries, not to the gel cell(s).

NOTE: This procedure is for negative-ground vehicles only.

A. To Ground
B. Third Connection
C. To Frame
D. Fourth Connection
E. To Starter
F. Second Connection
G. First Connection
1. Booster Battery
2. Discharged Starting Battery

Fig. 2, Jumper Connections, Three-Battery System

Don't operate the starter longer than 30 seconds. Wait at least two minutes between starting attempts to allow the starter to cool. If the engine doesn't start after several attempts, check for the cause.

6. After starting, allow the engine to idle. Disconnect the ground connection from the vehicle with the discharged battery. Then disconnect the opposite end of the cable.
7. Disconnect the other cable from the discharged battery first, then disconnect the opposite end.

General Information

WARNING

Before testing a battery, see "Battery Safety Precautions" in this section. Failure to follow the safety precautions could result in personal injury.

Test any maintenance-free battery that does not hold a charge to see if it needs to be replaced, or if the problem lies elsewhere in the electrical system. Accuracy of the test depends on variables such as temperature and age of the battery. Follow the recommended testing instructions listed below.

IMPORTANT: Two types of battery tests are discussed in this subject. The first test uses the Midtronics Micro740 battery tester, and must be used by all U.S. and Canadian dealers for battery warranty claims. The second test is a load test using a carbon pile type tester and should **not** be used by U.S. or Canadian dealers for battery warranty claims.

Visual Inspection

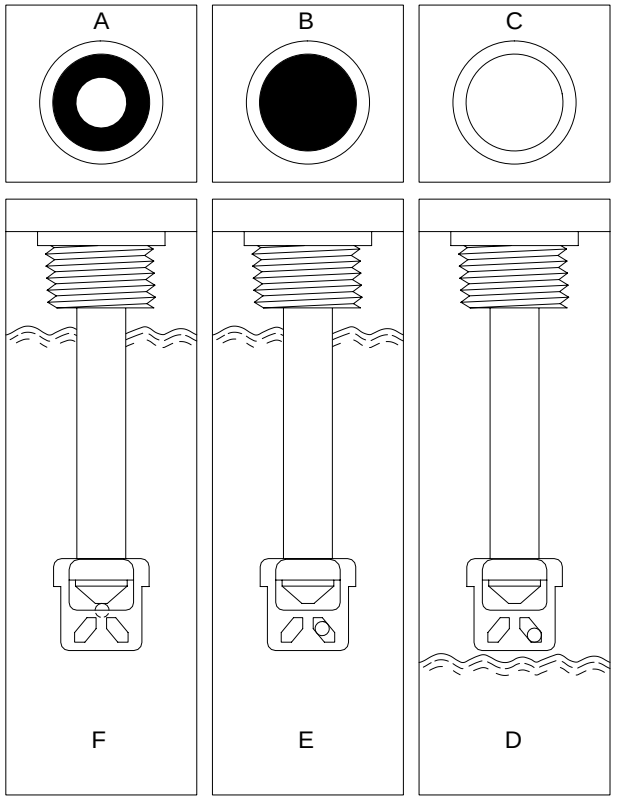
Check for obvious damage such as a cracked or broken case that could permit loss of electrolyte. If there is physical damage replace the battery. Find the cause of the damage and correct it as needed.

On maintenance-free batteries without a built-in hydrometer, perform the Midtronics PowerSensor Micro740 test or the load test.

On maintenance-free batteries with a built-in hydrometer, check the sight glass. If a green dot shows in the sight glass, test the battery. If the sight glass is dark, recharge the battery, then test it. See **Subject 150**. If the sight glass is clear, replace the battery. See **Fig. 1**.

Prior to Testing

1. Clean the battery terminals with a soft wire brush before testing.
2. At the start of the test, make sure all vehicle accessory loads are off and the ignition is in the off position.



A. Green Dot
B. Dark
C. Clear
D. Dead Battery
E. 65% or Less of Charge
F. 65% or More of Charge

Fig. 1, Built-In Hydrometer or Charge Indicator (on optional batteries only)

Midtronics PowerSensor Micro740 Test

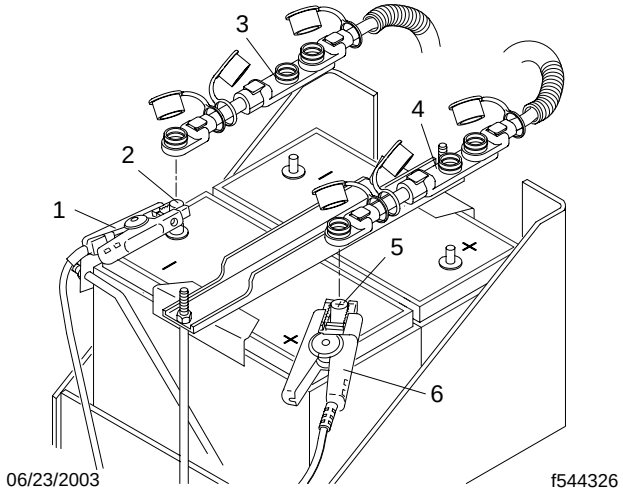
NOTE: This test must be used by all U.S and Canadian dealers for battery warranty claims.

Every battery in a pack of two or more must be disconnected before testing. If more than one battery is selected to be tested, the analyzer will test the first battery, then prompt you to connect to the next battery after the test has been completed. If the analyzer detects that the batteries are connected, it will remind you to disconnect the pack before starting the test.

Battery Testing

Connecting the Midtronics Tester

1. Screw an adapter onto the negative-terminal stud and one onto the positive-terminal stud. See **Fig. 2**.



1. Negative-Terminal Clamp
2. Negative-Terminal Stud Adaptor
3. Negative-Terminal Battery Jumper
4. Positive-Terminal Battery Jumper
5. Positive-Terminal Stud Adaptor
6. Positive-Terminal Clamp

Fig. 2, Battery Connection

IMPORTANT: For accurate test results, connect the clamps to the lead adaptors or to the lead bases of threaded studs. Lead stud adaptors are included with the Micro740. Do not connect the clamps directly onto the threaded studs or an inaccurate test result may occur.

2. Connect the red clamp to the positive-terminal stud adaptor.
3. Connect the black clamp to the negative-terminal stud adaptor.
4. Rock the clamps back and forth to ensure a secure connection. Both sides of the clamp must be firmly connected to the adaptors before testing. If the test message CHECK CONNECTION appears, clean the terminals and/or reconnect the clamps.

Battery Test

NOTE: If the analyzer displays a test message after you start the test, see *Test Messages* to determine the cause and remedy.

1. Use the arrow buttons at the top of the keypad to scroll to menu choices. Select BATTERY TEST. Press ENTER to select.
2. Enter the number of batteries being tested (1 to 6) and press ENTER to select.
3. Select the rating system; CCA, SAE, EN, IEC, DIN, or JIS then press ENTER.
4. Select the appropriate rating value (see **Table 1**) then press ENTER.
5. If the analyzer detects that the temperature of the battery may make a difference in the results it will ask you to select whether the battery temperature is above or below 32°F (0°C). It will resume the test after you make the selection and press ENTER.
6. At the end of the test, the Micro740 will display one of the following results from **Table 2** and the measured voltage and CCA, if applicable.

   If the result is REPLACE BATTERY or BAD CELL—REPLACE the analyzer will prompt you to press ENTER to generate a battery code.

   When the prompt BAT.SERIAL # appears enter the battery serial number. Use the ARROW buttons to scroll to the correct digit, then press ENTER to select it and move to the next digit. Pressing the BACK button will move the cursor back one space. When finished, press ENTER.
7. Turn on the printer and align the analyzer transmitter with the printer receiver. Press and hold the MENU button. Select PRINT RESULTS from the option menu by using the arrow buttons and pressing ENTER. It will take about 30 seconds to print all test results, which are displayed simultaneously on the screen.

Battery Rating Systems		
Rating System	**Description**	**Value Range**
CCA	Cold Cranking Amps, as specified by SAE. The most common rating for cranking batteries at 0°F (-18°C)	100 to 1700 A
SAE	European labeling of CCA	100 to 1700 A
EN	Europa-Norm	100 to 1700 A
IEC	International Electrotechnical Commission	100 to 1000 A
DIN	Deutsche Industrie-Norm	100 to 1000 A
JIS	Japanese Industrial Standard: (shown on a battery as a combination of numbers and letters, for example: 80D26)	43 values from 26A17 to 245H52

Table 1, Battery Rating Systems

Battery Test Results	
Result	**Recommendation**
Good Battery	Return to service.
Good—Recharge	The battery is good, but has an insufficient state of charge. Fully charge the battery and return to service.
Charge and Retest	The battery has a very low state of charge. Fully charge the battery and retest. Failure to fully charge the battery before retesting may cause false readings.
Replace Battery	Replace the battery and generate a test code.
Bad Cell—Replace	Replace the battery and generate a test code.

Table 2, Battery Test Results

Test Messages

Test Message—SYSTEM NOISE	
Possible Cause	**Remedy**
The analyzer has detected computer or ignition noise and will attempt to retest.	Make sure all vehicle loads are off and the ignition is in the off position. The analyzer will automatically retest when it no longer detects system noise
You may be testing too close to a noise source.	Move away from any high-current device and retest.
Battery charge is too low to test properly.	Recharge the battery and retest. If the message reappears, replace the battery.
Poor connection at battery terminal.	Connect the battery cables and retest.

Test Message—NON 12-VOLT BATTERY DETECTED	
Possible Cause	**Remedy**
You are attempting to test both batteries in a 24-volt system at the same time.	Disconnect the batteries and test each one individually.

Battery Testing

Test Message—INTERNAL ERROR, SERVICE REQUIRED	
Possible Cause	**Remedy**
The analyzer has detected a hardware or software problem.	See the Midtronics Micro740 *Instruction Manual*.

Test Message—REVERSE CONNECTION	
Possible Cause	**Remedy**
The clamps are connected in reverse polarity. i.e., Red to negative (–), and black to positive (+).	Disconnect the clamps and reclamp to proper polarity. i.e., Red to positive (+), and black to negative (–).

Test Message—UNSTABLE BATTERY	
Possible Cause	**Remedy**
Batteries that are very weak or that have just been charged may have sufficient electrical activity to alter test results. The analyzer will automatically retest when the battery has stabilized. Fully charged batteries should stabilize quickly.	Charge weak batteries and then retest.

Test Message—CHECK CONNECTION	
Possible Cause	**Remedy**
Poor connection. Both sides of the clamps must be firmly connected before testing.	Clean the battery terminals using a wire brush and a mixture of baking soda and water. Inspect and clean the clamps. Liberally apply baking soda and water with a clean cloth and thoroughly rub the jaw and spring. Use a soft wire brush to remove corrosion buildup. Rinse with water and let dry.

Load Test

NOTE: This test must **not** be used by U.S and Canadian dealers for battery warranty claims.

1. Test each battery separately, either installed or removed. Disconnect the battery cables from the battery, ground cable first.

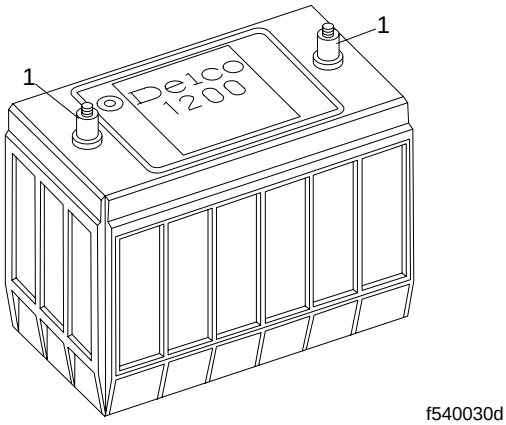
⚠ WARNING

Before charging a battery, see "Battery Safety Precautions" in this section. Failure to follow the safety precautions could result in personal injury.

When charging batteries, always wear eye protection. During charging, batteries give off explosive hydrogen gas. Exploding gas can cause blindness or other bodily injury.

2. Before beginning the load test, check the open circuit voltage (OCV) of each battery. If the voltage is below 12.4 volts, charge the battery on a shop charger for at least 2 hours. If the voltage is above 12.4 volts, proceed to the next step. See **Subject 150** for battery charging instructions.
3. Connect the tester leads to the battery terminals following the tester manufacturer's instructions. Batteries with sealed terminals require adaptors

to provide a place for attaching the tester's leads. See **Fig. 3**.



1. Terminal Stud Adaptor

Fig. 3, Sealed Battery

4. Check the rated CCA of the battery. Apply a load equal to one-half the rated CCA across the terminals for 15 seconds to remove the surface charge from the battery. Remove the load and wait 15 seconds for the battery to recover.

   Example: For a battery rated at 620 CCA, apply a load of 310 amperes across the terminals.

5. Estimate the battery temperature by touch and by the ambient temperature the battery was exposed to before this test, then find the voltage in **Specifications 400** that must be maintained while the battery supplies a specified electrical load.

   Example: At 70°F (21°C) the battery must supply 9.6V minimum.

6. Apply the specified test load to the battery for 15 seconds. The test load (amperes) is equal to one-half of the cold-cranking amperes of the 0°F (–18°C) rating of the battery.

7. Read the terminal voltage at the end of 15 seconds with the load still connected. Do not keep the load attached for a longer period of time before reading the voltage, as this would alter the test results.

8. Remove the load after 15 seconds and note the tester reading.

If the voltage drops below the minimum listed in the table replace the battery.

If the voltage is the same or greater than the minimum listed in the table the battery is capable of further service.

Charging a Conventional Battery

To ensure the general well being of the electrical system, the starting battery(s) should be kept at a high state of charge. In particular, if operating a vehicle with undercharged battery(s), the alternator can be overworked and may cause premature failure.

To charge a conventional liquid-electrolyte battery (wet cell), apply a charge rate in amperes for several hours. For example, a 10-ampere charge rate for five hours would produce a 50 ampere-hour charge to the battery.

General Guidelines for Charging Batteries

When charging multiple batteries on one charger, group batteries that have similar voltages and are of similar age. If not, the group will only charge as fast as the battery with the lowest state of charge. Batteries below 5 volts should be charged individually.

Important: Do not overcharge maintenance-free batteries. Overcharging causes excessive loss of water from the electrolyte and eventual battery damage.

Refer to **Table 1**, **Table 2**, **Table 3**, and **Table 4** for determining how long to charge the batteries.

Batteries below 11.8 volts should be charged at no more than 10 amps for a minimum of 24 hours per battery. Check after the first hour and ensure that the battery is not getting hot.

If after using the above charging method you receive a Charge and Retest result from a Midtronics battery tester and the voltage is above 11.8 volts, continue to charge normally. If the battery voltage is below 11.8 volts, condemn the battery.

Recharge Time Using Shop Charger for a Single Battery					
Voltage	State of Charge	Charger Maximum Rate			
		50 Amps	30 Amps	20 Amps	10 Amps
12.6	100%	Ready to Use			
12.4	75%	0.6 hrs	0.9 hrs	1.3 hrs	2.5 hrs
12.2	50%	1.2 hrs	1.9 hrs	2.7 hrs	5.1 hrs
12.0	25%	1.8 hrs	2.9 hrs	4.3 hrs	7.8 hrs
11.8	0%	2.5 hrs	4.0 hrs	5.7 hrs	10.7 hrs

Table 1, Recharge Time Using Shop Charger for a Single Battery

Recharge Time Using Shop Charger for a Two Battery System					
Voltage	State of Charge	Charger Maximum Rate			
		50 Amps	30 Amps	20 Amps	10 Amps
12.6	100%	Ready to Use			
12.4	75%	1.2 hrs	1.8 hrs	2.6 hrs	5.0 hrs
12.2	50%	2.4 hrs	3.8 hrs	5.4 hrs	10.2 hrs
12.0	25%	3.6 hrs	5.8 hrs	8.6 hrs	15.4 hrs
11.8	0%	5.0 hrs	8.0 hrs	11.4 hrs	21.4 hrs

Table 2, Recharge Time Using Shop Charger for a Two Battery System

Battery Charging

Recharge Time Using Shop Charger for a Three Battery System					
Voltage	State of Charge	Charger Maximum Rate			
		50 Amps	30 Amps	20 Amps	10 Amps
12.6	100%	Ready to Use			
12.4	75%	1.8 hrs	2.7 hrs	3.9 hrs	7.5 hrs
12.2	50%	3.6 hrs	5.7 hrs	8.1 hrs	15.3 hrs
12.0	25%	5.4 hrs	8.7 hrs	12.9 hrs	23.1 hrs
11.8	0%	7.5 hrs	12.0 hrs	17.1 hrs	32.1 hrs

Table 3, Recharge Time Using Shop Charger for a Three Battery System

Recharge Time Using Shop Charger for a Four Battery System					
Voltage	State of Charge	Charger Maximum Rate			
		50 Amps	30 Amps	20 Amps	10 Amps
12.6	100%	Ready to Use			
12.4	75%	2.4 hrs	3.6 hrs	5.2 hrs	10.0 hrs
12.2	50%	4.8 hrs	7.6 hrs	10.8 hrs	20.4 hrs
12.0	25%	7.2 hrs	11.6 hrs	17.2 hrs	31.2 hrs
11.8	0%	10.0 hrs	16.0 hrs	22.8 hrs	42.8 hrs

Table 4, Recharge Time Using Shop Charger for a Four Battery System

On optional batteries with built-in hydrometer (charge indicator), the battery is sufficiently charged when the green dot in the hydrometer is visible. Gently shake or tilt the battery at hourly intervals during charging to mix the electrolyte and check to see if the green dot appears. Do not tilt the battery beyond a 45-degree angle.

If the green dot does not appear after a 75 ampere-hour charge, continue charging for another 50 to 75 ampere-hours. If the green dot still does not appear, replace the battery.

NOTE: Batteries with built-in hydrometers (charge indicators) cannot be charged if the indicator color is clear or light yellow; this indicates low electrolyte level. Replace these batteries.

Refer to the following steps to charge a wet cell battery.

1. Clean the battery terminals.

NOTE: If the battery is cold, let it warm up. This will allow a normal charging rate.

2. Make sure that the charger is turned off.
3. Connect the charger to the battery following the manufacturer's instructions. Rock the charger lead clamps to make sure there is a good connection.
4. Turn on the charger and slowly increase the charging rate until the recommended ampere value is reached.

IMPORTANT: If the battery feels hotter than 125°F (52°C), or if rapid gassing or spewing of electrolyte occurs, lower the charging rate or stop charging the battery and allow it to cool.

5. After the battery(s) has charged for the recommended time, turn the charger off.
6. Disconnect the charger cables from the battery.

NOTE: If the vehicle is equipped with an isolated battery system, be sure that both battery systems are charged.

7. If the engine does not crank satisfactorily when a charged battery is installed, test the battery using

a Midtronics™ battery tester. For instructions, see **Subject 140**.

If the battery passes the Midtronics test, check the fuel, ignition, cranking, and charging systems to find and correct the problem.

If the battery does not pass the Midtronics test, replace it.

Gel Cell Charging

CAUTION

To avoid shortening the life of a gel cell, carefully regulate the charging voltage—between 13.8 and 14.1 volts.

It is hard to determine how long to charge a gel cell. Recharging time depends on the following factors:

- Depth of discharge
- Temperature
- Size and efficiency of the charger
- Age and condition of the battery

Because the chemical charging reaction slows down as it nears completion, about 60% of the total charging time will be spent bringing the battery from 10.5 volts under load (11.8 volts with no load) to 90% of full charge (12.92 volts, including surface charge). The other 40% of the time is required to charge the remaining 10% (full charge = 13.0 volts, including surface charge).

Example: If it takes 3-1/2 hours to charge a battery to 90%, it will take another 2-1/2 hours to bring it to full (100%) charge.

See **Table 5** for a list of estimated charging times to 90% of full charge. See **Table 6** for a list of estimated charging times to 100% of full charge. All charging times are based on the initial charge current accepted by the battery, using an automatic, temperature-sensing, voltage regulating charger set at 13.8 volts (2.30 to 2.35 volts per cell) on a totally discharged battery (at 11.80 to 12.00 volts, with no load).

Charging Time to 90% of Full Charge			
Battery	Initial Amps Needed to Recharge In		
	13 Hours	6 Hours	3-1/2 Hours
G27	8	21	41
G31*	9	24	45

* Freightliner uses the G31 (Group 31) gel cell.

Table 5, Gel Cell Charging Guide (90% charge)

HOW TO USE THESE CHARTS: Read amps about one minute after the charger is first turned on. Use this initial reading to estimate the approximate charging time.

Example: If a G31 battery reads about 24 amps charge current when first turned on, the battery will be at 90% charge in about six hours, and will be fully charged (100%) in about ten hours.

Charging Time to 100% of Full Charge			
Battery	Initial Amps Needed to Recharge In		
	22 Hours	10 Hours	6 Hours
G27	8	21	41
G31*	9	24	45

* Freightliner uses the G31 (Group 31) gel cell.

Table 6, Gel Cell Charging Guide (100% charge)

To charge a gel cell, do the following steps:

1. Remove the gel cell from the vehicle.
2. Clean the battery terminals.

NOTE: If the gel cell is cold, let it warm up to 68°F (20°C). This will allow a normal charging rate.

3. Make sure that the charger is turned off.
4. Connect the charger leads directly to the battery following the charger manufacturer's instructions. Rock the charger lead clamps to make sure there is a good connection.
5. Turn on the charger and set the charging rate between 13.8 and 14.1 volts (2.30 to 2.35 volts per cell).

Battery Charging

6. After about one minute, check the initial charge current. To charge to 90% of full charge, see **Table 5** to determine the approximate time of completion. To charge to 100% of full charge, see **Table 6** to determine the approximate time of completion.

IMPORTANT: If the battery feels hotter than 125°F (52°C), or if rapid gassing occurs, stop charging the battery and allow it to cool.

7. When finished, turn the charger off.
8. Disconnect the charger cables from the battery.

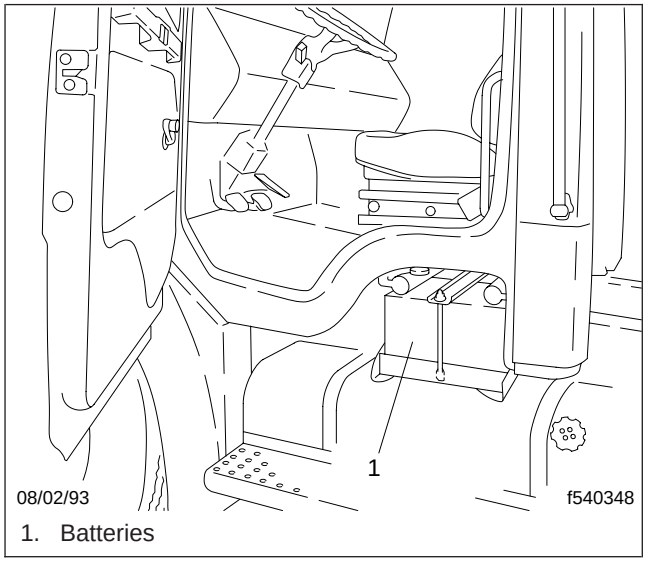
Battery Removal, Cleaning and Inspection, and Installation

WARNING

Before doing any of the following procedures, read the instructions in Subject 120. Failure to follow the safety precautions could result in personal injury.

Removal

1. Before working on the battery box, make sure all electrical loads (lights, ignition, accessories) are turned off.
2. For assembly reference, note the locations of the battery positive and negative terminals in relation to surrounding components.
3. Remove the battery retainer assembly; then remove the batteries from the carrier. See Fig. 1.



1. Batteries

Fig. 1, Typical Battery Installation

Cleaning and Inspection

1. Inspect all battery cables and inter-connectors for wear, and replace them if necessary. Remove corrosion from cables, terminals, and battery posts with a wire brush and a solution of baking soda and water. Rinse thoroughly with clean water, and dry.
2. Clean and tighten the battery ground cable at the weld stud on the frame rail. There are two locations to service. First, at the battery, and, second, at the engine behind the left wheel. Inspect and ensure that the nut is a self-locking type and that a flat washer is used. Do not use a split-lock washer or star washer. Torque the nut 15 to 18 lbf·ft (20 to 24 N·m). Seal the area with red dielectric spray enamel sealant.
3. Inspect the retainer assembly and battery box. Replace worn or damaged parts. Remove any corrosion with a wire brush, and wash with a weak solution of baking soda and water. Rinse with clean water, and dry. Paint the retainer assembly, if needed, to prevent rusting.
4. Be sure foreign objects, such as stones, bolts, and nuts, are removed from the battery box.

Installation

1. Be sure that the battery to be installed has a sufficient capacity to cover the electrical needs of the vehicle. For more information, see Subject 100.

CAUTION

Using an under-capacity battery will result in poor performance and premature battery failure, resulting in damage or reduced life of the starter.

2. Be sure the battery is at full charge when installed. If the battery has been in storage for some time, or if the installation is being made in subfreezing temperatures, give the battery a boost-charge before installing it. For instructions, see Subject 150.
3. Place the batteries in the carrier with the terminals in the proper position, as referenced earlier. The batteries should rest level in the carrier.
4. Install the battery retainer assembly, and tighten it until the batteries are secure. See Fig. 1.

CAUTION

Do not overtighten the battery retainer assembly. Overtightening could damage the batteries.

5. To provide corrosion protection, apply pumpable dielectric grease, part no. 48–02349–000, liberally to the terminal pads, then install the inter-

Battery Removal, Cleaning and Inspection, and Installation

connectors. For a list of approved suppliers, see **Specifications, 400**.

IMPORTANT: Many electrical components are located outside of the cab in areas subjected to harsh weather, road spray, etc. Some components also have exposed metal electrical terminals, which, when subjected to harsh conditions, may suffer corrosion at the electrical connection. Spray dielectric sealant on all exposed electrical terminals, and use dielectric grease on all covered terminals.

6. Connect the battery cables to the batteries; check for correct polarity with respect to the vehicle. Connect the ground cable last.

CAUTION

Reversed polarity may cause serious damage to the electrical system.

7. Tighten all battery connections to the torque specifications listed on the battery. Generally those are 10 to 15 lbf·ft (14 to 20 N·m). Proper torque is important for electrical system operation.
8. Start the engine, and check the operation of the charging system. If needed, adjust or repair the charging system to obtain the correct charging output. For instructions, see the appropriate section in **Group 15**.

CAUTION

Make sure all battery posts are covered with protective caps. Failure to do so could cause the battery box cover to short across the posts.

Troubleshooting

If the starting batteries test good, but fail to perform satisfactorily in service, check for the following causes:

1. Accessories were left on overnight.
2. A slipping alternator belt, high resistance in the wiring, or an inoperative voltage regulator is causing the batteries to discharge.
3. The electrical load is exceeding the charging system capacity.
4. Wires in the electrical system are shorted or pinched.
5. There are loose or damaged battery cable-to-terminal connections.
6. The batteries are still connected in a vehicle that has been out of service. Small current drains of accessories that are connected all the time can discharge the batteries in six to eight weeks. Batteries left in a discharged condition for a prolonged period of time are subject to freezing and may become difficult to charge.

Problem—The Starting Batteries Are Undercharged

Problem—The Starting Batteries Are Undercharged	
Possible Cause	**Remedy**
The drive belt is loose.	Check the drive belt. Refer to the drive belt subject in the appropriate engine section in **Group 01** for instructions. If necessary, tighten to the manufacturer's specifications. Start the engine and check the alternator voltage and output. Refer to the troubleshooting subject in the appropriate alternator section **in Group 15** for instructions.
The drive belt is damaged or missing.	Check the drive pulleys for locked bearings. Repair or replace any damaged components. Replace the drive belt and start the engine. Check the alternator voltage and output. Refer to the troubleshooting subject in the appropriate alternator section **in Group 15** for instructions.
The batteries are undercharged.	Do a load test on the batteries. Refer to **Subject 140** for instructions. Charge or replace batteries as needed. If the batteries were discharged, start the engine and check the alternator voltage and output. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.
The cranking circuit is broken.	If the batteries were fully charged and passed the load test, check the cranking circuit. Make repairs as needed. Start the engine to verify the repair.
The control circuit is broken.	Check the starter wiring. Make repairs as needed. Start the engine to verify the repair.
The starter is cold.	Perform a cold weather starting test.
The battery cables do not deliver sufficient voltage to the starter.	Check the available cranking voltage.
The starter ring gear or pinion gear is damaged.	Visually check the ring and pinion gears.
The starter is damaged.	Replace the starter.
The alternator is malfunctioning.	Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions.

Troubleshooting

Problem—The Starting Batteries Are Undercharged	
Possible Cause	**Remedy**
The isolator relay is not operating correctly (optional battery isolator system only).	Replace the isolator relay with an exact replacement continuous duty relay.

Problem—The Starting Batteries Are Overcharged

Problem—The Starting Batteries Are Overcharged	
Possible Cause	**Remedy**
The voltage regulator is damaged.	Run engine at approximately 2000 RPM. Using a digital voltmeter, check the voltage at the alternator. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions. If the voltmeter reads 15.5V or above, replace the alternator.
The dash voltmeter is broken.	Run engine at approximately 2000 RPM. Using a digital voltmeter, check the voltage at the alternator. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions. If the voltmeter reads below 15.5V, check and, if necessary, replace the dash voltmeter.
The batteries are overheated.	Check battery temperatures. If 120°F (49°C) or above, connect cool, fully charged batteries and recheck the voltage at the alternator. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions. If 119°F (48°C) or below, load test the batteries. Refer to **Subject 140** for instructions.
The batteries need replacing.	Check battery temperatures. If 119°F (48°C) or below, load test the batteries. Refer to **Subject 140** for instructions.

Specifications

Minimum Permissible Voltages	
Ambient Temperature °F (°C)	Minimum Voltage (After 15 seconds at 300 amps)
	12-Volt
70 (21) and Above	9.6
60 (16)	9.5
50 (10)	9.4
40 (4)	9.3
30 (–1)	9.1
20 (–7)	8.9
10 (–12)	8.7
0 (–18)	8.5

Table 1, Minimum Permissible Voltage at Various Ambient Temperatures

Charging Rates for Starting Batteries				
Rated Battery Capacity (reserve minutes)	Slow Charge *		Fast Charge †	
	Hours @	Amperes	Hours @	Amperes
180	30	5	7-1/2	20
	15	10	5	30
			2-1/2	45

* Slow charging is recommended for completely charging the batteries.

† An emergency boost charge, which consists of a high charging rate, can be obtained by reducing the fast-charge time to half, while maintaining the same recommended ampere charge may be used to crank an engine.

Table 2, Charging Rates

Manufacturer	Lubricant or Part Number
Shell Oil Co.	No. 71032; No. 71306
Texaco, Inc.	No. 955
Quaker State	No. NYK–77

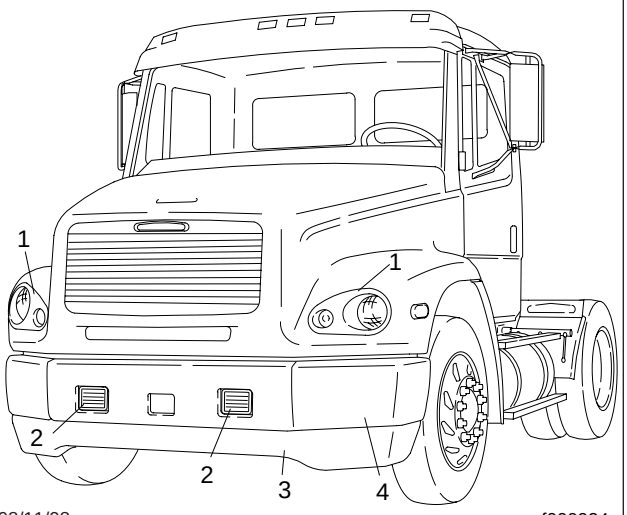
Table 3, Approved Electrical Lubricants

Reserve Capacity	Cold Cranking Amps (CCA)
180 minutes	750

Table 4, Standard Battery Specifications

General Information

NOTE: On FL112 vehicles, the headlights and front turn signal lights are mounted together in bezels attached to the hood. See **Fig. 1**. Road lights are normally mounted underneath the front bumper. If the vehicle has an air dam and tow hooks (which mount in the holes in the front bumper), rectangular cutouts are provided in the air dam to accommodate the road lights. If the vehicle has an air dam, but does not have tow hooks, the road lights are mounted in the holes in the front bumper.



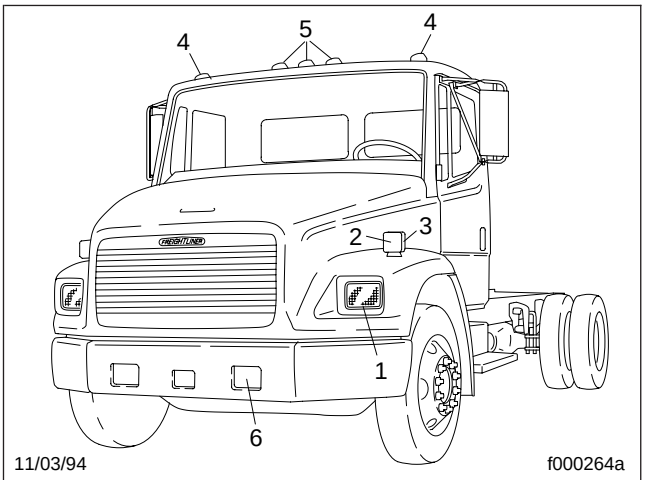
1. Headlight/Turn Signal Bezel
2. Road Light
3. Air Dam
4. Front Bumper

Fig. 1, Headlights and Road Lights (FL112 only)

Fig. 2 shows the exterior lighting system of the Short Conventional. In the front of the vehicle are headlights, fender-mounted turn-signal lights, and side-marker lights. On the roof of the cab there are clearance and identification lights. At the rear of the vehicle are the taillights, stoplights with turn signals, and backup lights. Optional fog lights are mounted in the front bumper.

NOTE: The fog lights will operate only if the low-beam headlights are turned on. The fog lights won't operate if the high-beam headlights are already on, and switching from low beams to high beams will switch off the fog lights. Also, with daytime running lights, the fog lights can be turned on any time the daytime running lights are on.

The instrument panel features fully lighted gauges and labels for switches and controls. The steering column-mounted turn-signal switch has the headlight dimmer switch built into it. A dome light is mounted in the rear center of the cab roof.



1. Headlight
2. Signal Light
3. Side Marker Light and Reflector
4. Clearance Light
5. Identification Lights
6. Fog Light

Fig. 2, Exterior Lighting (all but FL112)

On the dash is a marker light interrupt switch designed to allow the driver to blink the vehicle marker lights without turning off the headlights. When activated, the marker, taillight, front turn signal, and dash panel lights all blink. The marker light interrupter operates only with the headlights ON; it will not operate when only the parking lights are on.

Daytime running lights are a standard feature on vehicles built to operate in Canada; they are an option on other vehicles.

On Freightliner vehicles with this feature, switching on the ignition and releasing the parking brake automatically activates the headlight low beams at reduced voltage as daytime running lights.

Sure Power daytime running lights operate until the parking brakes are applied; then they will switch off. Turning on the regular headlights overrides the day-

General Information

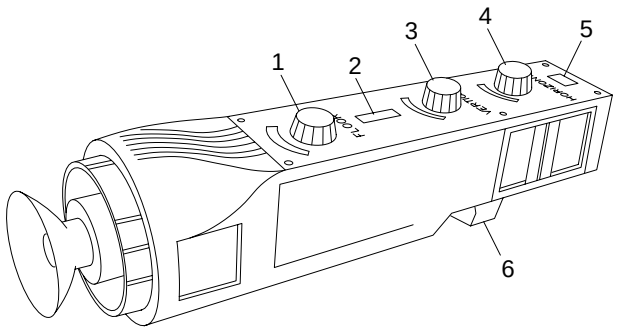
time running lights. Vehicles so equipped cannot be driven without the headlights or daytime running lights on.

The Sure Power model 1323F daytime running light (DRL) module turns on the low beam headlights at reduced voltage when the engine is operating. It does this by sensing when the ignition switch is on and the parking brake is released.

The DRL module applies approximately 86 percent of normal operating voltage to the low beam filaments. Model 1323F has a left and right low beam output. The voltage will vary from approximately 10.5 volts with the engine stopped to 12.5 volts with the engine running.

The 1323F module is designed to conform to the CMVSS 108 and FMVSS 108 specifications for low beam operation. In addition to turning on the low beams at reduced voltage, the module also provides an ACTIVE LOW (ground) signal to the dimmer relays, thereby forcing the dimmer relays into the high beam position. This is necessary to prevent the DRL module from feeding the remaining light circuitry. When the DRL module is deactivated, the dimmer relays return to normal operation.

Headlight aim can be checked and adjusted most easily, using the Hopkins mechanical aimer. The aimer attaches to the headlight with a vacuum cup activated by pushing the piston handle located on the base of the aimer. See **Fig. 3**.



04/11/97 f580162

1. Floor Slope Dial
2. Level Vial
3. Vertical Dial
4. Horizontal Dial
5. Split Image View Port
6. Piston Handle

Fig. 3, Headlight Aimer

To adjust the horizontal aim, turn the horizontal adjusting screw on the headlight until the split image aligns in the split image view port. To adjust the vertical aim, turn the vertical adjusting screw on the headlight until the bubble is centered in the level vial.

Headlight Replacement

1. Remove the headlight bezel. See **Fig. 1**.
2. Remove the retaining ring screws.
3. Remove the retaining rings.
4. Remove the lamp from the housing; then disconnect the wiring connector from the back of the lamp.
5. To provide corrosion protection, coat the prongs/base of the new lamp with dielectric grease. For approved electrical terminal lubricants, see the applicable table in **Specifications 400**.
6. Push the wiring connector onto the prongs at the rear of the new lamp.
7. Place the new lamp in the headlight housing.
8. Place the retaining ring over the lamp and install the retaining ring screws; then tighten the screws securely.
9. Check and, if necessary, adjust the headlight aim as described in **Subject 130**.
10. Install the headlight bezel.

Front Turn Signal/Side Marker Bulb Replacement

1. Remove the lens-to-housing attaching screws. See **Fig. 2** and **Fig. 3**.
2. Remove the bulb from the socket.
3. To provide corrosion protection, coat the base of the new bulb with dielectric grease. For approved lubricants, see the applicable table in **Specifications 400**. Install the new bulb.
4. Check for proper operation.
5. Install the lens and attaching screws.

Clearance\Identification Light Bulb Replacement

1. Using a screwdriver, unsnap the lens from the base to gain access to the bulb. See **Fig. 4**.
2. Remove the bulb.

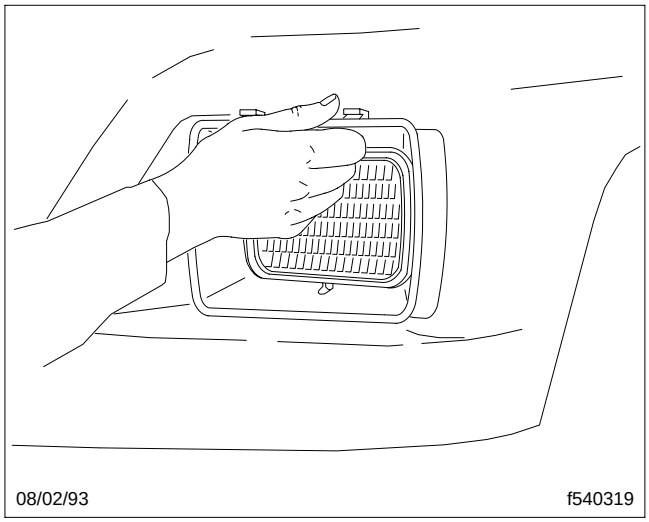


Fig. 1, Bezel Removal

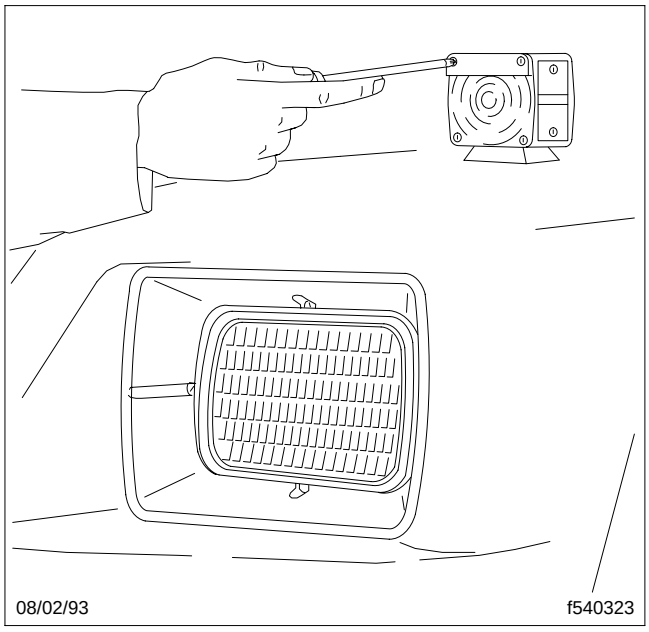


Fig. 2, Attaching Screws Removal

3. To provide corrosion protection, coat the base of the new bulb with dielectric grease.

   For approved electrical terminal lubricants, see the applicable table in **Specifications 400**.
4. Install the new bulb and test for proper operation.
5. Install the lens on the base, making sure that it is fully seated.

Exterior Light Replacement

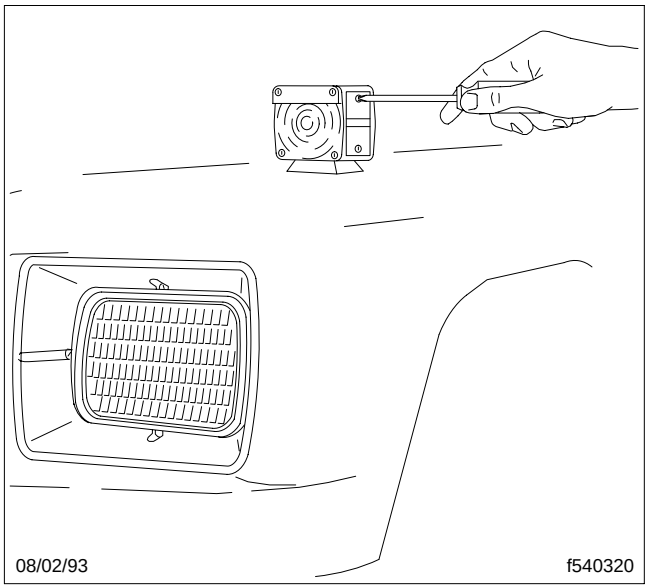


Fig. 3, Attaching Screws Removal

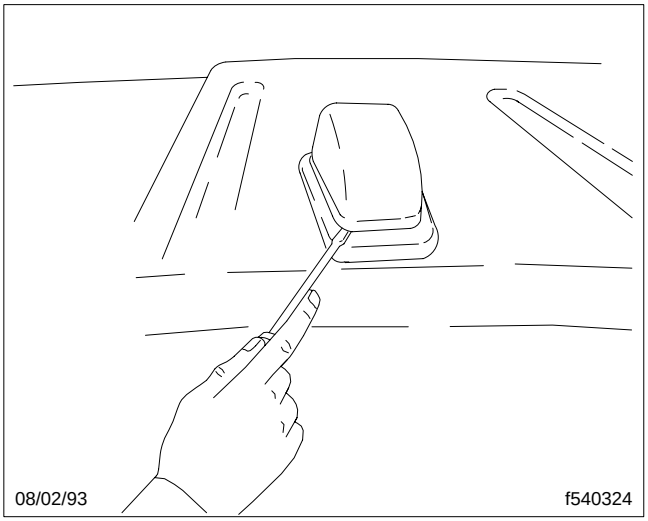


Fig. 4, Snapping Open the Lens

Fog Light Replacement, Per-Lux

1. Gain access to the front of the light assembly by removing the mounting bracket locknut. Remove the light assembly from the mounting bracket. See **Fig. 5**.
2. Remove the crosshead screws from both sides of the lens retainer.
3. Separate the lens retainer and louver from the main housing. Pull the lamp from the housing, and disconnect the blade connectors from the blade terminals on the bulb. See **Fig. 6**.
4. To provide corrosion protection, coat the blade terminals on the new bulb with dielectric grease. For approved electrical terminal lubricants, see the applicable table in **Specifications 400**.
5. Install the blade connectors on the terminals of the new lamp. Place the unit in the housing and test it for proper operation.
6. Place the lens and louver over the lamp. Make sure the word "TOP" appears on the top of the lamp. See **Fig. 7**. If not properly installed, the beam from the light will be directed upward instead of down.

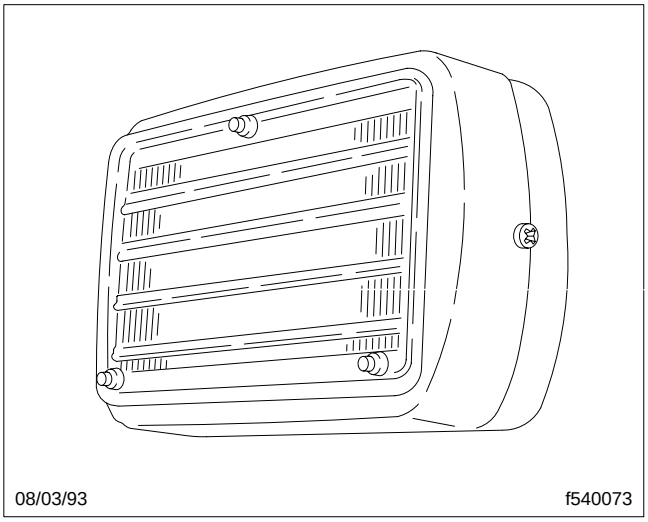


Fig. 5, Per-Lux Fog Light

7. Place the lens retainer over the louver. Install the crosshead screws.
8. Place the fog light assembly in the mounting bracket. Install the locknut. Make sure the lamp is aimed directly ahead. Then, tighten the locknut 75 lbf·ft (102 N·m).

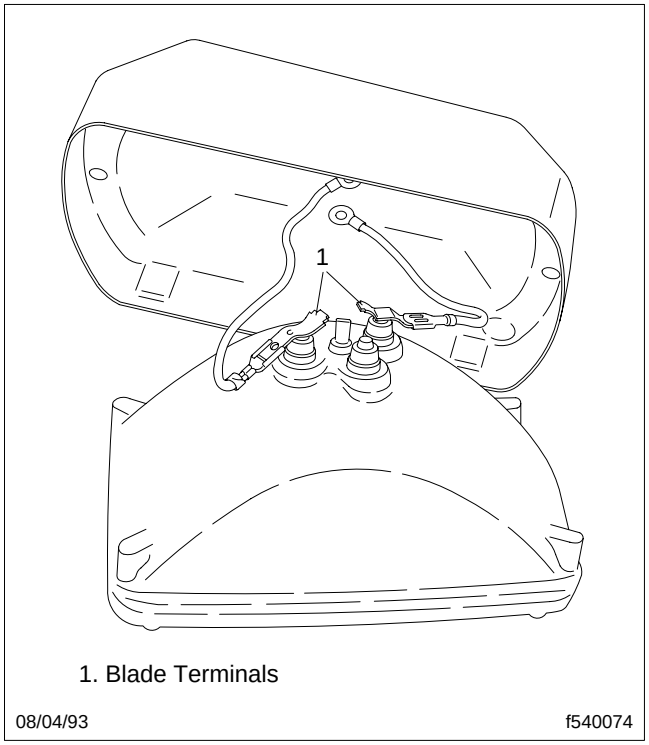


Fig. 6, Blade Terminal Removal

Stoplight and Taillight Replacement

1. Remove the screws attaching the lens to the light housing. See **Fig. 8**.
2. Press in on the bulb and turn it counterclockwise to release it from the socket. See **Fig. 9**.
3. To provide corrosion protection, coat the base of the new bulb with dielectric grease. For approved electrical terminal lubricants, see the applicable table in **Specifications 400**.
4. Press the new bulb into the socket, and turn it clockwise to lock it in place. Test the bulb for proper operation.
5. Install the lens on the housing. Fasten it in place with the attaching screws. Do not overtighten the screws or you will crack the lens.

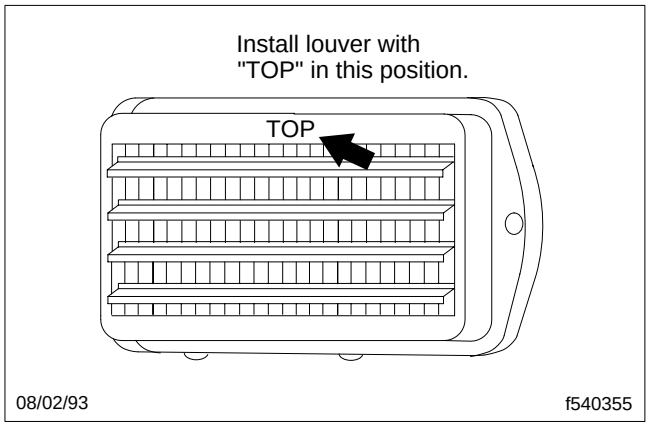


Fig. 7, TOP Position on Lamp

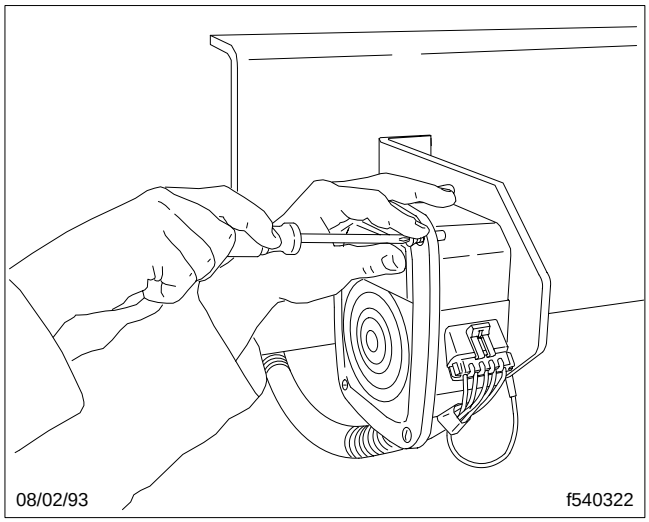


Fig. 8, Lens Removal

FL112 Headlight Replacement

1. Remove the two Phillips-head screws that attach the headlight/turn signal bezel to the hood. See **Fig. 10**. Pull the bezel away from the hood.
2. Remove the three Phillips-head screws that secure the headlamp retaining ring and the lamp to the bezel.
3. Disconnect the wire harness from the headlamp and remove the lamp.
4. To provide corrosion protection, coat the prongs/base of the new lamp with dielectric grease. For approved electrical terminal lubricants, see the applicable table in **Specifications 400**.

Exterior Light Replacement

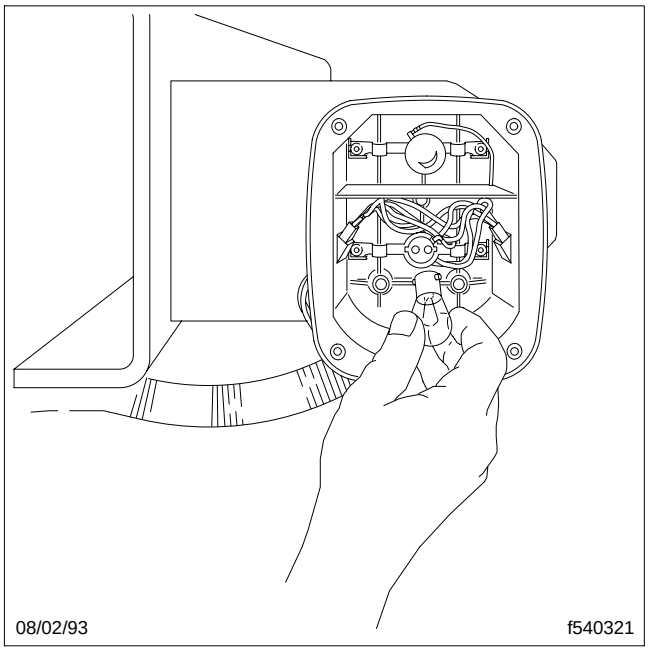
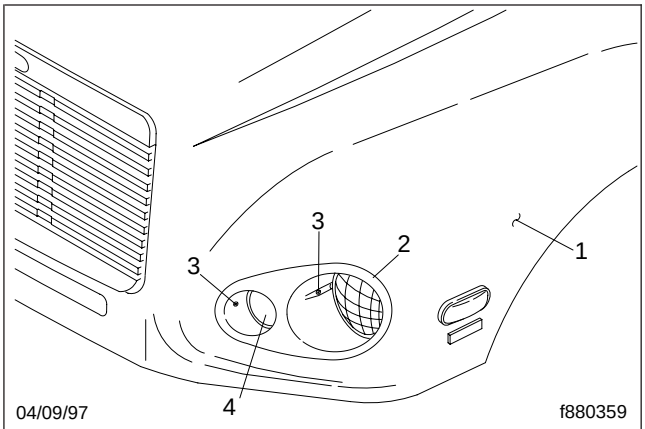


Fig. 9, Bulb Removal



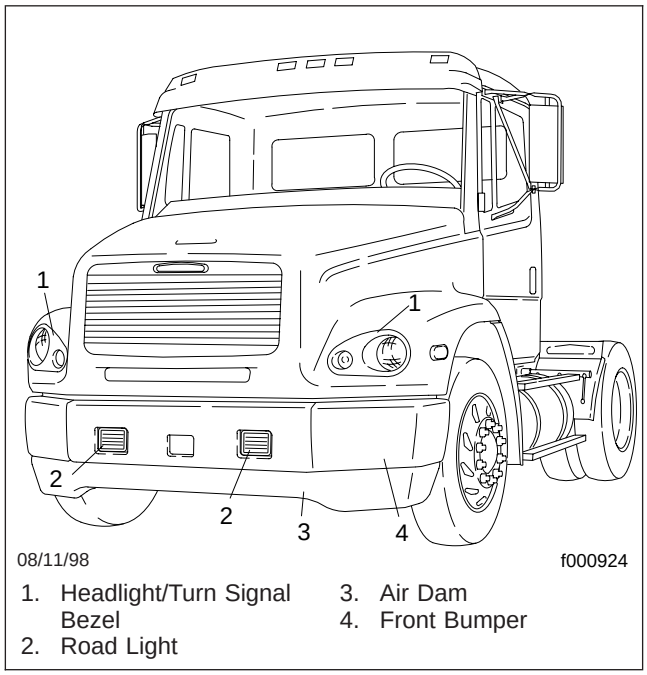
1. Hood
2. Headlight/Turn Signal Bezel
3. Mounting Screw
4. Turn Signal

Fig. 10, Headlight/Turn Signal Bezel Attachment (FL112 only)

5. Connect the wire harness to the new lamp and place it in position in the bezel.
6. Place the retaining ring over the lamp and install and tighten the three Phillips-head screws securely.
7. Insert the bezel into position in the hood and install and tighten the two Phillips-head screws securely.
8. Check and, if necessary, adjust the headlight aim as described in Group 54 of the *Business Class Trucks Maintenance Manual*.

FL112 Road Light Replacement

(See Fig. 11)



1. Headlight/Turn Signal Bezel
2. Road Light
3. Air Dam
4. Front Bumper

Fig. 11, Headlights and Roadlights (FL112 only)

1. Remove the two fasteners that attach the triangular road light mounting plate to the front bumper.
2. Disconnect the wire harness from the road light.
3. Remove the single fastener attaching the road light to the mounting plate.
4. Attach the mounting plate to the new road light with the single fastener and tighten it securely.
5. Connect the wire harness to the new road light.
6. To provide corrosion protection, coat the pins and base of the connector with dielectric grease. For approved electrical terminal lubricants, see the applicable table in **Specifications 400**.

7. Place the road light, with the attached mounting plate, in position on the bumper. Install the two fasteners and tighten them securely.
8. Wipe the lens with a clean cloth to remove any dirt or skin oil.
9. Test the light for proper operation.
10. Check the alignment of the light. Make sure the light is pointing forward and slightly toward the shoulder side of the road.

Instrument Panel Bulb Replacement

1. Loosen the cross-head screws through access holes in the instrument panel cover. **See Fig.1.**
2. Pull the panel out of the dash to provide access to the back of the panel, **as shown in Fig.2.**
3. Remove the bulb holder by twisting it 1/8 turn counterclockwise and pulling it away from the panel. Remove the bulb by pulling it straight out.
4. Install the new bulb and replace the bulb holder. Test the bulb for proper operation.
5. Place the instrument panel back in the dash, making sure that none of the wires are pinched, kinked, or otherwise incorrectly positioned. Install the screws.

Rocker Switch Bulb Replacement

1. Remove the vinyl extrusion trim from the groove above the switch panel.
2. Remove the screws from the top of the panel. Swing the panel out and lift it from the slots.
3. Unplug the wiring connector from the back of the switch. Pull the bulb holder from the switch and replace the bulb; then install the bulb holder in the switch. Reconnect the wiring harness to the switch.
4. Check the bulb for proper operation. Install the panel and the vinyl extrusion trim.

Temperature Control Panel Bulb Replacement

1. Remove the vinyl extrusion trim from the groove above the switch panel.
2. Remove the screws from the top of the panel. Swing the panel out.

NOTE: Both dash panels on either side may have to be removed to allow removal of the center panel.

3. Remove the bulb holder and replace the bulb.

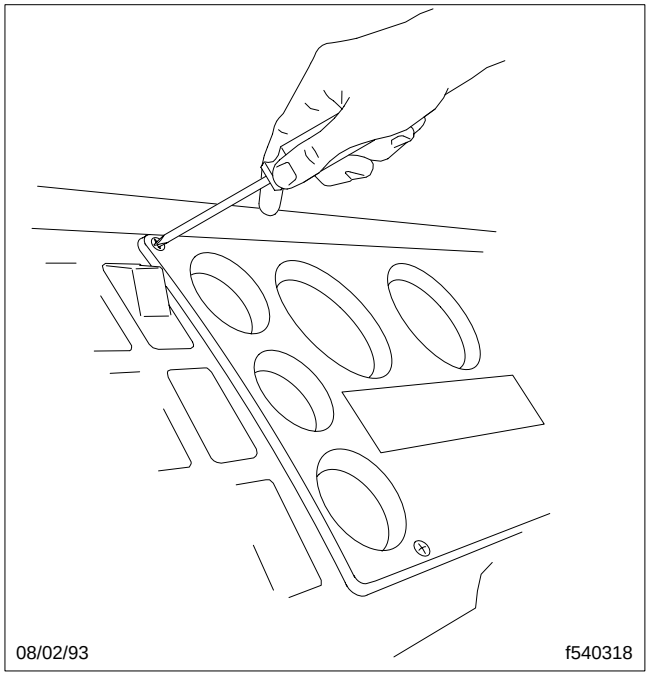


Fig. 1

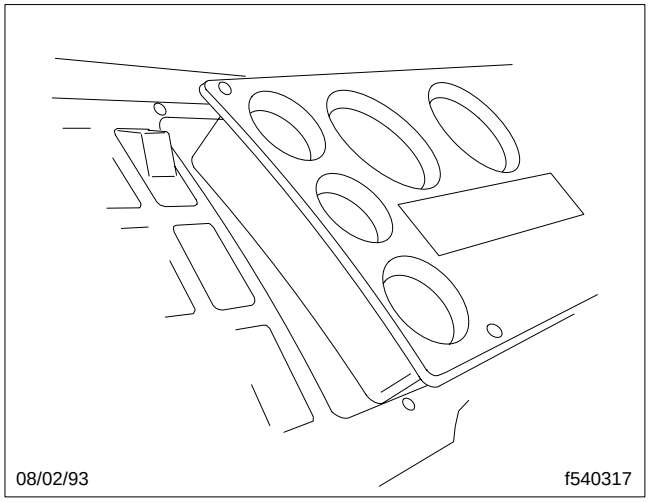


Fig. 2

4. Check the bulb for proper operation; then install the bulb holder.
5. Install the dash panels and the vinyl extrusion trim.

Interior Light Replacement

Headlight Dimmer, Hazard Light, and Turn Signal Switch Replacement

1. By hand, remove the turn signal switch cover.
2. Remove the two allen head screws that fasten the switch to the steering column.
3. Disconnect the wiring harness connector from the switch.
4. Reverse the procedure to install the new switch.

Dome Light Replacement

1. Unsnap the lens from the housing to gain access to the bulb; use a screwdriver to press in the prong on one side of the housing. **See Fig.3.**
2. Press in on the bulb and turn it counterclockwise to release it from the socket. **See Fig.4.**
3. Press the new bulb into the socket; then turn it clockwise to lock it in place. Test the bulb for proper operation.
4. Install the lens on the housing; be sure that it is fully seated.

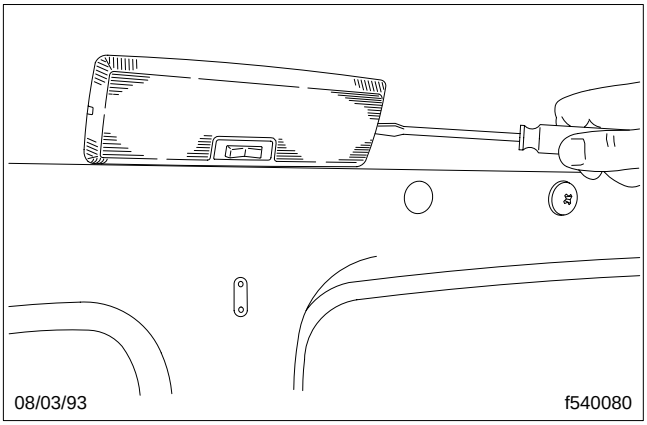


Fig. 3

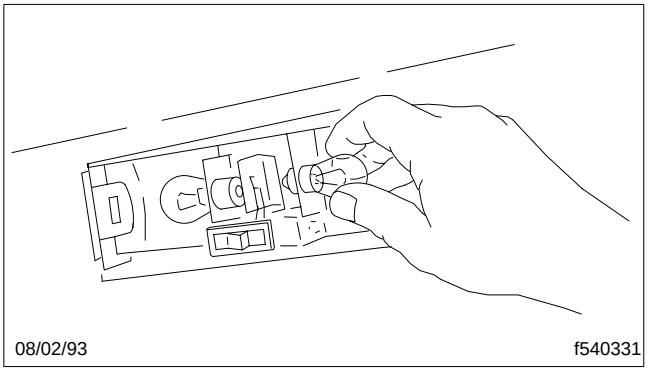


Fig. 4

Headlight Aim Checking and Adjusting

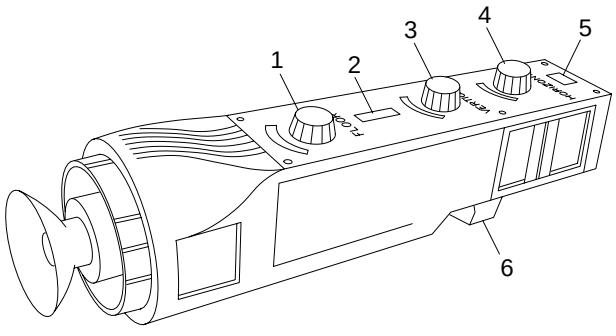
Before checking or adjusting the headlight aim, do the following:

- Remove large amounts of mud or ice from the undersides of the fenders.
- Check the springs for sagging or broken leaves. Check the suspension for proper functioning of the leveling mechanism.
- Clean the headlight lenses and aiming pads.
- Check the bulbs for burnout and broken aiming pads. Switch the beams from low to high to make sure they switch properly.
- With the vehicle unloaded, check that the tires are inflated to the recommended air pressure.

Checking

For a quick check to see if the headlights need aiming, do the following procedure.

1. Move the vehicle onto a flat surface that has been calibrated for slope. Shut down the engine, set the parking brake, and chock the tires.
2. Attach a headlight aimer to each headlight. See **Fig. 1**.



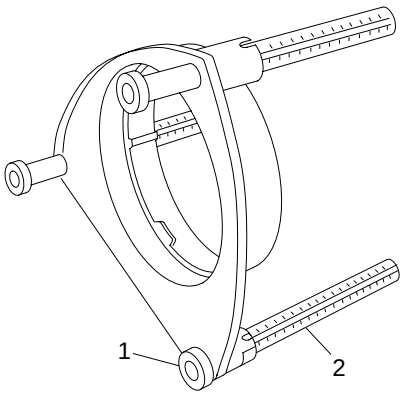
04/11/97 f580162

1. Floor Slope Dial
2. Level Vial
3. Vertical Dial
4. Horizontal Dial
5. Split Image View Port
6. Piston Handle

Fig. 1, Headlight Aimer

2.1 Attach the black universal adaptor to the aimer. Set the adjustment rods to "0" (zero). See **Fig. 2**.

On FL112 model vehicles, attach the seven-inch circular adaptor to the aimer. See **Fig. 3**.

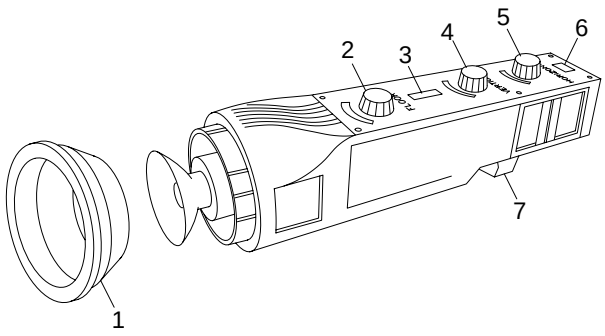


04/14/97 f580165

Set the adjustment rods to "0" (zero).

1. Adaptor Foot
2. Adjustment Rod

Fig. 2, Universal Adaptor



07/02/97 f580175

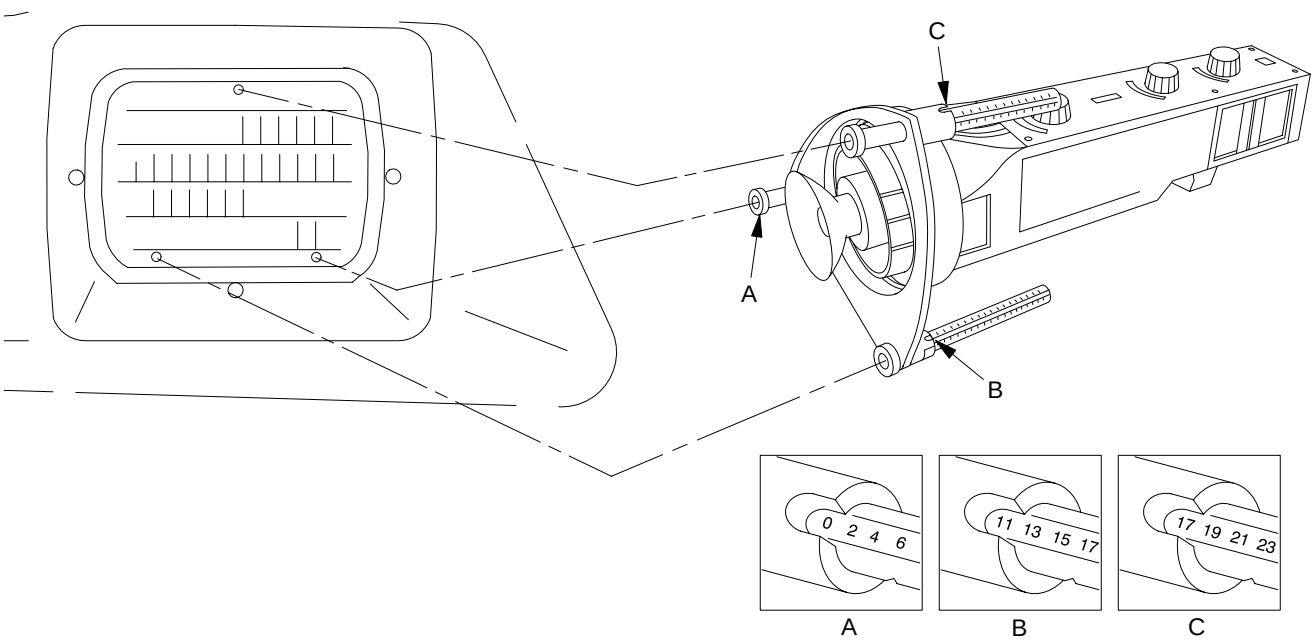
1. Seven-Inch Circular Adaptor
2. Floor Slope Dial
3. Level Vial
4. Vertical Dial
5. Horizontal Dial
6. Split Image View Port
7. Piston Handle

Fig. 3, Seven-Inch Circular Adaptor

NOTE: On older FL70s with sloping headlights, set the adjusting rods to the values marked on the headlights. See **Fig. 4**.

2.2 Align the adaptor with the aiming pads on the headlight lens.

Headlight Aim Checking and Adjusting



04/14/97 f580167

NOTE: On standard rectangular headlights, set all three adjusting rods to "0" (zero).
Turn rod clockwise to lock in an odd number; turn rod counterclockwise to lock in an even number.

A. The inboard lower adjustment rod is always set to "0" (zero).
B. Set the outboard lower adjustment rod to to the horizontal adjustment value on the headlight. *Example:* "11H."
C. Set the upper adjustment rod to to the vertical adjustment value on the headlight. *Example:* "17V."

Fig. 4, Aiming Pad Alignment

2.3 Push the piston handle on the base of the aimer forward to engage the vacuum cup. Immediately pull the handle backward until it locks. See **Fig. 5**.

2.4 Do the same procedure with the other aimer.

3. Check the floor slope dial for the correct setting. See **Fig. 6**.

4. Check the horizontal aim. See **Fig. 7**.

4.1 Turn the horizontal dial until the split image is in alignment.

4.2 If the horizontal dial scale on either aimer reads more than "4," re-aim the headlight.

NOTE: If adjustment is required, see the procedures under "Adjusting" below.

5. Check the vertical aim. See **Fig. 8**.

5.1 Turn the vertical dial until the level vial is centered.

5.2 If the vertical dial scale on either aimer reads more than "4," re-aim the headlight.

NOTE: If adjustment is required, see the procedures under "Adjusting" below.

6. Remove the two headlight aimers. Hold each aimer securely, and then press the vacuum release button.

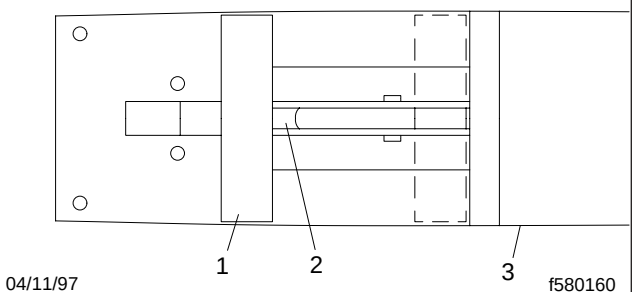
7. Remove the chocks from the tires.

Adjusting

If the headlights need adjusting, do this procedure.

1. If not already there, move the vehicle onto a flat surface that has been calibrated for slope. Shut

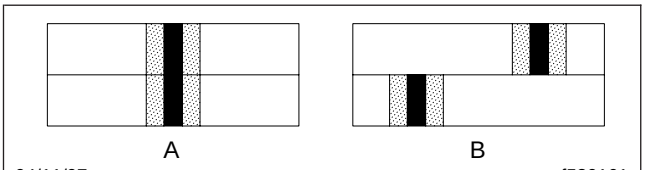
Headlight Aim Checking and Adjusting



To attach, push the piston handle forward to engage the vacuum cup. Immediately pull the handle backward until it locks.
To remove, press the vacuum release button.

1. Piston Handle
2. Vacuum Release Button
3. Base of Aimer

Fig. 5, Aimer Attachment and Removal

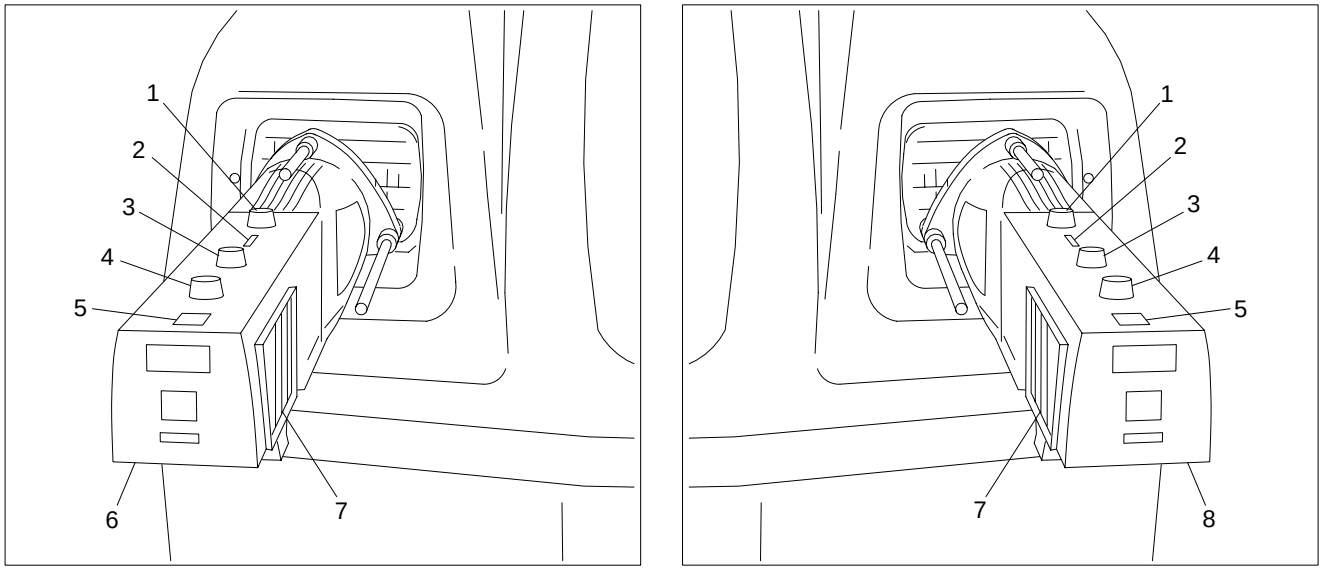


View through the split image view port.

A. Split Image Aligned
B. Split Image Not Aligned

Fig. 7, Horizontal Aim Split Image

2. Attach a headlight aimer to each headlight. See the procedures above under "Checking" for detailed instructions.
3. Check the floor slope dial for the correct setting. See **Fig. 6**.



The sight openings must face each other.

1. Floor Slope Dial
2. Vertical Aim Level Vial
3. Vertical Dial
4. Horizontal Dial
5. Split Image View Port
6. Aimer (RH side)
7. Sight Opening
8. Aimer (LH side)

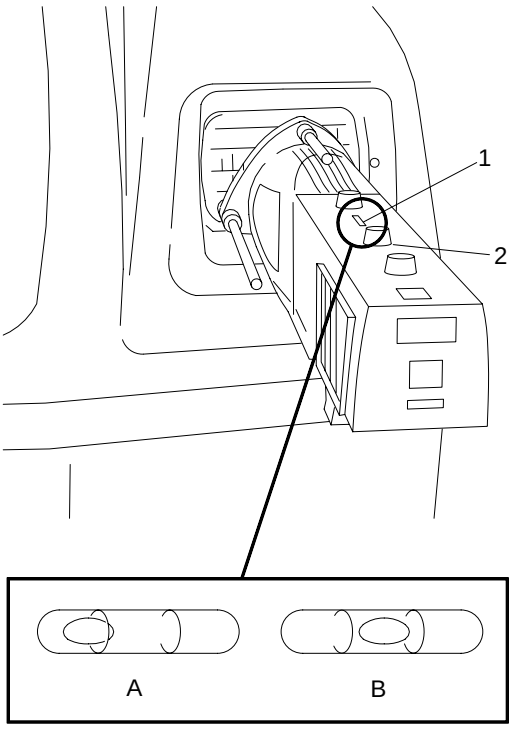
Fig. 6, Set-Up for Aiming

down the engine, set the parking brake, and chock the tires.

4. Adjust the horizontal aim. See **Fig. 7**.

   4.1 Set the horizontal dial to "0" (zero).

Headlight Aim Checking and Adjusting



07/28/97 f580177

Set the vertical dial to "0" (zero).

A. Bubble Not Centered
B. Bubble Centered
1. Level Vial
2. Vertical Dial

Fig. 8, Vertical Aim Level Vial

4.2 Look in the viewing port for the split image target lines. If necessary, rotate either or both aimers until the lines are visible.

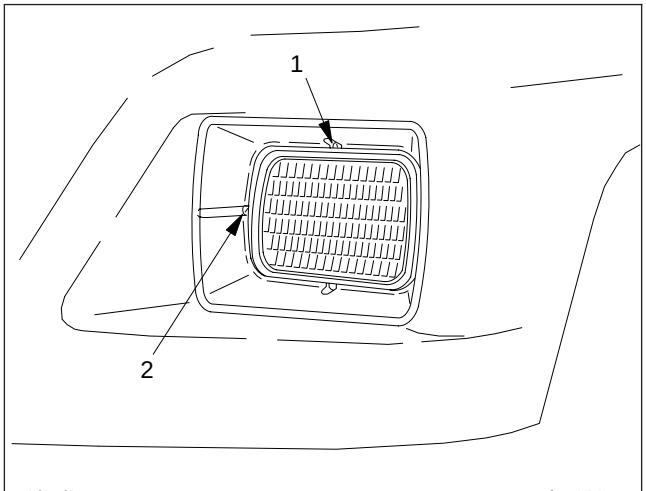
4.3 Turn the horizontal adjustment screw as needed to make the split image appear as one solid line. See **Fig. 9**.

IMPORTANT: To avoid backlash, make the final adjustment by turning the screw clockwise.

4.4 Do the same procedure for the other headlight.

5. Adjust the vertical aim. See **Fig. 8**.

5.1 Set the vertical dial to "0" (zero).



10/05/94 f540307a

1. Vertical Adjustment
2. Horizontal Adjustment

Fig. 9, Headlight Adjustment Screws

5.2 Turn the vertical adjustment screw as needed to center the bubble in the level vial between the lines. See **Fig. 9**.

IMPORTANT: To avoid backlash, make the final adjustment by turning the screw clockwise.

5.3 Do the same procedure for the other headlight.

6. Recheck the horizontal alignment on both aimers. Readjust if necessary.

7. Remove both headlight aimers. While holding the aimer securely, press the vacuum release button. See **Fig. 5**.

8. Remove the chocks from the tires.

Troubleshooting Table

Problem—Daytime Running Lights Are Not Operating Correctly

Possible Cause	Remedy
The DRL module connectors are not making proper contact.	Disconnect and inspect the connectors. Check the headlights for proper operation. Reconnect the module and retest.
The wiring, relay or switch does not work.	Correct the wiring or switch fault. Retest.
The DRL input levels are incorrect. Refer to **Table 1** for the voltage levels at the harness connector.	Correct the wiring, relay, or switch problem. Retest.
Tests in **Table 2** indicate that the DRL module has a problem.	Replace the DRL module and retest.

Testing the DRL System

See **Specifications 400** for the wiring diagrams of the DRL and the vehicle lighting systems. To test the operation of the daytime running lights (DRLs):

1. With the ignition key OFF, the headlight circuit works normally.
2. When the key ON, and the parking brake set or the headlight switch is ON, the headlights work as normal and will switch between high and low beams when the dimmer switch is toggled.

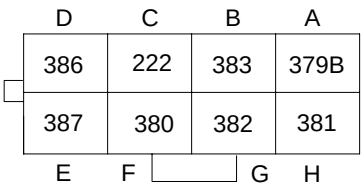
NOTE: The low beams will not turn fully off, however, if the key is ON with either the parking brakes released, or the headlight switch OFF, because the system is in the DRL mode.

3. With the key ON, the headlight switch OFF, and the parking brake released, the DRL module activates the low beam circuit only (through pins D and E) at approximately 86 percent of nominal voltage. The DRL voltage will range between 10.5 VDC with the engine stopped and 12.5 VDC with the engine running.

   NOTE: When the DRL system is active, pin C of the DRL module grounds and causes both dimmer relays to switch to the high beam position. This position prevents electricity from flowing from pins D and E of the DRL module to all the lights normally activated by the headlight switch. Only the low beams and the fog lamps can receive power in the DRL mode.

4. Disconnect the electrical connector from the DRL module. Perform the voltage tests on the harness connector as described in **Table 1** to make sure that the DRL module is receiving the correct inputs.
5. Connect the harness connector to the DRL module connector. Perform the tests described in **Table 2**. When the DRL system is active and the engine is not running, the DRL module must cause the voltages shown in the table at the locations specified.

Troubleshooting

Tests of the DRL Module Harness				
Circuit and Pin Locations on Harness  02/18/99 f542794				
Voltmeter		**Harness Connector Pin I.D. and Function**	**Condition**	**Volts (VDC) ***
– Probe	**+ Probe**			
Pin A	Battery +	"A" – Ground (Switched)	Park Brake Applied Park Brake Released	0 12
Ground	Pin B	"B" – Right Headlight Sense	Headlights Switch: OFF Headlights Switch: ON	0 12
Pin C	Battery +	"C" – Dimmer Switch Override	Dimmer Switch LOW Dimmer Switch HIGH	0 12
Ground	Pin D	"D" –Left Low Beam (and Fog Lamps Relay)	Headlights Switch: ON Dimmer: High Dimmer: Low	— 0 12
Ground	Pin E	"E" – Right Low Beam	Headlights Switch: ON Dimmer: High Dimmer: Low	— 0 12
Ground	Pin F	"F" – Ignition	Key ON Key OFF	12 0
Ground	Pin G	"G" – Left Headlight Sense	Headlights Switch: OFF Headlights Switch: ON	0 12
Ground	Pin H	"H" – Battery Positive	Good Fuse	12

* Nominal voltage with the engine stopped.

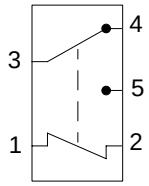
Table 1, Tests of the DRL Module Harness

Voltage Tests of the DRL System				
Voltmeter		**Test Location**	**Condition**	**Volts (VDC) ***
– Probe	**+ Probe**			
Pin 2 †	Battery +	Left Headlight Dimmer Relay	Key ON, Headlight Switch OFF, Park Brake Released	12

Voltage Tests of the DRL System				
Voltmeter		Test Location	Condition	Volts (VDC) *
– Probe	+ Probe			
Pin 2 †	Battery +	Right Headlight Dimmer Relay	Key ON, Headlight Switch OFF, Park Brake Released	12
Ground	Pin 4 †	Left Headlight Dimmer Relay	Key ON, Headlight Switch OFF, Park Brake Released	10.5
Ground	Pin 4 †	Right Headlight Dimmer Relay	Key ON, Headlight Switch OFF, Park Brake Released	10.5

* Nominal voltage with the engine stopped.
† See **Fig. 1**.

Table 2, Voltage Tests of the DRL System



02/03/99 f542765

1. Coil Positive
2. Coil Ground
3. Power Terminal
4. Switched (low beam)
5. Switched (high beam)

Fig. 1, Headlight Dimmer Relay Terminals

For a wiring diagram of the vehicle lighting system, see **Fig. 1**.

For a wiring diagram of the daytime running lights, see **Fig. 2**.

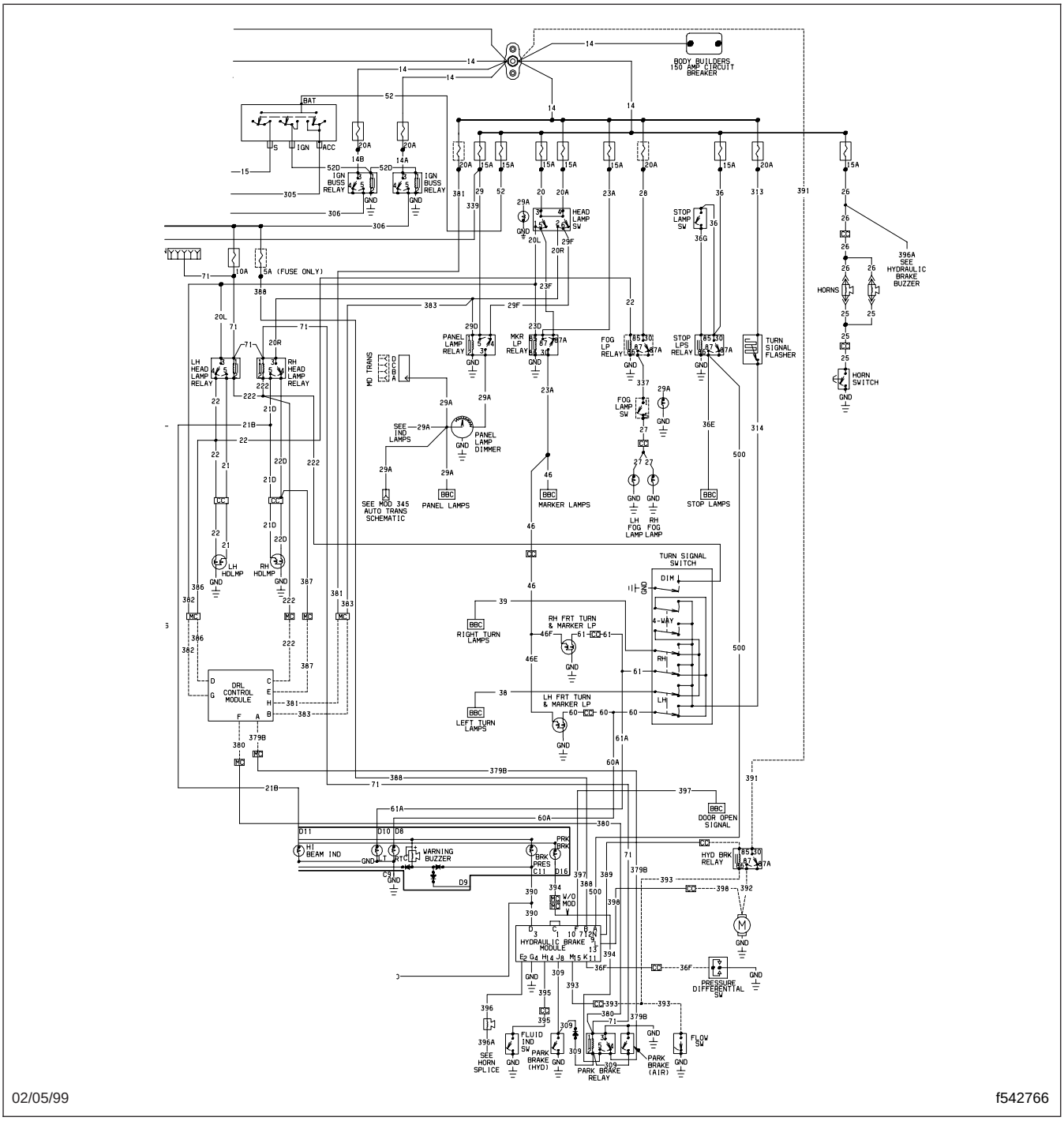


Fig. 1, Wiring Diagram for Lighting

Specifications

Approved Electrical Lubricants	
Manufacturer	**Lubricant**
Standard Oil Co.	White Vasoline
Shell Oil Co.	No. 71032; No. 71306
Texaco, Inc.	No. 955
Quaker State	No. NYK-77

Table 1, Approved Electrical Lubricants

Replacement Bulb and Relay Part Numbers	
Description	**Part Number**
Headlight, Rectangular, Halogen	WEE H6054
Headlight, Rectangular, Incandescent	WEE 6052
Headlight, Round, Incandescent	WEE 6014
Front Turn Signal Light	WEE 1156
Front Side Marker Light	WEE 193
Fog Light	GE H9421
Clearance and Identification Light	WEE 193
Tail/Brake/Rear Turn Signal Light	WEE 1157
Backup Light	WEE 1156
Instrument Panel Light	WEE 161
Temperature Control Panel Light	WEE 161
Dome Light	WEE 93
Rocker Switch Light	SPR 904 404
Lighting System Relay	680 545 00 05

Table 2, Replacement Bulb and Relay Part Numbers

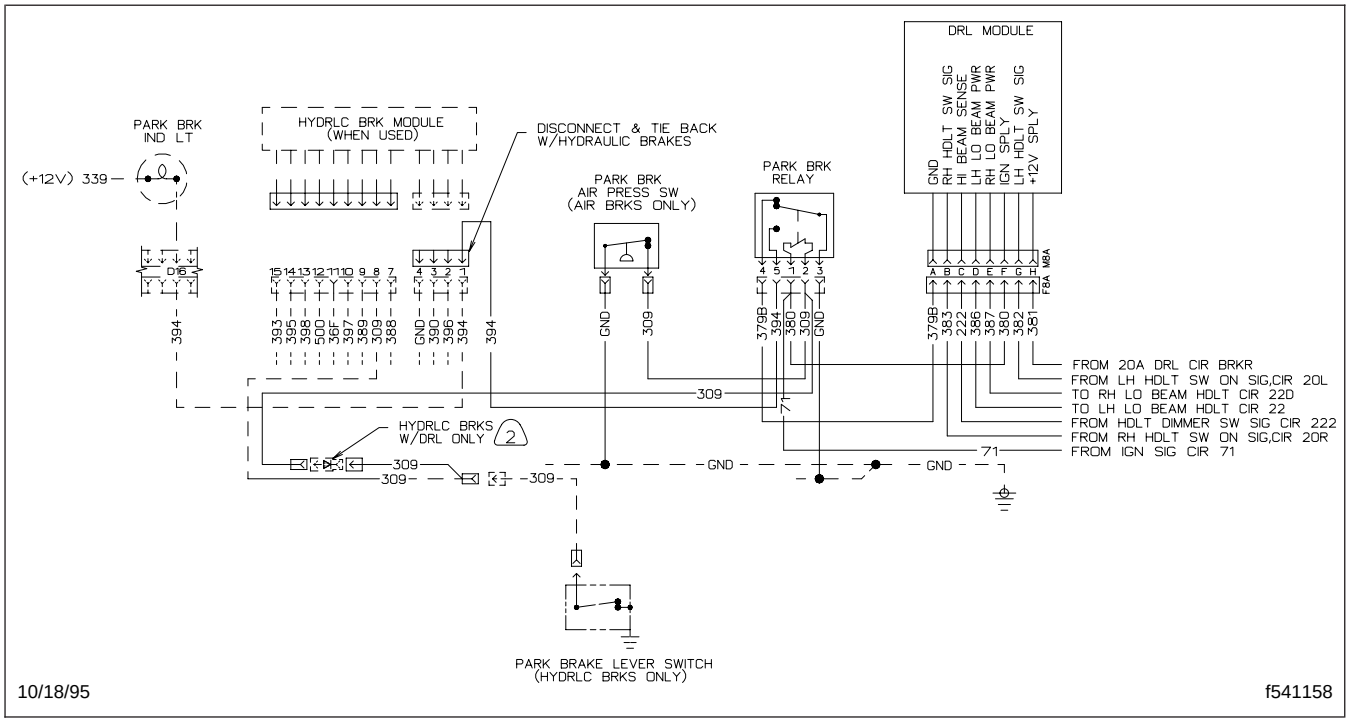


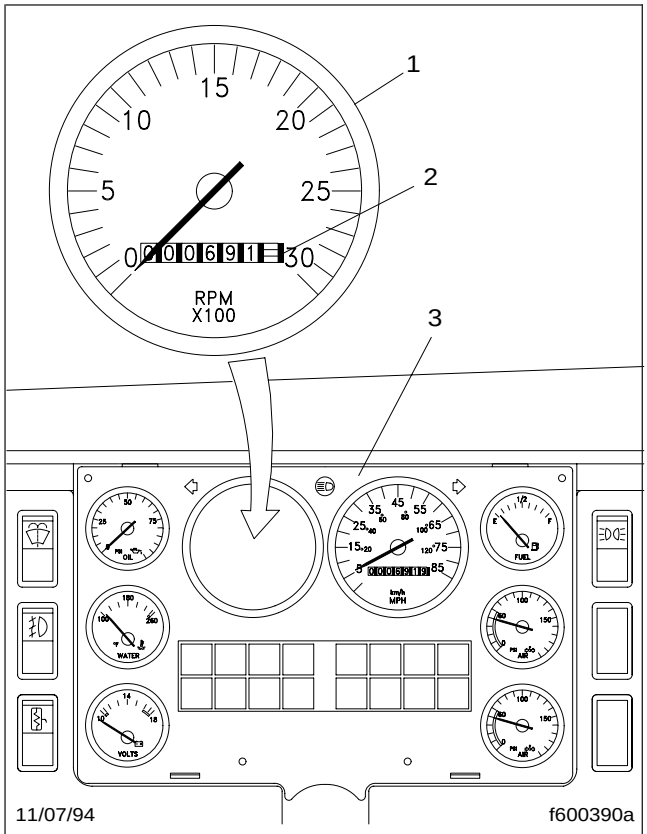
Fig. 2, Wiring Diagram for Sure Power Daytime Running Lights

General Information

The Ametek electronic tachometer consists of a dash-mounted gauge (tachometer head), a magnetic sensor mounted on the flywheel housing, and the electrical wires that provide power to the tachometer and complete the circuit between the components.

The tachometer head registers engine speed in revolutions per minute (rpm). It is used as a guide for shifting, and keeping the engine in the proper speed range. An optional tachometer is equipped with a 7-wheel hourmeter that records total hours of engine operation. See **Fig. 1**.

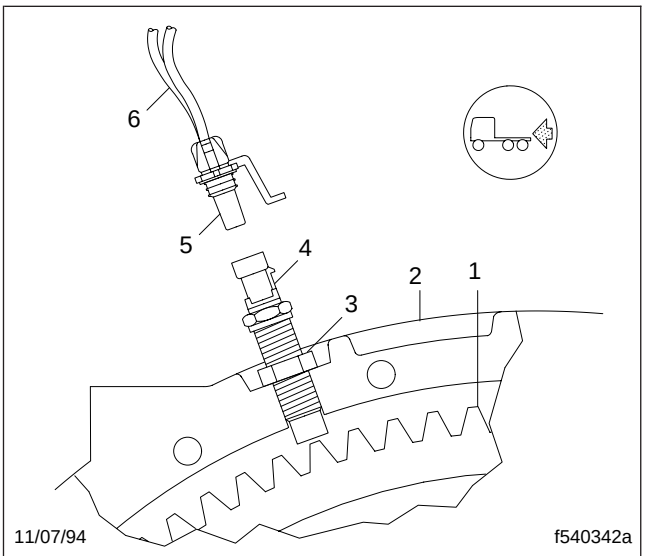
The magnetic sensor is mounted with its magnetic end extending through a threaded bore in the flywheel housing. It stops a little over 1/32 inch (1 mm) from the teeth of the flywheel ring gear. See **Fig. 2**.



1. Ametek Electronic Tachometer
2. Engine Hourmeter
3. Instrument Panel

Fig. 1, Tachometer/Hourmeter Location

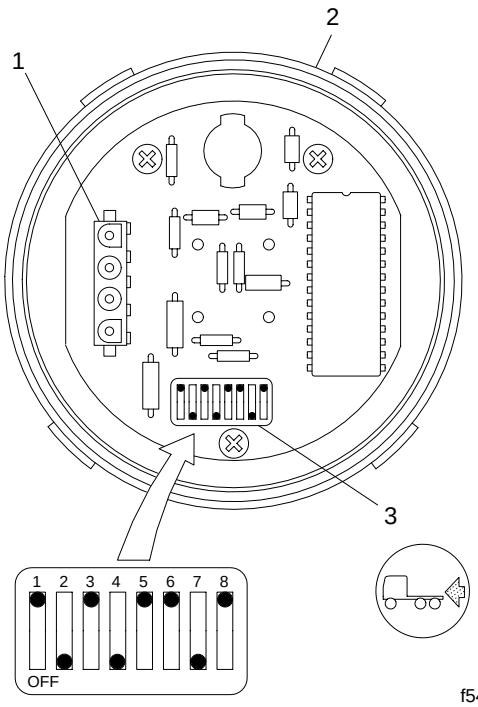
When the engine is running, the teeth of the turning flywheel ring gear generate electrical pulses in the sensor's magnetic field. These pulses tell the tachometer head how fast the engine is turning. For the tachometer head to interpret the pulses as engine speed, it must be programmed (calibrated) for the number of teeth on the flywheel ring gear. At the back of the tachometer head are 8 DIP switches (rocker switches). See **Fig. 3**. The tachometer is calibrated by positioning the rocker switches on or off to correspond to the code determined for the number of teeth on the ring gear. A new tachometer head must be calibrated before it is installed.



1. Flywheel Ring Gear
2. Flywheel Housing
3. Magnetic Sensor Jam Nut
4. Tachometer Magnetic Sensor
5. Metri-Pack Connector
6. Magnetic Sensor Wiring (to tachometer)

Fig. 2, Magnetic Sensor and Flywheel Ring Gear (rear view)

General Information



NOTE: Example shows switches set for calibration code 10101101: S1=ON, S2=OFF, S3=ON, S4=OFF, S5=ON, S6=ON, S7=OFF, and S8=ON. The black dot shows which end to press in.

1. Mate-N-Lok Connector Half
2. Tachometer Head
3. DIP Switches

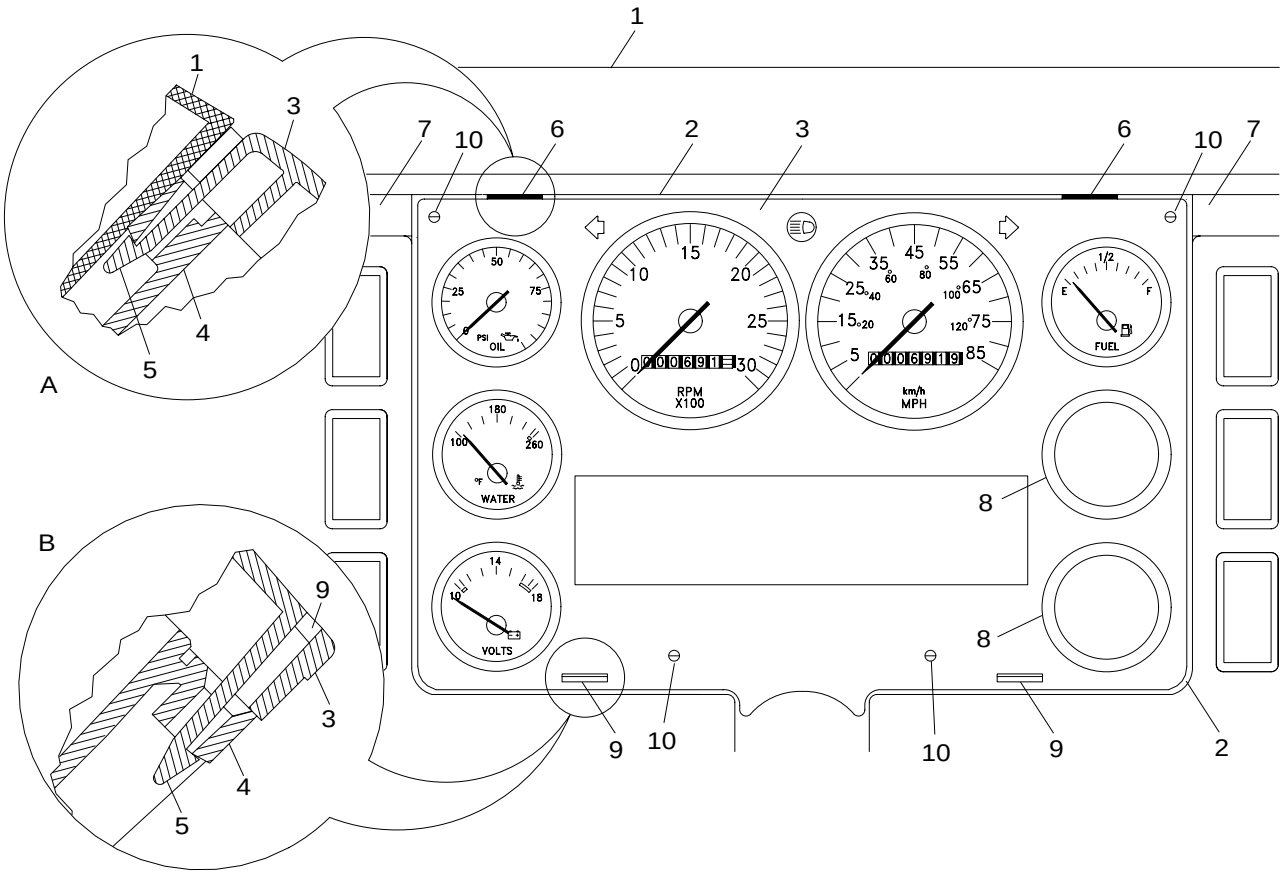
Fig. 3, Rear View of Tachometer Head

Removal

1. Remove the instrument panel.

   1.1 By hand, remove the vinyl extrusion trim (**Fig. 1**, Ref. 7) on the sides of the instrument panel.

   1.2 On vehicles built after late January/early February 1997, remove the four Torx-head screws from the instrument panel.



09/16/97 f600386a

A. Sectional Detail (left-side view)
B. Sectional Detail (left-side view)

1. Upper Dash Cover
2. Foam Gasket
3. Instrument Panel
4. Gauge Housing
5. Panel Locking Tab
6. Opening in Foam Gasket
7. Vinyl Extrusion Trim
8. Gauge Blank (block-off plug)
9. Slot in Panel
10. Torx-Head Screws

Fig. 1, Instrument Panel

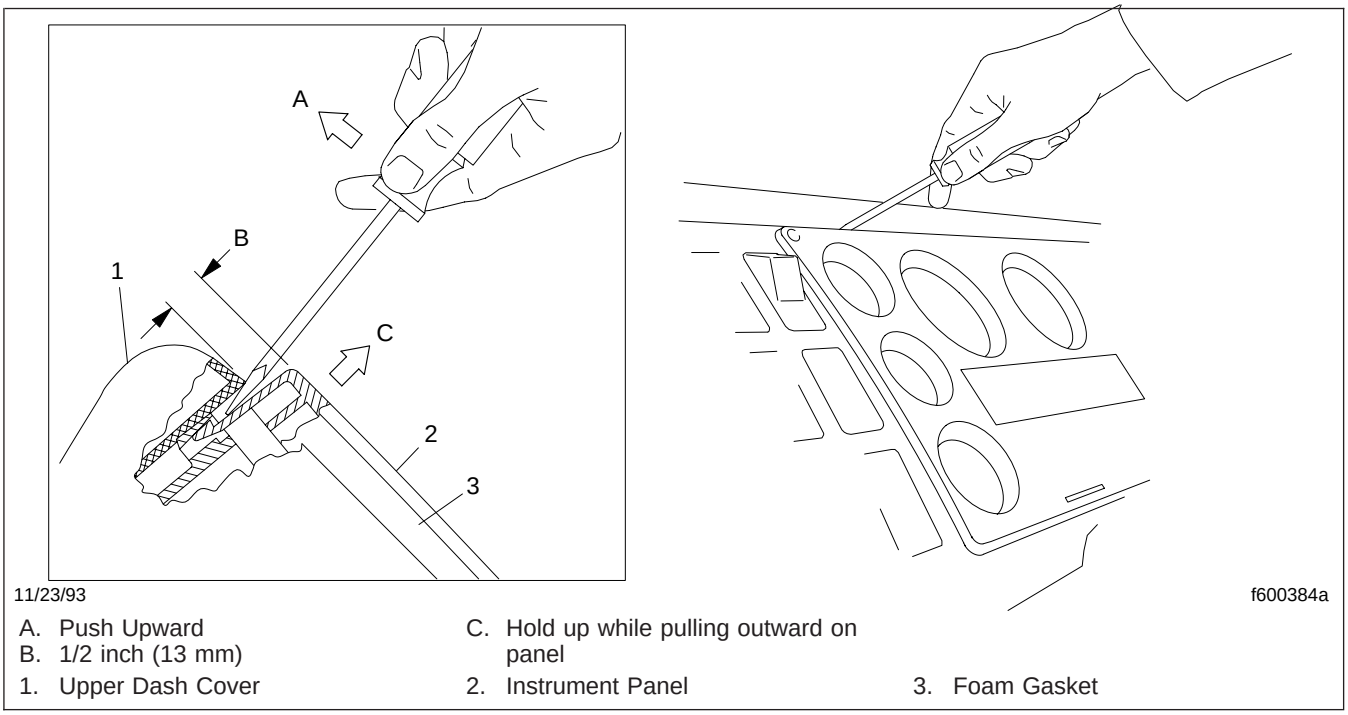
NOTE: Vehicles manufactured after late January/early February 1997, use spring-loaded Torx®-head screws to fasten the instrument panel (see **Fig. 1**, Ref. 10). This is in lieu of locking tabs.

1.3 On vehicles built earlier, insert a stubby plain-tip screwdriver in an opening in the foam gasket (see **Fig. 1**, Ref. 6), gently pry down the panel locking tab (**Fig. 1**,

Tachometer Head Removal and Installation

Ref. 5). Hold up on the screwdriver, while pulling that corner of the panel out about 1/2-inch (13 mm) from the upper dash cover. See **Fig. 2**. Use care not to damage the foam gasket.

2.2 Use your thumbs to gently, simultaneously press the locking tabs away from the bosses on the tachometer case. See **Fig. 5**. Then, lift the tachometer head away from the gauge housing.



A. Push Upward
B. 1/2 inch (13 mm)
C. Hold up while pulling outward on panel
1. Upper Dash Cover
2. Instrument Panel
3. Foam Gasket

Fig. 2, Upper Dash Cover

1.4 Repeat the above step for the other upper corner, then tilt the top of the panel out about 1 inch (25 mm). Work the bottom of the panel out of the dash. If the bottom of the panel won't move, use a screwdriver to pry up the locking tabs at the bottom of the panel. See **Fig. 3**.

1.5 Work the panel off the dash, using care not to damage the foam gasket.

2. Remove the tachometer head from the dashboard.

IMPORTANT: Don't touch the tachometer face or pointer.

2.1 Lift out the right-hand turn signal indicator-light tunnel and the right-hand warning-light separator. See **Fig. 4**.

2.3 Install the right-hand turn signal indicator-light tunnel and right-hand warning-light separator.

2.4 Squeeze the connector release tabs while pulling the harness half of the Mate-N-Lok connector, to disconnect it from the back of the tachometer head. See **Fig. 6** and **Fig. 7**.

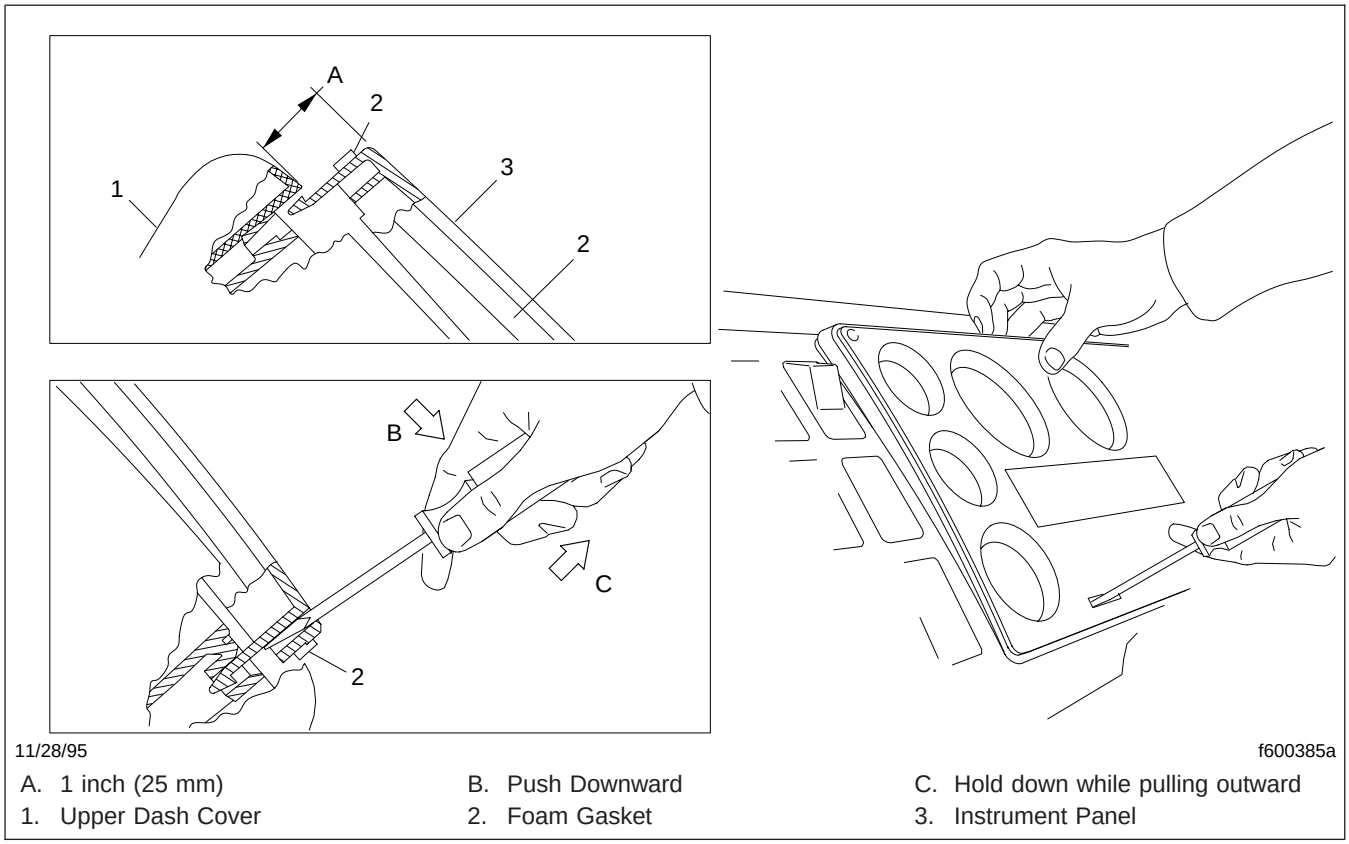
Installation

NOTE: Before installing the tachometer head, be sure it is calibrated; see **Subject 110**.

1. Install the tachometer head in the dashboard.

1.1 Connect the wiring harness to the tachometer head. See **Fig. 6**. Be sure the upper and lower lock tabs are locked.

Tachometer Head Removal and Installation



A. 1 inch (25 mm)
B. Push Downward
C. Hold down while pulling outward
1. Upper Dash Cover
2. Foam Gasket
3. Instrument Panel

Fig. 3, Panel Removal

1.2 Line up the bosses on the tachometer case with the locking tabs on the gauge housing. Feed the wiring harness through the opening in the gauge housing, and press the tachometer head into place until the locking tabs are locked over the bosses. See **Fig. 4**.

2. Install the instrument panel. See **Fig. 1**.

2.1 Position the instrument panel against the dash. See **Fig. 1**

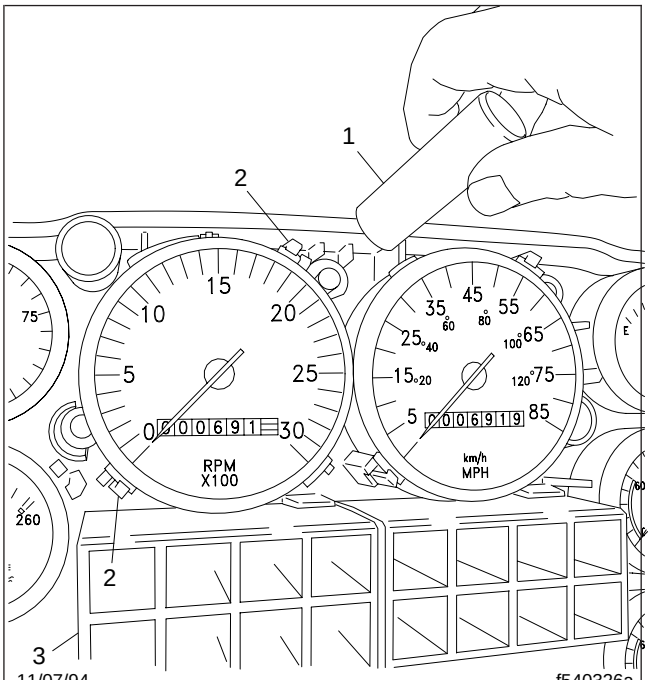
2.2 On vehicles built after late January/early February 1997, install the four spring-loaded Torx-head screws and tighten them until firm.

On vehicles built earlier, lock the four locking tabs, by pushing alternately, starting with the lower corner, against the bottom and top corners of the panel, until the face of the panel is flush with the rest of the instrument panel.

IMPORTANT: Don't push against the lenses of the gauge blanks.

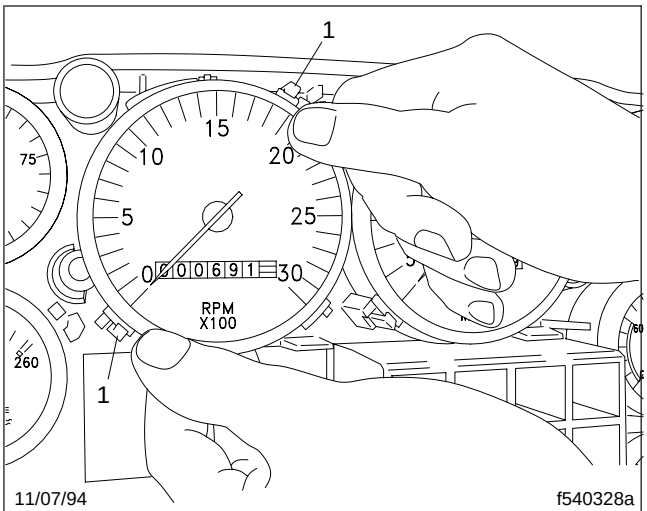
2.3 Install the vinyl extrusion trim (See **Fig. 1**, Ref. 7) on both sides of the panel.

Tachometer Head Removal and Installation



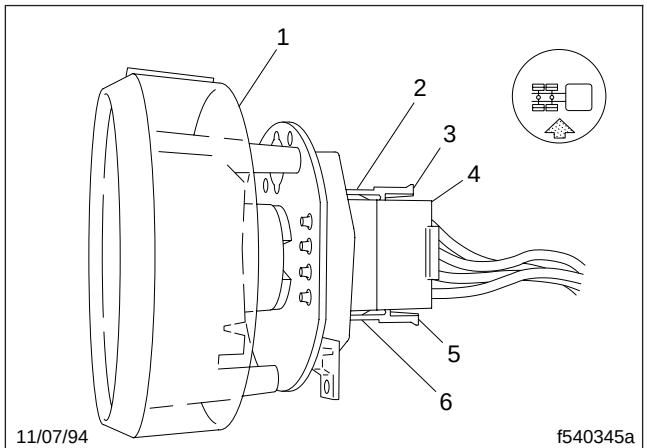
1. High-Beam Headlamp Indicator Light Tunnel
2. Tachometer Locking Tab
3. Left-Hand Warning-Light Separator

Fig. 4, Left-Hand Turn Signal Indicator-Light Tunnel



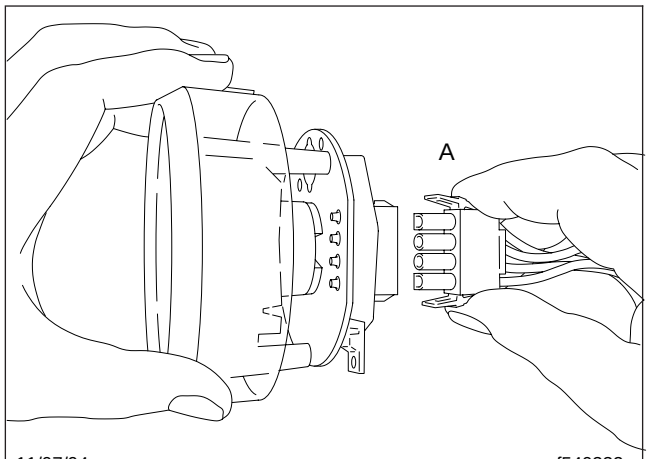
1. Locking Tabs

Fig. 5, Tachometer Head Removal



1. Tachometer Head
2. Lock Tab
3. Release Tab
4. Mate-N-Lok Connector
5. Release Tab
6. Lock Tab

Fig. 6, Wiring Harness and Tachometer Head (connected)



A. Squeeze the release tabs, then pull out on the connector to remove.

Fig. 7, Wiring Harness and Tachometer Head (disconnected)

Calibration

Always calibrate a new tachometer head before installing it.

1. See **Table 1** to determine the tachometer calibration setting.

Tachometer Calibration Settings								
Engine	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**
Cummins 6BTA	ON	OFF	ON	OFF	ON	ON	OFF	ON
Mercedes-Benz OM 366LA	ON	OFF	ON	OFF	ON	OFF	ON	OFF
Cummins C	ON	OFF	OFF	OFF	ON	OFF	ON	OFF
All Electronic Engines	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF

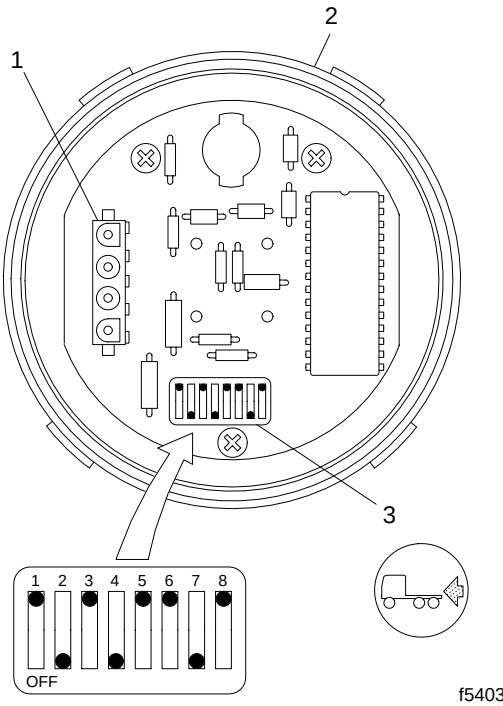
Table 1, Tachometer Calibration Settings

2. Set the positions of the eight rocker (DIP) switches to ON or OFF as indicated by the calibration code. See **Fig. 1**.

   A 0 (zero) indicates OFF, and a 1 (one) indicates ON. Using a scribe, an awl, or a straightened paper clip, depress the top of the rocker switch to set it to ON; depress the bottom to set it to OFF.

   For example, to match the calibration code 10101101, the number 1 rocker switch is ON (top is depressed), the number 2 switch is OFF (bottom is depressed), number 3 is ON, 4 is OFF, 5 and 6 are ON, 7 is OFF, and 8 is ON. See **Fig. 1**.

3. Remove the old tachometer and install the new calibrated tachometer; see **Subject 100.**



NOTE: Example shows switches set for calibration code 10101101: S1=ON, S2=OFF, S3=ON, S4=OFF, S5=ON, S6=ON, S7=OFF, and S8=ON. The black dot shows which end to press in.

1. Mate-N-Lok Connector Half
2. Tachometer Head
3. DIP Switches

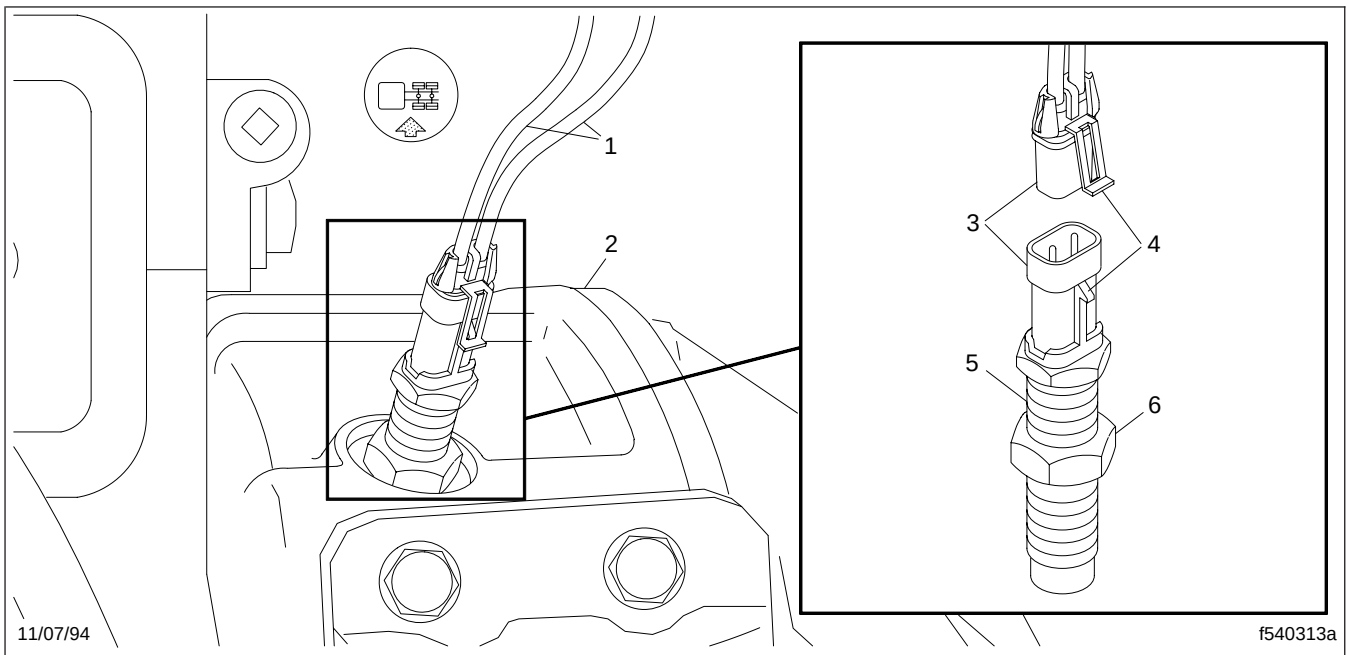
Fig. 1, Rear View of the Tachometer Head

Replacement and Adjustment

1. Apply the parking brakes, shut down the engine, and chock the tires.
2. Remove the magnetic sensor.
   - 2.1 Disconnect the Metri-Pack® connector from the magnetic sensor. See **Fig. 1**.
   - 2.2 Loosen the magnetic sensor jam nut. See **Fig. 2**. Turn the magnetic sensor out of the flywheel housing.
3. Adjust the new sensor. See **Fig. 3**.
   - 3.1 Back off to the outboard end of the new magnetic sensor.
   - 3.2 Turn the sensor by hand into the flywheel housing until it bottoms out on the teeth of the flywheel ring gear.
   - 3.3 Back out the sensor three-quarters of a turn. See **Fig. 3**.
4. Install the new sensor.
   - 4.1 While holding the sensor in place to keep it from turning, tighten the jam nut 18 lbf·ft (25 N·m).

IMPORTANT: Maintain the correct sensor adjustment, or the tachometer reading will not be correct.

   - 4.2 Connect the wiring to the sensor and be sure the Metri-Pack connector is locked in place. See **Fig. 1**.
5. Remove the chocks from the tires.
6. Test drive the vehicle and check that the tachometer is operating. If there is no tachometer reading, the magnetic sensor was probably not adjusted correctly; readjust the sensor.



1. Tachometer Wiring
2. Flywheel Housing
3. Metri-Pak Connector Halves
4. Connector Lock Halves
5. Magnetic Sensor
6. Jamnut

Fig. 1, Multi-Pack Connector Removal

Magnetic Sensor Replacement and Adjustment

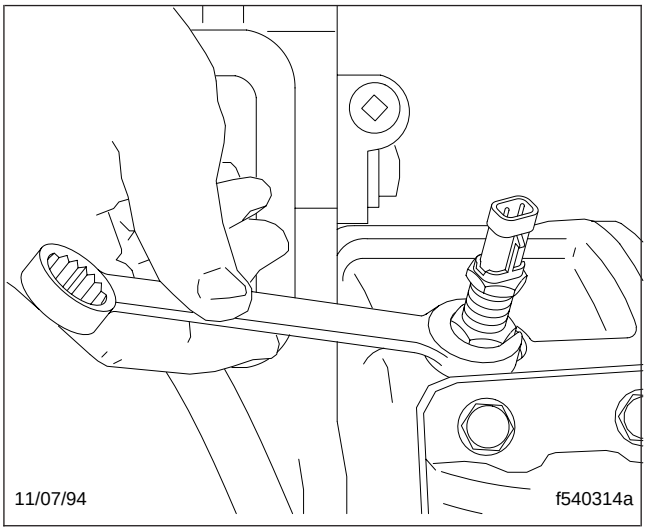
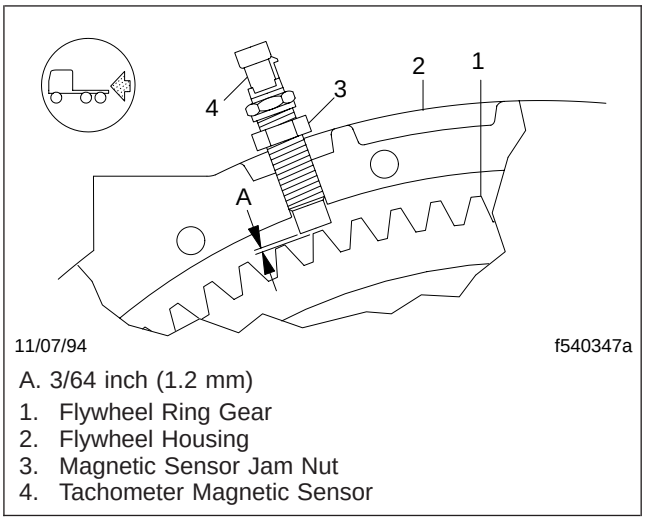


Fig. 2, Loosen the Magnetic Sensor Jam Nut



A. 3/64 inch (1.2 mm)
1. Flywheel Ring Gear
2. Flywheel Housing
3. Magnetic Sensor Jam Nut
4. Tachometer Magnetic Sensor

Fig. 3, Cutaway View of an Installed Sensor

Troubleshooting Procedures

Tachometer malfunctions are usually one of two types: the tachometer does not operate at all, or the tachometer readings are inaccurate.

INACCURATE TACHOMETER

Inaccurate tachometer readings may occur whenever a new tachometer head is installed. Calibrate the tachometer head using the procedure in **Subject 110**.

Inaccurate readings will also occur if the magnetic sensor is not adjusted correctly. Before troubleshooting the system, make sure the magnetic sensor is correctly adjusted. For instructions, see **Subject 120**. Also, make sure the batteries are fully charged.

THE TACHOMETER DOES NOT OPERATE

1. Test the magnetic sensor's output voltage.

   NOTE: To receive an accurate tachometer reading, a minimum of one volt AC output is needed from the magnetic sensor.

   1.1 Disconnect the Metri-Pack® connector from the magnetic sensor. See **Fig. 1**. Make sure that both halves of the connection are free of corrosion and moisture.

   1.2 Connect the leads of an AC voltmeter to the pins of the magnetic sensor. See **Fig. 2**.

   1.3 Run the engine at idle speed, and check the voltage output from the sensor. Then shut down the engine.

   If the voltage is less than one volt, and the sensor was correctly adjusted before troubleshooting the system, the magnetic sensor is damaged; replace it.

   If the voltage is at least one volt, continue the procedure.

2. Connect the leads of an ohmmeter to the pins of the magnetic sensor. See **Fig. 3**. The resistance should measure 876 ± 88 ohms.

   NOTE: Resistance will vary on optional sensors. Contact the manufacturer for the acceptable sensor resistance.

   If the resistance is outside the acceptable range, replace the sensor; see **Subject 120**.

   If the resistance is in the acceptable range, connect the wiring to the sensor and be sure the Metri-Pack connector is locked in place. See **Fig. 1**. Then go on to check the wiring between the magnetic sensor and the tachometer head.

3. Check the wiring between the magnetic sensor and the tachometer head. See **Fig. 4**.

   3.1 Remove the tachometer head from the dash and disconnect the wiring harness from the tachometer head; see **Subject 100**.

   3.2 Check for an open or short circuit by inserting the ohmmeter leads in towers 2 and 4 of the wiring harness half of the Mate-N-Lok connector (for wiring circuit numbers 162 and 163, respectively). See **Fig. 4**. The resistance should measure 876 ± 88 ohms.

   NOTE: Resistance will vary on optional sensors. Contact the manufacturer for the acceptable sensor resistance.

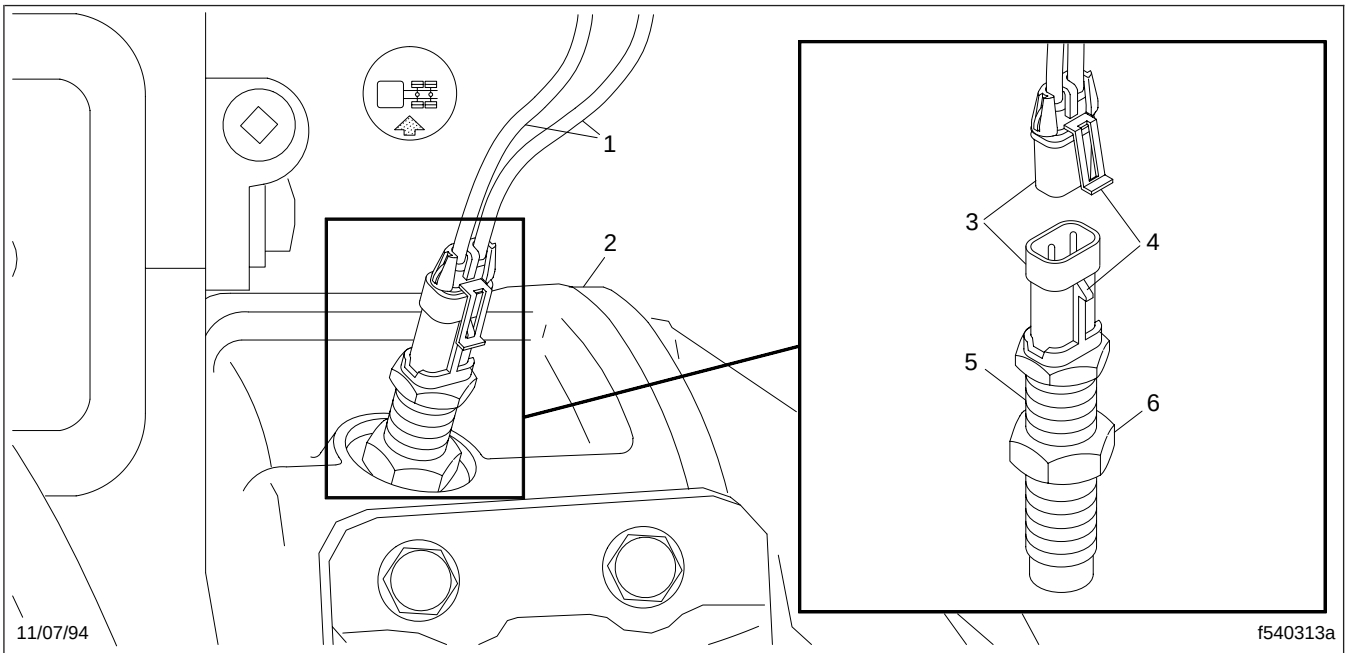
   3.3 If the resistance is outside the acceptable range, the problem is in the wiring between the tachometer head and the magnetic sensor. Repair or replace the damaged wiring. Then install the tachometer head; see **Subject 100**.

   If the resistance is in the acceptable range, connect the wiring harness to the tachometer head and be sure the Mate-N-Lok connector is locked in place. Then go on to check the battery voltage at the tachometer head.

4. Check the battery voltage at the tachometer head. See **Fig. 5**.

   4.1 With the ignition switch on, touch the probes of a DC voltmeter to pins 1 and 3 on the front side of the rear plate of the tachometer head (where the pins of the connector extend through the rear plate). See **Fig. 5**. Touch the negative (black) probe to pin 1, and the positive (red) probe to pin 3. The voltmeter should read 9 to 16 volts DC.

Troubleshooting



1. Tachometer Wiring
2. Flywheel Housing
3. Metri-Pack Connector Halves
4. Connector Lock Halves
5. Magnetic Sensor
6. Jamnut

Fig. 1, Metri-Pack Connector

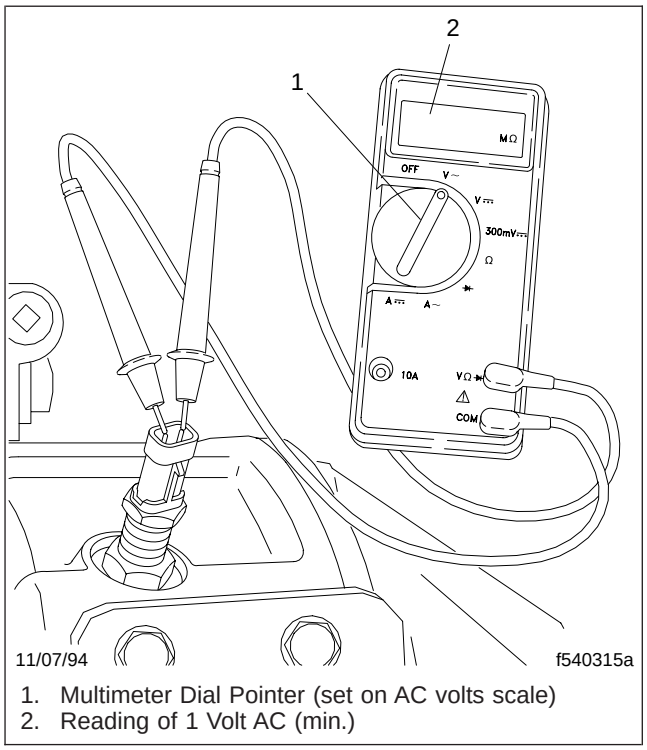
4.2 If the voltage *is* between 9 and 16 volts DC, but the tachometer readings are *not* accurate, then the tachometer head, not the wiring, is causing inaccurate readings. Disconnect the voltmeter and turn off the ignition switch. Replace the tachometer head; see **Subject 100**.

If the voltage is *not* between 9 and 16 volts DC, check the wiring between the ignition switch and the tachometer head, and between the tachometer head and ground. Disconnect the voltmeter and turn off the ignition switch. Repair or replace the damaged wiring. Install the tachometer head; see **Subject 100**.

Troubleshooting Tables

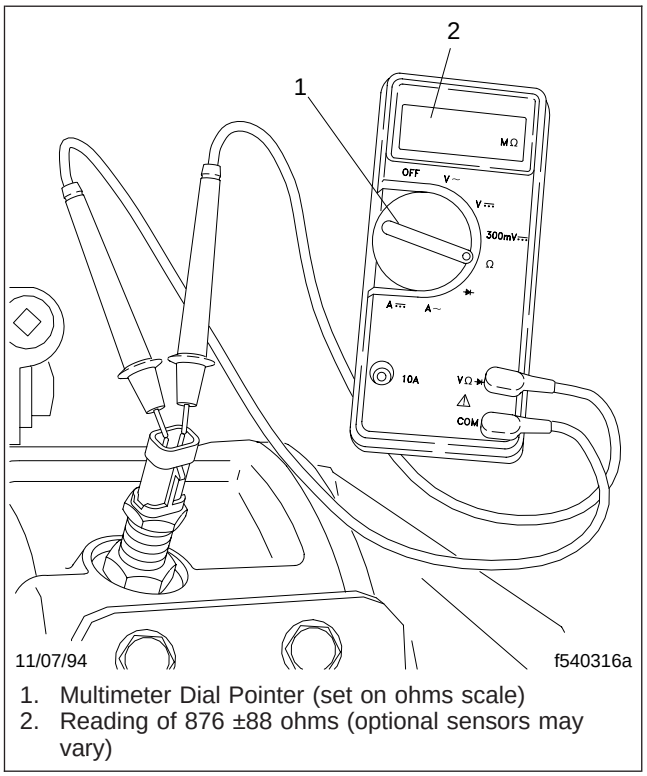
This subject contains the following troubleshooting tables:

- Less Than One Volt Reading from Magnetic Sensor
- Tachometer Head Will Not Register
- Inaccurate Tachometer Readings



1. Multimeter Dial Pointer (set on AC volts scale)
2. Reading of 1 Volt AC (min.)

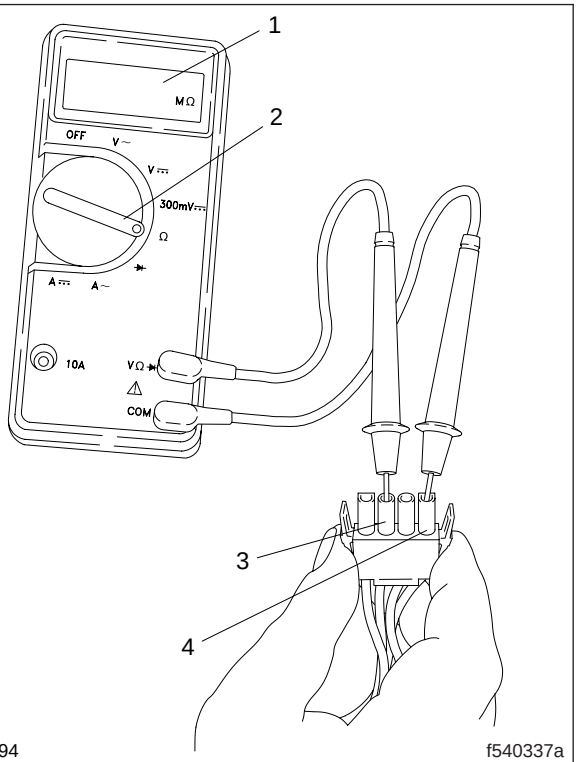
Fig. 2, Connect the Leads of AC Voltmeter to Magnetic Sensor



1. Multimeter Dial Pointer (set on ohms scale)
2. Reading of 876 ±88 ohms (optional sensors may vary)

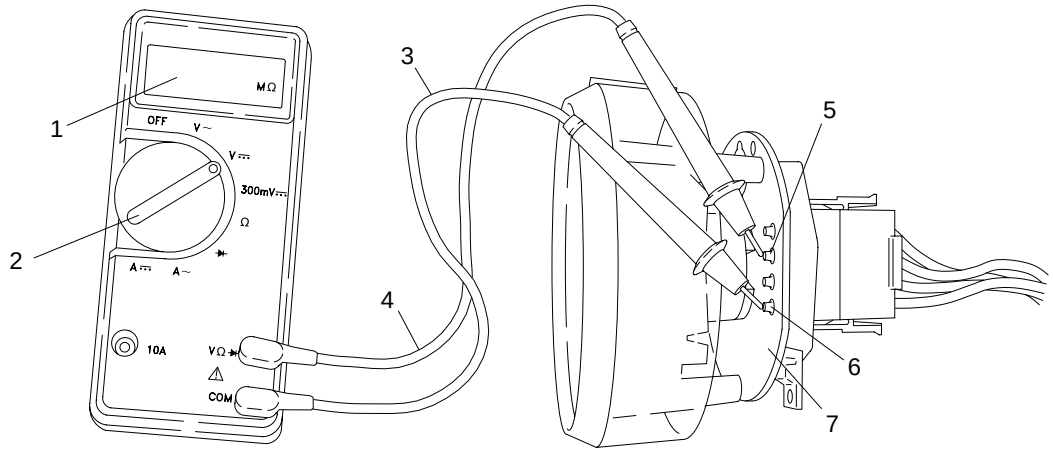
Fig. 3, Connect the Leads of the Ohmmeter to the Pins of the Magnetic Sensor

Troubleshooting



1. Reading of 876 ±88 ohms (optional sensors may vary)
2. Multimeter Dial Pointer (set on ohms scale)
3. Tower #2 of Mate-N-Lok Connector
4. Tower #4 of Mate-N-Lok Connector

Fig. 4, Check for Open or Short Circuit



11/07/94 f540333a

1. Reading of 9 to 16 Volts DC
2. Multimeter Dial Pointer (set on DC volts scale)
3. Black Lead
4. Red Lead
5. Pin #3
6. Pin #1
7. Rear Plate of Tachometer Head

Fig. 5, Touch Probes of Voltmeter to Tachometer Head

Problem—Less Than One Volt Reading from Magnetic Sensor

Problem—Less Than One Volt Reading from Magnetic Sensor	
Possible Cause	**Remedy**
The magnetic sensor gap is incorrectly adjusted.	Adjust the magnetic sensor.
The magnetic sensor is damaged.	Replace the magnetic sensor.

Problem—Tachometer Head Will Not Register

Problem—Tachometer Head Will Not Register	
Possible Cause	**Remedy**
The magnetic sensor gap is incorrectly adjusted.	Adjust the magnetic sensor.
The magnetic sensor is damaged.	Replace the magnetic sensor.
Loose or corroded terminals, broken contacts, broken wires, shorting, or frayed wires are causing an incomplete circuit.	Replace the damaged wiring component(s) as necessary.
The tachometer head is damaged internally.	Replace the tachometer head only after checking all other possible causes.

Troubleshooting

Problem—Inaccurate Tachometer Readings

Problem—Inaccurate Tachometer Readings	
Possible Cause	**Remedy**
The magnetic sensor gap is incorrectly adjusted.	Adjust the magnetic sensor.
Shorts are occurring in the magnetic sensor.	Check the resistance of the magnetic sensor. Replace the sensor if necessary.
The tachometer head is incorrectly calibrated.	Recalibrate the tachometer head.
Erratic readings are resulting from loose electrical connections.	Check all the wiring in the tachometer system. Tighten all loose connections.

Specifications

This subject contains the following table:

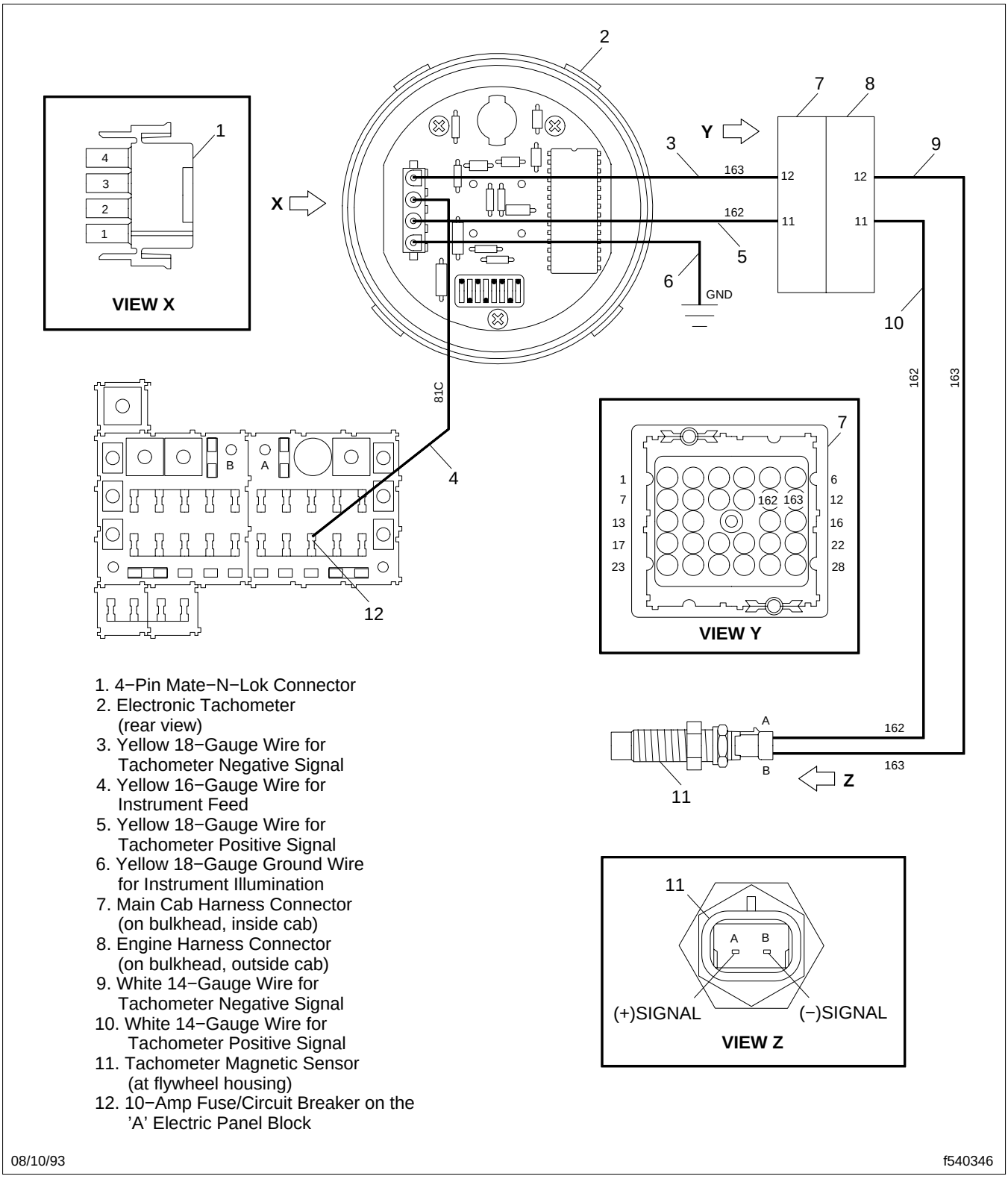
- Tachometer Head Calibration

See **Fig. 1** for a tachometer wiring diagram.

Engine	Calibration Code
Cummins 6BTA Mercedes-Benz OM 366LA	10101101

Table 1, Tachometer Head Calibration

Specifications



1. 4−Pin Mate−N−Lok Connector
2. Electronic Tachometer (rear view)
3. Yellow 18−Gauge Wire for Tachometer Negative Signal
4. Yellow 16−Gauge Wire for Instrument Feed
5. Yellow 18−Gauge Wire for Tachometer Positive Signal
6. Yellow 18−Gauge Ground Wire for Instrument Illumination
7. Main Cab Harness Connector (on bulkhead, inside cab)
8. Engine Harness Connector (on bulkhead, outside cab)
9. White 14−Gauge Wire for Tachometer Negative Signal
10. White 14−Gauge Wire for Tachometer Positive Signal
11. Tachometer Magnetic Sensor (at flywheel housing)
12. 10−Amp Fuse/Circuit Breaker on the 'A' Electric Panel Block

08/10/93 f540346

Fig. 1, Tachometer Wiring Diagram

General Information

The Ametek electronic speedometer consists of a dash-mounted gauge (speedometer head), a transmission-mounted magnetic sensor, and the electrical wires that provide power to the speedometer and complete the circuit between the components.

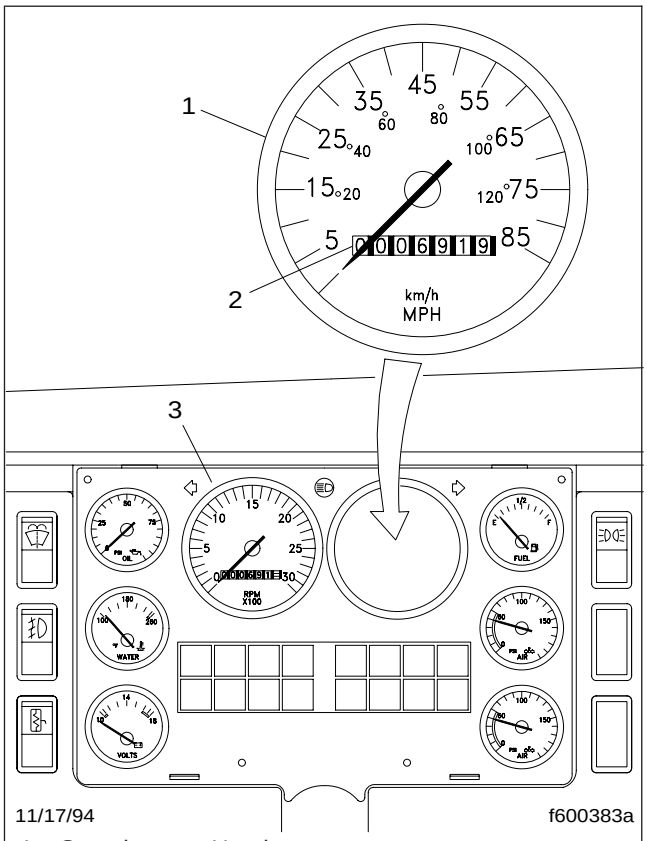
A vehicle built for use in the U.S.A. has a speedometer head that registers vehicle speed in miles per hour (mph) on its outer (major) scale and in kilometers per hour (km/h) on its inner (minor) scale, and records total distance traveled in miles on a 7-wheel odometer. See **Fig. 1**. A speedometer head for a vehicle built for use in Canada, registers vehicle speed in km/h on the outer scale (and mph on the inner scale), and has a 7-wheel odometer that records distance in kilometers.

The magnetic sensor is mounted with its magnetic end extending through a threaded bore in the transmission bearing cover. It stops a little over 1/32-inch (1 mm) from the teeth of a standard 16-tooth spacer gear located under the cover, on the inboard end of the transmission output shaft. See **Fig. 2**.

When the vehicle is moving, the teeth of the turning spacer gear generate electrical pulses in the sensor's magnetic field. These pulses tell the speedometer head how fast the transmission output shaft is turning. For the speedometer head to interpret the pulses as vehicle speed and distance traveled, it must be programmed (calibrated) for the components with which the vehicle is equipped.

At the back of the speedometer head are 10 DIP switches (rocker switches). See **Fig. 3**. The speedometer is calibrated by positioning the rocker switches on or off to correspond to the code determined for the specific combination of the number of teeth on the transmission spacer gear, the axle reduction ratio, and the tire size (tire revolutions per mile). For each possible combination, there is a different calibration code.

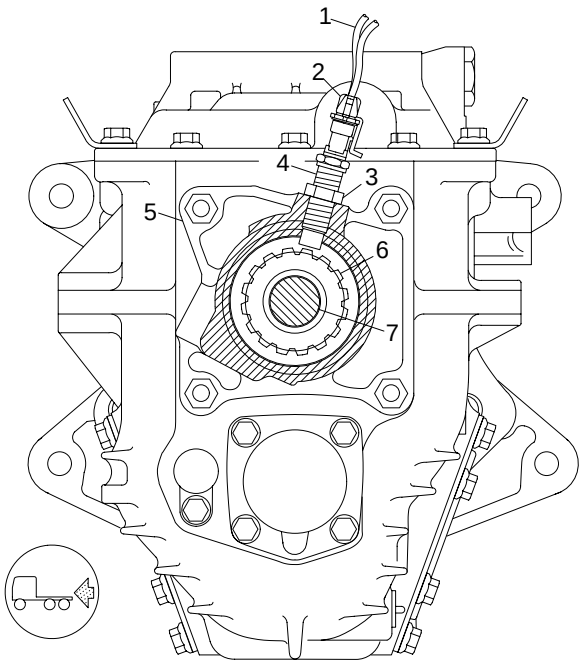
A new speedometer head must be calibrated before it is installed. Whenever different tires are installed on the vehicle, the speedometer head must be recalibrated.



1. Speedometer Head
2. Seven-Wheel Odometer
3. Instrument Panel

Fig. 1, Speedometer/Odometer Location

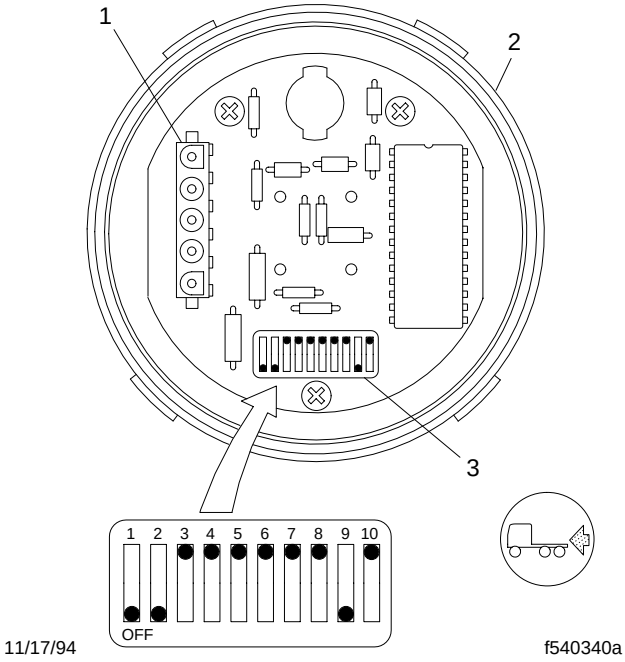
General Information



NOTE: Eaton FS4005 Series Transmission Shown

1. Speedometer Wiring
2. Connector
3. Sensor Jam Nut
4. Magnetic Sensor
5. Transmission Bearing Cover
6. Speedometer Spacer Gear
7. Transmission Output Shaft

Fig. 2, Cutaway View of an Installed Magnetic Sensor (typical)



Note: Example shows switches set for calibration code 1011000010: S1=OFF, S2=OFF, S3=ON, S4=ON, S5=ON, S6=ON, S7=ON, S8=ON, S9=OFF, and S10=ON. The black dot shows which end to press in.

1. Mate-N-Lok Connector Half
2. Tachometer Head
3. DIP Switches

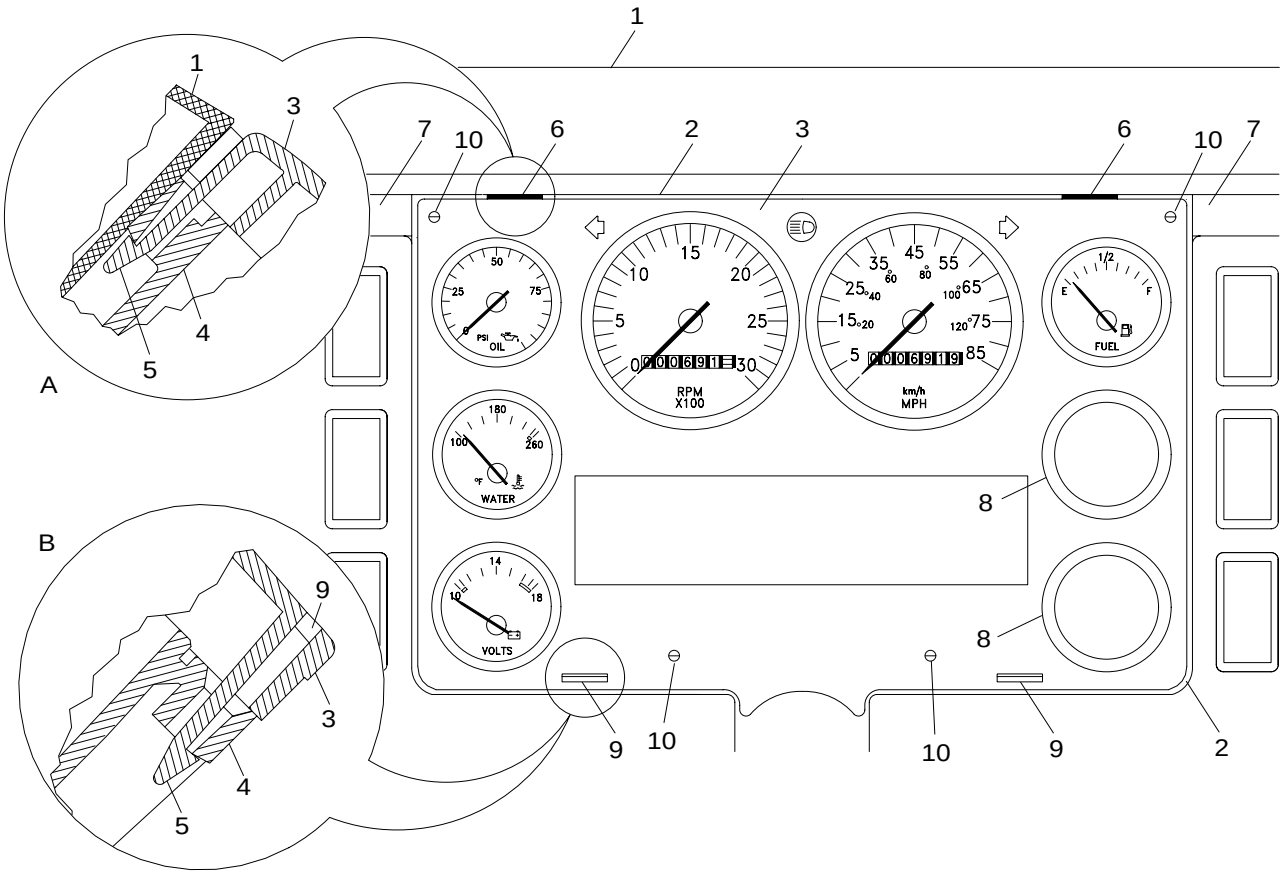
Fig. 3, Rear View of the Speedometer Head

Removal

1. Remove the instrument panel.

   1.1 By hand, remove the vinyl extrusion trim (**Fig. 1**, Ref. 7) on the sides of the instrument panel.

   1.2 On vehicles built after late January/early February 1997, remove the four Torx-head screws from the instrument panel.



A. Sectional Detail (left-side view)
B. Sectional Detail (left-side view)

1. Upper Dash Cover
2. Foam Gasket
3. Instrument Panel
4. Gauge Housing
5. Panel Locking Tab
6. Opening in Foam Gasket
7. Vinyl Extrusion Trim
8. Gauge Blank (Block-Off Plug)
9. Slot in Panel
10. Torx-head Screws

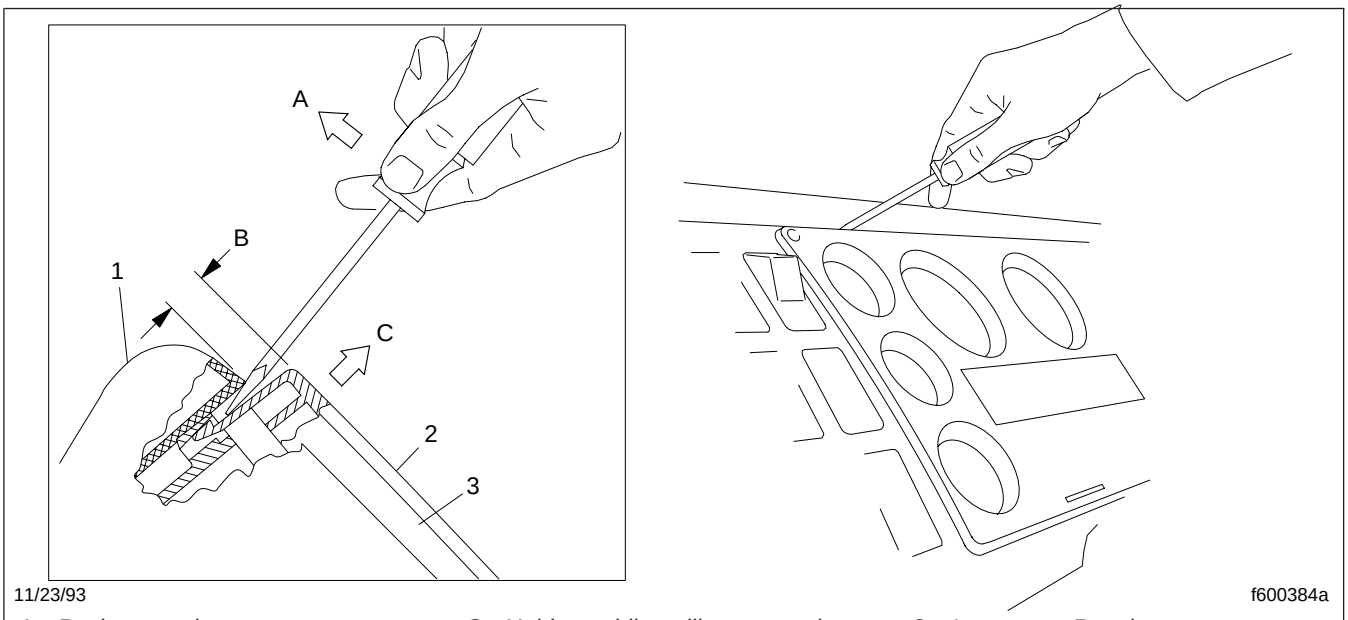
Fig. 1, Instrument Panel

NOTE: Vehicles manufactured after late January/early February 1997, use spring-loaded Torx®-head screws to fasten the instrument panel (see **Fig. 1**, Ref. 10). This is in lieu of locking tabs.

1.3 On vehicles built earlier, insert a stubby plain-tip screwdriver in an opening in the foam gasket (see **Fig. 1**, Ref. 6), gently pry down the panel locking tab (**Fig. 1**,

Speedometer Head Removal and Installation

Ref. 5). Hold up on the screwdriver, while pulling that corner of the panel out about 1/2 inch (13 mm) from the upper dash cover. See **Fig. 2**. Use care not to damage the foam gasket.



A. Push upward.
B. 1/2-inch (13 mm)
C. Hold up while pulling outward on panel.
1. Upper Dash Cover
2. Instrument Panel
3. Foam Gasket

Fig. 2, Upper Dash Cover

1.4 Repeat the above step for the other upper corner, then tilt the top of the panel out about 1 inch (25 mm). Work the bottom of the panel out of the dash. If the bottom of the panel won't move, use a screwdriver to pry up the locking tabs at the bottom of the panel. See **Fig. 3**.

Work the panel off the dash, using care not to damage the foam gasket.

2. Remove the speedometer head from the dashboard.

IMPORTANT: Don't touch the speedometer face or pointer.

2.1 Lift out the right-hand turn signal indicator-light tunnel and the right-hand warning-light separator. See **Fig. 4**.

2.2 Use your thumbs to gently, simultaneously press the locking tabs away from the bosses on the speedometer case. See **Fig. 5**. Then, lift the speedometer head away from the gauge housing.

2.3 Install the right-hand turn signal indicator-light tunnel and right-hand warning-light separator.

2.4 Squeeze the connector release tabs while pulling the harness half of the Mate-N-Lok connector, to disconnect it from the back of the speedometer head. See **Fig. 6** and **Fig. 7**.

Installation

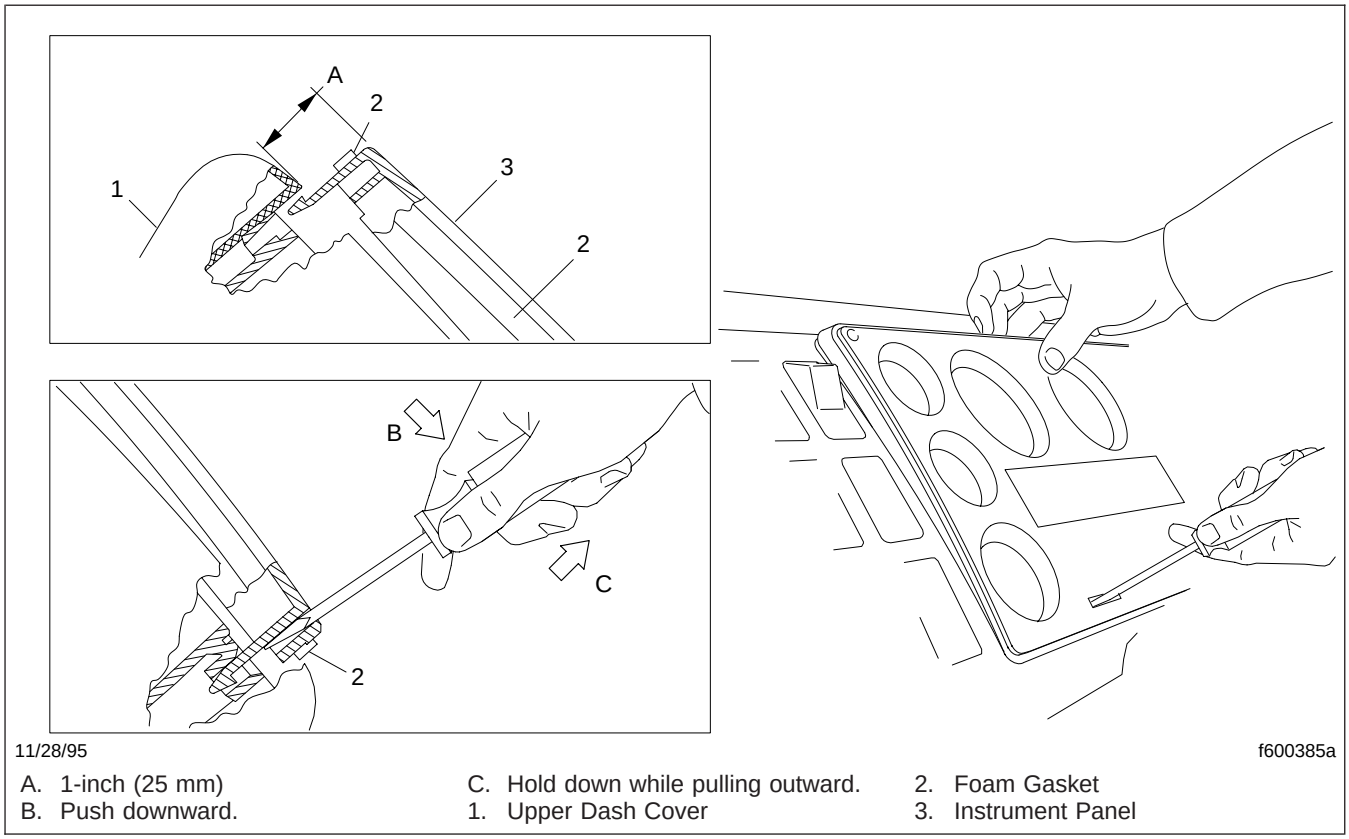
NOTE: Before installing the speedometer head, be sure it is calibrated; see **Subject 110**.

1. Install the speedometer head in the dashboard.

1.1 Connect the wiring harness to the speedometer head. See **Fig. 6**. Be sure the upper and lower lock tabs are locked.

1.2 Line up the bosses on the speedometer case with the locking tabs on the gauge

Speedometer Head Removal and Installation



A. 1-inch (25 mm)
B. Push downward.
C. Hold down while pulling outward.
1. Upper Dash Cover
2. Foam Gasket
3. Instrument Panel

Fig. 3, Panel Removal

housing. Feed the wiring harness through the opening in the gauge housing, and press the speedometer head into place until the locking tabs are locked over the bosses. See **Fig. 4**.

2. Install the instrument panel. See **Fig. 1**.

   2.1 Position the instrument panel against the dash. See **Fig. 1**

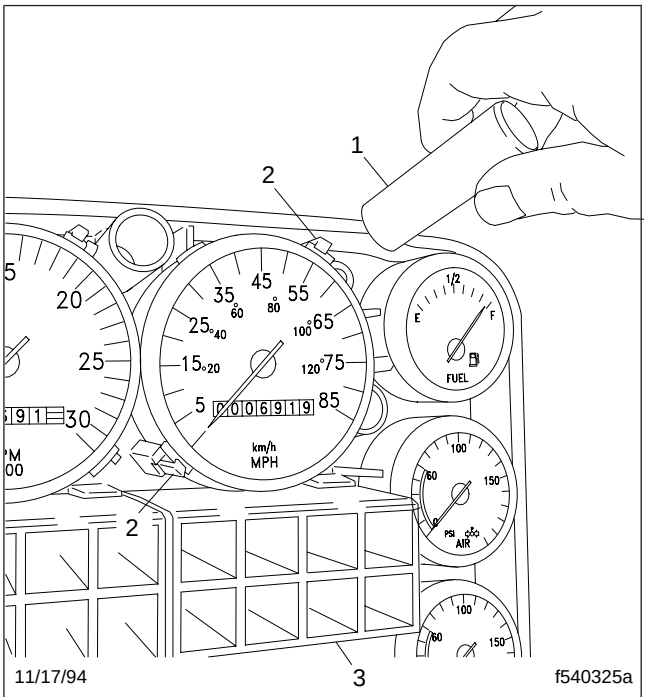
   2.2 On vehicles built after late January/early February 1997, install the four spring-loaded Torx-head screws and tighten them until firm.

   On vehicles built earlier, lock the four locking tabs, by pushing alternately, starting with the lower corner, against the bottom and top corners of the panel, until the face of the panel is flush with the rest of the instrument panel.

IMPORTANT: Don't push against the lenses of the gauge blanks.

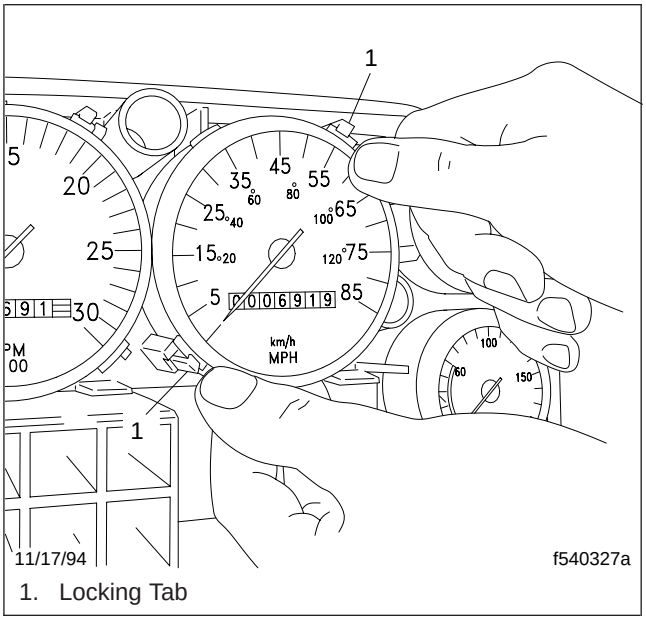
   2.3 Install the vinyl extrusion trim (See **Fig. 1**, Ref. 7) on both sides of the panel.

Speedometer Head Removal and Installation



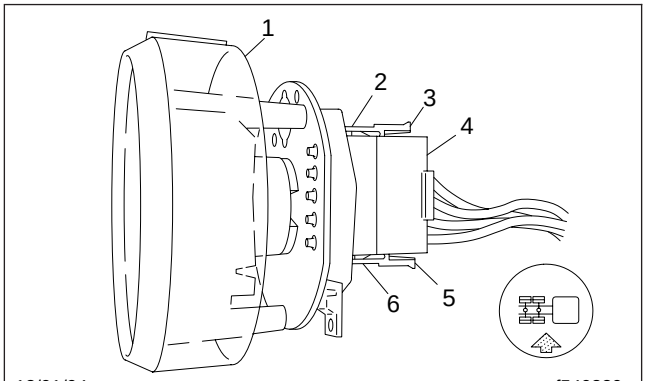
1. Right-Hand Turn Signal Indicator-Light Tunnel
2. Speedometer Locking Tab
3. Right-Hand Warning-Light Separator

Fig. 4, Right-Hand Turn Signal Indicator-Light Tunnel



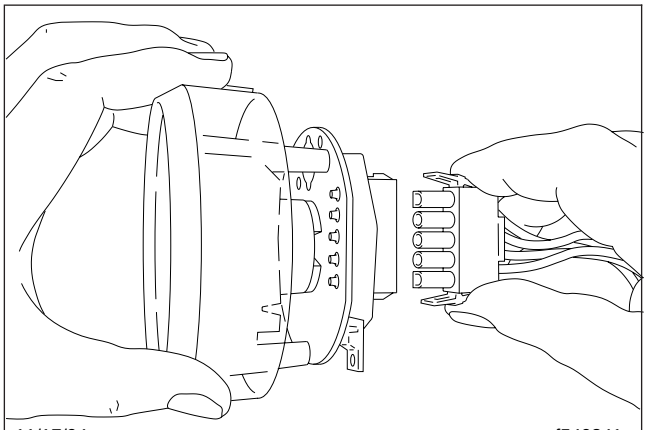
1. Locking Tab

Fig. 5, Speedometer Head Removal



1. Speedometer Head
2. Lock Tab
3. Release Tab
4. Mate-N-Lok Connector
5. Release Tab
6. Lock Tab

Fig. 6, Wiring Harness and Speedometer Head (connected)



Squeeze release tabs, then pull out on connector to remove.

Fig. 7, Wiring Harness and Speedometer Head (disconnected)

Calibration

Recalibrate the speedometer head whenever different tires (brand, size, or tread design) are installed. Always calibrate a new speedometer head before installing it.

1. Determine the speedometer calibration setting.

   1.1 Look on the sidewall of the vehicle's rear tires to find their size, manufacturer, and tread design. Contact the tire dealer or manufacturer to get the revolutions per mile (rev/mi) for those tires.

   1.2 Find the rear axle ratio (AR) on the vehicle specification decal, or on the identification plate attached to the axle housing.

   1.3 Calculate the number of electronic pulses per mile (pulses/mi) that are being sent to the speedometer, by multiplying the tire revolutions per mile (rev/mi) by the rear axle ratio (AR), then multiply the answer by the number of impulses (n) sent to the speedometer for each revolution of the transmission output shaft.

   NOTE: For all manual and automatic transmissions *n* equals 16 (there are 16 teeth on the transmission's speedometer impulse gear).

   1.4 Thus, rev/mi x AR x n = pulses/mi.

   For example, if the vehicle is equipped with Michelin 275/80R22.5 XZA-1 Pilote radial tires (516 rev/mi) and 3.91 rear axle ratio (3.91 AR), calculate pulses/mi as follows:

   516 (rev/mi) x 3.91 (AR) x 16 (n) = 32280 pulses/mi.

   1.5 Find the number in the "pulses per mile" column of the applicable table in **Specifications, 400** that comes closest to the calculated pulses per mile; then find the corresponding calibration code across from it in the other column.

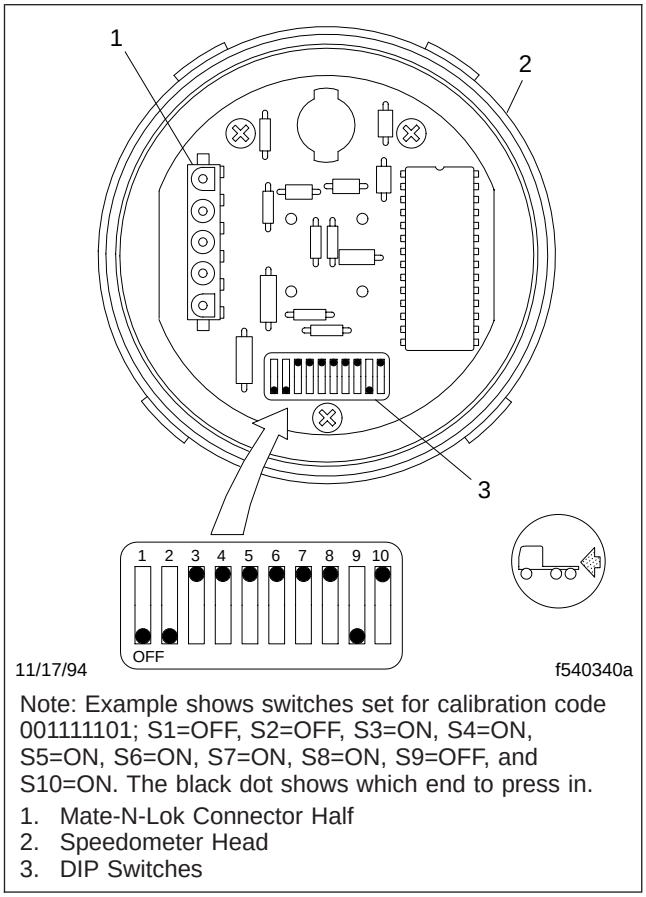
Using the calculation example, the corresponding calibration code for 32280 pulses/mi is 1011000010.

2. Remove the speedometer head from the dash; see **Subject 100.**
3. Set the positions of the ten rocker (DIP) switches to ON or OFF as indicated by the calibration code. See **Fig. 1**.

   A 0 (zero) indicates ON, and a 1 (one) indicates OFF.

   Using a scribe, an awl, or a straightened paper clip, depress the top of the rocker switch to set it to ON; depress the bottom to set it to OFF.

   Using the calculation example, the number 1 rocker switch is OFF (bottom is depressed), the number 2 switch is ON (top is depressed), number 3 is OFF, 4 is OFF, and so on, see **Fig. 1**.
4. Install the speedometer head; see **Subject 100.**.



Note: Example shows switches set for calibration code 001111101; S1=OFF, S2=OFF, S3=ON, S4=ON, S5=ON, S6=ON, S7=ON, S8=ON, S9=OFF, and S10=ON. The black dot shows which end to press in.

1. Mate-N-Lok Connector Half
2. Speedometer Head
3. DIP Switches

Fig. 1, Rear View of the Speedometer Head

Replacement and Adjustment

1. Apply the parking brakes, shut down the engine, and chock the tires.
2. Remove the magnetic sensor.
   - 2.1 Disconnect the Metri-Pack® connector from the magnetic sensor. See **Fig. 1**.
   - 2.2 Loosen the magnetic sensor jam nut. See **Fig. 2**. Turn the magnetic sensor out of the transmission bearing cover. If the sensor O-ring wasn't removed with the sensor, remove the O-ring from the bearing cover.
3. On Rockwell transmissions, install a new O-ring on the magnetic sensor. If installing a new sensor, leave the plastic cap on the end of the sensor. The cap serves as a gap gauge when installing the sensor. See **Fig. 1**.
4. Adjust the sensor. See **Fig. 3**.

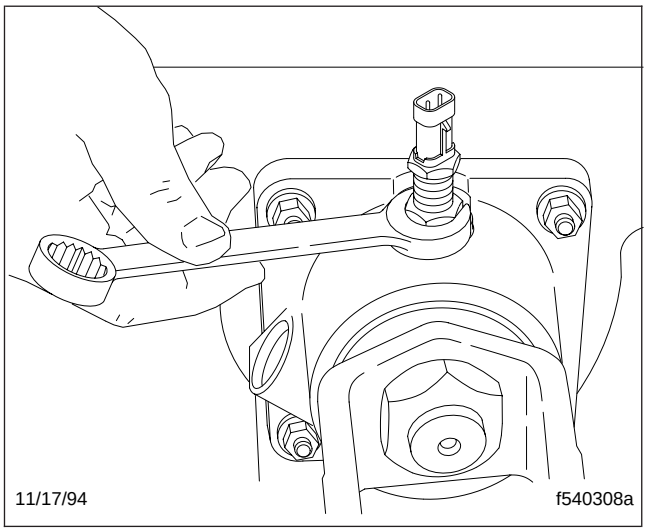
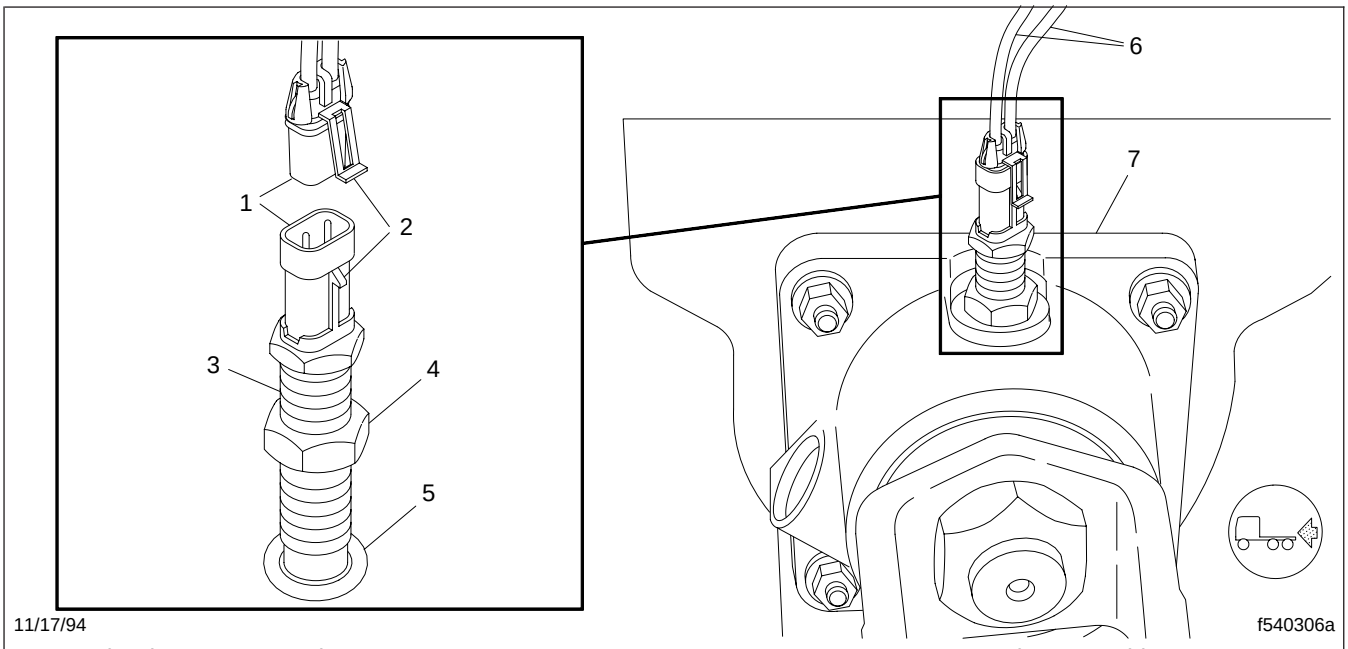


Fig. 2, Loosen the Magnetic Sensor Jam Nut

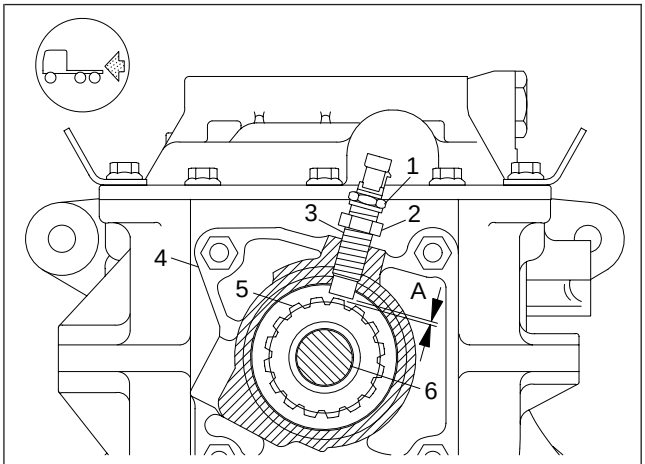
- 4.1 Back off the jam nut to the outboard end of the new magnetic sensor.
- 4.2 Turn the sensor by hand into the transmission bearing cover until it bottoms out on the gear teeth.



1. Metri-Pak Connector Halves
2. Connector Lock Halves
3. Magnetic Sensor
4. Jam Nut
5. O–Ring
6. Speedometer Wiring
7. Transmission Bearing Cover

Fig. 1, Multi-Pack Connector Removal

Magnetic Sensor Replacement and Adjustment



A. Space should be 3/64 inch (1.2 mm).
1. Magnetic Sensor
2. Magnetic Sensor Jam Nut
3. O–Ring
4. Transmission Bearing Cover
5. Speedometer Spacer Gear
6. Transmission Output Shaft

Fig. 3, Cutaway View of an Installed Sensor

4.3 If the magnetic sensor is installed without the plastic shim (gap gauge) back out the sensor three-quarters of a turn to adjust the gap.

NOTE: If the sensor was installed with the plastic cap (gap gauge), do not back out the sensor three-quarters of a turn since the gap has been set by the plastic cap.

5. Install the sensor. See **Fig. 1**

5.1 Holding the sensor in place to keep it from turning, tighten the jam nut 18 lbf·ft (25 N·m).

IMPORTANT: Maintain the correct sensor adjustment, or the speedometer reading won't be correct.

5.2 Connect the wiring to the sensor and be sure the Metri-Pack connector is locked in place. See **Fig. 1**.

6. Remove the chocks from the tires.

7. Test drive the vehicle and check that the speedometer is operating correctly. If there is no speedometer reading, the magnetic sensor was probably not adjusted correctly. Readjust the sensor.

Troubleshooting Procedures

INACCURATE SPEEDOMETER

Incorrect speedometer readings may occur whenever a new speedometer head or new tires are installed. In each case, calibrate the speedometer head using the procedure in **Subject 110**.

1. Test the accuracy of the speedometer head.

NOTE: Testing the accuracy of speedometer head readings is best done by commercial services specializing in such tests. If these commercial services aren't available, do the following odometer reading test.

2. Drive the vehicle over a measured mile to test the accuracy of the odometer.

An inaccurate odometer reading indicates incorrect speedometer head calibration. Calibrate the speedometer head; see **Subject 110**. Again check the accuracy of the odometer.

Inaccurate readings will also occur if the magmetic sensor is not adjusted correctly. Before troubleshooting the system, make sure the magnetic sensor is correctly adjusted. For instructions, see **Subject 120**. Also, make sure the batteries are fully charged.

THE SPEEDOMETER DOES NOT OPERATE

1. Check the resistance of the magnetic sensor.

   1.1 Disconnect the Metri-Pack® connector from the magnetic sensor. See **Fig. 1**. Make sure that both halves of the connection are free of corrosion and moisture.

   1.2 Connect the leads of an ohmmeter to the pins of the magnetic sensor. See **Fig. 2**. The resistance should measure 876 ± 88 ohms.

   If the resistance is outside the acceptable range, replace the sensor; see **Subject 120**.

   If the resistance is in the acceptable range, connect the wiring to the sensor and be sure the Metri-Pack connector is locked in place. See **Fig. 1**. Then go on to check the wiring between the magnetic sensor and the speedometer head.

2. Check the wiring between the magnetic sensor and the speedometer head. See **Fig. 3**.

   2.1 Remove the speedometer head from the dash and disconnect the wiring harness from the speedometer head; see **Subject 100** .

   2.2 Check for an open or short circuit by inserting the ohmmeter leads in towers 2 and 4 of the wiring harness half of the Mate-N-Lok connector (for wiring circuit numbers 117 and 118, respectively). See **Fig. 3**. The resistance should measure 876 ± 88 ohms.

   2.3 If the resistance is outside the acceptable range, the problem is in the wiring between the speedometer head and the magnetic sensor. Repair or replace the damaged wiring. Then install the speedometer head; see **Subject 100**.

   If the resistance is in the acceptable range, connect the wiring harness to the speedometer head and be sure the Mate-N-Lok connector is locked in place. Then go on to check the battery voltage at the speedometer head.

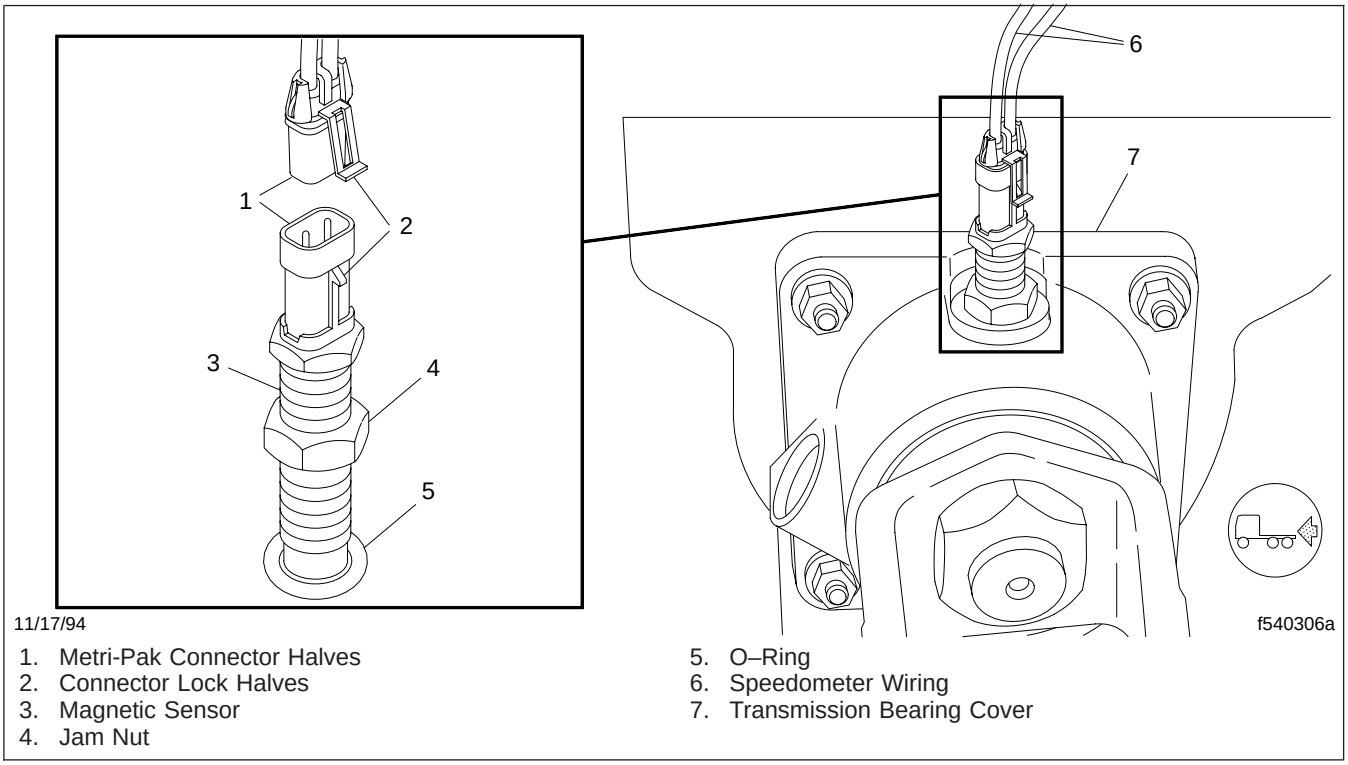
3. Check the battery voltage at the speedometer head. See **Fig. 4**.

   3.1 With the ignition switch on, touch the probes of a DC voltmeter to pins 1 and 3 on the front side of the rear plate of the speedometer head (where the pins of the connector extend through the rear plate). See **Fig. 4**. Touch the negative (black) probe to pin 1, and the positive (red) probe to pin 3. The voltmeter should read 9 to 16 volts DC.

   3.2 If the voltage is between 9 and 16 volts DC, but the speedometer readings are not accurate, then the speedometer head, not the wiring, is causing inaccurate readings. Disconnect the voltmeter and turn off the ignition switch. Replace the speedometer head; see **Subject 100**.

   If the voltage is not between 9 and 16 volts DC, check the wiring between the

Troubleshooting



1. Metri-Pak Connector Halves
2. Connector Lock Halves
3. Magnetic Sensor
4. Jam Nut
5. O–Ring
6. Speedometer Wiring
7. Transmission Bearing Cover

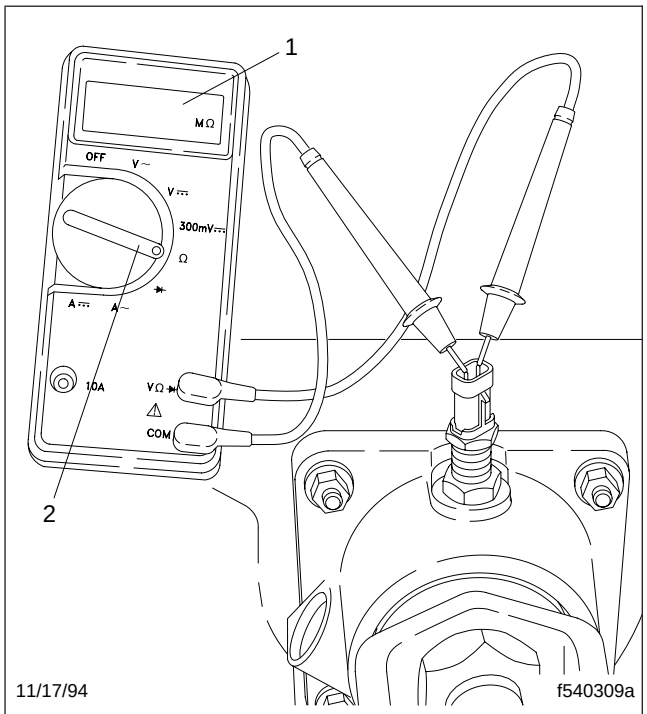
Fig. 1, Metri-Pack Connector

ignition switch and the speedometer head, and between the speedometer head and ground. Disconnect the voltmeter and turn off the ignition switch. Repair or replace the damaged wiring. Install the speedometer head; see **Subject 100.**

Troubleshooting Tables

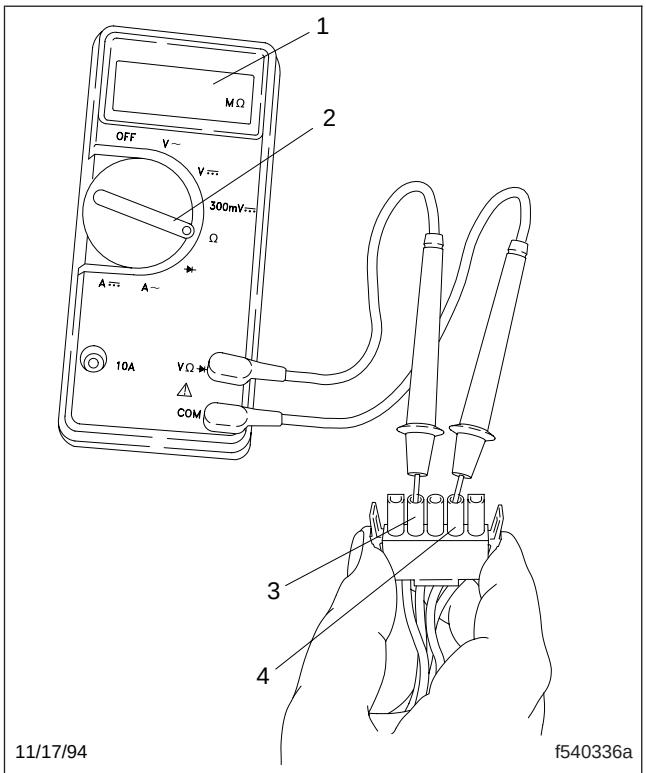
This subject contains the following troubleshooting tables:

- Speedometer Head Will Not Register
- Inaccurate Speedometer Readings



1. Reading of 876 ± 88 ohms
2. Multimeter Dial Pointer (set on ohms scale)

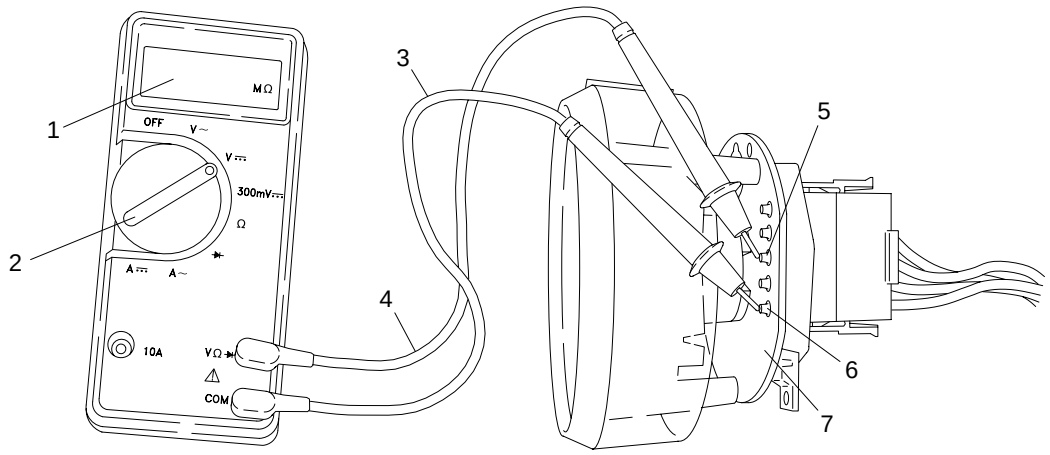
Fig. 2, Connect the Ohmmeter to the Pins of the Magnetic Sensor



1. Reading of 876 ± 88 ohms
2. Multimeter Dial Pointer (set on ohms scale)
3. Tower #2 of Mate-N-Lok Connector
4. Tower #4 of Mate-N-Lok Connector

Fig. 3, Connect Ohm Meter to Mate-N-Lok Connector

Troubleshooting



11/17/94 f540330a

1. Reading of 9 to 16 Volts DC
2. Multimeter Dial Pointer (Set on DC volts scale)
3. Black Lead
4. Red Lead
5. Pin #3
6. Pin #1
7. Rear Plate of Speedometer Head

Fig. 4, Touch Probes of Voltmeter to Speedometer Head

Problem—Speedometer Head Will Not Register

Problem—Speedometer Head Will Not Register	
Possible Cause	**Remedy**
The magnetic sensor gap is incorrectly adjusted.	Adjust the magnetic sensor.
The magnetic sensor is damaged.	Replace the magnetic sensor.
Loose or corroded terminals, broken contacts, broken wires, shorting, or frayed wires are causing an incomplete circuit.	Replace the damaged wiring component(s) as necessary.
The speedometer head is damaged internally.	Replace the speedometer head only after checking all other possible causes. **Speedometer Head Will Not Register**

Problem—Inaccurate Speedometer Readings

Problem—Inaccurate Speedometer Readings	
Possible Cause	**Remedy**
The magnetic sensor gap is incorrectly adjusted.	Adjust the magnetic sensor.
Shorts are occurring in the magnetic sensor.	Check the resistance of the magnetic sensor. Replace the sensor if necessary.
The speedometer head is incorrectly calibrated.	Recalibrate the speedometer head.
Erratic readings are resulting from loose electrical connections.	Check all the wiring in the speedometer system. Tighten all loose connections. **Inaccurate Speedometer Readings**

This subject contains the following table:

•Speedometer Head Calibration

See Fig. 1 for a speedometer wiring diagram.

Pulses-Per-Mile (ppm)	Calibration Code
6960	0101110000
7080	1101110000
7200	0011110000
7320	1011110000
7440	0111110000
7560	1111110000
7680	0000001000
7800	1000001000
7920	0100001000
8040	1100001000
8160	0010001000
8280	1010001000
8400	0110001000
8520	1110001000
8640	0001001000
8760	1001001000
8880	0101001000
9000	1101001000
9120	0011001000
9240	1011001000
9360	0111001000
9480	1111001000
9600	0000101000
9720	1000101000
9840	0100101000
9960	1100101000
10080	0010101000
10200	1010101000
10320	0110101000
10440	1110101000
10560	0001101000
10680	1001101000
10800	0101101000
10920	1101101000
11040	0011101000
11160	1011101000
11280	0111101000
11400	1111101000
11520	0000011000
11640	1000011000
11760	0100011000
11880	1100011000
12000	0010011000
12120	1010011000
12240	0110011000
12360	1110011000
12480	0001011000
12600	1001011000
12720	0101011000
12840	1101011000
12960	0011011000
13080	1011011000
13200	0111011000
13320	1111011000
13440	0000111000
13560	1000111000
13680	0100111000
13800	1100111000
13920	0010111000
14040	1010111000
14160	0110111000
14280	1110111000
14400	0001111000
14520	1001111000
14640	0101111000
14760	1101111000
14880	0011111000
15000	1011111000
15120	0111111000

Specifications

Pulses-Per-Mile (ppm)	Calibration Code
15240	1111111000
15360	0000000100
15480	1000000100
15600	0100000100
15720	1100000100
15840	0010000100
15960	1010000100
16080	0110000100
16200	1110000100
16320	0001000100
16440	1001000100
16560	0101000100
16680	1101000100
16800	0011000100
16920	1011000100
17040	0111000100
17160	1111000100
17280	0000100100
17400	1000100100
17520	0100100100
17640	1100100100
17760	0010100100
17880	1010100100
18000	0110100100
18120	1110100100
18240	0001100100
18360	1001100100
18480	0101100100
18600	1101100100
18720	0011100100
18840	1011100100
18960	0111100100
19080	1111100100
19200	0000010100
19320	1000010100
19440	0100010100

Pulses-Per-Mile (ppm)	Calibration Code
19560	1100010100
19680	0010010100
19800	1010010100
19920	0110010100
20040	1110010100
20160	0001010100
20280	1001010100
20400	0101010100
20520	1101010100
20640	0011010100
20760	1011010100
20880	0111010100
21000	1111010100
21120	0000110100
21240	1000110100
21360	0100110100
21480	1100110100
21600	0010110100
21720	1010110100
21840	0110110100
21960	1110110100
22080	0001110100
22200	1001110100
22320	0101110100
22440	1101110100
22560	0011110100
22680	1011110100
22800	0111110100
22920	1111110100
23040	0000001100
23160	1000001100
23280	0100001100
23400	1100001100
23520	0010001100
23640	1010001100
23760	0110001100

Pulses-Per-Mile (ppm)	Calibration Code
23880	1110001100
24000	0001001100
24120	1001001100
24240	0101001100
24360	1101001100
24480	0011001100
24600	1011001100
24720	0111001100
24840	1111001100
24960	0000101100
25080	1000101100
25200	0100101100
25320	1100101100
25440	0010101100
25560	1010101100
25680	0110101100
25800	1110101100
25920	0001101100
26040	1001101100
26160	0101101100
26280	1101101100
26400	0011101100
26520	1011101100
26640	0111101100
26760	1111101100
26880	0000011100
27000	1000011100
27120	0100011100
27240	1100011100
27360	0010011100
27480	1010011100
27600	0110011100
27720	1110011100
27840	0001011100
27960	1001011100
28080	0101011100

Pulses-Per-Mile (ppm)	Calibration Code
28200	1101011100
28320	0011011100
28440	1011011100
28560	0111011100
28680	1111011100
28800	0000111100
28920	1000111100
29040	0100111100
29160	1100111100
29280	0010111100
29400	1010111100
29520	0110111100
29640	1110111100
29760	0001111100
29880	1001111100
30000	0101111100
30120	1101111100
30240	0011111100
30360	1011111100
30480	0111111100
30600	1111111100
30720	0000000010
30840	1000000010
30960	0100000010
31080	1100000010
31200	0010000010
31320	1010000010
31440	0110000010
31560	1110000010
31680	0001000010
31800	1001000010
31920	0101000010
32040	1101000010
32160	0011000010
32280	1011000010
32400	0111000010

Specifications

Pulses-Per-Mile (ppm)	Calibration Code
32520	1111000010
32640	0000100010
32760	1000100010
32880	0100100010
33000	1100100010
33120	0010100010
33240	1010100010
33360	0110100010
33480	1110100010
33600	0001100010
33720	1001100010
33840	0101100010
33960	1101100010
34080	0011100010
34200	1011100010
34320	0111100010
34440	1111100010
34560	0000010010
34680	1000010010
34800	0100010010
34920	1100010010
35040	0010010010
35160	1010010010
35280	0110010010
35400	1110010010
35520	0001010010
35640	1001010010
35760	0101010010
35880	1101010010
36000	0011010010
36120	1011010010
36240	0111010010
36360	1111010010
36480	0000110010
36600	1000110010
36720	0100110010

Pulses-Per-Mile (ppm)	Calibration Code
36840	1100110010
36960	0010110010
37080	1010110010
37200	0110110010
37320	1110110010
37440	0001110010
37560	1001110010
37680	0101110010
37800	1101110010
37920	0011110010
38040	1011110010
38160	0111110010
38280	1111110010
38400	0000001010
38520	1000001010
38640	0100001010
38760	1100001010
38880	0010001010
39000	1010001010
39120	0110001010
39240	1110001010
39360	0001001010
39480	1001001010
39600	0101001010
39720	1101001010
39840	0011001010
39960	1011001010
40080	0111001010
40200	1111001010
40320	0000101010
40440	1000101010
40560	0100101010
40680	1100101010
40800	0010101010
40920	1010101010
41040	0110101010

Pulses-Per-Mile (ppm)	Calibration Code
41160	1110101010
41280	0001101010
41400	1001101010
41520	0101101010
41640	1101101010
41760	0011101010
41880	1011101010
42000	0111101010
42120	1111101010
42240	0000011010
42360	1000011010
42480	0100011010
42600	1100011010
42720	0010011010
42840	1010011010
42960	0110011010
43080	1110011010
43200	0001011010
43320	1001011010
43440	0101011010
43560	1101011010
43680	0011011010
43800	1011011010
43920	0111011010
44040	1111011010
44160	0000111010
44280	1000111010
44400	0100111010
44520	1100111010
44640	0010111010
44760	1010111010
44880	0110111010
45000	1110111010
45120	0001111010
45240	1001111010
45360	0101111010

Pulses-Per-Mile (ppm)	Calibration Code
45480	1101111010
45600	0011111010
45720	1011111010
45840	0111111010
45960	1111111010
46080	0000000110
46200	1000000110
46320	0100000110
46440	1100000110
46560	0010000110
46680	1010000110
46800	0110000110
46920	1110000110
47040	0001000110
47160	1001000110
47280	0101000110
47400	1101000110
47520	0011000110
47640	1011000110
47760	0111000110
47880	1111000110
48000	0000100110
48120	1000100110
48240	0100100110
48360	1100100110
48480	0010100110
48600	1010100110
48720	0110100110
48840	1110100110
48960	0001100110
49080	1001100110
49200	0101100110
49320	1101100110
49440	0011100110
49560	1011100110
49680	0111100110

Specifications

Pulses-Per-Mile (ppm)	Calibration Code
49800	1111100110
49920	0000010110
50040	1000010110
50160	0100010110
50280	1100010110
50400	0010010110
50520	1010010110
50640	0110010110
50760	1110010110
50880	0001010110
51000	1001010110
51120	0101010110
51240	1101010110
51360	0011010110
51480	1011010110
51600	0111010110
51720	1111010110
51840	0000110110
51960	1000110110
52080	0100110110
52200	1100110110
52320	0010110110
52440	1010110110
52560	0110110110
52680	1110110110
52800	0001110110
52920	1001110110
53040	0101110110
53160	1101110110
53280	0011110110
53400	1011110110
53520	0111110110
53640	1111110110
53760	0000001110
53880	1000001110
54000	0100001110

Pulses-Per-Mile (ppm)	Calibration Code
54120	1100001110
54240	0010001110
54360	1010001110
54480	0110001110
54600	1110001110
54720	0001001110
54840	1001001110
54960	0101001110
55080	1101001110
55200	0011001110
55320	1011001110
55440	0111001110
55560	1111001110
55680	0000101110
55800	1000101110
55920	0100101110
56040	1100101110
56160	0010101110
56280	1010101110
56400	0110101110
56520	1110101110
56640	0001101110
56760	1001101110
56880	0101101110
57000	1101101110
57120	0011101110
57240	1011101110
57360	0111101110
57480	1111101110
57600	0000011110
57720	1000011110
57840	0100011110
57960	1100011110
58080	0010011110
58200	1010011110
58320	0110011110

Pulses-Per-Mile (ppm)	Calibration Code
58440	1110011110
58560	0001011110
58680	1001011110
58800	0101011110
58920	1101011110
59040	0011011110
59160	1011011110
59280	0111011110
59400	1111011110
59520	0000111110
59640	1000111110
59760	0100111110
59880	1100111110
60000	0010111110
60120	1010111110
60240	0110111110
60360	1110111110
60480	0001111110
60600	1001111110
60720	0101111110
60840	1101111110
60960	0011111110
61080	1011111110
61200	0111111110
61320	1111111110
61440	0000000001
61560	1000000001
61680	0100000001
61800	1100000001
61920	0010000001
62040	1010000001
62160	0110000001
62280	1110000001
62400	0001000001
62520	1001000001
62640	0101000001

Pulses-Per-Mile (ppm)	Calibration Code
62760	1101000001
62880	0011000001
63000	1011000001
63120	0111000001
63240	1111000001
63360	0000100001
63480	1000100001
63600	0100100001
63720	1100100001
63840	0010100001
63960	1010100001
64080	0110100001
64200	1110100001
64320	0001100001
64440	1001100001
64560	0101100001
64680	1101100001
64800	0011100001
64920	1011100001
65040	0111100001
65160	1111100001
65280	0000010001
65400	1000010001
65520	0100010001
65640	1100010001
65760	0010010001
65880	1010010001
66000	0110010001
66120	1110010001
66240	0001010001
66360	1001010001
66480	0101010001
66600	1101010001
66720	0011010001
66840	1011010001
66960	0111010001

Specifications

Pulses-Per-Mile (ppm)	Calibration Code
67080	1111010001
67200	0000110001
67320	1000110001
67440	0100110001
67560	1100110001
67680	0010110001
67800	1010110001
67920	0110110001
68040	1110110001
68160	0001110001
68280	1001110001
68400	0101110001
68520	1101110001
68640	0011110001
68760	1011110001
68880	0111110001
69000	1111110001
69120	0000001001
69240	1000001001
69360	0100001001
69480	1100001001
69600	0010001001
69720	1010001001
69840	0110001001
69960	1110001001
70080	0001001001
70200	1001001001
70320	0101001001
70440	1101001001
70560	0011001001
70680	1011001001
70800	0111001001
70920	1111001001
71040	0000101001
71160	1000101001
71280	0100101001

Pulses-Per-Mile (ppm)	Calibration Code
71400	1100101001
71520	0010101001
71640	1010101001
71760	0110101001
71880	1110101001
72000	0001101001
72120	1001101001
72240	0101101001
72360	1101101001
72480	0011101001
72600	1011101001
72720	0111101001
72840	1111101001
72960	0000011001
73080	1000011001
73200	0100011001
73320	1100011001
73440	0010011001
73560	1010011001
73680	0110011001
73800	1110011001
73920	0001011001
74040	1001011001
74160	0101011001
74280	1101011001
74400	0011011001
74520	1011011001
74640	0111011001
74760	1111011001
74880	0000111001
75000	1000111001
75120	0100111001
75240	1100111001
75360	0010111001
75480	1010111001
75600	0110111001

Pulses-Per-Mile (ppm)	Calibration Code
75720	1110111001
75840	0001111001
75960	1001111001
76080	0101111001
76200	1101111001
76320	0011111001
76440	1011111001
76560	0111111001
76680	1111111001
76800	0000000101
76920	1000000101
77040	0100000101
77160	1100000101
77280	0010000101
77400	1010000101
77520	0110000101
77640	1110000101
77760	0001000101
77880	1001000101
78000	0101000101
78120	1101000101
78240	0011000101
78360	1011000101
78480	0111000101
78600	1111000101
78720	0000100101
78840	1000100101
78960	0100100101
79080	1100100101
79200	0010100101
79320	1010100101
79440	0110100101
79560	1110100101
79680	0001100101
79800	1001100101
79920	0101100101

Pulses-Per-Mile (ppm)	Calibration Code
80040	1101100101
80160	0011100101
80280	1011100101
80400	0111100101
80520	1111100101
80640	0000010101
80760	1000010101
80880	0100010101
81000	1100010101
81120	0010010101
81240	1010010101
81360	0110010101
81480	1110010101
81600	0001010101
81720	1001010101
81840	0101010101
81960	1101010101
82080	0011010101
82200	1011010101
82320	0111010101
82440	1111010101
82560	0000110101
82680	1000110101
82800	0100110101
82920	1100110101
83040	0010110101
83160	1010110101
83280	0110110101
83400	1110110101
83520	0001110101
83640	1001110101
83760	0101110101
83880	1101110101
84000	0011110101
84120	1011110101
84240	0111110101

Specifications

Pulses-Per-Mile (ppm)	Calibration Code
84360	1111110101
84480	0000001101
84600	1000001101
84720	0100001101
84840	1100001101
84960	0010001101
85080	1010001101
85200	0110001101
85320	1110001101
85440	0001001101
85560	1001001101
85680	0101001101
85800	1101001101
85920	0011001101
86040	1011001101
86160	0111001101
86280	1111001101
86400	0000101101
86520	1000101101
86640	0100101101
86760	1100101101
86880	0010101101
87000	1010101101
87120	0110101101
87240	1110101101
87360	0001101101
87480	1001101101
87600	0101101101
87720	1101101101
87840	0011101101
87960	1011101101
88080	0111101101
88200	1111101101
88320	0000011101
88440	1000011101
88560	0100011101

Pulses-Per-Mile (ppm)	Calibration Code
88680	1100011101
88800	0010011101
88920	1010011101
89040	0110011101
89160	1110011101
89280	0001011101
89400	1001011101
89520	0101011101
89640	1101011101
89760	0011011101
89880	1011011101
90000	0111011101
90120	1111011101
90240	0000111101
90360	1000111101
90480	0100111101
90600	1100111101
90720	0010111101
90840	1010111101
90960	0110111101
91080	1110111101
91200	0001111101
91320	1001111101
91440	0101111101
91560	1101111101
91680	0011111101
91800	1011111101
91920	0111111101
92040	1111111101
92160	0000000011
92280	1000000011
92400	0100000011
92520	1100000011
92640	0010000011
92760	1010000011
92880	0110000011

Pulses-Per-Mile (ppm)	Calibration Code
93000	1110000011
93120	0001000011
93240	1001000011
93360	0101000011
93480	1101000011
93600	0011000011
93720	1011000011
93840	0111000011
93960	1111000011
94080	0000100011
94200	1000100011
94320	0100100011
94440	1100100011
94560	0010100011
94680	1010100011
94800	0110100011
94920	1110100011
95040	0001100011
95160	1001100011
95280	0101100011
95400	1101100011
95520	0011100011
95640	1011100011
95760	0111100011
95880	1111100011
96000	0000010011
96120	1000010011
96240	0100010011
96360	1100010011
96480	0010010011
96600	1010010011
96720	0110010011
96840	1110010011
96960	0001010011
97080	1001010011
97200	0101010011

Pulses-Per-Mile (ppm)	Calibration Code
97320	1101010011
97440	0011010011
97560	1011010011
97680	0111010011
97800	1111010011
97920	0000110011
98040	1000110011
98160	0100110011
98280	1100110011
98400	0010110011
98520	1010110011
98640	0110110011
98760	1110110011
98880	0001110011
99000	1001110011
99120	0101110011
99240	1101110011
99360	0011110011
99480	1011110011
99600	0111110011
99720	1111110011
99840	0000001011
99960	1000001011
100080	0100001011
100200	1100001011
100320	0010001011
100440	1010001011
100560	0110001011
100680	1110001011
100800	0001001011
100920	1001001011
101040	0101001011
101160	1101001011
101280	0011001011
101400	1011001011
101520	0111001011

Specifications

Pulses-Per-Mile (ppm)	Calibration Code
101640	1111001011
101760	0000101011
101880	1000101011
102000	0100101011
102120	1100101011
102240	0010101011
102360	1010101011
102480	0110101011
102600	1110101011
102720	0001101011
102840	1001101011
102960	0101101011
103080	1101101011
103200	0011101011
103320	1011101011
103440	0111101011
103560	1111101011
103680	0000011011
103800	1000011011
103920	0100011011
104040	1100011011
104160	0010011011
104280	1010011011
104400	0110011011
104520	1110011011
104640	0001011011
104760	1001011011
104880	0101011011
105000	1101011011
105120	0011011011
105240	1011011011
105360	0111011011
105480	1111011011
105600	0000111011
105720	1000111011
105840	0100111011

Pulses-Per-Mile (ppm)	Calibration Code
105960	1100111011
106080	0010111011
106200	1010111011
106320	0110111011
106440	1110111011
106560	0001111011
106680	1001111011
106800	0101111011
106920	1101111011
107040	0011111011
107160	1011111011
107280	0111111011
107400	1111111011
107520	0000000111
107640	1000000111
107760	0100000111
107880	1100000111
108000	0010000111
108120	1010000111
108240	0110000111
108360	1110000111
108480	0001000111
108600	1001000111
108720	0101000111
108840	1101000111
108960	0011000111
109080	1011000111
109200	0111000111
109320	1111000111
109440	0000100111
109560	1000100111
109680	0100100111
109800	1100100111
109920	0010100111
110040	1010100111
110160	0110100111

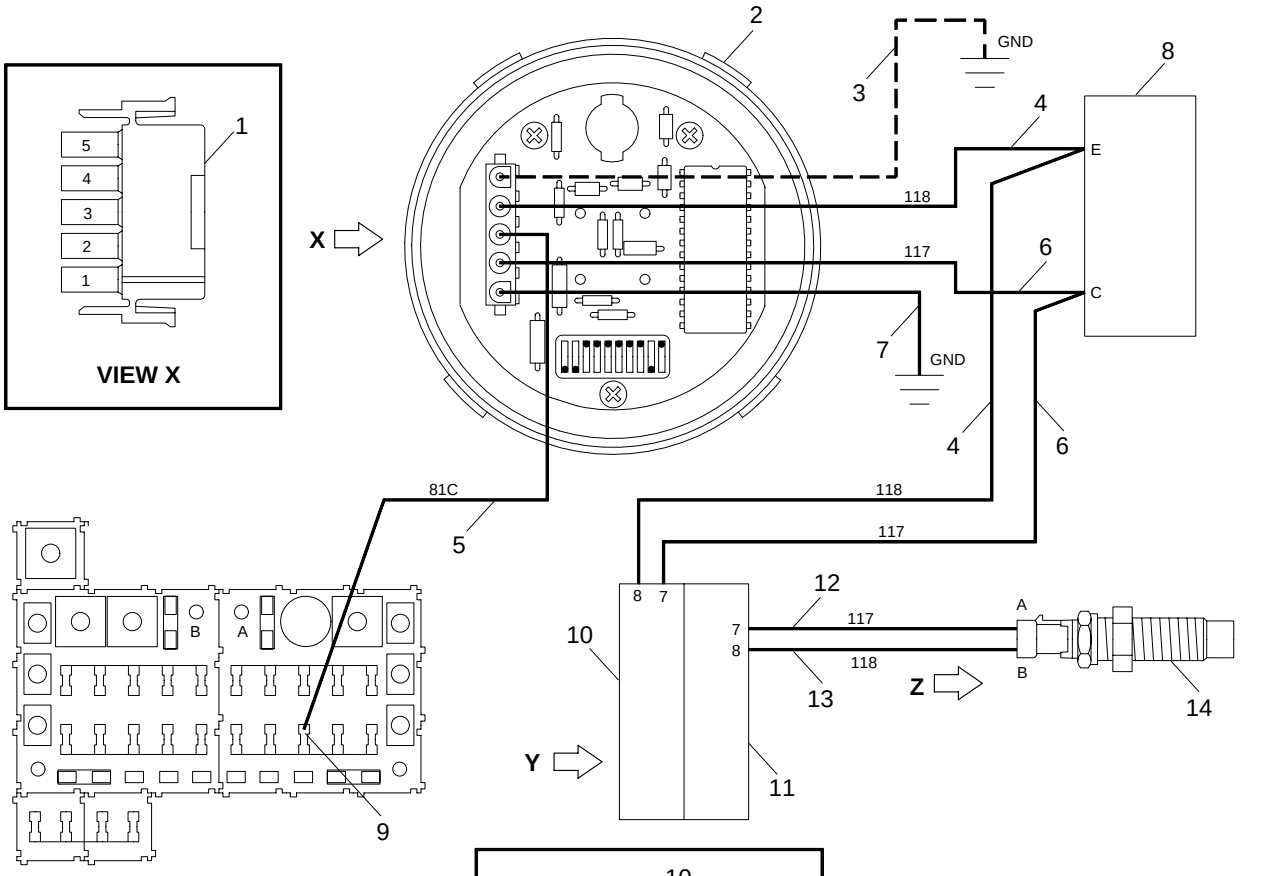
Pulses-Per-Mile (ppm)	Calibration Code
110280	1110100111
110400	0001100111
110520	1001100111
110640	0101100111
110760	1101100111
110880	0011100111
111000	1011100111
111120	0111100111
111240	1111100111
111360	0000010111
111480	1000010111
111600	0100010111
111720	1100010111
111840	0010010111
111960	1010010111
112080	0110010111
112200	1110010111
112320	0001010111
112440	1001010111
112560	0101010111
112680	1101010111
112800	0011010111
112920	1011010111
113040	0111010111
113160	1111010111
113280	0000110111
113400	1000110111
113520	0100110111
113640	1100110111
113760	0010110111
113880	1010110111
114000	0110110111
114120	1110110111
114240	0001110111
114360	1001110111
114480	0101110111

Pulses-Per-Mile (ppm)	Calibration Code
114600	1101110111
114720	0011110111
114840	1011110111
114960	0111110111
115080	1111110111
115200	0000001111
115320	1000001111
115440	0100001111
115560	1100001111
115680	0010001111
115800	1010001111
115920	0110001111
116040	1110001111
116160	0001001111
116280	1001001111
116400	0101001111
116520	1101001111
116640	0011001111
116760	1011001111
116880	0111001111
117000	1111001111
117120	0000101111
117240	1000101111
117360	0100101111
117480	1100101111
117600	0010101111
117720	1010101111
117840	0110101111
117960	1110101111
118080	0001101111
118200	1001101111
118320	0101101111
118440	1101101111
118560	0011101111
118680	1011101111
118800	0111101111

Specifications

Pulses-Per-Mile (ppm)	Calibration Code
118920	1111101111
119040	0000011111
119160	1000011111
119280	0100011111
119400	1100011111
119520	0010011111
119640	1010011111
119760	0110011111
119880	1110011111
120000	0001011111
120120	1001011111
120240	0101011111
120360	1101011111
120480	0011011111
120600	1011011111
120720	0111011111
120840	1111011111

Pulses-Per-Mile (ppm)	Calibration Code
120960	0000111111
121080	1000111111
121200	0100111111
121320	1100111111
121440	0010111111
121560	1010111111
121680	0110111111
121800	1110111111
121920	0001111111
122040	1001111111
122160	0101111111
122280	1101111111
122400	0011111111
122520	1011111111
122640	0111111111
122760	1111111111



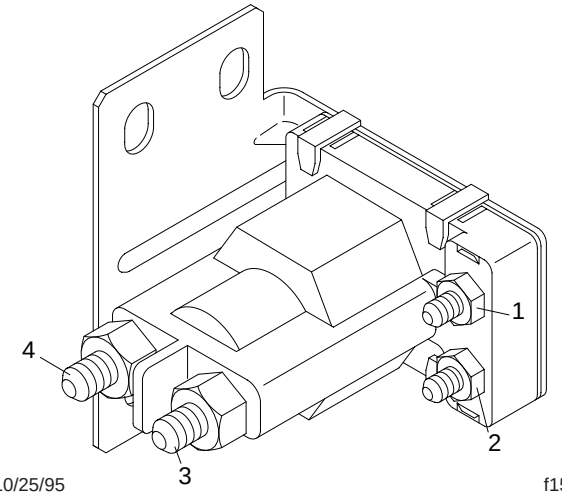
1. 5−Pin Mate−N−Lok Connector
2. Electronic Speedometer (rear view)
3. Ground Wire for Optional 2−Speed Rear Axle
4. Yellow 18−Gauge Wire for Speedometer Negative Signal
5. Yellow 16−Gauge Wire for Instrument Feed
6. Yellow 18−Gauge Wire for Speedometer Positive Signal
7. Yellow 18−Gauge Ground Wire for Instrument Illumination
8. Optional Automatic Transmission Electronic Control Module (ECM)
9. 10−Amp Fuse/Circuit Breaker on the 'A' Electric Panel Block
10. Main Cab Harness Connector (on bulkhead, inside cab)
11. Engine Harness Connector (on bulkhead, outside cab)
12. White 14−Gauge Wire for Speedometer Positive Signal
13. White 14−Gauge Wire for Speedometer Negative Signal
14. Speedometer Magnetic Sensor (at transmission output shaft)

08/10/93 f540343

Fig. 1, Speedometer Wiring Diagram

General Information

All 12-volt starting systems are equipped with a heavy-duty starter relay, or magnetic switch. See **Fig. 1**. The magnetic switch is attached to the front-wall, on the right side of the vehicle. When the starter button is pushed, the magnetic switch closes, connecting electrical current to the starter solenoid, which engages the starter motor pinion with the engine flywheel ring gear, and then energizes the starter motor.



1. Coil Terminal (to ground)
2. Coil Terminal (to ignition switch)
3. Switch Terminal (to solenoid)
4. Switch Terminal (to starter BAT terminal)

Fig. 1, Magnetic Switch

The magnetic switch consists of a winding, mounted around a hollow cylinder containing a movable core or plunger, with a contact disk that is assembled onto the plunger.

When the winding is energized, plunger movement causes the contact disk to be held tightly against the two main switch terminals; this closes the circuit between these terminals, and activates the starting motor. When the winding is de-energized, a return spring causes the plunger to return to its original position, opening the circuit to the starter motor.

Preliminary Checks

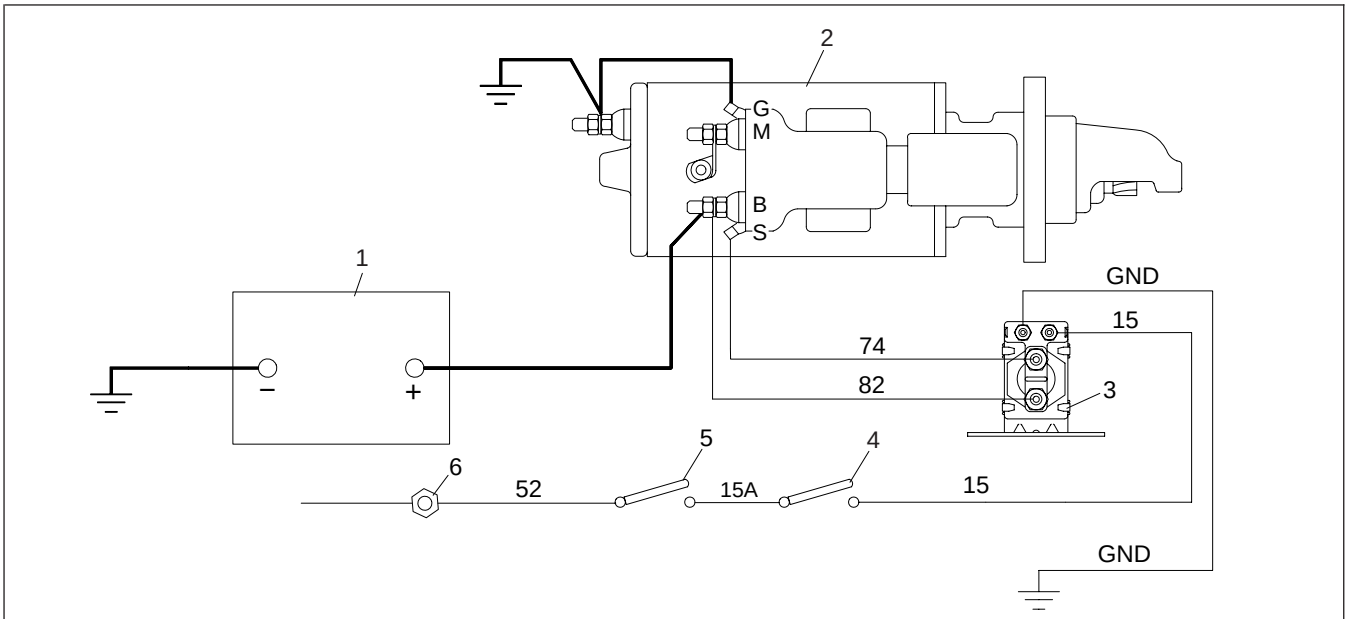
Before replacing the magnetic switch, or repairing or replacing any of the starting and charging circuits, do the preliminary checks and the magnetic switch circuit test in **Troubleshooting 300**.

Replacement

NOTE: The magnetic switch cannot be disassembled. If the switch does not work, replace it.

1. Apply the parking brakes, and chock the tires.
2. Disconnect the batteries and tilt the hood.
3. Mark the wires for later reference, then disconnect the wires that are attached to the magnetic switch. See **Fig. 1**.
4. Remove the magnetic switch.
   - 4.1 Remove the two large terminal nuts.
   - 4.2 Remove the two small terminal nuts.
   - 4.3 Disconnect the wires from the terminal switch.
   - 4.4 Remove the magnetic switch mounting nuts, lockwashers, and bolts.
5. Install the new magnetic switch.
   - 5.1 Install the new magnetic switch, using the mounting bolts, lockwashers, and nuts just removed. Tighten the nuts securely.
   - 5.2 Connect the wires to the magnetic switch.
   - 5.3 Install and tighten the nuts securely.

   NOTE: Tighten # 10 nuts to a maximum of 40 lbf·in (460 N·cm) and 5/16-inch nuts to a maximum of 95 lbf·in (1080 N·cm).
6. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.



1. Battery
2. Cranking Motor (top view)
3. Magnetic Switch
4. Pushbutton Start Switch
5. Keyswitch
6. Cab Power Stud

Fig. 1, Magnetic Switch Wiring

Magnetic Switch Replacement

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

7. Connect the batteries and lower the hood.
8. Remove the chocks from the tires.

Preliminary Checks

Before replacing the magnetic switch, or repairing or replacing any of the starting and charging circuits, do these preliminary checks and the "Magnetic Switch Circuit Test."

1. Apply the parking brakes, and chock the tires.
2. Check the condition of the batteries. Follow the battery testing procedure in **Section 54.03**. Be sure the batteries are fully charged.

NOTE: The wiring, switches, and starter motor cannot be checked if the batteries are damaged or discharged.

3. Check the starting motor, ignition switch, and solenoid for damage or wear. Repair or replace the component(s), as needed.

Magnetic Switch Circuit Test

Before replacing the magnetic switch, or repairing or replacing any of the starting and charging circuits, do this test.

1. Apply the parking brakes, and chock the tires.
2. Check the condition of the batteries. Follow the battery testing procedure in **Section 54.03**. Be sure the batteries are fully charged.

NOTE: The wiring, switches, and starter motor cannot be checked if the batteries are damaged or discharged.

3. Check the starting motor, ignition switch, and solenoid for damage or wear. Repair or replace the component(s), as needed.
4. Check the wiring and the magnetic switch for wear or damage. See **Section 54.01, Specifications 400**.
5. Check the circuit between the magnetic switch and the starter "B" terminal (circuit 82) for correct voltage.

   5.1 Disconnect the circuit running from the starter "S" terminal to the magnetic switch (circuit 74).

   5.2 Connect a voltmeter to the magnetic switch terminal where the circuit from the starter "B" terminal is connected (circuit 82).

   5.3 If the voltmeter reading is 0 volt, check for an open circuit.

   If the voltmeter reading is less than 12.0 volts, check for corroded or loose connections.

   If the voltmeter reading is 12.0 volts or more, go to the next step.

   5.4 Repair or replace any damaged wires.

6. Check the magnetic switch ground circuit (circuit GND).

   6.1 Connect an ohmmeter between the magnetic switch ground terminal and a known good ground.

   6.2 If the ohmmeter reading is more than 0.5 ohm, check for corroded or loose connections.

   6.3 Repair or replace any damaged wires.

7. Check the magnetic switch ignition wiring (circuit 15) for correct voltage.

   NOTE: This check requires two persons.

   7.1 Have one person turn on the ignition keyswitch and hold in the start button.

   7.2 Have the other person connect a voltmeter between the magnetic switch terminal where the ignition circuit is connected (circuit 15) and a known good ground.

   7.3 If the voltmeter reading is 0 volt, check for an open in circuit 15.

   If the voltmeter reading is less than 11.0 volts, check for corroded or loose connections.

   Repair or replace any damaged wires, circuit breakers, or relays.

   7.4 If the voltmeter reading is 11.0 volts or more, go to the next step.

8. Check the circuit between the magnetic switch and the starter "S" terminal (circuit 74) for correct voltage.

Troubleshooting

NOTE: This check requires two persons.

8.1 Have one person turn on the ignition keyswitch and hold in the start button.

8.2 Have the other person connect a voltmeter between the magnetic switch terminal where the circuit from the starter "S" terminal is connected (circuit 74) and a known good ground.

8.3 If the voltmeter reading is less than 12.0 volts, replace the magnetic switch.

Magnetic Switch Contactor Test

The cranking circuit includes the battery, starter solenoid, cranking motor, magnetic switch, and ignition keyswitch.

If there is excessive voltage loss in the cranking circuit, the starter may not engage the flywheel at all, or it may drop out too soon when battery voltage goes down. In this case, check the cranking circuit and starter solenoid for voltage loss.

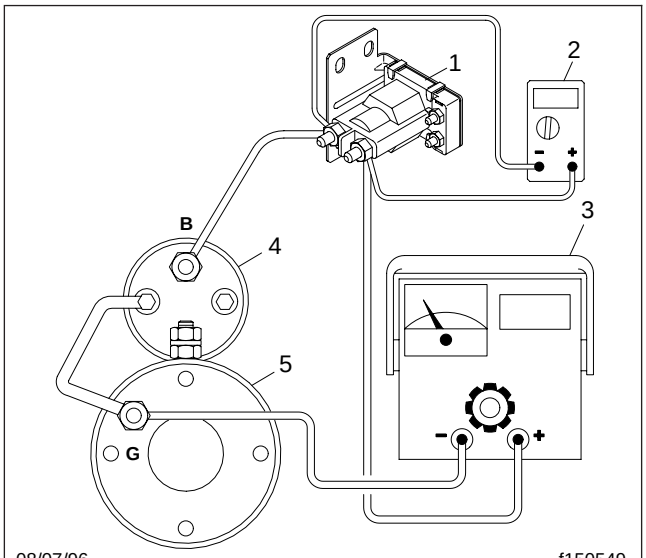
If the magnetic switch closes during the cranking circuit test and the starter wiring test, also check the magnetic switch contactors for voltage loss.

1. Disconnect the lead from the magnetic switch to the "S" (solenoid) terminal on the starter (leave as in "Starter Wiring Test").
2. Connect this lead to the positive lead of a carbon pile tester. Connect the negative lead of the carbon pile to the starter "G" (ground) terminal (leave as in "Starter Wiring Test").
3. Set a digital voltmeter on the low scale and connect the positive lead to the magnetic switch terminal to which the carbon pile is already connected. Connect the negative lead to the other large terminal on the magnetic switch. See **Fig. 1**.
4. Start the engine and check the voltage.

   NOTE: This check requires two persons.

   4.1 Have one person turn on the ignition keyswitch and hold in the start button.

   4.2 Have the other person read the voltage on the voltmeter. It should read 0 volt.



1. Magnetic Switch
2. Digital Voltmeter
3. Carbon Pile
4. Starter Solenoid
5. Cranking Motor

Fig. 1, Magnetic Switch Contactor Test

5. Turn on the carbon pile and adjust it to a 100-amp load.

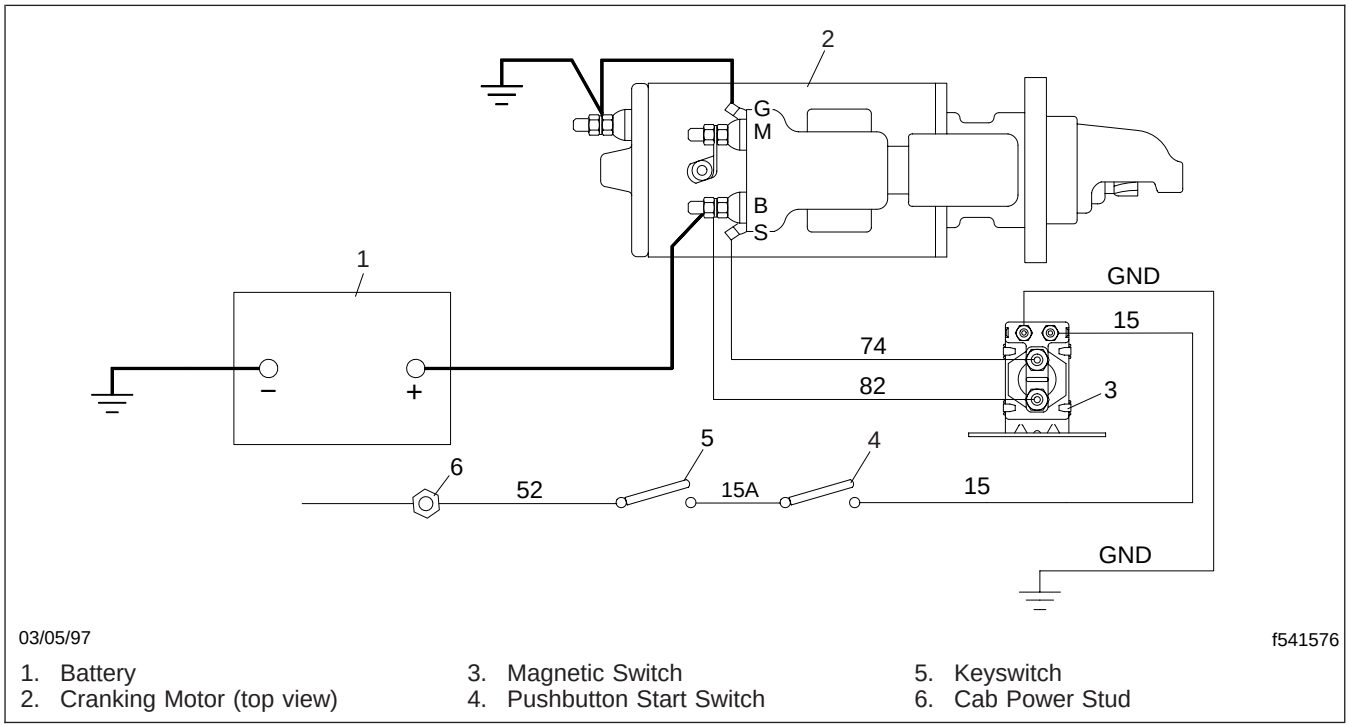
   5.1 Now read and record the voltage on the voltmeter. Turn off the carbon pile.

   5.2 If the voltage reads 11.8 volts or greater, the magnetic switch contactors are OK.

   If the voltage reads less than 11.8 volts, replace the magnetic switch.

Specifications

For a typical magnetic switch wiring diagram, see **Fig. 1**.



1. Battery
2. Cranking Motor (top view)
3. Magnetic Switch
4. Pushbutton Start Switch
5. Keyswitch
6. Cab Power Stud

Fig. 1, Magnetic Switch Wiring

General Information

An air restriction gauge **(Fig. 1)** indicates how much air filter capacity has been used and how much remains. It registers the actual maximum restriction of the filter element (or elements, if two air cleaners are installed) when the engine is operating at full load. The yellow indicator inside the air restriction gauge retains the reading so that the remaining capacity can be read even after the engine is shut down.

The air restriction gauge and tap fittings sometimes become plugged from moisture or engine vapors, possibly causing an incorrect reading.

IMPORTANT: Most engine degreasers are harmful to the polycarbonate (Lexan) plastics that are used in air restriction gauges. When cleaning an engine or other components, avoid getting degreaser on these plastic parts.

The air restriction gauge is mounted on the air cleaner intake piping **(see Fig. 2).** A gauge mounted on the air cleaner or intake piping has a push-type reset button located at the end opposite the mounting fitting.

NOTE: Avoid opening the air cleaner and disturbing the seals or filter element until the yellow indicator shows maximum restriction ("red line") **(see Fig. 3).** When this occurs, the air cleaner needs to be serviced; however, immediate engine shutdown is not necessary.

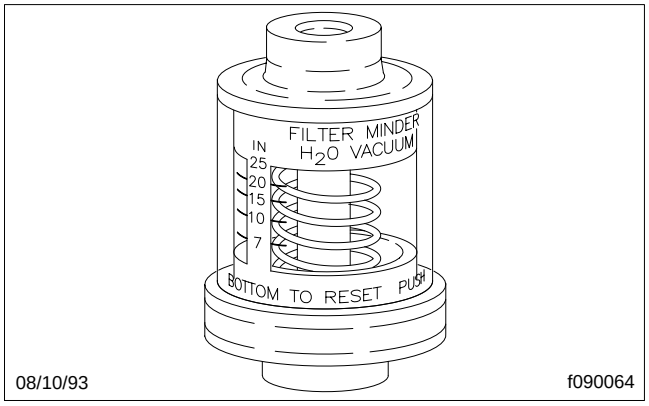


Fig. 1, Air Restriction Gauge

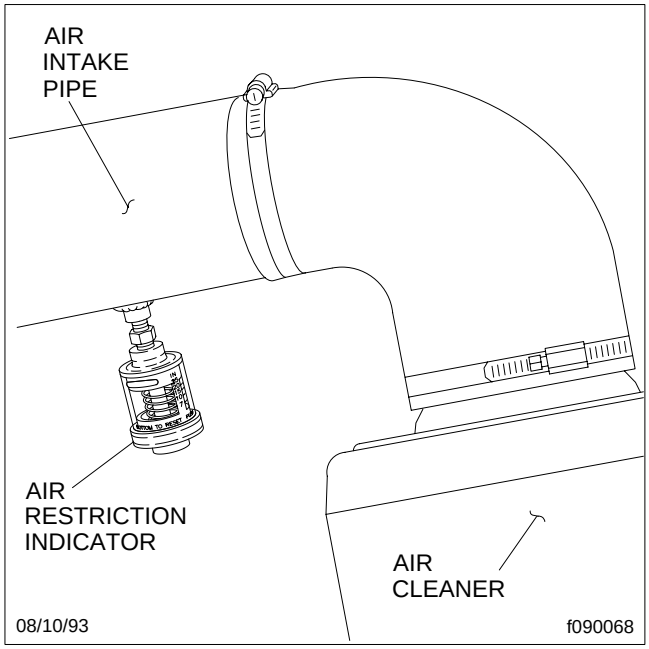


Fig. 2, Air Restriction Gauge Mounted on the Intake Piping

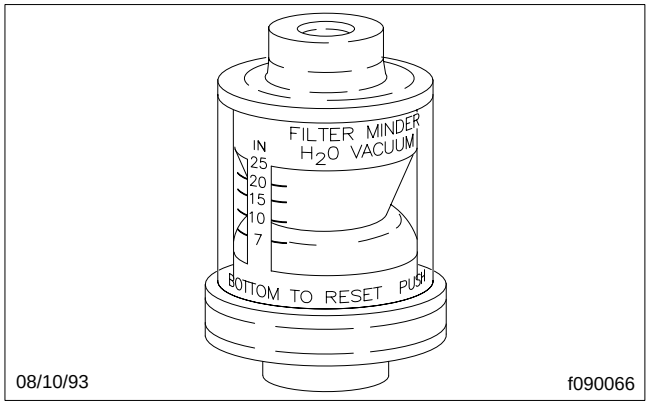


Fig. 3, Maximum Restriction

Replacement

AIR INTAKE PIPE MOUNTED

1. Chock the tires, then tilt the hood. For instructions, refer to the vehicle driver's manual.
2. Using a wrench, unscrew the gauge from the air intake piping.
3. Install the new air restriction gauge using the instruction above, in reverse order.

NOTE: The fitting in the intake pipe is a special fitting incorporating an orifice and a filter. Be sure that the correct fitting is installed.

Problem—No Restriction Reading

Problem—No Restriction Reading	
Possible Cause	**Remedy**
The gauge leaks.	Remove the air restriction gauge. Apply a vacuum to the gauge until the yellow indicator reaches the red line. With your thumb on the mounting fitting, close the end of the gauge airtight. Hold in the reset button. The yellow indicator will drop slightly and then not move unless the gauge has a leak. If the gauge is functioning properly, install it and press the reset button. If the yellow indicator continues to move, replace the air restriction gauge. Repeat the troubleshooting procedure to verify that the new gauge does not leak. When the gauge is functioning properly, install it and press the reset button.
The air cleaner or intake pipe fitting is plugged.	Remove the obstruction.
Engine airflow is too low to generate a reading.	Turbocharged engines must be at full load to pull full engine airflow. Restrictions can be simulated by gradually closing off air intake. If there is still no restriction reading, check for leaks in the gauge or vacuum hose, as appropriate, and take corrective action.
The safety filter, if equipped, is plugged.	Do not clean the safety filter. Replace it with a new one.

Problem—High Restriction Readings

Problem—High Restriction Readings	
Possible Cause	**Remedy**
The element is plugged.	Anytime a high restriction is noted, it should be verified by resetting the restriction indicator and checking it again after several hundred miles of normal operation. Install a new filter element.
The intake screens or ducts are plugged.	Check the system upstream from the air restriction gauge and remove any debris. Check for damage or improper installation, and take necessary corrective action.
Heavy snow or rain.	Temporary high restriction can occur during a rain or snow storm and disappear after drying out. Anytime a high restriction is noted, it should be verified by resetting the restriction indicator and checking it again after several hundred miles of normal operation.

See Fig. 1 for a full view of the Caterpillar CFE Series wiring diagram (the cab side).

See Fig. 2 and **Fig. 3** for partial (detailed) views of the Caterpillar CFE Series wiring diagram.

See Fig. 4 for a full view of the Caterpillar CFE Series wiring diagram (the engine side).

See Fig. 5 and **Fig. 6** for partial (detailed) views of the Caterpillar CFE Series wiring diagram.

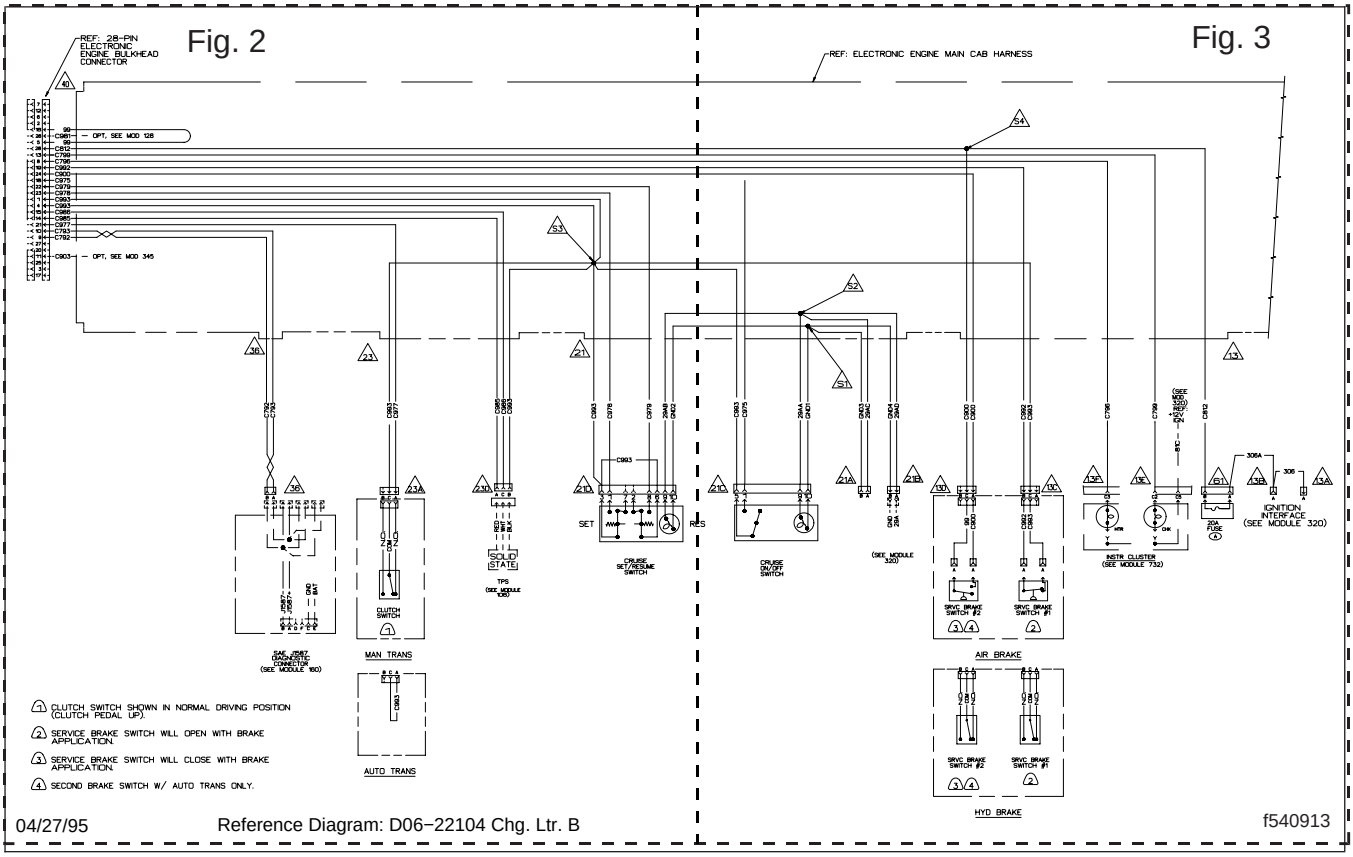


Fig. 1, Wiring Diagram for Caterpillar CFE Series Engine (cab side of FTL wiring)

Specifications

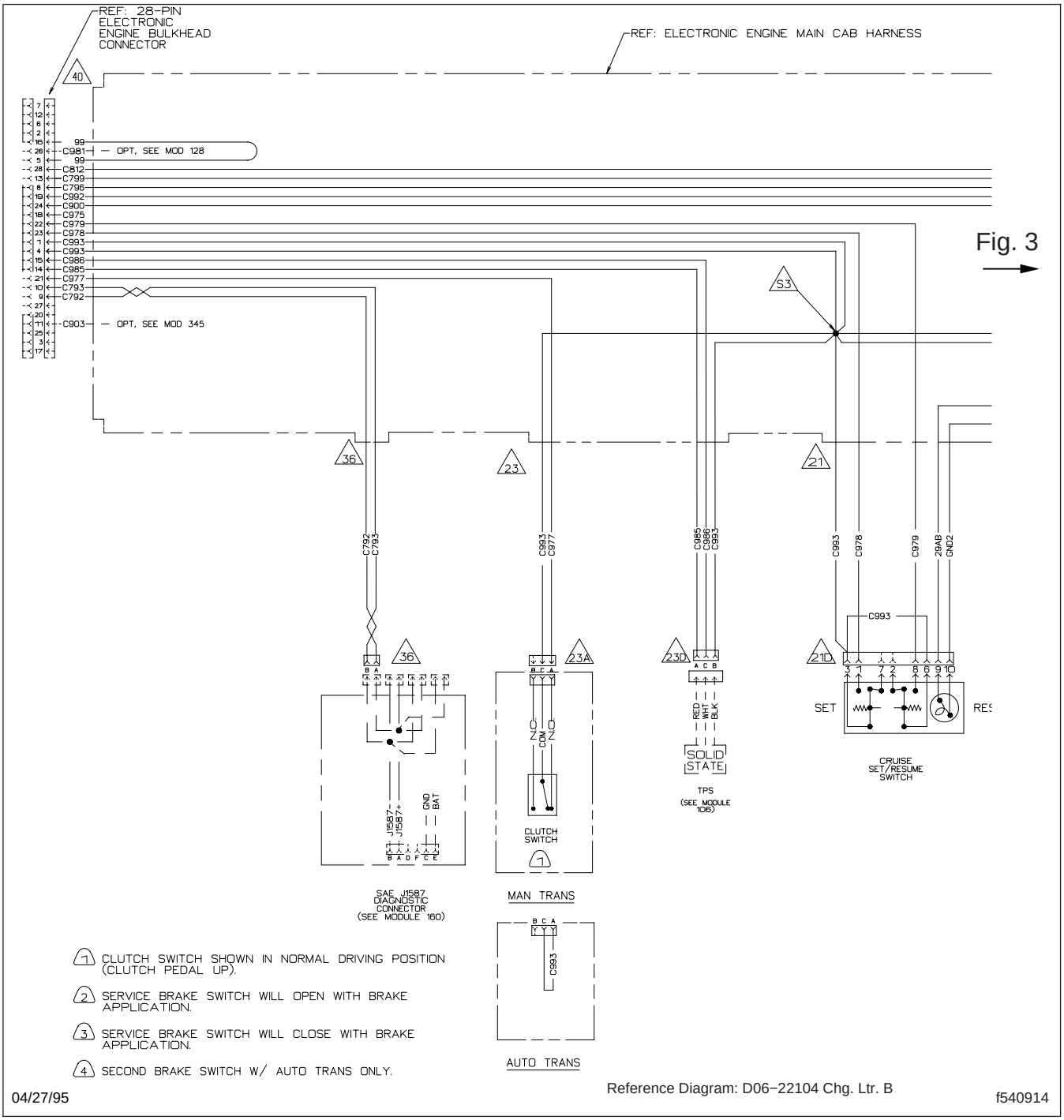


Fig. 2, Wiring Diagram for Caterpillar CFE Series Engine (detail)

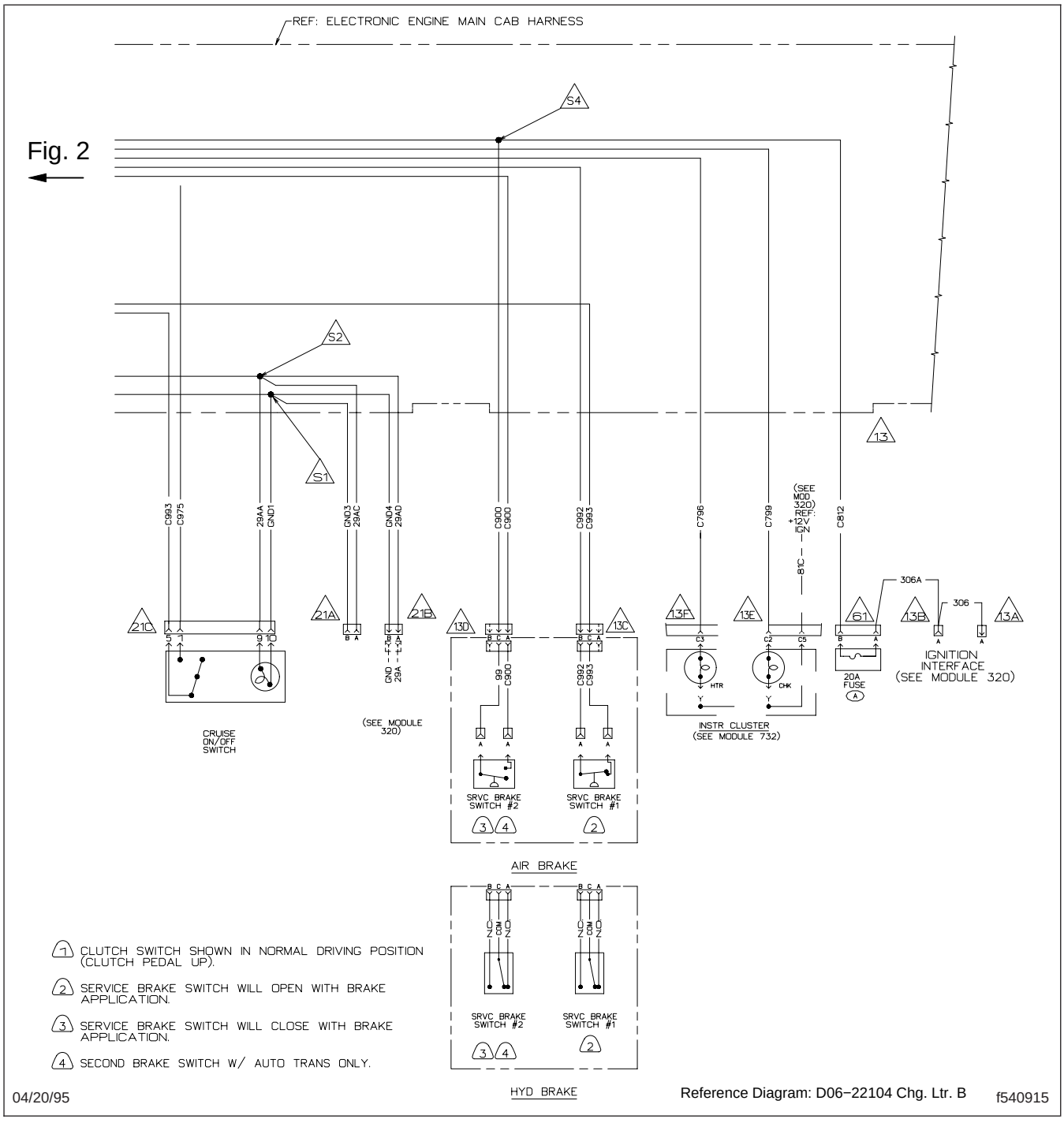


Fig. 3, Wiring Diagram for Caterpillar CFE Series Engine (detail)

Specifications

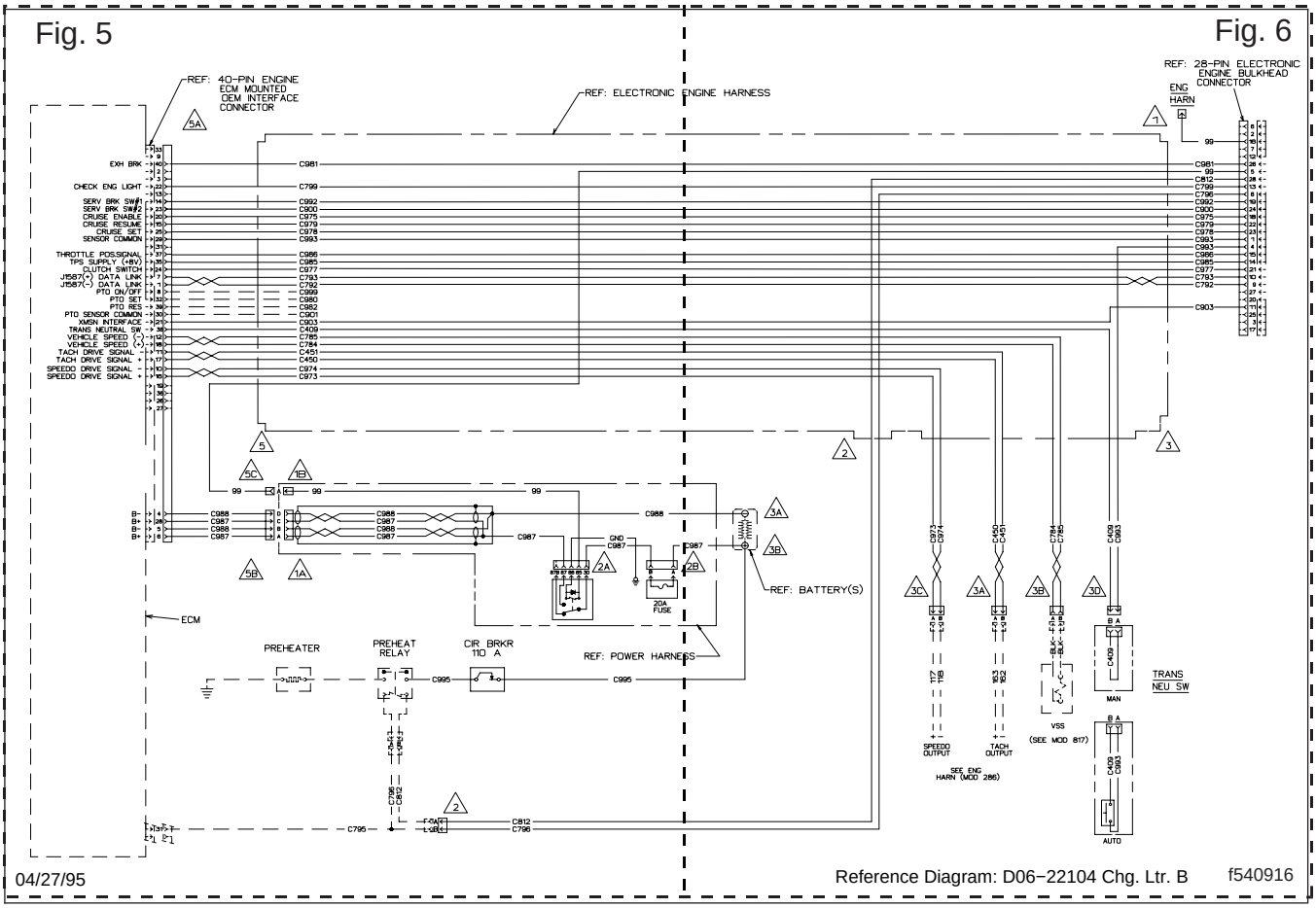


Fig. 4, Wiring Diagram for Caterpillar CFE Series Engine (engine side of FTL wiring)

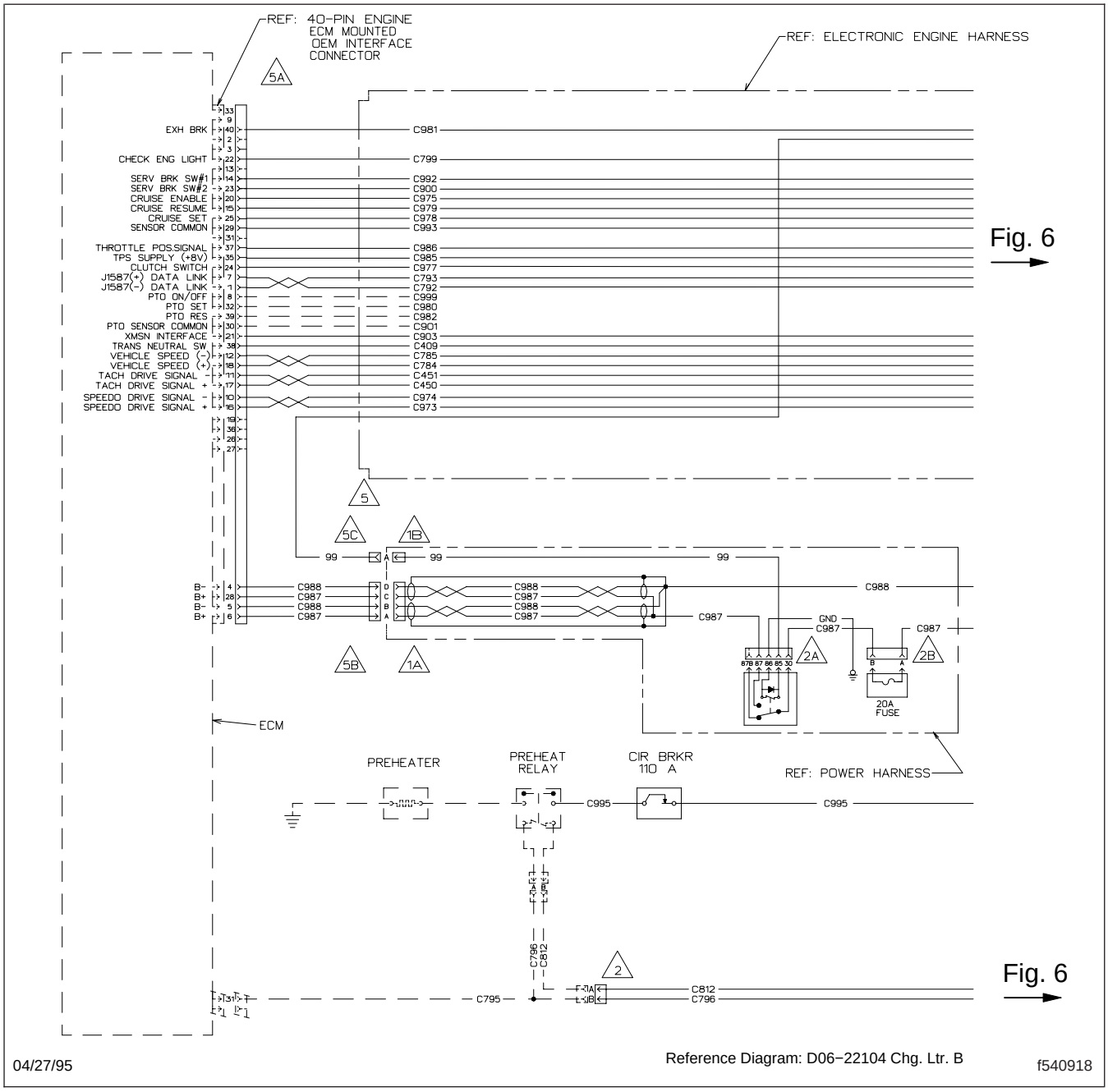


Fig. 5, Wiring Diagram for Caterpillar CFE Series Engine (detail)

Specifications

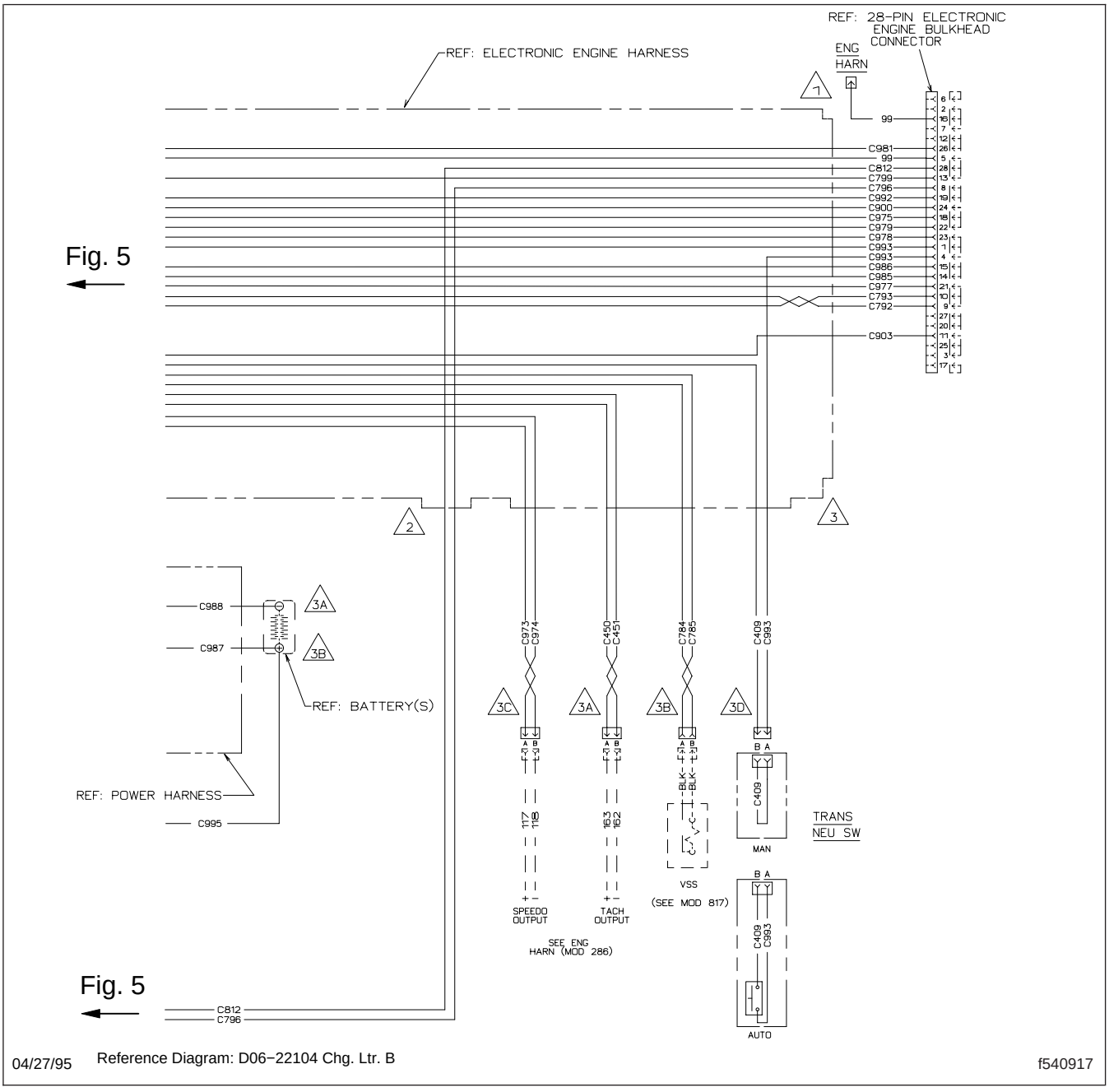


Fig. 6, Wiring Diagram for Caterpillar CFE Series Engine (detail)

Specifications

See Fig. 1 for a full view of the Detroit Diesel Electronic Control (DDEC II) electronic engine wiring diagram (the engine side). **See Fig. 2** and **Fig. 3** for partial (detailed) views of the DDEC II wiring diagram.

See Fig. 4 for a full view of the DDEC II wiring diagram (the cab side). **See Fig. 5** and **Fig. 6** for partial (detailed) views of the DDEC II wiring diagram (the cab side).

See Fig. 7 for a full view of the DDEC II engine brake wiring diagram. See **Fig. 8** and **Fig. 9** for partial (detailed) views of the DDEC II engine brake wiring diagram.

See Fig. 10 for a full view of the DDEC III wiring diagram (the engine side). **See Fig. 11** and **Fig. 12** for partial (detailed) views of the DDEC III wiring diagram (the engine side).

See Fig. 13 for a full view of the DDEC III wiring diagram (the cab side). **See Fig. 14** and **Fig. 15** for partial (detailed) views of the DDEC III wiring diagram (the cab side).

See Fig. 16 for a full view of the DDEC III engine brake wiring diagram. **See Fig. 17** and **Fig. 18** for partial (detailed) views of the DDEC III engine brake wiring diagram.

Specifications

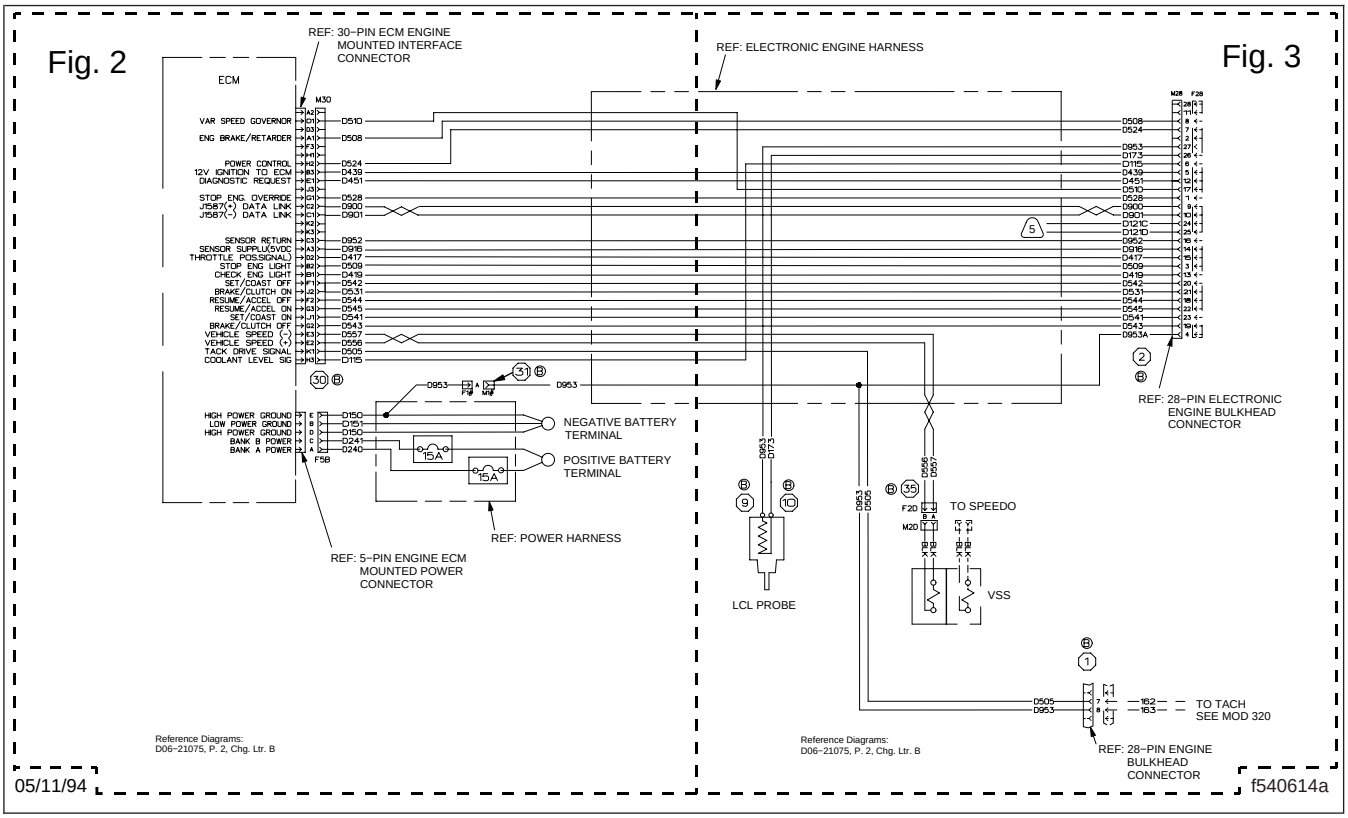


Fig. 1, DDEC II Electrical Engine Wiring Harness, Engine to Bulkhead Connector

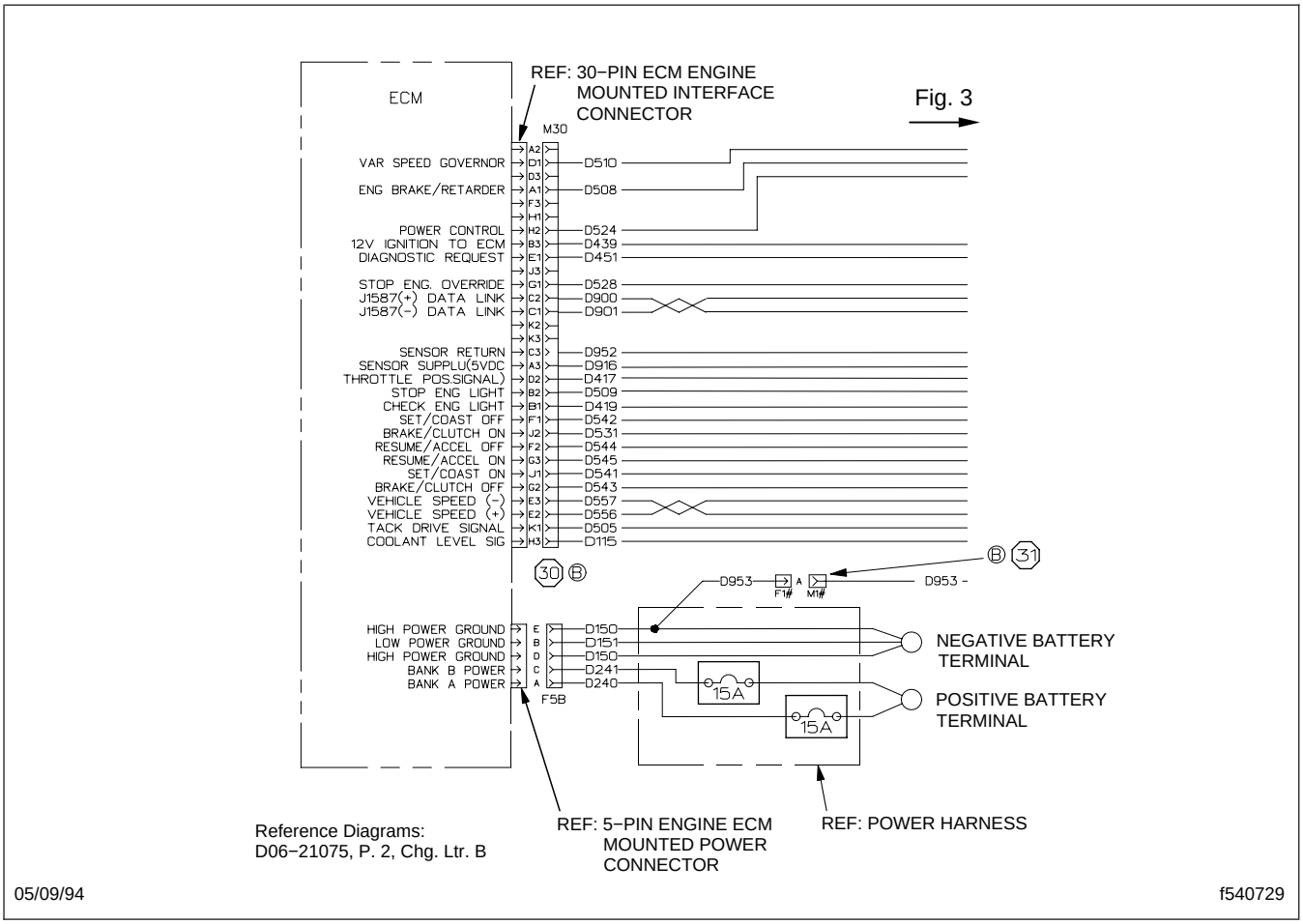


Fig. 2, DDEC II Electrical Engine Wiring Harness, Engine to Bulkhead Connector (enlarged portion of Figure 1)

Specifications

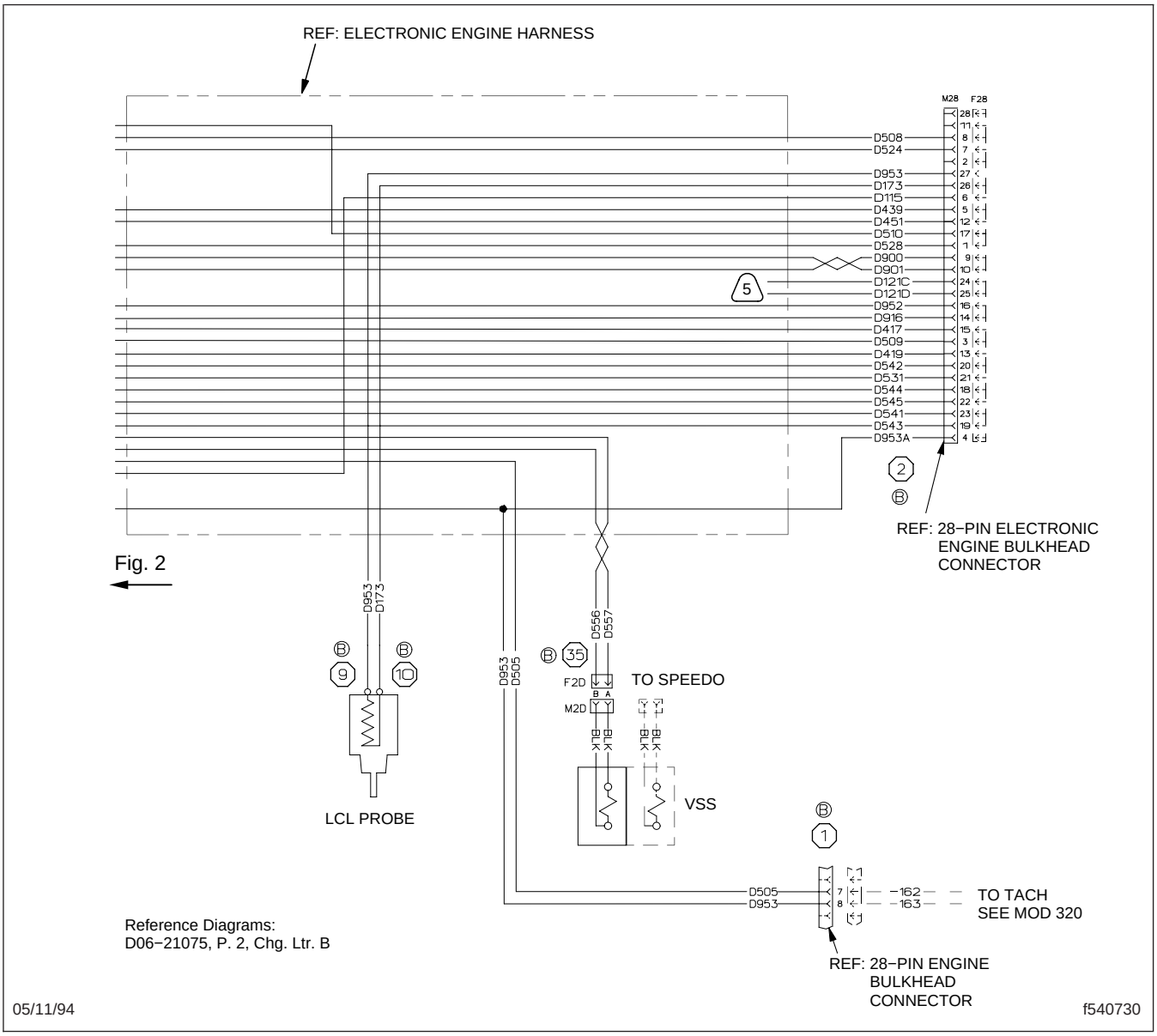


Fig. 3, DDEC II Electrical Engine Wiring Harness, Engine to Bulkhead Connector (enlarged portion of Figure 1)

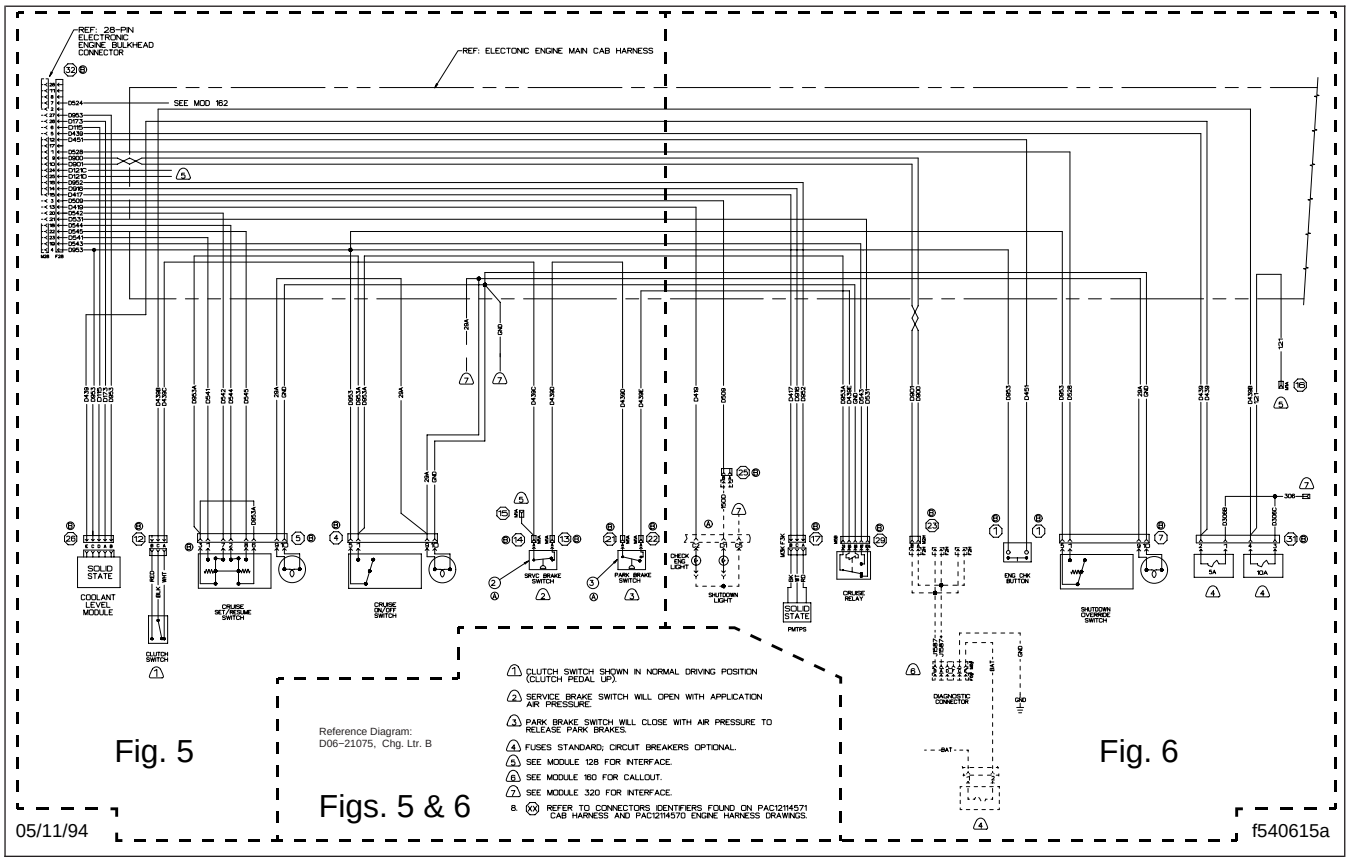


Fig. 4, DDEC II Cab Wiring Harness

Specifications

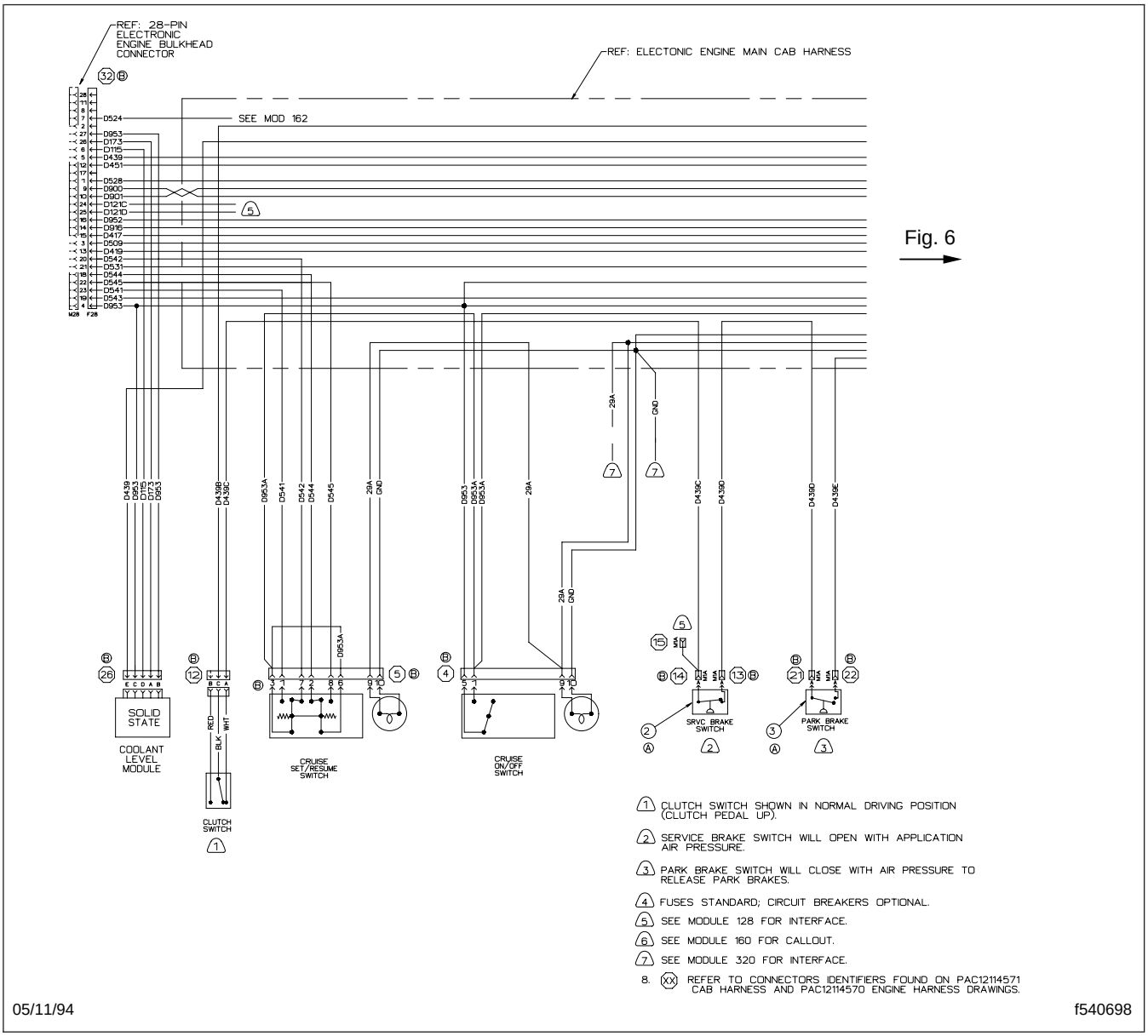


Fig. 5, DDEC II Cab Wiring Harness (enlarged portion of Figure 4)

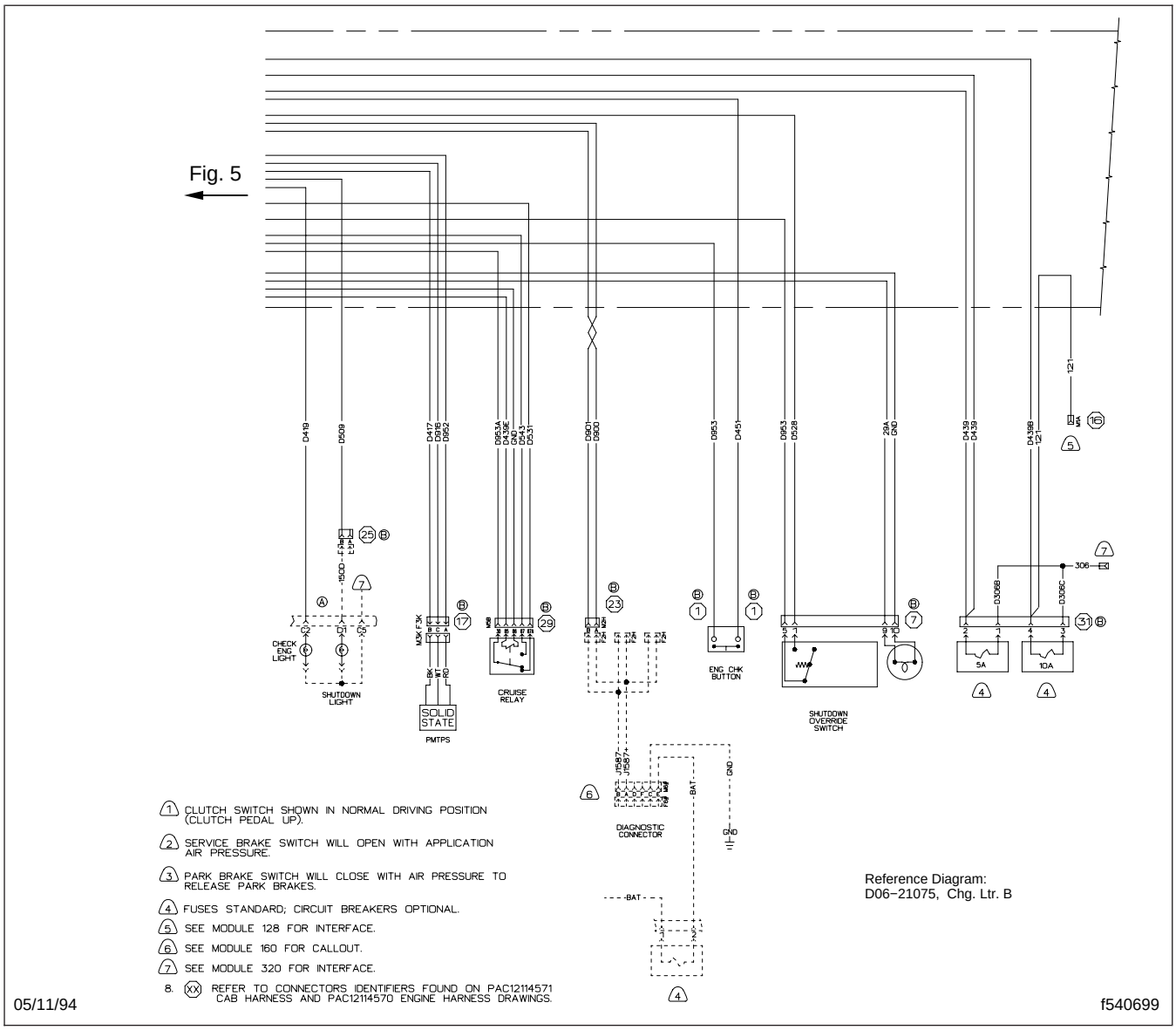


Fig. 6, DDEC II Cab Wiring Harness (enlarged portion of Figure 4)

Specifications

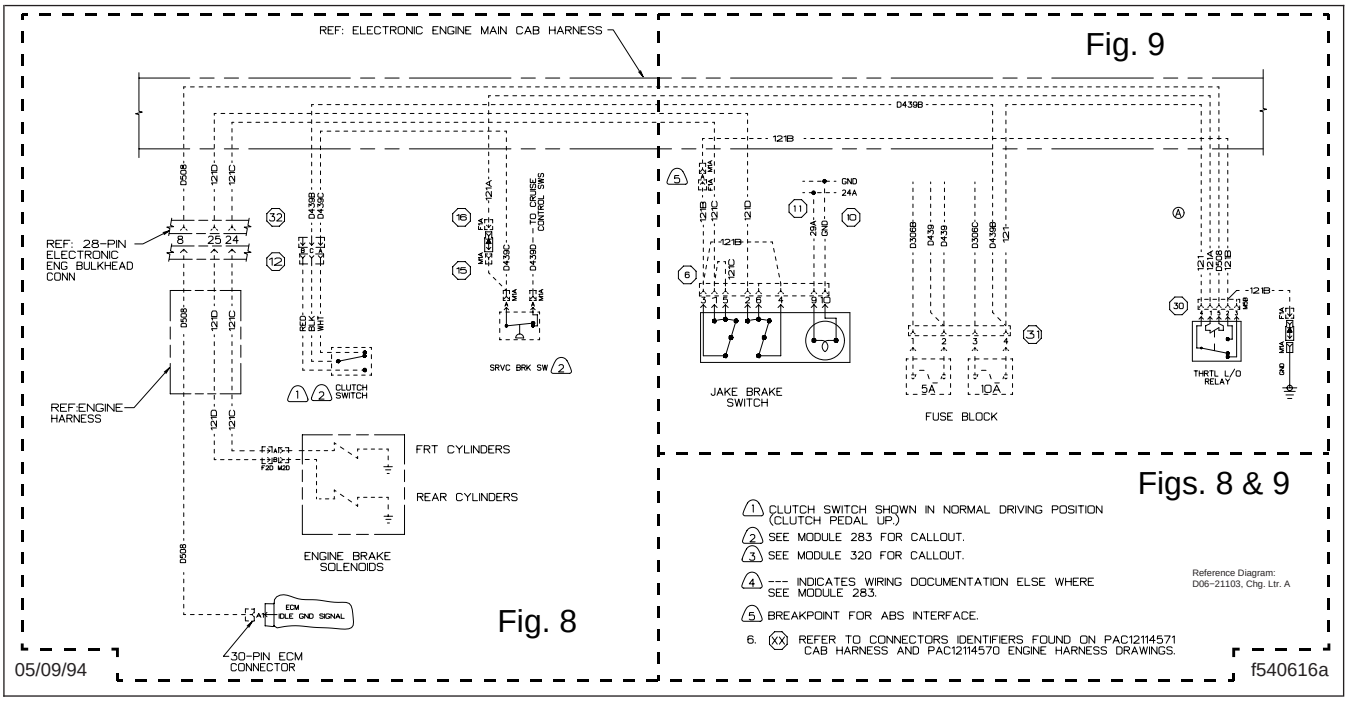


Fig. 7, DDEC II Engine Brake Wiring

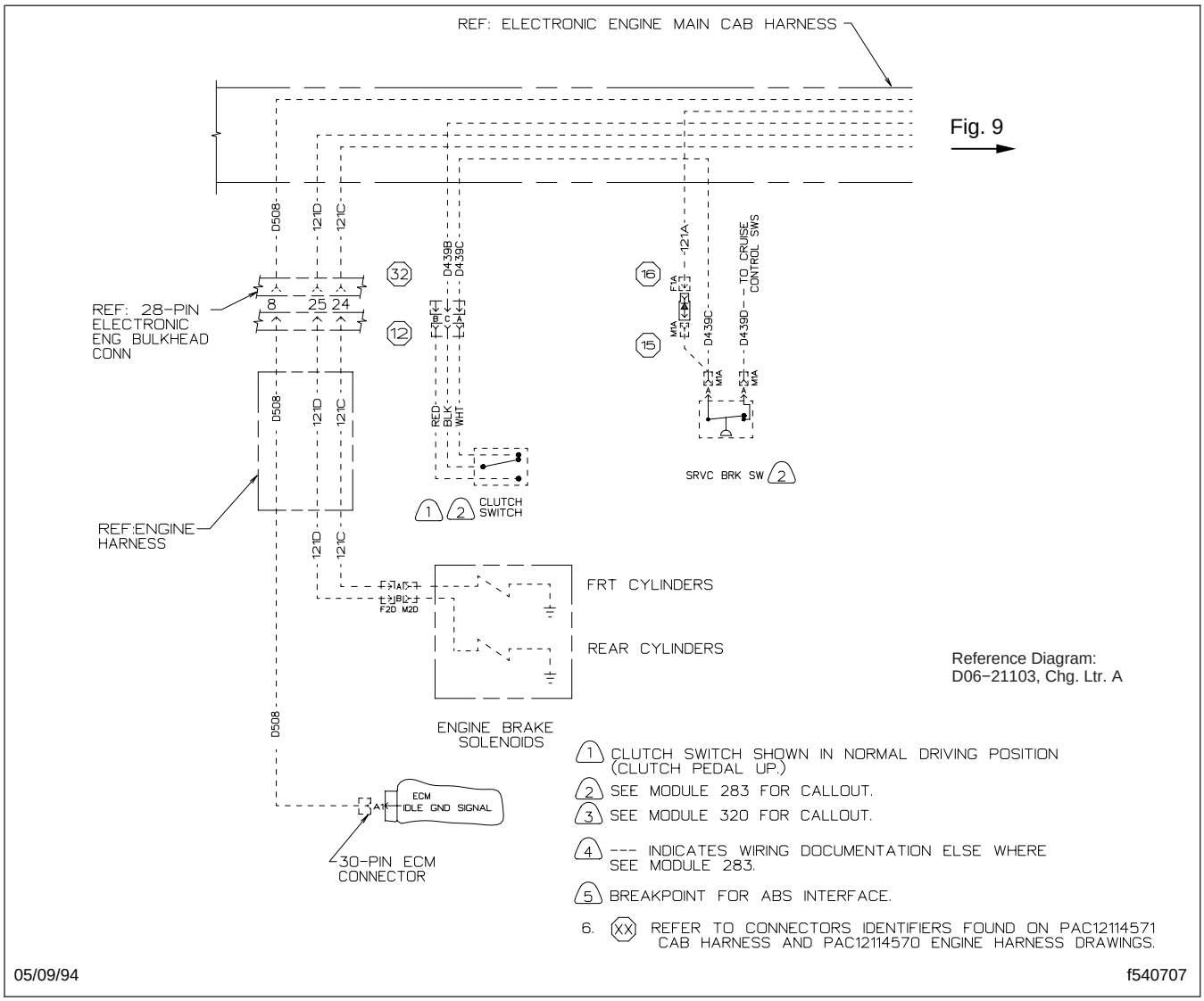


Fig. 8, DDEC II Engine Brake Wiring (enlarged portion of Figure 7)

Specifications

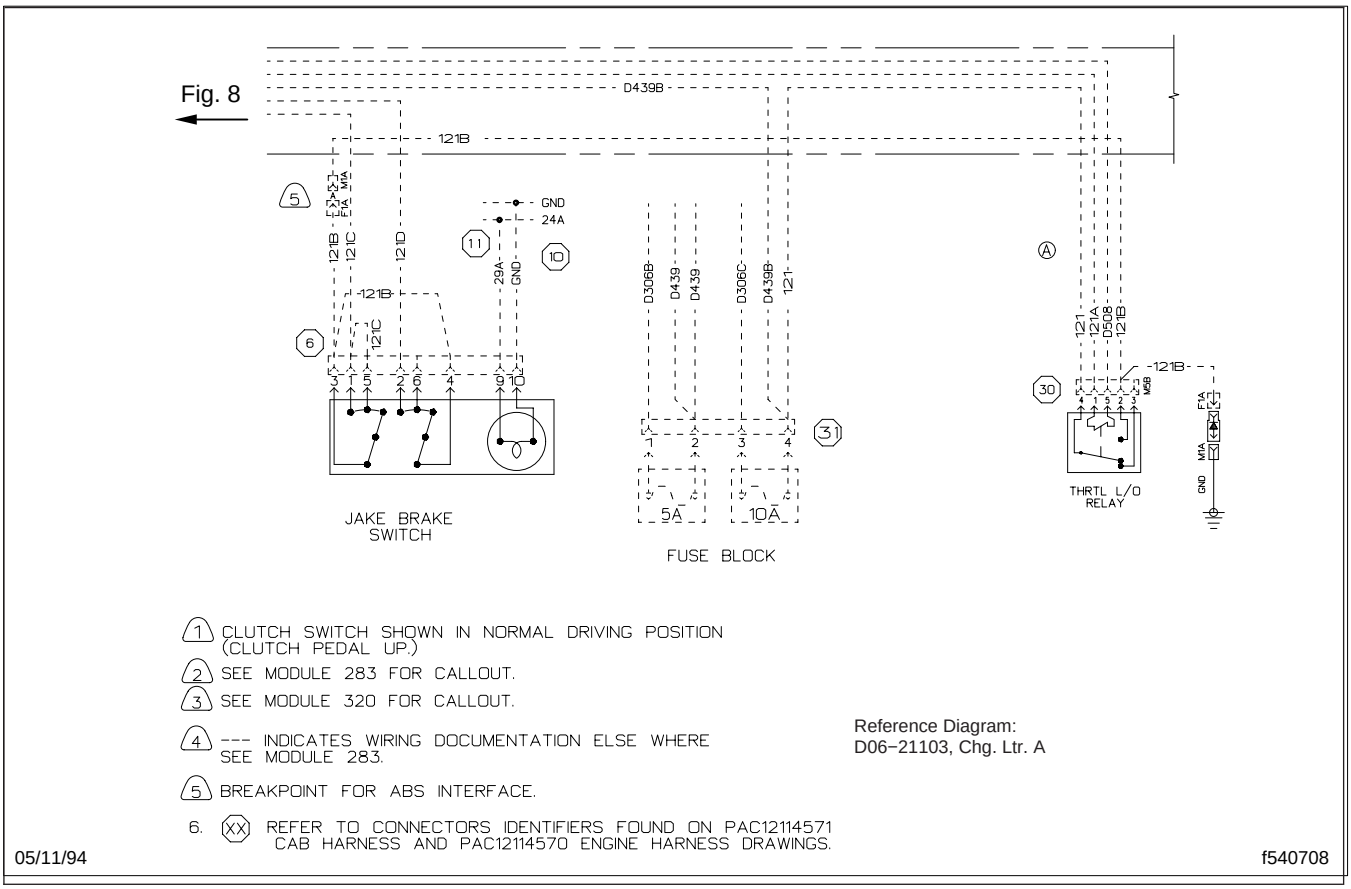


Fig. 9, DDEC II Engine Brake Wiring (enlarged portion of Figure 7)

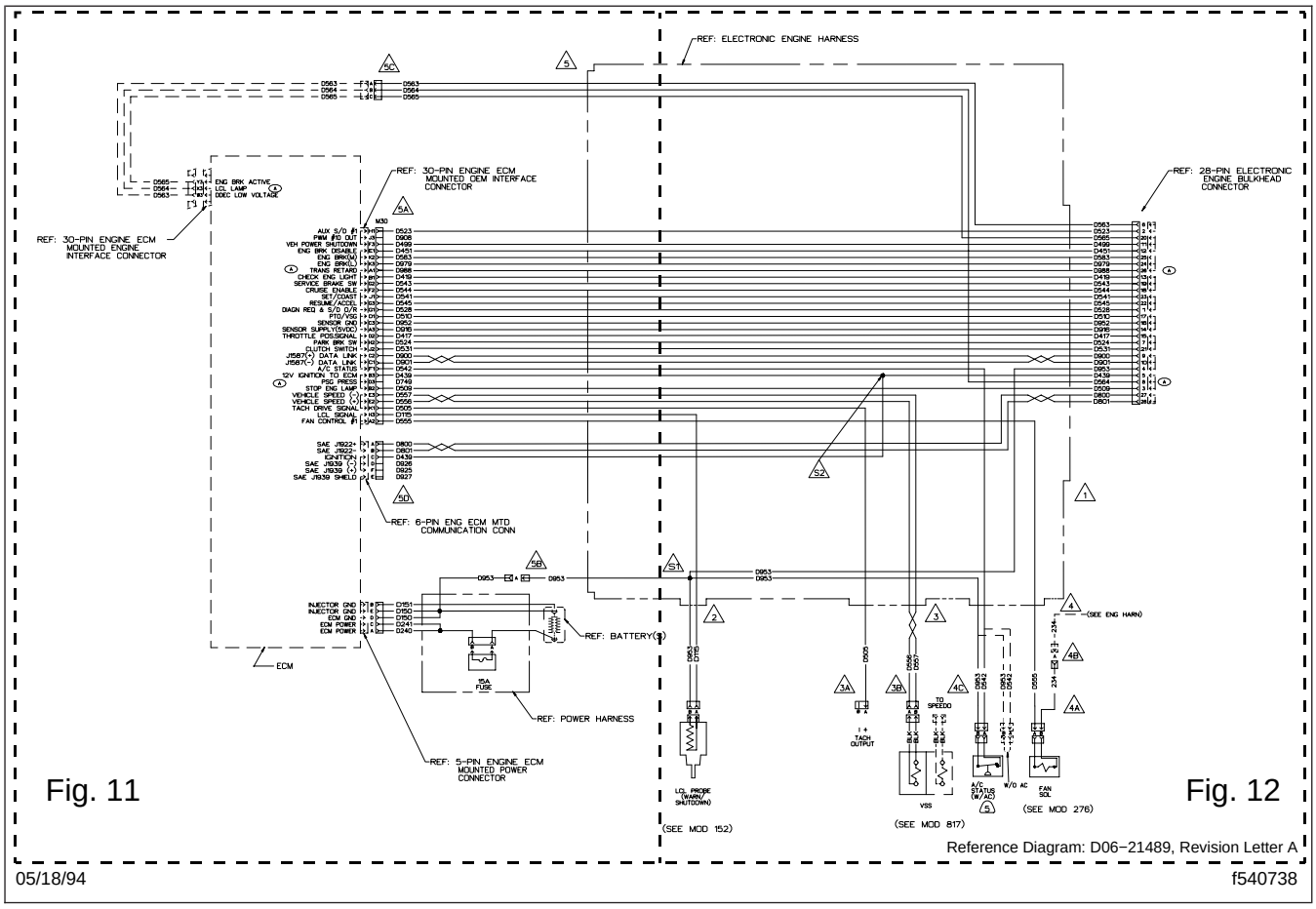


Fig. 10, DDEC III Electrical Engine Wiring Harness, Engine to Bulkhead Connector

Specifications

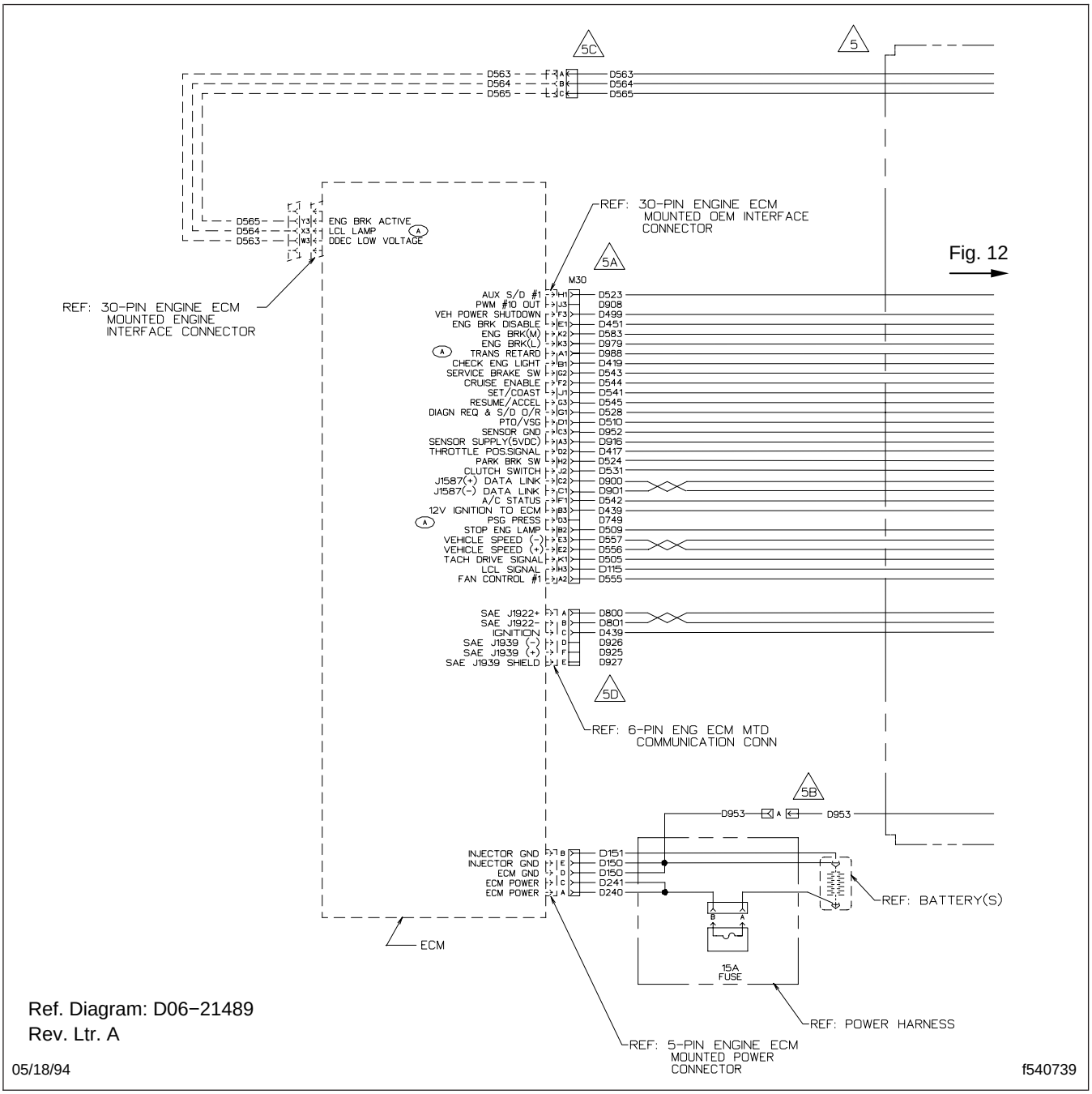


Fig. 11, DDEC III Electrical Engine Wiring Harness, Engine to Bulkhead Connector (enlarged portion of Figure 10)

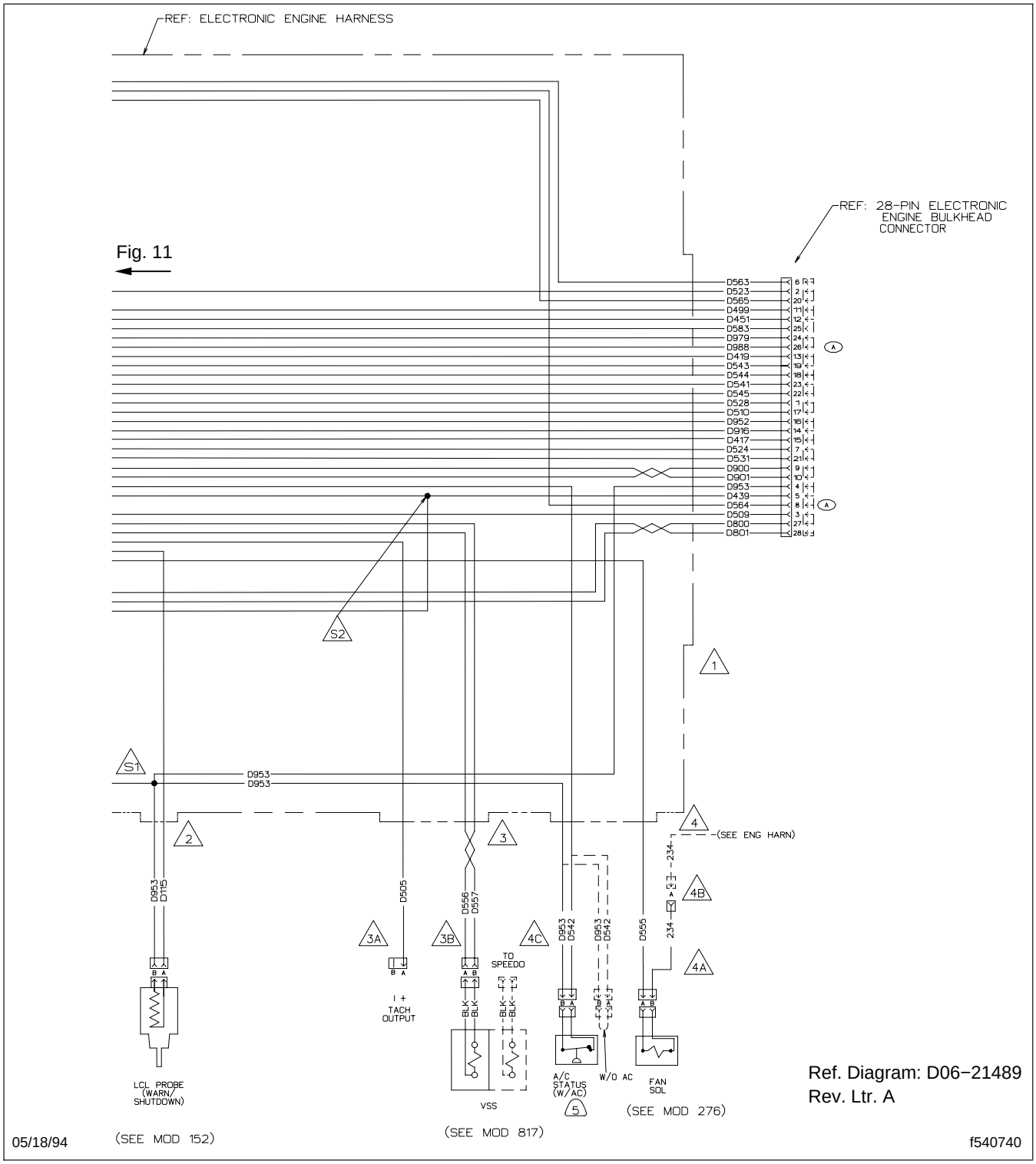


Fig. 12, DDEC III Electrical Engine Wiring Harness, Engine to Bulkhead Connector (enlarged portion of Figure 10)

Specifications

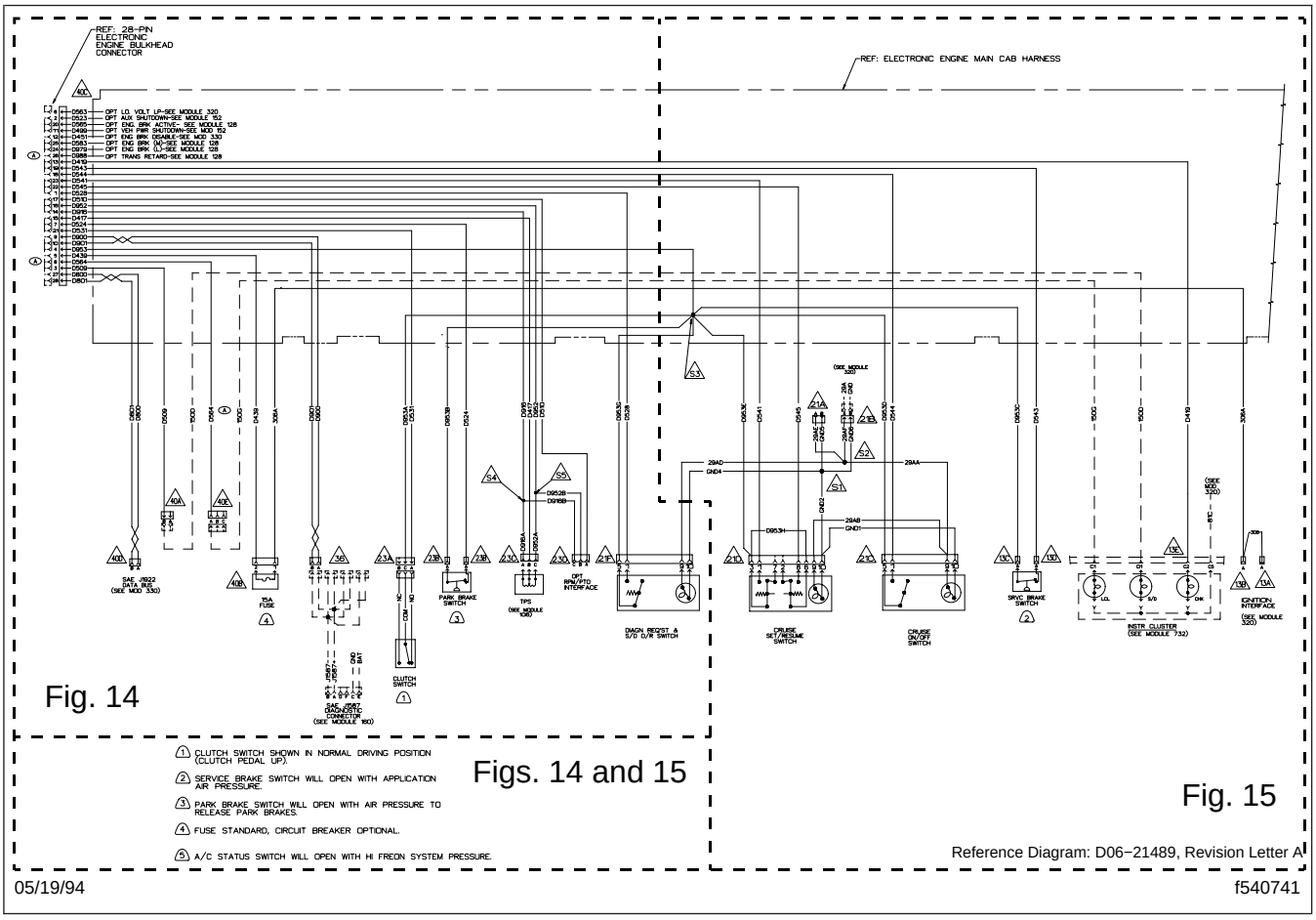


Fig. 13, DDEC III Cab Wiring Harness

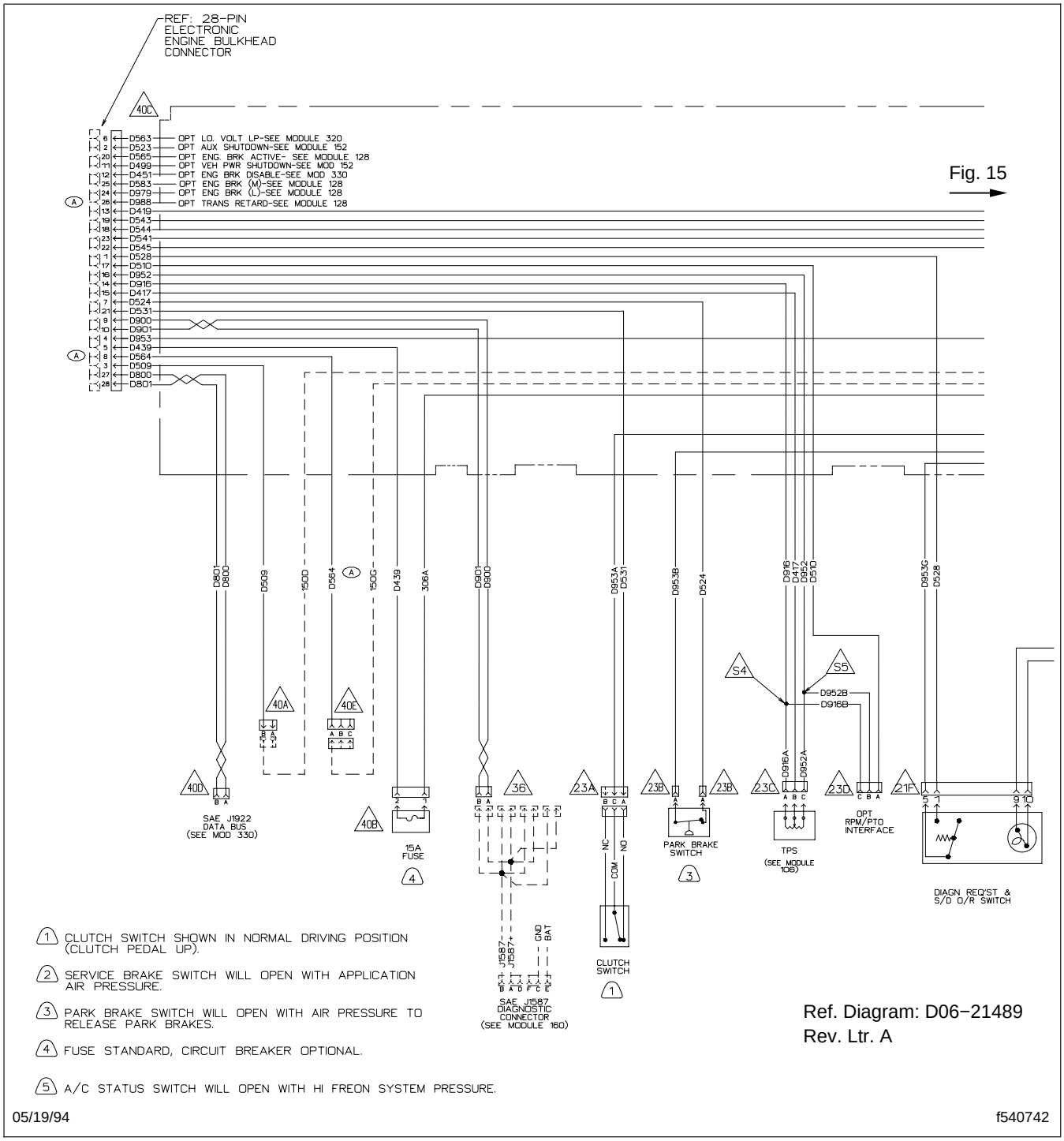


Fig. 14, DDEC III Cab Wiring Harness (enlarged portion of Figure 13)

Specifications

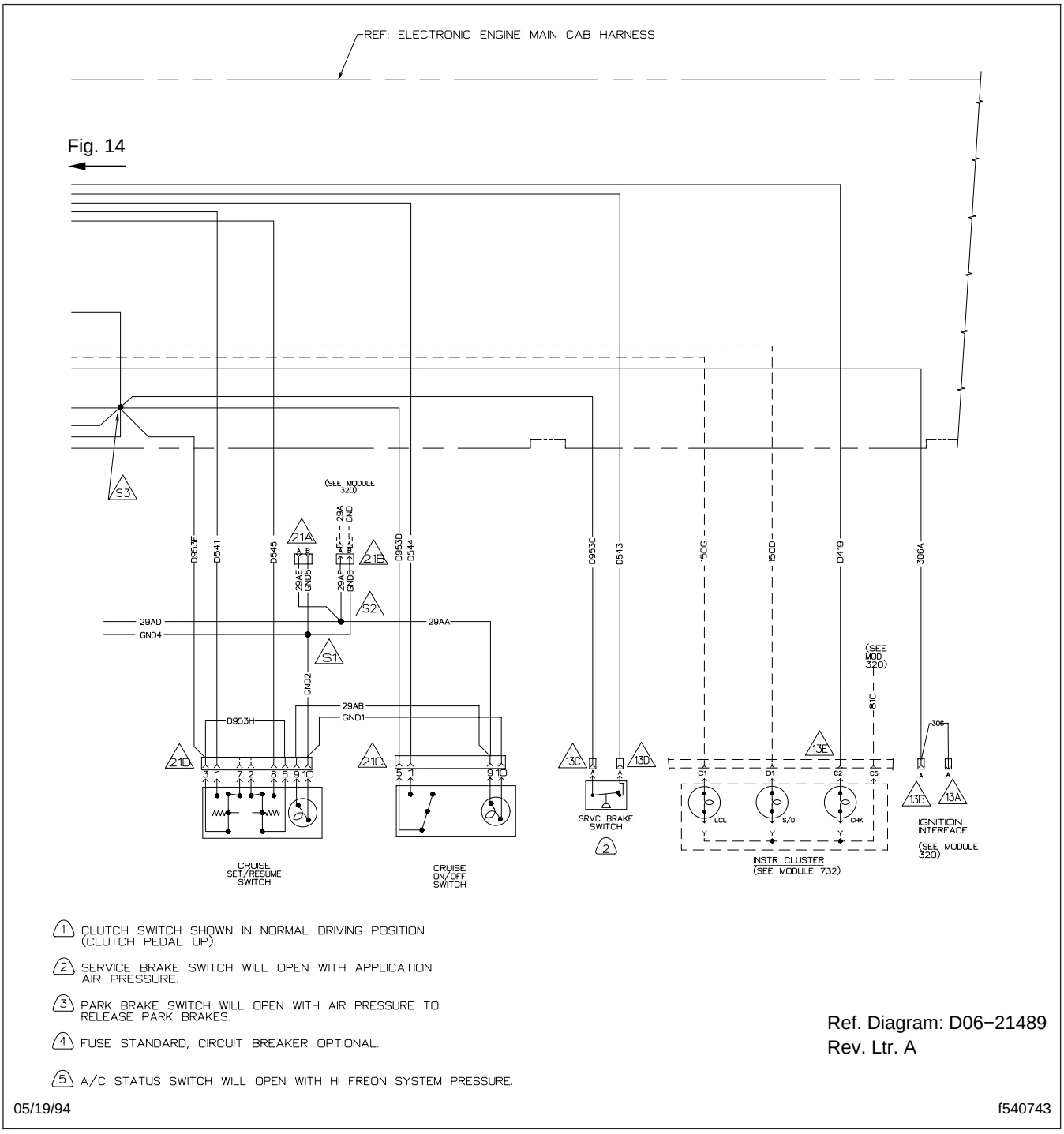


Fig. 15, DDEC III Cab Wiring Harness (enlarged portion of Figure 13)

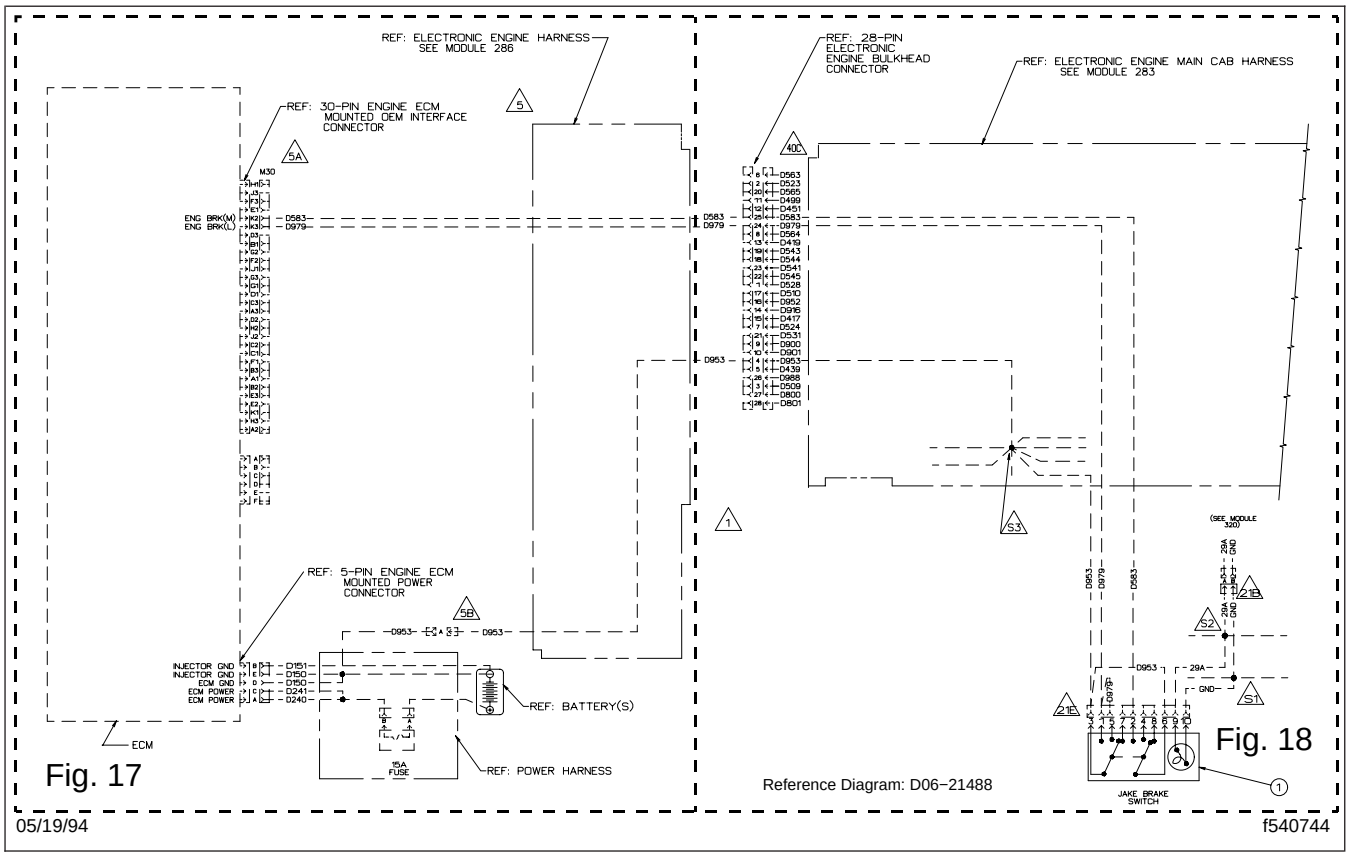


Fig. 16, DDEC III Exhaust Brake Wiring Harness

Specifications

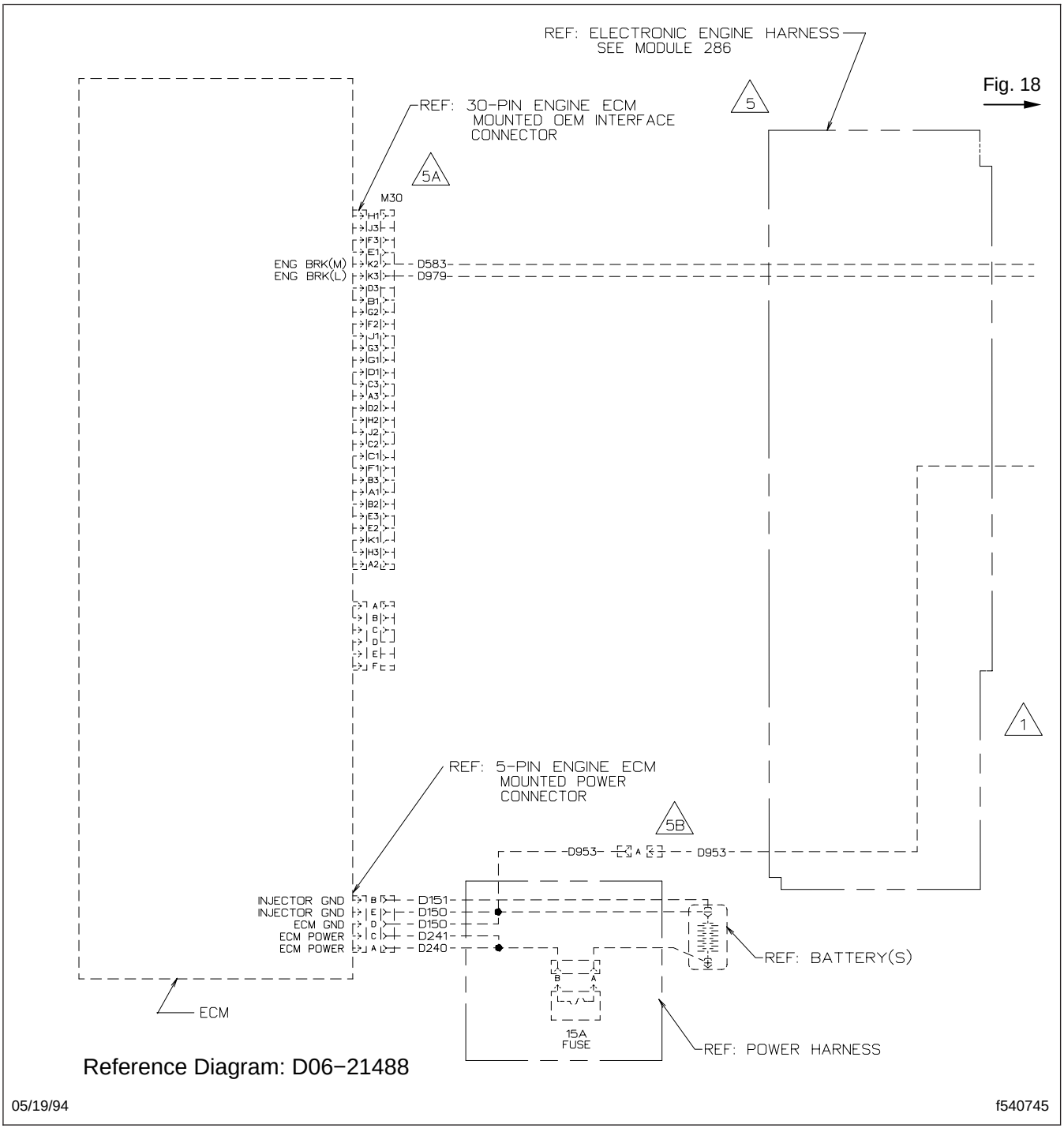


Fig. 17, DDEC III Exhaust Brake Wiring Harness (enlarged portion of Figure 16)

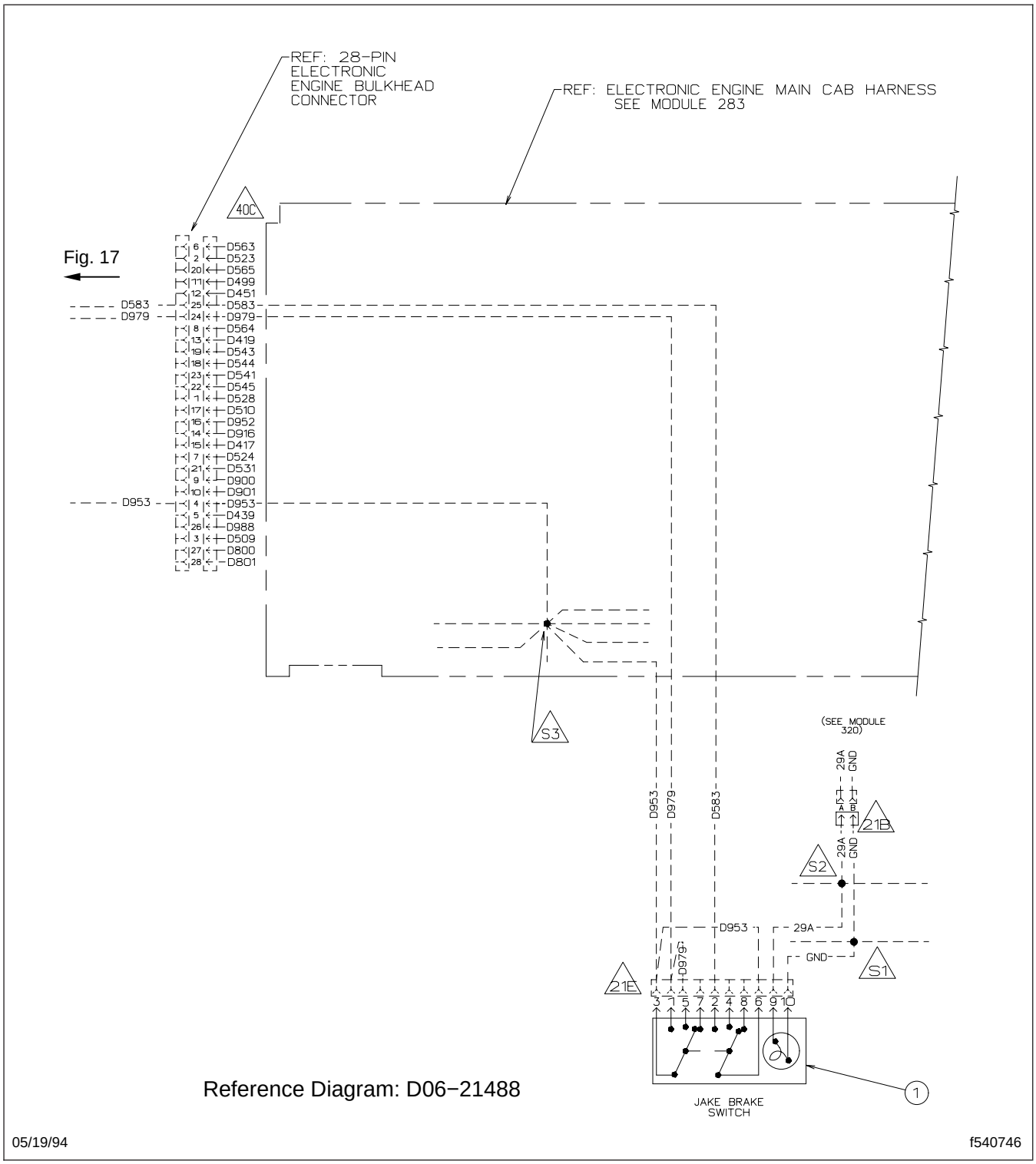


Fig. 18, DDEC III Exhaust Brake Wiring Harness (enlarged portion of Figure 16)

See **Fig. 1** for a full view of the Allison electronic transmission wiring diagram. See **Fig. 2** and **Fig. 3** for detailed (partial) views of the Allison electronic transmission wiring.

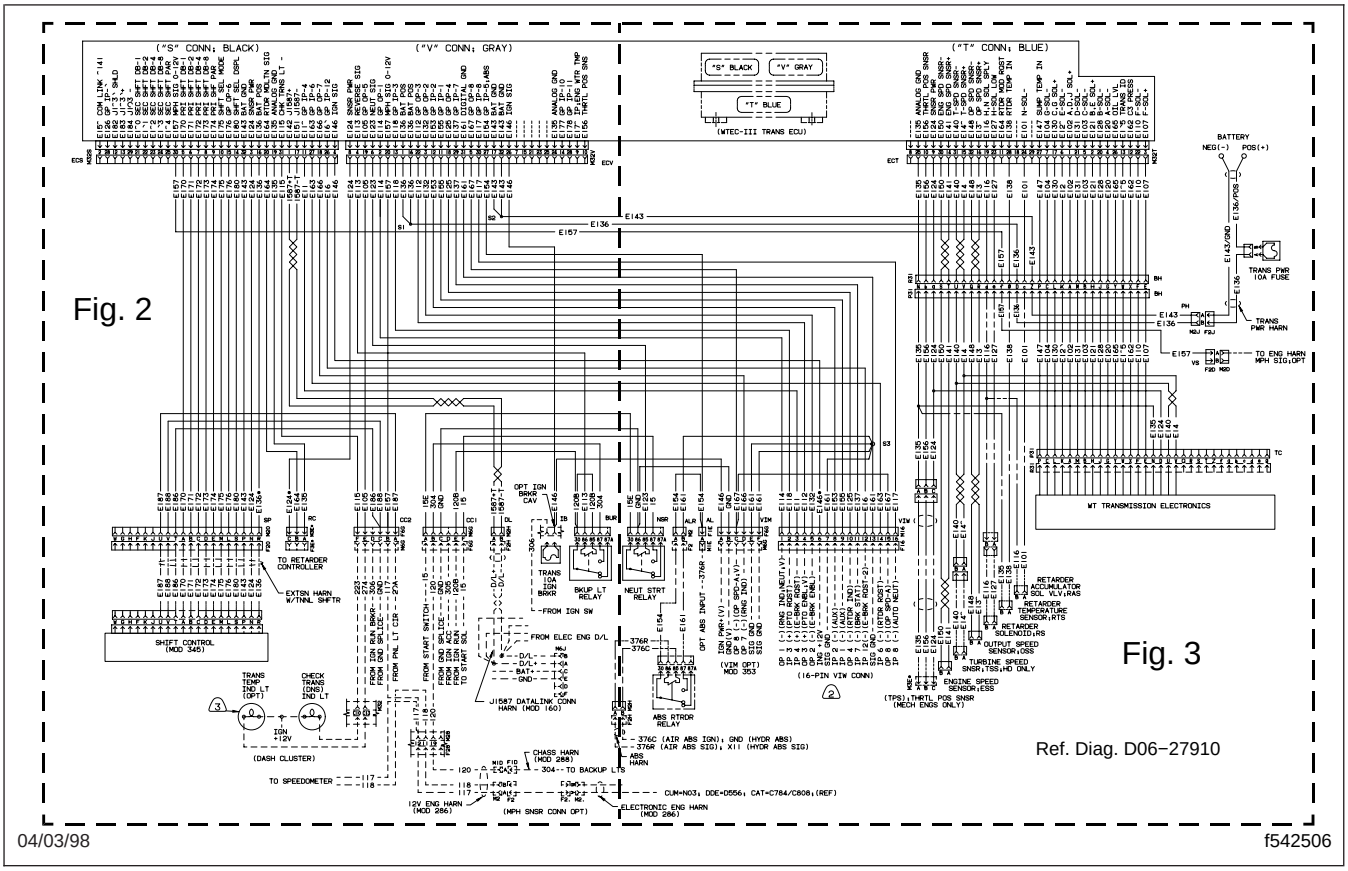


Fig. 1, Allison Transmission Wiring (full view)

Specifications

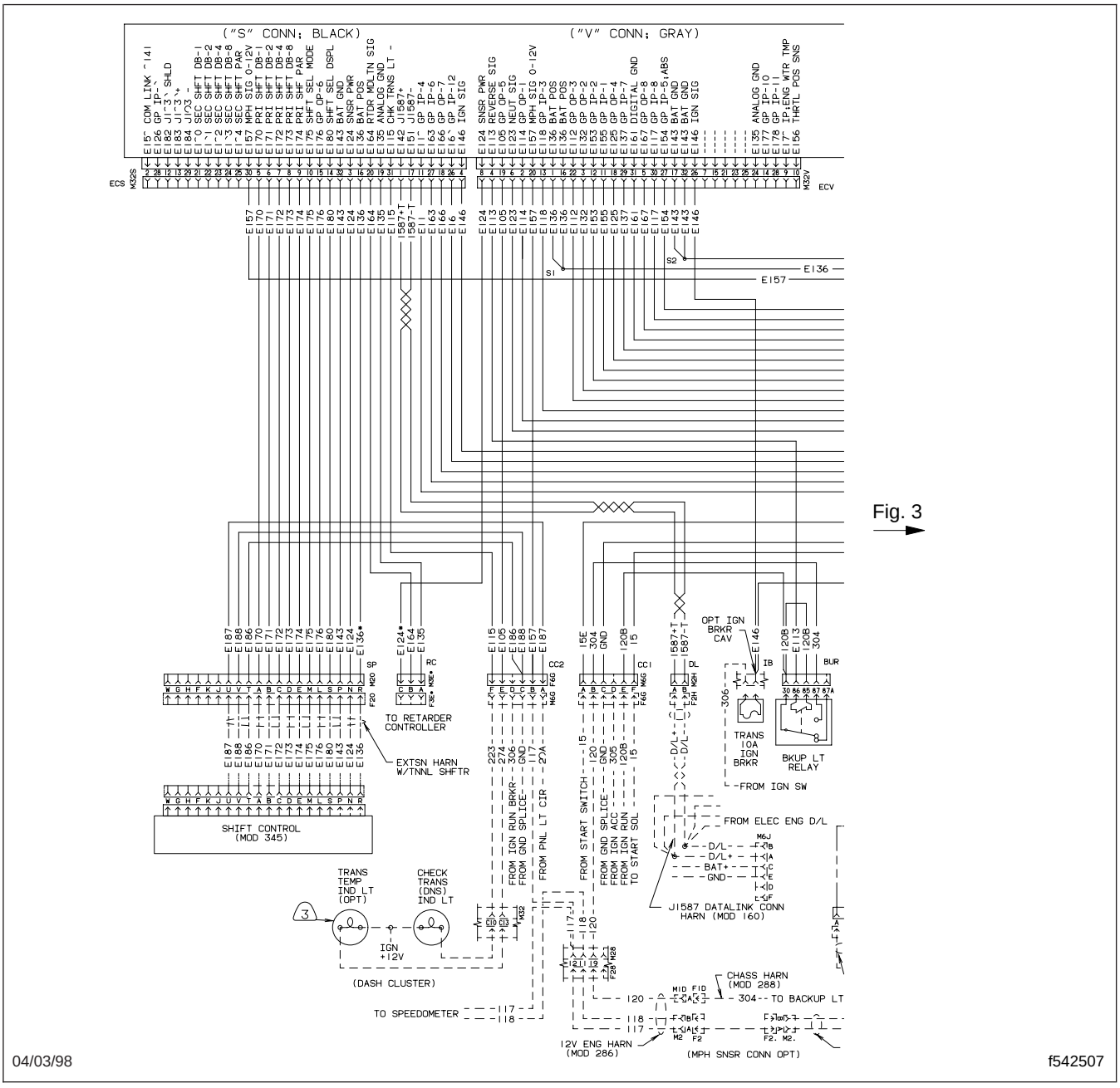


Fig. 3

Fig. 2, Allison Transmission Wiring (partial view)

Fig. 2

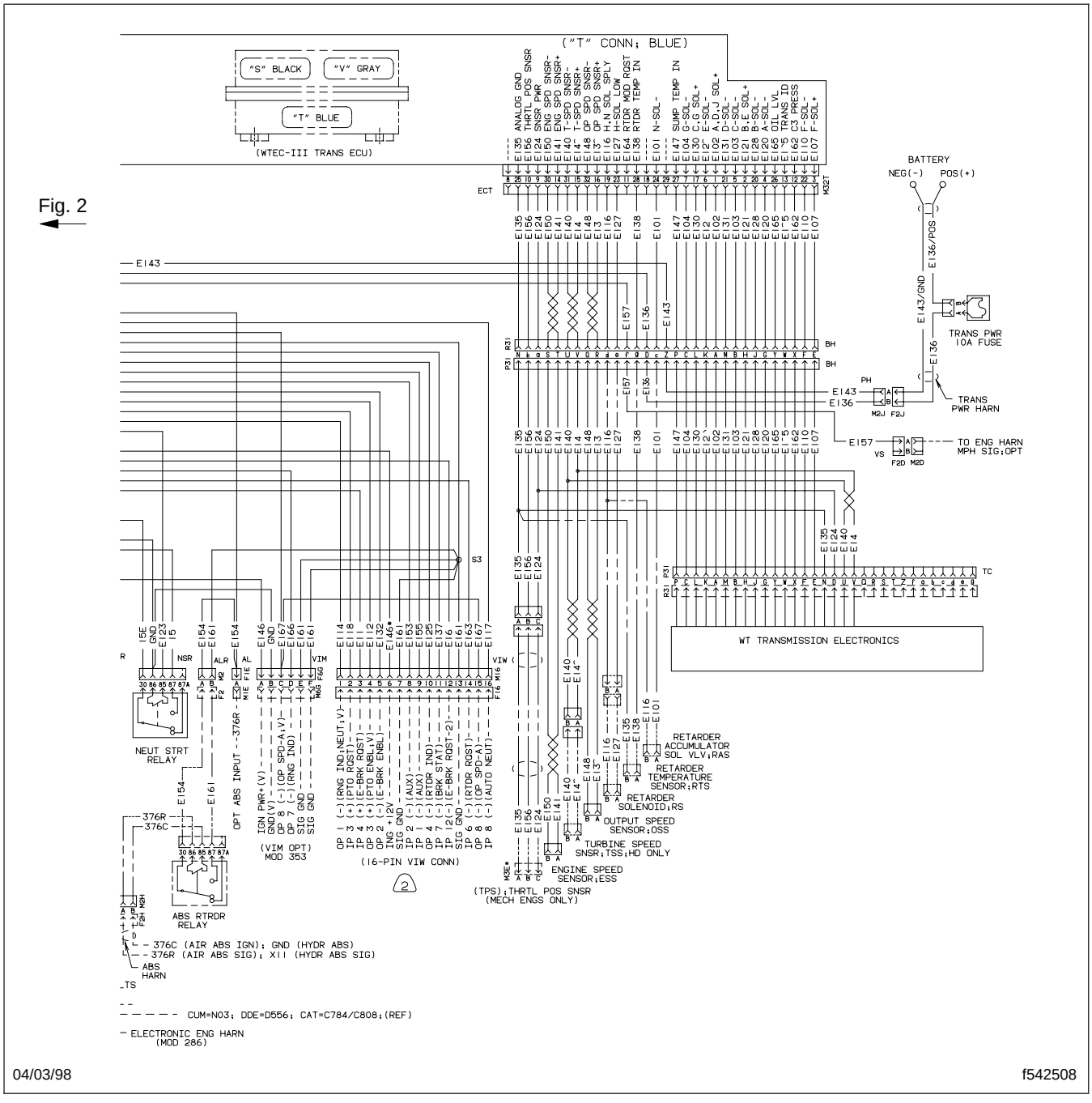
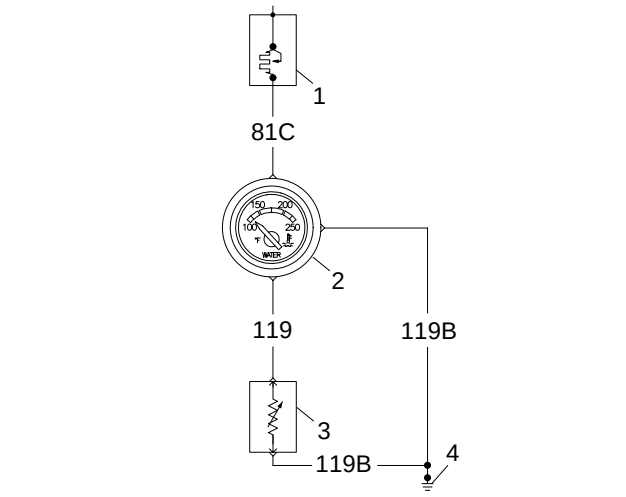


Fig. 3, Allison Transmission Wiring (partial view)

General Information

The Ametek coolant temperature gauge system is standard equipment on all vehicles. The system consists of a dash-mounted gauge (electrical type), an engine-mounted temperature sender, and the electrical wires that connect these components. Circuitry is similar, but not identical, for diesel and gasoline powered vehicles. See **Fig. 1** and **Fig. 2**.



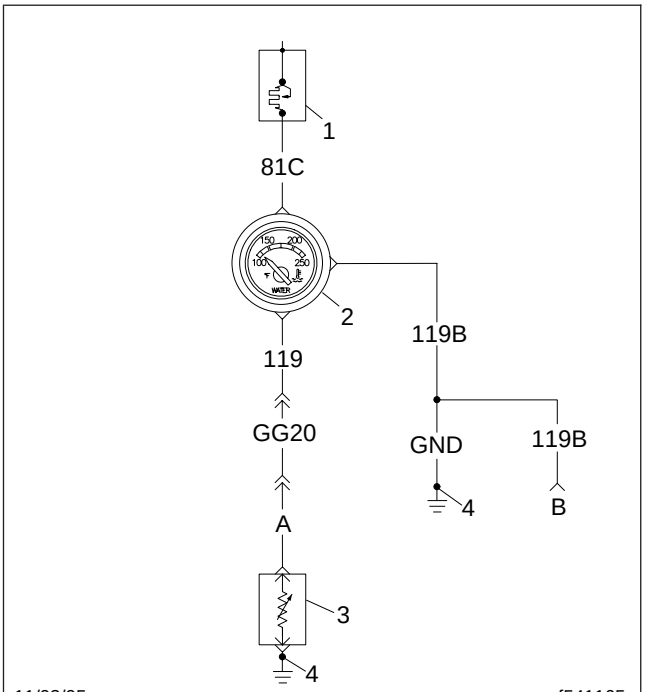
1. Power Supply Circuit Breaker
2. Coolant Temperature Gauge
3. Coolant Temperature Sender
4. Ground Point

Fig. 1, Engine Coolant Temperature Gauge System, Diesel Engines

The coolant temperature gauge is a cross-coil electric gauge with a 90-degree sweep. The gauge body is made of clear plastic and has a painted face. A light bulb fitted to the gauge mounting panel illuminates the gauge face from behind. The gauge is easily removed and installed from the front of the instrument panel.

Vehicles built for use in North America have a gauge that registers coolant temperature in degrees Fahrenheit (°F). Vehicles built for export out of North America have a gauge that registers coolant temperature in degrees Celsius (°C).

The coolant temperature sender is threaded into a fitting on the engine, where its tip comes in direct contact with engine coolant. The specific location



A. This wire is violet with a yellow stripe.
B. Circuit 119B ends at a connector and is not used.
1. Power Supply Circuit Breaker
2. Coolant Temperature Gauge
3. Coolant Temperature Sender
4. Ground Point

Fig. 2, Engine Coolant Temperature Gauge System, V-8 Gasoline Engines

varies according to engine manufacturer and model, but is usually near the thermostat.

Diesel engines are fitted with a two-terminal coolant temperature sender (see **Fig. 3**); V-8 gasoline engines are fitted with a similar single-terminal sender.

The coolant temperature sender is a temperature sensitive resistor (thermistor) whose electrical resistance decreases as coolant temperature increases. In other words, the resistance across the sensor terminals is high when the engine is cold (about 400 ohms) and drops as the engine warms up (resistance is about 50 ohms when the engine is hot).

General Information

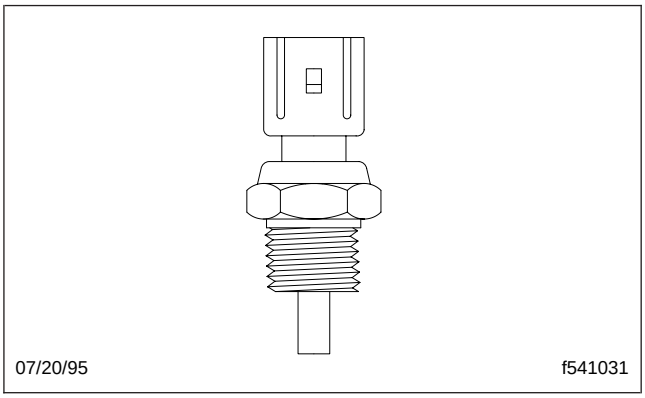


Fig. 3, Two-Terminal Coolant Temperature Sender, Diesel Engines

Coolant Temperature Gauge Removal and Installation

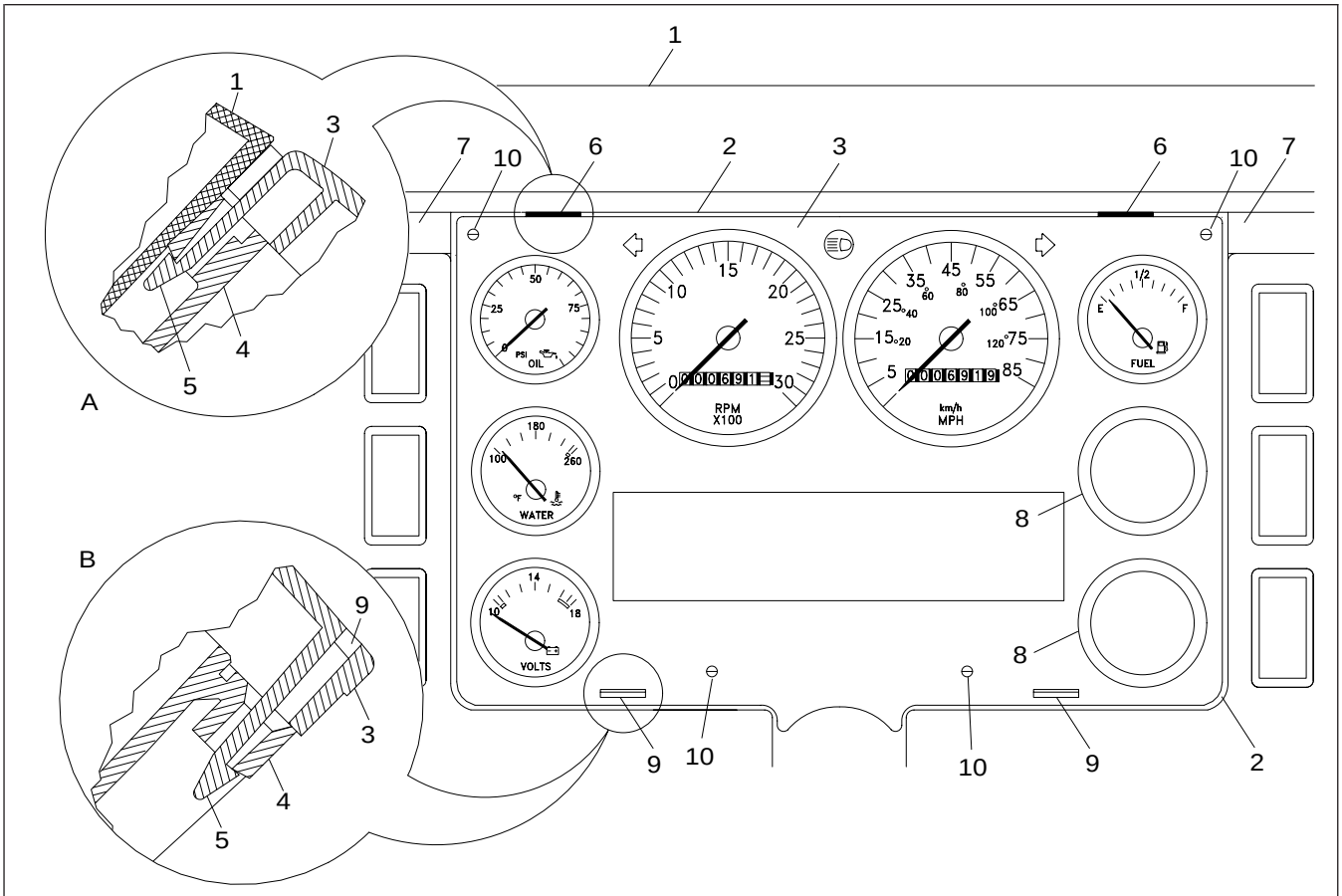
Removal

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Disconnect the batteries.
3. Remove the instrument cluster bezel. See **Fig. 1**.

3.1 If present, remove the four Torx-head screws from the bezel.

3.2 By hand, remove the vinyl extrusion trim (see **Fig. 1**, Ref. 7) on each side of the instrument cluster bezel.

3.3 Insert a stubby, flat-tipped screwdriver



A. Sectional Detail (Left Side View of Upper Left-Hand Locking Tab)
B. Sectional Detail (Left Side View of Lower Left-Hand Locking Tab)
1. Instrument Panel Upper Cover
2. Foam Gasket
3. Instrument Cluster Bezel
4. Gauge Mounting Panel
5. Bezel Locking Tab
6. Opening in Foam Gasket
7. Vinyl Extrusion Trim
8. Gauge Blank (Block-Off Plug)
9. Slot in Bezel
10. Location of Torx-Head Mounting Screw

Fig. 1, Instrument Cluster Bezel Details

NOTE: On some vehicles, the bezel is also secured to the instrument panel with four Torx®-head screws (**Fig. 1**, Ref. 10).

into the opening above the upper left-hand corner of the instrument cluster bezel (see **Fig. 1**, Ref. 6) and release the bezel locking tab (Ref. 5) by gently pivot-

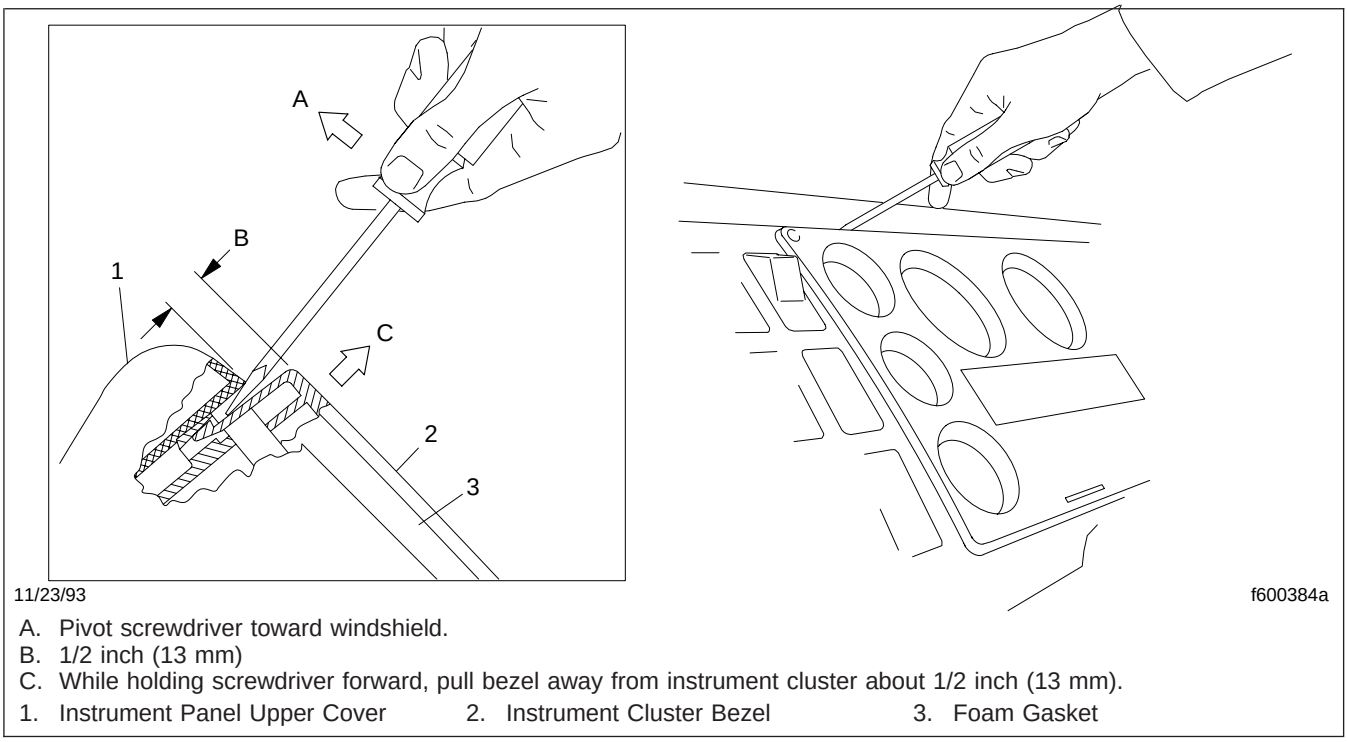
Coolant Temperature Gauge Removal and Installation

ing the screwdriver handle toward the vehicle windshield. See **Fig. 2**.

While keeping pressure on the screwdriver, use your other hand to pull the corner of the bezel away from the instrument panel about 1/2 inch (13 mm).

The gauge illumination bulb will remain in the gauge mounting panel; do not remove the bulb unless it must be replaced. See **Fig. 4**.

Installation



A. Pivot screwdriver toward windshield.
B. 1/2 inch (13 mm)
C. While holding screwdriver forward, pull bezel away from instrument cluster about 1/2 inch (13 mm).
1. Instrument Panel Upper Cover 2. Instrument Cluster Bezel 3. Foam Gasket

Fig. 2, Releasing the Bezel Upper Edge

3.4 Repeat the previous step for the upper right-hand corner of the bezel.

3.5 With both corners released, tilt the entire top edge of the bezel away from the instrument panel about 1 inch (25 mm) and try to work the bottom edge of the bezel loose.

If the bottom of the bezel won't come loose, use the screwdriver to release the locking tabs at the bottom edge of the bezel. See **Fig. 3**.

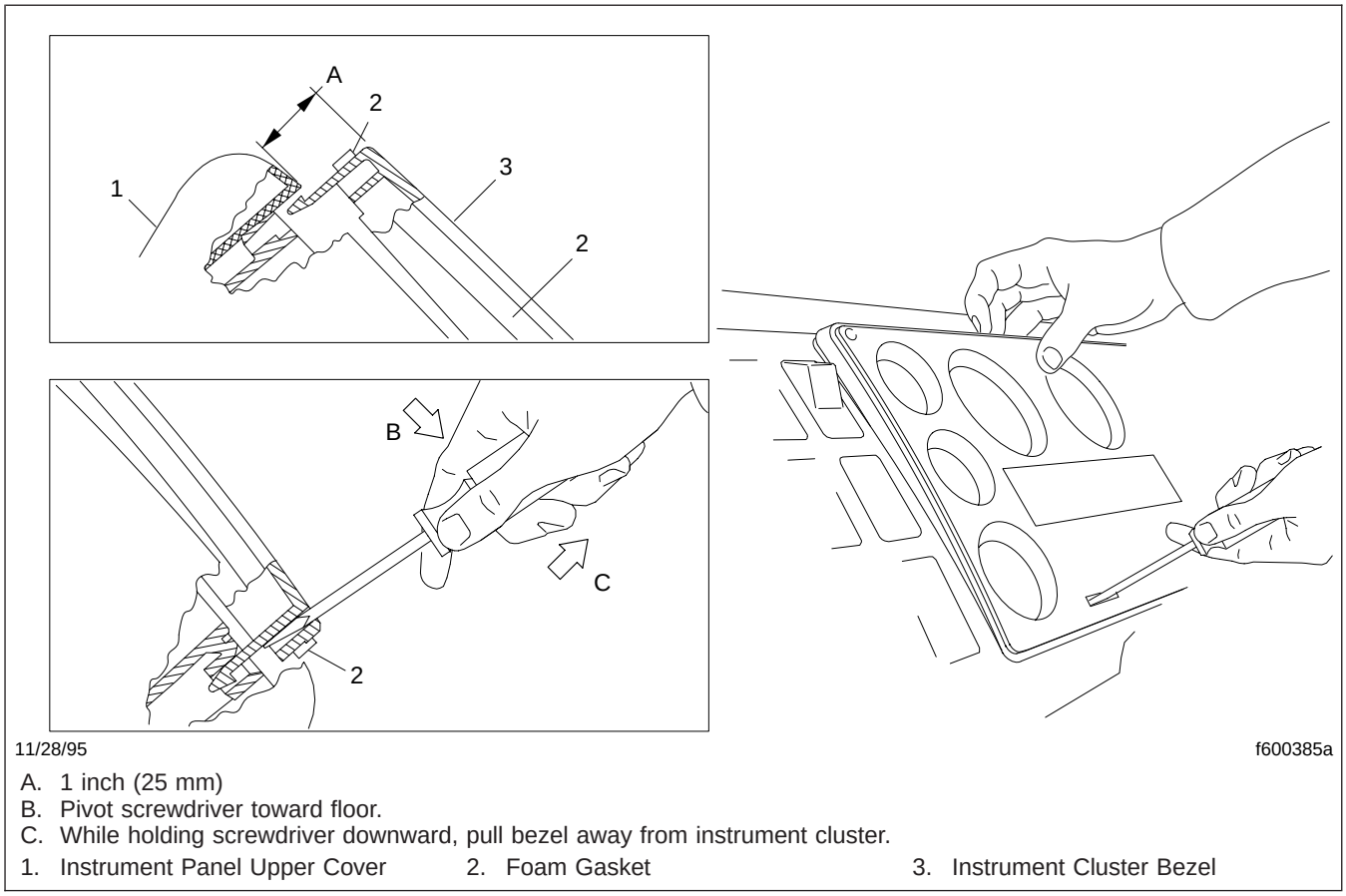
Set the bezel aside.

4. Remove the coolant temperature gauge from the gauge mounting panel by grasping the gauge firmly and pulling it straight out of the mounting panel.

1. Position the coolant temperature gauge over the gauge mounting panel, making sure that the panel terminals line up with the gauge sockets.
2. Push the gauge into place until it seats against the mounting panel.
3. Position the instrument cluster bezel against the instrument panel. Starting with the lower corners, alternately push against the bottom and top corners of the bezel, until all four locking tabs are locked and the face of the bezel is flush with the surfaces of the instrument panel. Don't push against the gauge lenses or gauge blanks (block-off plugs).

NOTE: On some vehicles, the bezel is also secured to the instrument panel with four Torx®-head screws (**Fig. 1**, Ref. 10).

Coolant Temperature Gauge Removal and Installation

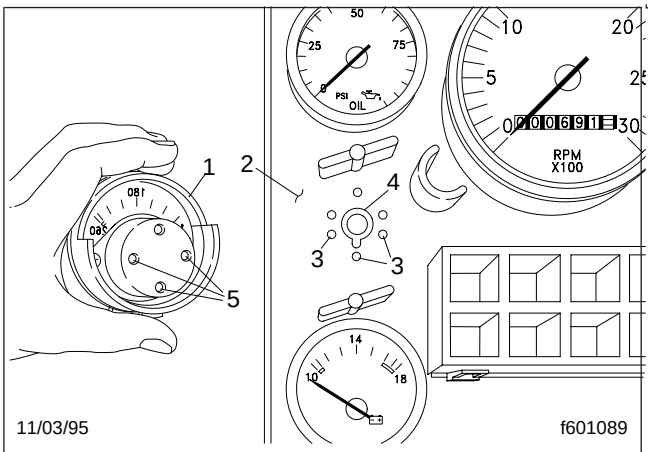


A. 1 inch (25 mm)
B. Pivot screwdriver toward floor.
C. While holding screwdriver downward, pull bezel away from instrument cluster.
1. Instrument Panel Upper Cover 2. Foam Gasket 3. Instrument Cluster Bezel

Fig. 3, Releasing the Bezel Lower Edge

4. If removed, install the screws in the instrument cluster bezel.
5. Install the vinyl extrusion trim on both sides of the bezel.
6. Connect the batteries.
7. Start the engine and verify that the coolant temperature gauge is operating properly.
8. Remove the chocks from the tires.

Coolant Temperature Gauge Removal and Installation



1. Coolant Temperature Gauge
2. Gauge Mounting Panel
3. Panel Electrical Terminals
4. Illumination Bulb and Socket
5. Gauge Electrical Socket

Fig. 4, Coolant Temperature Gauge Installation View

Coolant Temperature Sender Removal and Installation

Removal

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Open the hood and locate the coolant temperature sender. Sender location varies according to engine manufacturer and model, but is usually near the coolant thermostat. **See Fig. 1**, **Fig. 2**, **Fig. 3**, **Fig. 4**, **Fig. 5**, **and Fig. 6.**

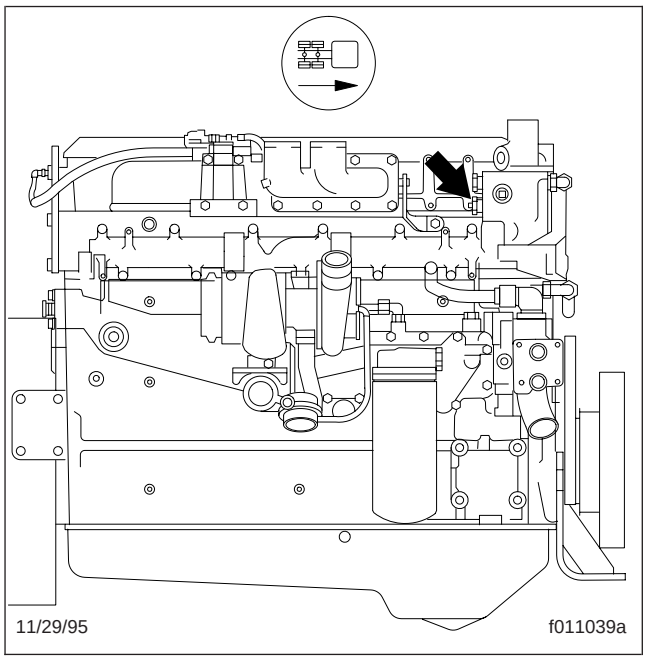


Fig. 1, Coolant Temperature Sender Location, Caterpillar 3126 Engine

⚠ WARNING

WARNING: Don't drain the cooling system while the engine is hot. To avoid personal injury from scalding coolant, wait until the engine has cooled down before draining the system.

3. Drain coolant from the system until the coolant level drops below the coolant temperature sender location.
   - 3.1 With the engine cool, loosen the radiator cap to release pressure from the radiator, then tighten the cap.
   - 3.2 Place a clean drain pan under the drain plug or petcock located at the bottom of the radiator left end-tank. **See Fig. 7.** Remove the drain plug or open the petcock. If necessary, use a deflector to channel coolant away from the front springs and into the drain pan.

     On some Caterpillar and Detroit Diesel Engines, the radiator drain plug is located on the forward end of the coolant outlet pipe. **See Fig. 8.** On these vehicles, re-

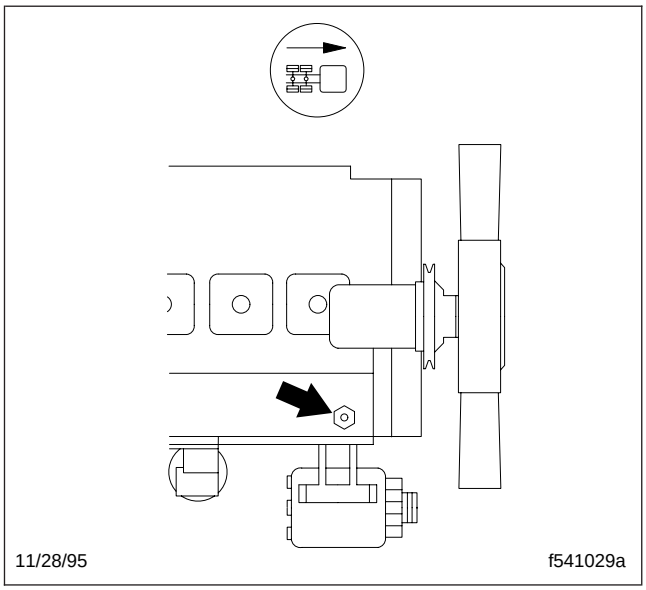


Fig. 2, Coolant Temperature Sender Location, Cummins B Series Engine

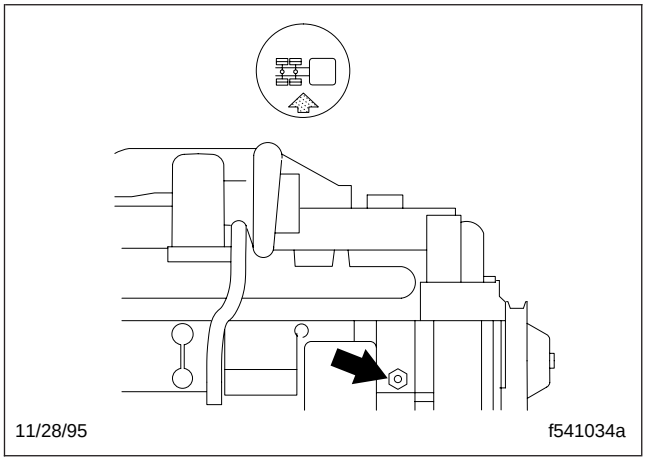


Fig. 3, Coolant Temperature Sender Location, Cummins C Series Engine

Coolant Temperature Sender Removal and Installation

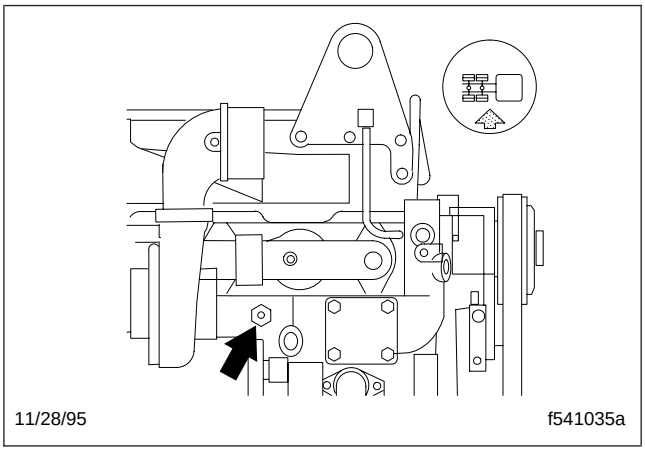


Fig. 4, Coolant Temperature Sender Location, Cummins M11 Engine

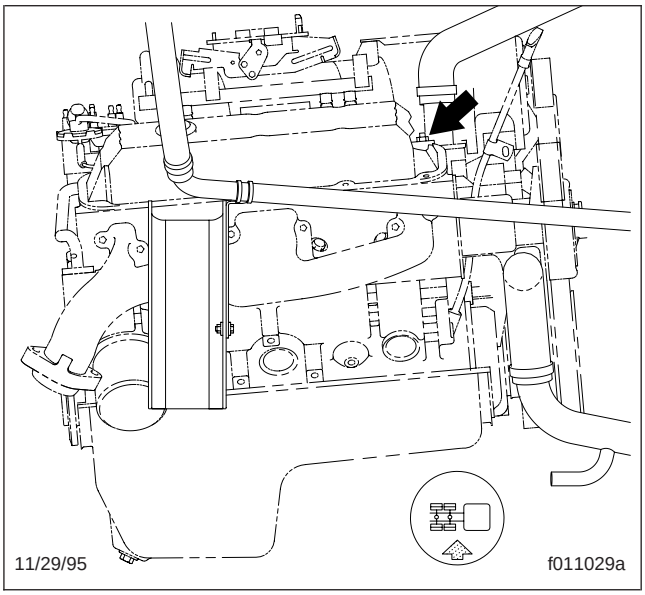


Fig. 5, Coolant Temperature Sender Location, Dodge Magnum Engine

move the aerodynamic cover to access the drain plug.

3.3 Install the drain plug or tighten the petcock.

4. Unplug the wiring harness connector from the coolant temperature sender, and remove the sender from the engine.

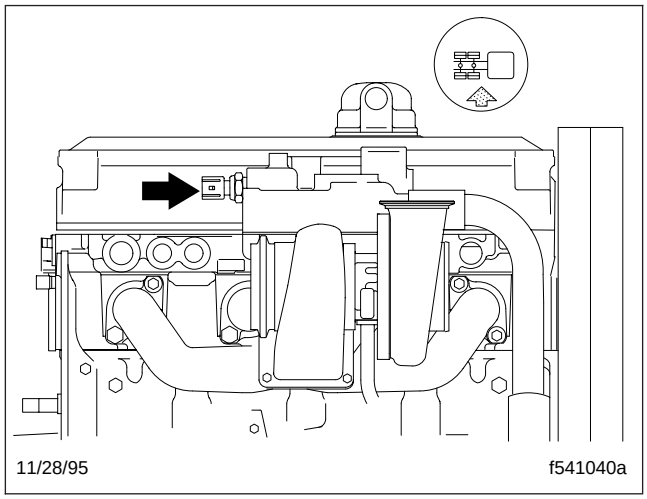


Fig. 6, Coolant Temperature Sender Location, Detroit Diesel 50 Series Engine

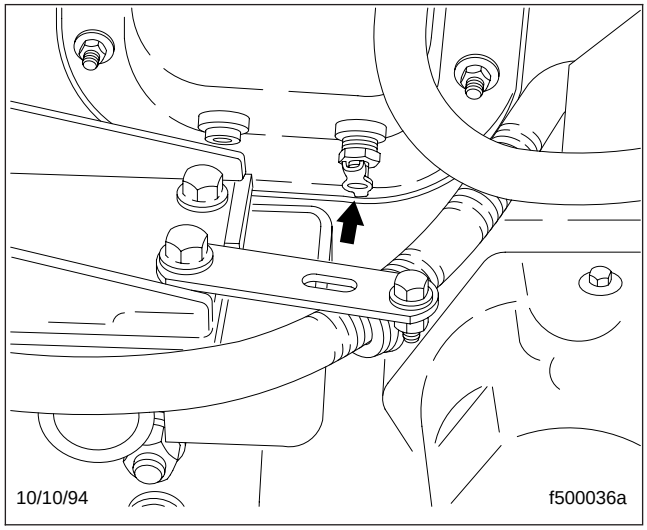


Fig. 7, Radiator Drain Location, Typical

Installation

1. Clean old sealant residue from the threads of the coolant temperature sender opening.
2. Apply pipe thread sealant to the threads of the new coolant temperature sender, and install the sender in the engine opening. Tighten the sender until it is snug.
3. Connect the vehicle wiring harness to the sender.

Coolant Temperature Sender Removal and Installation

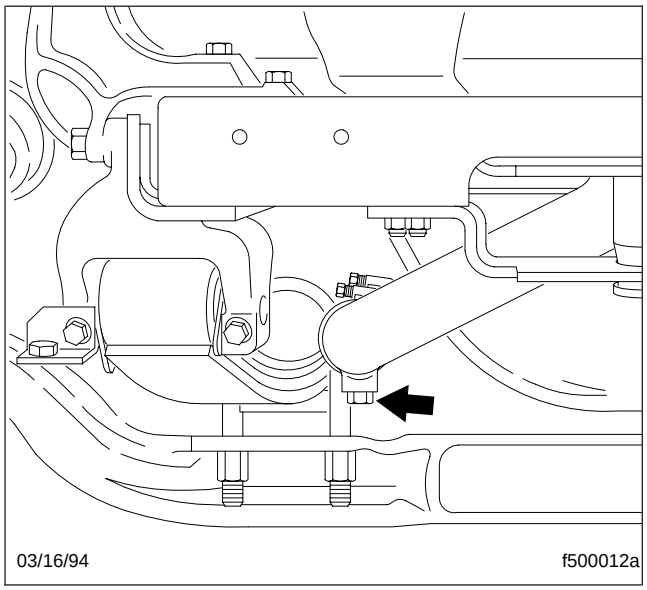


Fig. 8, Radiator Drain Location, Some Caterpillar and Detroit Diesel Engines

4. Fill the cooling system.
5. Start the engine, check for leaks, and check that the coolant temperature gauge is operating properly.
6. Remove the chocks from the tires.

Troubleshooting Procedures

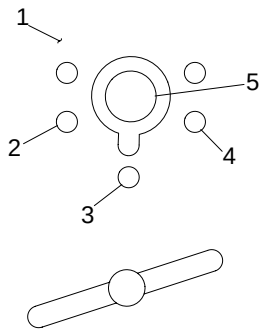
Coolant temperature gauge malfunctions are usually one of two types: the gauge does not operate at all (always shows that the engine is cold), or the coolant temperature indicated by the gauge is believed to be incorrect.

Before proceeding with any troubleshooting when an inaccurate gauge or sender is suspected, confirm that the coolant level is correct and the engine thermostat and fan clutch are operating properly. Simply removing the radiator cap and inserting a thermometer may reveal that the problem is not in the gauge system, but in the cooling system itself. For cooling system troubleshooting, see **Group 20**.

Malfunctions that would cause a totally inoperative coolant temperature gauge include open circuits in the gauge, sender, or wiring. To isolate the cause of an inoperative coolant temperature gauge, follow the troubleshooting procedures in the order given.

1. Switch off the ignition and unplug the wiring harness connector from the coolant temperature sender.
2. Switch on the ignition and observe the gauge needle; it should remain at the left end of the scale (low temperature indicated).
3. Switch off the ignition and, using a jumper wire, connect the sender wiring harness terminal to ground (if a one-terminal sender is used) or short the sender wiring harness terminals together (if a two-terminal sender is used).
4. Switch on the ignition again and watch the gauge needle; it should move immediately to the extreme right or "hot" end of the scale.
5. If the gauge operates as described in the previous steps, it is functioning properly and the wiring to the gauge is okay. The problem is in the sender; replace it following the instructions in **Subject 110** and verify that the gauge operates properly.

   If the gauge does not function as described previously, continue troubleshooting with the following steps:
6. Switch off the ignition, unground (or remove the jumper wire from) the wiring harness connector and reconnect it to the coolant temperature sender.
7. Remove the instrument cluster bezel and the coolant temperature gauge. If necessary, refer to **Subject 100**.
8. Identify the coolant temperature gauge terminals that are part of the gauge mounting panel. See **Fig. 1**.



02/22/99 f601090

1. Gauge Mounting Panel
2. Ground Terminal
3. Ignition Power Terminal
4. Sender Signal Terminal
5. Gauge Illumination Bulb

Fig. 1, Coolant Temperature Gauge Connection

9. Check the coolant temperature gauge ground circuit wiring for an open circuit.

   9.1 With the ignition switch turned off, connect the leads of an ohmmeter between the cab metal (an unpainted bolt or screw attached directly to cab structure works well) and the ground circuit terminal (see **Fig. 1**. Ref. 2) in the gauge mounting panel.

   9.2 Resistance should be less than one ohm. If it is, go to the next step. If resistance is higher than one ohm, verify that you have good connections at both the terminal and the cab metal.

   9.3 If the connections are good, but resistance is still greater than one ohm, locate the damaged section of wiring between the terminal and ground. Repair the damage by splicing in a length of replacement wiring following the instructions in this group.

Troubleshooting

10. Check the signal circuit between the coolant temperature gauge and the sender.

    10.1 With the gauge removed from the gauge mounting panel, connect one ohmmeter lead to the mounting panel signal terminal (see **Fig. 1**. Ref. 4) and the other lead to the mounting panel ground terminal (Ref. 2).

    10.2 If the harness and sender are good, resistance will depend upon engine temperature and should be, approximately, no more than 400 ohms for a cold engine and at least 50 ohms for a hot engine.

    NOTE: The resistance values are approximations only. Test the sensor in place, on the engine. For the purpose of the resistance test, a cold engine is one which has been sitting overnight, or for a minimum of two hours. A hot engine is one which has reached operating temperature, a minimum of 180°F (82°C).

    10.3 If resistance is within specifications, go to the next step. If resistance is too low, temporarily unplug the sender and recheck resistance. If resistance is still too low, find and repair the short to ground in circuit 119 (119, GG20, and Violet/Yellow on V-8 gasoline engines). If resistance is too high, unplug the sender, connect the sender wiring harness terminal to ground (if a one-terminal sender is used) or short the sender wiring harness terminals together (if a two-terminal sender is used), and recheck resistance. If resistance is still too high, find and repair the poor connection or damaged wire in circuit 119 (119, GG20, and Violet/Yellow on V-8 gasoline engines).

11. Check for battery voltage at the coolant temperature gauge terminal in the gauge mounting panel.

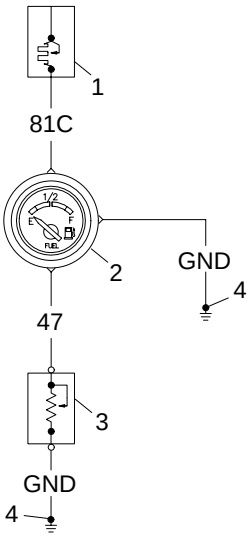
    11.1 Turn the ignition switch on.

    11.2 Connect a voltmeter (set on 20 volt scale, DC voltage) to the gauge terminals in the gauge mounting panel as follows; positive (red) probe to the ignition power circuit (see **Fig. 1**. Ref. 3) and the negative (black) probe to the ground circuit (Ref. 2). The voltmeter should read between 9 and 16 volts DC.

    11.3 If voltage is between 9 and 16 volts, the gauge itself is malfunctioning, and must be replaced. For instructions, refer to **Subject 100**. If the voltage reading is not within the limits mentioned above, check the circuit breaker that supplies power to the gauge. If the circuit breaker is okay, locate and repair the damage to the power circuit. General wire repair information can be found elsewhere in this group.

General Information

The Ametek fuel level gauge system consists of a dash-mounted gauge (electrical type), a fuel tank-mounted fuel level sender, and the electrical wires that connect these components. Circuitry is similar, but not identical for diesel and gasoline powered vehicles. **See Fig. 1** and **Fig. 2**.



09/07/95 f541044

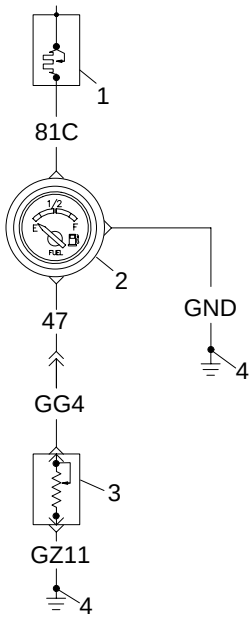
1. Power Supply Circuit Breaker
2. Fuel Level Gauge
3. Fuel Level Sender
4. Ground Point

Fig. 1, Fuel Level Gauge System, Diesel Engines

The fuel level gauge is a cross-coil electric gauge with a 90-degree sweep. The gauge body is made of clear plastic and has a painted face. A light bulb fitted to the gauge mounting panel illuminates the gauge face from behind. The gauge is easily removed and installed from the front of the instrument panel.

On diesel engine-equipped vehicles, the fuel level sender (**see Fig. 3**) is mounted inside the fuel tank (right hand tank on dual tank vehicles) and is serviced by removing a plate fitted to the top of the tank.

On gasoline engine-equipped vehicles, the fuel level sender (**see Fig. 4**) is also mounted inside the fuel tank, but is part of the fuel pump module. The module is made up of an electric fuel pump, an inlet filter,

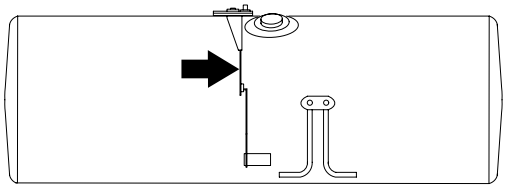


11/28/95 f541166

1. Power Supply Circuit Breaker
2. Fuel Level Gauge
3. Fuel Level Sender
4. Ground Point

Fig. 2, Fuel Level Gauge System, V-8 Gasoline Engines

a combination outlet filter/pressure regulator, a pressure relief/rollover valve, and the fuel level sender.

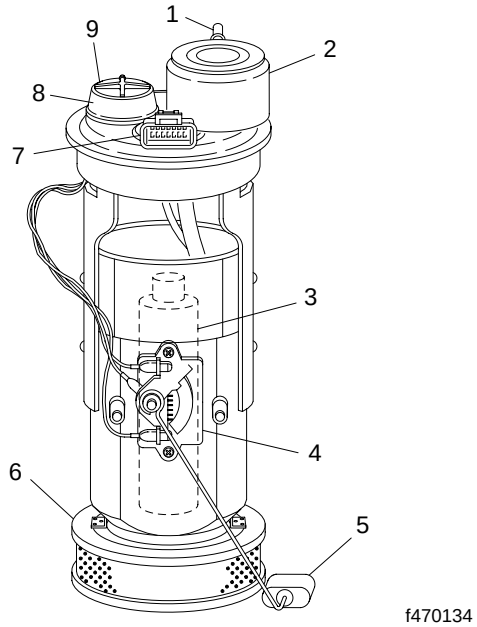


07/25/95 f541045

Fig. 3, Fuel Level Sender, Diesel Engine

The fuel level sender consists of a float and arm fitted to a variable resistor; the float rests on the fuel surface and, as the fuel level drops, the float drops with it. When the fuel tank is full, fuel level sender resistance is about 30 ohms for diesels and 10 ohms for gasoline senders. When the tank is about half full, sender resistance is about 103 ohms for diesel senders and 32 ohms for gasoline senders. When the tank is empty, resistance is about 245 ohms for diesels, 100 ohms for gasoline senders.

General Information



1. Fuel Supply Line Connector
2. Fuel Filter/Pressure Regulator
3. Electric Fuel Pump
4. Fuel Level Sender
5. Sender Float
6. Inlet Filter
7. Electrical Connector
8. Pressure Relief/ Rollover Valve
9. Ribbed Cover

Fig. 4, Fuel Level Sender, Gasoline Engine

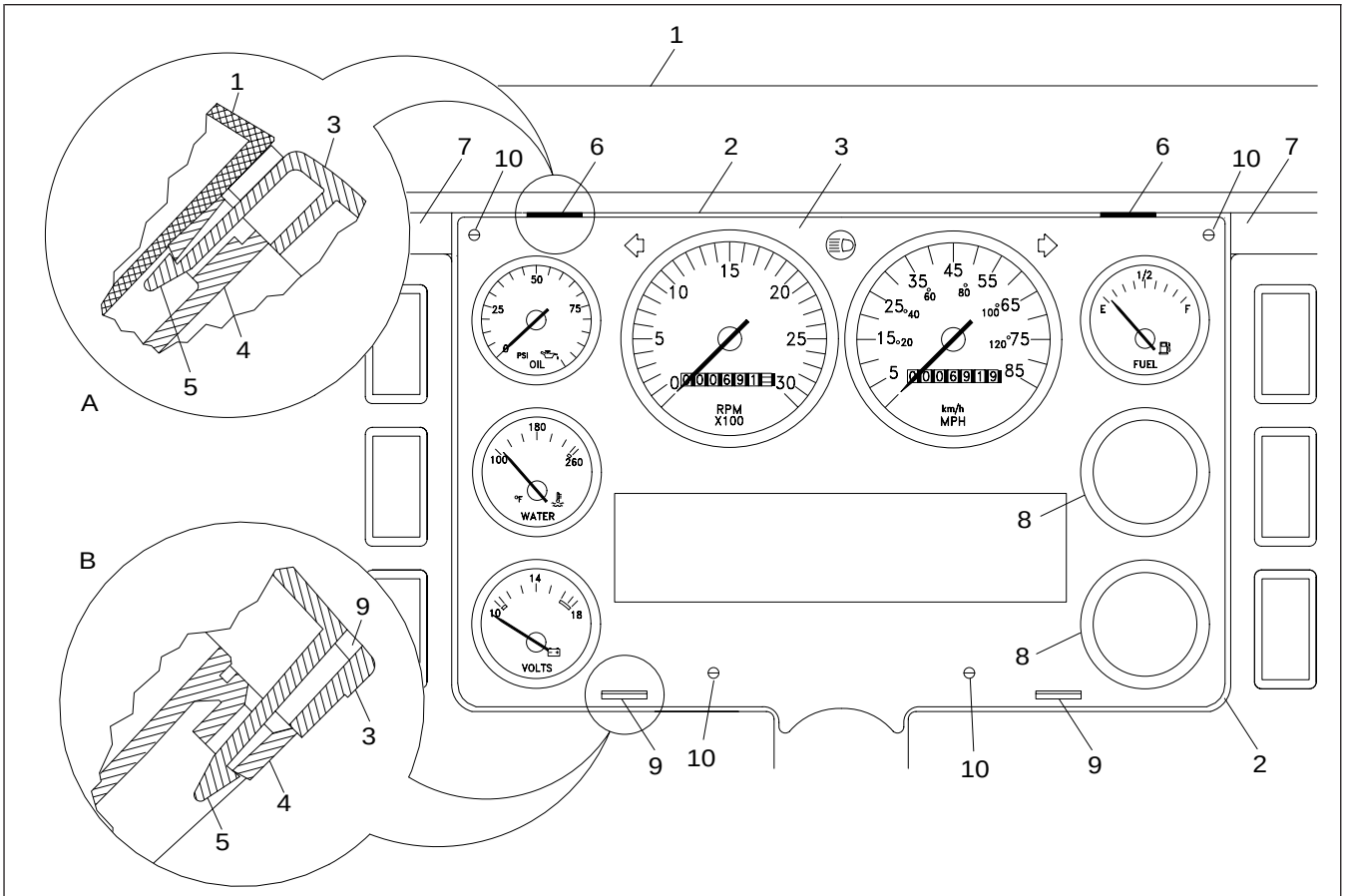
Removal

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Remove the instrument cluster bezel. See **Fig. 1**.

3.1 If present, remove the four Torx-head screws from the bezel.

3.2 By hand, remove the vinyl extrusion trim (see **Fig. 1**, Ref. 7) on each side of the instrument cluster bezel.

3.3 Insert a stubby, flat-tipped screwdriver



A. Sectional Detail (Left Side View of Upper Left-Hand Locking Tab)
B. Sectional Detail (Left Side View of Lower Left-Hand Locking Tab)

1. Instrument Panel Upper Cover
2. Foam Gasket
3. Instrument Cluster Bezel
4. Gauge Mounting Panel
5. Bezel Locking Tab
6. Opening in Foam Gasket
7. Vinyl Extrusion Trim
8. Gauge Blank (Block-Off Plug)
9. Slot in Bezel
10. Location of Torx-Head Mounting Screw

Fig. 1, Instrument Cluster Bezel Details

NOTE: On some vehicles, the bezel is also secured to the instrument panel with four Torx®-head screws (**Fig. 1**, Ref. 10).

into the opening above the upper left-hand corner of the instrument cluster bezel (see **Fig. 1**, Ref. 6) and release the bezel locking tab (Ref. 5) by gently pivot-

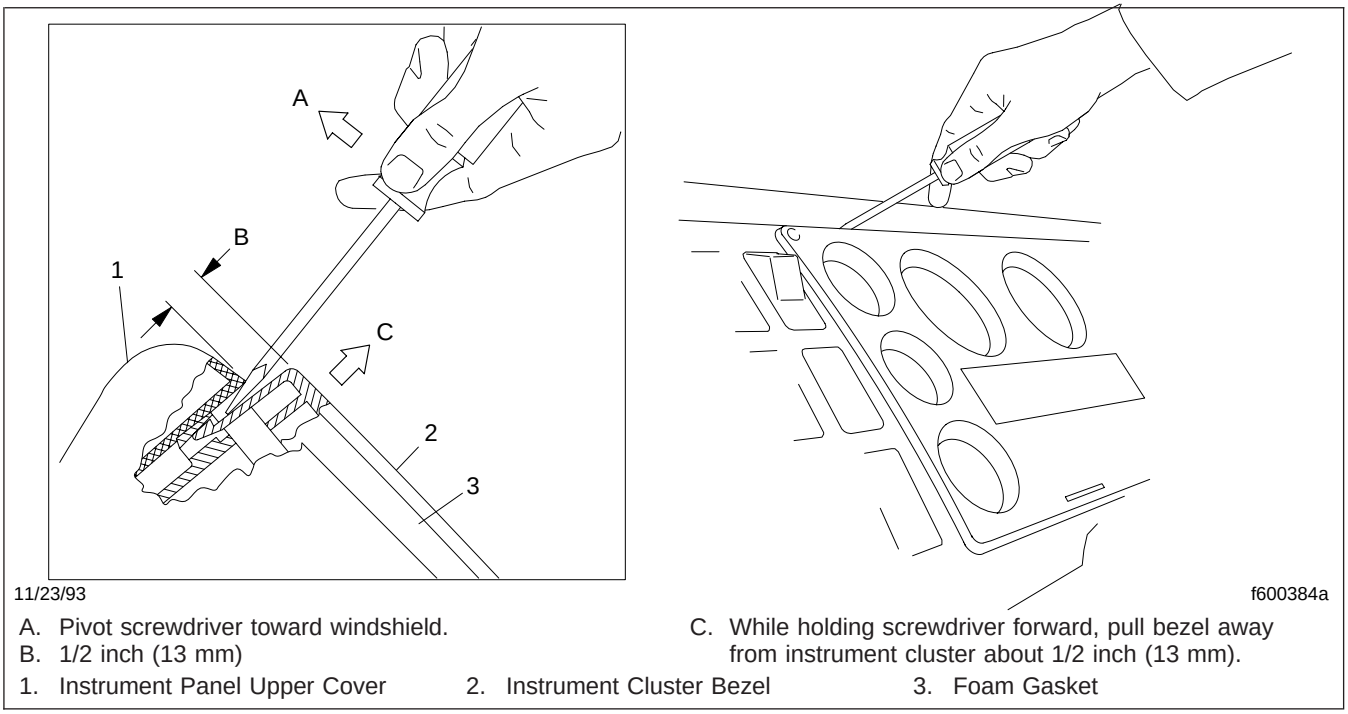
Fuel Level Gauge Removal and Installation

ing the screwdriver handle toward the vehicle windshield. See **Fig. 2**.

While keeping pressure on the screwdriver, use your other hand to pull the corner of the bezel away from the instrument panel about 1/2 inch (13 mm).

The gauge illumination bulb will remain in the gauge mounting panel; do not remove the bulb unless it must be replaced. See **Fig. 4**.

Installation



A. Pivot screwdriver toward windshield.
B. 1/2 inch (13 mm)
C. While holding screwdriver forward, pull bezel away from instrument cluster about 1/2 inch (13 mm).
1. Instrument Panel Upper Cover
2. Instrument Cluster Bezel
3. Foam Gasket

Fig. 2, Releasing the Bezel Upper Edge

3.4 Repeat the previous step for the upper right-hand corner of the bezel.

3.5 With both corners released, tilt the entire top edge of the bezel away from the instrument panel about 1 inch (25 mm) and try to work the bottom edge of the bezel loose.

If the bottom of the bezel won't come loose, use the screwdriver to release the locking tabs at the bottom edge of the bezel. See **Fig. 3**.

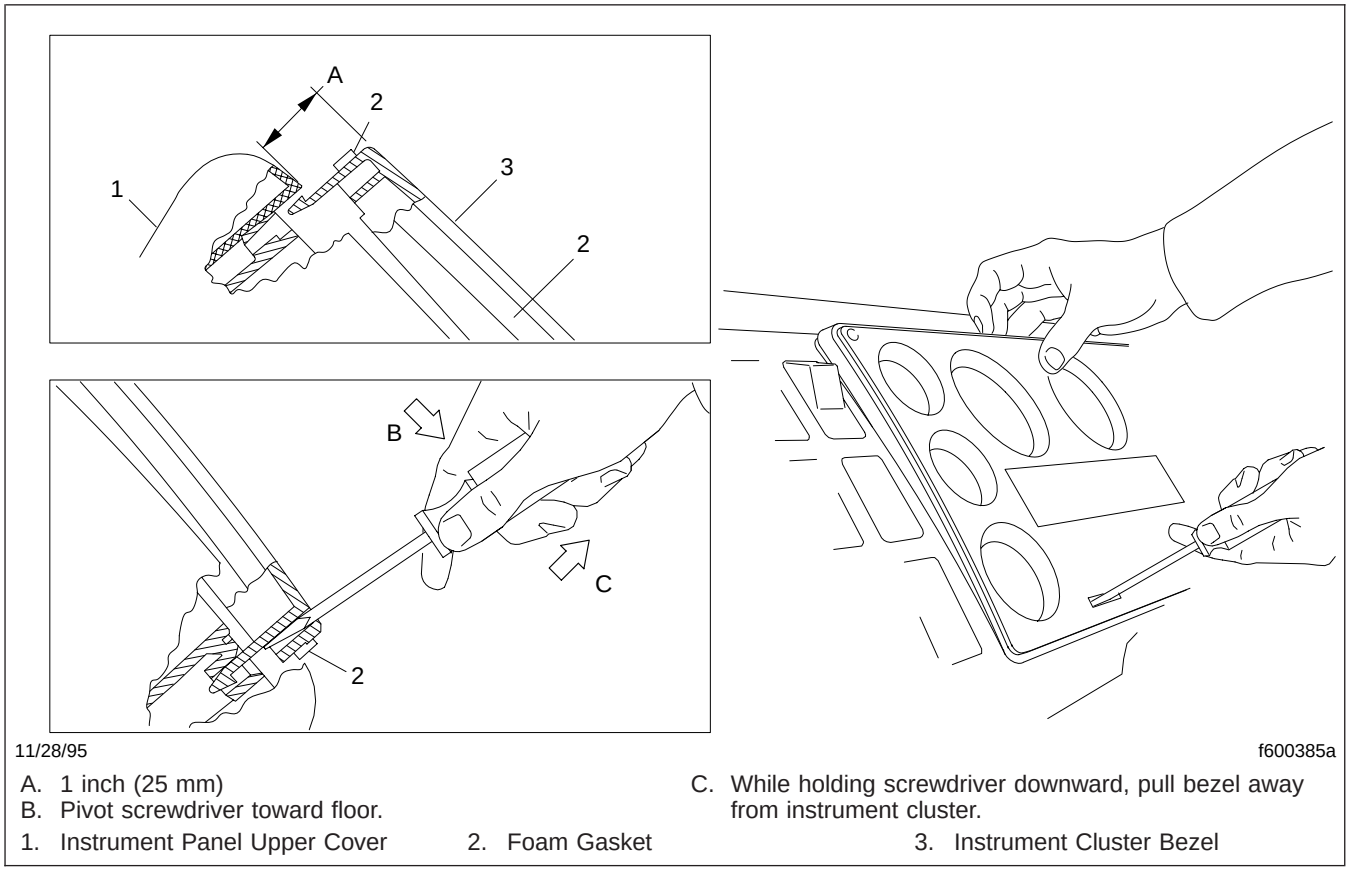
Set the bezel aside.

4. Remove the fuel level gauge from the gauge mounting panel by grasping the gauge firmly and pulling it straight out of the gauge mounting panel.

1. Position the gauge over the gauge mounting panel, making sure that the panel terminals line up with the gauge sockets.
2. Push the gauge into place until it seats against the mounting panel.
3. Position the instrument cluster bezel against the instrument panel. Starting with the lower corners, alternately push against the bottom and top corners of the bezel, until all four locking tabs are locked and the face of the bezel is flush with the surfaces of the instrument panel. Don't push against the gauge lenses or gauge blanks (block-off plugs).

NOTE: On some vehicles, the bezel is also secured to the instrument panel with four Torx®-head screws (**Fig. 1**, Ref. 10).

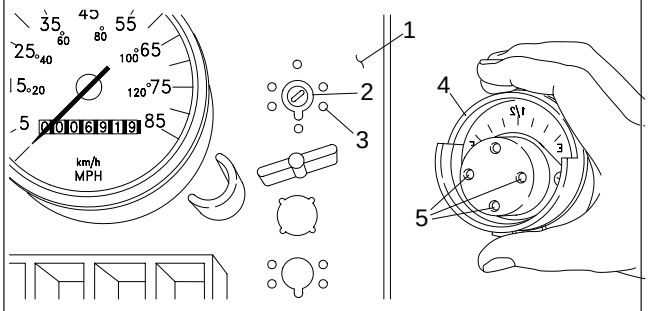
4. If removed, install the screws in the instrument cluster bezel.
5. Install the vinyl extrusion trim on both sides of the bezel.
6. Connect the batteries.
7. Start the engine and verify that the fuel level gauge is operating properly.
8. Remove the chocks from the tires.



A. 1 inch (25 mm)
B. Pivot screwdriver toward floor.
C. While holding screwdriver downward, pull bezel away from instrument cluster.
1. Instrument Panel Upper Cover
2. Foam Gasket
3. Instrument Cluster Bezel

Fig. 3, Releasing the Bezel Lower Edge

Fuel Level Gauge Removal and Installation



11/04/95 f541167

1. Gauge Mounting Panel
2. Illumination Bulb and Socket
3. Panel Electrical Terminal
4. Fuel Level Gauge
5. Gauge Electrical Socket

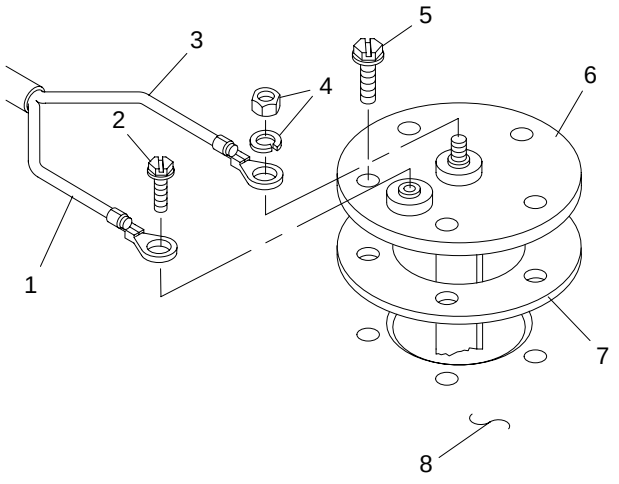
Fig. 4, Fuel Level Gauge Installation View

Fuel Level Sender Removal and Installation

Removal

NOTE: On gasoline engine equipped vehicles, the fuel level sender is serviced by replacing the entire fuel pump module assembly. For information, refer to **Group 47**.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. If necessary, remove any fairings or skirts blocking access to the top of the fuel tank (right hand fuel tank on dual tank vehicles).
3. Use masking tape and a felt-tipped marker to label the fuel sender wires; this will ease reassembly.
4. Remove the screws securing the fuel level signal and ground wires to the fuel level sender, then disconnect the wires from the sender. **See Fig. 1.**



1. Ground Wire
2. 10-24 Machine Screw
3. Circuit 47
4. 10-32 Hexnut and Split Lockwasher
5. 10-32 Machine Screw
6. Fuel Level Sender
7. Gasket
8. Fuel Tank

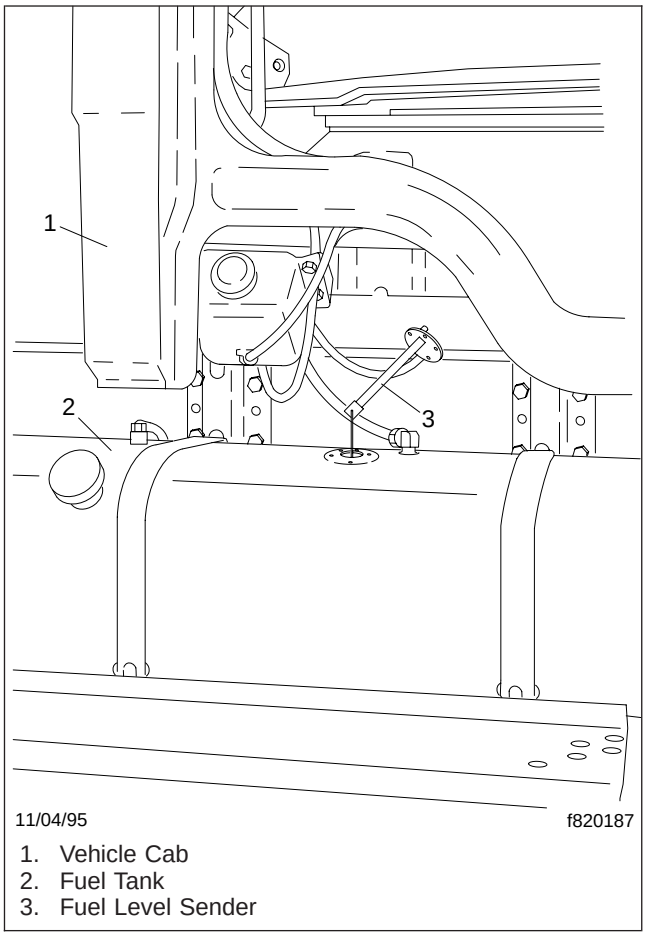
Fig. 1, Fuel Level Sender Mounting, Diesel Engines

5. Using a felt-tipped permanent marker, make alignment marks on both the fuel level sender plate and the fuel tank; this will simplify the assembly process.

⚠ WARNING

WARNING: Do not service the fuel system in the presence of sparks, open flames, or intense heat. These could ignite the fuel, possibly causing severe burns.

6. Remove the screws securing the fuel level sender to the fuel tank and carefully withdraw the sender and gasket from the tank. **See Fig. 2.** Be careful to avoid bending the float arm or damaging the float itself. The sender assembly *can* be removed from the tank opening without being damaged by tilting and rotating the sender as it is being withdrawn.



1. Vehicle Cab
2. Fuel Tank
3. Fuel Level Sender

Fig. 2, Fuel Level Sender Removal/Installation, Diesel Engines

Fuel Level Sender Removal and Installation

Installation

NOTE: If the fuel level sender is being replaced with a new unit, be sure to "transfer" the sender alignment mark from the old sender to the new sender.

1. Make sure the gasket is in place on the fuel sender assembly and insert the fuel level sender into the fuel tank, being careful to avoid damage to the float or float arm.
2. Rotate the sender assembly as necessary to line up the alignment marks made earlier, install the sender mounting screws, and tighten them. **See Fig. 1.**
3. Connect the vehicle wiring harness to the sender. Circuit 47 ("47" marked directly on the wire) must be connected to the insulated post at the center of the sender plate. The ground wire (marked "GND") must be connected to the remaining terminal post. **See Fig. 1.**
4. Start the engine, check for leaks, and check that the fuel level gauge is operating properly.
5. Install any side skirts or fairings that were removed to access the fuel level sender.
6. Remove the chocks from the tires.

Troubleshooting Procedures

Fuel level gauge malfunctions are usually one of two types: the gauge does not operate at all (always shows that the tank is empty), or the fuel level indicated by the gauge is believed to be incorrect.

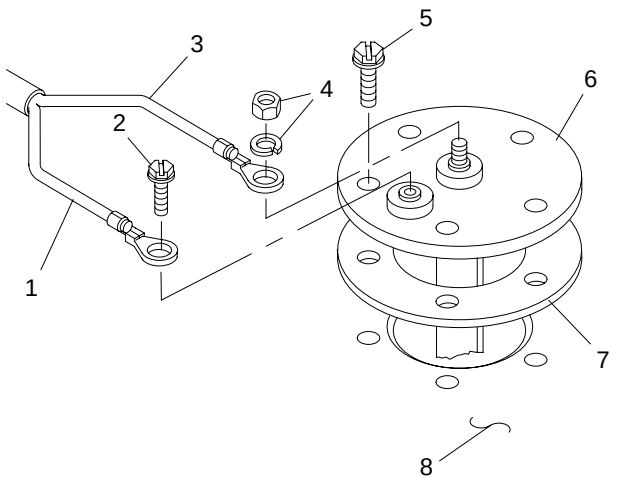
Before proceeding with any troubleshooting when an inaccurate gauge or sender is suspected, confirm the actual fuel level by inserting a clean dipstick into the tank (right hand tank on dual tank vehicles since this tank contains the sender).

If the vehicle is equipped with dual fuel tanks, check to see that the fuel level is approximately the same in both tanks. If the levels are different, check for problems with the fuel equalizing line and/or valve. For fuel tank and line information, refer to **Group 47**.

A possible, but unlikely, cause of incorrect gauge readings is that the wrong gauge is installed. Diesel engine gauges and gasoline engine gauges are not the same, but look very similar. Confirm that the proper gauge is installed by checking the part number label on the gauge.

Malfunctions that would cause a totally inoperative fuel level gauge include open circuits in the gauge, sender, or wiring. To isolate the cause of an inoperative fuel level gauge, follow the troubleshooting procedures in the order given.

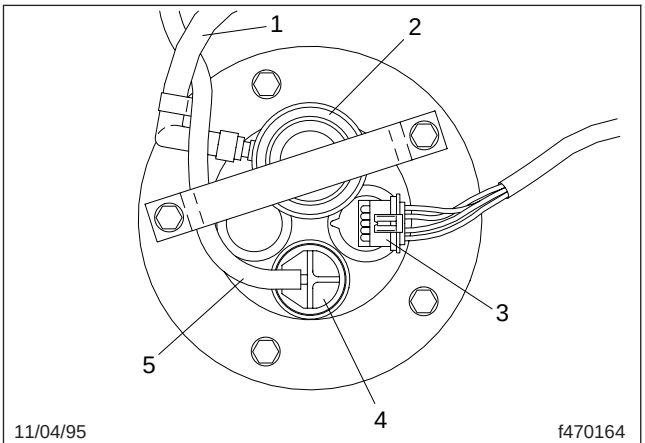
1. Switch off the ignition and disconnect the fuel level signal circuit from the fuel level sender.
   - 1.1 Remove side skirts or fairings, if necessary, to access the top of the fuel tank (right hand tank on dual tank vehicles).
   - 1.2 On diesel engine powered vehicles, remove the screw securing the signal wire (marked "47") to the insulated center terminal of the fuel level sender, disconnect the wire from the terminal, and prop up the wire so it can't touch the sender or the tank itself. **See Fig. 1.**
   - 1.3 On gasoline engine powered vehicles, unplug the electrical connector at the fuel pump module. **See Fig. 2.**
2. Switch on the ignition and observe the gauge needle; it should remain at the left end of the scale (empty tank indicated).
3. Switch off the ignition and, using a jumper wire, connect the fuel level gauge signal wire terminal



07/26/95 f541047

1. Ground Wire
2. 10-24 Machine Screw
3. Circuit 47 Wire
4. 10-32 Hexnut and Split Lockwasher
5. 10-32 Machine Screw
6. Fuel Level Sender
7. Gasket
8. Fuel Tank

Fig. 1, Fuel Level Sender Connections, Diesel Engines



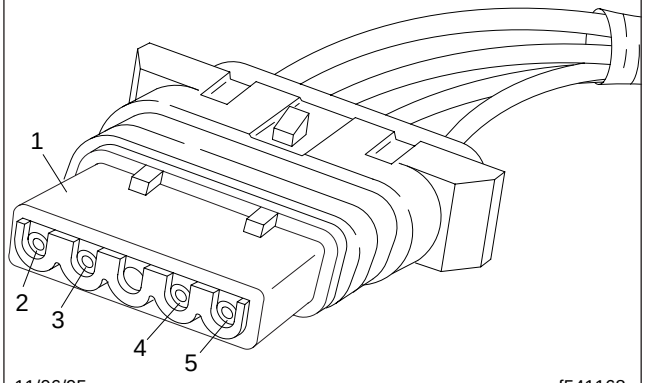
11/04/95 f470164

1. Fuel Supply Line
2. Fuel Filter/Pressure Regulator
3. Electrical Connector
4. Pressure Relief/Rollover Valve
5. Evaporative Canister Line

Fig. 2, Fuel Pump/Level Sender Connector, Gasoline Engines

Troubleshooting

(circuit 47) to the sender ground terminal. **See Fig. 1** (diesel engine) or **Fig. 3** (gasoline engine).



1. Wiring Harness Connector
2. Fuel Pump Motor Power (circuit A61)
3. Fuel Level Gauge Signal (circuit 47)
4. Fuel Level Gauge Ground (circuit Z11)
5. Fuel Pump Motor Ground (circuit Z13)

Fig. 3, Fuel Pump Module Connector Terminals

4. Switch on the ignition again and watch the gauge needle; it should move immediately to the extreme right or "full" end of the scale.

5. If the gauge operates as described in the above steps, it is functioning properly and the wiring to the gauge is okay. The problem is in the sender; replace it following the instructions in **Subject 110** and verify that the gauge operates properly.

   If the gauge does not function as described above, continue troubleshooting with the following steps:

6. Check the fuel level sender ground circuit.

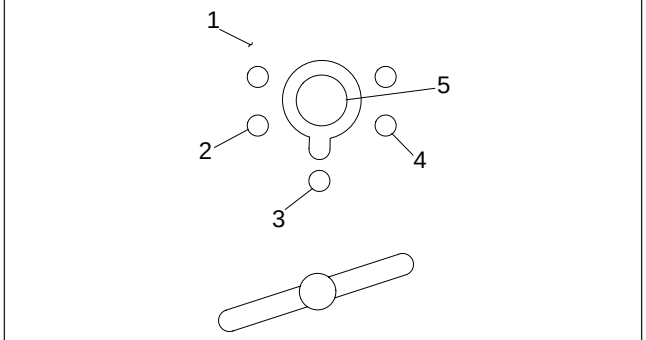
   6.1 Switch off the ignition and disconnect the jumper previously installed between the sender signal and ground wires.

   6.2 Connect one lead of an ohmmeter to an exposed part of the frame, and connect the remaining lead to the sender ground terminal. Resistance should be very low—less than 5 ohms. Higher resistance indicates a problem in the ground circuit. Look for a loose wire, corrosion at the terminal, or a damaged wire.

   6.3 If the sender ground circuit checks out, leave the sender signal wire or fuel pump module connector disconnected and continue with the following steps:

7. Remove the instrument cluster bezel and the fuel level gauge. If necessary, refer to **Subject 100**.

8. Identify the fuel level gauge terminals that are part of the gauge mounting panel. **See Fig. 4.**



1. Gauge Mounting Panel
2. Ground Terminal
3. Ignition Power Terminal
4. Sender Signal Terminal
5. Illumination Bulb

Fig. 4, Fuel Level Gauge Connection

9. Check the fuel level gauge ground circuit wiring for an open circuit.

   9.1 With the ignition switch turned off, connect the leads of an ohmmeter between the cab metal (an unpainted bolt or screw attached directly to cab structure works well) and the ground circuit terminal in the gauge mounting panel. **See Fig. 4**, Ref. 2.

   9.2 Resistance should be very low—less than 5 ohms. If it is, go to the next step. If resistance is higher than 5 ohms, verify that you have good connections at both the terminal and the cab metal.

   9.3 If the connections are good, but resistance is still greater than 5 ohms, locate the damaged section of wiring between the terminal and ground. Repair the dam-

age by splicing in a length of replacement wiring following the instructions in this manual.

10. Check the signal circuit between the fuel level gauge and sender.
    - 10.1 With the gauge still removed from the gauge mounting panel, connect one ohmmeter lead to the mounting panel signal terminal (**see Fig. 4**, Ref. 4) and the other lead to the harness connector signal wire (still disconnected) at the fuel level sender (diesel) or fuel pump module (gasoline). **See Fig. 1** or **Fig. 3**.
    - 10.2 Resistance should be very low—less than 5 ohms. If it is, continue troubleshooting. If resistance is too high, locate and repair the loose connection or damaged section of wire between the fuel level gauge and the sender.
    - 10.3 Check the sender signal wire for a short to ground by measuring resistance between the gauge mounting panel signal terminal (gauge still removed) and a good ground. The ohmmeter should indicate infinite resistance. Any other reading means that the signal wire is shorted to ground. Look for a pinched, chafed or otherwise damaged circuit 47 between the gauge and the sender.
11. Check for battery voltage at the fuel gauge power terminal in the gauge mounting panel.
    - 11.1 Turn the ignition switch on.
    - 11.2 Connect a voltmeter (set on 20 volt scale, DC voltage) to mounting panel terminals as follows; positive (red) probe to the ignition power terminal (**see Fig. 4**, Ref. 3) and the negative (black) probe to the ground terminal (Ref. 2). The voltmeter should read between 9 and 16 volts DC.
    - 11.3 If voltage is between 9 and 16 volts DC, the gauge itself is malfunctioning, and must be replaced. For instructions, refer to **Subject 100**. If the voltage reading is not between 9 and 16 volts DC, check the circuit breaker that supplies power to the gauge. If the circuit breaker is okay, locate and repair the damage to the power circuit. General wire repair information can be found elsewhere in this manual.
12. Install the fuel level gauge and instrument cluster bezel. Connect the fuel level sender wires (diesel) or fuel pump module connector (gasoline). Make sure that the gauge is now operating properly.

Specifications

See **Fig. 1** for the 1995 Dodge Magnum V-8 engine wiring, cab to bulkhead connector.

See **Fig. 2** and **Fig. 3** for detailed views of the 1995 Dodge Magnum V-8 engine wiring, cab to bulkhead connector.

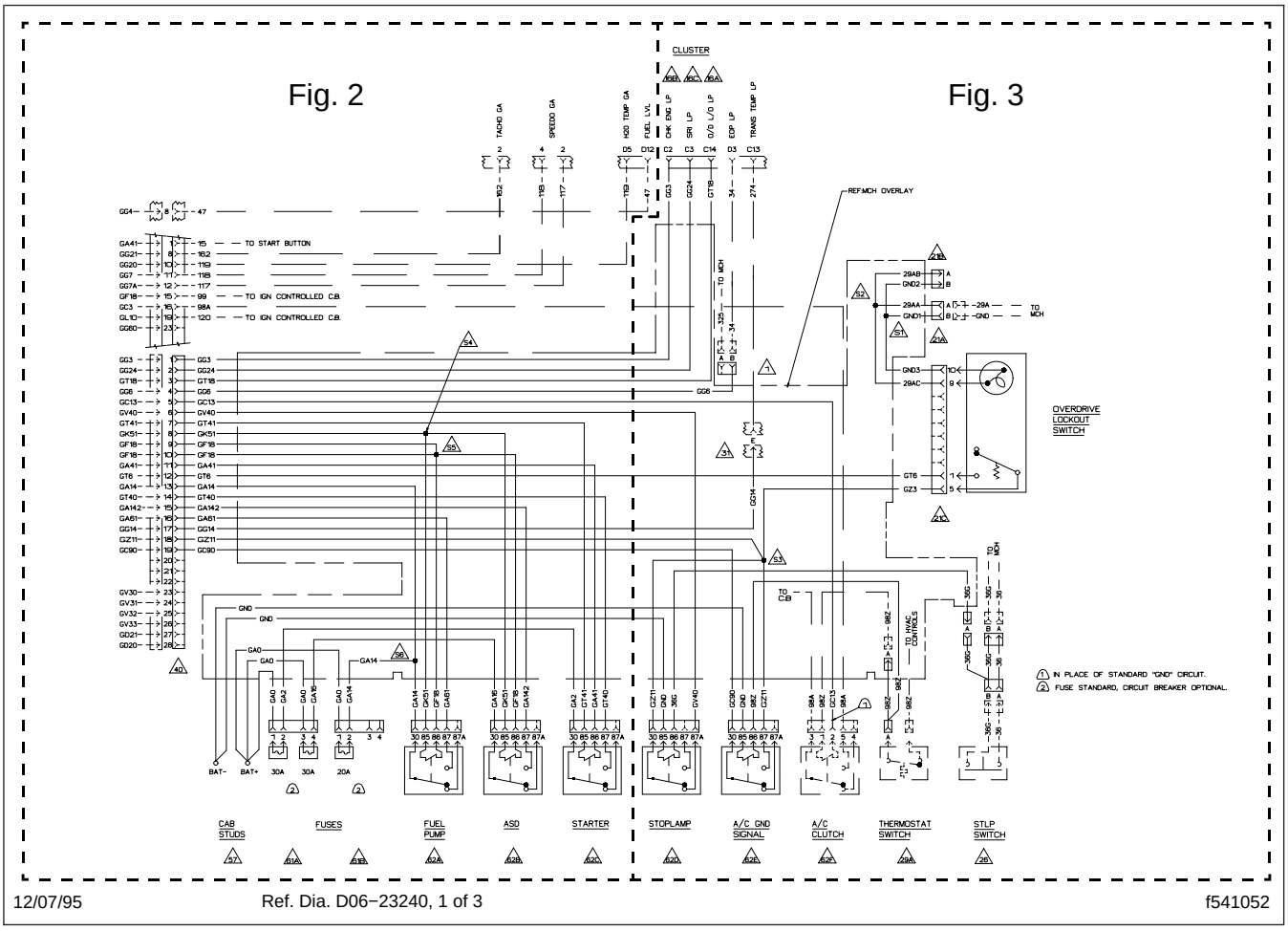
See **Fig. 4** for the 1995 Dodge Magnum V-8 engine wiring, bulkhead connector to engine connector.

See **Fig. 5** and **Fig. 6** for detailed views of the 1995 Dodge Magnum V-8 engine wiring, bulkhead connector to engine connector.

See **Fig. 7** for the 1995 Dodge Magnum V-8 engine wiring, engine connector to engine.

See **Fig. 8** and **Fig. 9** for detailed views of the 1995 Dodge Magnum V-8 engine wiring, engine connector to engine.

Specifications



12/07/95 Ref. Dia. D06−23240, 1 of 3 f541052

Fig. 1, 1995 Dodge Magnum V-8 Engine Wiring, Cab to Bulkhead Connector

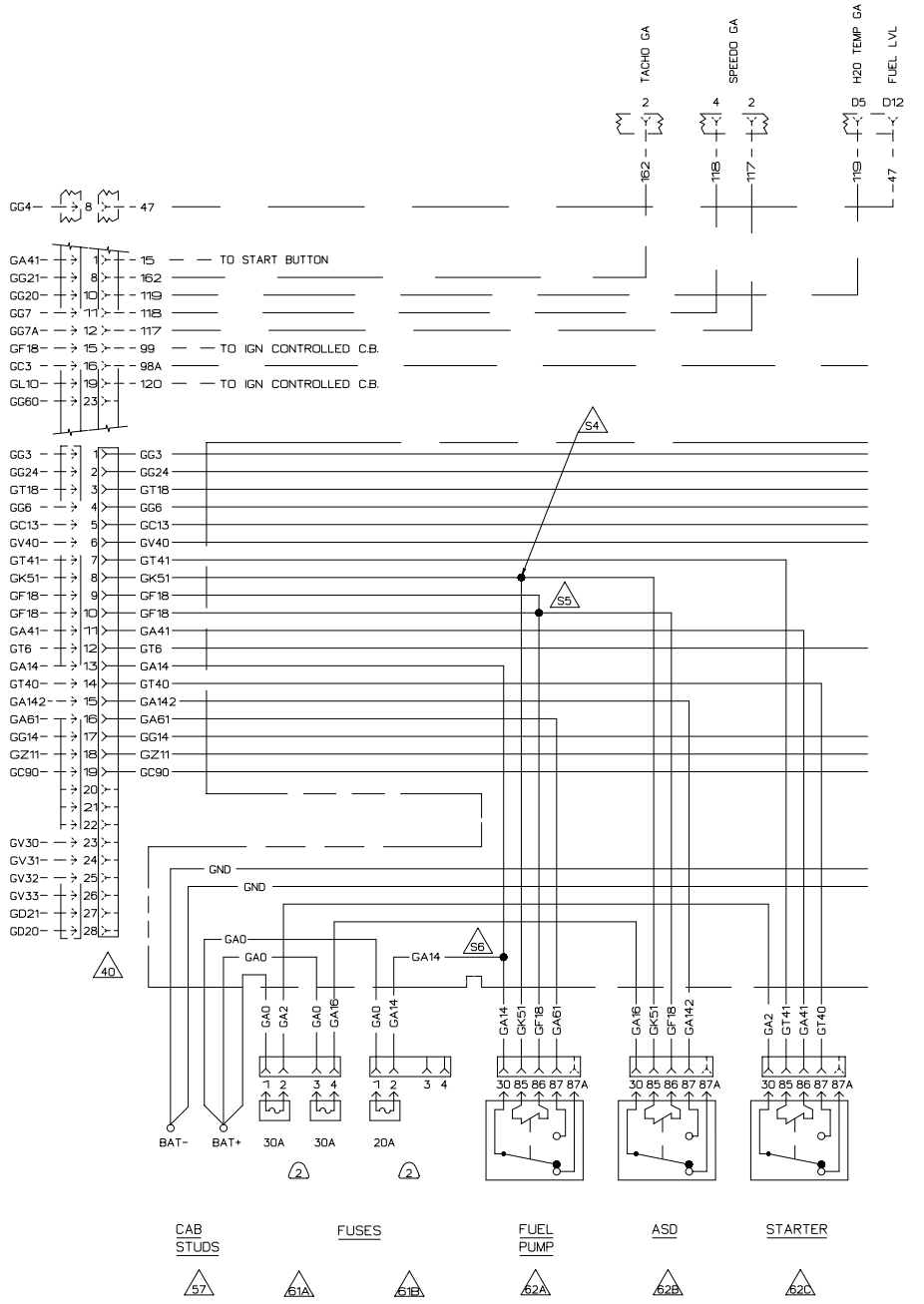


Fig. 3

Fig. 2, 1995 Dodge Magnum V-8 Engine Wiring, Cab to Bulkhead Connector (detailed view)

Specifications

Fig. 2

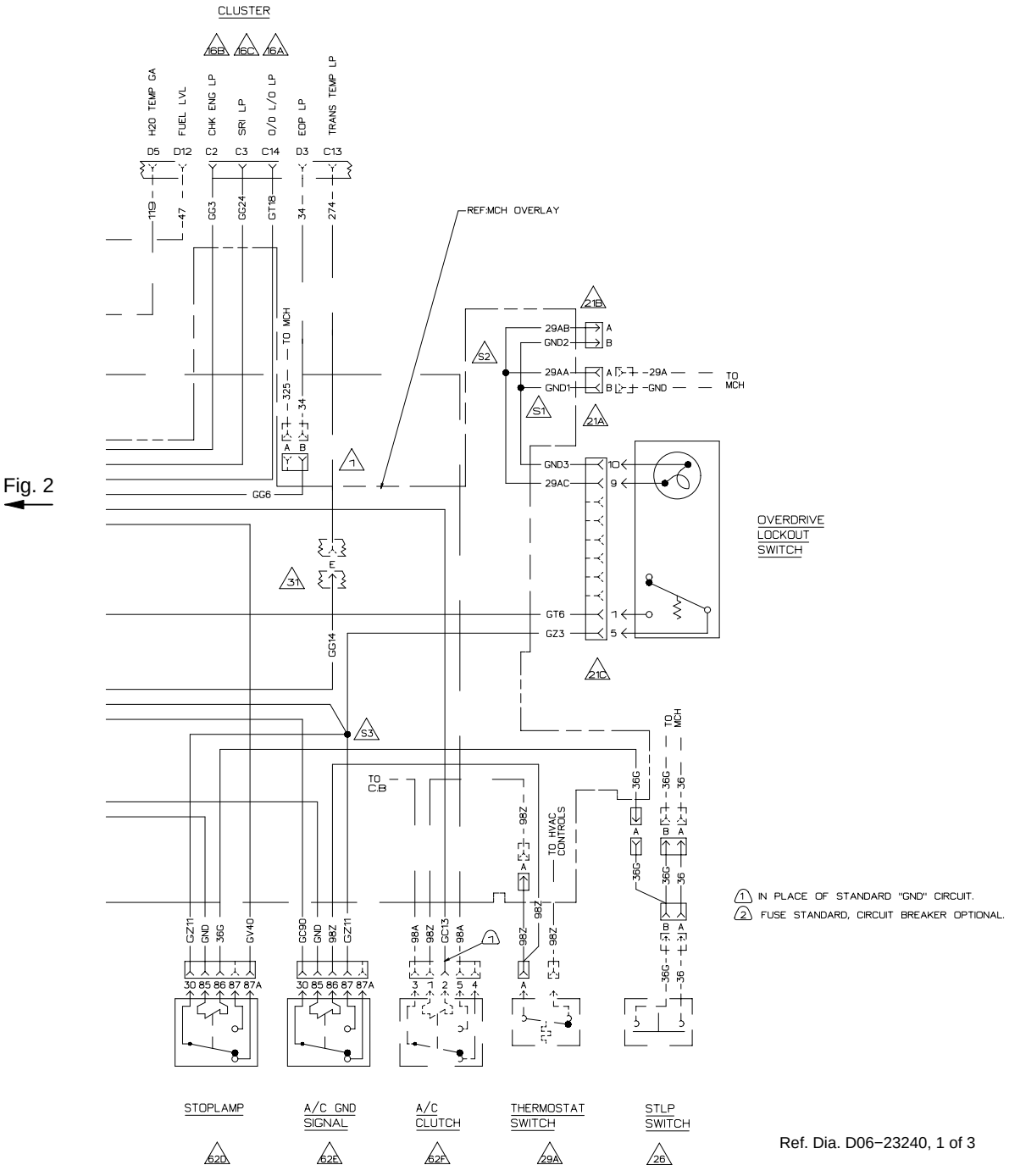


Fig. 3, 1995 Dodge Magnum V-8 Engine Wiring, Cab to Bulkhead Connector (detailed view)

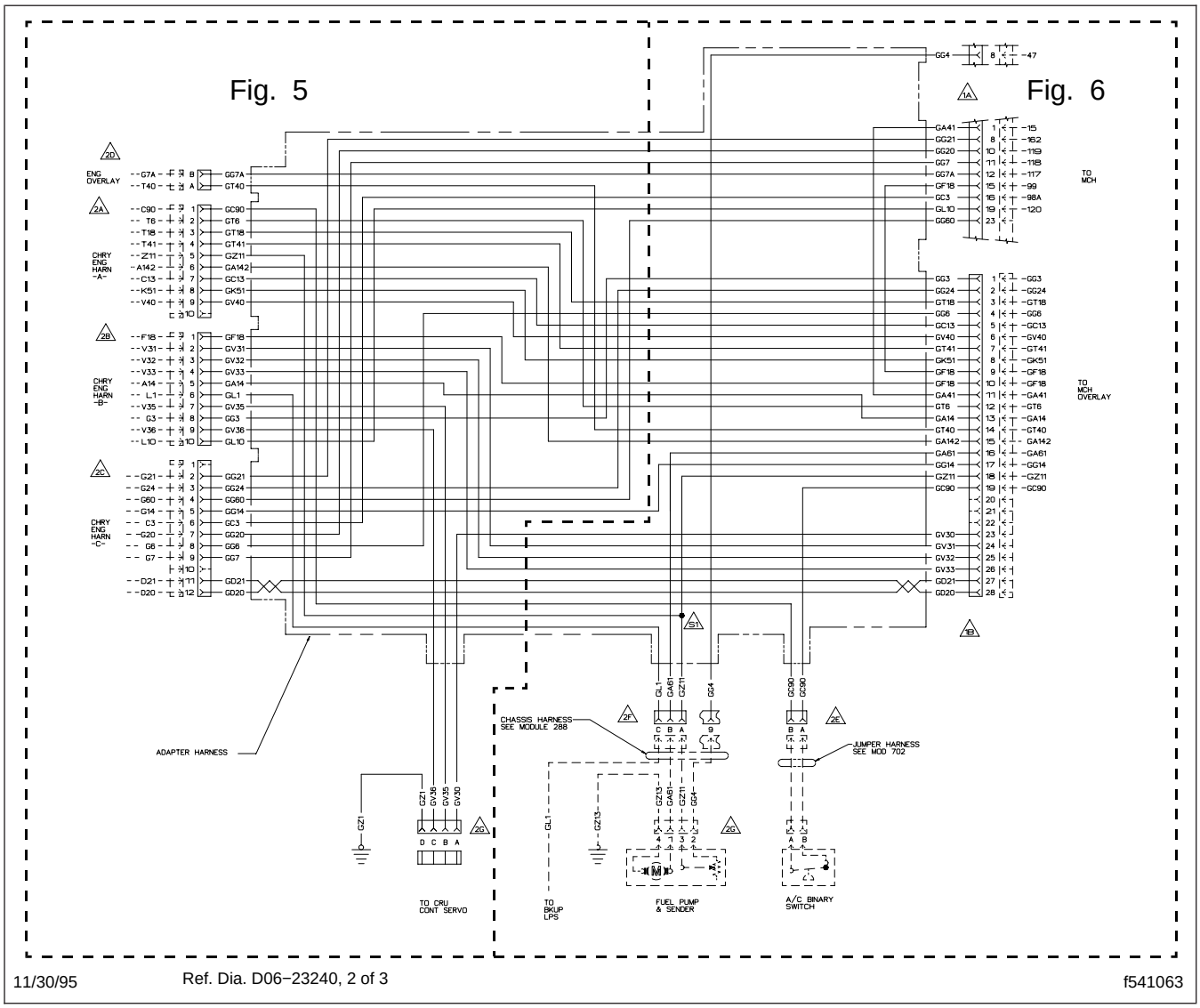


Fig. 4, 1995 Dodge Magnum V-8 Engine Wiring, Bulkhead Connector to Engine Connector

Specifications

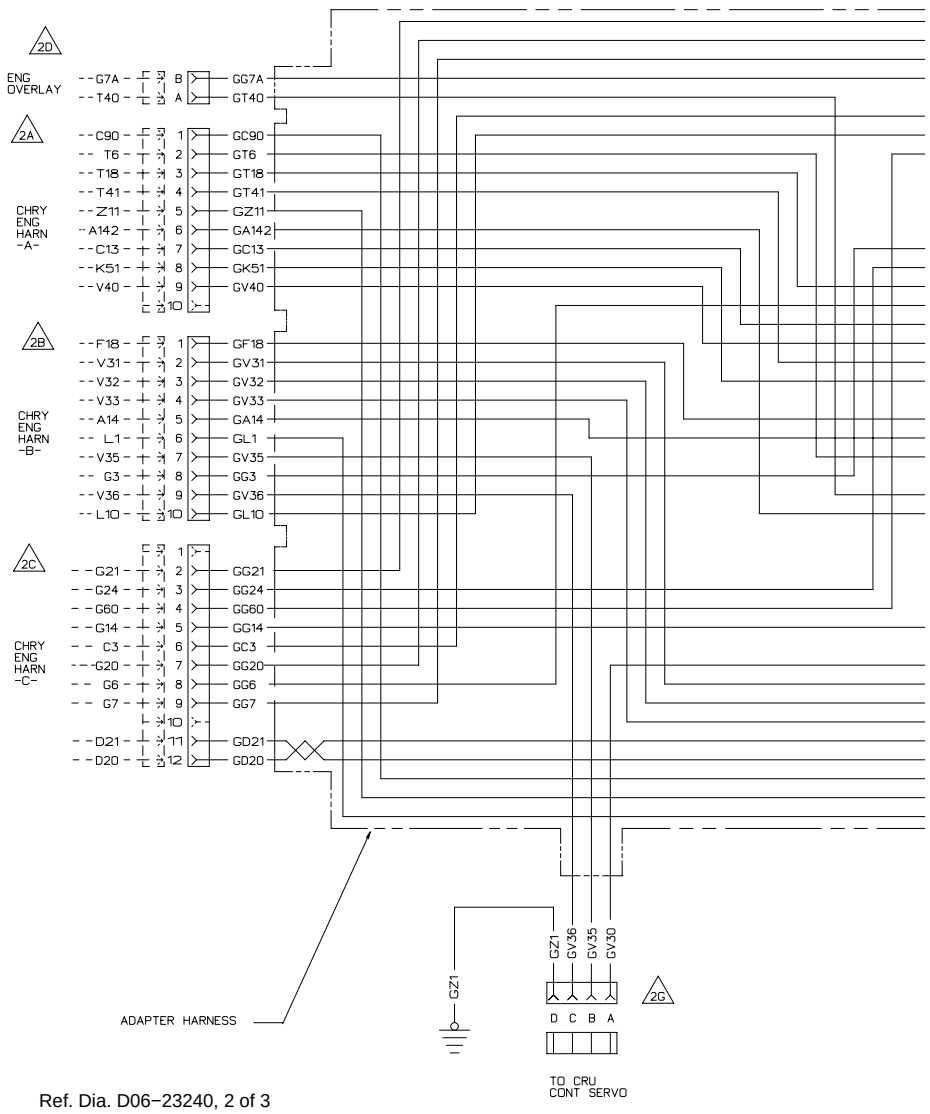


Fig. 6

11/30/95 Ref. Dia. D06−23240, 2 of 3 f541064

Fig. 5, 1995 Dodge Magnum V-8 Engine Wiring, Bulkhead Connector to Engine Connector (detailed view)

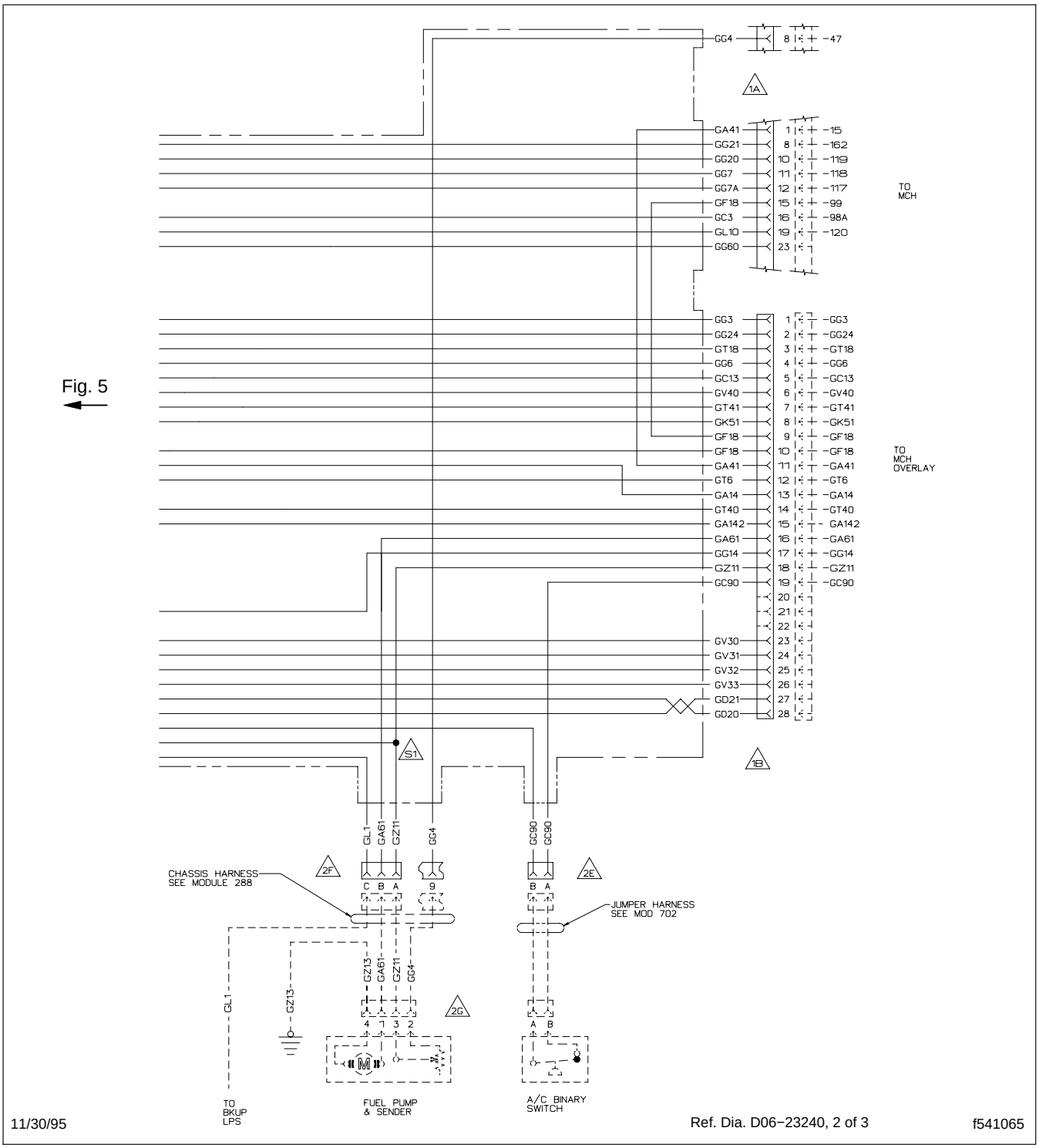


Fig. 6, 1995 Dodge Magnum V-8 Engine Wiring, Bulkhead Connector to Engine Connector (detailed view)

Specifications

Fig. 8

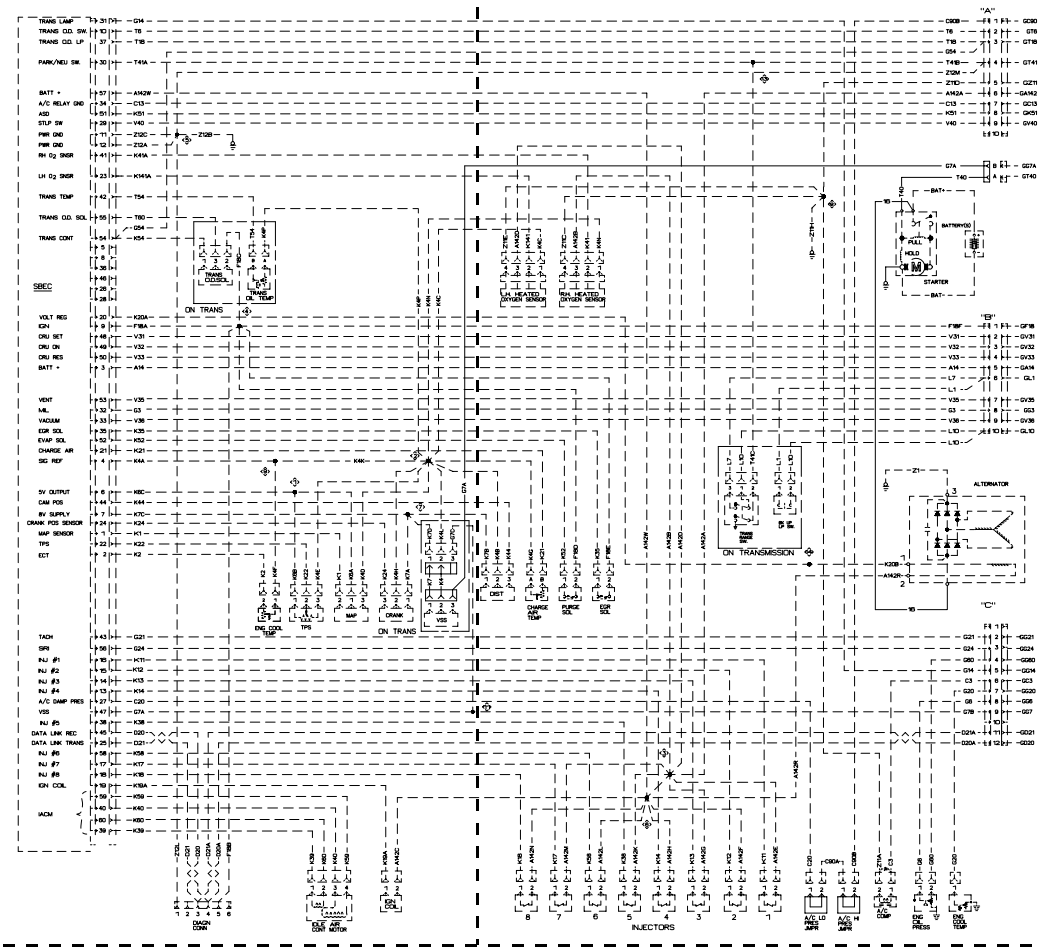


Fig. 9

11/30/95 Ref. Dia. D06−23240, 3 of 3 f541161

Fig. 7, 1995 Dodge Magnum V-8 Engine Wiring, Engine Connector to Engine

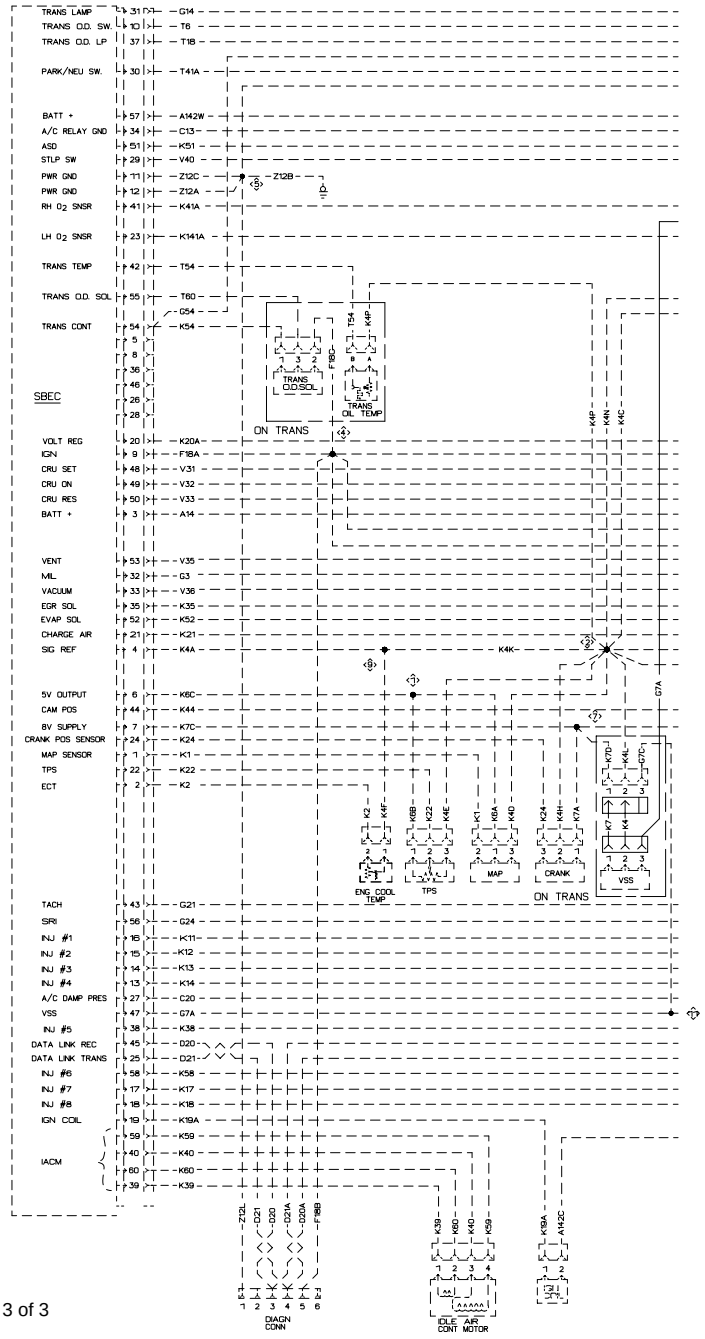


Fig. 9

Ref. Dia. D06−23240, 3 of 3

12/07/95

f541162

Fig. 8, 1995 Dodge Magnum V-8 Engine Wiring, Engine Connector to Engine (detailed view)

Specifications

Fig. 8

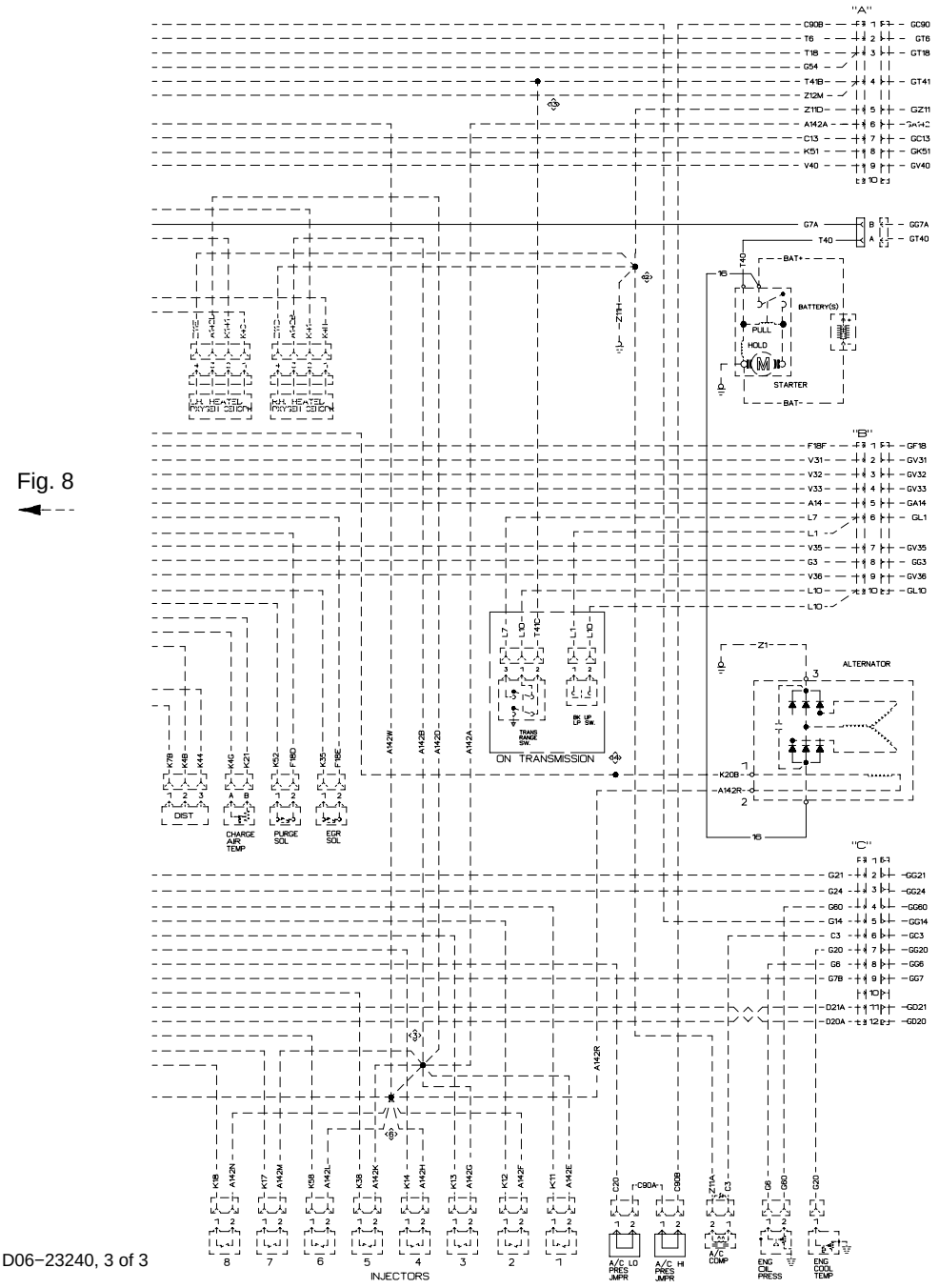


Fig. 9, 1995 Dodge Magnum V-8 Engine Wiring, Engine Connector to Engine (detailed view)

For a schematic of the cab side wiring for the Cummins ISB and ISC electronic engines, see **Fig. 1** for a standard vehicle wiring diagram. For a detailed (partial) schematic showing the cab wiring behind the electronic engine frontwall connector, see **Fig. 2** or **Fig. 3**.

For a schematic of the engine side wiring for the Cummins ISB and ISC electronic engines, see **Fig. 4** for a standard vehicle wiring diagram. For a detailed (partial) schematic showing the engine ECM connectors, see **Fig. 5**. For a detailed (partial) schematic showing the electronic engine frontwall connector, see **Fig. 6**.

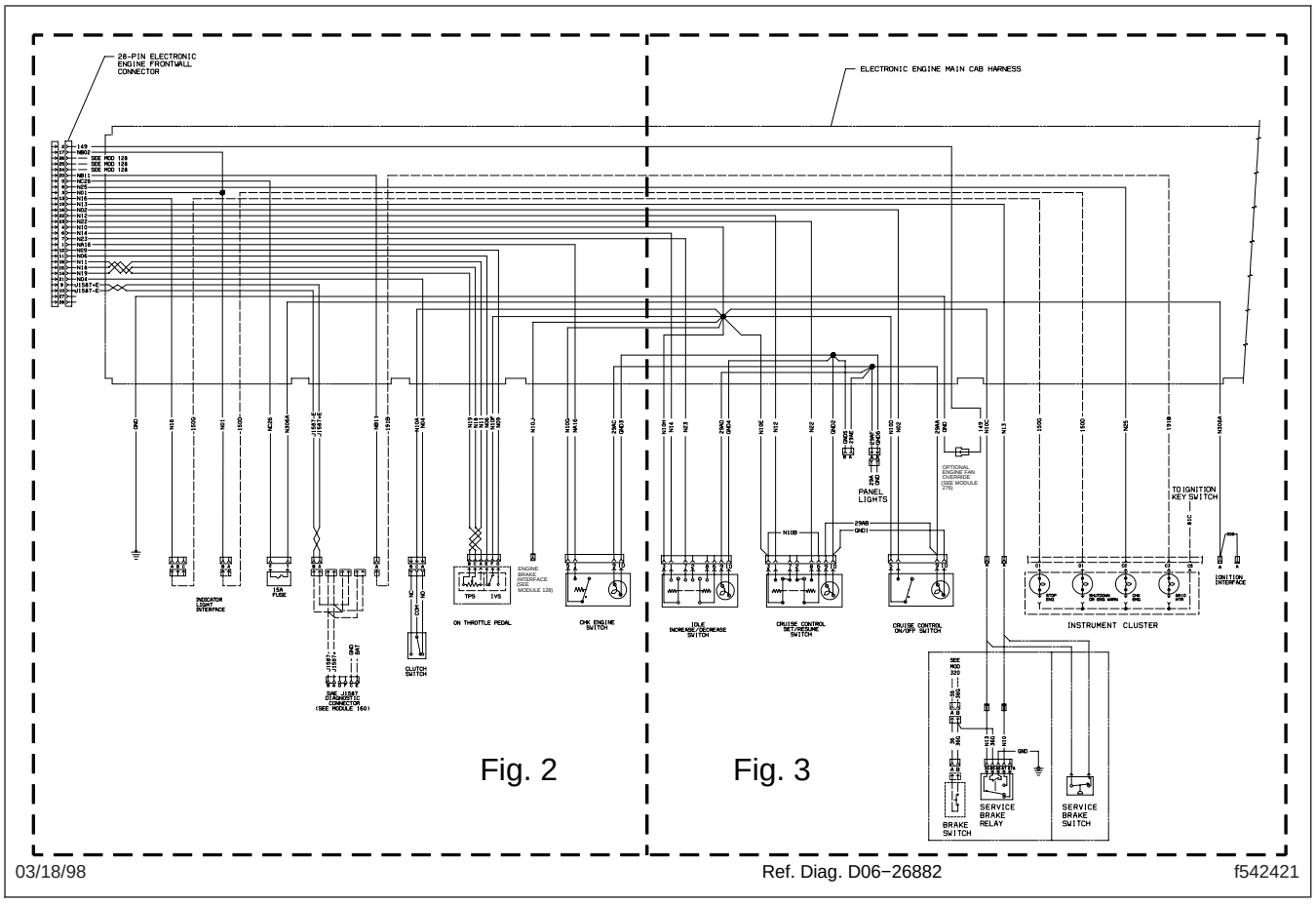


Fig. 1, Cummins ISB and ISC Engines, Cab Side Wiring Schematic

Specifications

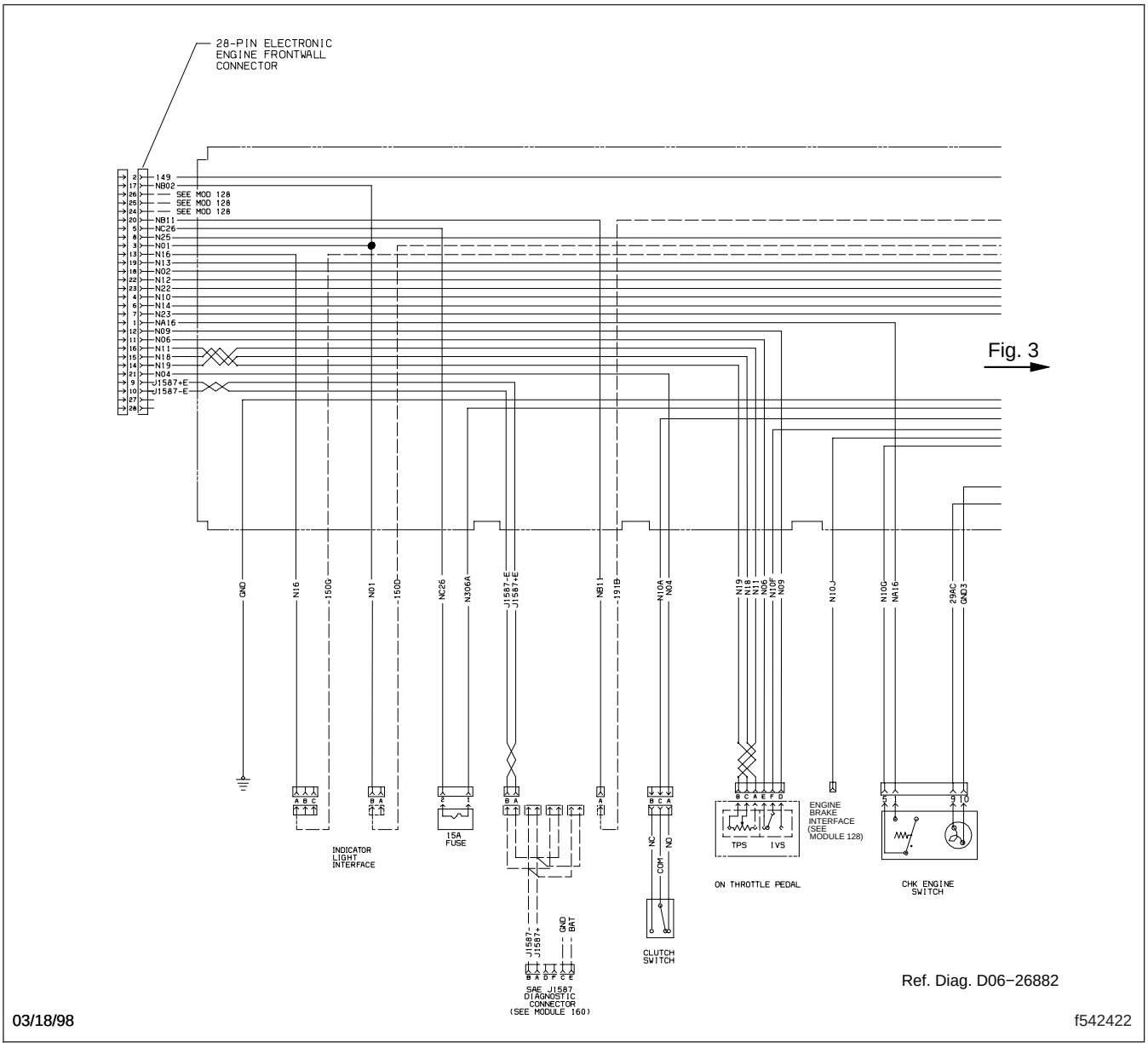


Fig. 2, Cummins ISB and ISC Engines, Cab Side Wiring Schematic (detailed view)

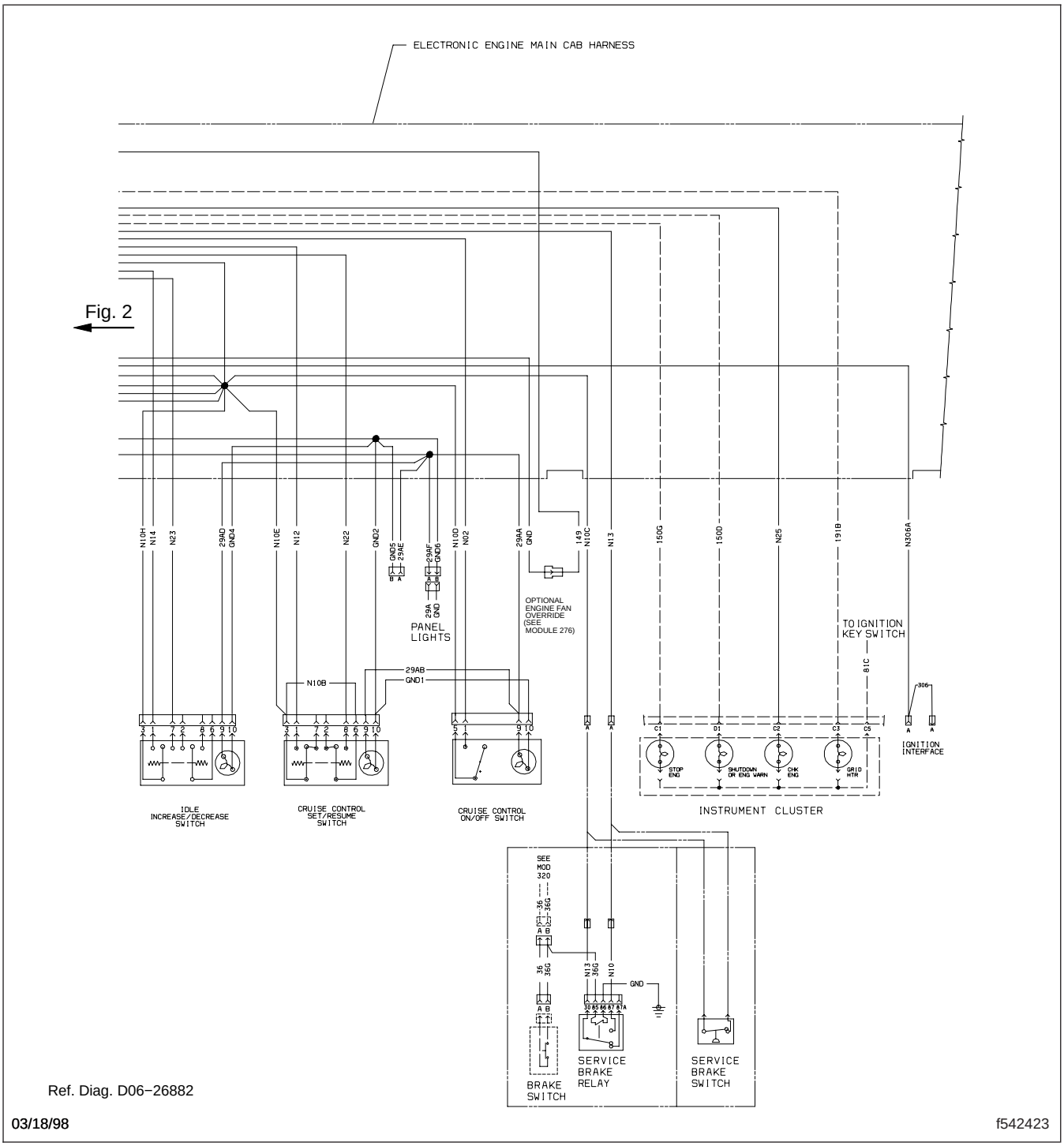


Fig. 3, Cummins ISB and ISC Engines, Cab Side Wiring Schematic (detailed view)

Specifications

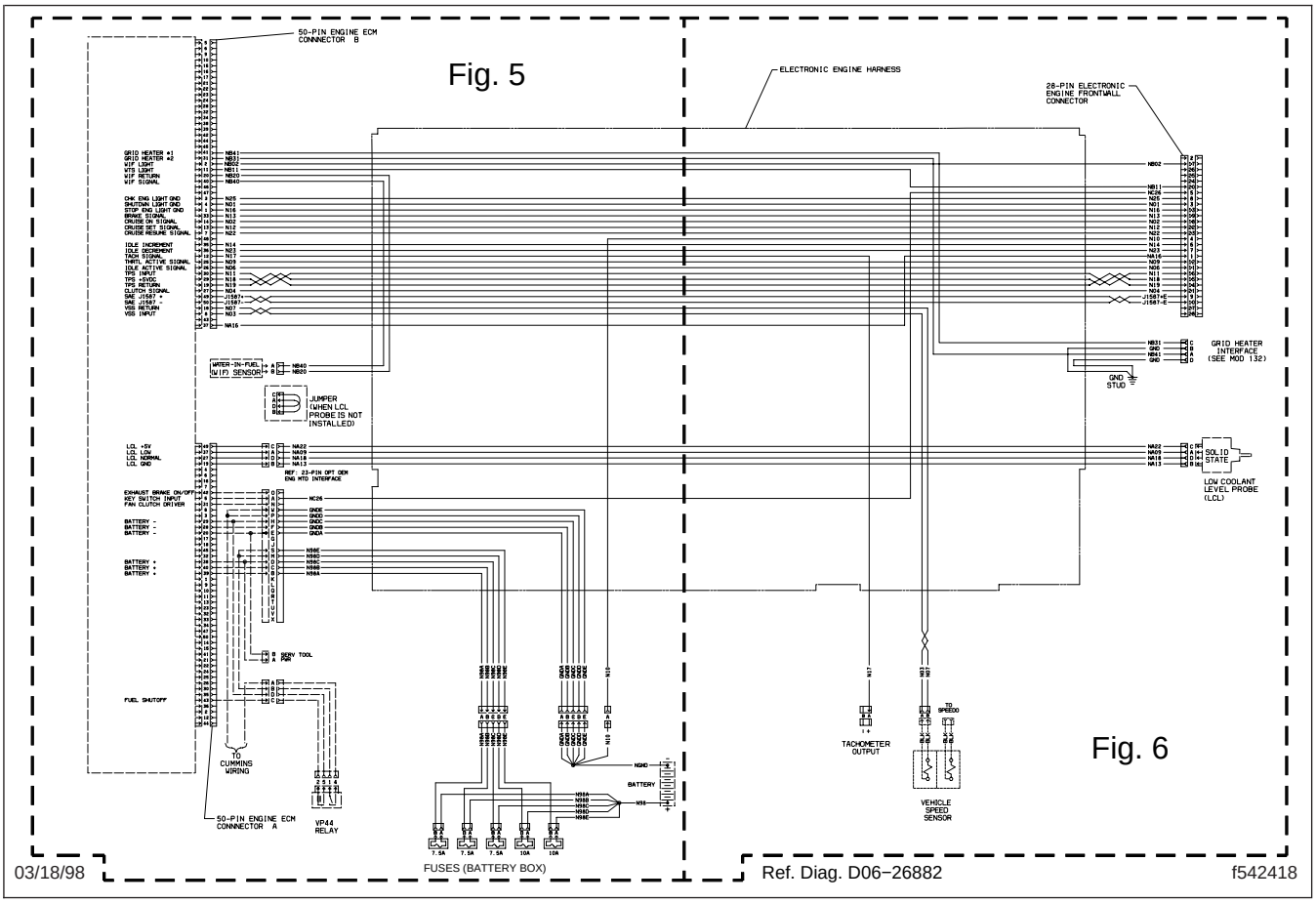
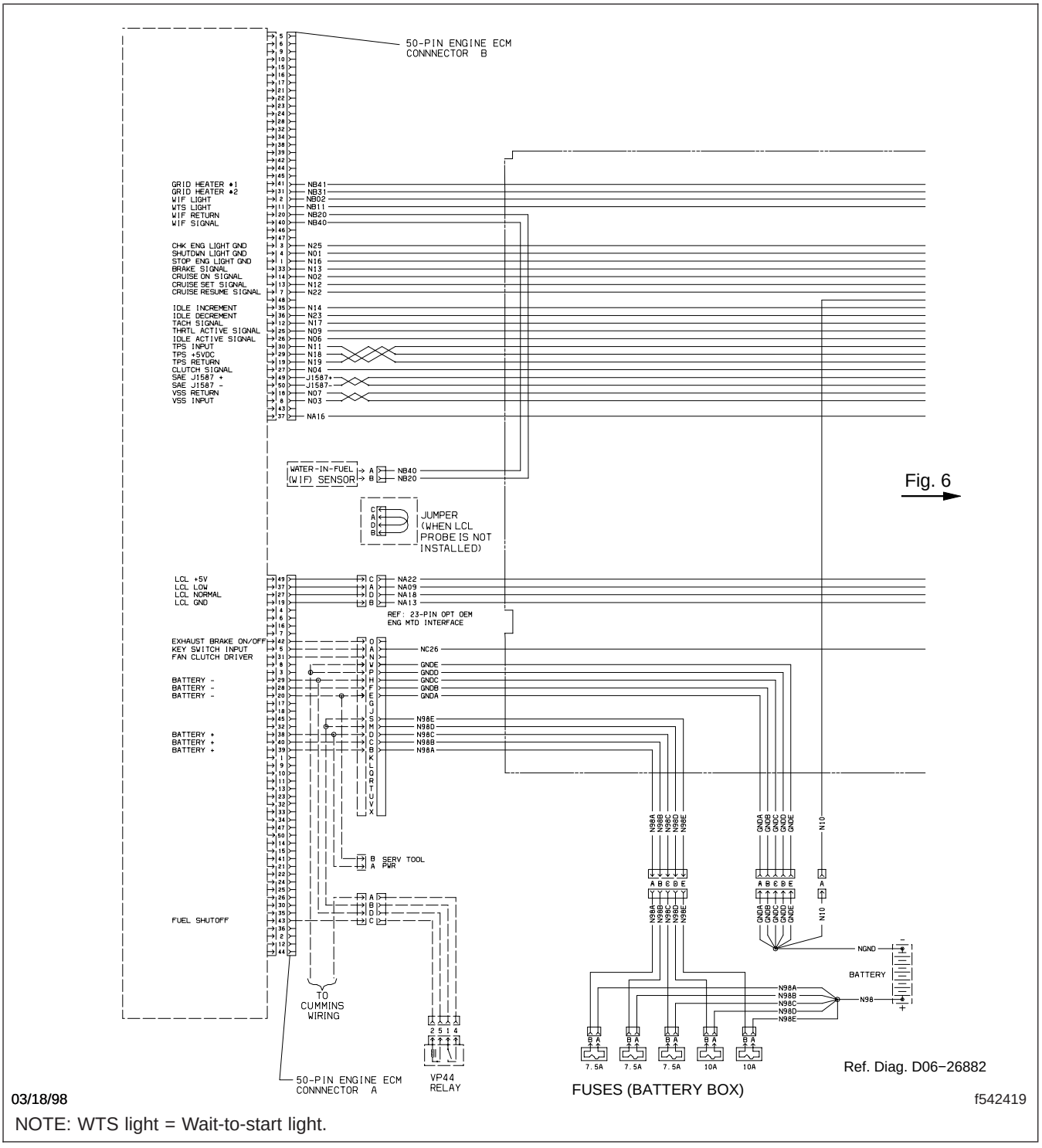


Fig. 4, Cummins ISB and ISC Engines, Wiring Schematic



NOTE: WTS light = Wait-to-start light.

Fig. 5, Cummins ISB and ISC Engines, ECM Connectors (detailed view)

Specifications

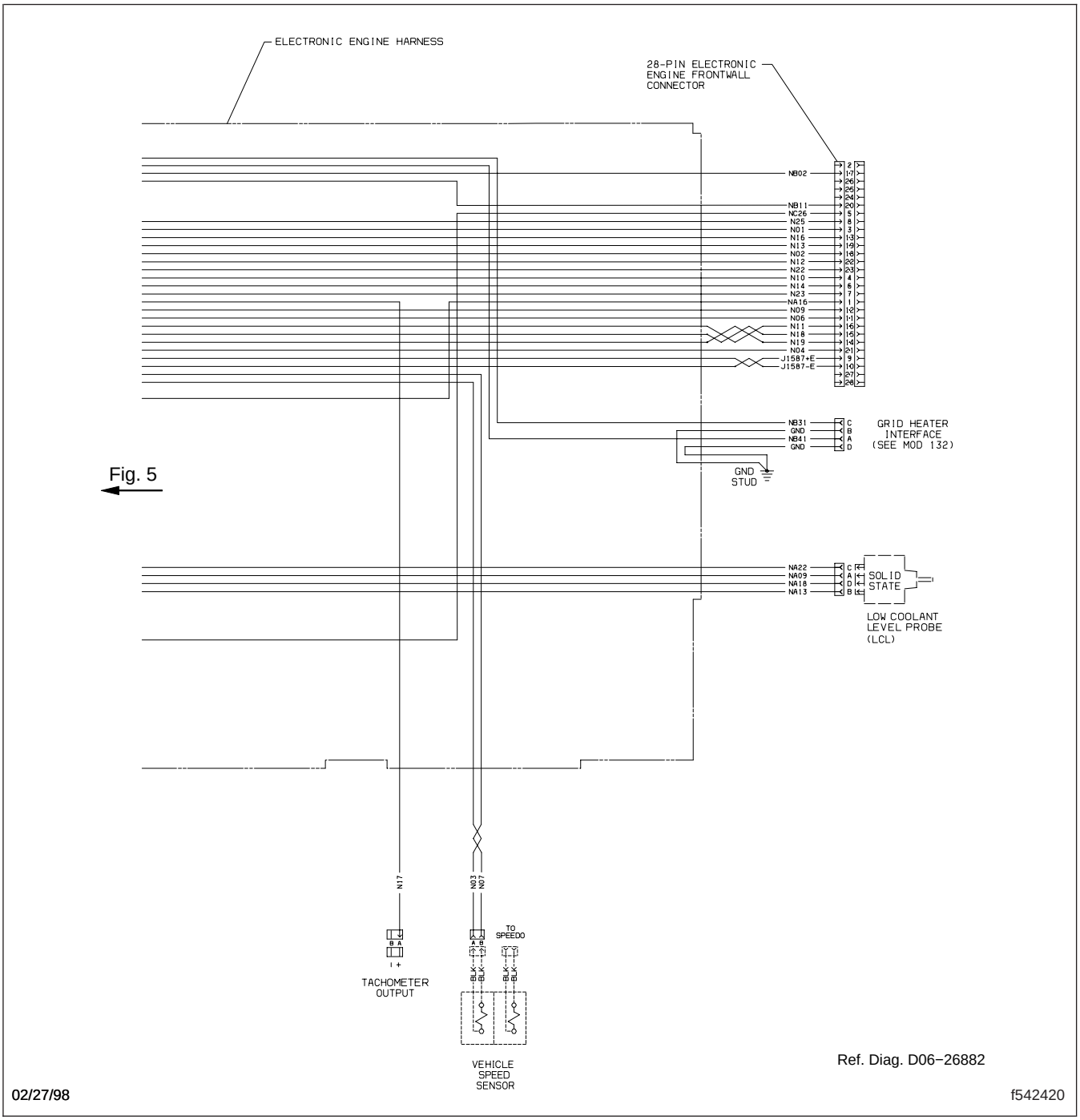
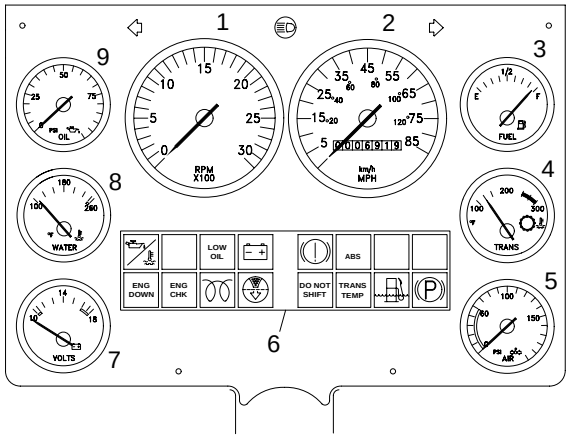


Fig. 6, Cummins ISB and ISC Engines, Frontwall Connector (detailed view)

General Information

The Ametek transmission fluid temperature gauge system consists of a dash-mounted electrical gauge, a fluid temperature sensor mounted on the transmission case, and the necessary electrical wires.

The transmission fluid temperature gauge is a cross-coil electric gauge with a 90-degree sweep and a light bulb for illumination. See **Fig. 1** for a typical instrument cluster with a transmission fluid temperature gauge installed. For gauge removal instructions, see **Subject 100**.



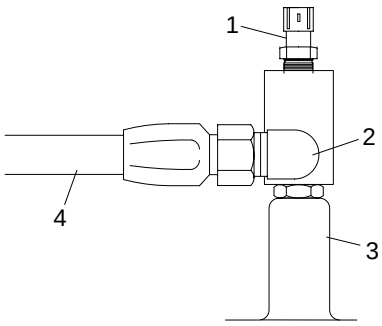
10/09/96 f601190

Typical installation shown; light and gauge layout may vary.

1. Tachometer
2. Speedometer
3. Fuel Level Gauge
4. Transmission Fluid Temperature Gauge
5. Dual Air Gauge
6. Warning and Indicator Lights
7. Voltmeter
8. Coolant Temperature Gauge
9. Engine Oil Pressure Gauge

Fig. 1, Instrument Cluster with Transmission Fluid Temperature Gauge Installed

The temperature sensor screws into the fluid outlet port on the transmission case. See **Fig. 2**. For detailed instructions, see **Subject 110**.



02/22/99 f541357

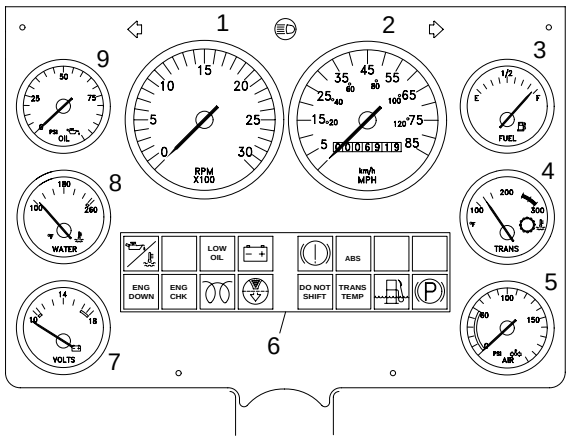
1. Temperature Sensor
2. 90° Elbow
3. Outlet Port
4. Outlet Line to Cooler

Fig. 2, Temperature Sensor Location

Transmission Fluid Temperature Gauge Removal and Installation

Removal

1. Apply the parking brake, shut down the engine, and chock the tires.
2. Disconnect the batteries.
3. Remove the instrument cluster bezel.



10/09/96 f601190

Typical installation shown; light and gauge layout may vary.

1. Tachometer
2. Speedometer
3. Fuel Level Gauge
4. Transmission Fluid Temperature Gauge
5. Dual Air Gauge
6. Warning and Indicator Lights
7. Voltmeter
8. Coolant Temperature Gauge
9. Engine Oil Pressure Gauge

Fig. 1, Instrument Cluster

4. Remove the transmission fluid temperature gauge from the dash.
   - 4.1 Using finger pressure, release the locking clip on the side of the gauge.
   - 4.2 Grasp the gauge firmly and pull it straight out of the mounting panel.

IMPORTANT: Don't touch the transmission fluid temperature gauge face or pointer.

Installation

1. Install the transmission fluid temperature gauge.
   - 1.1 Grasp the gauge firmly and insert it in the mounting panel.
   - 1.2 Make sure the gauge is firmly seated and that the locking clip is holding it in place.
2. Install the instrument cluster bezel.
3. Remove the chocks from the tires.

Transmission Fluid Temperature Sensor Removal and Installation

Removal

1. Shut down the engine, apply the parking brake, and chock the tires.

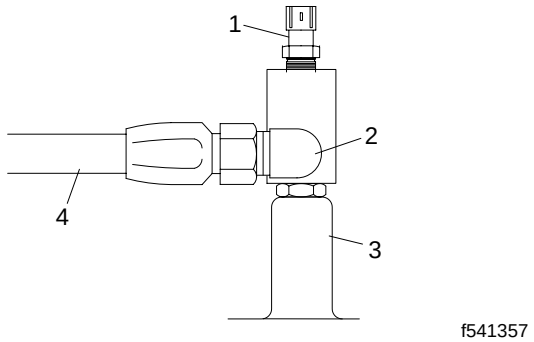
⚠ WARNING

Do not service the temperature sensor until the transmission case has cooled. Touching a hot transmission case could result in burns to fingers and hands.

⚠ CAUTION

Automatic transmissions are sensitive to contamination of any kind. To prevent transmission damage, make sure that no dirt enters the system.

2. Remove the sensor from the transmission case. See **Fig. 1**.



02/22/99 f541357

1. Temperature Sensor
2. 90° Elbow
3. Outlet Port
4. Outlet Line to Cooler

Fig. 1, Transmission Fluid Temperature Sensor

2.1 Clean dirt and oil from the area around the sensor.

2.2 Disconnect the electrical connector from the sensor. Unscrew the sensor from the transmission outlet port.

2.3 To prevent contamination of the automatic transmission fluid (ATF), cover the hole with a shop towel.

Installation

1. Install the transmission fluid temperature sensor in the outlet port of the transmission case.

   1.1 Remove the shop towel and install the sensor into the port.

   1.2 Tighten the sensor to 18 lbf·ft (25 N·m).

2. Connect the wiring to the transmission fluid temperature sensor.
3. Start the engine and check for leaks.
4. Remove the chocks from the tires.
5. Test drive the vehicle to check the transmission fluid temperature gauge for correct operation.

Troubleshooting Procedures

Transmission temperature gauge malfunctions are usually one of two types: the gauge does not operate at all (it always shows that the transmission is cold), or the transmission temperature indicated by the gauge is incorrect.

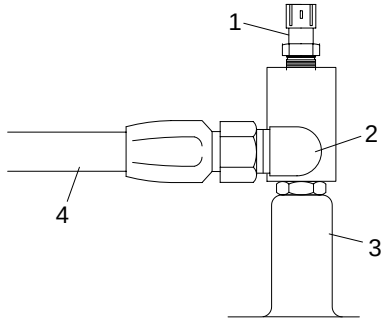
Malfunctions that would cause a totally inoperative transmission temperature gauge include open circuits in the gauge, sensor, or wiring. To isolate the cause of a faulty transmission temperature gauge system, follow the troubleshooting procedures in the order given.

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the rear tires.

⚠ WARNING

Do not touch the transmission case until the case has cooled. Touching a hot transmission case could result in burns to fingers and hands.

2. Turn the ignition key to the OFF position and remove the electrical connector from the transmission temperature sensor. See **Fig. 1**.



02/22/99 f541357

1. Temperature sensor
2. 90° Elbow
3. Transmission Outlet Port
4. Outlet Line to Cooler

Fig. 1, Transmission Temperature Sensor Connection

3. Check the sensor unit with the electrical connector disconnected.

   3.1 Operate the vehicle until the transmission is at operating temperature. Carefully avoiding touching the hot transmission case, put the ohmmeter probes on the temperature sensor terminals. The ohmmeter reading should be less than 200 ohms when the transmission oil is hot.

   3.2 When the transmission cools to about 80° F (25° C) or less, connect one probe of an ohmmeter to one of the terminals on the sensor and the other probe to the other terminal. The ohmmeter reading should be at least 500 ohms. If the readings are not as indicated, replace the transmission temperature sensor, following the instructions in Group 54.16, **Subject 110** and verify that the gauge operates properly.

4. If the sensor readings are within specifications, turn the ignition key to the ON position and, with the electrical connector to the sensor disconnected, observe the gauge needle. The gauge needle should remain at the left end of the scale (low temperature indicated). If not, find and repair the short circuit in the wiring or gauge.

5. Test the wiring harness and gauge.

   5.1 Turn the ignition key to the OFF position and connect both terminals in the harness connector together with a jumper.

   5.2 Turn the ignition key to the ON position again and watch the gauge needle; it should move immediately to the extreme right or "hot" end of the scale.

   If the gauge needle moves to full scale in this test, the gauge unit and the wiring to the gauge are functioning properly or the problem is intermittent.

   Turn the ignition key to the OFF position, remove the jumper from the wiring harness connector and reconnect the harness connector to the transmission temperature sensor.

   IMPORTANT: If the problem is intermittent, test the current carrying capacity of the wires and pins and replace any damaged parts.

   5.3 If the gauge needle stays at the low end of the scale with the jumper connected, test the harness ground circuit by connecting the jumper from ground to the

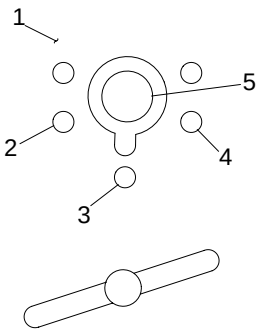
Troubleshooting

sensor harness connector terminal for circuit 30. The gauge needle should move to the full scale position.

If the gauge now indicates full scale, the other wire in the sensor harness (from the harness connector to ground) is not making a good connection. Fix the wire problem and retest. If the gauge needle remains at the low end of the scale during this check, the gauge or the wire (circuit 30) from the sensor to the gauge has a problem.

6. If the previous tests indicate that the wiring and the sensor are good, check the gauge mounting panel and gauge.

   Remove the instrument cluster bezel and the transmission temperature gauge. If necessary, refer to Group 54.16, **Subject 100**. See **Fig. 2** to identify the transmission temperature gauge terminals .



02/22/99 f601090

1. Gauge Mounting Panel
2. Ground Terminal (–)
3. Ignition Power Terminal (+)
4. Sensor Signal Terminal
5. Gauge Illumination Bulb

Fig. 2, Transmission Temperature Gauge Connection

7. Check the ground circuit wiring of the transmission temperature gauge.

   7.1 With the ignition key in the OFF position, connect the probes of an ohmmeter between the cab metal (an unpainted bolt or screw attached directly to cab structure works well) and the ground circuit terminal (see **Fig. 2**) in the gauge mounting panel.

   7.2 The resistance should be less than 1 ohm. If it is, go to the next step. If the resistance is higher than 1 ohm, verify that you have good connections at both the terminal and the cab metal.

   7.3 If the connections are good, but the resistance is still greater than 1 ohm, locate the damaged section of wiring between the gauge ground terminal and ground. Repair the damage by splicing in a length of replacement wiring following the instructions in this group.

8. Check the signal circuit between the transmission temperature gauge and the sensor.

   8.1 With the gauge removed from the gauge mounting panel, connect one ohmmeter lead to the sensor signal terminal (see **Fig. 2**) and the other lead to the mounting panel ground terminal.

   8.2 If the harness and sensor are good, the resistance will depend upon the transmission fluid temperature. The resistance should be more than 500 ohms for a cold transmission and less than 200 ohms for a transmission at operating temperature.

   8.3 If the sensor resistance at this test point is within specifications, the sensor and the wiring are functioning correctly. If the resistance is not with specifications, go to the next step to test for power to the gauge.

9. Check for battery voltage at the transmission temperature gauge terminal in the gauge mounting panel.

   9.1 Turn the ignition key to the ON position.

   9.2 Connect a voltmeter (set on the 20 volt scale, DC voltage) to the gauge terminals in the gauge mounting panel as follows; positive (red) probe to the ignition power terminal (see **Fig. 2**) and the negative (black) probe to the ground terminal. The voltmeter should read between 9 and 16 volts DC.

9.3 If the voltage is between 9 and 16 volts, the gauge itself is malfunctioning, and must be replaced. For instructions, refer to Group 54.16, **Subject 100**. If the voltage reading is not within the limits mentioned above, check the circuit breaker that supplies power to the gauge. If the circuit breaker is functioning correctly, locate and repair the damage to the power circuit.

IMPORTANT: The level I ICU is also known (on ServiceLink) as the ICU3.

General Description

This section covers the instrumentation control unit, level I (level I ICU).

LEVEL I ICU (ICU3)

The level I ICU (ICU3) is a basic electronic dashboard that accepts input from the fuel level sensor, the transmission temperature sensor (if installed), and the J1587 datalink. The information is processed by a micro-computer and displayed on electronic gauges driven by stepper motors. Only air gauges operate mechanically.

The following gauges are available:

- Speedometer
- Tachometer (optional)
- Engine Oil Pressure
- Coolant Temperature
- Fuel Level
- Transmission Fluid Temperature (optional)
- Primary Air Pressure (optional)
- Secondary Air Pressure (optional)

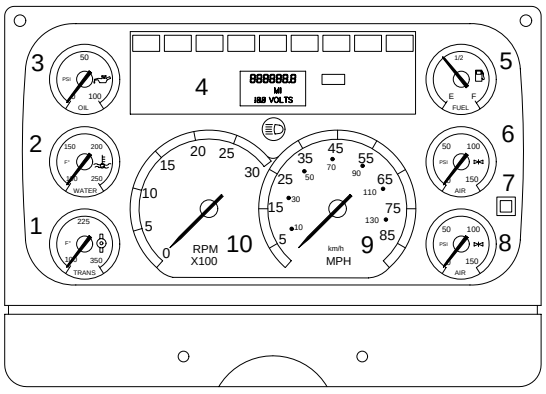
The transmission fluid temperature gauge is required on vehicles with automatic transmissions.

The speedometer and tachometer are large-faced electronic gauges located below the dash message center. See **Fig. 1**.

The other gauges are small-faced gauges on the driver's instrument panel, to either side of the speedometer and tachometer. The engine oil pressure, coolant temperature, transmission fluid temperature, and fuel level gauges are electronic; the air pressure gauges are mechanical. The level I ICU can not drive gauges located on the auxiliary instrument panel.

The following items are replaceable:

- air pressure gauges
- light bulbs
- lens/mask assembly
- mode/reset button



06/02/99 f610205b

1. Transmission Fluid Temperature Gauge
2. Coolant Temperature Gauge
3. Engine Oil Pressure Gauge
4. Dash Message Center
5. Fuel Level Gauge
6. Primary Air Pressure Gauge
7. Optional Mode/Reset Push Button
8. Secondary Air Pressure Gauge
9. Speedometer
10. Tachometer

Fig. 1, Level I ICU Gauge Layout (typical)

- top row warning and indicator lenses
- back cover

DASH MESSAGE CENTER

The heart of the level I ICU is the dash message center. It has two parts: a set of 26 warning and indicator lights similar to those found on a conventional lightbar, and a dash driver display screen. The dash driver display screen is a 1-line by 7-character liquid crystal display (LCD) that is normally used to display the odometer reading. In addition, there is a separate voltmeter display underneath the odometer display.

The information that can be provided by the message center includes:

- odometer readings
- trip miles
- trip engine hours
- a listing of active faults

With the optional Mode/Reset button, you can switch the odometer to display either miles or kilometers,

General Information

invoke the trip odometer and trip engine hours, and call up diagnostic messages (active faults).

WARNING AND INDICATOR LIGHTS

There are spaces on the level I ICU for 26 warning and indicator lights. See **Fig. 2** for a typical installation.

There are four rows of lights. The lights in the top row are all optional and may be installed in any order, except for two lights that are typically installed at a fixed position.

- Position 1: Stop Engine Warning (Red)—installed on vehicles with Cummins engines only
- Position 7: Wheel Spin Indicator (Amber)

NOTE: Positions 1 through 8 are ground-activated circuits; position 2 can be activated with the ignition switch in the OFF position; position 9 is power-activated.

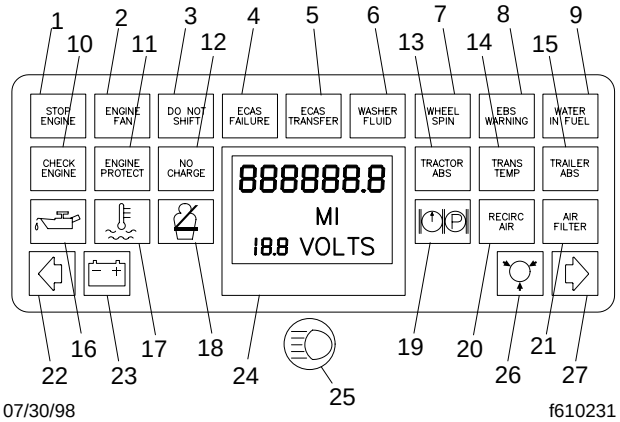
On the other three rows, the lights are installed at fixed positions that do not vary. Some lights are optional; if an optional light is not requested, the position is blank (does not light up).

The following fixed-position lights are standard:

- Check Engine Indicator (Amber)
- Low Engine Oil Pressure Warning (Red)
- High Coolant Temperature Warning (Red)
- Fasten Seat Belt Warning (Red)
- Left Turn Signal (Green)
- Low Battery Voltage Indicator (Amber)
- Tractor ABS Indicator (Amber)
- Parking Brake On Warning (Red)
- Recirculated Air Indicator (Amber)
- Low Air Pressure Warning (Red)
- Right Turn Signal (Green)
- High Beams On Indicator (Blue)
- Engine Protection Warning (Red)

The following fixed-position lights are optional:

- Alternator No Charge Indicator (Amber)



Typical installation shown. Location of legends installed in the top row may vary, and other legends may be specified.

1. Stop Engine Warning (Cummins engine only)
2. Engine Fan On Indicator (optional)
3. Do Not Shift Indicator (optional)
4. ECAS Failure Warning (optional)
5. ECAS Transfer Indicator (optional)
6. Low Washer Fluid Indicator (optional)
7. Wheel Spin Indicator (optional)
8. EBS Warning (optional)
9. Water In Fuel Indicator (optional)
10. Check Engine Indicator
11. Engine Protection Warning
12. Alternator No Charge Indicator (optional)
13. Tractor ABS Warning
14. Transmission Temperature Warning (optional)
15. Trailer ABS Warning (optional)
16. Low Engine Oil Pressure Warning
17. High Coolant Temperature Warning
18. Fasten Seat Belt Warning
19. Parking Brake On Warning
20. Recirculated Air Indicator
21. Air Restriction Indicator (optional)
22. Left Turn Signal
23. Low Battery Voltage Warning
24. Dash Driver Display Screen
25. High Beams On Indicator
26. Low Air Pressure Warning
27. Right Turn Signal

Fig. 2, Dash Message Center, Level I ICU (ICU3)

- High Transmission Temperature Warning (Amber)—installed on vehicles with automatic transmissions
- Trailer ABS Indicator (Amber)—installed on vehicles designed to be used with a trailer
- Air Restriction Indicator (Amber)

The following lights are optional and their installed location may vary anywhere in the top row:

- Engine Fan On Indicator (Amber)
- Do Not Shift Indicator (Amber)
- ECAS Failure Warning (Red)
- ECAS Transfer Indicator (Amber)
- Low Washer Fluid Indicator (Amber)
- EBS (Electronic Braking System) Warning (Red)
- Water In Fuel Indicator (Amber)

Other optional lights may be specified.

All light bulbs are replaceable in the field, including gauge light bulbs and warning/indicator light bulbs.

Principles of Operation

IGNITION SEQUENCE

When the ignition keyswitch is turned on, the level I ICU (ICU3) runs through the ignition sequence. See **Fig. 3**. If the headlights are turned on, the screen displays the odometer and waits for the ignition to be turned on.

IMPORTANT: When the ignition keyswitch is first turned on, all the electronic gauges complete a full sweep of their dials, the warning and indicator lights light up, and the buzzer sounds for three seconds.

The following warning and indicator lights go on during the ignition sequence:

- Low Engine Oil Pressure Warning
- High Coolant Temperature Warning
- Low Air Pressure Warning
- Parking Brake On Warning
- Low Battery Voltage Indicator
- Fasten Seat Belt Warning
- All engine warning lights, including Engine Protection, Check Engine, and Stop Engine (on Cummins only)
- All ABS warning lights, including Wheel Spin, Tractor ABS, and Trailer ABS (if installed)

NOTE: While the engine and ABS warning lights go on during the ignition sequence, they are not controlled by the level I ICU, but by their own system ECU (electronic control unit).

Once the ignition keyswitch has been turned on, the ICU performs a self-test, looking for active faults. During the first half of the self-test, all segments of the display illuminate as follows: "888888.8." During the second half of the self-test, the software revision level is displayed.

If there are no active faults, the screen displays the odometer.

If, however, the level I ICU has received active fault codes from other devices, it displays the three-letter acronym and MID number for each for three seconds, one after the other, until the parking brake is released or the ignition keyswitch is turned off.

The screen displays a code, called the message identifier (MID), indicating the ECU or system that is not functioning properly.

For a complete list of possible screen displays, see **Specifications 400**.

NOTE: If the level I ICU receives a message from an ECU that has not been pre-programmed into the ICU's memory, it displays "SYS ###" instead, where ### is replaced by the MID of the broadcasting device.

Once the parking brake is released, the level I ICU displays the odometer again.

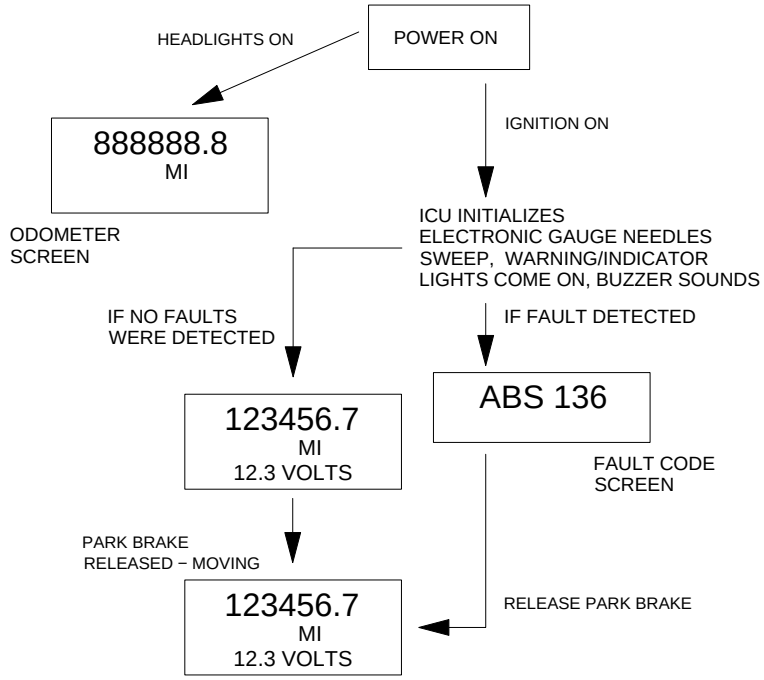
ODOMETER

The odometer is set to display in either miles or kilometers, depending on the primary scale of the speedometer. The legend, either "MI" or "KM," illuminates between the odometer and the volts display when the engine is running or the headlights are turned on.

The odometer is a seven-digit display with a decimal point, until the vehicle has traveled 999,999.9 miles or kilometers (km). At one million miles (km), the odometer rolls over to "1000000," without the decimal point, and can continue up to 9,999,999. The odometer only displays significant figures (no leading zeros).

IMPORTANT: Although the odometer uses data supplied by the engine ECM to update its count,

General Information



During the first half of the self-test, all segments of the display illuminate. During the second half of the self-test, the software revision level is displayed.

NOTE: If there is more than one fault, the level I ICU displays them, one after another, changing every three seconds, until the park brake is released.

Fig. 3, Level I ICU Ignition Sequence

it keeps its own mileage starting from zero, when it was first installed. The ICU odometer may not match the engine ECU odometer. This may occur if the engine has been operated with the ICU disconnected, as may occur during factory break-in or engine service, or if the ICU has been replaced.

BUZZER

The buzzer sounds during the ignition sequence and whenever one of the following conditions exist:

- The engine oil pressure falls below the preset level, which is 5 to 9 psi (35 to 60 kPa) on most engines.
- The coolant temperature rises above the preset level, which is 215°F (101°C) on Caterpillar and Detroit Diesel engines; 220°F (104°C) on Cummins engines; and 189°F (87°C) on MBE900 engines.
- The air pressure falls below the preset level of approximately 70 psi (483 kPa).
- The parking brake is set with the vehicle moving at a speed greater than 2 miles per hour.

IMPORTANT: The level I ICU is also known (on ServiceLink) as the ICU3.

Replacement

The instrumentation control unit, level I (level I ICU) is a self-contained one-piece unit, including housing, gauges, and the dash message center. See **Fig. 1**.

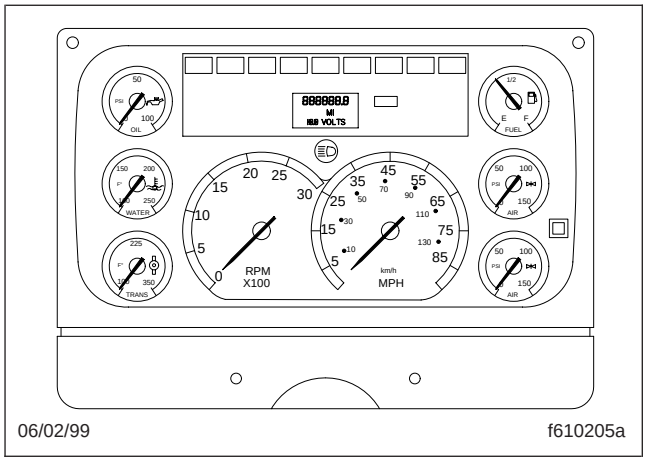


Fig. 1, Level I ICU

1. Reduce air pressure in the primary and secondary air systems to 25 psi (172 kPa) or less.

CAUTION

Electronic components of the level I ICU (ICU3) are vulnerable to damage from static electricity. If available, wear a wrist grounding strap connected to a ground in the cab or workbench. If a grounding strap is not available, touch a grounded component immediately before doing any work which could bring a tool or body part in contact with level I ICU circuitry.

2. Remove the four fasteners from the level I ICU bezel. See **Fig. 2**. Fasteners used on the level I ICU are T25 Torx-head dog-point screws. See **Fig. 3**.

CAUTION

Do not forcibly pull the driver's panel from the dash. This may dislodge wires from the harness

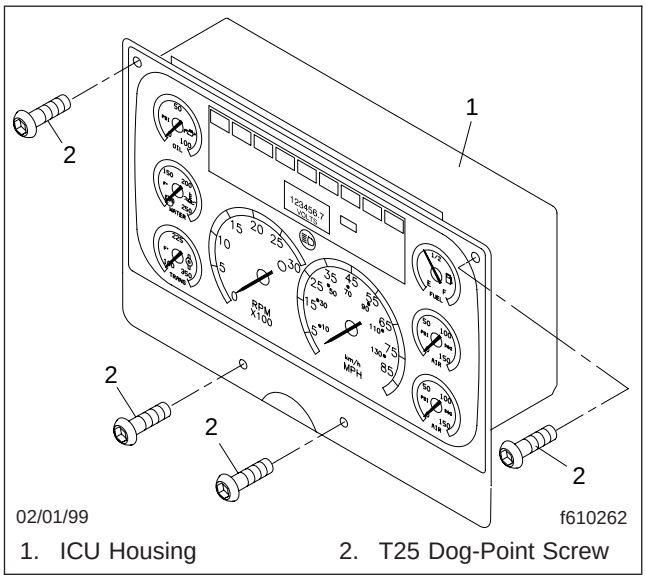


Fig. 2, Level I ICU Installation

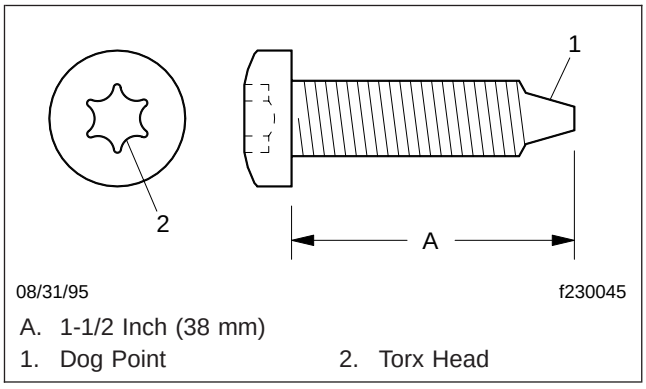


Fig. 3, Dog-Point Screw

electrical connectors on the back of the ICU housing and damage the wires, the ICU, or the dash.

3. Pull the old ICU away from the dash. Pull the top of the unit towards you until the back of the housing is free, then pull up to remove the rest of the unit.

4. Remove the connectors from the back of the housing.

   4.1 From behind the ICU housing, disconnect the two electrical connectors in the center of the housing.

Level I Instrumentation Control Unit Replacement

4.2 Disconnect all air hoses. Hoses and connectors are color-coded for ease of installation.

5. Remove the old ICU from the vehicle. See **Fig. 2**.
6. Install the level I ICU on the dash. See **Fig. 2**.
   - 6.1 Connect the air hoses to the air gauges, as removed.
   - 6.2 Connect the two electrical connectors, as removed.
   - 6.3 Place the new level I ICU in the dash and install the fasteners.
7. Turn on the ignition and test the operation of the new level I ICU. All the electronic gauges should make one complete sweep and return to their normal indicating positions; the warning and indicator lights should turn on, then off.

   If any gauges are not working properly, the level I ICU will need to be serviced or replaced.

NOTE: Mechanical (air) gauges do not make a sweep.

Replacement

1. Reduce air pressure in the primary and secondary air systems to 25 psi (172 kPa) or less.

CAUTION

To avoid damaging the ICU, please read and follow the cautions in Subject 100 regarding grounding the ICU and forcibly pulling it from the dash.

2. Remove the level I ICU. See **Fig. 1**. For detailed instructions, see **Subject 100**.

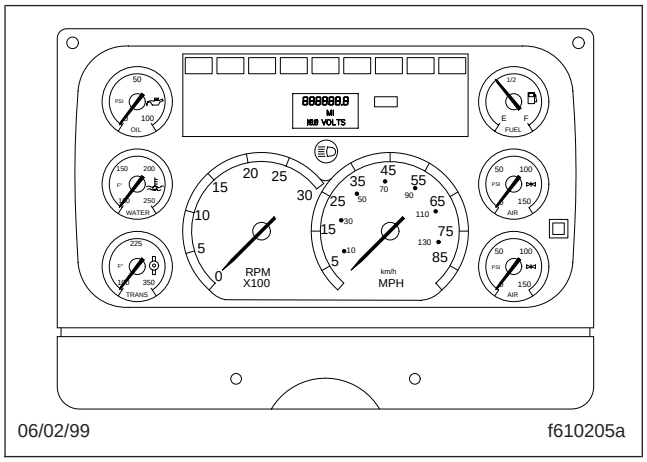


Fig. 1, Level I ICU

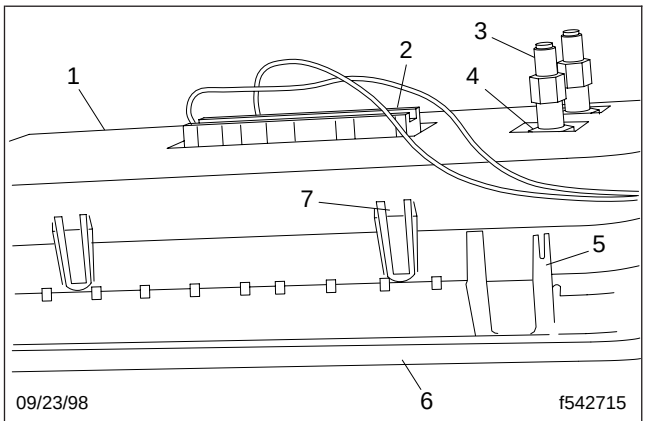
CAUTION

Use extreme care to avoid breaking the clips when prying them off the ICU housing. The clips are under tension and are easy to damage.

3. Using a thin-bladed screwdriver, very carefully pry the nine large white clips away from the sides of the ICU housing. It is helpful to use a small thin piece of metal, such as a spade terminal, to hold each clip away from the housing after it has been gently levered off its pawl. Remove the bezel from the ICU housing. See **Fig. 2**.

4. From the back of the ICU housing, remove the quick-disconnect fitting and nut from the threaded tube coming out the back of the air gauge.

5. Remove the old air gauge from the ICU.



1. ICU Housing
2. Electrical Connector
3. Quick-Disconnect Fitting
4. Nut
5. Bezel Clip (white)
6. Bezel
7. Back Cover Clip (black)

Fig. 2, Air Pressure Gauge Installation

6. Install the new air gauge.
   - 6.1 Insert the new gauge into the hole in the ICU housing.
   - 6.2 Tighten the nut on the threaded tube.
   - 6.3 Install the quick-disconnect fitting.
7. Position the bezel on the ICU housing. Fasten the nine white clips to the sides of the ICU housing.
8. Install the level I ICU. For detailed instructions, see **Subject 100**.
9. Start the engine and verify the proper operation of the new gauge as the air pressure builds up.

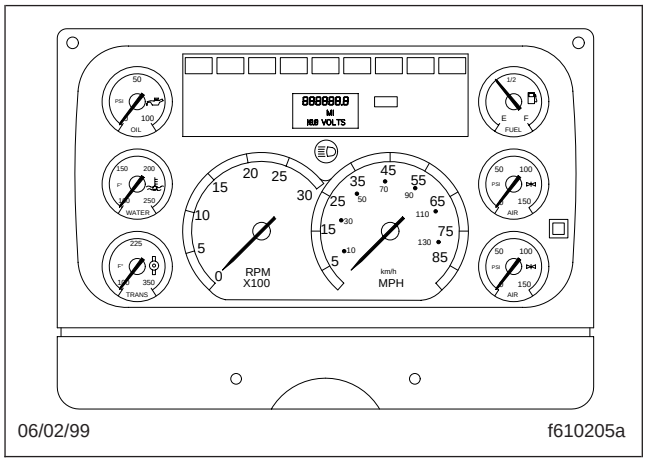
Replacement

1. Reduce air pressure in the primary and secondary air systems to 25 psi (172 kPa) or less.

CAUTION

To avoid damaging the ICU, please read and follow the cautions in Subject 100 regarding grounding the ICU and forcibly pulling it from the dash.

2. Remove the level I ICU. See **Fig. 1**. For detailed instructions, see **Subject 100**.



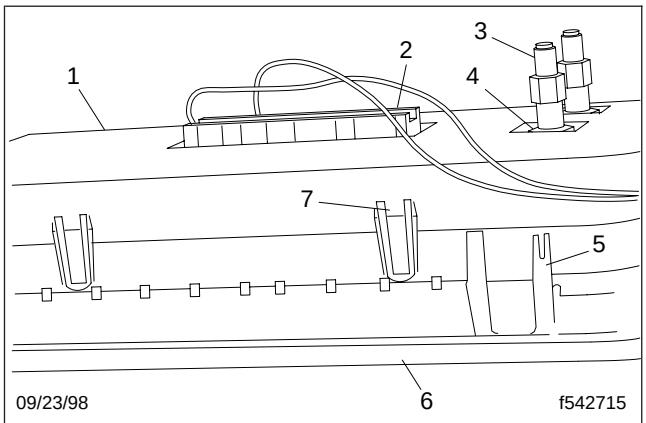
06/02/99 f610205a

Fig. 1, Level I ICU

CAUTION

Use extreme care to avoid breaking the clips when prying them off the ICU housing. The clips are under tension and are easy to damage.

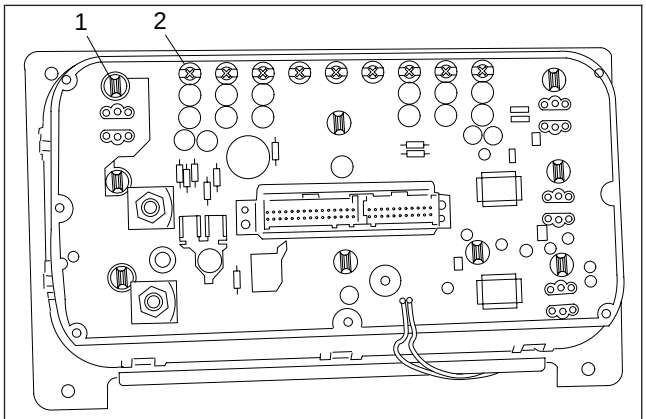
3. Pry off the four small black clips from the sides of the ICU housing. See **Fig. 2**.
4. Remove the two screws from the back of the housing, one on the middle of each side, and remove the back cover from the ICU housing.
5. Remove the burnt-out light bulb(s). See **Fig. 3**.
   - 5.1 To remove gauge light bulbs, twist the bulb base 1/4-turn counter-clockwise, then pull out.



09/23/98 f542715

1. ICU Housing
2. Electrical Connector
3. Quick-Disconnect Fitting
4. Nut
5. Bezel Clip (white)
6. Bezel
7. Back Cover Clip (black)

Fig. 2, Back Cover Installation



09/29/98 f542716

1. Gauge Light Bulb Base
2. Warning and Indicator Light Bulb Base

Fig. 3, Light Bulb Installation

   - 5.2 To remove warning/indicator light bulbs, use a small screwdriver to twist out the bulb base behind the affected light.
6. Install the new light bulb(s).
   - 6.1 To install gauge light bulbs, twist the bulb holder into the slot from which the old one was removed.

Light Bulb Replacement

6.2 To install warning/indicator light bulbs, insert the new bulb base into the proper slot and use a small screwdriver to tighten it.

NOTE: LEDs must be installed with correct polarity. Insert the LED into the socket, rotating and pushing gently until it touches the contacts. If it lights, push it the rest of the way into the socket. Otherwise, pull it out, rotate it 1/2 turn, and check for lighting again. If it still doesn't light, you need to push it further into the socket, the socket isn't getting power, or you may have a bad LED.

7. Position the back cover on the ICU housing. Fasten the four black clips to the sides of the ICU housing.
8. Install the two screws on the back of the housing, one on the middle of each side.
9. Install the level I ICU. For detailed instructions, see **Subject 100**.
10. Turn on the ignition keyswitch. Check all bulbs for correct operation.

IMPORTANT: The level I ICU is also known (on ServiceLink) as the ICU3.

The two connectors are pink and plug into pins located in the center of the unit, on the back. Connector #1 has 24 cavities, numbered A1 through A12, and B1 through B12. Connector #2 has 32 cavities, numbered C1 through C16, and D1 through D16.

Level I ICU Connector #1 Pin Assignments, Pins A1 Through B12		
Number	**Description**	**Wire**
A1	Panel Lights	29A
A3	Low Air Pressure Indicator	390
A4	Transmission Temp Indicator	274
A5	Air Restriction Indicator	183A
A7	Do Not Shift Indicator	223
A9	No Charge Indicator	137
A12	High Beam Indicator	21B
B3	J1587 Databus –	M08
B10	J1587 Databus +	M27

Table 1, Level I ICU Connector #1 Pin Assignments, Pins A1 through B12

Level I ICU Connector #2 Pin Assignments, Pins C1 through D16		
Number	**Pin Assignment**	**Wire**
C5	Parking Brake	394
C8	Left Turn Signal	60A
C12	Transmission Fluid Temperature Sender Return	30G
C13	Transmission Fluid Temperature Sender Feed	30
D1	Fuel Level Gauge Sender Feed	47
D2	Fuel Level Gauge Sender Return	47G
D3	Ground	GND
D8	Right Turn Signal	61A
D13	Ground	GND
D14	Battery Feed—Unswitched	339
D15	Ignition—Switched	81C
D16	Odometer Light (from headlight)	20L

Table 2, Level I ICU Connector #2 Pin Assignments, Pins C1 through D16

Message Identifiers (MIDs)		
MID	**Description**	**Text Message**
128	Engine Control Unit	ECU128
130	Transmission Control Unit	tCU130
136	Anti-Lock Brake System (ABS)	AbS136

Specifications

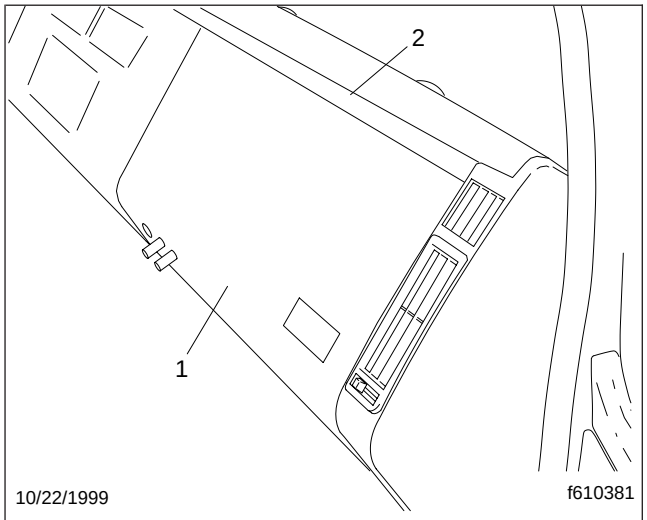
Message Identifiers (MIDs)		
MID	**Description**	**Text Message**
140	Instrumentation Control Unit	ICU140
223	Tranmission Shift Unit	tSU223
###	Generic MID	SYS###

Table 3, Message Identifiers (MIDs)

Vehicle Control Unit Removal and Installation

Removal

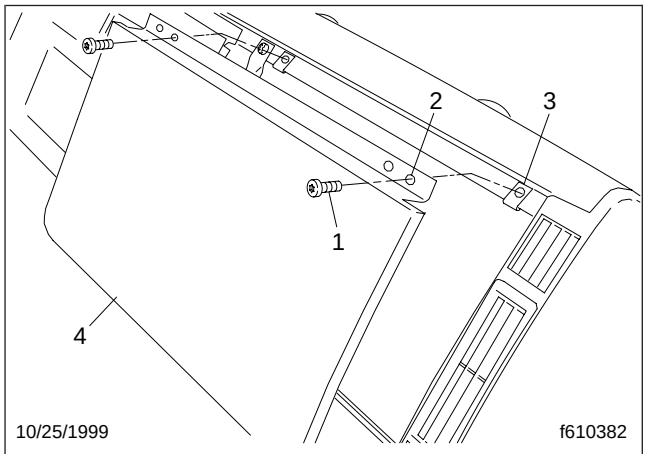
1. Remove the vinyl extrusion trim at the top of the passenger's-side dash panel. See **Fig. 1**.



Left-hand drive is shown; right-hand drive is similar.
1. Passenger's-Side Dash Panel
2. Vinyl Extrusion Trim

Fig. 1, Passenger's-Side Dash Panel

2. Using a T25 torx-head screwdriver, remove the two mounting screws along the top edge of the dash panel. See **Fig. 2**.



1. T25 Torx-Head Screw
2. Hole in Panel
3. Spring Clip
4. Passenger's-Side Dash Panel

Fig. 2, Dash Panel Mounting

3. Disconnect the three electrical connectors (violet, gray, and brown) by pressing the release at the bottom of each connector. See **Fig. 3**.
4. Push on the VCU (vehicle control unit) case in the direction away from the connectors to loosen the clips on the back of the box. See **Fig. 4**.

Installation

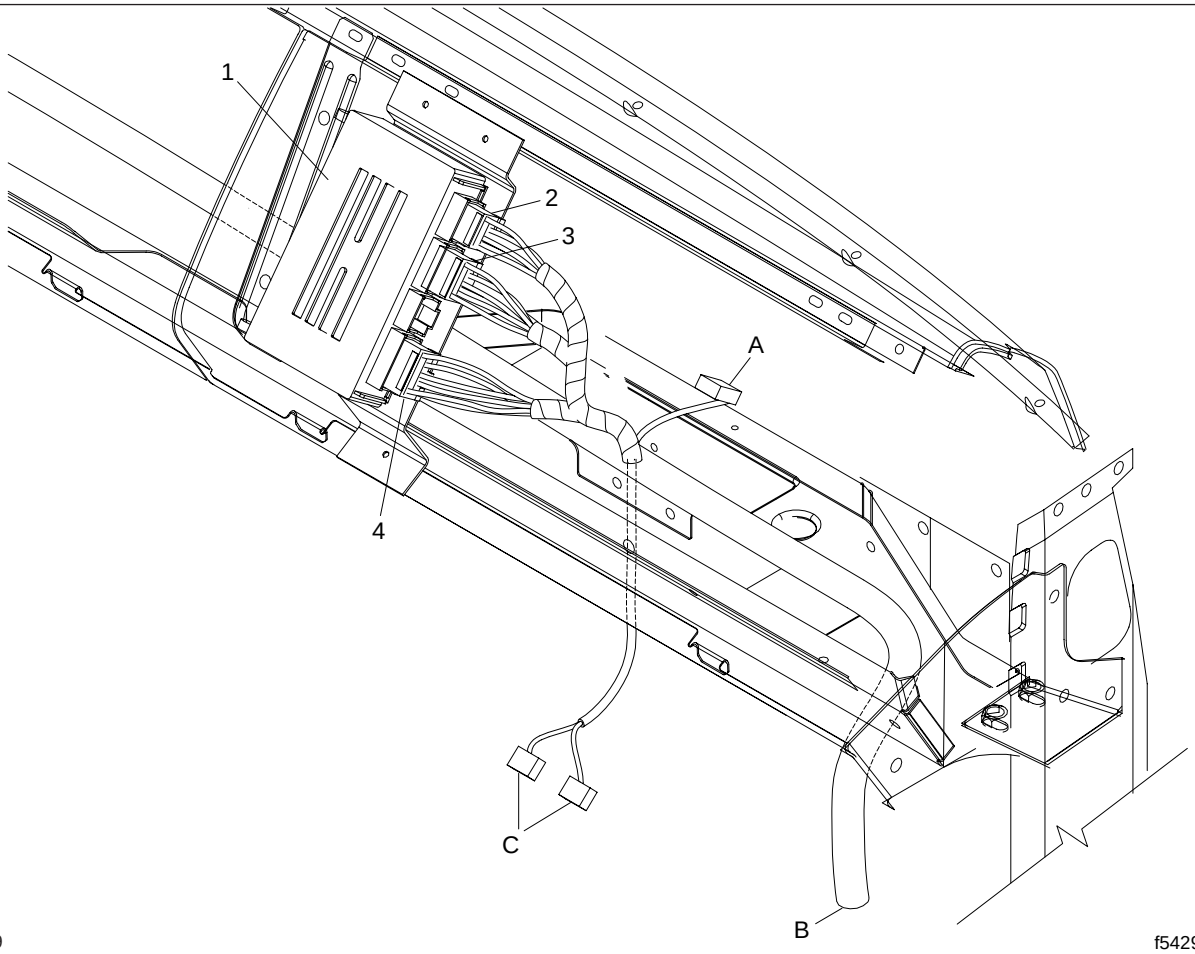
1. Install the VCU. Push in until the clips are firmly seated.
2. Connect the violet, gray, and brown electrical connectors to the VCU, as removed.

IMPORTANT: The connectors cannot be installed on the wrong plug location on the VCU, because they each have different numbers of pins. Connector VC2 is not used at this time.

- Connector VC1 has 21 pins.
- Connector VC3 has 18 pins.
- Connector VC4 has 15 pins.

3. Install the passenger's-side dash panel and tighten the two mounting screws until firm.
4. Install the vinyl extrusion trim at the top of the panel.

Vehicle Control Unit Removal and Installation



A. To J1587 Datalink
B. To Electronic Engine Connector
C. To J1939 Backbone

1. Vehicle Control Unit (VCU)
2. 15-Pin Connector VC4 (violet)
3. 18-Pin Connector VC3 (gray)
4. 21-Pin Connector VC1 (brown)

Fig. 3, VCU Installation

Vehicle Control Unit Removal and Installation

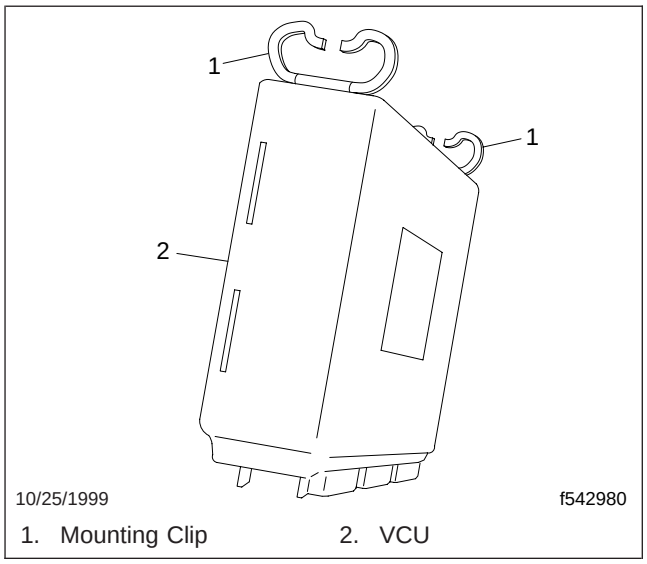
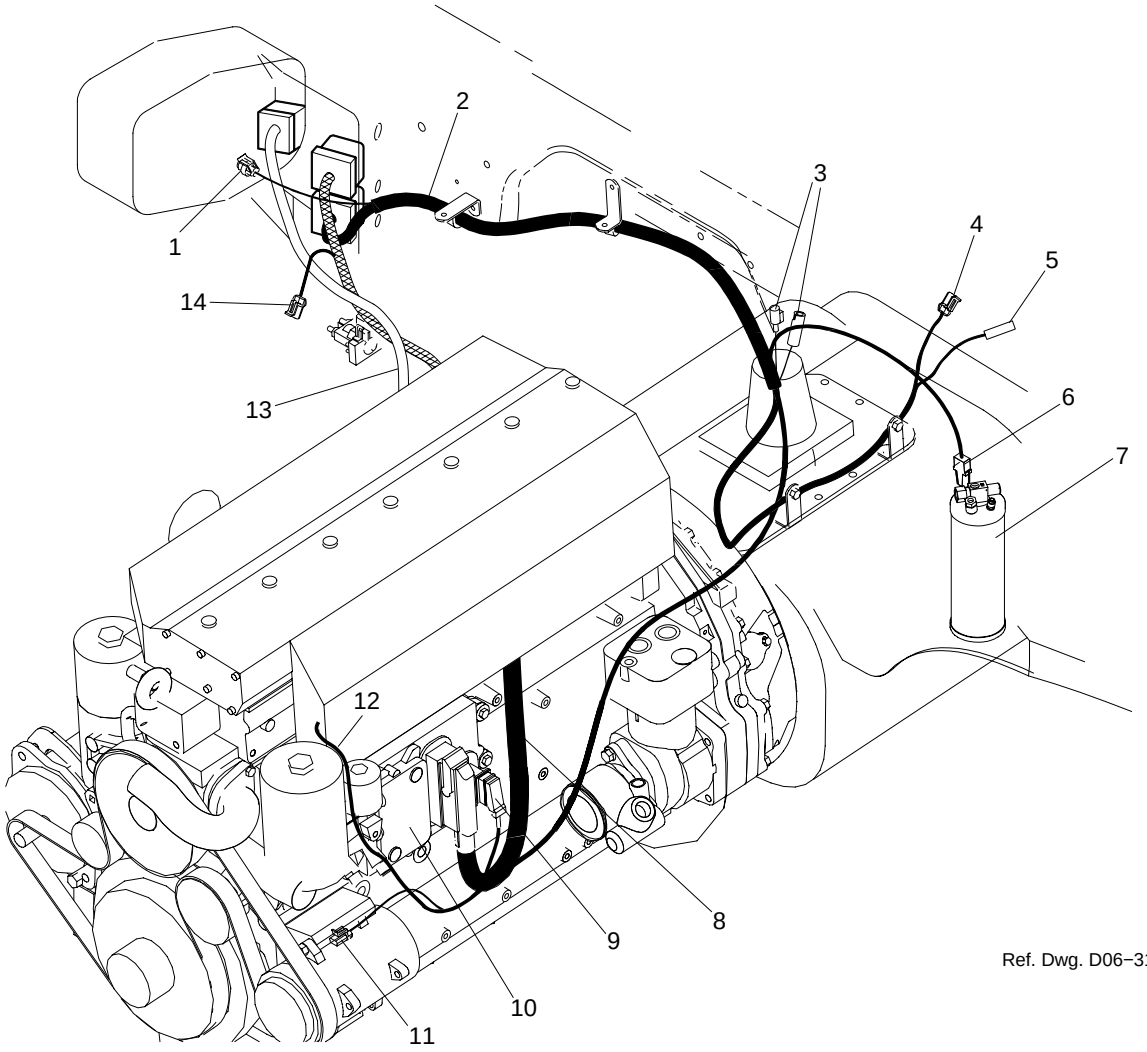


Fig. 4, VCU Mounting Clips

Harness Routing Diagrams

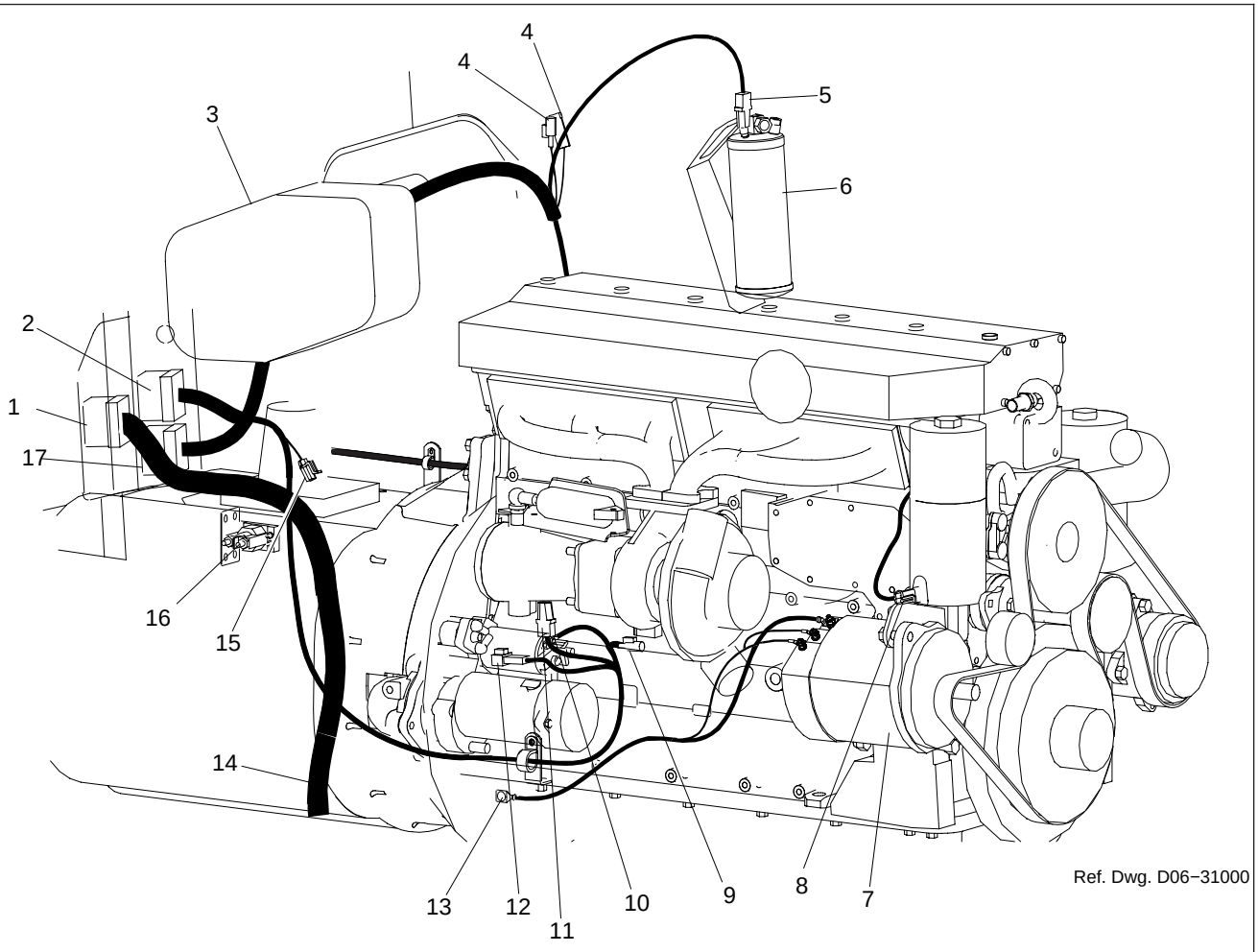
For a routing diagram showing the engine wiring harnesses, see **Fig. 1** for the left-hand side and **Fig. 2** for the right-hand side.



1. Coolant Level Sensor
2. Main Engine Harness
3. Binary Switch Housing and Connector
4. Back-Up Light Switch
5. Vehicle Speed Sensor
6. A/C Status Switch
7. Receiver-Drier
8. Fuel Injection Wiring
9. Electronic Engine Connector (EC1)
10. PLD Control Unit
11. A/C Compressor Plug
12. Fan Wiring (optional)
13. Chassis Harness
14. Magnetic Switch Connector

Fig. 1, Freightliner MBE900 Engines, Routing Diagram (left-hand side)

Harness Routing Diagrams



10/07/99 f542892

1. Chassis Connector
2. 12V Connector
3. Surge Tank
4. Binary Switch Housing and Connector
5. A/C Status Switch
6. Receiver-Drier
7. Alternator
8. Oil Pressure/Temperature Sensor
9. Starter Solenoid Ground
10. To Starter Solenoid
11. Battery Ground (PLD control unit)
12. PLD Control Unit Power Supply
13. Ground Stud
14. Chassis Harness
15. Magnetic Switch Connector
16. Magnetic Switch
17. Electronic Engine Connector

Fig. 2, Freightliner MBE900 Engines, Routing Diagram (right-hand side)

Schematics

For a schematic of the wiring connected to the violet connector, VCU (vehicle control unit) connector VC4, see **Fig. 1**.

For a schematic of the wiring connected to the gray connector, VCU connector VC3, see **Fig. 2**. For a detailed (partial) schematic showing the wiring connected to VCU connector VC3, see **Fig. 3** or **Fig. 4**.

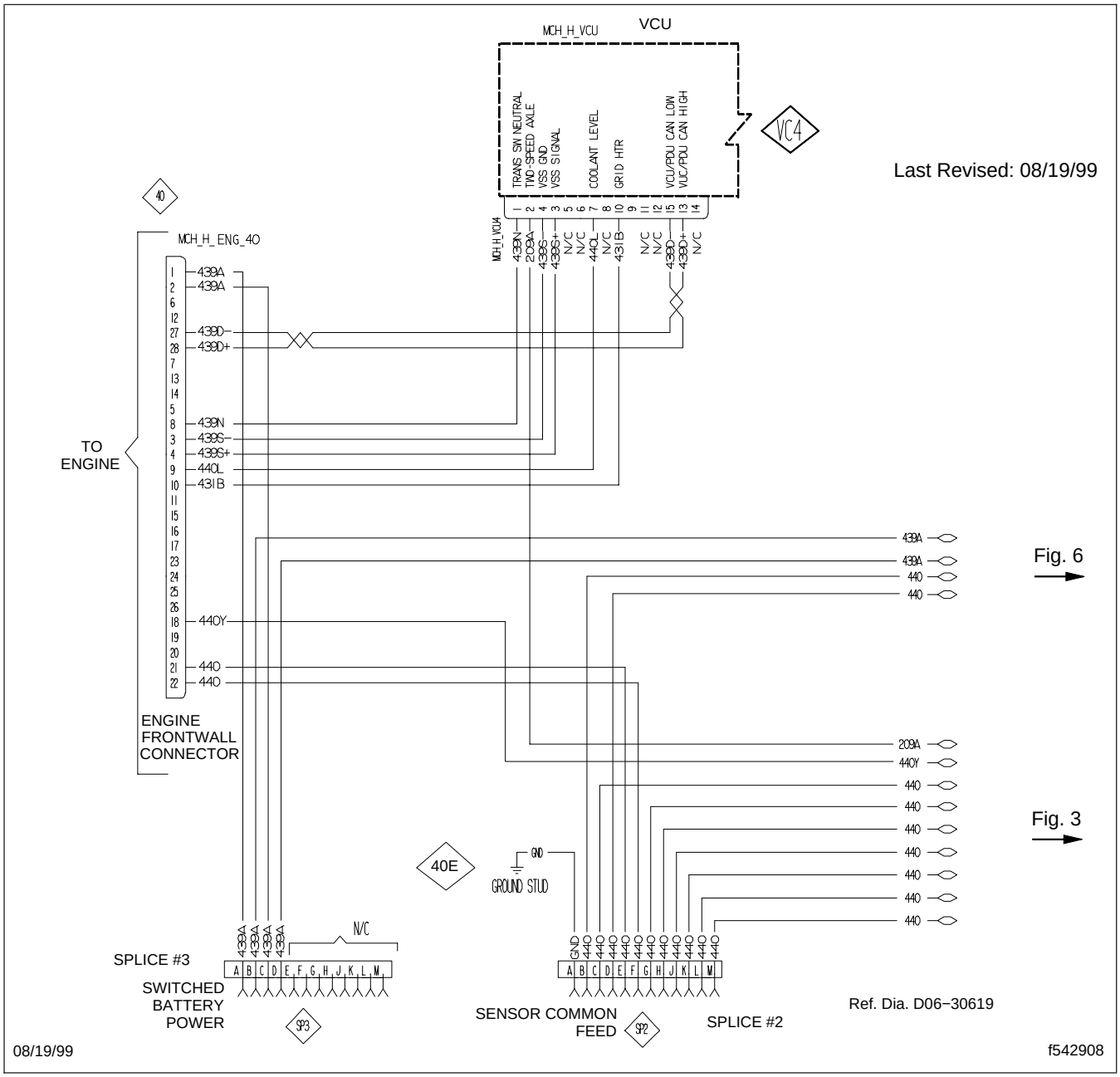


Fig. 1, Wiring Schematic, VCU Connector VC4 (violet)

Vehicle Control Unit Wiring Schematics

For a schematic of the wiring connected to the brown connector, VCU connector VC1, see **Fig. 5**. For a detailed (partial) schematic showing the wiring connected to VCU connector VC1, see **Fig. 6** or **Fig. 7**.

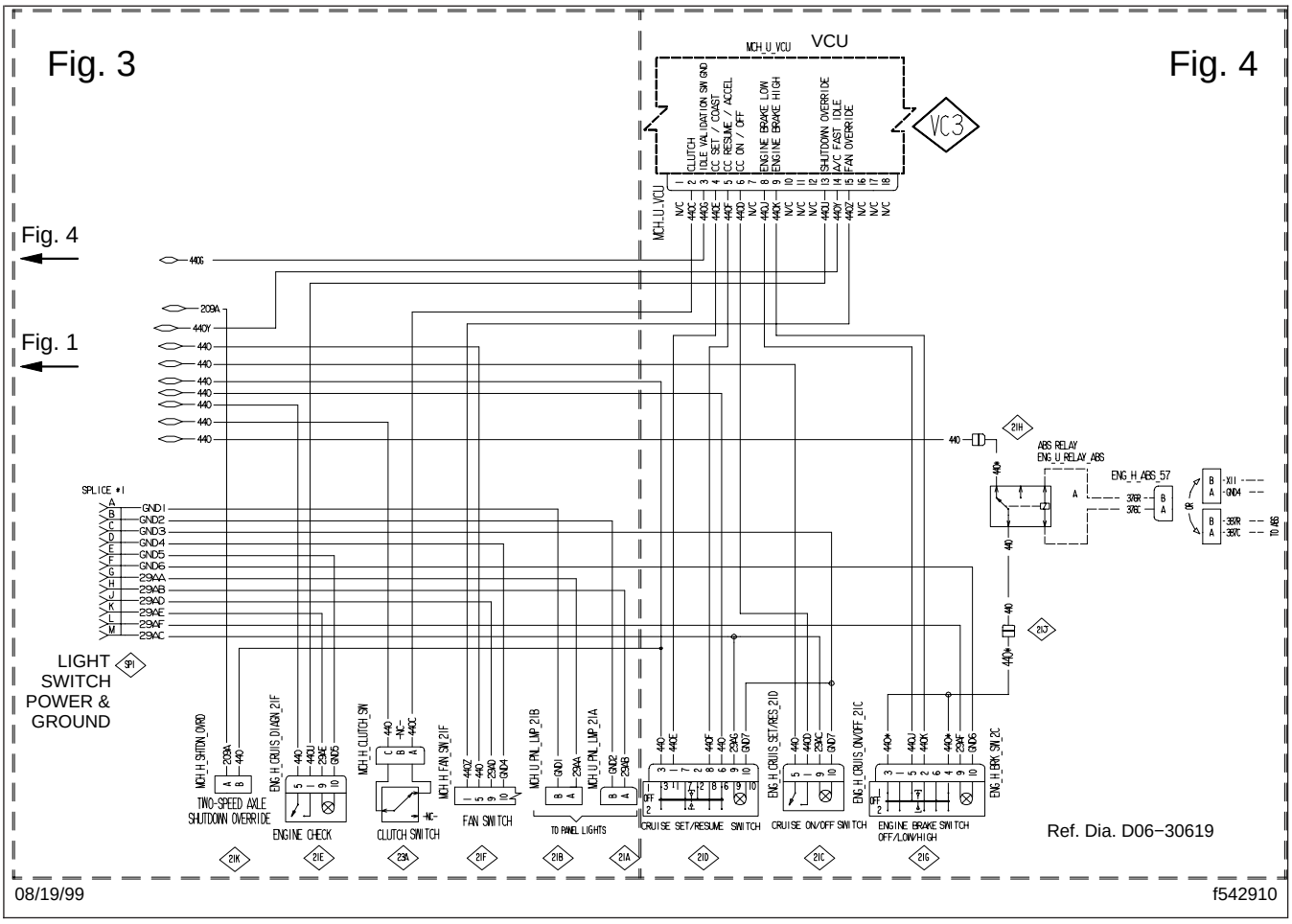


Fig. 2, Wiring Schematic, VCU Connector VC3 (gray)

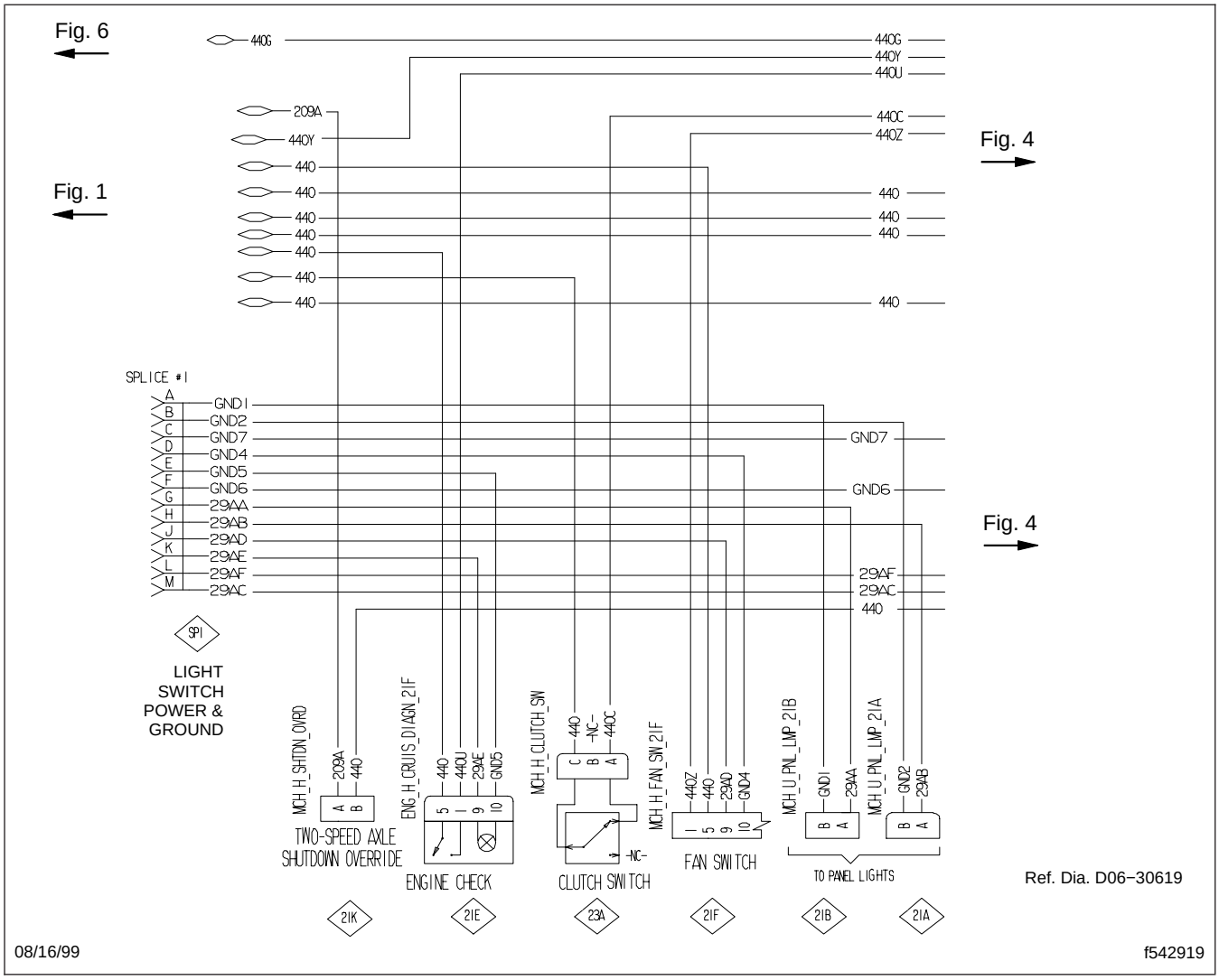


Fig. 3, Wiring Schematic, VCU Connector VC3 (detailed view, gray connector)

Vehicle Control Unit Wiring Schematics

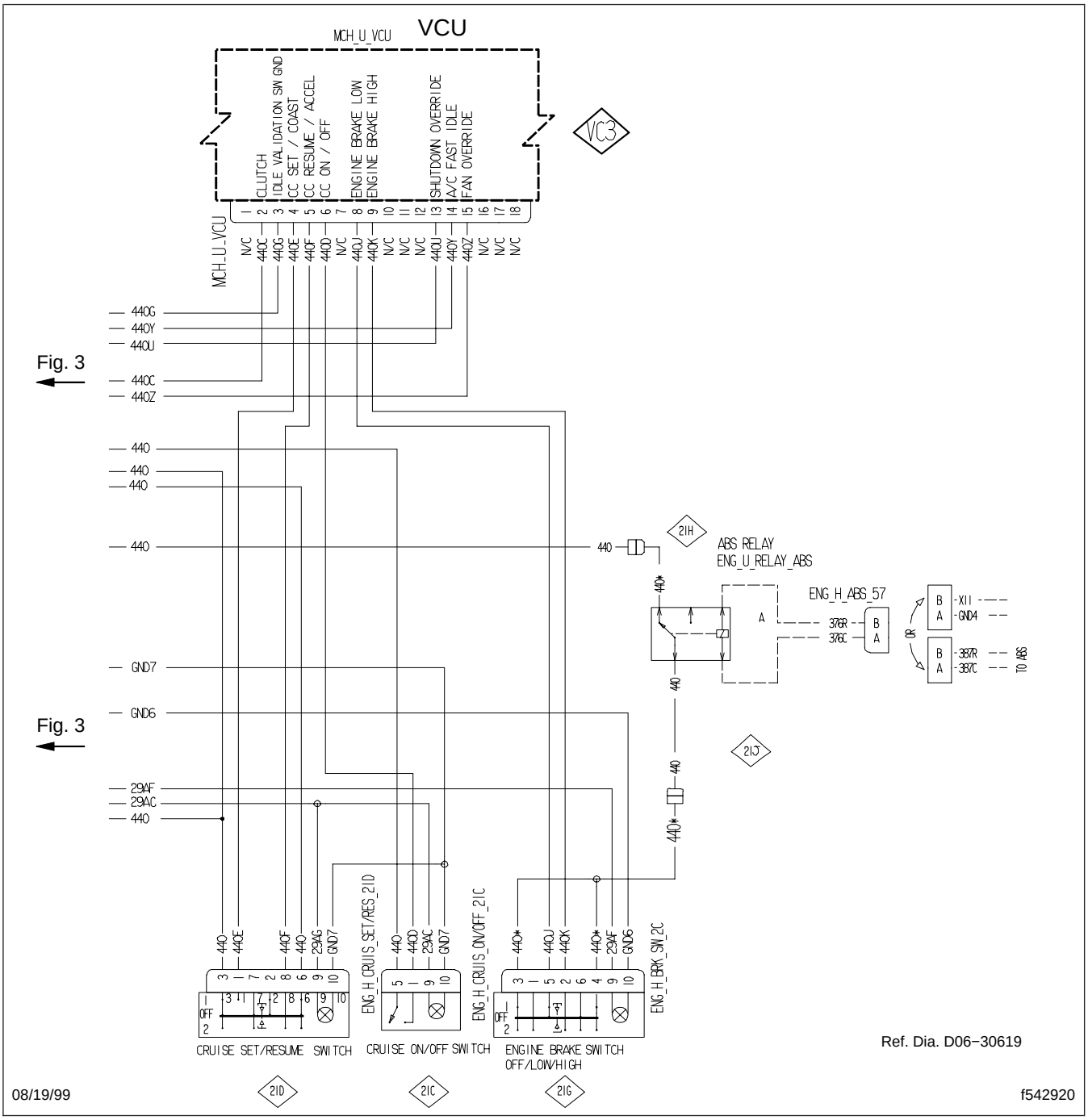


Fig. 4, Wiring Schematic, VCU Connector VC3 (detailed view, gray connector)

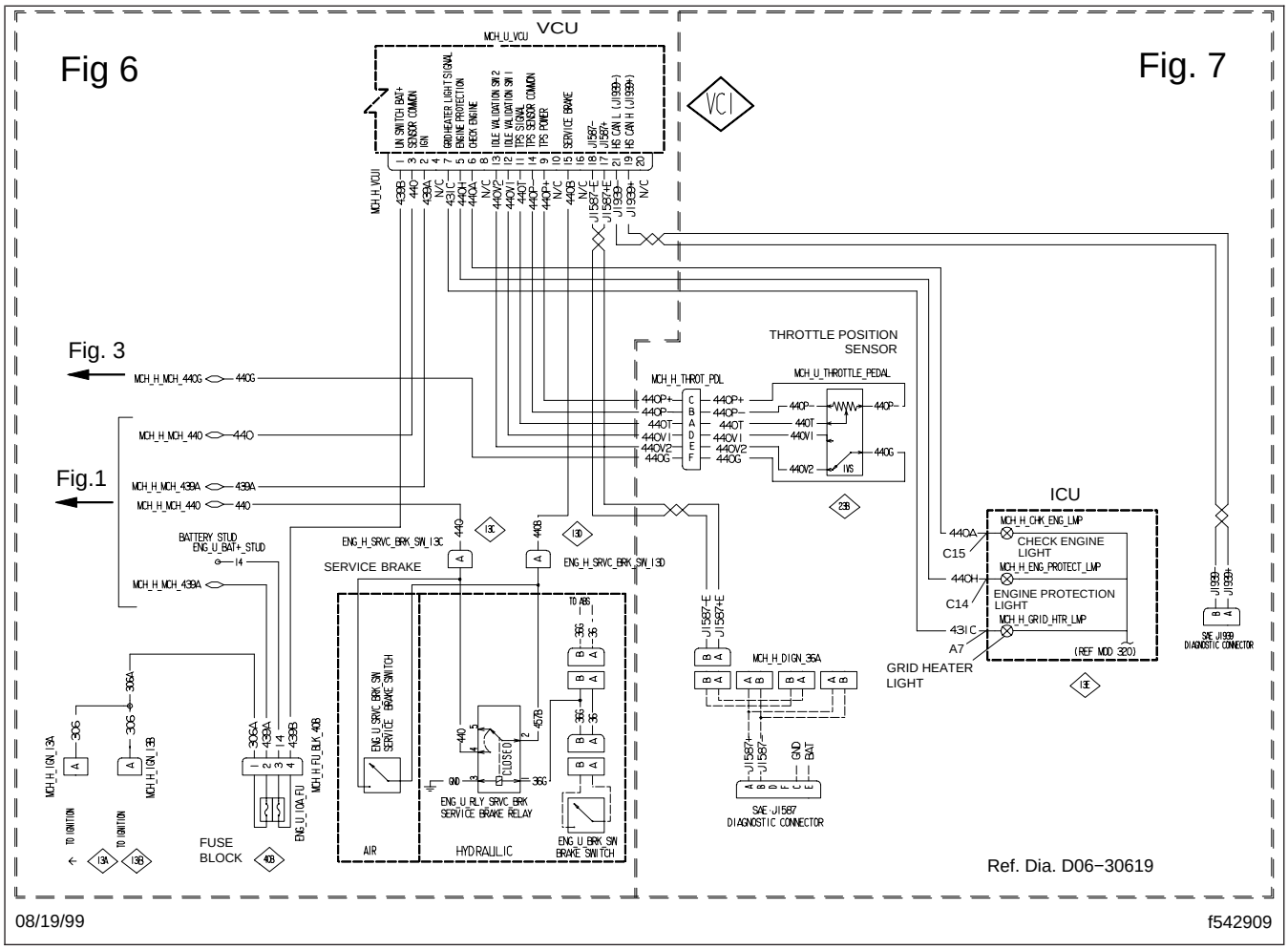


Fig. 5, Wiring Schematic, VCU Connector VC1 (brown)

Vehicle Control Unit Wiring Schematics

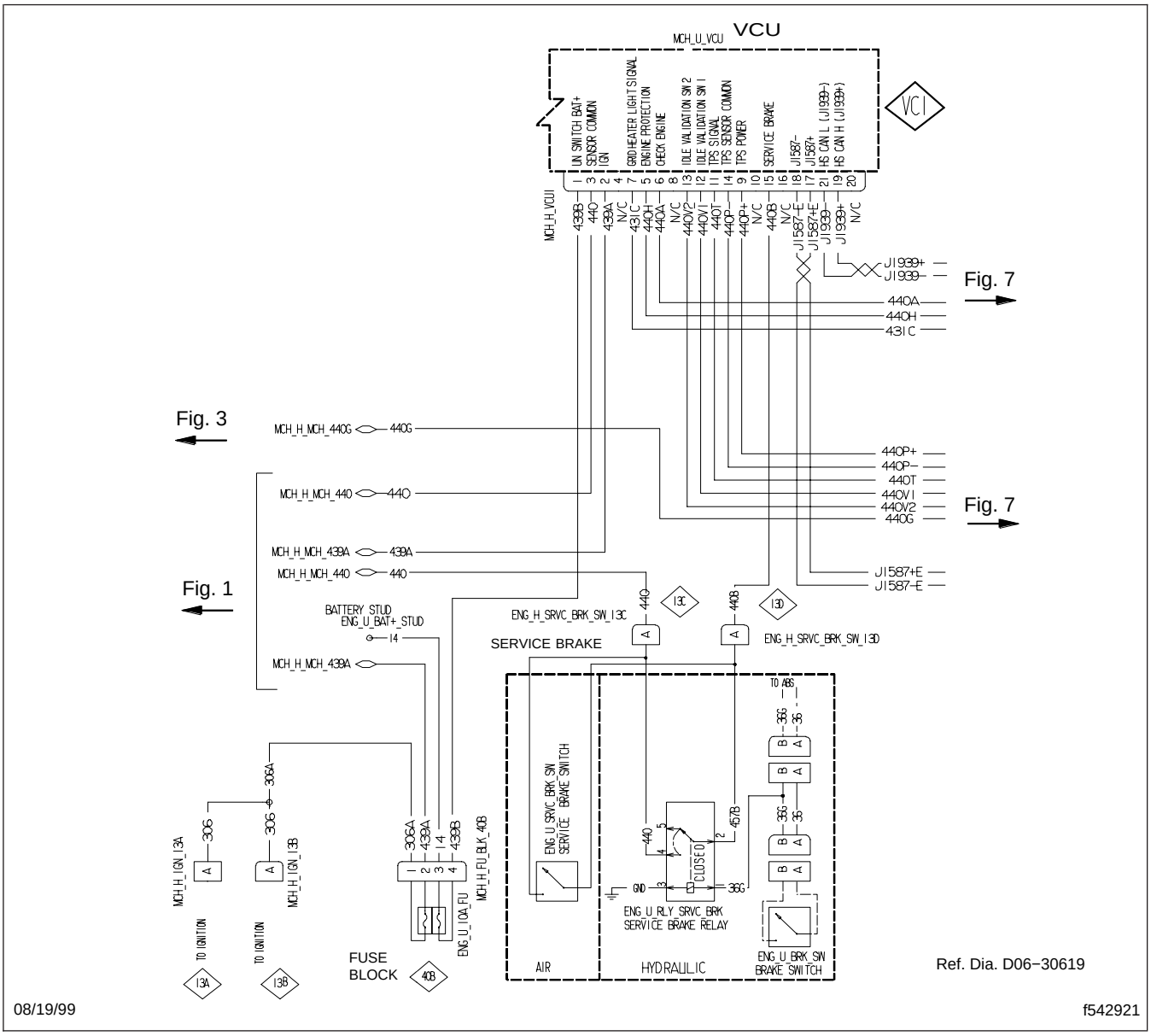


Fig. 6, Wiring Schematic, VCU Connector VC1 (detailed view, brown connector)

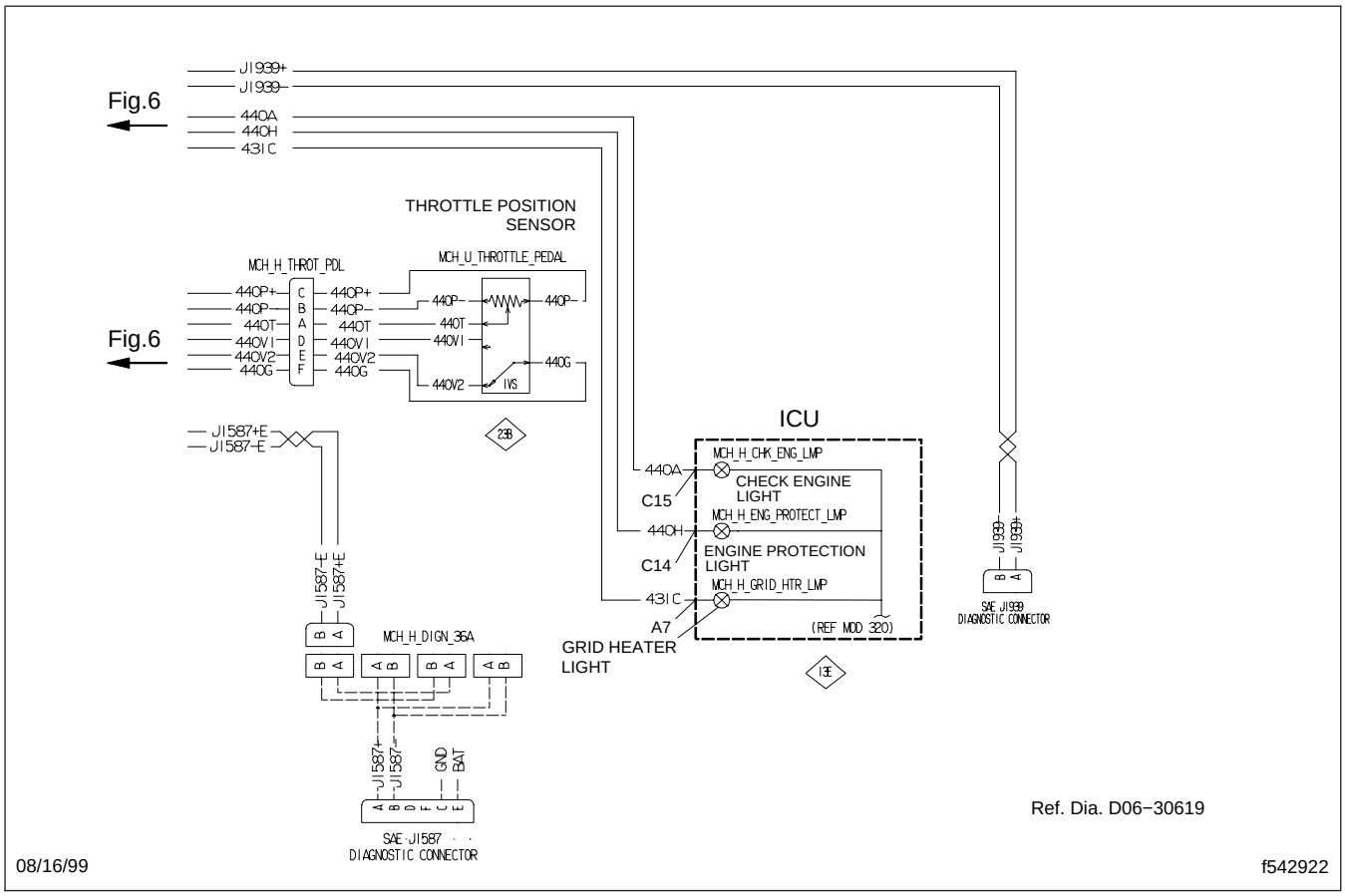


Fig. 7, Wiring Schematic, VCU Connector VC1 (detailed view, brown connector)

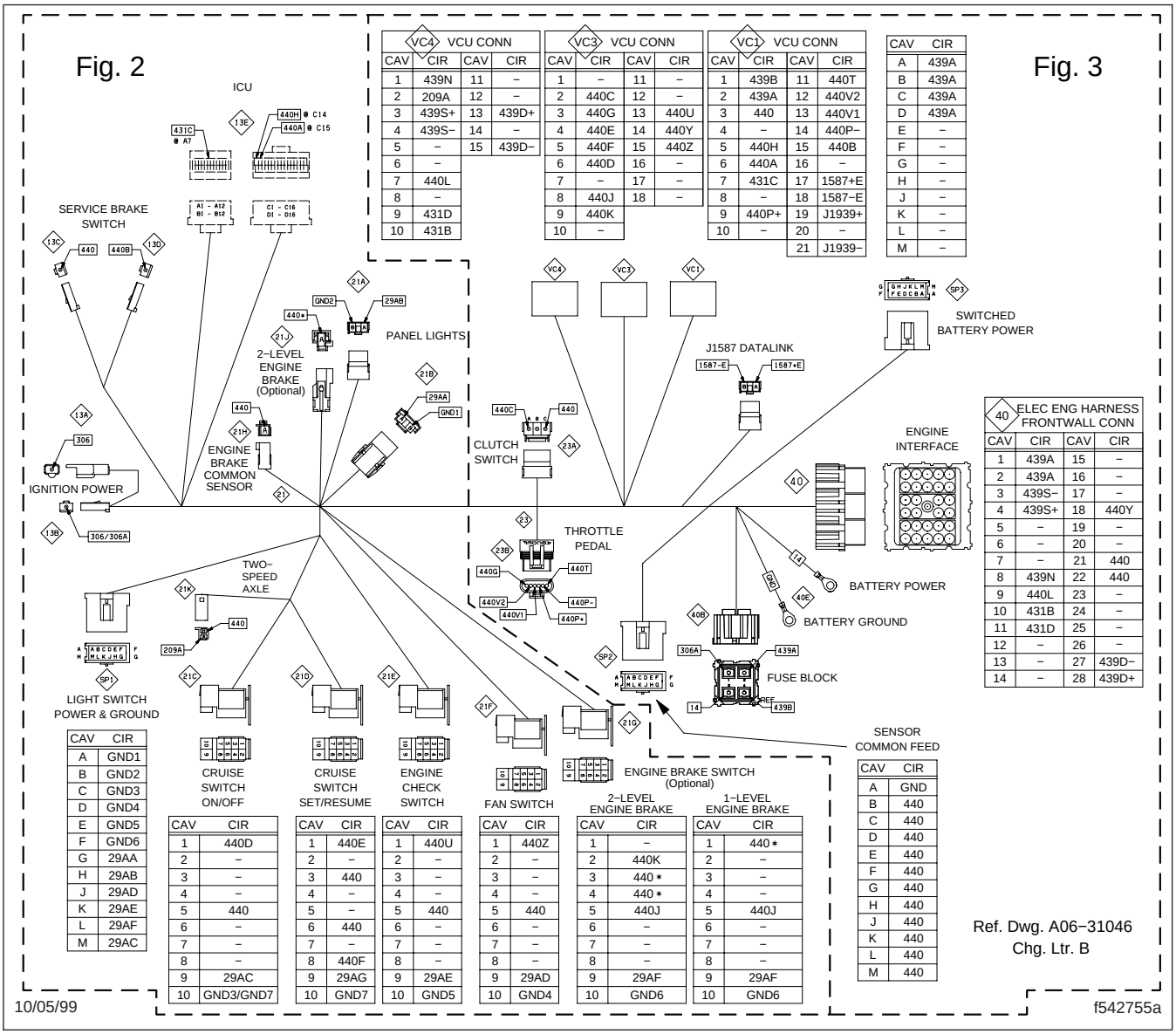
Harness Wiring

For a drawing of the cab side wiring harness for the Freightliner MBE900 electronic engines, see **Fig. 1**. For a detailed (partial) drawing showing the cab wiring harness behind the electronic engine frontwall connector, see **Fig. 2** or **Fig. 3**.

For a drawing of the engine side wiring harness for the Freightliner MBE900 electronic engines, see **Fig. 4**.

For a drawing of the grid heater harness, see **Fig. 5**.

Harness Wiring



VC4 VCU CONN			
CAV	CIR	CAV	CIR
1	439N	11	–
2	209A	12	–
3	439S+	13	439D+
4	439S−	14	–
5	–	15	439D−
6	–		
7	440L		
8	–		
9	431D		
10	431B		

VC3 VCU CONN			
CAV	CIR	CAV	CIR
1	–	11	–
2	440C	12	–
3	440G	13	440U
4	440E	14	440Y
5	440F	15	440Z
6	440D	16	–
7	–	17	–
8	440J	18	–
9	440K		
10	–		

VC1 VCU CONN			
CAV	CIR	CAV	CIR
1	439B	11	440T
2	439A	12	440V2
3	440	13	440V1
4	–	14	440P−
5	440H	15	440B
6	440A	16	–
7	431C	17	1587+E
8	–	18	1587−E
9	440P+	19	J1939+
10	–	20	–
		21	J1939−

CAV	CIR
A	439A
B	439A
C	439A
D	439A
E	–
F	–
G	–
H	–
J	–
K	–
L	–
M	–

40 ELEC ENG HARNESS FRONTWALL CONN			
CAV	CIR	CAV	CIR
1	439A	15	–
2	439A	16	–
3	439S−	17	–
4	439S+	18	440Y
5	–	19	–
6	–	20	–
7	–	21	440
8	439N	22	440
9	440L	23	–
10	431B	24	–
11	431D	25	–
12	–	26	–
13	–	27	439D−
14	–	28	439D+

CAV	CIR
A	GND1
B	GND2
C	GND3
D	GND4
E	GND5
F	GND6
G	29AA
H	29AB
J	29AD
K	29AE
L	29AF
M	29AC

CAV	CIR
1	440D
2	–
3	–
4	–
5	440
6	–
7	–
8	–
9	29AC
10	GND3/GND7

CAV	CIR
1	440E
2	–
3	440
4	–
5	–
6	440
7	–
8	440F
9	29AG
10	GND7

CAV	CIR
1	440U
2	–
3	–
4	–
5	440
6	–
7	–
8	–
9	29AE
10	GND5

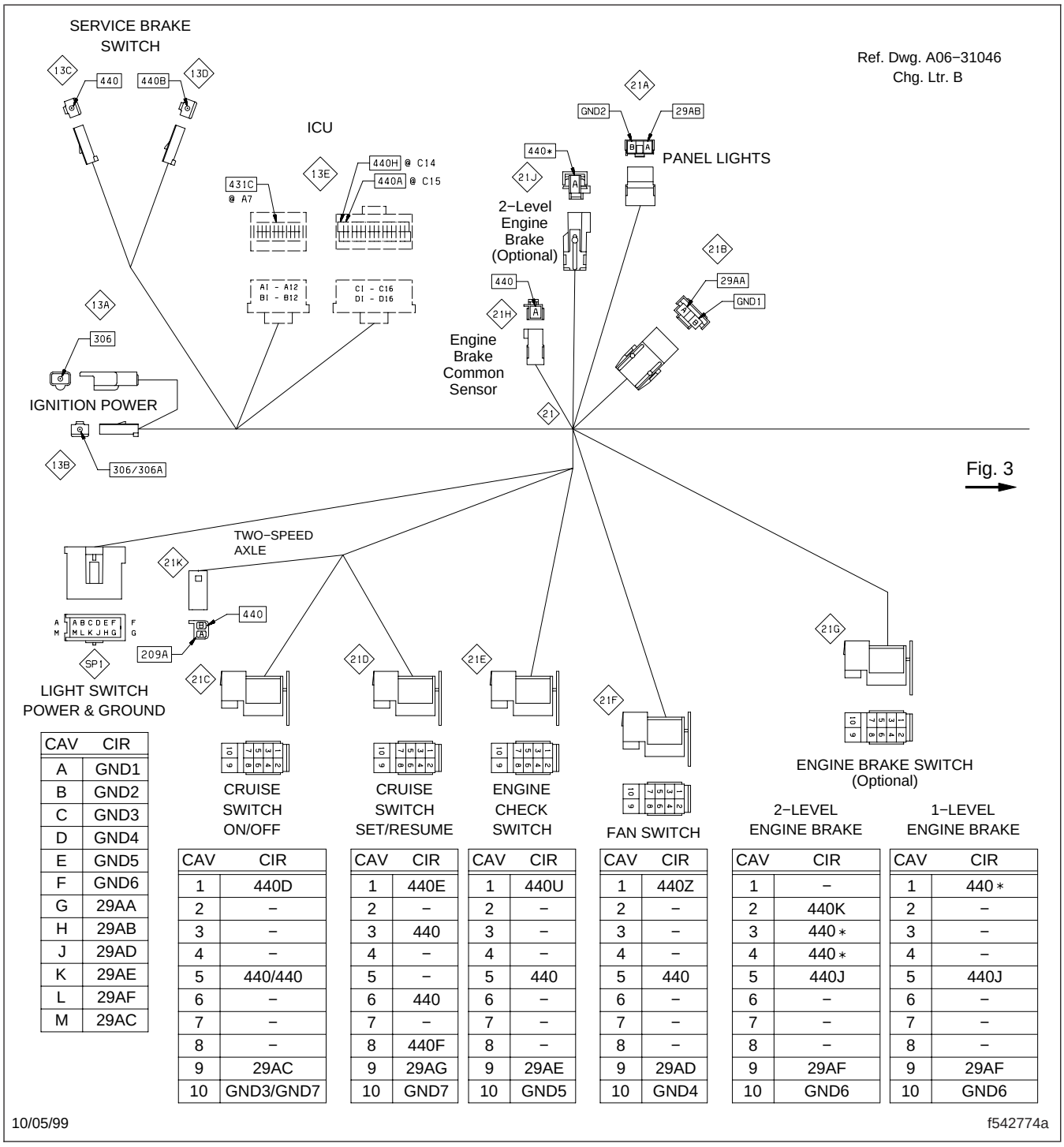
CAV	CIR
1	440Z
2	–
3	–
4	–
5	440
6	–
7	–
8	–
9	29AD
10	GND4

CAV	CIR
1	–
2	440K
3	440 *
4	440 *
5	440J
6	–
7	–
8	–
9	29AF
10	GND6

CAV	CIR
1	440 *
2	–
3	–
4	–
5	440J
6	–
7	–
8	–
9	29AF
10	GND6

CAV	CIR
A	GND
B	440
C	440
D	440
E	440
F	440
G	440
H	440
J	440
K	440
L	440
M	440

Fig. 1, Freightliner MBE900 Engines, Cab Side Wiring Harness



CAV	CIR
A	GND1
B	GND2
C	GND3
D	GND4
E	GND5
F	GND6
G	29AA
H	29AB
J	29AD
K	29AE
L	29AF
M	29AC

CAV	CIR
1	440D
2	–
3	–
4	–
5	440/440
6	–
7	–
8	–
9	29AC
10	GND3/GND7

CAV	CIR
1	440E
2	–
3	440
4	–
5	–
6	440
7	–
8	440F
9	29AG
10	GND7

CAV	CIR
1	440U
2	–
3	–
4	–
5	440
6	–
7	–
8	–
9	29AE
10	GND5

CAV	CIR
1	440Z
2	–
3	–
4	–
5	440
6	–
7	–
8	–
9	29AD
10	GND4

CAV	CIR
1	–
2	440K
3	440*
4	440*
5	440J
6	–
7	–
8	–
9	29AF
10	GND6

CAV	CIR
1	440*
2	–
3	–
4	–
5	440J
6	–
7	–
8	–
9	29AF
10	GND6

10/05/99 f542774a

Fig. 2, Freightliner MBE900 Engines, Cab Side Wiring Harness (detailed view)

Harness Wiring

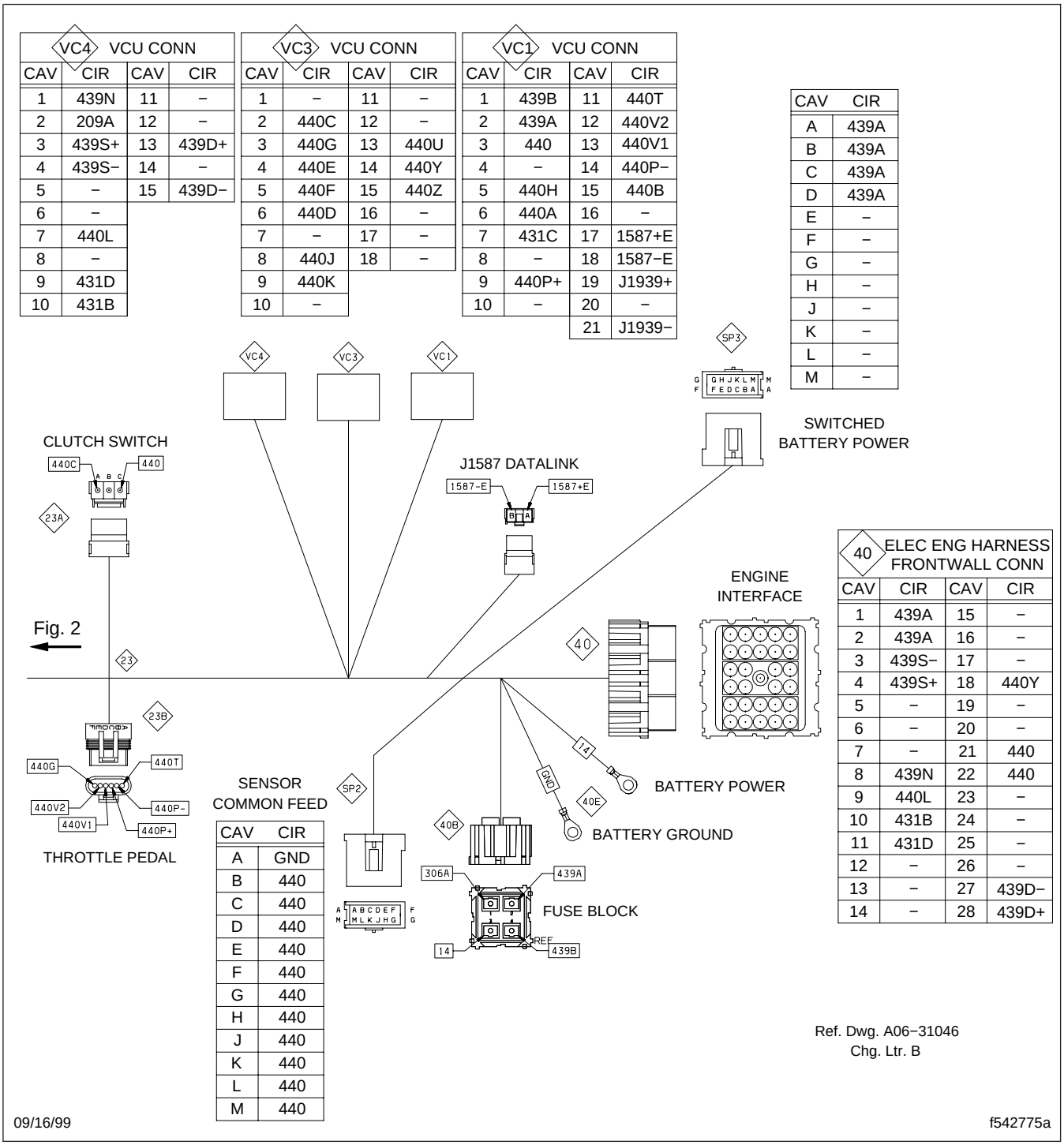
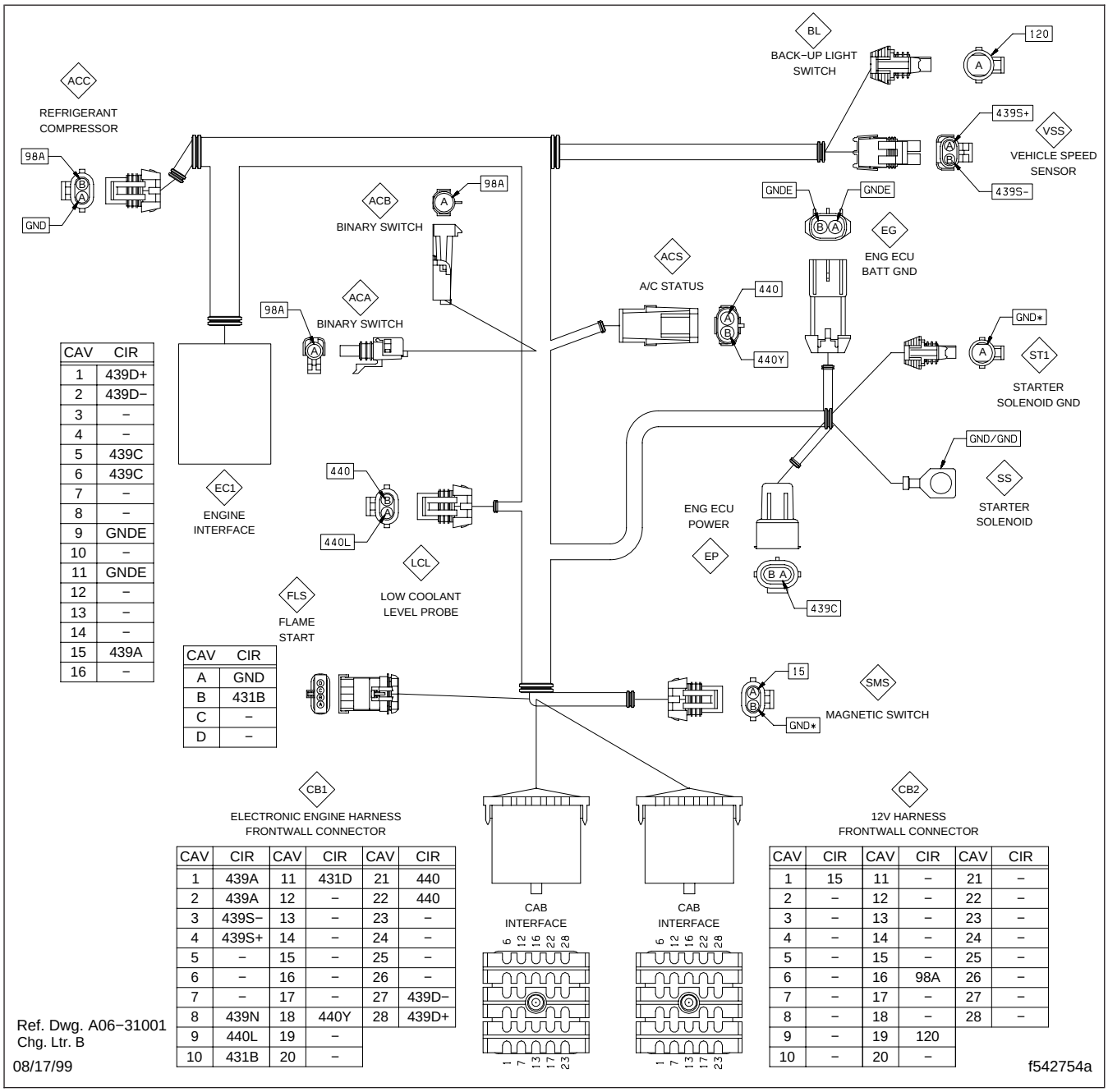


Fig. 3, Freightliner MBE900 Engines, Cab Side Wiring Harness (detailed view)



CAV	CIR
1	439D+
2	439D−
3	−
4	−
5	439C
6	439C
7	−
8	−
9	GNDE
10	−
11	GNDE
12	−
13	−
14	−
15	439A
16	−

CAV	CIR
A	GND
B	431B
C	−
D	−

CAV	CIR	CAV	CIR	CAV	CIR
1	439A	11	431D	21	440
2	439A	12	−	22	440
3	439S−	13	−	23	−
4	439S+	14	−	24	−
5	−	15	−	25	−
6	−	16	−	26	−
7	−	17	−	27	439D−
8	439N	18	440Y	28	439D+
9	440L	19	−		
10	431B	20	−		

CAV	CIR	CAV	CIR	CAV	CIR
1	15	11	−	21	−
2	−	12	−	22	−
3	−	13	−	23	−
4	−	14	−	24	−
5	−	15	−	25	−
6	−	16	98A	26	−
7	−	17	−	27	−
8	−	18	−	28	−
9	−	19	120		
10	−	20	−		

Fig. 4, Freightliner MBE900 Engines, Engine Side Wiring Harness

Harness Wiring

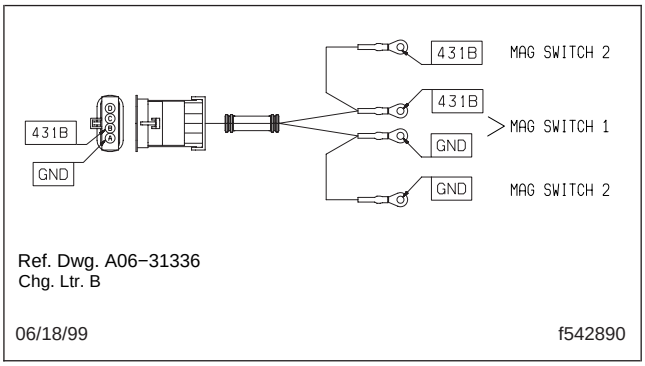


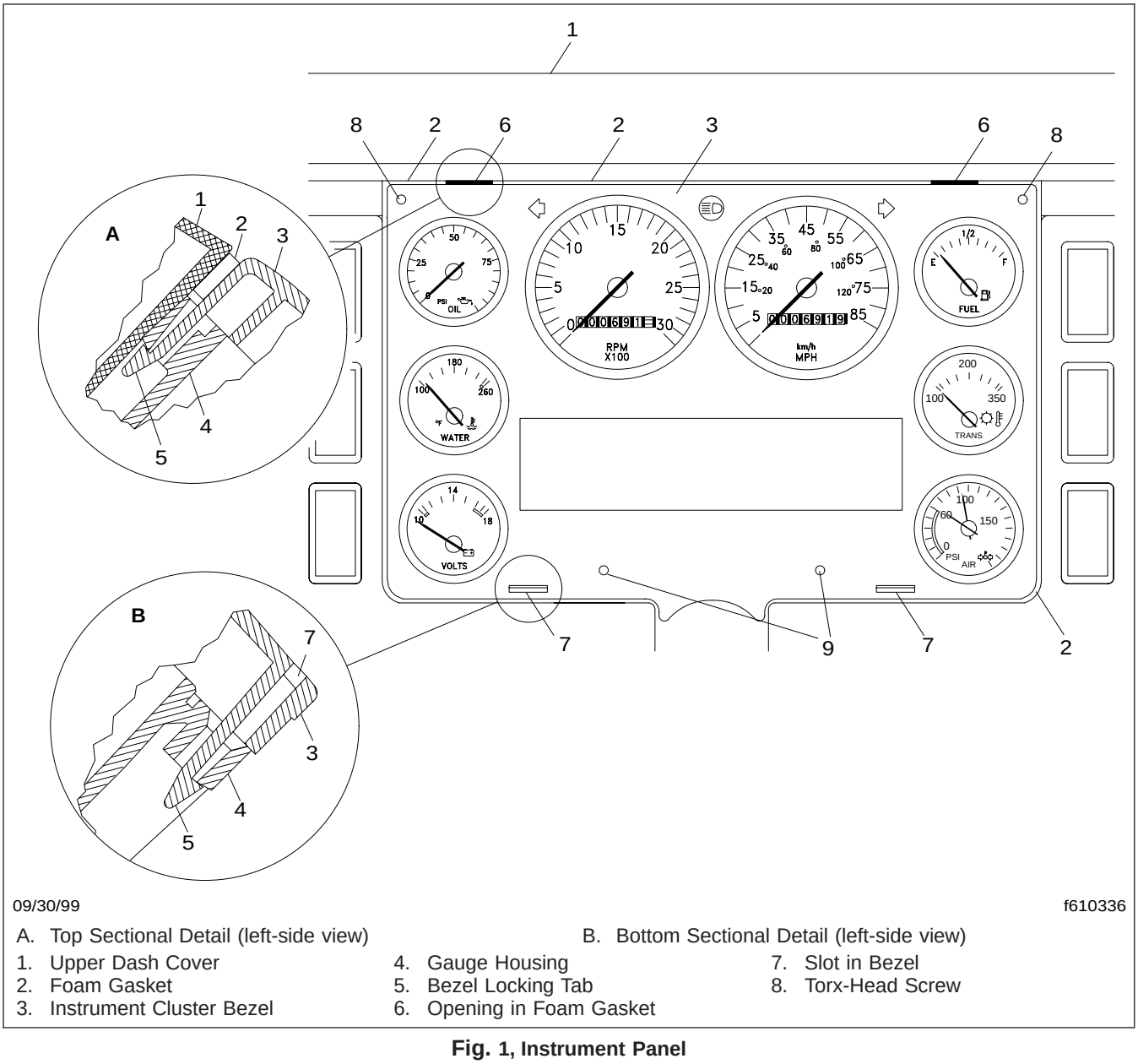
Fig. 5, Freightliner MBE900 Engines, Grid Heater Harness

General Description

The voltmeter is located in the lower left instrument panel. The voltmeter indicates battery voltage level, and should read 12.8 volts to 14.6 volts (or higher) when the engine is running. When the engine is being started, battery voltage will be lower than normal. Once the engine has been started, battery voltage will be temporarily higher than normal as the batteries are being recharged. If the voltmeter indicates a low or high voltage for an extended period of time, check the charging system and batteries.

Removal

1. Park the vehicle on a level surface and apply the parking brake. Shut down the engine. Chock the rear tires.
2. Disconnect the batteries.
3. Remove the instrument cluster bezel. See **Fig. 1**.
   - 3.1 Remove the four Torx®-head screws from the bezel.
   - 3.2 Remove the instrument panel from the dash.
   - 3.3 Remove the bezel and set it aside.



A. Top Sectional Detail (left-side view)
B. Bottom Sectional Detail (left-side view)

1. Upper Dash Cover
2. Foam Gasket
3. Instrument Cluster Bezel
4. Gauge Housing
5. Bezel Locking Tab
6. Opening in Foam Gasket
7. Slot in Bezel
8. Torx-Head Screw

Fig. 1, Instrument Panel

Voltmeter Removal and Installation

4. Remove the voltmeter from the gauge mounting panel by firmly grasping the gauge and pulling it straight out of the mounting panel.

   The gauge illumination bulb will remain in the gauge mounting panel; do not remove the bulb unless it must be replaced.

Installation

1. Position the voltmeter over the gauge mounting panel, making sure that the panel terminals line up with the gauge sockets.
2. Push the gauge into place until it seats against the mounting panel.
3. Position the instrument cluster bezel against the instrument panel.
4. Install the Torx-head screws in the instrument cluster bezel and tighten until firm.
5. Connect the batteries.
6. Start the engine and verify that the voltmeter is operating properly.
7. Remove the chocks from the tires.

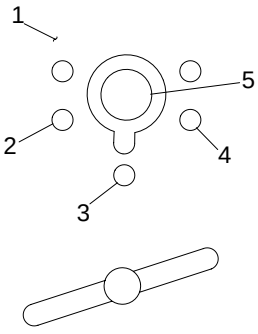
Troubleshooting Procedures

Voltmeter gauge malfunctions are usually one of two types: the gauge does not operate at all, or the gauge is believed to be incorrect.

Before proceeding with any troubleshooting when an inaccurate gauge is suspected, confirm the actual battery voltage and charging voltage with a known good voltmeter.

Malfunctions that would cause a totally inoperative voltmeter include open circuits in the gauge or wiring.

1. Remove the instrument cluster bezel and the voltmeter gauge. For instructions, see **Subject 100**.
2. Identify the voltmeter terminals that are part of the gauge mounting panel. See **Fig. 1**.



02/22/99 f601090

1. Gauge Mounting Panel
2. Ground Terminal
3. Ignition Power Terminal (12 volts)
4. Not Used
5. Illumination Bulb

Fig. 1, Voltmeter Connection

3. Check the voltmeter gauge ground circuit wiring for an open circuit.
   - 3.1 With the ignition switch turned off, connect the leads of an ohmmeter between the cab metal (an unpainted bolt or screw attached directly to cab structure works well) and the ground circuit terminal in the gauge mounting panel. See **Fig. 1**, Ref. 2.
   - 3.2 Resistance should be very low—less than 5 ohms. If it is, go to the next step. If resistance is higher than 5 ohms, verify that you have good connections at both the terminal and the cab metal.
   - 3.3 If the connections are good, but resistance is still greater than 5 ohms, locate the damaged section of wiring between the terminal and ground. Repair the damage by splicing in a length of replacement wiring following the instructions in this manual.
4. Check for battery voltage at the voltmeter gauge power terminal in the gauge mounting panel with the ignition switch in the on position.
   - 4.1 Turn the ignition switch on.
   - 4.2 Connect a voltmeter (set on 20 volt scale, DC voltage) to mounting panel terminals as follows; positive (red) probe to the ignition power terminal (see **Fig. 1**, Ref. 3) and the negative (black) probe to the ground terminal (Ref. 2). The voltmeter should read between 9 and 16 volts DC.
   - 4.3 If voltage is between 9 and 16 volts DC, the gauge itself is malfunctioning, and must be replaced. For instructions, see **Subject 100**. If the voltage reading is not between 9 and 16 volts DC, check the circuit breaker that supplies power to the gauge. If the circuit breaker is okay, locate and repair the damage to the power circuit. General wire repair information can be found elsewhere in this group.
5. Install the voltmeter gauge and instrument cluster bezel. Make sure that the gauge is now operating properly.

General Information

The Short Conventional cab is supported at four points on the vehicle chassis. **See Fig. 1.**

Isolators, located at each of the four support points, cushion the cab from shock by absorbing energy as they are compressed. Each front support point has an upper and lower, solid, synthetic rubber isolator.

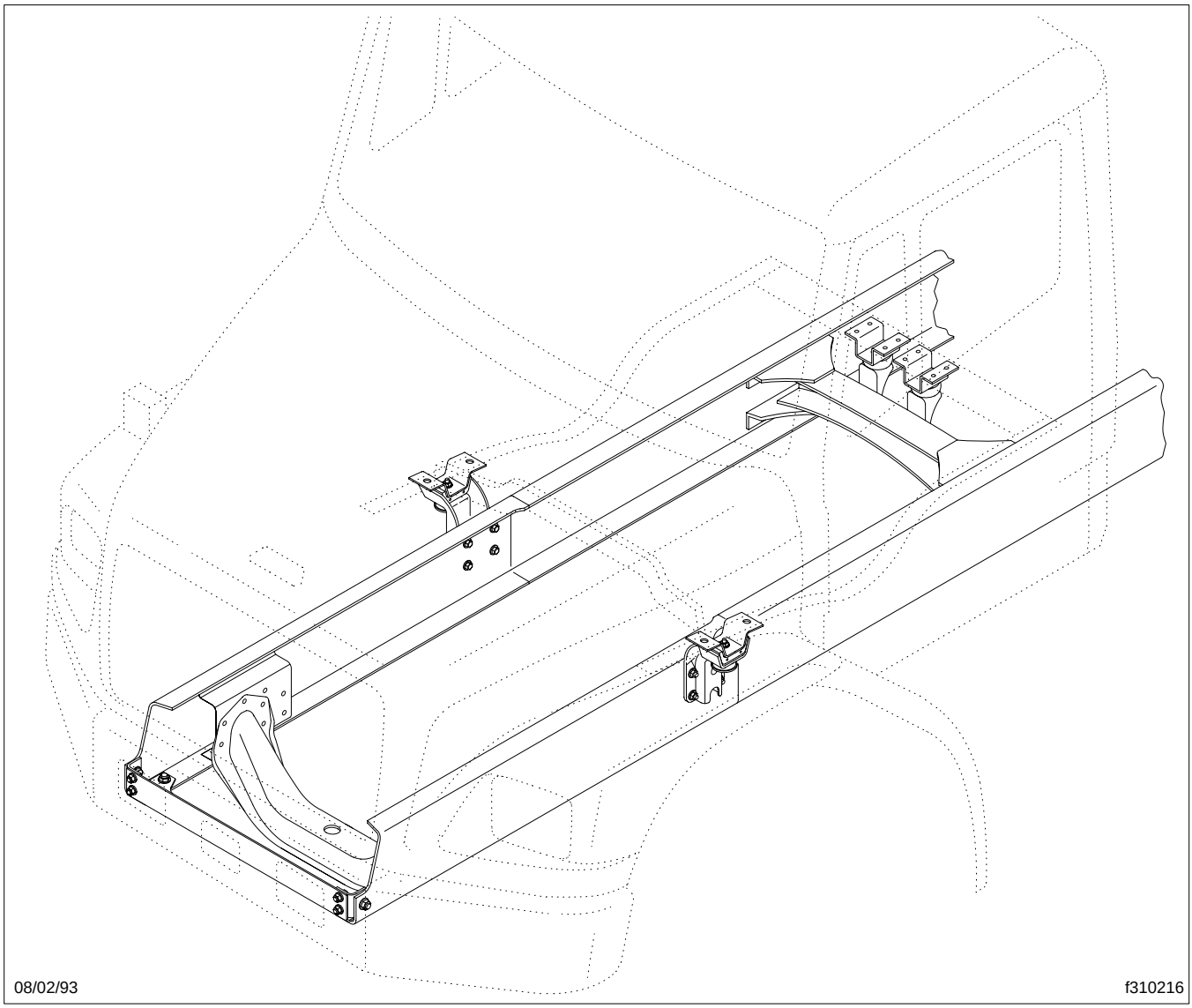


Fig. 1

The front of the cab has a cab mounting bracket at each side, directly above a cab support bracket attached to the outboard side of each frame rail. The rear of the cab is mounted on a pair of cab support brackets attached near the center of a frame crossmember.

Each rear support point has either an upper and lower solid rubber isolator or a single hydraulic isolator. Solid rubber upper isolators are fastened between the cab mounting brackets and cab support brackets, to compress when the cab and chassis are forced toward each other. Solid rubber lower isolators

General Information

are attached to the bottom of the cab support brackets, to compress when the cab and chassis are forced away from each other.

The hydraulic isolators are fastened between the cab mounting brackets and cab support brackets; they absorb energy both as they are compressed and stretched.

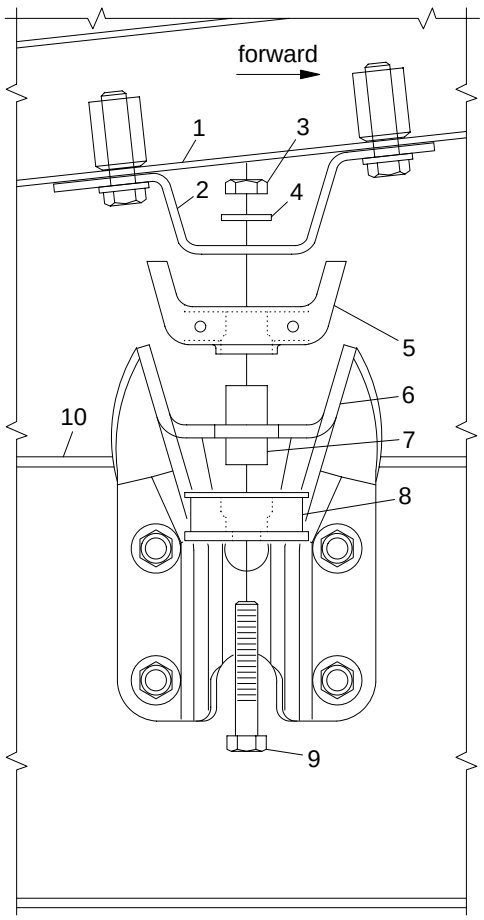
Replacement

NOTE: Don't replace only one isolator or a pair of isolators; as a set, replace the upper and lower isolators on both sides of the front of the vehicle.

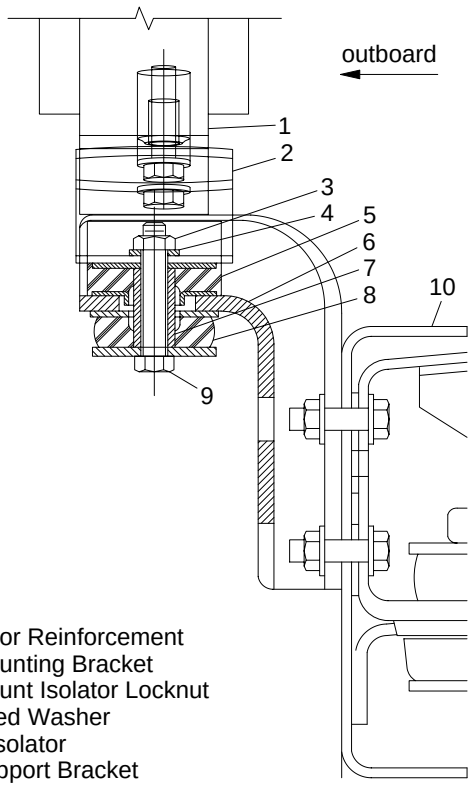
1. Tilt the hood; refer to the vehicle driver's manual.
2. Remove the half fenders; **refer to the hood group** for instructions.
3. Remove the old isolators. **Refer to Fig. 1 .**
   - 3.1 From each side of the cab, remove the locknut, hardened washer, bolt, lower isolator, and spacer.
   - 3.2 Use a jack to raise the front of the cab about 13 mm (1/2 in).
   - 3.3 Remove the upper isolator from each cab support bracket.
4. Install the new isolators. **Refer to Fig. 1 .**
   - 4.1 Inspect the original locknuts, hardened washers, bolts, and spacers. If any wear, distortion, or other damage is found, replace the part.
   - 4.2 Install the new upper isolator in each cab support bracket.
   - 4.3 Lower the cab until the cab mount brackets just contact the top of the upper isolators.
   - 4.4 Install a spacer and bolt in one of the new lower isolators, then install these parts at the bottom of one of the cab support brackets. Install a hardened washer and locknut.

     Repeat this for the other side of the cab.
   - 4.5 Lower the cab, and remove the jack.
   - 4.6 Tighten the locknuts 92 N·m (68 lbf·ft).
5. Install the half fenders; **refer to the hood group** for instructions.

Front Mount Isolator Replacement



RIGHT−SIDE VIEW



1. Cab Floor Reinforcement
2. Cab Mounting Bracket
3. Cab Mount Isolator Locknut
4. Hardened Washer
5. Upper Isolator
6. Cab Support Bracket
7. Isolator Spacer
8. Lower Isolator
9. Cab Mount Isolator Bolt
10. Right−Hand Frame Rail

08/02/93 f310214

Fig. 1

Rear Mount Solid Rubber Isolator Replacement

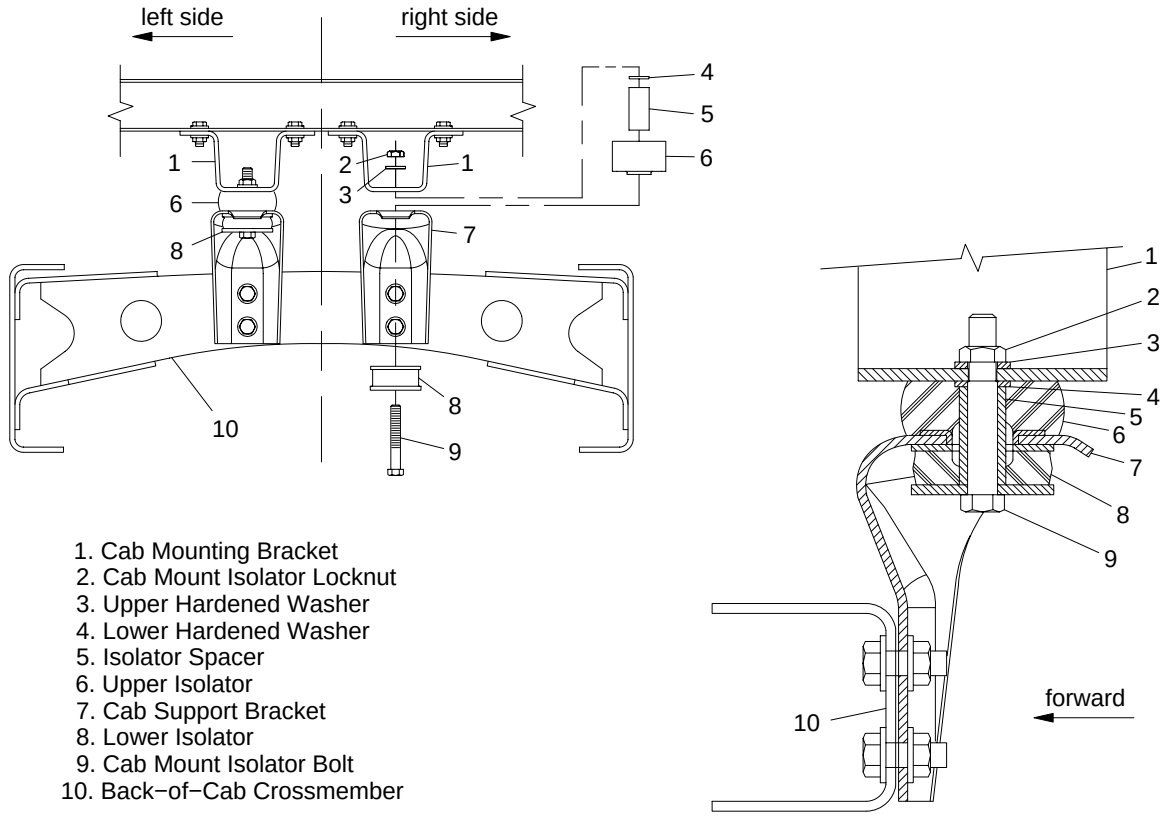
Replacement

NOTE: Don't replace only one isolator or a pair of isolators; as a set, replace the upper and lower isolators on both sides of the rear of the vehicle.

1. Tilt the hood; refer to the vehicle driver's manual.
2. Remove the old isolators. **Refer to Fig. 1 .**
   - 2.1 From each side of the cab, remove the locknut, upper hardened washer, bolt, lower isolator, and spacer.
   - 2.2 Use a jack to raise the rear of the cab about 25 mm (1 in).
   - 2.3 Remove the upper isolator and lower hardened washer from each cab support bracket.
3. Install the new isolators. **Refer to Fig. 1 .**
   - 3.1 Inspect the original locknuts, hardened washers, bolts, and spacers. If any wear, distortion, or other damage is found, replace the part.
   - 3.2 Install the new upper isolator and the lower hardened washer on each cab support bracket.
   - 3.3 Lower the cab until the cab mount brackets just contact the top of the upper isolators.
   - 3.4 Install a spacer and bolt in one of the new lower isolators, then install these parts at the bottom of one of the cab support brackets. Install a hardened washer and locknut.

     Repeat this for the other cab support bracket.
   - 3.5 Lower the cab, and remove the jack.
   - 3.6 Tighten the locknuts 92 N·m (68 lbf·ft).

Rear Mount Solid Rubber Isolator Replacement



1. Cab Mounting Bracket
2. Cab Mount Isolator Locknut
3. Upper Hardened Washer
4. Lower Hardened Washer
5. Isolator Spacer
6. Upper Isolator
7. Cab Support Bracket
8. Lower Isolator
9. Cab Mount Isolator Bolt
10. Back−of−Cab Crossmember

08/02/93 f310213

Fig. 1

Rear Mount Hydraulic Isolator Replacement

Replacement

NOTE: Don't replace only one isolator; replace both isolators at the rear of the vehicle as a set.

1. Tilt the hood; refer to the vehicle driver's manual.
2. Remove the old isolators. **Refer to Fig. 1 .**
   - 2.1 From each side of the cab, remove the locknut and hardened washer from the upper and lower studs on the isolator.
   - 2.2 Using a jack, raise the rear of the cab about 25 mm (1 in).
   - 2.3 Remove the isolator from each cab support bracket.
3. Install the new isolators. **Refer to Fig. 1 .**
   - 3.1 Inspect the original locknuts and hardened washers. If any wear, distortion, or other damage is found, replace the part.
   - 3.2 Install each new isolator with the blue-colored stud pointing up.
   - 3.3 Lower the cab and remove the jack.
   - 3.4 Install the hardened washers and locknuts. Tighten the locknuts 92 N·m (68 lbf·ft).

Rear Mount Hydraulic Isolator Replacement

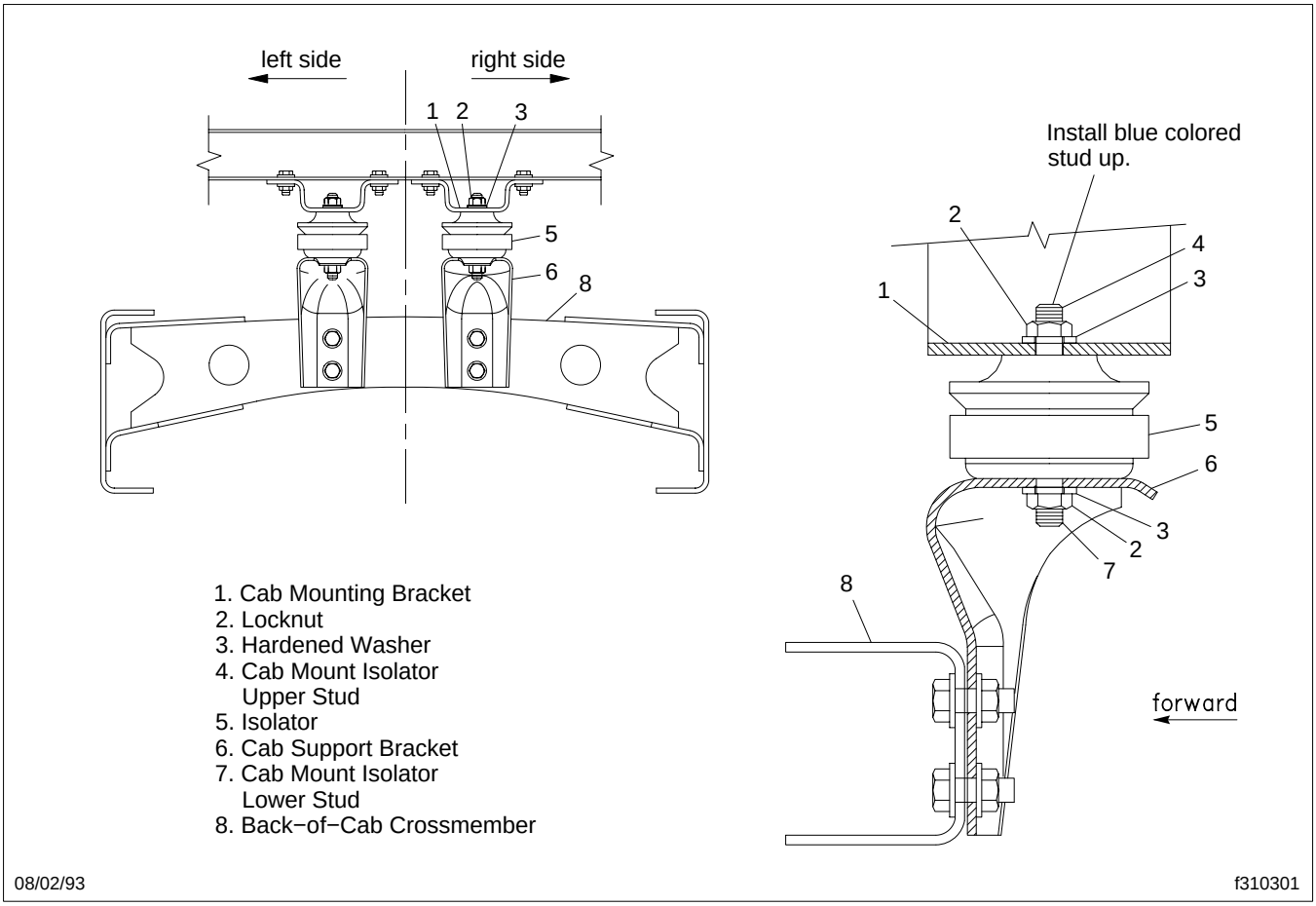


Fig. 1

Replacement

NOTE: Don't replace only one front cab mount; replace both front mounts as a set.

Front Cab Mounts

1. Park the vehicle on a level surface. Apply the parking brake; then chock the tires.
2. Tilt the hood; see the vehicle driver's manual.
3. Remove the half fenders; see **Group 88** for instructions.
4. Remove the cab mount assembly.
   - 4.1 Remove the isolator bolt. See **Fig. 1.**
   - 4.2 Place a bottle jack between the frame rail and cab deck; then raise the cab about 1-1/2 inches (40 mm).

   NOTE: The four frame-rail mounting bracket bolts go through the engine mounts.

   - 4.3 Place a jack under the transmission bell housing; then jack up the bell housing just enough to support the engine.
   - 4.4 Remove the four bolts from the cab support bracket along with the bracket.
   - 4.5 Remove two capscrews from the cab mounting bracket along with the bracket.
5. Install the cab mount assembly. See **Fig. 1.**
   - 5.1 Apply Loctite® 272 or equivalent to the cab mounting bracket capscrews. With the new cab mounting bracket separated from the cab mount assembly, position the cab mounting bracket; then install the two capscrews with washers. Tighten each capscrew 75 lbf·ft (100 N·m).
   - 5.2 Position the cab support bracket; then install the four capscrews, locknut, and hardened washers in the lower bracket assembly. Tighten each capscrew 190 lbf·ft (260 N·m).
   - 5.3 Position the upper isolator on the cab support bracket.
   - 5.4 Lower the cab until the cab mounting bracket just contacts the top of the upper isolator.
   - 5.5 Install a spacer and bolt and hardened washer in the lower isolator; then install these parts at the bottom of the cab support bracket. Install the hardened washer and locknut.
6. Install the half fenders; see **Group 88** for instructions.
7. Remove chocks from the tires.

FL106 and FL112 Front Cab Mounts

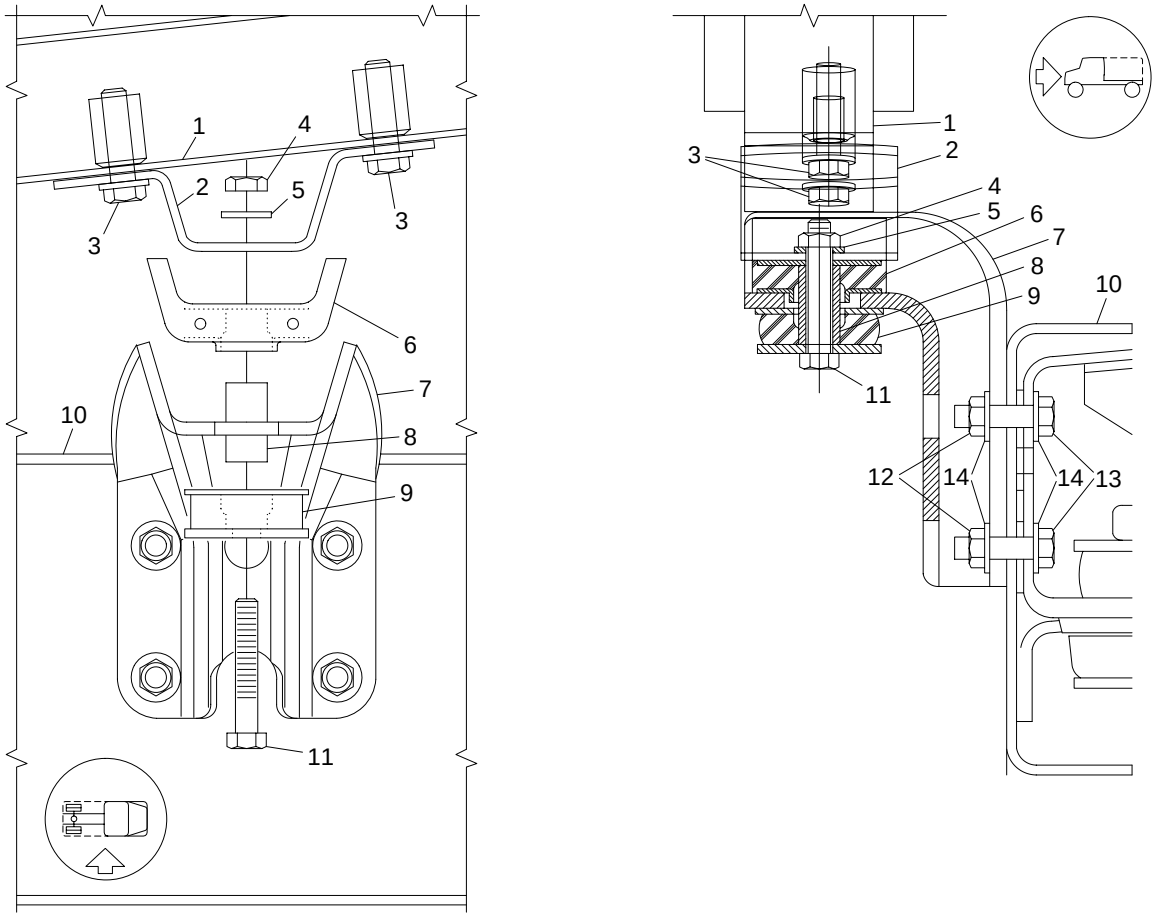
NOTE: FL106 and FL112 front cab mounts built after July 7, 1995 are slightly different. See **Fig. 2**.

1. Park the vehicle on a level surface. Apply the parking brake; then chock the tires.
2. Tilt the hood; see the vehicle driver's manual.
3. Remove the half fenders; see **Group 88** for instructions.
4. Remove the cab mount assembly.
   - 4.1 Remove the isolator bolt. See **Fig. 3**.
   - 4.2 Place a bottle jack between the frame rail and cab deck; then raise the cab about 1-1/2 inches (40 mm).
   - 4.3 Place a jack under the transmission bell housing; then jack up the bell housing just enough to support the engine.

   NOTE: Four of the five cab support bracket bolts go through the engine mount.

   - 4.4 Remove the five bolts from the cab support bracket along with the bracket itself.
   - 4.5 Remove three capscrews from the cab support bracket along with the bracket itself.
5. Install the new cab mount assembly. See **Fig. 3**.
   - 5.1 Apply Loctite® 272 or equivalent to the cab mounting bracket M14–1.5 capscrews. With the cab mounting bracket separated from the cab mount assembly, position the cab mounting bracket; then install three (driver's side) or two (passenger's side) capscrews with washers. Tighten each capscrew 75 lbf·ft (100 N·m).

Front Mount Replacement



11/21/96 f310567

1. Cab Floor Reinforcement
2. Cab Mounting Bracket
3. Capscrew and Hardened Washer
4. Isolator Locknut
5. Hardened Washer
6. Upper Isolator
7. Cab Support Bracket
8. Isolator Spacer
9. Lower Isolator
10. Frame Rail
11. Isolator Bolt
12. Locknut
13. Capscrew
14. Hardened Washer

Fig. 1, Early-Style Front Cab Mount Assembly

5.2 Position the cab support bracket; then install the five capscrews, locknuts and hardened washers. Tighten each capscrew 190 lbf·ft (260 N·m).

5.3 Position the upper isolator on the cab support bracket.

5.4 Lower the cab until the cab mount bracket just contacts the top of the upper isolator.

5.5 Install the isolator spacer, isolator bolt and hardened washer in the lower isolator; then install these parts at the bottom of the cab support bracket. Install the hardened washer and locknut.

6. Repeat procedure for the other side of the cab.
7. Lower the cab, and remove the jack under the cab and the jack under the bell housing.
8. Install the half fenders; see **Group 88** for instructions.

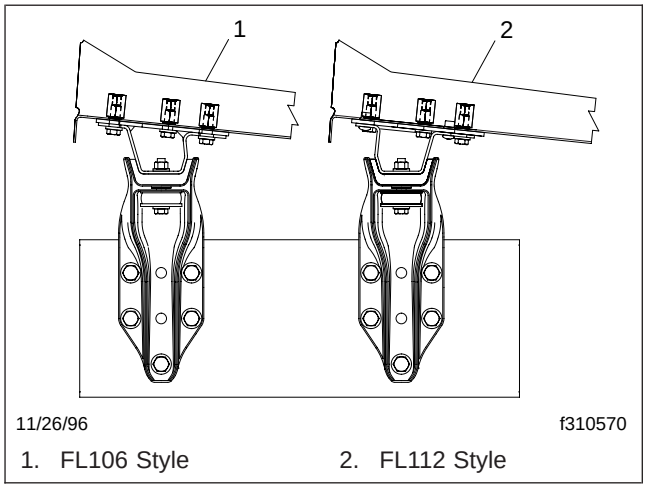


Fig. 2, Driver's-Side Cab Mount Assemblies, FL106 and FL112 Vehicles Built After July 7, 1995 (passenger's side similar)

9. Remove the chocks from the tires.

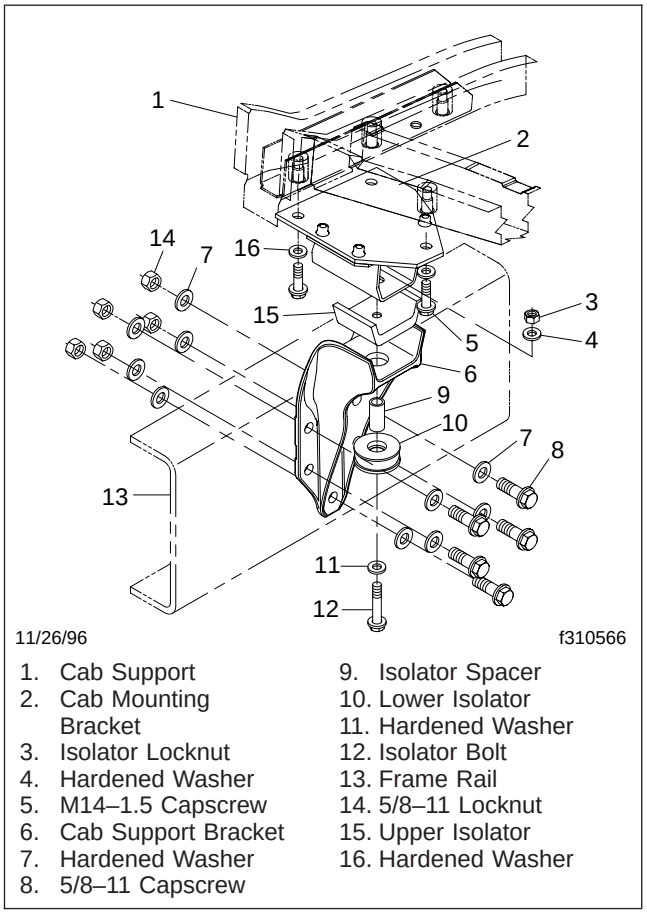


Fig. 3, Driver's-Side Cab Mount Assembly, FL106 and FL112 Vehicles Built After July 7, 1995 (passenger's side similar)

Rear Solid Rubber Isolator Mount Replacement

Replacement

NOTE: Don't replace only one rear cab mount; replace both mounts at the rear of the vehicle as a set.

1. Park the vehicle on a level surface. Apply the parking brake; then chock the tires.
2. Tilt the hood; refer to the vehicle driver's manual.
3. Remove the cab mounts. See **Fig. 1.**

3.1 From each side of the cab, remove the locknut, upper hardened washer, isolator bolt, lower isolator, and isolator spacer.

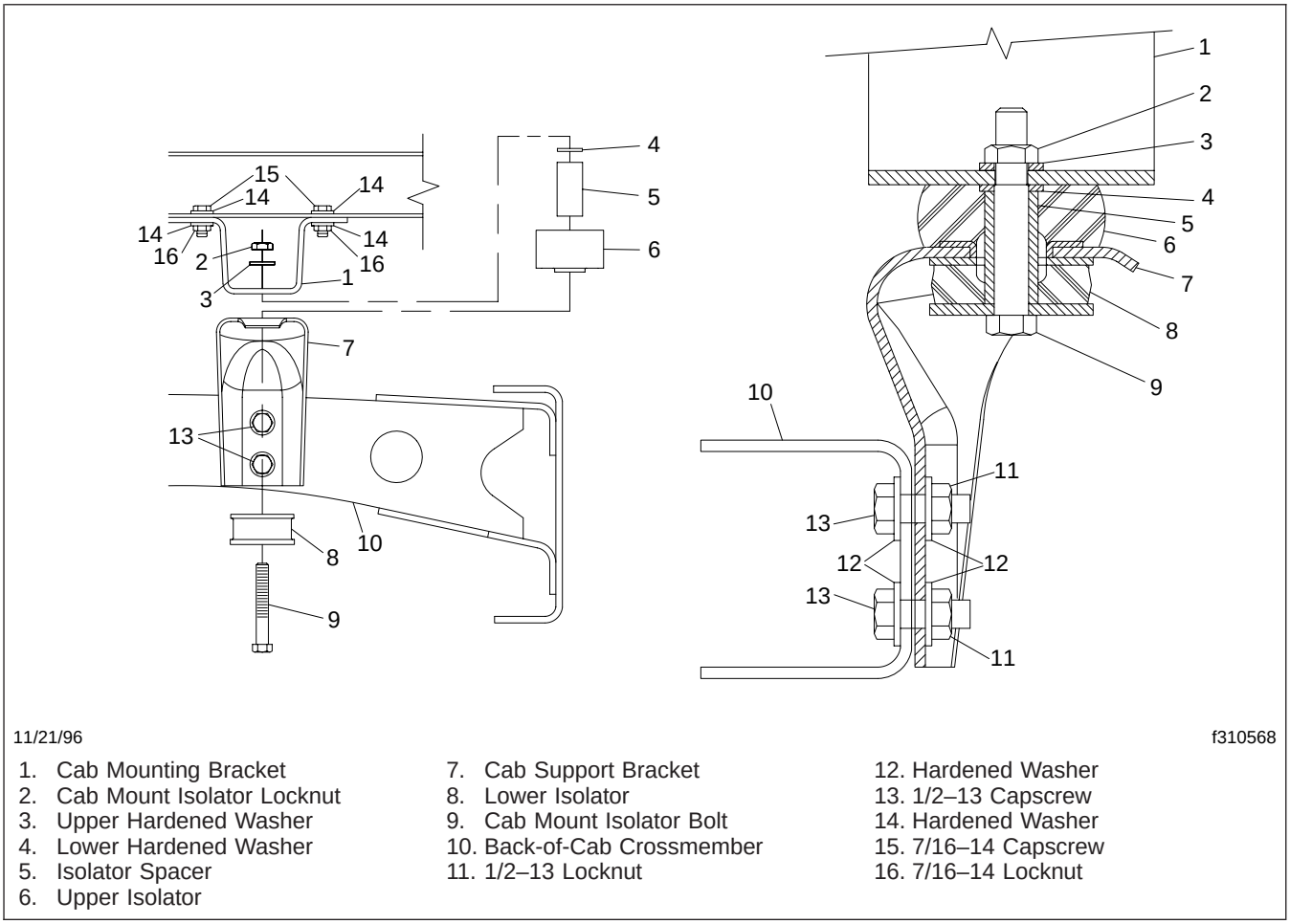
3.2 Using a jack, raise the rear of the cab about 1 inch (25 mm).

3.3 Remove the upper isolator and lower hardened washer from each cab support bracket.

3.4 Remove the two capscrews, hardened washers, and locknuts from the cab support bracket along with the cab support brackets.

3.5 Remove the two cab mounting bracket capscrews, hardened washers and locknuts along with each cab mounting bracket.

4. Install the new rear cab mounts. See **Fig. 1 .**



11/21/96 f310568

1. Cab Mounting Bracket
2. Cab Mount Isolator Locknut
3. Upper Hardened Washer
4. Lower Hardened Washer
5. Isolator Spacer
6. Upper Isolator
7. Cab Support Bracket
8. Lower Isolator
9. Cab Mount Isolator Bolt
10. Back-of-Cab Crossmember
11. 1/2–13 Locknut
12. Hardened Washer
13. 1/2–13 Capscrew
14. Hardened Washer
15. 7/16–14 Capscrew
16. 7/16–14 Locknut

Fig. 1, Rear Rubber Isolator Cab Mount

Rear Solid Rubber Isolator Mount Replacement

4.1 Inspect the original locknuts and hardened washers. If any wear, distortion, or other damage is found, replace the part.

4.2 Install the cab mounting brackets, capscrews, hardened washers and locknuts. Tighten each capscrew to 65 lbf·ft (90 N·m).

4.3 Install the cab support brackets, capscrews, hardened washers and locknuts. Tighten each capscrew to 95 lbf·ft (130 N·m).

4.4 Install the upper isolator and lower hardened washer at each cab support bracket.

4.5 Lower the cab until the cab mount brackets just contact the top of the upper isolators.

4.6 Install a spacer and bolt in one of the new lower isolators, then install these parts at the bottom of one of the cab support brackets. Install a hardened washer and locknut.

Repeat this for the other cab support bracket.

4.7 Lower the cab, and remove the jack.

4.8 Tighten the upper and lower isolator stud locknuts 65 lbf·ft (90 N·m).

4.9 Remove chocks from the tires.

Rear Hydraulic Isolator Mount Replacement

Replacement

NOTE: Don't replace only one rear cab mount; replace both mounts at the rear of the vehicle as a set.

1. Park the vehicle on a level surface. Apply the parking brake; then chock the tires.
2. Tilt the hood; see the vehicle driver's manual.
3. Remove the cab mounts. See **Fig. 1.**

3.1 From each side of the cab, remove the locknut and hardened washer from the upper and lower studs on the isolator.

3.2 Using a jack, raise the rear of the cab about 1 inch (25 mm).

3.3 Remove the isolator from each cab support bracket.

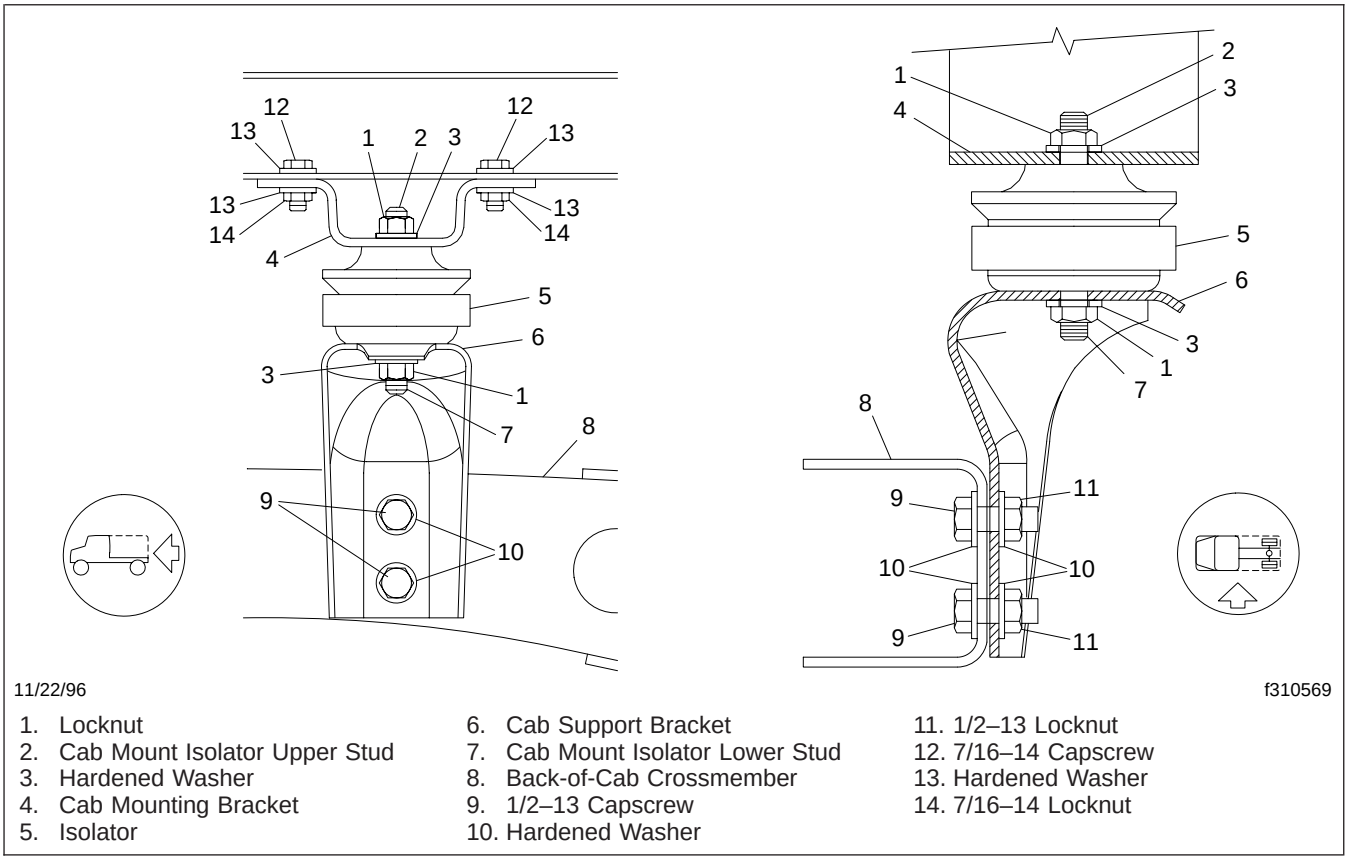
3.4 Remove the two capscrews, hardened washers and locknuts from the cab support bracket along with the cab support brackets.

3.5 Remove the two cab mounting bracket capscrews, hardened washers and locknuts along with each cab mounting bracket.

4. Install the new rear cab mounts. See **Fig. 1 .**

4.1 Inspect the original locknuts and hardened washers. If any wear, distortion, or other damage is found, replace the part.

4.2 Install the cab mounting brackets, capscrews, hardened washers and locknuts. Tighten each capscrew to 65 lbf·ft (90 N·m).



1. Locknut
2. Cab Mount Isolator Upper Stud
3. Hardened Washer
4. Cab Mounting Bracket
5. Isolator
6. Cab Support Bracket
7. Cab Mount Isolator Lower Stud
8. Back-of-Cab Crossmember
9. 1/2–13 Capscrew
10. Hardened Washer
11. 1/2–13 Locknut
12. 7/16–14 Capscrew
13. Hardened Washer
14. 7/16–14 Locknut

Fig. 1, Rear Hydraulic Isolator Cab Mount

Rear Hydraulic Isolator Mount Replacement

4.3 Install the cab support brackets, capscrews, hardened washers and locknuts. Tighten each capscrew to 95 lbf·ft (130 N·m).

4.4 Install each new isolator with the blue-colored stud pointing up.

4.5 Lower the cab and remove the jack.

4.6 Install the hardened washers and isolator stud locknuts. Tighten the locknuts 68 lbf·ft (90 N·m).

4.7 Remove chocks from the tires.

Specifications

Fastener Torques			
Description	**Size**	**Grade**	**Torque lbf·ft (N·m)**
Front Isolator Locknut	1/2–13	8	68 (92)
Rear Solid Rubber Isolator Locknut	1/2–13	8	68 (92)
Rear Hydraulic Isolator Locknut	1/2–13	8	68 (92)
Rear Cab Mounting Bracket Capscrew	7/16–14	8	65 (88)
Rear Cab Support Bracket Hexnut	1/2–13	8	68 (92)
Front Cab Mounting Bracket Hexnut	1/2–13	8	68 (92)
Front Cab Support Bracket Capscrew	5/8–11	8	190 (258)

Table 1, Fastener Torques

General Description

The windshield is a single curved piece of glass, available clear or tinted. Both types include a permanent, black band at the base of the windshield to mask dash components.

The cab rear windows are two flat pieces of glass, available clear or tinted. One-piece rubber retainers hold the rear windows and the windshield in the cab and seal the joints between the glass and the cab shell.

Removal (Refer to Fig. 1)

CAUTION

CAUTION: When replacing a cracked windshield glass, it is very important that you find the cause of glass breakage, and correct the condition before installing a new windshield. If not removed, a small obstruction or high spot somewhere around the windshield opening may crack or break the replacement windshield, especially when the glass is exposed to high winds, pressure, temperature extremes, and vehicle motion.

IMPORTANT: At least two people are required to remove a windshield.

1. Protect the paint finish and instrument panel inside the cab. Using tape and paper around the windshield opening and outside surfaces, lay suitable covering across the hood and fenders. Before removing the windshield, mark the windshield retainer and the windshield opening flange with the location of the break on the edge of the window.
2. Remove the windshield wiper arms.
   - 2.1 Remove the nut that holds each wiper arm on each wiper motor splined pivot shaft.
   - 2.2 Gently pull each wiper arm off its pivot shaft.

IMPORTANT: When handling the windshield glass, wear heavy protective gloves to prevent cutting your hands.

3. If replacing the windshield glass but not the retainer **(refer to Fig. 2)** loosen the lip of the windshield retainer from the flange along the top and at the sides by applying controlled pressure to the edge of the glass. At the same time, use a putty knife to lift the retainer over the flange. Remove the windshield.

   If replacing the windshield retainer or both the glass and the retainer, cut off the lip of the old retainer from the inside of the cab before applying pressure to the edge of the glass. **Refer to Fig. 2.** This will ease removal of the glass.

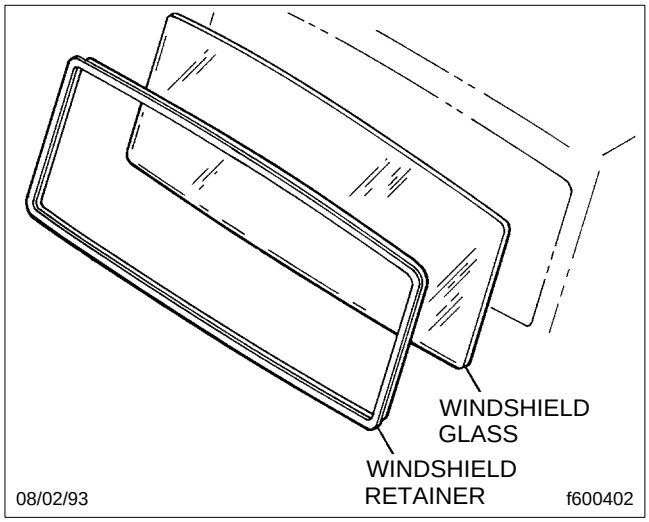


Fig. 1

Installation

CAUTION

CAUTION: When handling the windshield glass, use care not to nick or splinter the edges of the glass. Chipped edges could cause future breaks.

IMPORTANT: At least two people are required to install a windshield.

1. Remove all sealant from the flange around the windshield opening. **See Fig. 3.**
2. If a stress crack occurred, thoroughly check the windshield opening flange and retainer before installing a replacement windshield.

   Check for the following conditions at the previously marked point of fracture on the windshield opening flange:

   - Chipped edges on the glass.
   - High spots or obstructions in the flange and surrounding surfaces.
   - High spots or obstructions in the windshield retainer.

   Correct any areas on the flange that need to be fixed.
3. Install the retainer on the glass.

Windshield Removal and Installation

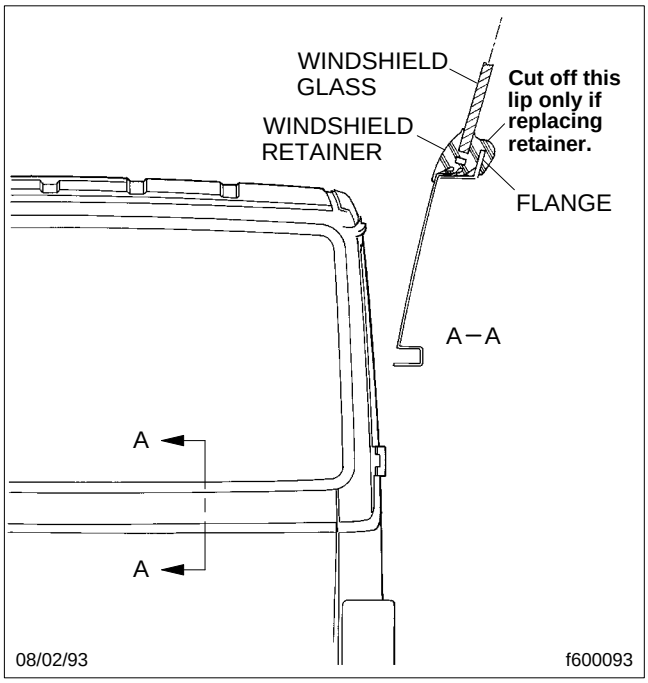


Fig. 2

4. Install a 3-mm (1/8-inch) nylon cord around the edge of the retainer **(refer to Fig. 4),** leaving a loop at the top and loose ends at the bottom.

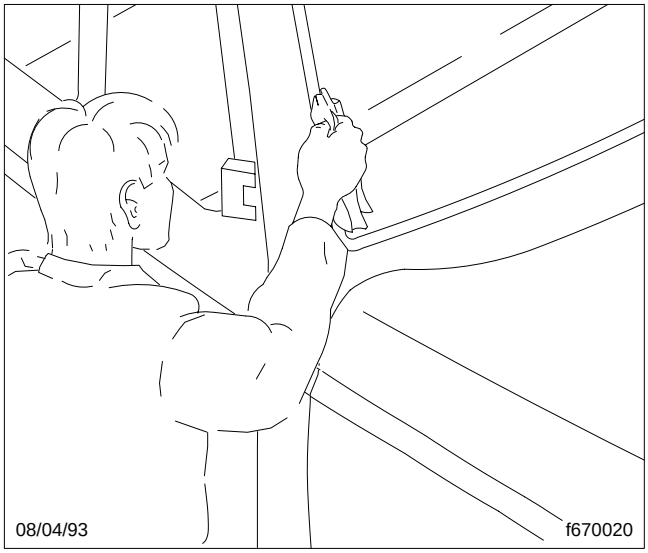


Fig. 3

5. Make sure the protective covering is over the front fenders and hood.

6. Place the windshield and retainer assembly in the windshield opening.

7. With one person lightly pushing in on the windshield, have another person pull on the loose ends of the cord until each is within 51 mm (2 inches) of its respective upper corner. **See Fig. 5.**

8. Finish seating the corners by pulling both ends of the cord at the same time at each corner. This will position the upper corners.

9. Be sure the windshield and retainer are properly positioned in relation to each other.

10. Install the windshield wiper arms.

    10.1 Place each arm on its splined pivot shaft. Be careful the splines within the hole at the base of the arm are aligned with the splines on the pivot shaft. **See Fig. 6.**

    10.2 Install and tighten the wiper arm nuts 19 N·m (14 lbf·ft).

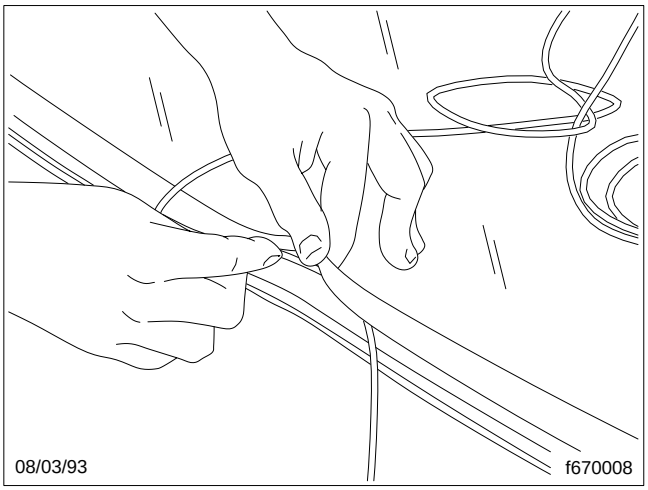


Fig. 4

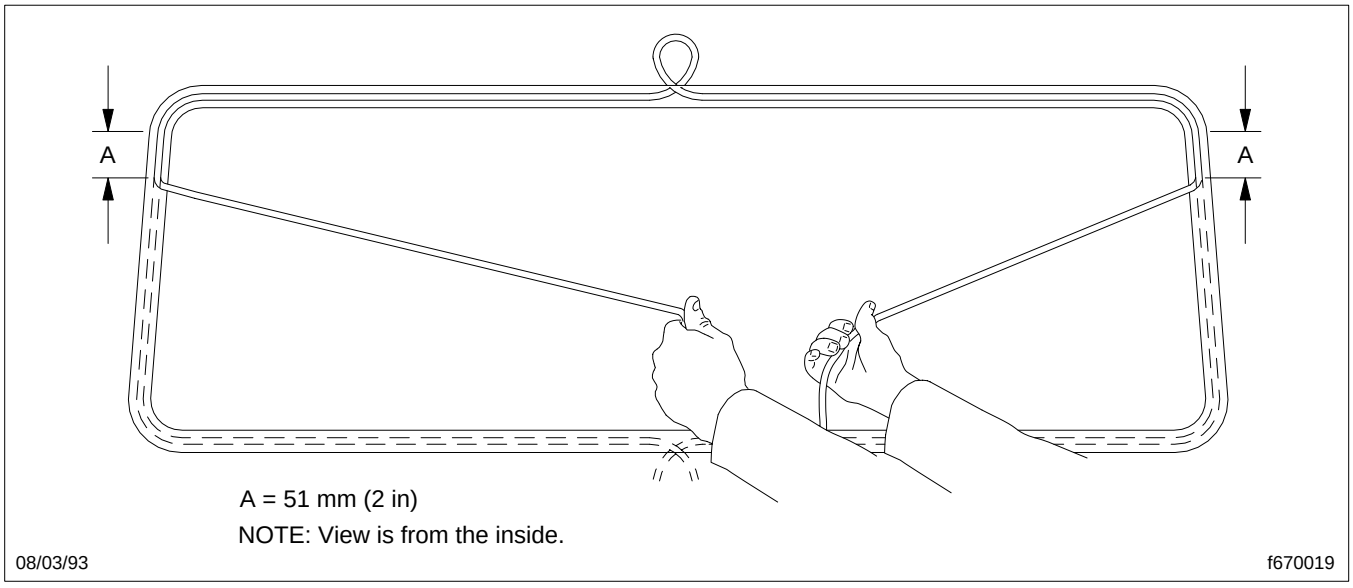

A
A
A = 51 mm (2 in)
NOTE: View is from the inside.
08/03/93
f670019

Fig. 5

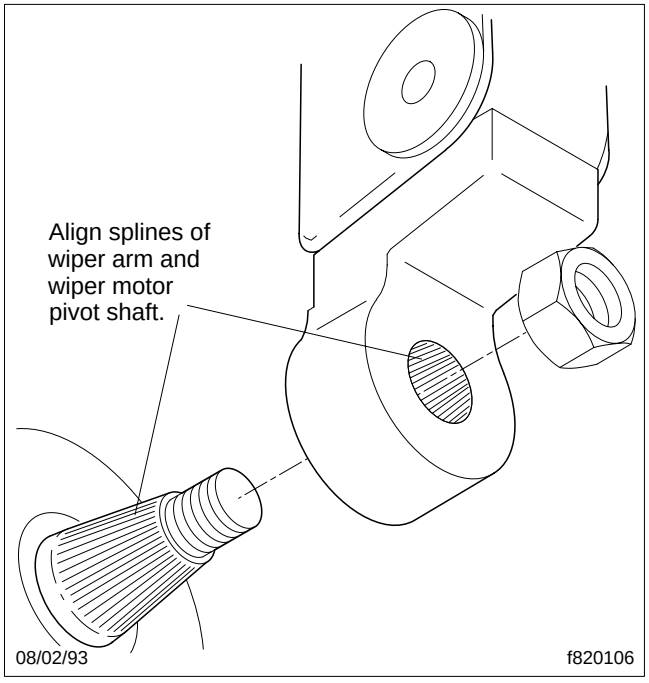

Align splines of wiper arm and wiper motor pivot shaft.
08/02/93
f820106

Fig. 6

Rear Window Removal and Installation

Removal (Refer to Fig. 1 and Fig. 2)

CAUTION

CAUTION: When replacing a broken rear window, it is very important that you find the cause of glass breakage, and correct the condition before installing a new window. If not removed, a small obstruction or high spot somewhere around the window opening may break the replacement glass, especially when it is exposed to high winds, pressure, temperature extremes, and vehicle motion.

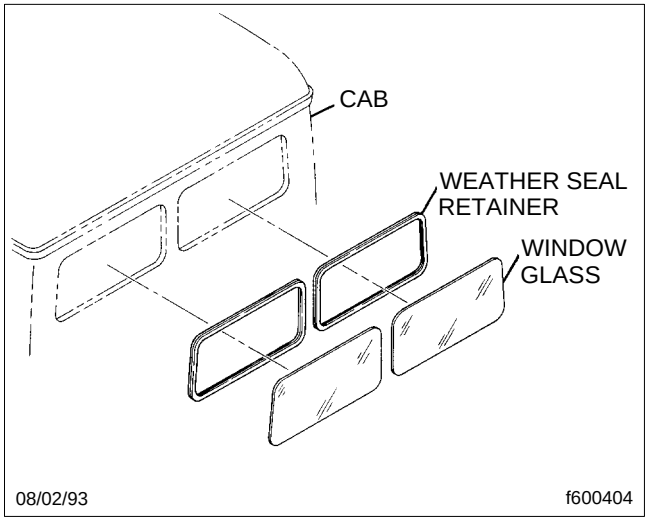


Fig. 1

1. Protect the paint finish and cab interior, using tape and paper around the window opening and outside surfaces. Before removing the window, mark the weather-seal retainer and the opening with the location of the break at the edge of the window.

IMPORTANT: When handling the window glass, wear heavy protective gloves to prevent cutting your hands.

2. Loosen the lip of the weather-seal retainer from the flange along the top and at the sides by applying firm, controlled pressure to the edge of the glass. At the same time, use a putty knife to lift the retainer over the window opening flange. Remove the window glass.

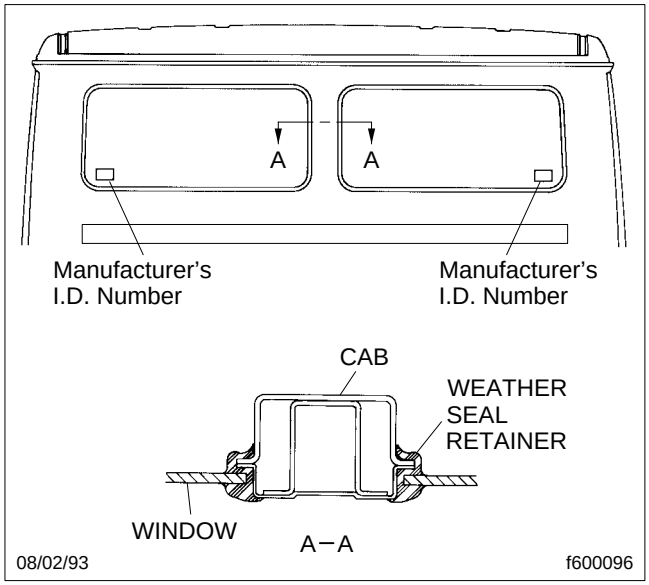


Fig. 2

Installation

CAUTION

CAUTION: When handling the window glass, use care not to nick or splinter the edges of the glass. Chipped edges could cause future breaks.

IMPORTANT: Two people are required to install a rear window glass.

Thoroughly check the window opening flange and the weather-seal retainer for alignment and roughness before installing a replacement glass. To check the alignment, hold the replacement glass up to the opening and use it as a guide.

1. Remove all sealant from the window opening flange.
2. Check for the following conditions at the previously marked point of fracture on the window opening flange:
   - Chipped edges on the glass.
   - High spots or obstructions in the window opening flange.
   - High spots or obstructions in the weather-seal retainer.

Rear Window Removal and Installation

Correct any areas on the window opening that need to be fixed.

3. With the window supported and centered in the opening, check the relationship of the glass to the opening.
4. Mark any areas on the flange to be fixed, remove the glass, and correct as necessary.
5. Install the retainer on the glass.
6. Install a 3-mm (1/8-inch) nylon cord around the edge of the retainer, leaving a loop at the top and loose ends at the bottom. **See Fig. 3.**

NOTE: Make sure the reinforcement plate **(see Fig. 4 and Fig. 5)** is in place between the interior trim panel and the cab back skin along the lower edge of the window opening.

7. Place the window and retainer assembly in the opening.

   The rear window glass is not a rectangle: The upper edge of the glass is slightly shorter than the lower edge. If installing a left-side (driver's-side) window, locate the glass in the opening so that the manufacturer's I.D. number is in the lower left corner. If installing a right-side (passenger's side) window, locate the glass in the opening so that the manufacturer's I.D. number is in the lower right corner. **Refer to Fig. 2.**

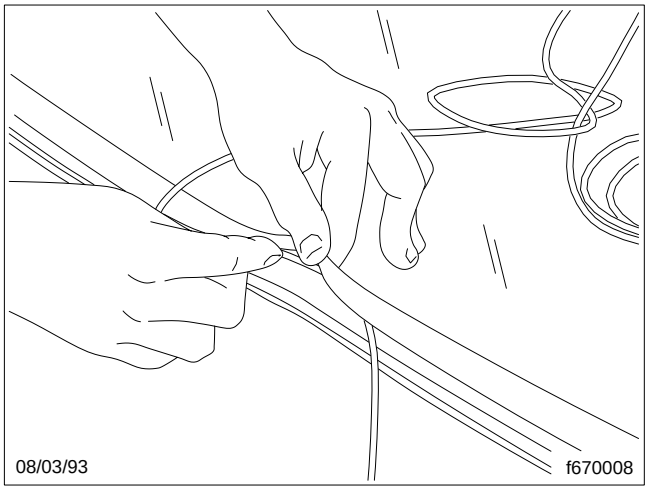


Fig. 3

8. With one person lightly pushing in on the window, have another person pull on the loose ends of the cord until each is within 51 mm (2 inches) of its respective upper corner.
9. Pull on the loop until the cord is within 51 mm (2 inches) of the upper corners.
10. Finish seating the corners by pulling both ends of the cord at the same time at each corner. This will position the upper corners.
11. Be sure the window and retainer are correctly positioned in relation to each other.

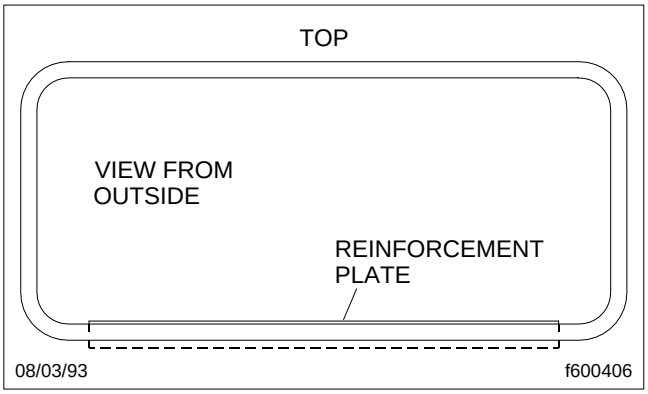


Fig. 4, Window Opening Frame

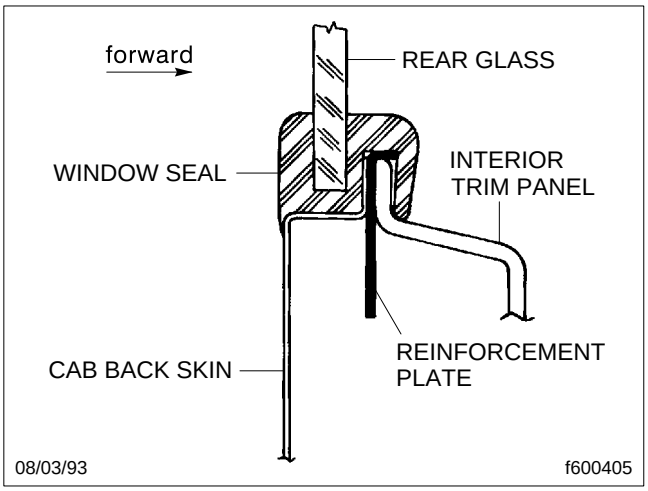


Fig. 5, Bottom Reinforcement Plate and Window Assembly, Installed

Specifications

Description	Grade	Size	Torque N·m (lbf·ft)
Wiper Arm Nuts	8.8	M6 x 1	19 (14)

Table 1, Fastener Torques

General Information

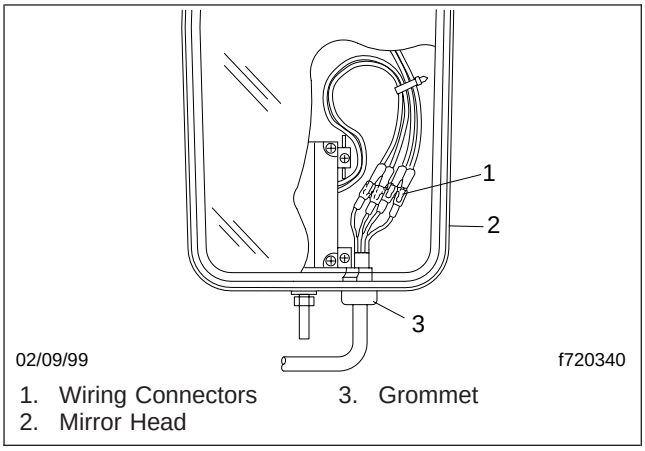
The Velvac mirror is an 8 by 16 inch (20 by 40 cm) electrically heated, remote-controlled mirror with marker lights. Using switches that mount in the cab, a driver can remotely adjust the position of each mirror. The mirror is rotated by an electric motor mounted to a slip clutch. The slip clutch allows for manual adjustment of the mirrors without damage to the electric motor or drive gears. A temperature-controlled heater heats the mirror surface to remove moisture and ice. Marker lights on the mirrors signal the widest points of the vehicle to oncoming traffic.

Removal

1. Apply the parking brake and chock the tires.
2. Disconnect the batteries.

NOTE: Most repairs to the Velvac mirrors can be made with the mirror head still mounted to the brackets on the vehicle.

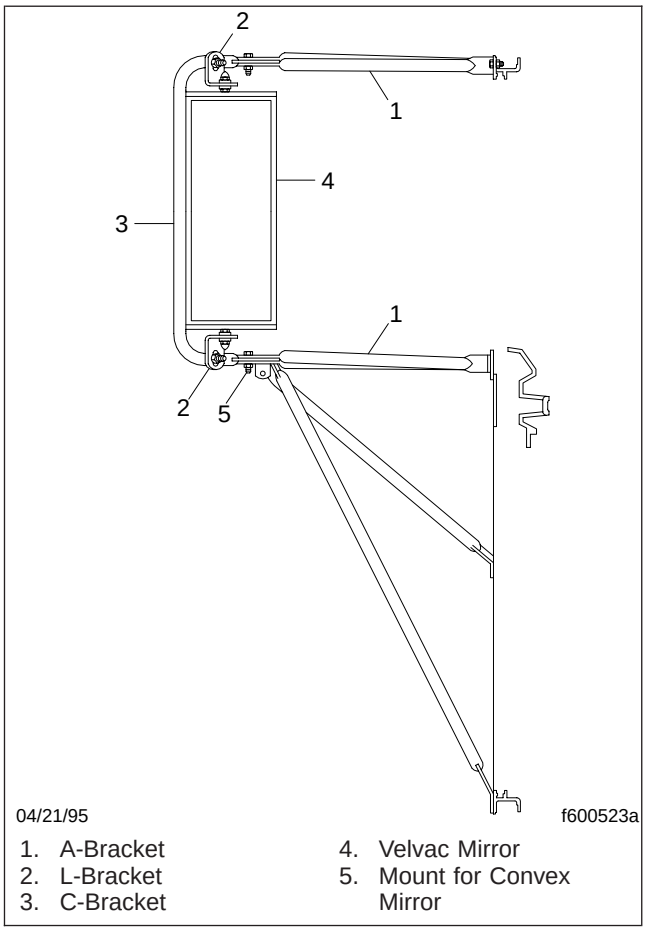
3. Using pliers or a grommet tool, depress the grommet tab and remove the plastic grommet for the mirror wiring harness from the bottom of the mirror head. See **Fig. 1**.



1. Wiring Connectors
2. Mirror Head
3. Grommet

Fig. 1, Disconnecting the Wiring

4. Pull the wires through the hole for the grommet so that the wire connectors are outside the mirror head. Disconnect all the electrical connectors at the mirror.
5. If a convex mirror is mounted on the bottom shaft of the Velvac mirror, remove the convex mirror.
6. Remove the nuts securing the L-brackets to the C-bracket and remove the Velvac mirror from the vehicle. See **Fig. 2**.
7. Using a 1/2 inch backup wrench to prevent the jam nuts at the top of the mirror head from turning on the shaft, remove the locknut from the top shaft. Remove the washers and L-bracket from the top shaft.
8. Using a 9/16 inch backup wrench to prevent the nut at the bottom of the mirror head from turning, remove the locknut from the bottom shaft. Remove the washers and L-bracket from the bottom shaft. See **Fig. 3**.



1. A-Bracket
2. L-Bracket
3. C-Bracket
4. Velvac Mirror
5. Mount for Convex Mirror

Fig. 2, Typical Mirror Mounting Arrangement

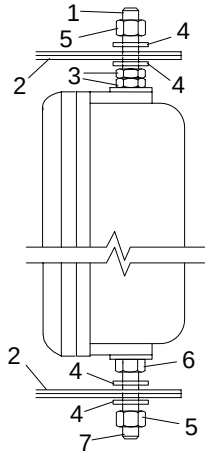
IMPORTANT: Do not allow the lower nut next to the mirror head to turn on the bottom shaft when removing the locknut. The torque on this nut is set at the factory.

Installation

1. Install a flatwasher on top of the two jam nuts on the top shaft of the mirror head. Install the top L-bracket and another flatwasher. Install a hexnut with a split lockwasher onto the top shaft.

IMPORTANT: Use a backup wrench on the jam nuts to prevent the jam nuts from turning on the top shaft of the mirror. These jam nuts have

Velvac Mirror Removal and Installation



1. 5/16–18 Thread
2. Clamp
3. Jam Nuts
4. Flatwasher
5. Locknut
6. Large Nut
7. Motor Shaft

Fig. 3, Typical Mirror Mounting Arrangement

been tightened at the factory and must not rotate when tightening the top L-bracket locknut. The top shaft must be free to rotate onthe mirror head.

2. With a backup wrench on the jam nuts, tighten the locknut that holds the L-bracket on the top shaft as follows:
   - 60 to 80 lbf·in (680 to 900 N·cm) for the non-motorized mirrors
   - 125 to 200 lbf·in (1410 to 2260 N·cm) for the motorized mirrors
3. Install a flatwasher on the bottom shaft of the mirror head. Install the bottom L-bracket and another flatwasher. Install the hexnut with a split lockwasher onto the bottom shaft.

IMPORTANT: Use a backup wrench on the nut next to the mirror head to prevent the nut from turning on the bottom shaft of the mirror. The nut was tightened at the factory and must not rotate when tightening the bottom L-bracket locknut. If the nut has loosened, tighten it only until the bottom shaft starts turning with the nut.

4. With a backup wrench on the nut next to the mirror head, tighten the locknut that holds the L-bracket on the bottom shaft 14 lbf·ft (19 N·m).
5. Connect the wires from the mirror to the wiring harness according to the color code chart in **Table 1**.

Mirror Wiring Color Code	
Mirror Head	**Harness**
Red (heater +)	Red
Black (heater, light –)	Black
Blue (light +)	Blue
White (motor)	White
Green (motor)	Green

Table 1, Mirror Wiring Color Code

6. Slide the plastic grommet to its original position on the jacket of the mirror harness. Using pliers or a grommet tool, push the grommet and harness into the hole in the bottom of the mirror head. Make sure that the grommet tab locks the grommet in place.
7. Install the convex mirror (if removed) on the end of the lower A-bracket.

⚠ WARNING

Grab only the mirror head when turning the mirror by hand. Do not apply force to the mirror glass or the glass could break and cause injury.

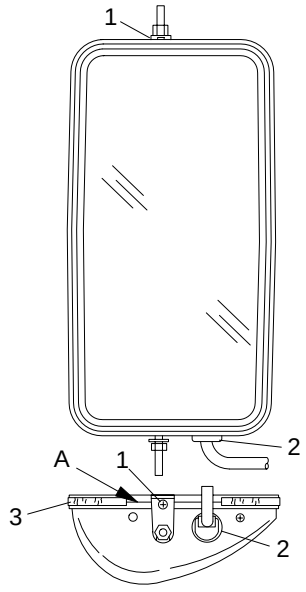
8. Rotate the mirror head by hand to make sure that there is clearance.
9. Connect the batteries.
10. Test the operation of all the mirror functions using the switches inside the cab. The mirror should be warm to the touch within 5 minutes of starting the mirror heater.
11. Remove the chocks from the tires.

Replacement

1. Apply the parking brake, and chock the tires.
2. Disconnect the batteries.

NOTE: The motor in the Velvac mirror can be replaced with the mirror head still mounted to the brackets on the vehicle.

3. Remove any tape from the perimeter of the bezel. Remove the two screws on both the top and the bottom of the mirror head. See **Fig. 1**.



A. Separate bezel/mirror head here.
1. Bezel Screws
2. Grommet
3. Tape

Fig. 1, Velvac Mirror Disassembly

CAUTION

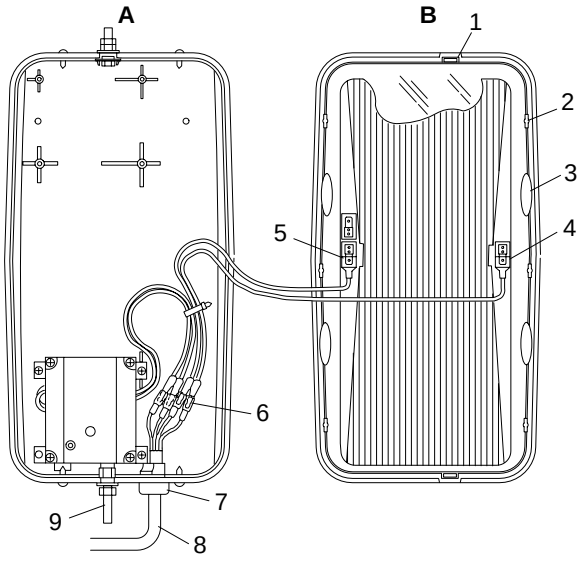
Avoid putting force on the glass or using sharp tools to separate the glass from the mirror housing. The glass can easily break and the housing can be scratched by the use of sharp tools.

4. Use your hands to carefully separate the bezel and glass assembly from the mirror housing. The plastic bezel is held in the housing by six Tinnerman® clips in the internal groove along the rear edge of the mirror housing.
5. Remove the wire connectors from the heater element on the back of the mirror glass. Put the mirror glass and heater element is a safe place.
6. Cut the tie strap and remove the wires to the mirror motor.
7. Remove the lower L-bracket from the A-bracket. Remove the locknut, L-bracket, and flatwashers from the motor shaft at the lower bracket.
8. Install two jam nuts on the motor shaft and tighten against each other. Hold a backup wrench on the outer jam nut to prevent the motor shaft from turning. Remove the large nut from the motor shaft.

NOTE: The nut on the motor shaft uses thread sealant to help it stay in position.

9. Using a Phillips screwdriver, remove the four screws that hold the motor to the housing. Lift the motor from the mirror housing.
10. Install the shaft of the new motor into its hole in the housing.
11. Install and carefully tighten the four screws that hold the motor to the housing.
12. Apply Loctite® 271 to the threads of the motor shaft nut and install it on the shaft. Tighten the nut until the shaft begins to turn.
13. Install a flatwasher, the lower L-bracket, another flatwasher, and a new nylon-insert locknut, but do not tighten the locknut.
14. Fasten the lower L-bracket to the A-bracket. Use a 9/16 inch backup wrench to prevent the shaft nut from turning and tighten the locknut on the end of the motor shaft.
15. Connect the wires from the motor to the wires of the same color in the harness. Install a tie strap in the same location as before.
16. Remove any Tinnerman clips left in the groove in the housing or on the bezel. Install new clips in the six locations on the bezel shown in **Fig. 2**.
17. Connect the black wire and the blue wire to the two terminals on the ground side of the heating element. Connect the red wire to the terminal on the other side of the element.
18. Align the tabs on the top and bottom of the bezel with the slots in the housing. Carefully and

Velvac Mirror Motor Replacement



A. Mirror Head
B. Glass/Heating Element and Bezel
1. Alignment Tab
2. Tinnerman Clips
3. Factory-applied Silicone
4. Heating Element Power Connection
5. Heating Element Ground Connection
6. Wire Connectors
7. Grommet
8. Wire Harness
9. Motor Shaft

Fig. 2, Velvac Mirror Assembly

evenly press the glass and bezel assembly into the groove in the housing so that the clips firmly hold the bezel assembly in place.

19. Carefully press the glass and bezel assembly against the housing while installing the bezel mounting screws into the housing. Push down on the screwdriver while turning the screws, but do not over-tighten the screws into the plastic mirror housing.
20. Apply the tape, that was removed earlier, around the perimeter of the bezel.
21. Connect the batteries and test the mirror operation.
22. Remove the chocks from the tires.

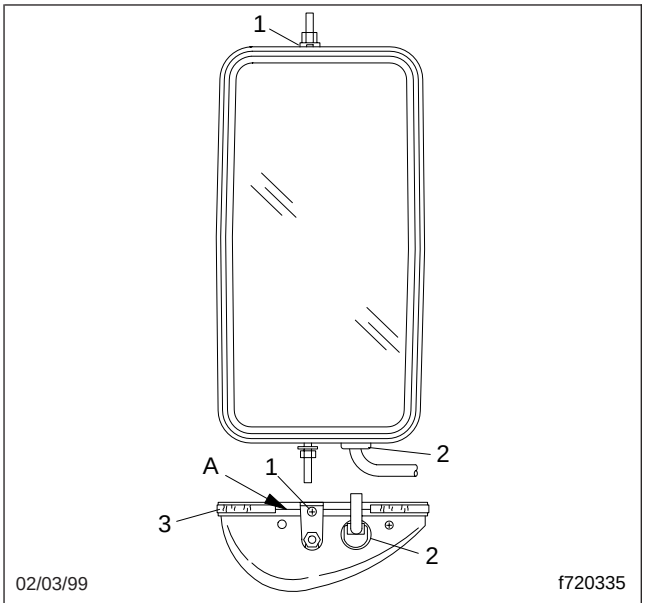
Velvac Mirror Glass and Heating Element Removal and Installation

Removal

1. Apply the parking brake, and chock the tires.
2. Disconnect the batteries.

NOTE: The heating element in the Velvac mirror can be replaced with the mirror head still mounted to the brackets on the vehicle.

3. Remove and discard any tape from the perimeter of the bezel. Remove the screws on the top and the bottom that hold the bezel to the mirror head. See **Fig. 1**.



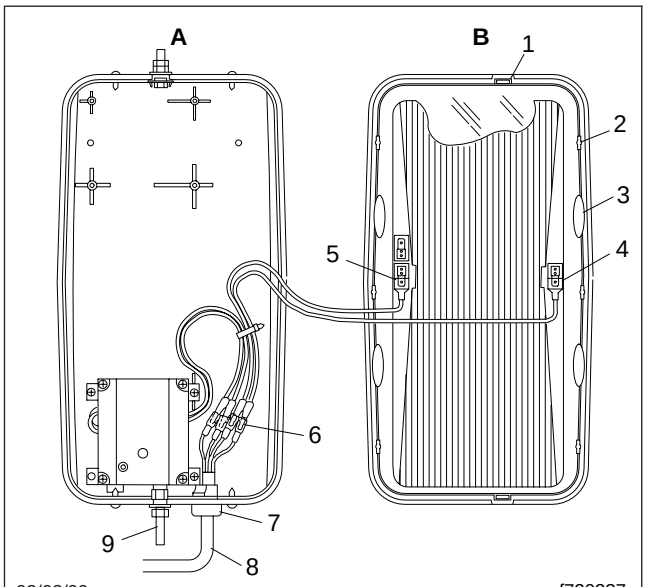
A. Separate bezel/mirror head here.
1. Bezel Screws
2. Grommet
3. Tape

Fig. 1, Removing the Bezel

CAUTION

Avoid putting force on the glass or using sharp tools to separate the glass from the mirror housing. The glass can easily break and the housing can be scratched by the use of sharp tools.

4. Use your hands to carefully separate the bezel and glass assembly from the mirror housing. The plastic bezel is held in the housing by six Tinnerman® clips in the internal groove along the rear edge of the mirror housing. See **Fig. 2**.



A. Mirror Head
B. Glass/Heating Element and Bezel
1. Alignment Tab
2. Tinnerman Clips
3. Factory-applied Silicone
4. Heating Element Power Connection
5. Heating Element Ground Connection
6. Wire Connectors
7. Grommet
8. Wire Harness
9. Motor Shaft

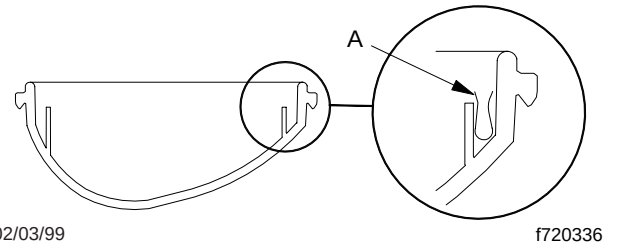
Fig. 2, Velvac Mirror Assembly

5. Remove the wire connectors from the heater element on the back of the mirror glass.
6. Peel the silicon from the bezel and remove the mirror glass and heating element.

Installation

1. Remove any Tinnerman clips left in the groove in the housing or on the bezel. See **Fig. 3**. Install new clips in the six locations on the bezel shown in **Fig. 2**.
2. Install the glass and heater element into the bezel. Apply silicon sealer four places along the glass perimeter to hold the glass to the bezel.
3. Connect the black wire and the blue wire to the two terminals on one side of the heating ele-

Velvac Mirror Glass and Heating Element Removal and Installation



A. Remove the clips from the groove in the housing.

Fig. 3, Removing the Clips

ment. Connect the red wire to the terminal on the other side of the element.

4. Align the tabs on the top and bottom of the bezel with the slots in the housing. Carefully and evenly press the glass and bezel assembly into the groove in the housing so that the clips firmly hold the bezel assembly in place.
5. Carefully press the glass and bezel assembly against the housing while installing the bezel mounting screws into the housing. Push down on the screwdriver while turning the screws, but do not over-tighten the screws into the plastic mirror housing.
6. Connect the batteries and test the mirror operation.
7. Remove the chocks from the tires.

Troubleshooting

Use the information in the following troubleshooting tables to determine the possible causes and remedies of problems with the Velvac mirrors. To test the mirror components, go to the appropriate heading in this subject.

Problem—The Mirror Will Not Rotate When the Switch Is Closed

Problem—The Mirror Will Not Rotate When the Switch Is Closed	
Possible Cause	**Remedy**
An obstruction is in the path of the mirror.	Remove the obstruction.
The motor switch does not have power.	Turn the power on.
The fuse or circuit breaker is open.	Replace the fuse or reset the circuit breaker.
The switch is not working.	Test the switch. Replace it, if necessary.
The wiring is damaged.	Check and repair the wiring.
The motor is worn.	Test the motor. Go to "Testing the Electric Motor" in this subject.

Problem—The Heater Does Not Work

Problem—The Heater Does Not Work	
Possible Cause	**Remedy**
There is no power to the heater switch.	Turn the power on.
The fuse or circuit breaker is open.	Replace the fuse or reset the circuit breaker.
The switch is not working.	Test the switch. Replace it, if necessary.
The wiring is damaged.	Check and repair the wiring.
The heating element is not working.	Test the element. Go to "Testing the Heater" in this subject.

Problem—The Mirror Will Not Stay Adjusted, Moves at High Speed, or Vibrates

Problem—The Mirror Will Not Stay Adjusted, Moves at High Speed, or Vibrates	
Possible Cause	**Remedy**
The fasteners are not tight.	Tighten the mirror mounting hardware.
The slip clutch is worn.	Test the slip clutch. Go to "Testing the Slip Clutch" in this subject.

Problem—The Glass Is Broken

Problem—The Glass Is Broken	
Possible Cause	**Remedy**
An object has struck the glass.	Replace the glass. For instructions, go to **Subject 120**.

Troubleshooting

Problem—The Glass Surface Has Scratches

Problem—The Glass Surface Has Scratches	
Possible Cause	**Remedy**
The glass was cleaned incorrectly.	Replace the glass, if necesary. Use only non-abrasive cleaners and soft cloths to clean the glass surface.

Problem—The Glass Is Distorted

Problem—The Glass Is Distorted	
Possible Cause	**Remedy**
The mounting brackets are misaligned causing the head to flex.	Align the mounting brackets.
The mirror hits an obstruction during its rotation.	Remove the obstruction.

Problem—The Marker Light Does Not Illuminate

Problem—The Marker Light Does Not Illuminate	
Possible Cause	**Remedy**
The bulb is burnt.	Replace the bulb.
The switch is not working.	Test the switch. Replace it, if necessary.
The wiring is damaged.	Check and repair the wiring.
The fuse or circuit breaker is open.	Replace the fuse or reset the circuit breaker.

TESTING THE SLIP CLUTCH

The Velvac mirror slip clutch allows the mirror head to be positioned manually without damaging the motor gear assembly. The slip clutch resistance to rotation keeps the mirror from moving unintentionally. To test the torque needed to rotate the mirror head in relation to the motor shaft, use the following procedure.

1. Apply the parking brake and chock the tires.
2. Disconnect the batteries.
3. Remove the Velvac mirror head from the vehicle. See **Subject 100** for the instructions.
4. Install two 5/16–18 jam nuts on the motor shaft of the mirror head. Using a backup wrench on one of the jam nuts, tighten the other jam nut against the first. See **Fig. 1**.
5. Use a beam-type or dial-type torque wrench on the outer jam nut. Hold the mirror head from rotating and note the reading on the torque wrench while rotating the jam nuts and motor shaft.

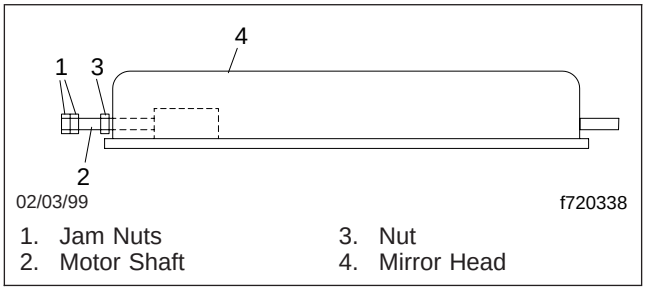


Fig. 1, Testing the Slip Clutch

6. The torque required to turn the motor shaft in relation to the motor head must be between 60 and 110 lbf·in (680 to 1230 N·cm).
7. Replace the motor assembly if the torque needed to rotate the shaft is more than 110 lbf·in (1230 N·cm). For instructions, see **Subject 110**. If the motor shaft begins to turn at a torque value of less than 60 lbf·in (680 N·cm), tighten the large nut on the motor shaft just until the shaft begins to turn with the nut. Check the rotating torque again. Replace the motor assembly if the torque needed to turn the shaft is still not correct.

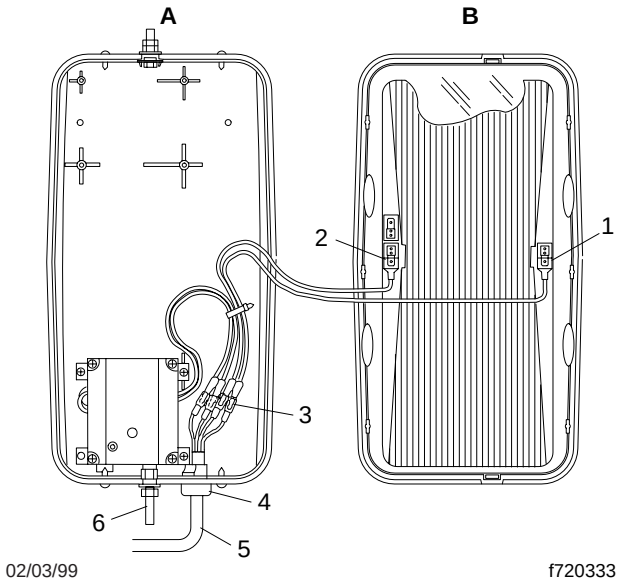
TESTING THE ELECTRIC MOTOR

To test the electric motor that rotates the mirror head, use the following procedure.

1. Apply the parking brake and chock the tires.
2. Disconnect the batteries.

NOTE: Most repairs to the Velvac mirrors can be made with the mirror head still mounted to the brackets on the vehicle.

3. Using pliers or a grommet tool, depress the grommet tab and remove the plastic grommet for the mirror wiring harness from the bottom of the mirror head. See **Fig. 2**.



A. Mirror Head
B. Glass/Heating Element and Bezel
1. Heating Element Power Connection
2. Heating Element Ground Connection
3. Wire Connectors
4. Grommet
5. Wire Harness
6. Motor Shaft

Fig. 2, Velvac Mirror Assembly

4. Pull the mirror wires through the hole for the grommet so that the wire connectors are outside the mirror head. Disconnect the electrical connectors for the white and the green wires.
5. Connect a jumper wire from the battery negative post (or a good ground) to the white wire in the mirror head.

⚠ CAUTION

The mirror head will immediately start rotating when you complete the temporary circuit. Make sure that your hands and all objects are out of the way of the mirror head before starting this test. Disconnect the wires before the mirror head can hit any object. Failure to do so could cause personal injury or damage to the mirror.

6. Temporarily touch a jumper wire from the battery positive post to the green wire in the mirror head. The motor should immediately start turning the mirror head in a clockwise direction (looking from the top).
7. Disconnect the white wire from the jumper wire connected to the battery negative post (or ground). Connect the grounded jumper to the green wire in the mirror.
8. With your hands away from the mirror head, temporarily touch a jumper wire from the battery positive post to the white wire in the mirror head. The motor should immediately start turning the mirror head in a counter-clockwise direction (looking from the top).
9. Replace the motor if it does not operate as stated above. See **Subject 110** for the motor replacement procedure.
10. Remove the jumper wires and connect the batteries.
11. Remove the chocks from the tires.

TESTING THE HEATER

To test the electric heating element in the mirror head, use the following procedure.

1. Apply the parking brake, and chock the tires.
2. Disconnect the batteries.
3. Using pliers or a grommet tool, depress the grommet tab and remove the plastic grommet for the mirror wiring harness from the bottom of the mirror head. See **Fig. 2**.
4. Pull the mirror wires through the hole for the grommet so that the wire connectors are outside

Troubleshooting

the mirror head. Disconnect the electrical connectors for the black and the red wires.

5. Test for continuity in the heater circuit by connecting one probe of an ohmmeter to the black wire from the mirror and the other probe to the red wire. The ohmmeter must indicate continuity. Replace the mirror glass/heating element if the ohmmeter indicates an open circuit.
6. Connect a jumper wire from the battery negative post (or a good ground) to the black wire in the mirror head.
7. Connect a jumper wire from the battery positive post to the red wire in the mirror head. The heating element will make the mirror glass warm to the touch within 5 minutes.
8. Replace the mirror glass and heating element assembly if it does not operate as stated above. See **Subject 120** for the heating element replacement procedure.
9. Remove the jumper wires and connect the batteries.
10. Remove the chocks from the tires.

General Information

The extended cab version of the Business Class truck or tractor includes a side window opening in each side of the cab extension. **See Fig. 1.** The window opening may contain a piece of tinted, fixed, solid tempered glass, a moveable (tip out) window assembly, or an aluminum plate. A one-piece rubber seal is used to hold the side window in the cab opening.

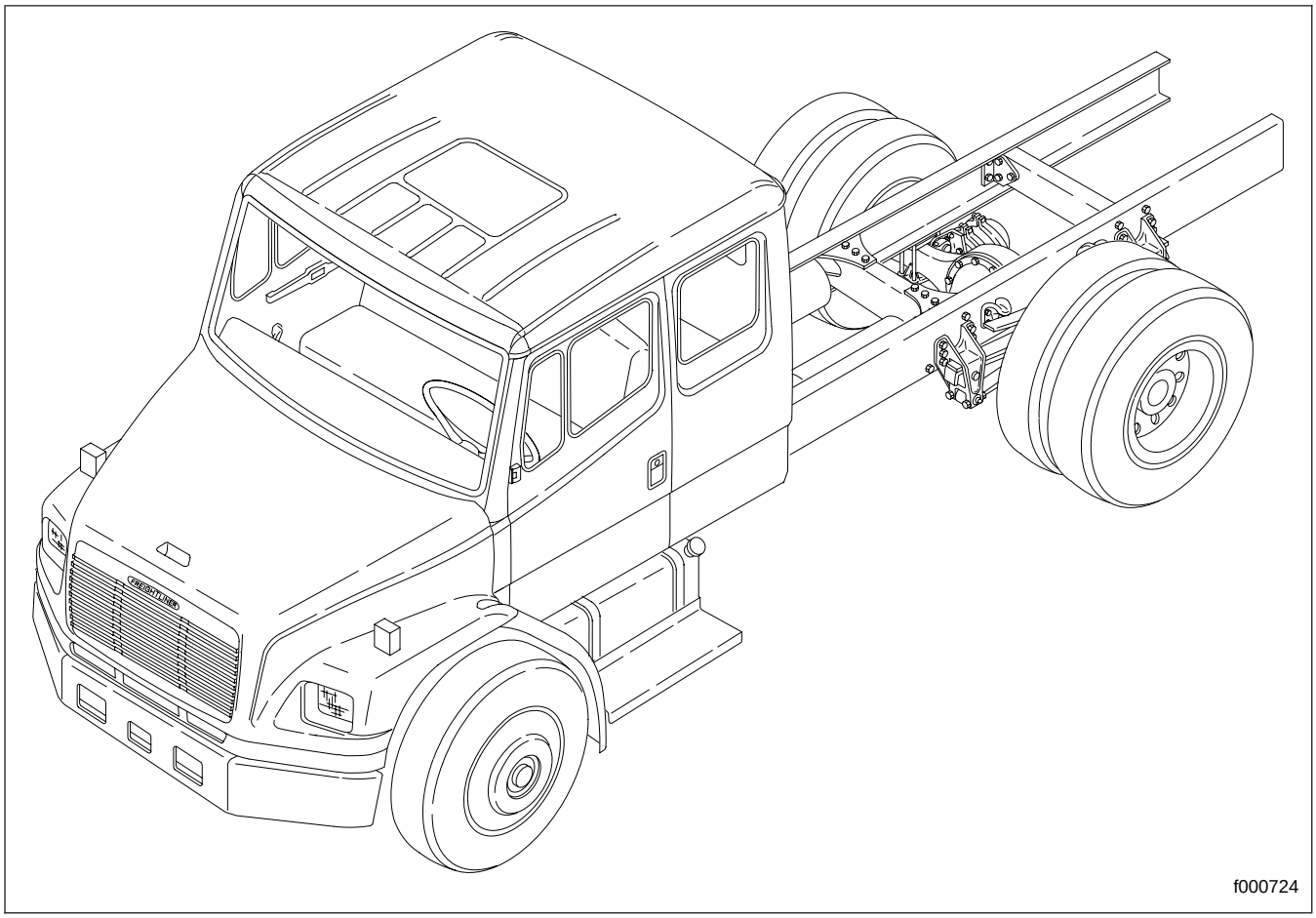
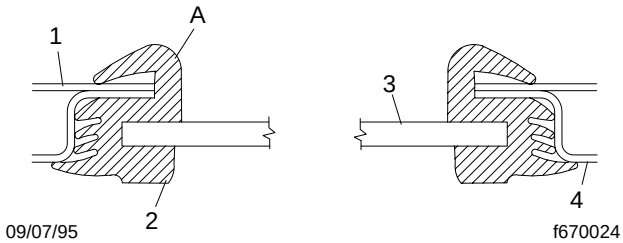


Fig. 1, Extended Cab, With Rear Side Windows

Removal and installation procedures are the same for both types of side windows: fixed, solid tempered glass, and moveable (tip out) window, as well as for the aluminum blanking plate.

The side window is retained in the cab opening by a reuseable rubber seal. **See Fig. 1.** No sealants or adhesives are used.



A. Cut this lip away from inside the cab if the seal will be replaced.
1. Cab Inner Skin
2. Window Seal
3. Side Window Glass
4. Cab Outer Skin

Fig. 1, Window Installation View

Side Window Removal

NOTE: Use an assistant to help you remove the side window. This will make the job easier, as well as reduce the possibility of accidental window breakage.

1. Protect the paint finish by taping paper around the side window opening.
2. Position your assistant outside the cab, and instruct him to apply constant, light hand pressure to the window. This will reduce the possibility of sudden window movement and dropping the window.
3. Remove the window.

   3.1 If the window seal will be replaced with a new seal, carefully cut the seal lip away from inside the cab. **See Fig. 1,** Ref. A.

   With the seal lip cut away, push the window and seal out of the cab opening.

   3.2 If the window seal will be re-used, use a windshield pick **(see Fig. 2)** to bend the seal lip away from the cab inner panel while pushing outward on the window. Start at a corner and work your way around the window until it can be pushed out of the cab opening.

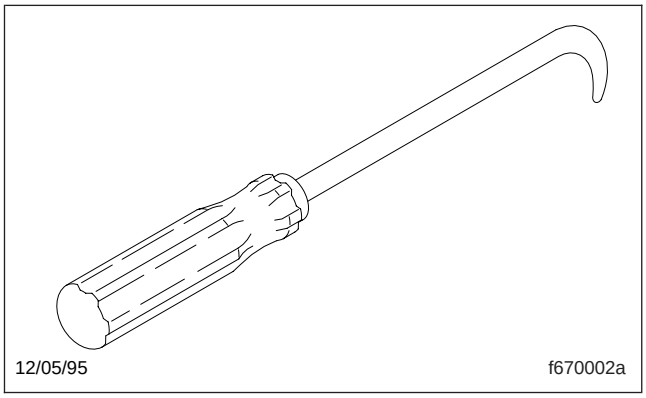


Fig. 2, Typical Windshield Pick

4. Separate the seal from the glass.

Side Window Installation

WARNING

WARNING: When handling side window glass, wear protective gloves to protect your hands from sharp edges and to allow a better grip. Not wearing protective gloves when handling glass could result in personal injury.

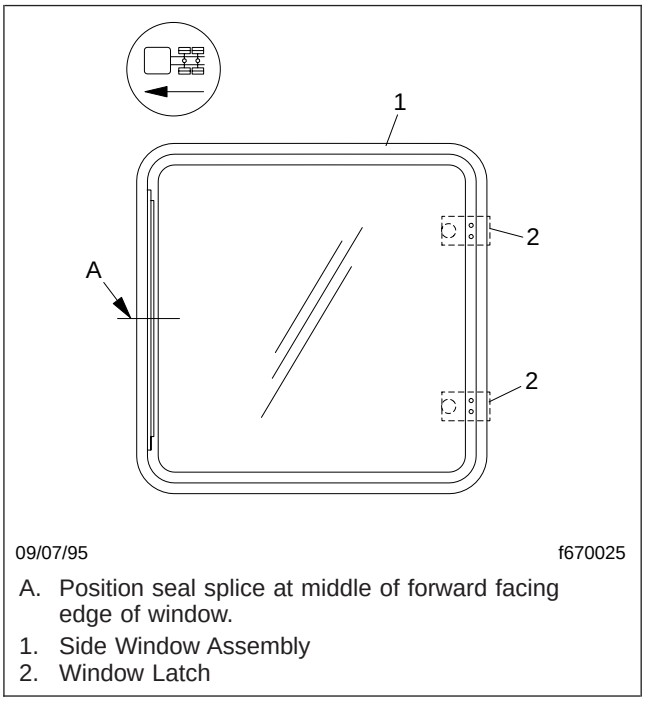
1. Clean the cab side window opening area using glass cleaner or a soap-and-water solution.
2. Lubricate the rubber window seal thoroughly with a soap-and-water solution. Make sure that all grooves in the seal are wetted.

NOTE: Before installing the window seal on the window glass or frame, be sure to position the seal splice at the middle of the forward facing edge of the window. **See Fig. 3.**

3. Stretch the rubber seal around the outside of the glass, window frame, or blanking plate.
4. Install two cords in the outside seal groove **(see Fig. 4)** as shown in **Fig. 5.** Leave the loose ends of the cords at the front and rear edges of the window.

NOTE: The cord should be a braided cotton cord (trade size number 5 minimum to number 8 maximum) with a reinforced core.

Side Window Removal and Installation



A. Position seal splice at middle of forward facing edge of window.
1. Side Window Assembly
2. Window Latch

Fig. 3, Seal Splice Location

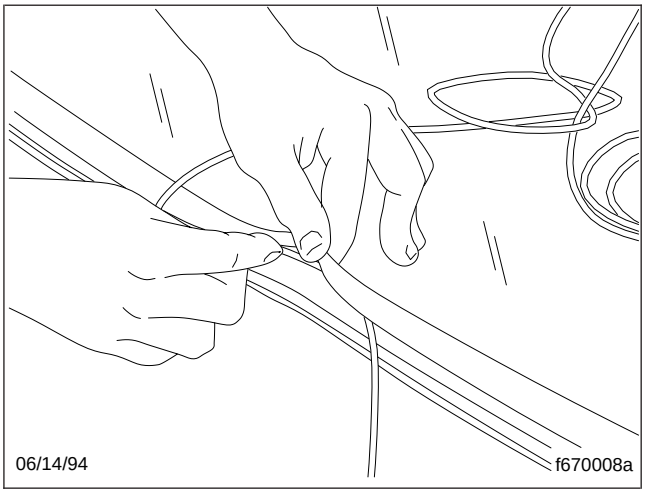


Fig. 4, Inserting Cord in Window Seal

5. Lubricate the window seal and the cord with a soap-and-water solution; then, wet the cab skin with plain clear water just before installing the window.
6. Have your assistant hold the window assembly in position against the cab window opening using light pressure. From inside the cab, pull one of the cord ends around a lower corner of the window, across the bottom, and up the other side.

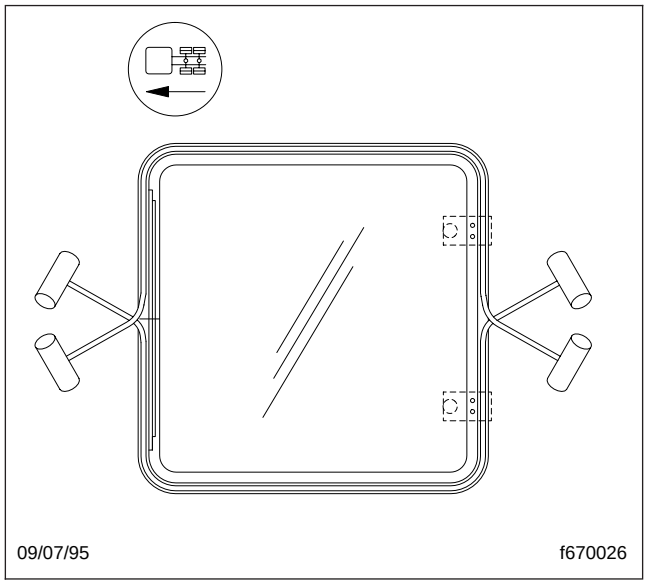


Fig. 5, Cord Installed in Window Seal

7. With the assistant maintaining pressure against the window, repeat the procedure with the other cord, going across the top of the window.
8. Using a sandbag, finish seating the glass by tapping on the glass until the glass and seal are correctly positioned. **See Fig. 1.**
9. Remove any protective paper and tape.

The tool shown in **Fig. 1**, and others, can be purchased from the following distributors:

Sommer & Maca
5501 West Ogden Avenue
Chicago, IL 60650
1–800–323–9200

C.R. Laurence Co., Inc.
P.O. Box 21345
Los Angeles, CA 90021-0345
1–800–421–6144

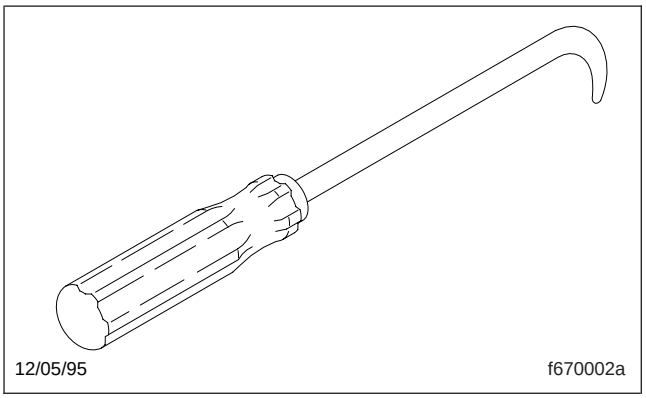


Fig. 1, Windshield Pick

Air Horn Valve Removal and Installation

Removal

1. Park the vehicle. Set the parking brake. Shut down the engine and chock the tires.
2. Disconnect the electrical supply.
3. Remove the left-side A-pillar cover.
4. Remove the driver's sun visor.
5. Remove the left-side speaker, or remove the speaker plug, if necessary.

NOTE: Removing the speaker or speaker plug allows access to the air horn valve and attached air lines and cables.

6. Disconnect the antenna cable, and move it aside.
7. Disconnect the air lines attached to the air horn valve. Mark the air lines for later reference.
8. Remove the fasteners that attach the air horn valve to the mounting bracket.
9. Disconnect the air horn control cable from the headliner and from the air horn valve.
10. Remove the air horn valve.

NOTE: It may be necessary to loosen the headliner above the door to allow for easier removal of the air horn valve.

Installation

1. Position the air horn valve.
2. Connect the air horn valve control cable to the air horn valve and to the headliner.
3. Attach the air horn valve to the mounting bracket.
4. Connect the air lines to the air horn valve.

⚠ CAUTION

CAUTION: Do not overtighten the air line fittings. Hand-tighten the fittings 1/2-turn after tightening begins.

5. Connect the antenna cable.
6. Install the speaker, or the speaker plug.
7. Install the sun visor, and the headliner, if loosened.
8. Install the A-pillar cover.
9. Connect the electrical supply.
10. Remove the chocks from the tires.

General Description and Principles of Operation

Freightliner designed and manufactured cab rear air-suspension systems are standard equipment on extended cab vehicles and FL112 day cabs. They are optional equipment on other day cab-equipped Business Class trucks.

The Freightliner system installed on FL112 day cab equipped vehicles mounts on top of a frame crossmember (see **Fig. 1**). The system installed on all other Business Class trucks mounts to a frame crossmember web (see **Fig. 2**).

The cab air-suspension system absorbs road shocks and compensates for changing cab loads. Both Freightliner cab air-suspension systems have the same basic parts: an air spring, a leveling valve, a shock absorber, a transverse torque arm, and top and bottom units. See **Fig. 1** and **Fig. 2**.

TOP AND BOTTOM UNITS

Both Freightliner systems are similar in design and operation. The main difference between the two systems is that the FL112 bottom unit mounts on top of a frame crossmember, while the bottom unit for other vehicles mounts to the back (web) of a frame crossmember.

For both systems, the top unit is secured to the cab rear crossmember by four bolts, and the bottom unit is secured to a frame crossmember by four bolts. See **Fig. 1** and **Fig. 2**. A transverse torque arm, which connects the bottom unit to a cab crosmember, prevents top-unit-to-bottom-unit side-to-side misalignment.

AIR SPRINGS

For both Freightliner systems, the top of the air spring has a stud which is secured to the top unit by a single nut; the bottom of the air spring is attached to the bottom unit by a single fastener as well.

Together with the leveling valve, the air spring compensates for changes in cab load by maintaining the correct distance between the rear of the cab and the frame rails.

LEVELING VALVE

All of the air in the cab air-suspension system is admitted through or exhausted from the leveling valve (**Fig. 1**, Ref. 6, and **Fig. 2**, Ref. 6). The leveling valve mounts on a bracket attached to the bottom unit. A horizontal arm connects the leveling valve control shaft to the vertical link attached to the top unit.

The same leveling valve (WABCO) is used on both Freightliner systems.

CAB-MOUNT STOP ASSEMBLY

The cab-mount stop assembly consists of a rubber bumper (**Fig. 1**, Ref. 4, and **Fig. 2**, Ref. 4), attached to the top unit. The bumper limits downward movement of the cab by contacting the bottom unit. If a leak occurs in the cab air-suspension system, the bumper supports the cab until the leak can be repaired.

NOTE: If a leak occurs in the cab air-suspension system, a pressure protection valve (located in the air supply line to the leveling valve) will maintain at least 65 psi (450 kPa) in the vehicle secondary air system.

SHOCK ABSORBER

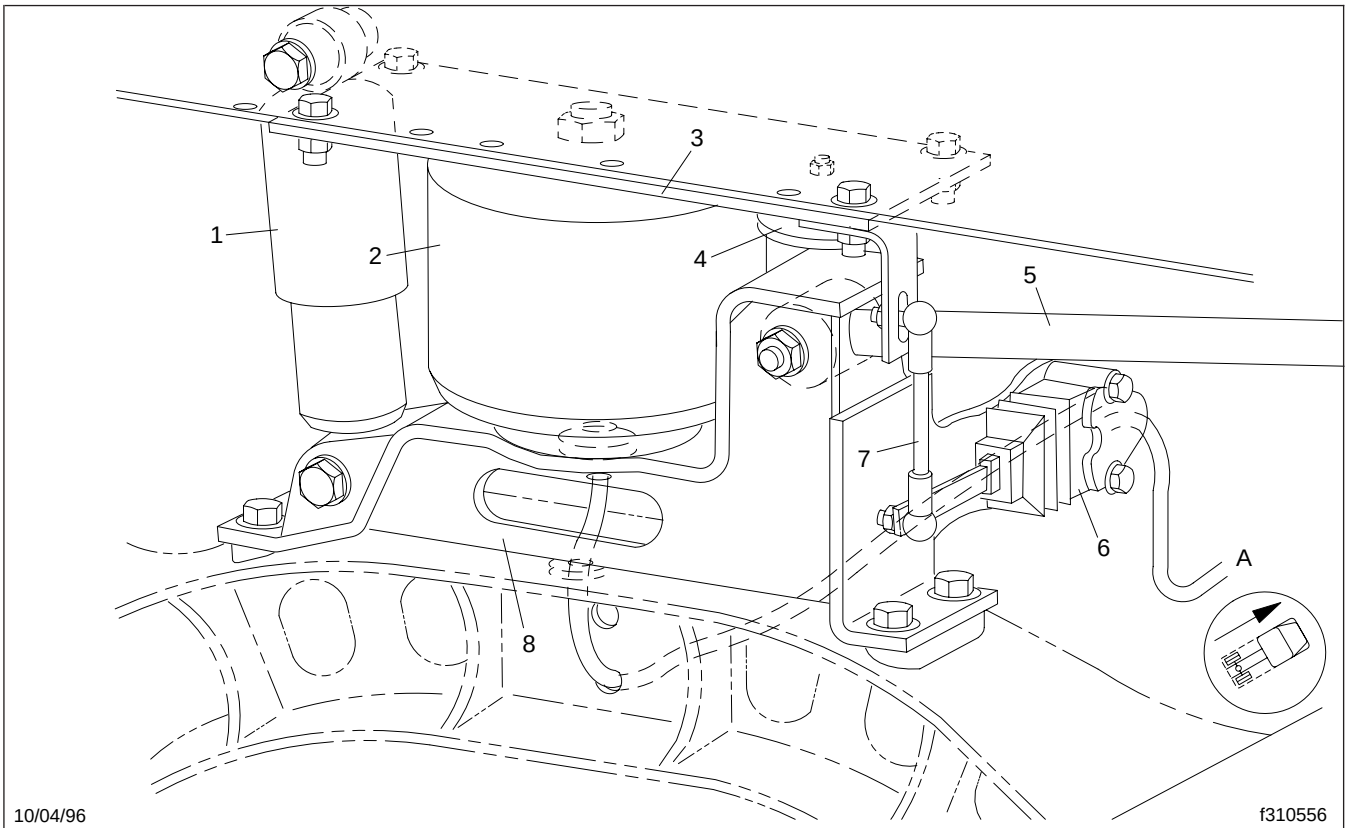
On both cab air-suspension systems, a single shock absorber attaches to the cab rear crossmember at the top, and to the bottom unit at the bottom. In addition to damping cab oscillations, the shock absorber limits upward movement of the rear of the cab.

SYSTEM OPERATION

When cab load increases, the distance between the top and bottom units decreases, causing the vertical link to push down on the leveling valve horizontal arm. This rotates the leveling valve control shaft, which activates an intake valve core inside the leveling valve. Air flows through the valve and tubing into the air spring, until increasing pressure in the spring raises the cab to the correct height. As the cab reaches the correct height, the horizontal arm and the control shaft return to their neutral positions, closing the intake valve, and stopping the flow of air into the air spring.

When cab load decreases, the rear of the cab rises, causing the vertical link to pull up on the end of the horizontal arm. Rotating the leveling valve control shaft in this direction activates an exhaust valve

General Description and Principles of Operation



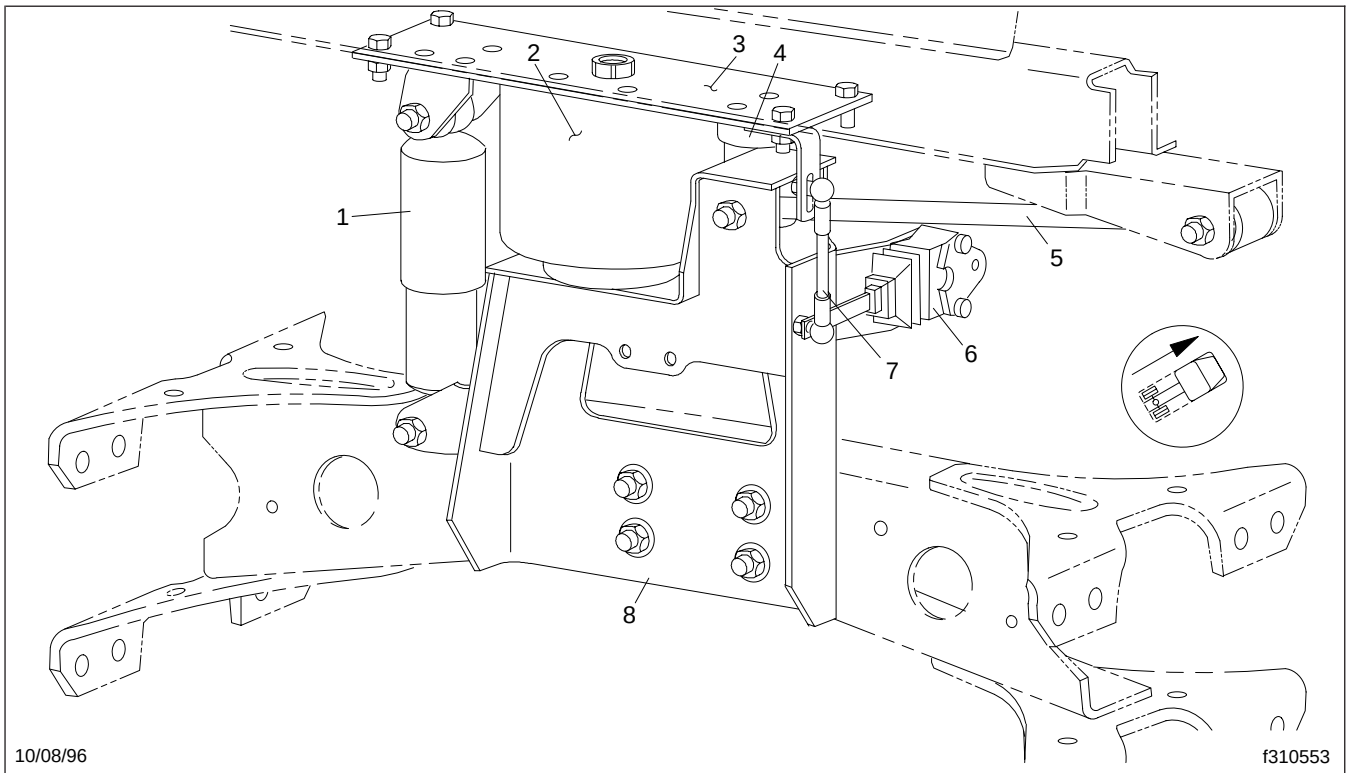
1. Shock Absorber
2. Air Spring
3. Top Unit
4. Rubber Bumper
5. Transverse Torque Arm
6. Leveling Valve
7. Leveling Valve Link
8. Bottom Unit

Fig. 1, FL112 Day Cab Air Suspension System

core. Air is exhausted from the spring until the cab lowers to the correct height. Again, the horizontal arm and control shaft return to their neutral positions as the cab reaches the correct height, and air exhausting is stopped.

When the vehicle is moving, small and abrupt movements of the cab will occur, resulting in movements of the leveling valve horizontal arm. Small movements of the arm do not activate the leveling valve because of a built-in free-travel range: a gap between the leveling valve control shaft and both of the valve cores (intake and exhaust). Abrupt movements do not activate the leveling valve because it is filled with a silicone fluid, which delays the opening of one valve core for as long as five seconds after the closing of the other.

Changes in load which result in larger movements of the horizontal arm (beyond the free-travel range) for more than five seconds will activate the leveling valve. Such changes in load occur when occupants or heavy items are added to, or removed from, the cab. Also, when the vehicle is moving forward at high speed or in a strong headwind, a major change in load occurs from the downward force applied by an optional air shield or air fairing. When these changes in load occur, the cab air-suspension system will adjust the height at the rear of the cab.



1. Shock Absorber
2. Air Spring
3. Top Unit
4. Rubber Bumper
5. Transverse Torque Arm
6. Leveling Valve
7. Leveling Valve Link
8. Bottom Unit

Fig. 2, Day Cab (except FL112) and Extended Cab Air Suspension System

Checks

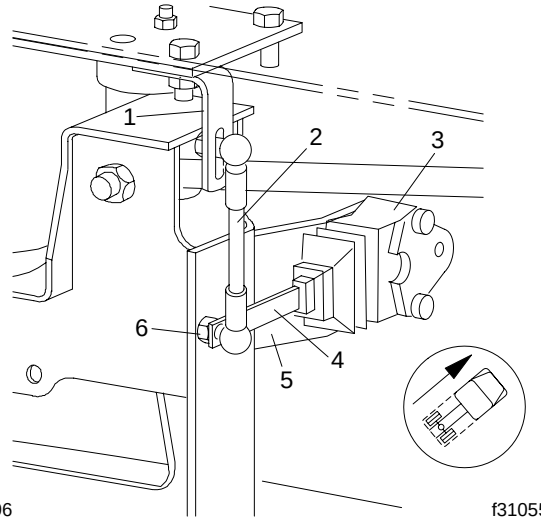
To keep the cab air-suspension system operating reliably, the air system must be kept free of oil, moisture, and other foreign material. Regularly inspect and maintain the vehicle air system components. See Group 42 of the *Business Class Trucks Maintenance Manual*.

⚠ CAUTION

Failure to take precautions against the entry of oil, moisture, and other foreign material into the cab air-suspension system could eventually lead to sludge forming in the air system. Sludge could adversely affect the operation of the cab air-suspension system and other air system components.

Before replacing the leveling valve, do the following steps to see if the valve is actually damaged, or is merely out of adjustment. These steps apply to both Freightliner systems.

1. Run the engine to build up vehicle air pressure to at least 100 psi (690 kPa). Shut down the engine.
2. Chock the tires to prevent the vehicle from moving.
3. Remove the hex nut and washer securing the vertical link (lower end) to the leveling valve horizontal arm. See **Fig. 1**.
4. Push the arm down about 45 degrees for 6 to 8 seconds. If air passes through the valve and inflates the air spring, that section of the valve is okay.
5. Return the lever to the neutral position. Air should stop flowing. If so, that section of the valve is okay.
6. Pull the lever up about 45 degrees for 6 to 8 seconds. If air exhausts from the air spring, that section of the valve is okay.
7. Return the lever to the neutral position. If the air stops again in the neutral position, the valve is working correctly.
8. If the valve works as stated in all of the above steps, no further checking is needed. Connect the vertical link to the horizontal arm.



1. Slotted Mounting Tab
2. Vertical Link
3. Leveling Valve
4. Leveling Valve Horizontal Arm
5. Leveling Valve Mounting Bracket
6. Hex Nut

Fig. 1, WABCO Leveling Valve and Linkage

If the valve doesn't work as stated in all of the above steps, replace it. Refer to **Subject 120** for instructions.

9. If adjustment of the leveling valve is needed, refer to **Subject 110**.

Leveling Valve Adjustment

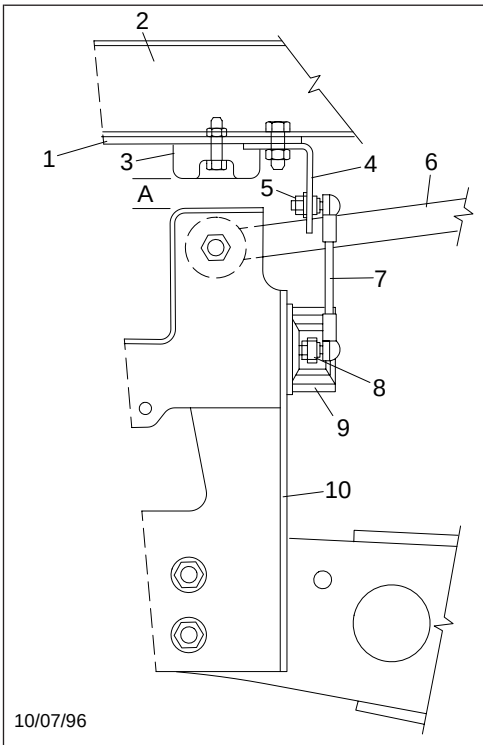
Adjustment

The leveling valve adjustment procedure is identical for both Freightliner cab rear air suspension systems.

1. Park the vehicle on a level surface and apply the parking brakes.
2. Run the engine to build up vehicle air pressure to at least 100 psi (690 kPa). Shut down the engine.
3. Chock the front tires to prevent the vehicle from moving.

IMPORTANT: Before checking leveling valve adjustment, make sure that the rubber bumper (see **Fig. 1** , Ref. 3) is present on the cab rear air suspension upper unit. If the rubber bumper is missing or in poor condition, replace it.

4. Check the leveling valve adjustment.
   - 4.1 Measure the distance from the bottom of the rubber bumper to the top of the bottom unit. It should be 3/4 to 1-1/8 inch (19 to 29 mm). **See Fig. 1** , Ref. A.
   - 4.2 If the distance is within specifications, no adjustment is needed. If it isn't, go to the next step.
5. Perform the leveling valve adjustment.
   - 5.1 Remove the hex nut (Ref. 5) securing the leveling valve control rod vertical link (upper end) to the slotted cab-mounting tab.
   - 5.2 Raise the rear of the cab by pushing down on the leveling valve horizontal arm.
   - 5.3 Insert a 7/8 inch (22 mm) spacer between the rubber bumper and the bottom unit.
   - 5.4 Lower the cab by pivoting the leveling valve lever upward until the rubber bumper contacts the spacer.
   - 5.5 Lift the flap on the side of the lever boot to expose the hole in the valve body and move the lever up and down slightly near the valve neutral position (lever horizontal) until the hole in the valve arm aligns with the hole in the valve body.
   - 5.6 Lock the leveling valve arm in the neutral position by inserting a 5/32" (4mm) pin or drill bit through the holes in the valve body and valve arm.
   - 5.7 Using a scribe or permanent ink marker, mark the vertical link upper stud centerline position on the slotted mounting tab.
   - 5.8 Remove the pin or drill bit previously inserted into the leveling valve.
   - 5.9 Push down on the leveling valve arm until enough air enters the air spring to lift the rubber bumper off the spacer.



A. 3/4 to 1-1/8 inch (19 to 29 mm)
1. Top Unit
2. Cab Rear Crossmember
3. Rubber Bumper
4. Slotted Mounting Tab
5. Hex Nut
6. Torque Arm
7. Vertical Link
8. Leveling Valve Horizontal Arm
9. Leveling Valve
10. Bottom Unit

Fig. 1, Freightliner Cab Rear Air Suspension Ride Height Measurement

Leveling Valve Adjustment

5.10 Remove the spacer, then raise the leveling valve arm until enough air exhausts from the air spring for the rubber bumper to contact the bottom unit.

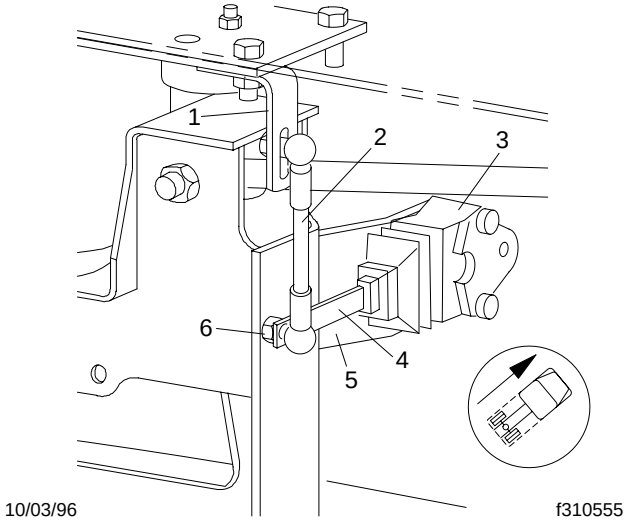
5.11 Insert the vertical link upper stud in the slotted tab and align the stud with the mark made on the tab. Let the system raise the cab, allowing about 5 seconds for the valve delay time.

5.12 Measure the distance between the rubber bumper and the bottom unit to ensure that it is between 3/4 and 1-1/8 inch (19 and 29 mm). If it is, install the vertical link hex nut and tighten it firmly. If it isn't, repeat the leveling valve adjustment procedure.

Replacement

NOTE: Before replacing the leveling valve, do the steps in **Subject 100** to see if the valve is actually damaged, or is merely out of adjustment.

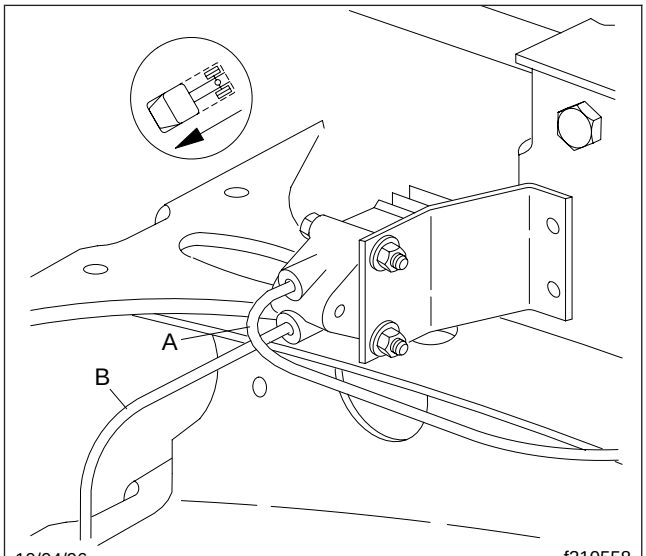
1. Chock the tires to prevent the vehicle from moving.
2. Remove the leveling valve.
   - 2.1 Remove the hex nut and washer securing the leveling valve control rod vertical link (lower end) to the leveling valve horizontal arm and disconnect the arm from the link. See **Fig. 1**. Save the nut and washer for attaching the link to the new valve.



1. Slotted Mounting Tab
2. Vertical Link
3. Leveling Valve
4. Leveling Valve Horizontal Arm
5. Leveling Valve Mounting Bracket
6. Hex Nut

Fig. 1, WABCO Leveling Valve and Linkage

   - 2.2 Raise the leveling valve arm, and hold it there to exhaust all air from the air spring.
   - 2.3 Disconnect the air lines from the fittings on the leveling valve. See **Fig. 2**. Mark the lines for assembly reference. Cover the open ends of the air lines to prevent dirt or other foreign material from entering the system.



A. to air supply
B. to air spring

Fig. 2, Air Line Connections, WABCO Leveling Valve

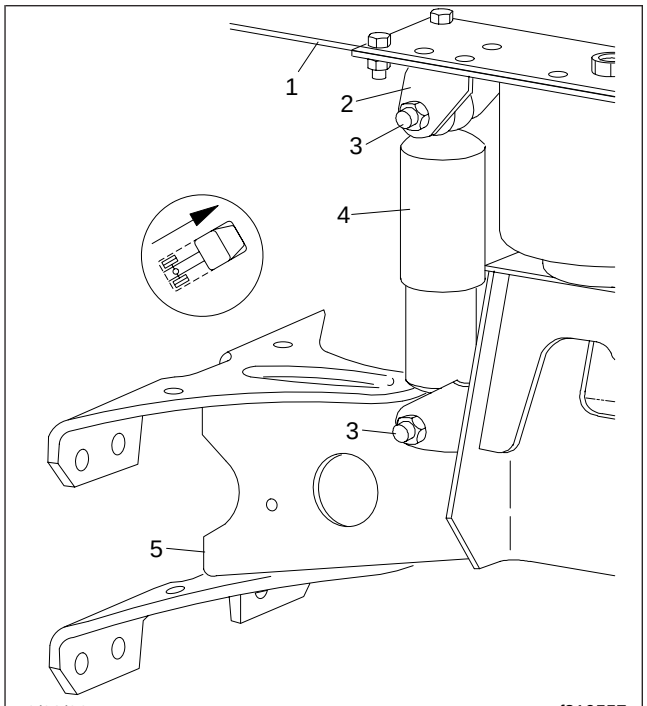
   - 2.4 Remove the leveling valve mounting fasteners; then, remove the valve from its mounting bracket.
3. Install the new leveling valve.
   - 3.1 Mount the new valve on the bracket. Tighten the hexhead capscrews 18 lbf·ft (24 N·m).
   - 3.2 Connect the valve horizontal arm to the vertical link. Tighten the nut securely.
   - 3.3 Remove the covers from the air lines. Connect the air lines to the leveling valve as marked earlier or as shown in **Fig. 2**. Tighten the fitting nuts finger-tight; then, tighten them two more turns or until no threads show on the fitting body.
4. Close the drain cocks on all air reservoirs. Run the engine to build up vehicle air pressure to at least 100 psi (690 kPa).
5. Check the operation of the new leveling valve. For instructions, refer to **Subject 100**.
6. Check all air lines and connections for leaks; eliminate any found.

Leveling Valve Replacement

7. Adjust the leveling valve. Refer to **Subject 110** for instructions.

Replacement

1. Chock the front tires to prevent vehicle movement.
2. Remove the locknuts from the shock absorber upper and lower mounting bolts. See **Fig. 1**.



1. Cab Rear Crossmember
2. Shock Absorber Upper Bracket
3. Mounting Nut, Bolt
4. Shock Absorber
5. Frame Crossmember

Fig. 1, Shock Absorber Mounting

3. Remove the bolts and pull the shock absorber out of the mounting brackets.
4. Install the replacement shock absorber in the mounting brackets, and secure it with the bolts and locknuts.
5. Tighten the locknuts 45 lbf·ft (61 N·m).
6. Remove the chocks from the front tires.

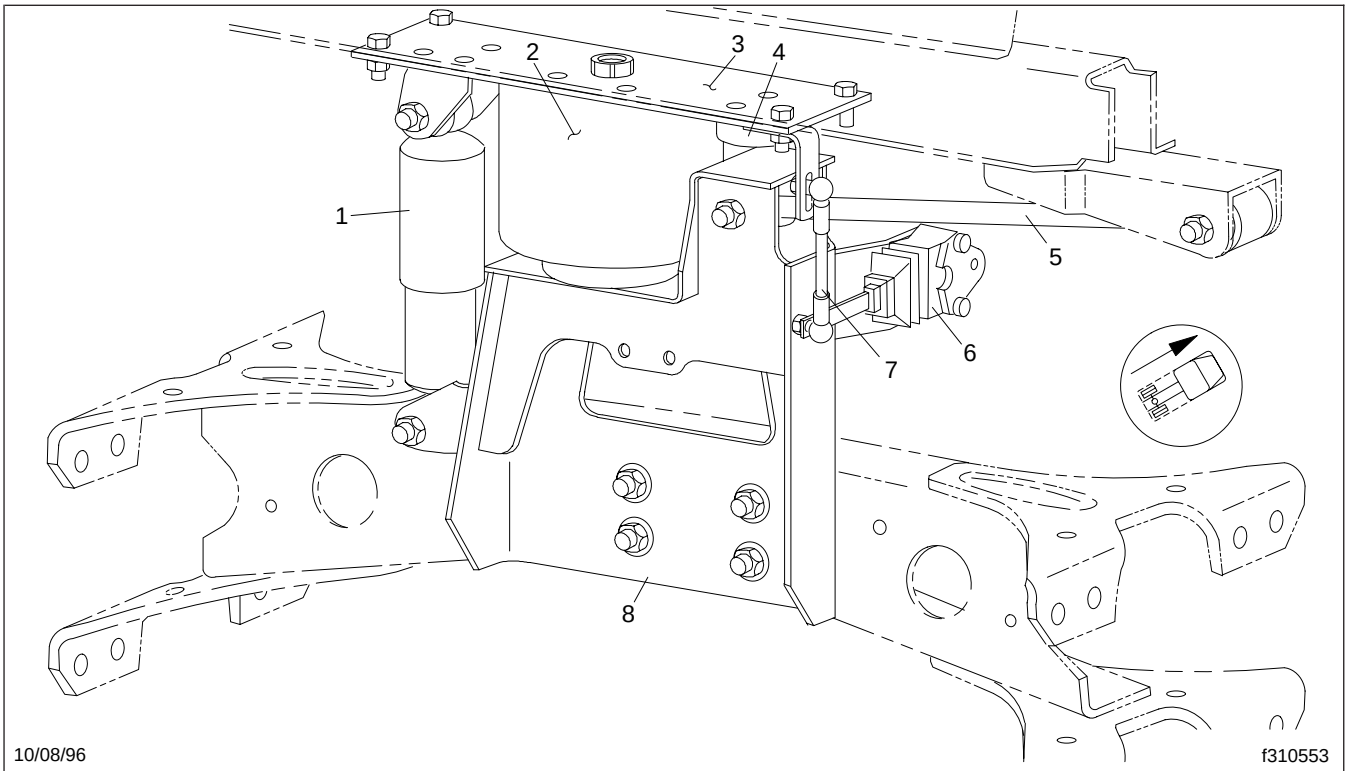
Replacement

1. Chock the front tires to prevent the vehicle from moving.
2. Drain the vehicle air system. For instructions, see Group 42 of the *Business Class Trucks Maintenance Manual*.
3. Remove the four bolts securing the cab air-suspension top unit to the cab rear crossmember. The right rear bolt also secures the leveling valve linkage slotted mounting tab to the cab. See **Fig. 1**.

DANGER

Before doing the work below, block the raised cab securely. Failure to block the cab while working on the cab rear air suspension system could allow the cab to fall, possibly resulting in serious injury or death.

5. With the cab raised, place blocks of wood between the frame rails and the cab rear crossmember on both sides of the vehicle. Then, lower the bottle jack and allow the cab to rest on the blocks of wood.



1. Shock Absorber
2. Air Spring
3. Top Unit
4. Rubber Bumper
5. Transverse Torque Arm
6. Leveling Valve
7. Vertical Link
8. Bottom Unit

Fig. 1, Cab Rear Air-Suspension System

4. Using a hydraulic bottle jack and blocks of wood (for spacers, if necessary), raise the rear of the cab until the cab suspension system shock absorber reaches its end stop.
6. Remove the air spring.
   - 6.1 Raise the slotted mounting tab, vertical link, and leveling valve horizontal arm and hold it up until all air exhausts from the air spring.

Air Spring Replacement

6.2 Disconnect the air spring air supply hose from the fitting on the bottom of the air spring. Cover the end of the hose to keep out dirt, moisture, etc.

6.3 Remove the fitting from the air spring being replaced.

6.4 Remove the nuts from the air spring upper and lower mounting bosses.

6.5 Remove the air spring.

7. Install a new air spring.

7.1 With the new air spring in its installed position, install the retaining nut on the air spring lower mounting boss and tighten it 60 lbf·in (700 N·cm).

7.2 Position the top unit over the air spring, making sure that the rubber bumper is on the right-hand side of the vehicle. Install the retaining nut on the air spring upper mounting boss and tighten it 60 lbf·in (700 N·cm).

7.3 Position the leveling valve slotted mounting tab (with vertical link and leveling valve horizontal arm atteched) at the right-hand rear corner of the upper unit, then install the four bolts securing the upper unit to the cab rear crossmember. Tighten the bolts 60 lbf·ft (81 N·m)

7.4 Install the air hose fitting in the air spring. Tighten it finger-tight plus one turn. Do not apply Teflon® tape to the fitting threads.

7.5 Remove the cover from the air spring supply line and attach the line to the air spring fitting. Tighten the air line nut finger-tight plus two turns or until no threads show on the fitting.

8. Using the hydraulic bottle jack, raise the rear end of the cab just enough to remove the wooden support blocks.

9. Lower the cab and remove the jack.

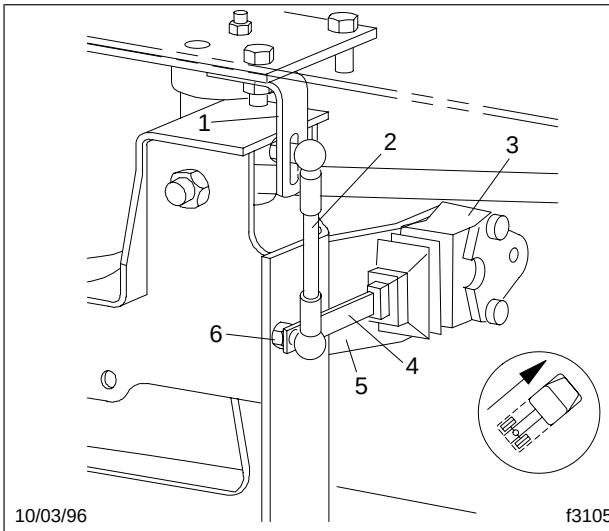
10. Start the engine and build vehicle air pressure to at least 100 psi (690 kPa).

11. Check for air leaks at the air spring and at the leveling valve. Tighten the fittings or replace the parts, if necessary.

12. Remove the chocks from the front tires.

Replacement

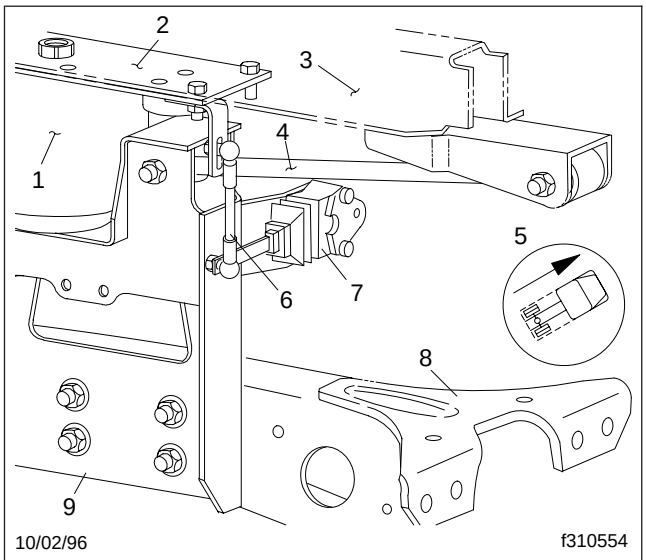
1. Chock the front tires to prevent the vehicle from moving.
2. Remove the hex nut securing the leveling valve arm to the vertical link. See **Fig. 1**.



1. Slotted Mounting Tab
2. Vertical Link
3. Leveling Valve
4. Leveling Valve Horizontal Arm
5. Leveling Valve Mounting Bracket
6. Hex Nut

Fig. 1, WABCO Leveling Valve and Linkage

3. Separate the leveling valve arm from the vertical link and raise the arm until the cab lowers onto its bottom stop.
4. With the cab lowered, lower the leveling valve arm to its neutral position and lock the arm there by inserting a 5/32" (4 mm) pin or drill through the hole in the valve body.
5. Remove the torque arm nuts. See **Fig. 2**.
6. Remove the torque arm bolts, then remove the torque arm from its mounting brackets.
7. Install the new torque arm in the mounting brackets and secure it with the mounting bolts and nuts.
8. Tighten the locknuts 45 lbf·ft (61 N·m).



1. Air Spring
2. Top Unit
3. Cab Rear Crossmember
4. Transverse Torque Arm
5. Torque Arm Fasteners
6. Vertical Link
7. Leveling Valve
8. Frame Crossmember
9. Bottom Unit

Fig. 2, Cab Rear Air-Suspension System

9. Connect the leveling valve arm to the vertical link and install the hex nut.
10. Tighten the hex nut securely.
11. Remove the chocks from the front tires.

Problem—Air Spring Is Flat

Possible Cause	Remedy
Low air pressure in the secondary air system.	Check the air pressure gauge on the instrument panel. If secondary air pressure is low, run the engine until at least 70 psi (482 kPa) is indicated.
Air is leaking from the cab air-suspension system.	Check for leakage from fittings, air lines, air springs, and the leveling valve. Tighten loose fittings to stop leakage; replace worn or damaged parts. Do not use Teflon tape on fittings.
The leveling valve is out of adjustment.	Adjust the leveling valve.
The leveling valve is inoperative.	If downward movement of the arm on a properly adjusted valve fails to inflate the air spring, replace the leveling valve.
The leveling valve linkage is damaged.	Check for damage to the leveling valve vertical link and arm Repair or replace damaged linkage parts.
The air spring is punctured.	Replace the air spring. Check the area around the damaged air spring for contact with other components. Correct the problem areas as needed.
The air spring is leaking due to continual or repeated over-extension.	Check the height of the air spring. Make sure the correct height is maintained. Adjust if needed. Check for a broken shock absorber or shock bracket; replace if broken.

Problem—Air Bags Deflate Rapidly When the Engine Is Not Running

Possible Cause	Remedy
Air is leaking from the cab air-suspension system.	Check for leakage from fittings, air lines, the air spring, and the leveling valve. Tighten loose fittings to stop leakage; replace worn or damaged parts. Do not use Teflon tape on fittings.

Problem—Rear of Cab Rides Too High or Too Low

Possible Cause	Remedy
The leveling valve is out of adjustment.	Adjust the leveling valve.

Problem—Bouncy Ride

Possible Cause	Remedy
The cab air suspension shock absorber is leaking or worn out.	Replace the shock absorber.

General Description

The Link Cabmate® cab rear air-suspension system is standard equipment on Crew Cab-equipped vehicles.

The cab rear air-suspension system absorbs road shocks and compensates for changing cab loads. The cab air suspension system consists of: an air spring, a height control valve, a shock absorber, a lateral control rod, top and bottom units, and left and right outrigger-style auxiliary jounce travel limiters. See **Fig. 1**.

FL106 models equipped with the Crew Cab also use a spacer between the top unit and the cab crossmember, but do not have the auxiliary jounce travel limiters. See **Fig. 2**.

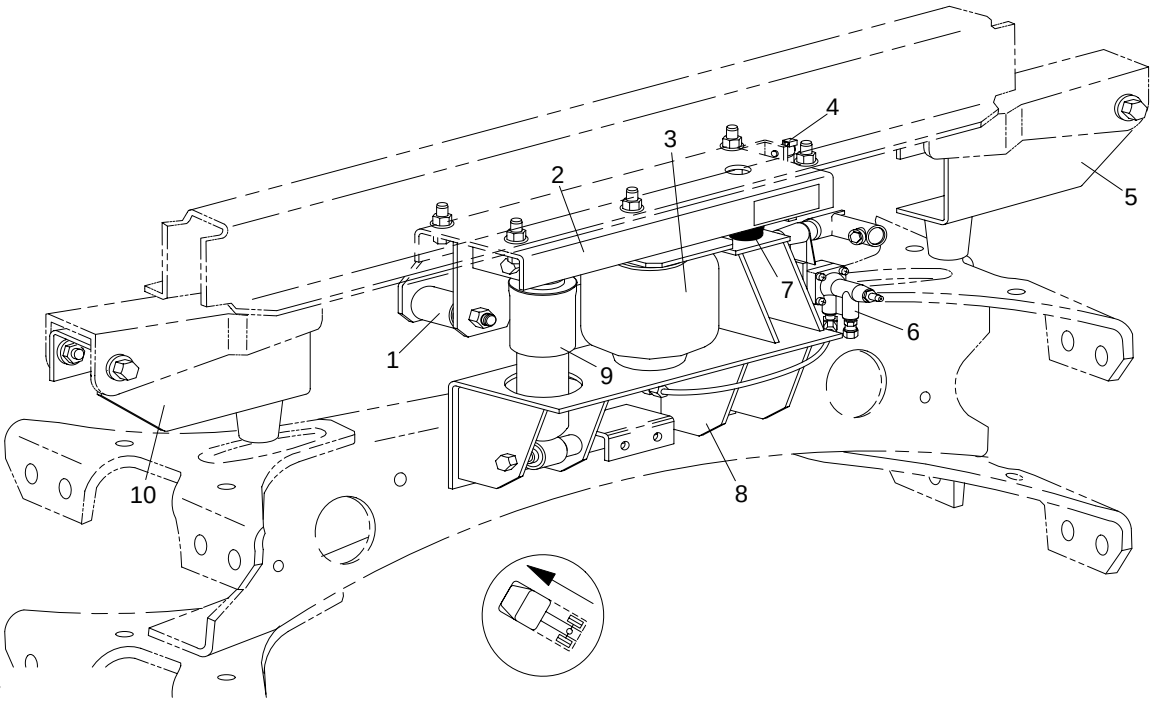
TOP AND BOTTOM UNITS

The top unit is secured to the cab rear crossmember by five bolts; the bottom unit is secured to a frame crossmember by four bolts. A lateral control rod, which connects the top and bottom units, prevents side-to-side misalignment. See **Fig. 1** and **Fig. 2**.

AIR SPRING

The top of the air spring has a threaded hole which mates with a stud welded to the top unit; the bottom of the air spring has a threaded stud and is attached to the bottom unit by a nut.

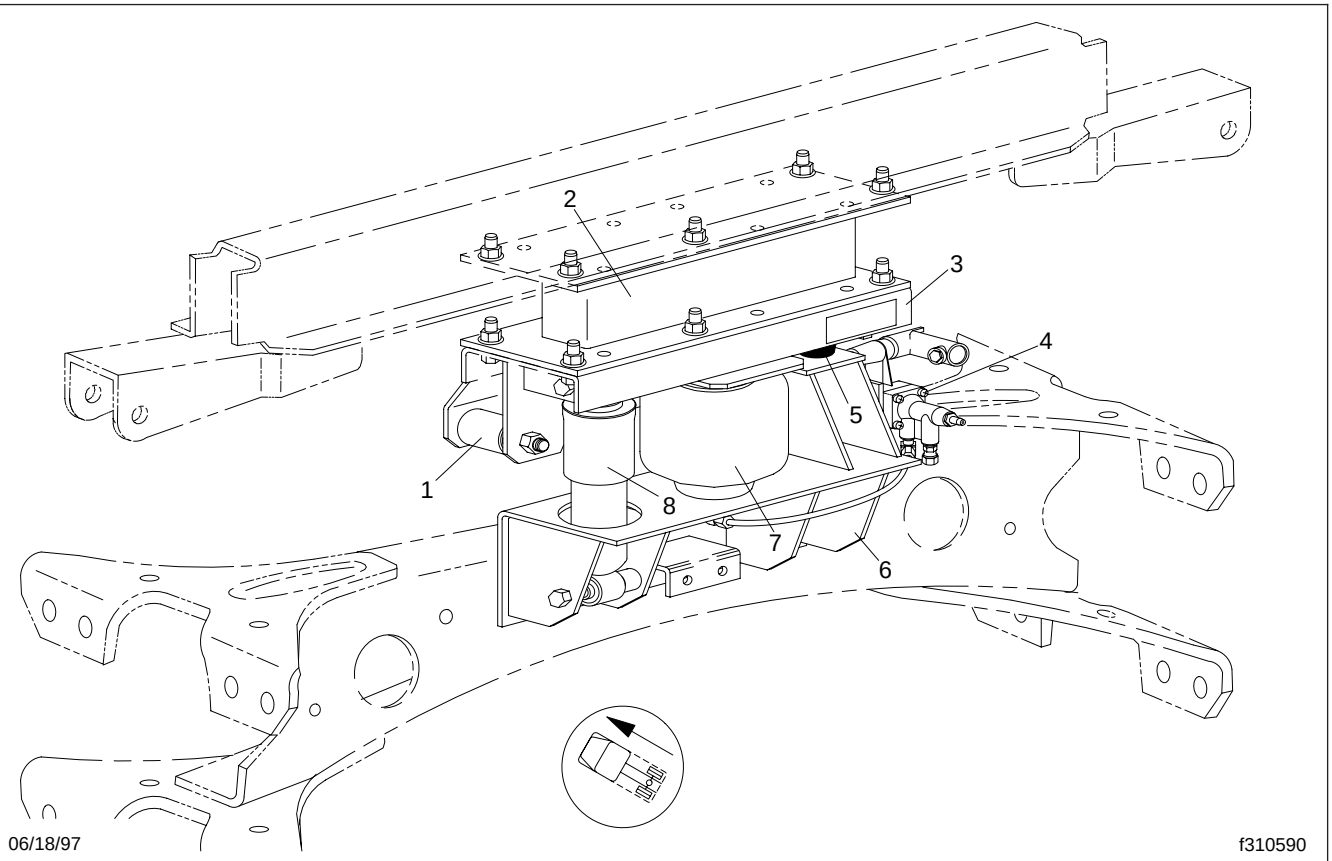
Together with the height control valve, the air spring compensates for changes in cab load by maintaining the correct distance between the rear of the cab and the frame rails.



1. Lateral Control Rod
2. Top Unit
3. Air Spring
4. Height Control Valve Link
5. Right Auxiliary Jounce Travel Limiter
6. Height Control Valve
7. Rubber Bumper
8. Bottom Unit
9. Shock Absorber
10. Left Auxiliary Jounce Travel Limiter

Fig. 1, Link Cabmate Cab Air Suspension System (All models except FL106)

General Description and Principles of Operation



1. Lateral Control Rod
2. Spacer
3. Top Unit
4. Height Control Valve
5. Rubber Bumper
6. Bottom Unit
7. Air Spring
8. Shock Absorber

Fig. 2, Link Cabmate Cab Air Suspension System (FL106 models only)

HEIGHT CONTROL VALVE

All of the air in the cab air-suspension system is admitted through or exhausted from the height control valve (**Fig. 1**, Ref. 6 or **Fig. 2**, Ref. 4). The height control valve mounts on a bracket attached to the bottom unit. A horizontal arm connects the valve control shaft to the vertical linkage attached to the top unit.

CAB-MOUNT STOP ASSEMBLY

The cab-mount stop assembly consists of a rubber bumper (see **Fig. 1**, Ref. 7 or **Fig. 2**, Ref. 5) attached to the top unit. The bumper limits downward movement of the cab by contacting the bottom unit. If a leak occurs in the cab air-suspension system, the bumper supports the cab until the leak can be repaired.

NOTE: If a leak occurs in the cab air-suspension system, a pressure protection valve (located in the air supply line to the leveling valve) will maintain at least 65 psi (450 kPa) in the vehicle secondary air system.

SHOCK ABSORBER

A single shock absorber attaches to both the top and bottom units. In addition to damping cab movement, the shock absorber limits upward movement of the rear of the cab.

AUXILIARY JOUNCE TRAVEL LIMITERS

On all models except the FL106, auxiliary jounce travel limiters (see **Fig. 1**, Refs. 5 and 10) are attached to the cab rear crossmember. Each travel limiter is fitted with a rubber bumper, which contacts the top of a frame crossmember to prevent excessive cab lean.

Principles of Operation

When cab load increases, the distance between the top and bottom units decreases, causing the vertical linkage to push down on the height control valve arm. This rotates the valve control shaft, which activates an intake valve core inside the valve. Air flows through the valve and tubing into the air spring, until increasing pressure in the spring raises the cab to the correct height. As the cab reaches the correct height, the horizontal arm and the control shaft return to their neutral positions, closing the intake valve core, and stopping the flow of air into the air spring.

When cab load decreases, the rear of the cab rises, causing the vertical linkage to pull up on the end of the horizontal arm. Rotating the height control valve control shaft in this direction activates an exhaust valve core. Air is exhausted from the spring until the cab lowers to the correct height. Again, the horizontal arm and control shaft return to their neutral positions as the cab reaches the correct height, and air exhausting is stopped.

When the vehicle is moving, small and abrupt movements of the cab will occur, resulting in movements of the height control valve arm. Small movements of the arm do not activate the valve because of a built-in free-travel range: a gap between the height control valve control shaft and both of the valve cores (intake and exhaust). Abrupt movements do not activate the valve because it is filled with a silicone fluid, which delays the opening of one valve core for as long as five seconds after the closing of the other.

Changes in load which result in larger movements of the horizontal arm (beyond the free-travel range) for more than five seconds will activate the height control valve. Such changes in load occur when occupants or heavy items are added to, or removed from, the cab. Also, when the vehicle is moving forward at high speed or in a strong headwind, a major change in load occurs from the downward force applied by an optional air shield or air fairing. When these changes in load occur, the cab air-suspension system will adjust the height at the rear of the cab.

Checks

To keep the cab air-suspension system operating reliably, the air system must be kept free of oil, moisture, and other foreign material. Regularly inspect and maintain the vehicle air system components. For instructions, see Group 42 of the *Business Class Trucks Maintenance Manual*.

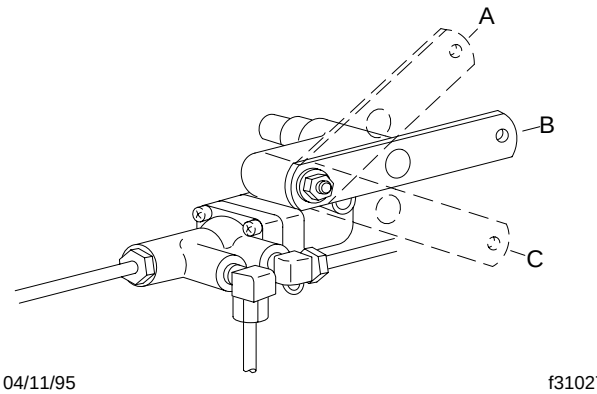
⚠ CAUTION

Failure to take precautions against the entry of oil, moisture, and other foreign material into the cab air-suspension system could eventually lead to sludge forming in the air system. Sludge could adversely affect the operation of the cab air-suspension system and other air system components.

Before replacing the height control valve, do the following steps to see if the valve is actually damaged, or is merely out of adjustment.

1. Chock the tires. Run the engine to build up vehicle air pressure to at least 100 psi (690 kPa).
2. Using a screwdriver, snap the vertical linkage off the horizontal arm attached to the height control valve.
3. Check the operation of the valve.
   - 3.1 Push the arm down about 45 degrees for 6 to 8 seconds. See **Fig. 1**, Ref. C. Air should pass through the valve and inflate the air spring.
   - 3.2 Return the arm to the neutral position. See **Fig. 1**, Ref. B. Air should stop flowing.
   - 3.3 Pull the arm up about 45 degrees for 6 to 8 seconds. See **Fig. 1**, Ref. A. Air should exhaust from the valve.
   - 3.4 Return the arm to the neutral position. The air should stops exhausting in the neutral position.
   - 3.5 If the valve works as stated in all of the above checks, no further checking is needed. Connect the vertical linkage to the valve horizontal arm.

If the valve doesn't work as stated in all of the above checks, replace it. See **Subject 120** for instructions.



A. Air Exhausts From Valve
B. Air Stops Flowing From Valve
C. Air Passes through Valve

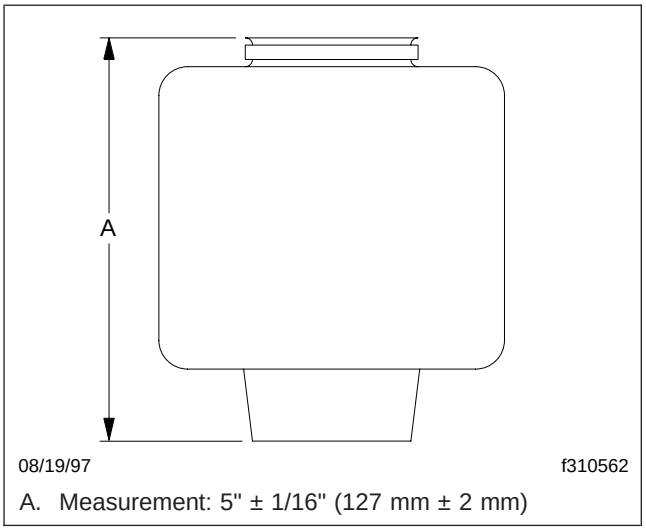
Fig. 1, Height Control Valve

4. If adjustment of the leveling valve is needed, see **Subject 110**.

Adjustment

1. Park the vehicle on a level surface and apply the parking brakes.
2. Chock the front tires to prevent the vehicle from moving.
3. Run the engine to build up vehicle pressure to at least 100 psi (690 kPa).
4. Check the height control valve adjustment.

   4.1 Measure the height of the air spring (see **Fig. 1**). It should be 5 inches ± 1/16 inch (127 mm ± 2 mm).



A. Measurement: 5" ± 1/16" (127 mm ± 2 mm)

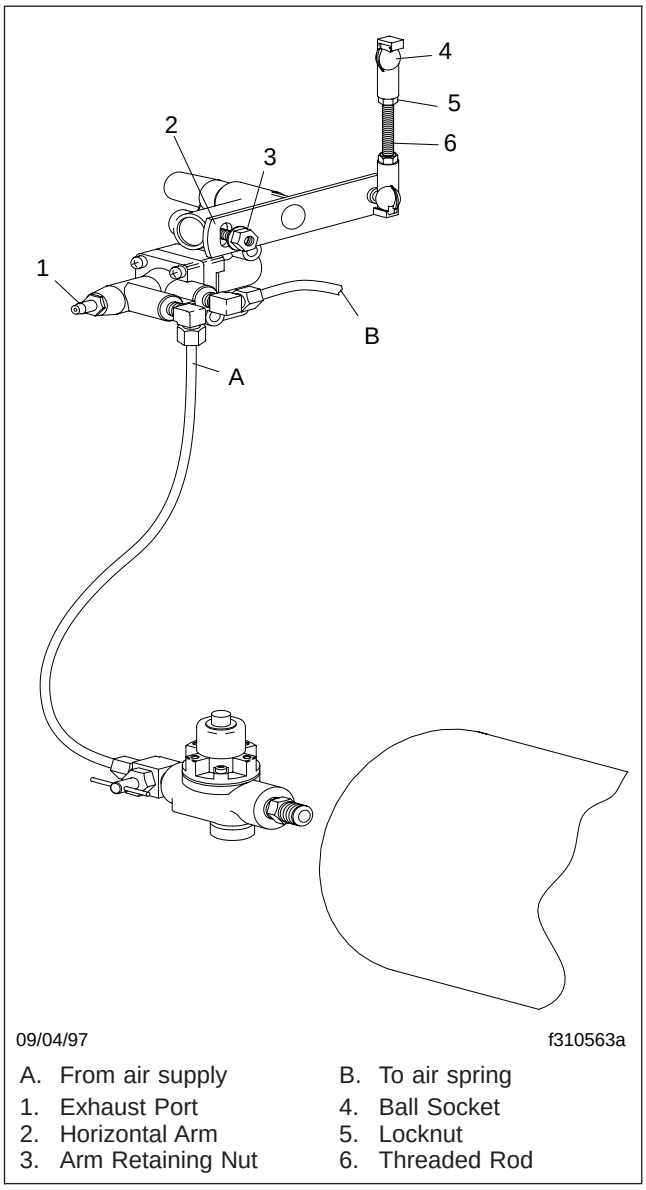
Fig. 1, Air Spring Height

   4.2 If the height is within specifications, no adjustment is needed. If it is not within specifications, go to the next step.

NOTE: If the air spring height is out of specification by more than 1/4 inch (6 mm), perform the coarse adjustment procedure. If design height is out of specification by less than 1/4 inch (6 mm), skip to the fine adjustment procedure.

5. Coarse adjustment is obtained by changing the position of the height control valve shaft, relative to the horizontal arm position.

   5.1 Loosen the retaining nut (see **Fig. 2**, Ref. 3) which secures the horizontal arm to the valve shaft.



A. From air supply
B. To air spring
1. Exhaust Port
2. Horizontal Arm
3. Arm Retaining Nut
4. Ball Socket
5. Locknut
6. Threaded Rod

Fig. 2, Height Control Valve and Linkage

   5.2 Move the height control valve shaft up or down, relative to the arm, until air spring height is within 1/4 inch (6 mm) of specifications.

   5.3 Using care to avoid moving the valve shaft, tighten the nut securing the horizontal arm to the valve shaft.

Height Control Valve Adjustment

6. When the required adjustment is less than 1/4 inch (6 mm), do the height control valve fine adjustment.

   6.1 Loosen the locknuts (**Fig. 2**, Ref. 5) securing the linkage ball sockets to the threaded rod.

   6.2 Lengthen or shorten the linkage as necessary by rotating the threaded rod in or out until the air spring design height is within specifications.

   6.3 Tighten the ball socket locknuts and recheck the air spring height. Make any corrections as needed.

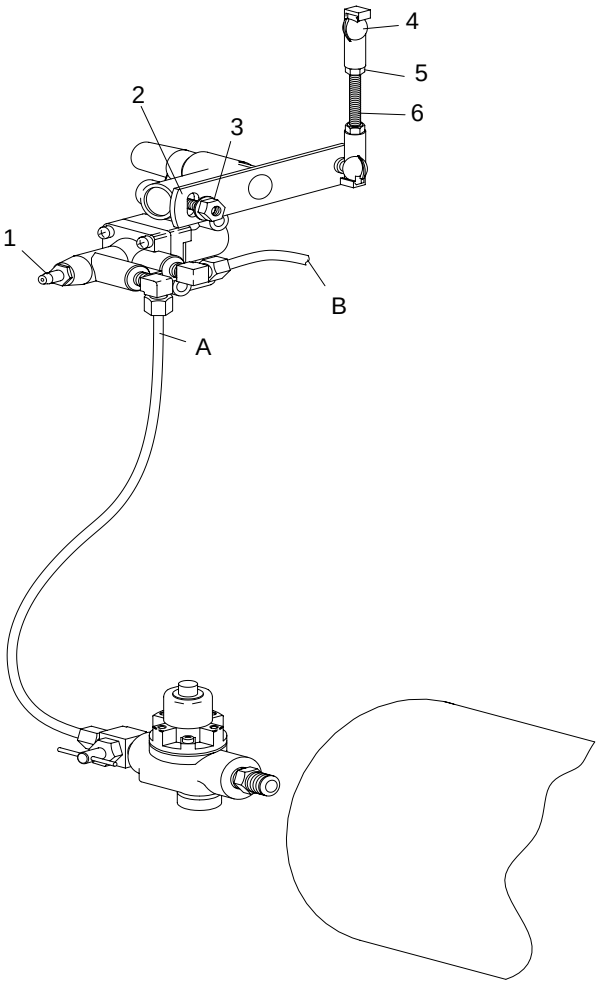
IMPORTANT: Because of a built-in delay in the height control valve, it may take as long as five seconds after making adjustments before the air spring height changes.

7. Remove the chocks from the front tires.

Replacement

NOTE: Before replacing the height control valve, do the steps in **Subject 100** to see if the valve is actually damaged, or is merely out of adjustment.

1. Park the vehicle on a level surface and apply the parking brakes.
2. Chock the front tires to prevent the vehicle from moving.
3. Drain the vehicle air system.
4. Remove the height control valve.
   - 4.1 Using a screwdriver, disconnect the vertical linkage ball socket from the height control valve horizontal arm. See **Fig. 1**, Ref. 4. Move the arm down, and hold it there to exhaust all air from the air spring.
   - 4.2 Remove the retaining nut (Ref. 3) that attaches the horizontal arm to the stud on the height control valve. Remove the arm, and save it for installation on the new valve.
   - 4.3 Disconnect the air lines from the fittings at the height control valve ports. Mark the lines for assembly reference. Cover the open ends of the air lines to prevent dirt or other foreign material from entering.
   - 4.4 Remove the height control valve mounting fasteners; then, remove the valve from its mounting plate.
5. Install the new height control valve.
   - 5.1 Mount the new valve on the plate. Tighten the hexhead capscrews 120 lbf·in (1350 N·cm).
   - 5.2 Mount the horizontal arm on the valve stud and tighten the locknut.
   - 5.3 Remove the covers from the air lines. Connect the air lines to the height control valve as marked earlier or as shown in **Fig. 1**. Tighten the fitting nuts hand-tight; then, tighten them one more turn or until no threads show on the fitting body.
6. Run the engine to build up vehicle air pressure to at least 100 psi (690 kPa).



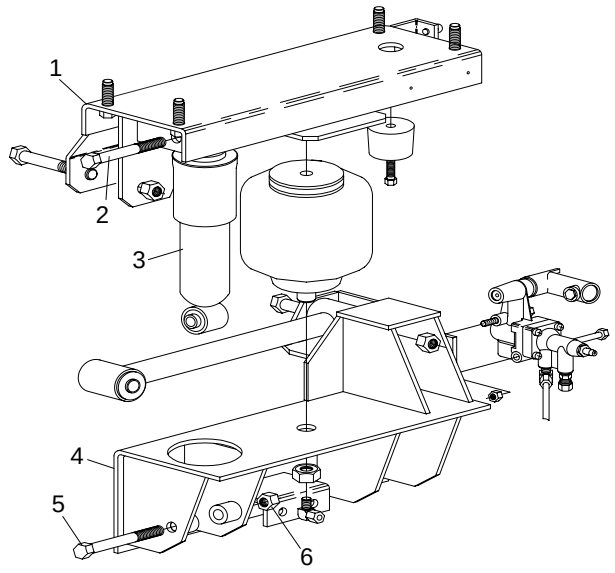
09/04/97 f310563a

A. From air supply	B. To air spring
1. Exhaust Port	4. Ball Socket
2. Horizontal Arm	5. Locknut
3. Arm Retaining Nut	6. Threaded Rod

Fig. 1, Height Control Valve and Linkage

7. Check the operation of the new height control valve. For instructions, see **Subject 100**.
8. Check all air lines and connections for leaks; repair as needed.
9. Adjust the height control valve. See **Subject 110** for instructions.
10. Remove the chocks from the front tires.

Replacement (See 1)



1. Top Unit
2. Upper Mounting Bolt
3. Shock Absorber
4. Bottom Unit
5. Lower Mounting Bolt
6. Locknut

Fig. 1, Shock Absorber Mounting

1. Park the vehicle on a level surface and apply the parking brakes.
2. Chock the front tires to prevent vehicle movement.
3. Remove the locknuts from the shock absorber upper and lower mounting bolts. Remove the bolts. Pull the shock absorber out of the mounting brackets.
4. Install the replacement shock absorber in the mounting brackets, and secure it with the bolts and locknuts.

NOTE: The longer bolt is used at the bottom of the shock absorber.

5. Tighten the locknuts 45 lbf·ft (61 N·m).
6. Remove the chocks from the front tires.

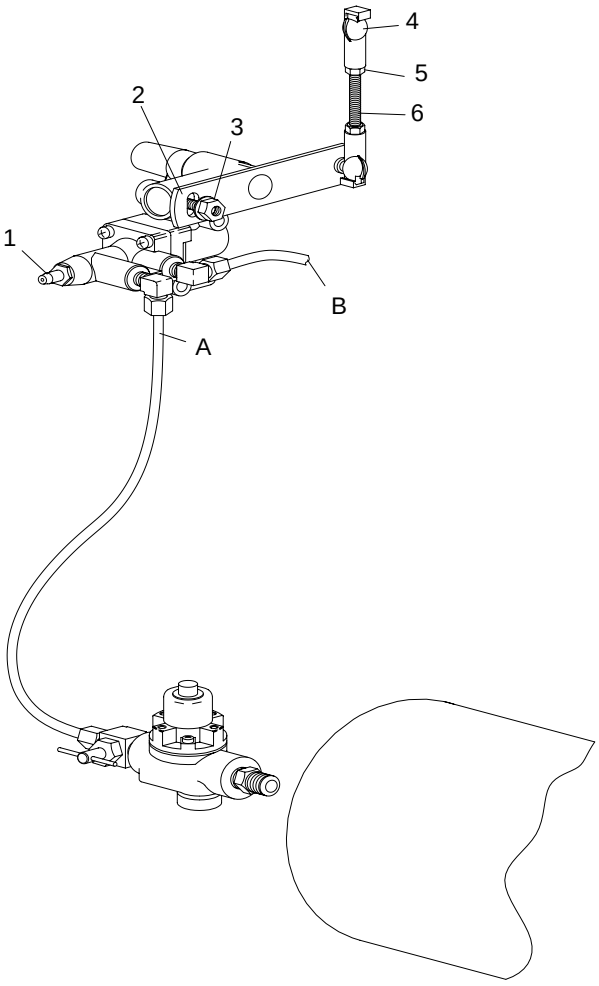
Replacement

1. Park the vehicle on a level surface and apply the parking brakes.
2. Chock the front tires to prevent the vehicle from moving.
3. Drain the vehicle air system.
4. Using a hydraulic bottle jack and blocks of wood (for spacers, if necessary), raise the rear of the cab until the cab suspension system shock absorber reaches its end stop.

⚠ DANGER

Before doing the work below, block the raised cab securely. Failure to block the cab while working on the cab rear air suspension system could result in serious injury or death.

5. With the cab raised, place blocks of wood between the frame rails and the cab rear crossmember on both sides of the vehicle. Then, lower the jack and allow the cab to rest on the blocks of wood.
6. Remove the air spring.
   - 6.1 Using a screwdriver, disconnect the ball socket (see **Fig. 1**, Ref. 4) from the height control valve arm. Move the arm up and hold it there until all air exhausts from the air spring.
   - 6.2 Disconnect the air supply hose from the fitting on the bottom of the air spring. See **Fig. 2**, Ref. 4. Cover the end of the hose to keep out dirt, moisture, etc.
   - 6.3 Unscrew the air fitting (Ref. 4) from the air spring.
   - 6.4 Remove the nut (Ref 3) securing the air spring to the bottom unit.
   - 6.5 Using both hands, grasp the air spring firmly and unscrew it from the stud on the top unit.
7. Install a new air spring.
   - 7.1 Position the new air spring under the top unit and screw it onto the top unit stud. Tighten the air spring finger-tight.

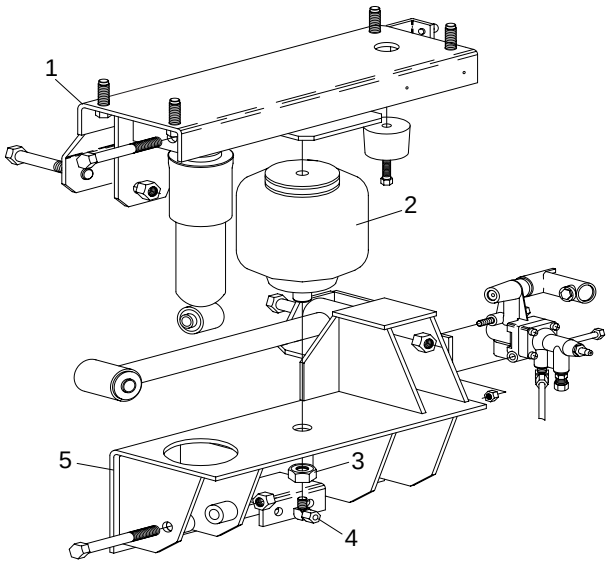


A. From air supply
B. To air spring
1. Exhaust Port
2. Horizontal Arm
3. Arm Retaining Nut
4. Ball Socket
5. Locknut
6. Threaded Rod

Fig. 1, Height Control Valve and Linkage

   - 7.2 Squeeze the air spring to extend it and insert its bottom stud through the mounting hole in the bottom unit. Install the lower mounting nut and tighten it finger-tight. Using a wrench, tighten one more turn.
   - 7.3 Install the air hose fitting (Ref. 4) in the air spring bottom stud. Tighten it finger-tight. Use a wrench to position the fitting

Air Spring Replacement



08/22/97 f310617

1. Top Unit
2. Air Spring
3. Lower Mounting Nut
4. Air Fitting
5. Bottom Unit

Fig. 2, Air Spring Mounting

so it faces rearward. Do not apply Teflon® tape to the fitting threads.

7.4 Remove the cover from the air spring supply line and attach the line to the air spring fitting. Tighten the air line nut finger-tight. Using a wrench, tighten one more turn.

8. Using the hydraulic bottle jack, raise the rear end of the cab just enough to remove the wooden support blocks.
9. Lower the cab and remove the jack.
10. Start the engine and build vehicle air pressure to at least 100 psi (690 kPa).
11. Check for air leaks at the air spring and at the height control valve. Tighten the fittings or replace the parts, if necessary.
12. Remove the chocks from the front tires.

Replacement

1. Park the vehicle on a level surface and apply the parking brakes.
2. Chock the front tires to prevent vehicle movement.
3. Drain the vehicle air system.
4. Using a screwdriver, disconnect the ball socket (see **Fig. 1**, Ref 4) from the height control valve arm.
5. Move the arm upward until all air exhausts from the air spring and the rubber bumper attached to the top unit contacts the bottom unit.
6. Remove the locknuts from the lateral control rod mounting bolts and remove the bolts. Pull the control rod out of the mounting brackets. See **Fig. 2**.
7. Install the replacement control rod in the mounting brackets, and secure it with the bolts and locknuts.

NOTE: The longer bolt is used to attach the control rod to the cab suspension top unit.

8. Tighten the locknuts 40 lbf·ft (54 N·m).
9. Connect the vertical linkage to the height control valve arm.
10. Start the engine and build vehicle air pressure to at least 100 psi (690 kPa).
11. Remove the chocks from the front tires.

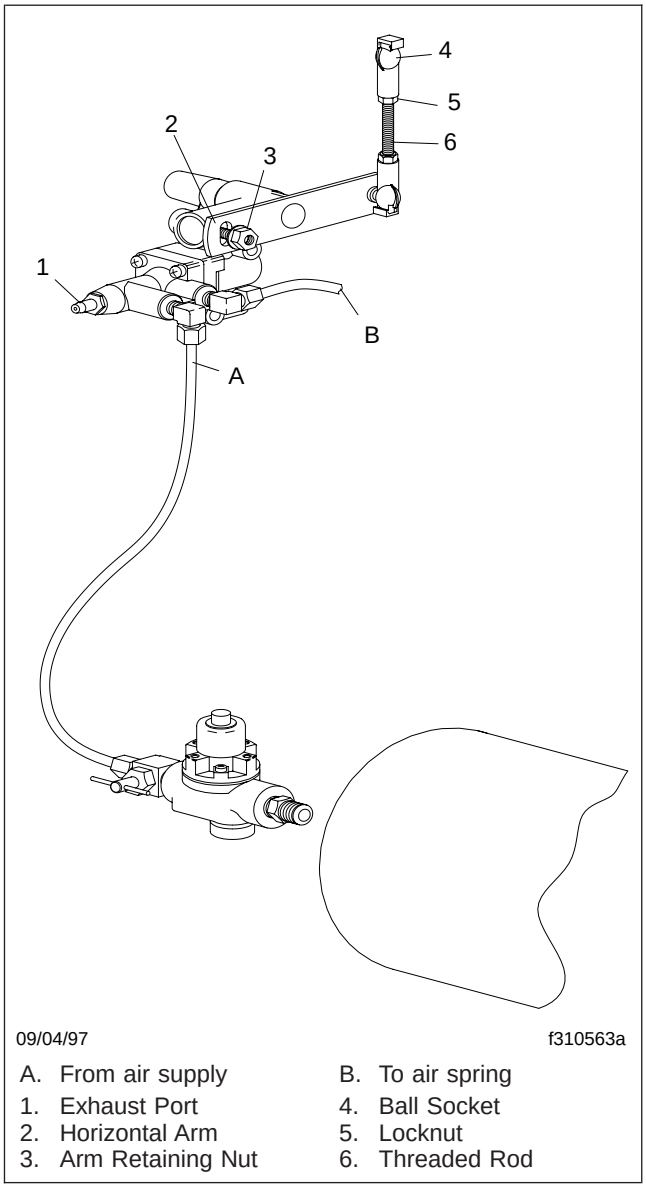
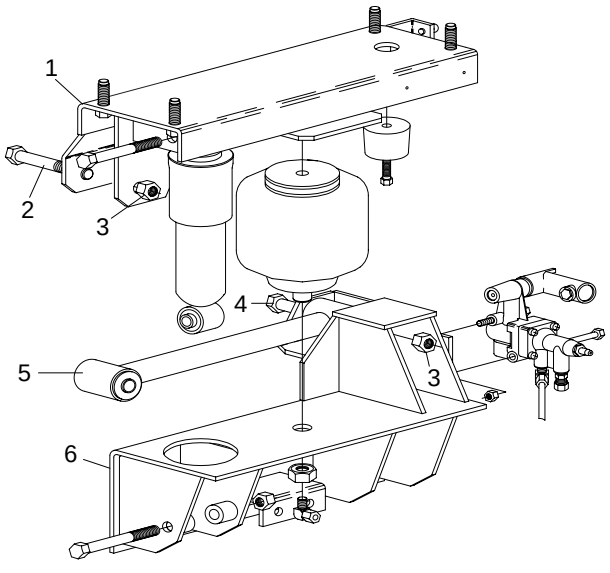


Fig. 1, Height Control Valve and Linkage

Lateral Control Rod Replacement



08/19/97 f310616

1. Top Unit
2. Upper Mounting Bolt
3. Locknut
4. Lower Mounting Bolt
5. Lateral Control Rod
6. Bottom Unit

Fig. 2, Lateral Control Rod Mounting

Troubleshooting Tables

Problem—Air Spring Is Flat

Possible Cause	Remedy
Low air pressure in the secondary air system.	Check the air pressure gauge on the instrument panel. If secondary air pressure is low, run the engine until at least 70 psi (482 kPa) is indicated.
Air is leaking from the cab air-suspension system.	Check for leakage from fittings, air lines, air spring, and the height control valve. Tighten loose fittings to stop leakage; replace worn or damaged parts. Do not use Teflon tape on fittings.
The height control valve is out of adjustment.	Adjust the height control valve.
The height control valve is inoperative.	If upward movement of the arm on a properly adjusted valve fails to inflate the air springs, replace the height control valve.
The height control valve linkage is damaged.	Check for damage to the height control valve linkage and the arm. Repair or replace damaged linkage parts.

Problem—Air Spring Deflates Rapidly When the Engine Is Not Running

Possible Cause	Remedy
Air is leaking from the cab air-suspension system.	Check for leakage from fittings, air lines, air springs, and the height control valve. Tighten loose fittings to stop leakage; replace worn or damaged parts. Do not use Teflon tape on fittings.

Problem—Rear of Cab Rides Too High or Too Low

Possible Cause	Remedy
The height control valve is out of adjustment.	Adjust the height control valve.

Problem—Collapsed Air Spring

Possible Cause	Remedy
An air spring is punctured.	Replace the air spring. Check the area around the damaged air spring for contact with other components. Correct the problem areas as needed.
The air spring is continually or repeatedly over-extended.	Check the height of the air spring. Make sure the correct height is maintained. Adjust if needed. Check for a broken shock absorber or shock bracket; replace if broken.

Problem—Bouncy Ride

Possible Cause	Remedy
The cab air suspension shock absorber is leaking or worn out.	Replace the shock absorber.

Specifications

Tightening Torques		
Description	**Size**	**Torque**
Air Line Fitting Nuts	—	finger-tight + one turn
Air Spring Air Fitting Nut (Plastic Fitting)	—	finger-tight + one turn
Height Control Valve Cover Screws	—	30 lbf·in (340 N·cm)
Height Control Valve Mounting Bolts	1/4 x 2 UNC	120 lbf·in (1350 N·cm)
Lateral Control Rod Mounting Bolts:		
Upper	1/2 x 3-1/4 UNF (Gr. 8)	40 lbf·ft (54 N·m)
Lower	1/2 x 3 UNF (Gr. 8)	40 lbf·ft (54 N·m)
Shock Absorber Mounting Bolts:		
Upper	7/16 x 3-1/4 UNF	45 lbf·ft (61 N·m)
Lower	7/16 x 3-3/4 UNF	45 lbf·ft (61 N·m)
Valve Arm Retaining Nut	1/4 UNC	84 lbf·in (940 N·cm)

Table 1, Tightening Torques

Cab Water-Leak Detection

Use the following procedure to locate areas where water may intrude into the cab.

1. With the vehicle parked, apply the parking brakes and chock the tires.
2. Prepare a wash solution of at least one-quarter cup of soap to one gallon of water in a spray bottle.
3. Close all doors, windows, and vents.
4. With the HVAC system in "Fresh Air" mode, turn the fan blower motor on high.

NOTE: Perform the leak detection test with the HVAC system in the "Fresh Air" mode only. Do not set the system in the "Recirculation" mode.

5. Spray the cab with the wash solution and look for bubbles. See **Fig. 1**. Inspect all applicable areas listed below:
    - windshield perimeter
    - visor brackets (if so equipped)
    - air horns and marker lights (if so equipped)
    - roof deflector mounts (if so equipped)
6. Mark areas of suspected leaks.

NOTE: This method of leak detection may also identify areas that will not leak water, even though those areas produce bubbles. Bubbles around door seals and along the vehicle side walls will likely not cause water intrusion issues.

If small bubbles are found in an area that is not suspected to leak, a repair may not be necessary.

7. Rinse the wash solution off the vehicle with water.
8. Turn off the fan blower motor.
9. Remove the chocks from the tires.

Cab Water-Leak Repair

If a leak is found, the repair method will depend on the area and type of leak. It may be necessary to remove some components, though most leaks should be repairable by sealing the area of the leak with silicone sealant.

Repair leaks in the windshield using the approved method. See **Section 60.01, Subject 100**.

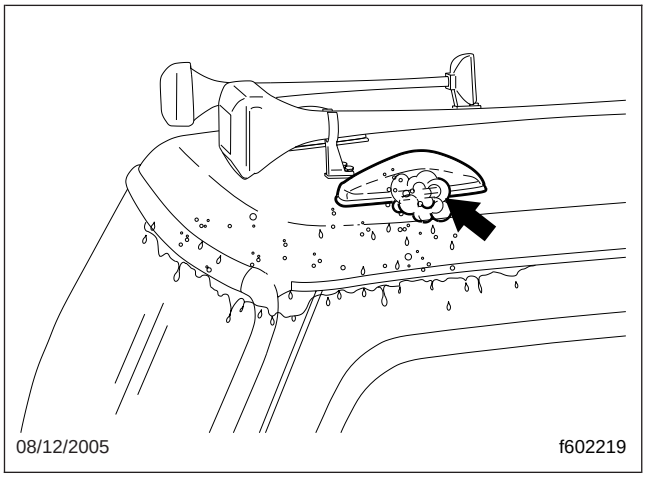


Fig. 1, Cab Water-Leak Detection with Wash Solution

General Information

The cab door features a steel outer skin, welded to a one-piece formed steel inner panel and frame, to make a highly rigid assembly. The unitized construction provides necessary support for various parts attached to the door.

A sector-gear-and-arm window regulator assembly raises and lowers the roll-up window. **See Fig. 1** , Refs. 7 and 4. The regulator assembly bolts to the inner door panel (Ref. 3). Window up-and-down movement is guided by a channel assembly (Ref. 5). The lower portion of the channel assembly bolts to the inside of the inner door panel; screws are installed in the channel around the window opening. A glass-lift support and roller guide (Ref. 8) supports the window at its lower edge.

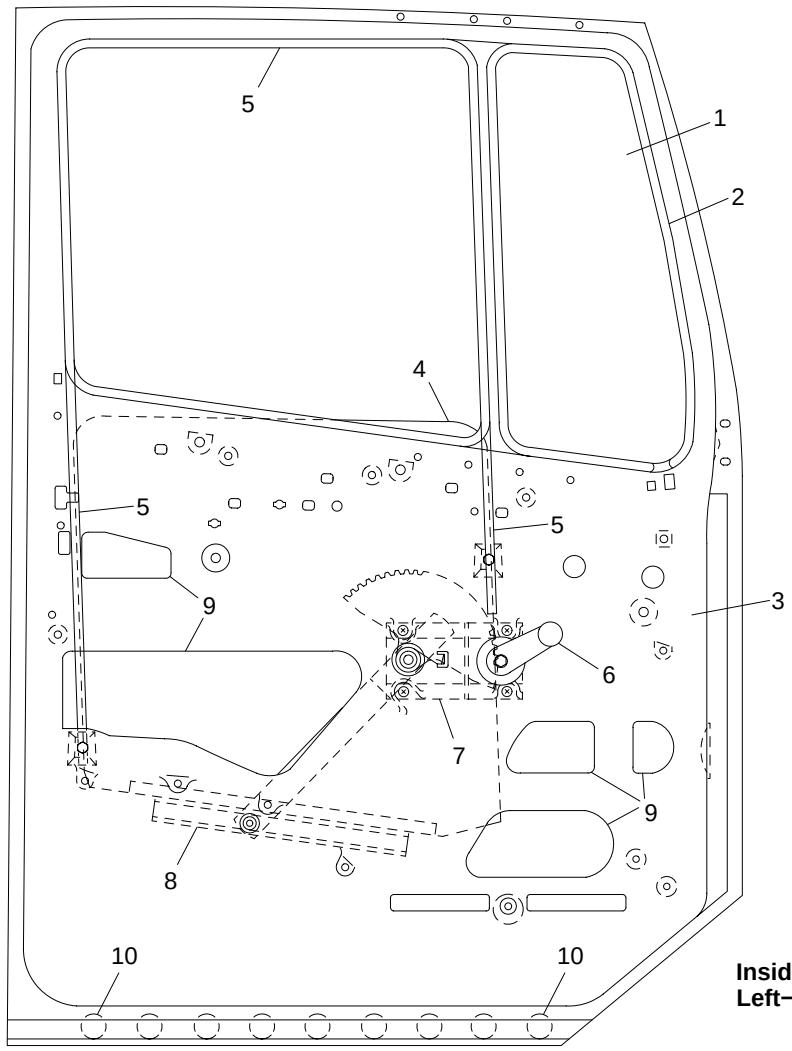
A fixed-position wing window is installed in each door, ahead of the roll-up window. **See Fig. 1** , Ref. 1. A one-piece weather seal (Ref. 2) surrounds each wing window opening.

A door-latch handle inside the cab is recessed in an armrest and grab-handle assembly (called the inner door handle). **See Fig. 2** , Ref. 1. A rod (Ref. 3) links the inner door handle with the latch and lock mechanisms (Refs. 6, 11, and 12) at the rear of the door frame. The flush-mounted exterior door handle assembly (Ref. 10) attaches to the door with two handle retainer clips (wedges) (Ref. 15) from the inside. The lockset tumbler (Ref. 11) is installed just above the paddle handle in the exterior door handle assembly.

Openings in the inner door panel provide easy access to the window regulator and to the latch and lock mechanisms. **See Fig. 1** and **Fig. 2.** Three sections of sound-damping material are bonded to the inside of the outer door skin. Drain holes in the bottom of the door prevent any water from collecting.

Two widely spaced hinges attach the door to the front door post of the cab door-opening frame. **See Fig. 3** , Refs. 2, 7, and 3. The hinges can be independently positioned for in-and-out, fore-and-aft, and up-and-down adjustment. A door check arm (Ref. 8) prevents the door from being opened too far. A door-latch striker pin (Ref. 11) attaches to a floating plate in the rear door post of the cab door-opening frame, and can be adjusted vertically and horizontally to correctly engage the latch assembly jaw (Ref. 9). For fore-and-aft adjustment, shims (Ref. 12) are added (or removed) behind the striker pin coned washer. The circumference of the cab door-opening frame is sealed with a strip of preformed rubber (Ref. 5).

General Information



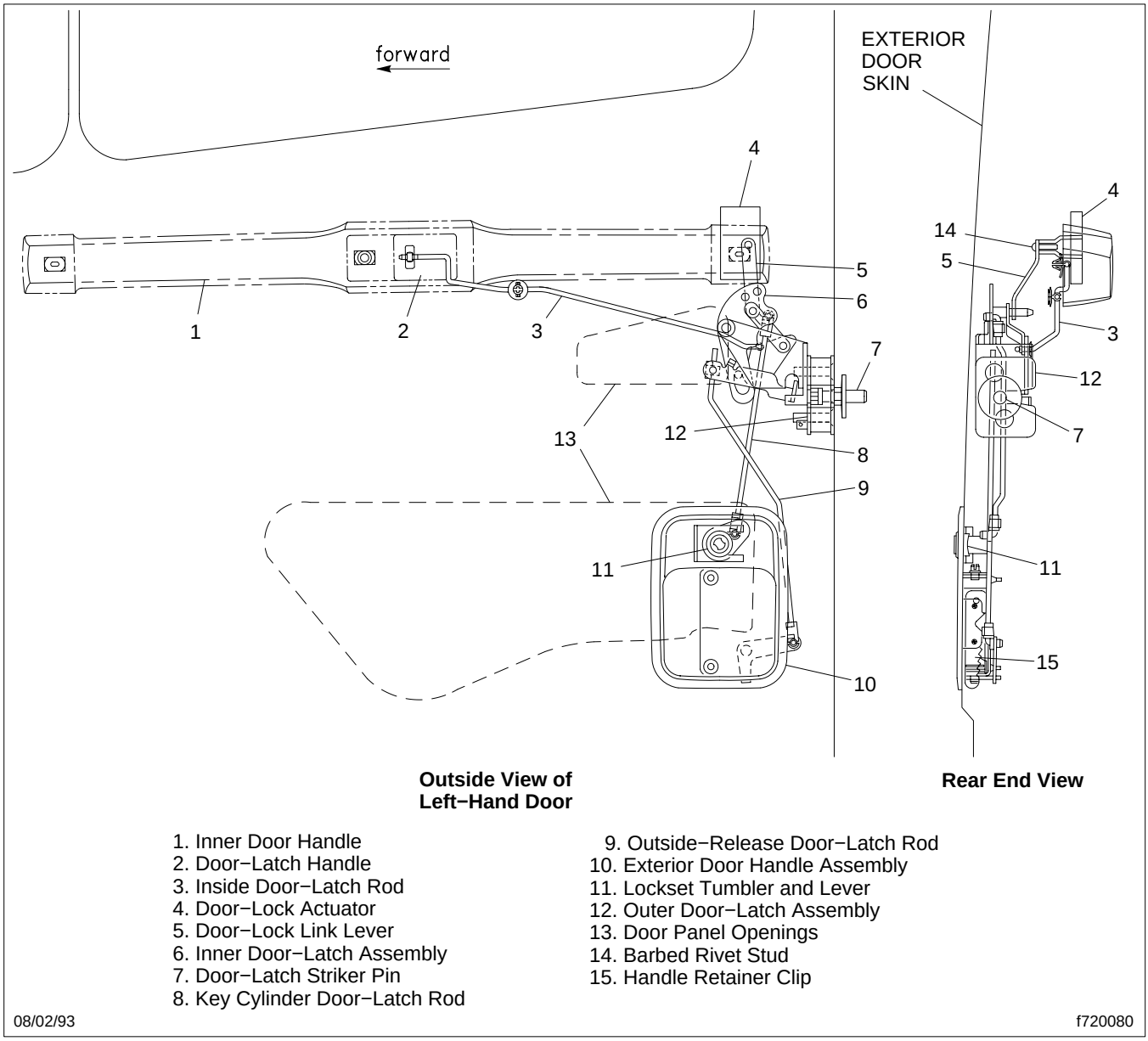
1. Fixed−Position Wing Window
2. Wing Window Weather−Seal
3. Inner Door Panel
4. Roll−up Window
5. Window−Glass Channel Assembly
6. Window Regulator Crank Arm
7. Sector−Gear−and−Arm Window Regulator Assembly
8. Glass Lift−Support and Roller Guide
9. Door Panel Openings
10. Drain Hole

NOTE: Interior door trim panel, inner door handle assembly, and door moulding are not shown.

Inside View of Left−Hand Door

08/02/93 f720077

Fig. 1



Outside View of Left−Hand Door

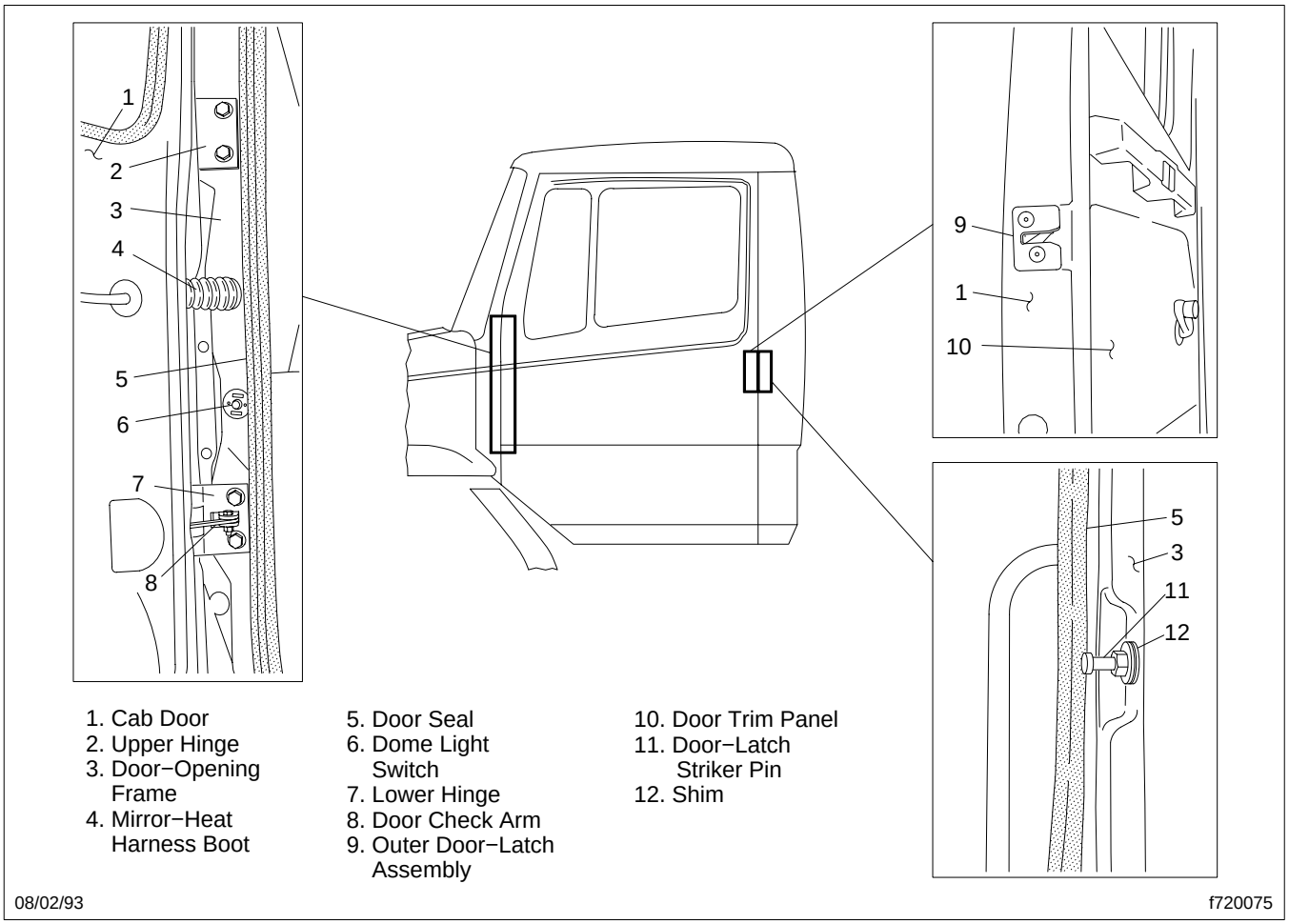
Rear End View

1. Inner Door Handle
2. Door−Latch Handle
3. Inside Door−Latch Rod
4. Door−Lock Actuator
5. Door−Lock Link Lever
6. Inner Door−Latch Assembly
7. Door−Latch Striker Pin
8. Key Cylinder Door−Latch Rod
9. Outside−Release Door−Latch Rod
10. Exterior Door Handle Assembly
11. Lockset Tumbler and Lever
12. Outer Door−Latch Assembly
13. Door Panel Openings
14. Barbed Rivet Stud
15. Handle Retainer Clip

08/02/93 f720080

Fig. 2

General Information



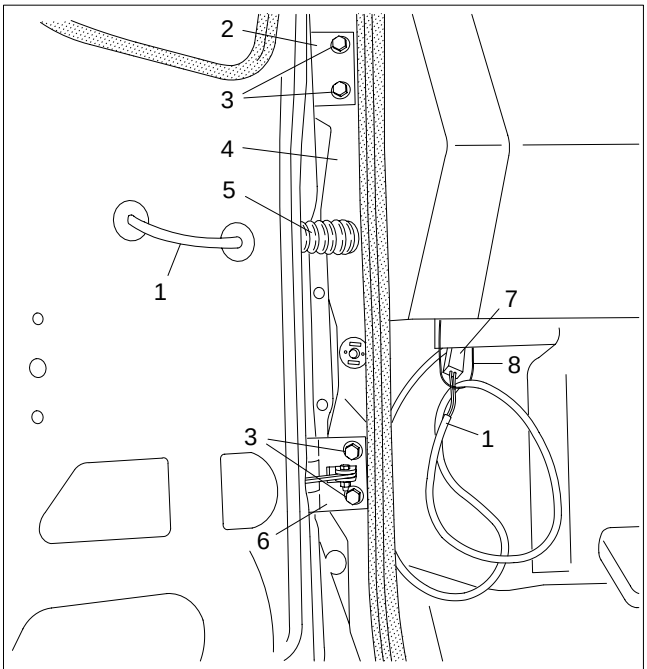
1. Cab Door
2. Upper Hinge
3. Door−Opening Frame
4. Mirror−Heat Harness Boot
5. Door Seal
6. Dome Light Switch
7. Lower Hinge
8. Door Check Arm
9. Outer Door−Latch Assembly
10. Door Trim Panel
11. Door−Latch Striker Pin
12. Shim

Fig. 3

Removal

1. Apply the parking brakes, and chock the tires.
2. Lower the roll-up window for easier handling of the door during removal.
3. Support the door frame from the bottom to prevent the door from falling or tipping.
4. If so equipped, disconnect the mirror-heat wiring. **See Fig. 1 .**

   4.1 Carefully, pull the end of the mirror-heat harness boot (Ref. 5) out of the cab door-opening frame (Ref. 4).



1. Mirror−Heat Harness
2. Upper Hinge
3. Hinge Fasteners
4. Cab Door−Opening Frame
5. Mirror−Heat Harness Boot
6. Lower Hinge and Door Check
7. Mirror−Heat Harness Connector
8. Tie Strap

NOTE: Interior door trim panel, inner door handle assembly, and door moulding are not shown.

08/02/93 f720074

Fig. 1

   4.2 If removing the right-hand door, remove the right-hand, lower dash panel to gain access to the mirror-heat wiring harness connector.

   4.3 Separate the halves of the mirror-heat harness connector (Ref. 7). Remove any harness clamps, then feed the harness (Ref. 1) through any tie straps (Ref. 8), and through the cab door-opening frame.

5. Remove the four capscrews, flatwashers, and split lockwashers that attach the door check and hinges to the cab door-opening frame. **See Fig. 1** , Refs. 2, 3, and 6. Remove the door.

Installation

IMPORTANT: Use a support or have another person hold the door from the bottom to prevent it from falling or tipping during installation.

1. Align the hinges with their mounting holes in the door-opening frame, then install the fasteners. Tighten the capscrews just tight enough to prevent unintentional hinge movement during door adjustment.
2. If so equipped, connect the mirror-heat wiring. **See Fig. 1 .**

   2.1 Feed the mirror-heat harness (Ref. 1) into the cab through the door-opening frame, and through any tie straps (Ref. 8). Install any harness clamps, then join the halves of the harness connector (Ref. 7).

   2.2 If it was removed, install the lower right-hand dash panel.

   2.3 Install the end of the mirror-heat harness boot (Ref. 5) in the door-opening frame.

3. Adjust the door, then tighten the hinge capscrews and striker pin. **See Fig. 2 .**

   NOTE: A misaligned door can cause wind noise, poor temperature control in the cab due to drafts, water damage to the cab interior, difficult closing of the cab door, or premature wear of the door seal. The striker pin and both door hinges are attached to floating plates that move up and down and in and out so the door can be adjusted.

Door Removal and Installation

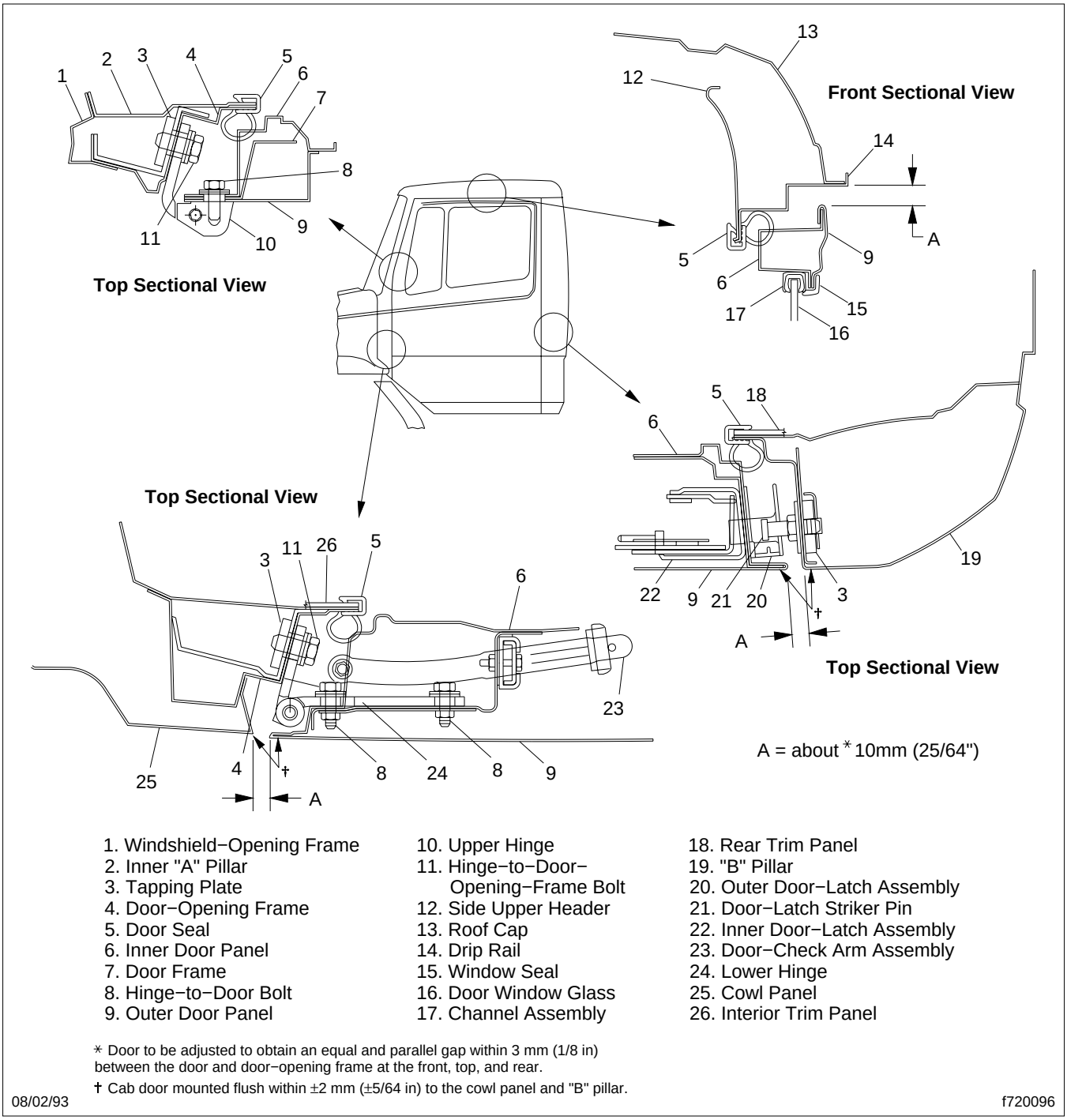


Fig. 2

3.1 Loosen the striker pin (**Fig. 2** , Ref. 21), then tighten it finger-tight.

3.2 Carefully close the door. As needed, move the door in or out until its outer sur-

face is flush, within 2 mm (5/64 in), with the surface of the cab skin at *both* its front and rear edges.

3.3 As needed, raise or lower the door until the space between the top of it and the door-opening frame is uniform, and is equal within 3 mm (1/8 in) to the spaces between the front and rear edges of the door and the door-opening frame. **See Fig. 2 .** Be careful not to disturb the in-and-out adjustment.

3.4 Without disturbing the positions of the hinges or striker pin, carefully open and support the door, then tighten the hinge capscrews 46 N·m (34 lbf·ft).

3.5 Securely tighten the striker pin. From outside the cab, partially close the door until the latch jaws are about 25 to 50 mm (1 to 2 in) from the striker pin. Be sure the striker pin will be centered in the latch jaw when the door is closed. If needed, reposition the striker pin.

3.6 Tighten the striker pin 61 N·m (45 lbf·ft), then close the door and recheck the door alignment.

4. Check the door seal (**Fig. 2** , Ref. 5) for damage or wear. If needed, replace it; **see Subject 120.**

5. Remove the chocks.

Up-and-Down Adjustment

(See Fig. 1)

From outside the cab, visually check the alignment of the door with the cab door-opening frame. See if the spaces around the top of the door are uniform, the gaps are all about 10 mm (3/8-inch), and are within 3 mm (1/8-inch) of being equal.

1. Mark both the vertical and horizontal positions of the latch striker pin and the two hinges before loosening them for adjustment. This will greatly simplify the procedure.
2. Loosen the striker pin, then tighten it finger-tight.
3. Loosen the capscrews that attach the hinges to the cab door-opening frame, but keep them tight enough to prevent unintentional hinge movement.
4. Carefully close the door, then raise or lower it until the space across the top of it is uniform, the gap is about 10 mm (3/8-inch), and is within 3 mm (1/8-inch) of the gaps at both the front and rear vertical edges of the door. Be careful not to disturb the in-and-out adjustments at the front or rear of the door.
5. Without disturbing the positions of the hinges or striker pin, carefully open and support the door, then tighten the hinge capscrews 46 N·m (34 lbf·ft).
6. Securely tighten the striker pin. From outside the cab, partially close the door until the latch jaws are about 25 to 50 mm (1 to 2 inches) from the striker pin. Be sure the striker pin will be centered in the latch jaw when the door is closed. If needed, reposition the striker pin.
7. Tighten the striker pin 61 N·m (45 lbf·ft), then close the door and recheck door alignment.

In-and-Out Adjustment

Poor in-and-out adjustment of the door is often indicated by hard closing of the door, wind and water leaks around the edge of the door, or premature wear of the door seal. Move the door in or out until its outer surface is flush, within ± 2 mm (± 5/64-inch), with the surface of the cab skin at *both* its front and rear edges.

1. If only the rear edge of the door needs adjusting, go on to the step for adjusting the rear edge.

   If the front edge of the door needs adjusting (**see Fig. 2**), mark the vertical and horizontal positions of the hinges before loosening them for adjustment. This will greatly simplify the procedure.
2. Loosen the capscrews that attach the hinges to the cab door-opening frame, but keep them tight enough to prevent unintentional hinge movement.
3. Carefully close the door, then move the front edge of the door in or out until its outer surface is flush, within ±2 mm (±5/64-inch), with the surface of the cab skin. Be careful not to disturb the up-and-down adjustment.
4. Without disturbing the positions of the hinges, carefully open and support the door, then tighten the hinge capscrews 46 N·m (34 lbf·ft).
5. If the rear edge of the door needs adjusting, mark the vertical and horizontal positions of the latch striker pin before loosening it for adjustment. **See Fig. 3.**
6. Loosen the striker pin, then tighten it finger-tight.
7. Carefully close the door, then move the rear edge of the door in or out until its outer surface is flush, within ±2 mm (±5/64-inch), with the surface of the cab skin. Be careful not to disturb the up-and-down adjustment.
8. Without disturbing the position of the striker pin, carefully open the door, then tighten the striker pin 61 N·m (45 lbf·ft).
9. Close the door and recheck door alignment.

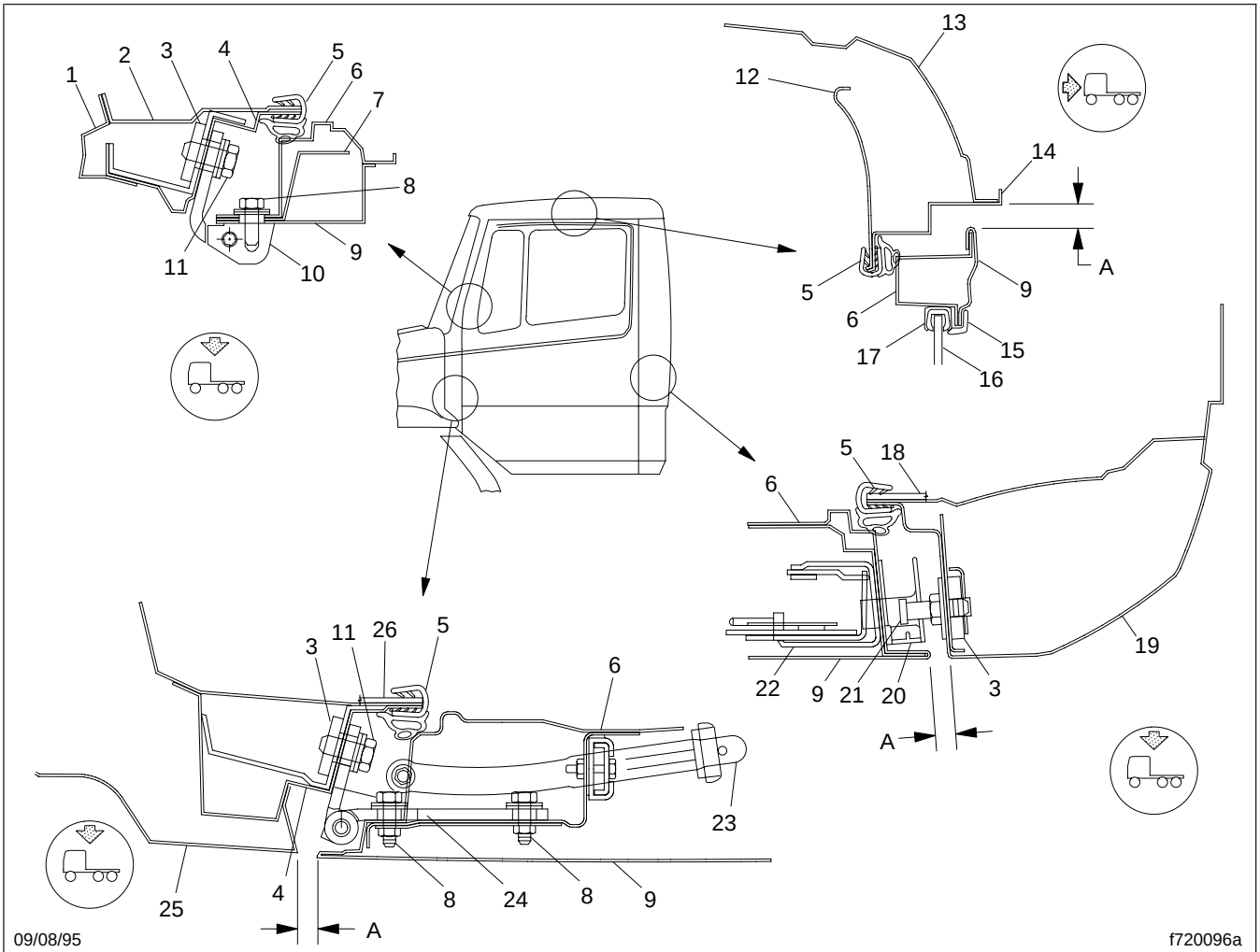
Fore-and-Aft Adjustment

(See Fig. 1)

NOTE: Although fore-and-aft adjustment of the door is possible, it should not normally be needed unless a new door is installed.

From outside the cab, visually check the alignment of the front and rear vertical edges of the door with the cab door-opening frame. See if the spaces are uniform, the gaps are about 10 mm (3/8-inch), and are within 3 mm (1/8-inch) of being equal.

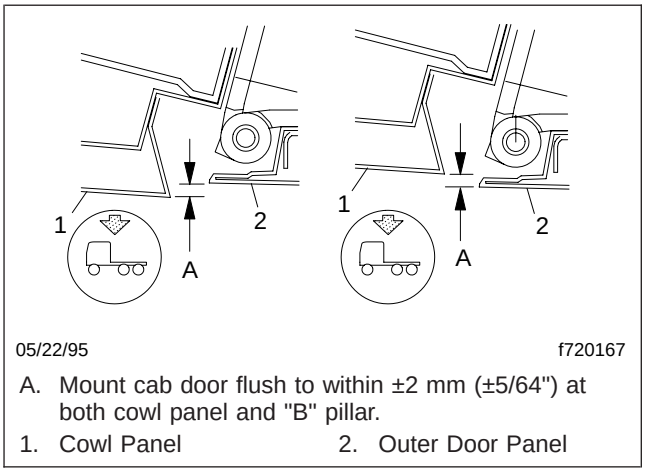
Door and Latch Adjustment



A. At the front, top, and rear, check for a 10 mm (3/8-inch) gap that is parallel and equal to within 3 mm (1/8-inch).

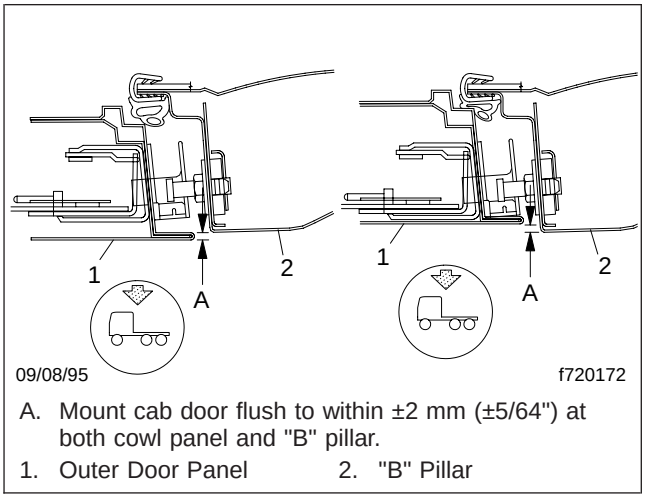
1. Windshield-Opening Frame
2. Inner "A" Pillar
3. Tapping Plate
4. Door-Opening Frame
5. Door Seal
6. Inner Door Panel
7. Door Frame
8. Hinge-to-Door Bolt
9. Outer Door Panel
10. Upper Hinge
11. Hinge-to-Door-Opening-Frame Bolt
12. Side Upper Header
13. Roof Cap
14. Drip Rail
15. Window Seal
16. Door Window Glass
17. Channel Assembly
18. Rear Trim Panel
19. "B" Pillar
20. Outer Door-Latch Assembly
21. Door-Latch Striker Pin
22. Inner Door-Latch Assembly
23. Door Check-Arm Assembly
24. Lower Hinge
25. Cowl Panel
26. Interior Trim Panel

Fig. 1



A. Mount cab door flush to within ±2 mm (±5/64") at both cowl panel and "B" pillar.
1. Cowl Panel 2. Outer Door Panel

Fig. 2, Door Adjustment (In-and-Out), at the Cowl Panel



A. Mount cab door flush to within ±2 mm (±5/64") at both cowl panel and "B" pillar.
1. Outer Door Panel 2. "B" Pillar

Fig. 3, Door Adjustment (In-and-Out), at the B Pillar

1. If the door needs adjusting, loosen the capscrews that attach the upper and lower hinges to the door, then tighten them finger-tight.
2. Gently close the door. Move the door as needed to align its front and rear vertical edges with the door-opening frame. Adjust the door until the spaces around the door are uniform, the gaps are about 10 mm (3/8-inch), and are within 3 mm (1/8-inch) of being equal.
3. Without disturbing the positions of the hinges, carefully open the door, then tighten the hinge-to-door capscrews 18 N·m (13 lbf·ft).
4. From outside the cab, partially close the door until the latch jaws are about 25 to 50 mm (1 to 2 inches) from the striker pin. Be sure the striker pin will be centered in the latch jaw when the door is closed. If needed, reposition the striker pin.
   - 4.1 Remove the striker pin.
   - 4.2 Add shims between the striker pin coned washer and the rear post of the cab door-opening frame.

   NOTE: Add only enough shims to correct the engagement of the jaws around the pin. Too many shims will cause interference between the pin and latch.
5. Tighten the striker pin 61 N·m (45 lbf·ft), then close the door and recheck door alignment.

Door Latch Adjustment

An incorrectly adjusted door latch mechanism can prevent the opening of the cab door from the outside.

If the outside door latch will not open, do the following steps:

1. First, check and adjust, if necessary, the vertical positioning of the striker pin.
2. Adjust the door latch mechanism.

STRIKER PIN ADJUSTMENT

As the door closes, watch to see if the door-latch striker pin is centered in relation to the latch jaws. **See Fig. 1.** The door should not move up or down when the latch jaws engage the striker pin. Only the center of the pin must contact the latch jaws; neither the forward end nor the hex portion of the pin should contact any part of the latch.

1. To center the striker pin vertically in the latch jaws, adjust the striker pin up or down.
   - 1.1 Loosen the pin fasteners, then tighten them finger-tight.
   - 1.2 Close the door (the latch jaws will center the pin). Move the rear of the door in or out if needed, until its outer surface is flush, within ±2 mm (±5/64 in), with the surface of the cab skin.

Door and Latch Adjustment

1.3 Carefully open the door without disturbing the position of the pin. Tighten the pin 61 N·m (45 lbf·ft), then close the door and recheck the adjustment.

2. If needed, adjust the striker pin fore and aft in the latch jaws. For procedures, see "Fore-and-Aft Adjustment."

DOOR LATCH MECHANISM ADJUSTMENT (ON VEHICLES BUILT 4/15/94 AND EARLIER)

If the outside paddle handle does not open, adjust the door latch mechanism. If needed, replace the old outside-release rod and spring clip with the revised rod, plastic retainer, and slip link.

1. Open the door and remove the interior door panel.
2. Disconnect the threaded end of the outside-release rod from the spring clip on the latch mechanism.
3. Disconnect the lower end of the outside-release rod by rotating the plastic retainer clip (**see Fig. 4**) counterclockwise to unsnap the clip from the rod.

   3.1 To move the lever into a position where the clip can be unsnapped, pull on the outside door handle.

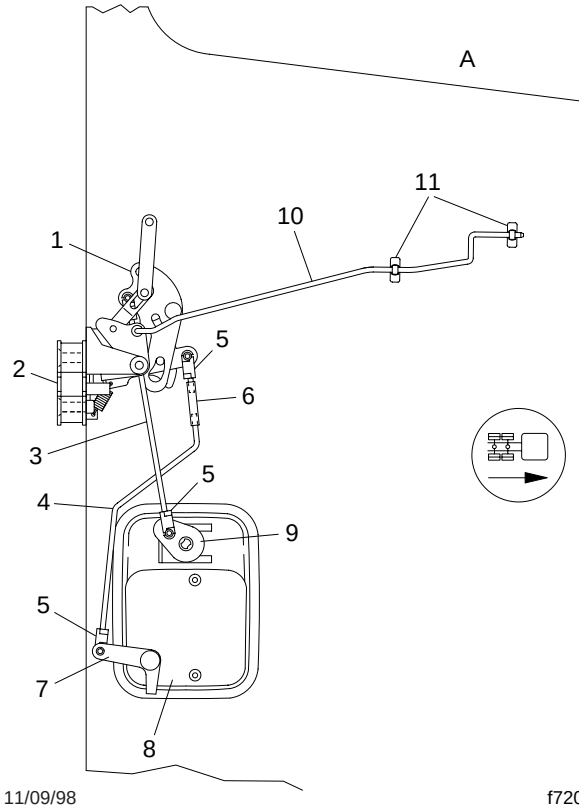
   3.2 After unsnapping the clip, remove the rod from the door. Discard the rod.

4. Remove the spring clip that attached the rod to the inner door latch.

   4.1 Using a 3/16-inch drill bit, drill out the rivet that attaches the spring clip to the inner door latch. While drilling, place a steel plate behind the spring clip to protect the outer door panel.

   4.2 Discard the spring clip.

5. Insert a new plastic retainer clip KIC04075 4 into the rivet hole in the inner door latch. Make sure the barb of the plastic clip faces the outer door panel.
6. Insert a new outside-release rod (18–30394–000 for the left-hand door; 18–30394–001 for the right-hand door) into the release lever.



A. Door Window Opening
1. Inner Door Latch Assembly
2. Outer Door Latch Assembly
3. Key Cylinder Release Rod
4. Outside-Release Rod
5. Plastic Retainer Clip
6. Slip Link
7. Release Lever
8. Exterior Door Handle Assembly
9. Lockset Tumbler Lever
10. (Inside-Release) Door-Latch Rod
11. Door Latch Rod Clips

Fig. 4, Door Latch Mechanism Interior View (Left-Hand Door)

7. Thread a slip link A18–30397–000 onto the upper end of the outside-release rod.
8. With the latch mechanism in the unlocked position, raise the arm with the newly installed plastic clip as high as possible. Adjust the slip link until it lines up with the inner door latch lever. Insert the slip link into the clip.

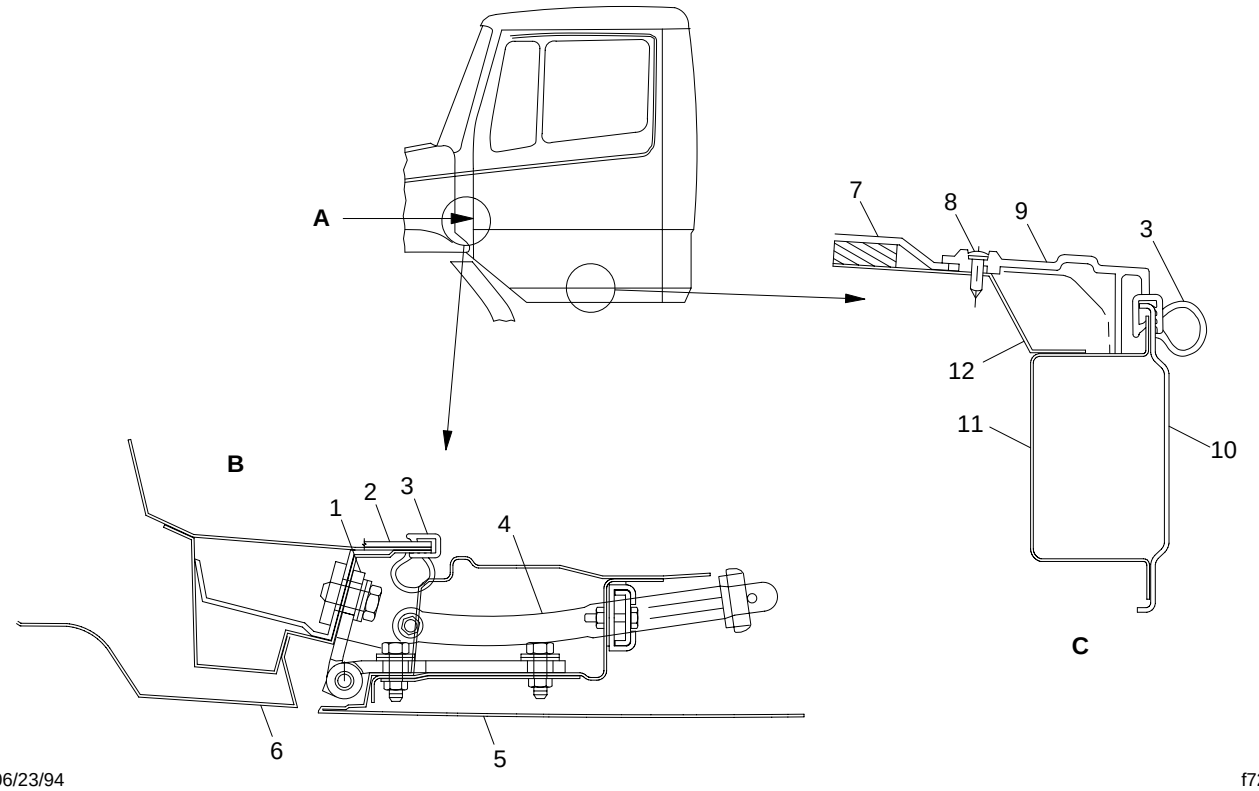
DOOR LATCH MECHANISM ADJUSTMENT (ON VEHICLES BUILT AFTER 4/15/94)

1. With the door still open, manually close the latch jaws. Turn the outside door handle and see if the jaws unlatch. If they don't, disconnect the slip link from the plastic clip and rotate it one or two turns lower on the rod. Repeat this procedure as necessary until the outside handle opens the latch jaws.

NOTE: The latch jaws should open at approximately 90 per cent travel of the outside door handle. If they open too soon, the mechanism can go over-center and refuse to open the door. In order to open it, the door must be locked again and then unlocked.

2. Check door latch operation with the door both locked and unlocked.
3. Install the interior panel.

Replacement (See Fig. 1)



A. Ends of Seal
B. Top Sectional View
C. Front Sectional View

1. Lower Hinge
2. Interior Trim Panel
3. Door Seal
4. Door Check-Arm Assembly
5. Outer Door Panel
6. Cowl Panel
7. Floor Mat
8. Door Sill Cover Screw
9. Door Sill Cover
10. Outer Door Sill Panel
11. Inner Door Sill Panel
12. Floor Pan

Fig. 1, Door Seal

1. Remove the three screws that attach the door sill cover to the floor pan; remove the door sill cover.
2. Pull the entire length of the old door seal from the flange of the cab door-opening frame.
3. Adjust the door so that the gap between the door and door opening is uniform. From inside the cab, use a padded block of wood and a hammer to bend the door seal flange until there is a uniform gap of 14 to 15 mm (about 9/16-inch) between the door and the door seal mounting flange.
4. Install the new door seal by pushing its open channel firmly onto the flange of the cab door-opening frame so the ends of the seal will meet at the center of the lower door hinge.

   Make sure the seal is pushed completely onto the flange all the way around the door-opening frame; there must be no creases or buckles on the sealing surface.

Door Seal Replacement

CAUTION

CAUTION: Do not stretch the door seal during installation. To do so may reduce its sealing ability, which could result in water leaks.

5. Trim the seal to length as needed, and butt the ends together.
6. Install the door sill cover, and tighten the screws snugly.

Interior Door Trim Removal and Installation

Removal (Refer to Fig. 1)

1. Remove the inner door handle assembly. **Refer to Fig.2** and **Fig.3.**
   - 1.1 Use a small hook to remove the two door handle plugs from the inner door handle assembly. **See Fig.2.**
   - 1.2 Hold the door handle so that it doesn't fall while removing the three machine screws. Gently pull the handle from the door panel.
   - 1.3 Pull straight out on the door-lock actuator and actuator guide, to disengage the barbed rivet stud that attaches the actuator to the door-lock link lever. **See Fig. 3 .**
2. Remove the window regulator handle. **See Fig.4 .**
   - 2.1 Remove the phillips screw that attaches the window regulator handle to the splined shaft. **See Fig.4 .**
   - 2.2 Pull the handle straight off the regulator splined shaft. If necessary, insert a straight-blade screwdriver under the regulator handle plate, and twist it until the handle slides off. Remove the regulator handle plate.
3. Remove the door trim panel assembly. **See Fig.5 .**
   - 3.1 Gently insert a straight-blade screwdriver under a corner of the door trim panel, and lift the panel to pull the first quarter-turn fastener out of the inner door panel. **See Fig.5 .** Use care not to damage the door trim panel.
   - 3.2 Working around the edge of the panel, pull out each of the thirteen quarter-turn fasteners, one at a time.

     If any of the quarter-turn fasteners are damaged, replace them (insert the head of the new fastener in the backing-board hole, and twist it a quarter turn).
4. Remove the door moulding and door moulding seal. **See Fig.6** and **Fig.7.**
   - 4.1 Remove the four screws and flatwashers that attach the door moulding to the door. **See Fig.6.**
   - 4.2 Remove the door moulding and door moulding seal, **as shown in Fig.7.** To prevent damaging the two positioning tabs, rotate the rear of the moulding slightly downward, and the front slightly upward, while sliding it forward and off the door.

Installation (Refer to Fig. 1)

1. Install the door moulding and door moulding seal. **See Fig. 6and Fig.7 .**
   - 1.1 Install the door moulding and door moulding seal, **as shown in Fig. 7 .** To prevent damaging the two positioning tabs, rotate the rear of the moulding upward, and the front slightly downward while sliding it backward and onto the door.
   - 1.2 Install and tighten the four screws that attach the door moulding to the door. **See Fig.6.**
2. Install the door trim panel assembly.
   - 2.1 Make sure all thirteen of the quarter-turn fasteners are correctly installed in the door panel.
   - 2.2 Working around the edge of the door trim panel, push in each of the fasteners, one at a time.
3. Install the window regulator handle and regulator handle plate. **See Fig. 4 .**
   - 3.1 Install the regulator handle plate on the splined shaft, then push the handle straight onto the shaft.
   - 3.2 Install the phillips screw, and tighten it snugly while holding the regulator handle in place to keep the splined shaft from turning. **See Fig. 4 .**
4. Install the inner door handle assembly. **See Fig. 3 .**
   - 4.1 Install the door-lock actuator and actuator guide, by engaging the barbed rivet stud that attaches the actuator to the door-lock

Interior Door Trim Removal and Installation

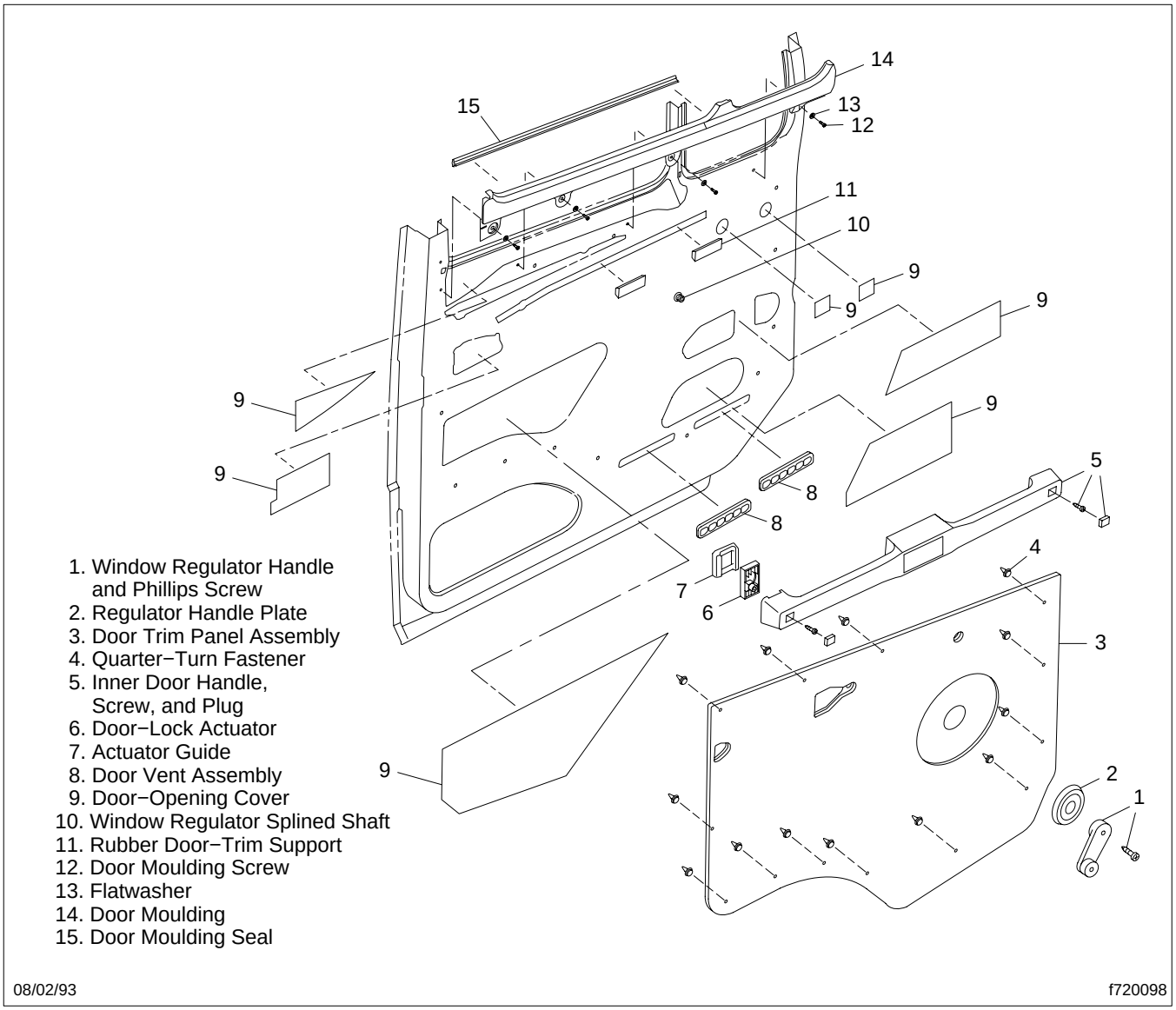


Fig. 1

link lever. **See Fig. 3 .** Hold them in place while installing the inner door handle.

4.2 While holding the inner door handle assembly in place, install and tighten the three screws.

4.3 Press the two door handle plugs into the ends of the inner door handle assembly.

Interior Door Trim Removal and Installation

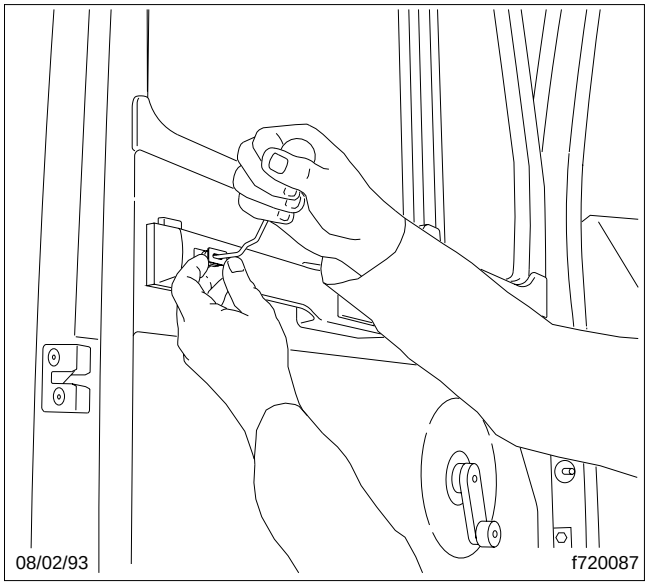


Fig. 2

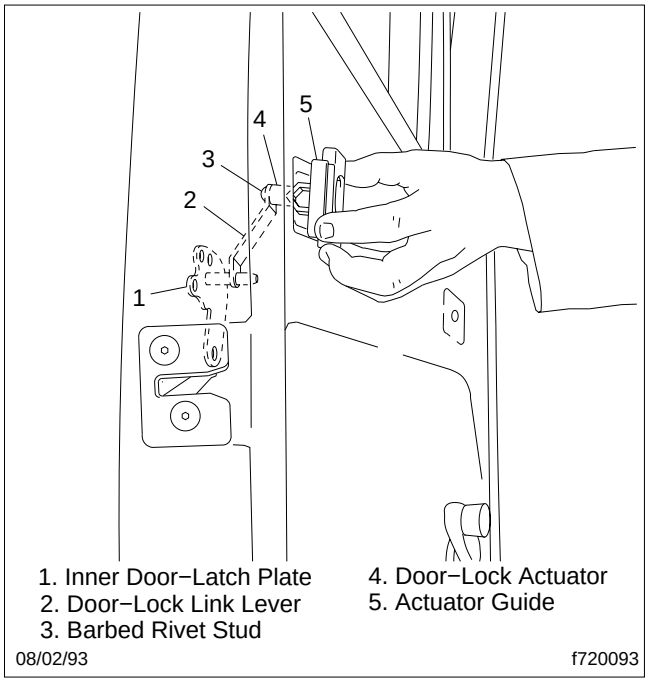


Fig. 3

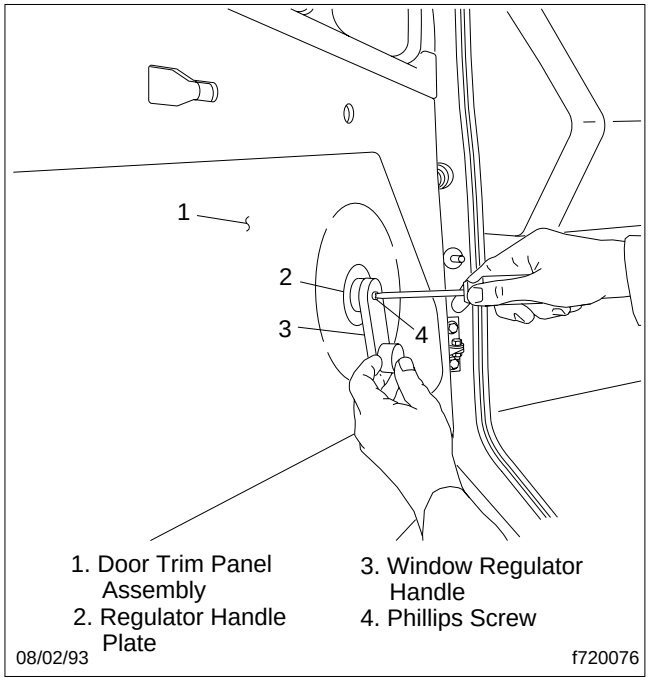


Fig. 4

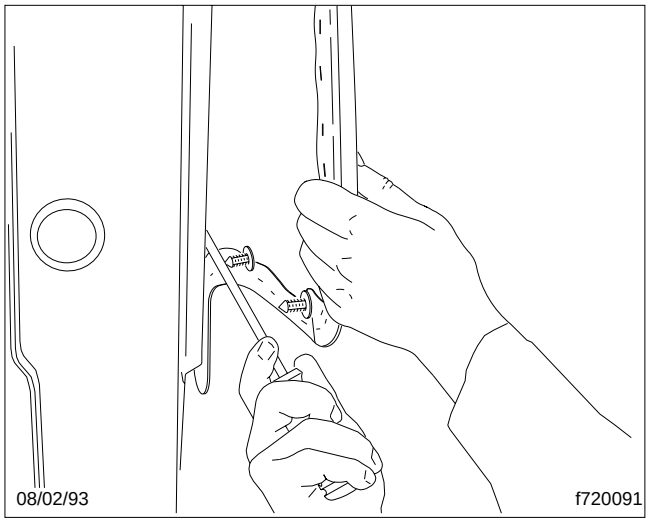


Fig. 5

Interior Door Trim Removal and Installation

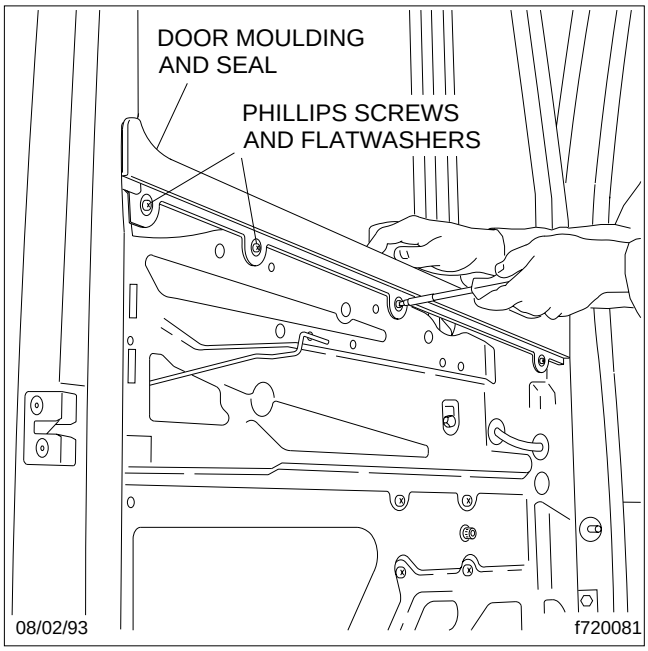


Fig. 6

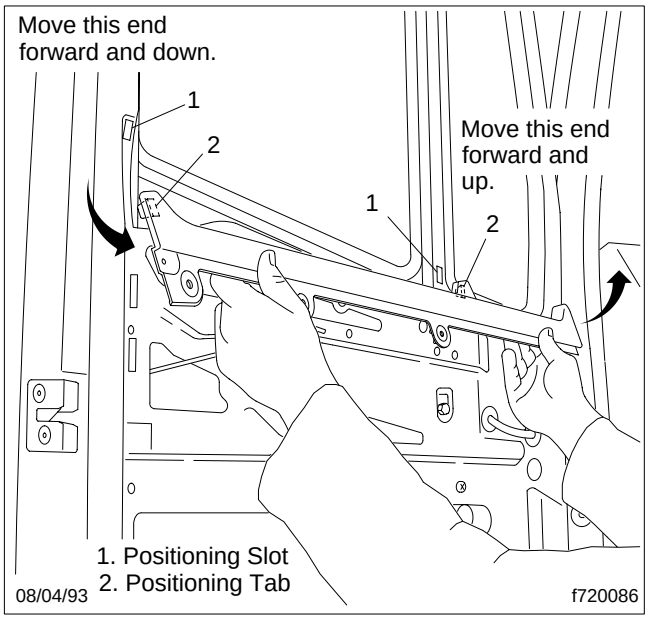


Fig. 7

Fixed Window Replacement

General Information

No special tools are needed to remove and install the glass. A thin, flat tool, such as a putty knife, can be used if a special corkscrew instrument (utilized in major body shops for window glass replacement) isn't available.

⚠ WARNING

WARNING: Use care when working around or handling glass. Wear protective gloves to eliminate the possibility of personal injury resulting from accidentally breaking or splintering the glass.

When a broken window is being replaced, it is very important that the cause of glass breakage be found, and the condition corrected before a new window is installed. If not removed, a small obstruction or high spot somewhere around the window opening may break the replacement glass, especially when it is exposed to high winds, pressure, temperature extremes, and vehicle motion.

Wing Window Replacement

(Refer to Fig. 1)

1. Remove the inner door handle assembly, window regulator handle, door trim panel assembly, and the door moulding and door moulding seal; **refer to Subject 130.**
2. Wear heavy protective gloves to prevent cutting your hands while removing all of the shattered glass from the weather seal. Using a putty knife, lift up the inside lip of the weather seal and pry it over the inner door-panel flange. If the weather seal will be re-used, take care not to damage it with the putty knife.
3. Check for high spots or obstructions in the window opening flange and the weather seal. Correct any areas on the window opening that need to be fixed. Inspect the weather seal for damage or deterioration; replace it if needed.

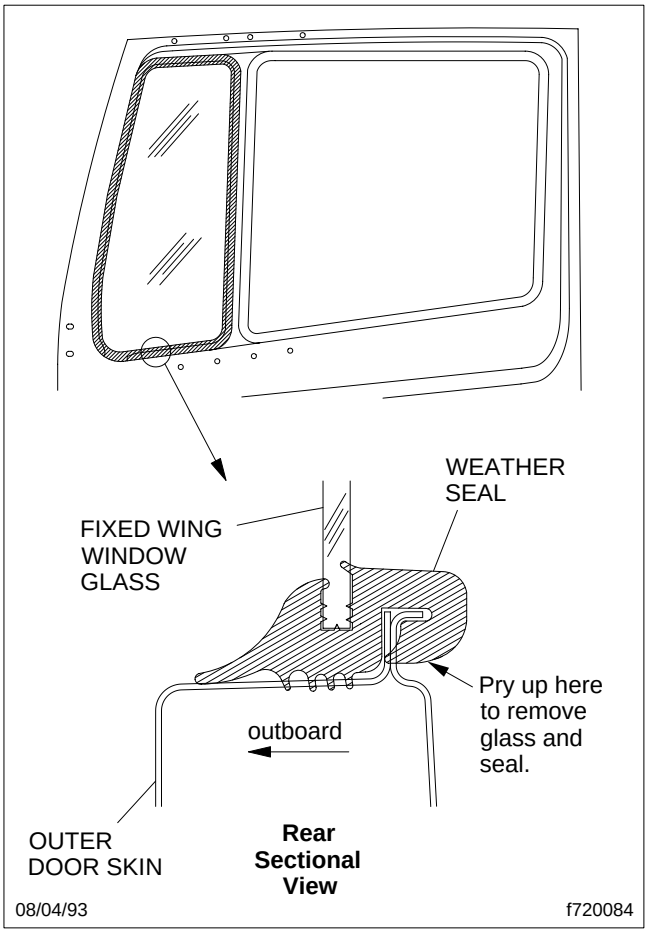


Fig. 1

⚠ CAUTION

CAUTION: When handling the new window glass, use care not to nick or splinter the edges; chipped edges could cause future breaks.

4. Using soap and water, lubricate the weather seal, then install the weather seal on the new window glass, beginning at the bottom, and ending at the upper front corner. **See Fig. 2 .**
5. Place the assembled glass and weather seal in the window opening, from the outside. With another person lightly pushing in on the glass, use a putty knife to pry the weather seal lip over the window opening flange. Begin with the upper edge, and continue down both sides, across the bottom to the lower front corner. **See Fig. 3 .**

Fixed Window Replacement

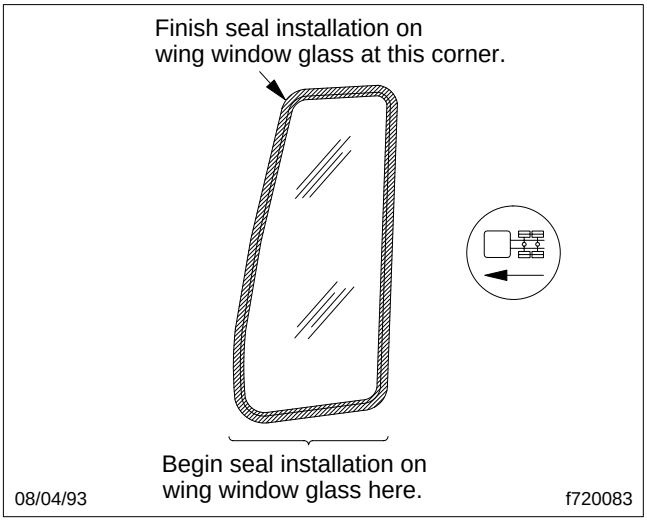


Fig. 2

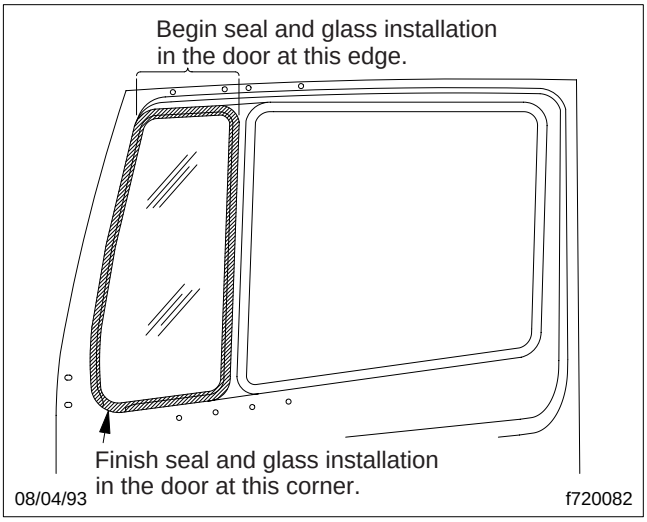


Fig. 3

IMPORTANT: To prevent cab water leaks, the weather seal should lie flat against the glass and the inner and outer door panels, and should not crease at any point, especially around the corners. Reinstall the window if the weather seal creases.

6. Install the inner door handle assembly, window regulator handle, door trim panel assembly, and the door moulding and door moulding seal; **refer to Subject 130.**

Roll-Up Window Removal and Installation

Removal (Refer to Fig. 1)

1. Remove the inner door handle assembly, window regulator handle, door trim panel assembly, and the door moulding and door moulding seal; **refer to Subject 130.**
2. Lower the roll-up window. Loosen the six screws in the window-channel seal. **See Fig. 2 .** Use needle-nose pliers to remove the screws, and be careful to keep them from falling down the window cavity.
3. Remove the two hexbolts attaching the channel to the lower portion of the inner door panel. **See Fig. 3.**
4. Pull the upper portion of the channel toward the inside until it is clear of the top of the door frame.

CAUTION

CAUTION: Failure to wear rubber gripper gloves while removing the window glass from the door

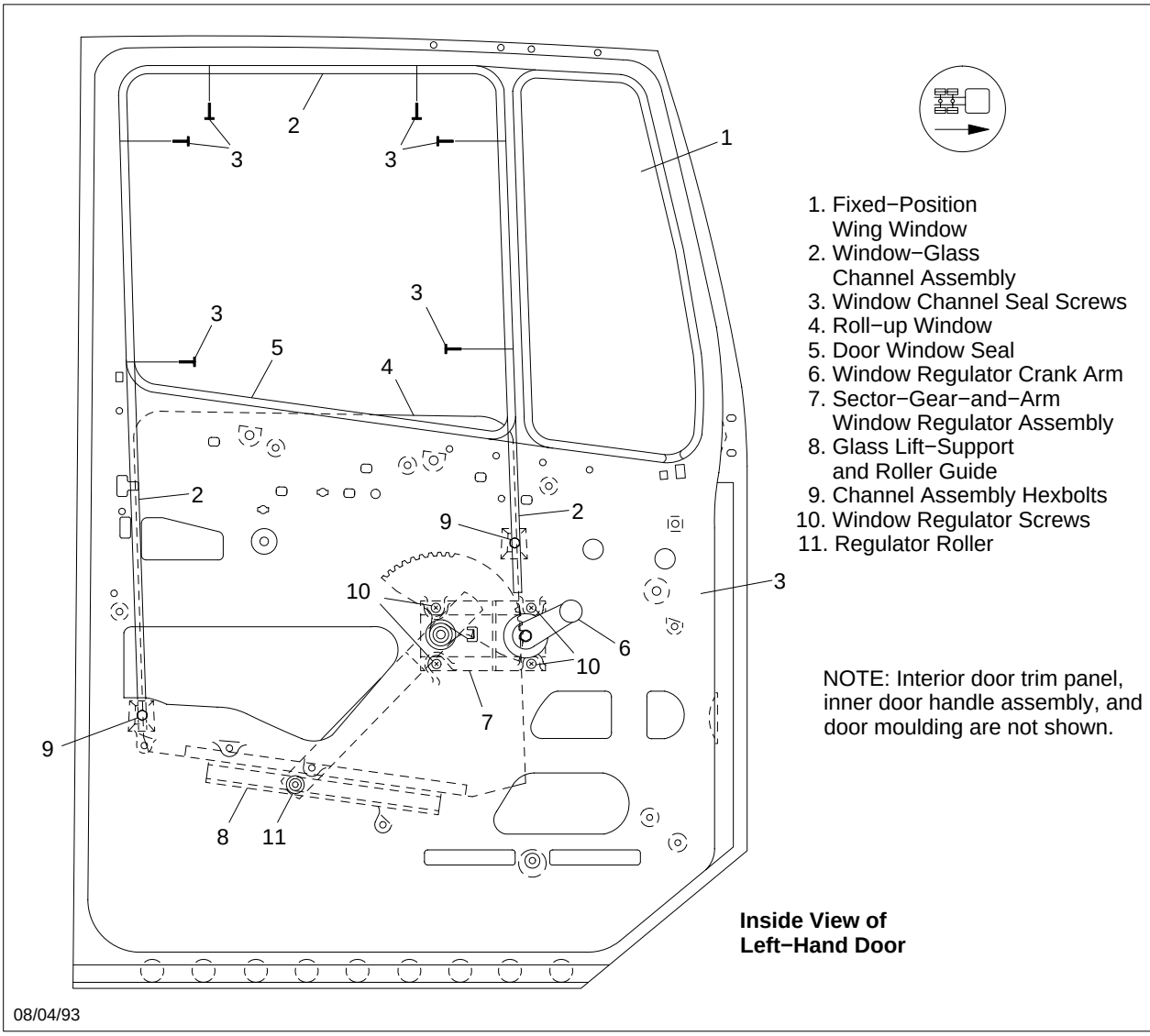


Fig. 1

Roll-Up Window Removal and Installation

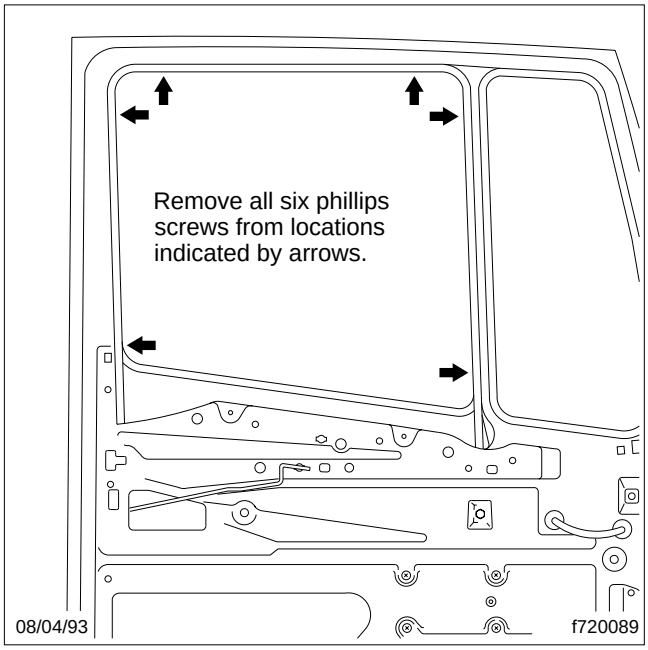


Fig. 2

could result in the glass slipping out of your hands and breaking.

IMPORTANT: Wear rubber gripper gloves when removing the window glass. Usually, service operations performed on the door will be done while the door is in a vertical position (that is, attached to the vehicle). Because of this, you will need a secure grip when handling the glass.

5. Place the window regulator handle on the splined shaft, and raise the window in the channel. Grasp the glass securely, and pull it up and in while cranking the window glass and channel out of the door. **See Fig. 4 .** Stop cranking when the window regulator roller reaches the end of the glass-lift support roller guide.
6. Carefully remove the glass and channel assembly. Leave the regulator roller arm in a vertical position.
7. Remove the window seal by pulling it off of the window opening flange.

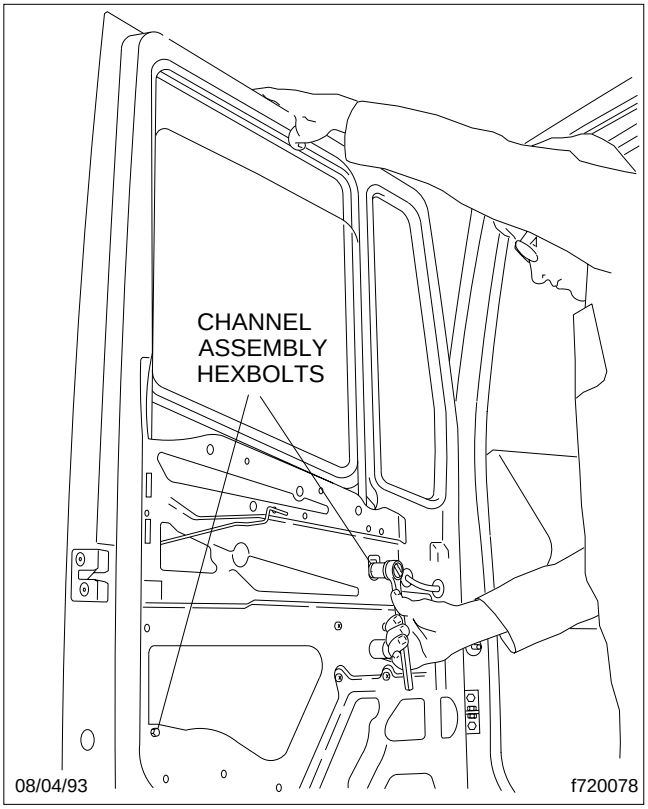


Fig. 3

Installation (Refer to Fig. 1)

1. Inspect the window channel seal, door moulding seal, and window seal for deterioration or damage; replace them if needed.
2. Install the window seal **as shown in Fig. 5 ,** by working it onto the flange of the window opening so its seal brush is at the bottom of the opening.

⚠ CAUTION

CAUTION: Incorrect positioning of the cushion in the glass-lift support can cause the glass to contact the metal, which may crack the glass.

3. Check the position of the window glass cushion in the glass-lift support. **See Fig. 6 .** The cushion must be centered in the support, with equal lengths of cushion extending beyond the ends of the support.

Roll-Up Window Removal and Installation

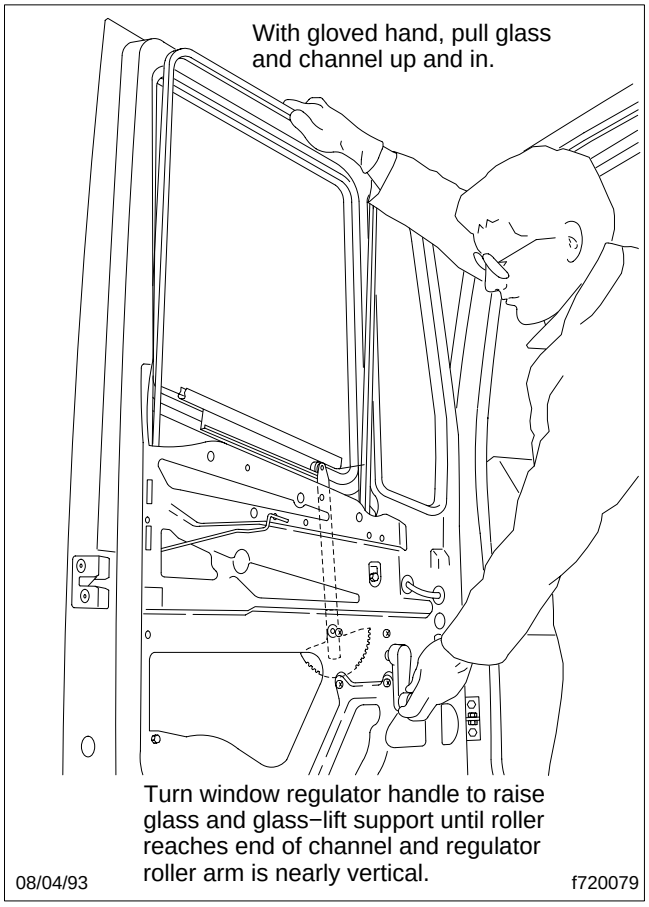


Fig. 4

Then check the position of the glass-lift support on the window glass. **See Fig. 6 .** The lowest corner of the support roller guide must be 141.0 mm (5-9/16 in) back from the lower front corner of the window glass.

4. Clean and lubricate the window regulator roller and the roller guide on the glass-lift support.
5. Place the regulator roller arm in a vertical position. Loosen the four regulator assembly mounting screws. **See Fig. 7 .**

IMPORTANT: Wear rubber gripper gloves when installing the window glass. Usually, service operations performed on the door will be done while the door is in a vertical position (that is, attached to the vehicle). Because of this, you will need a secure grip when handling the glass.

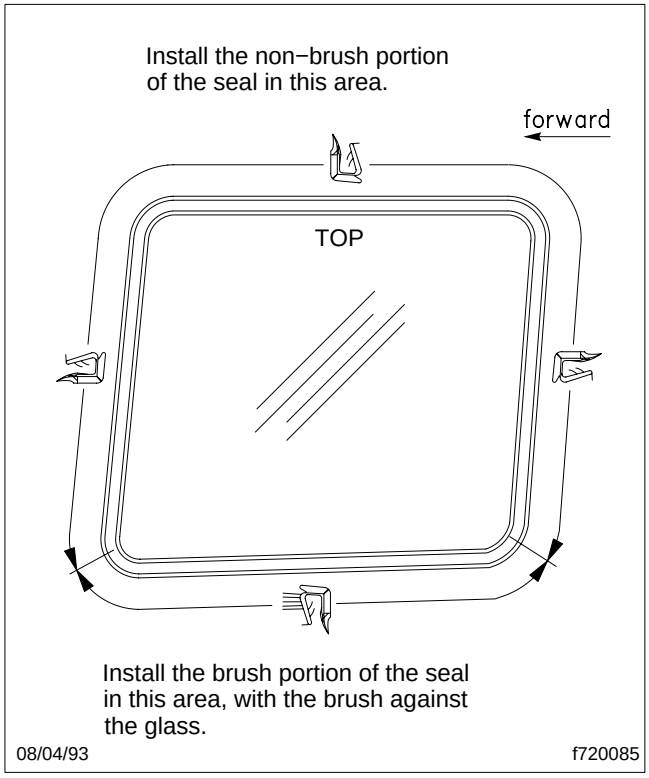


Fig. 5

CAUTION

CAUTION: Failure to wear rubber gripper gloves while installing the window glass in the door could result in the glass slipping out of your hands and breaking.

6. Grasp the glass securely, and lower the window glass and channel assembly into the door. Continue to lower the assembly until the regulator roller can be installed in the roller guide of the glass-lift support.
7. Place the regulator handle on the splined shaft, and slowly crank the glass down into the channel. Push the upper portion of the channel firmly into the window opening until it seats.
8. Install the two hexbolts attaching the channel to the lower portion of the inner door panel; don't fully tighten them at this time. **See Fig. 3 .**

   Install and tighten the six screws in the upper channel seal. **See Fig. 2.** The screw heads must not stick out into the channel. Fully tighten the

Roll-Up Window Removal and Installation

regulator screws, then tighten the two channel hexbolts 18 N·m (13 lbf·ft).

NOTE: Roll the window up and down a couple of times before fully tightening the channel screws and window regulator screws. This will help to align the window in the tracks.

9. Install the inner door handle assembly, window regulator handle, door trim panel assembly, and the door moulding and door moulding seal; **refer to Subject 130.**

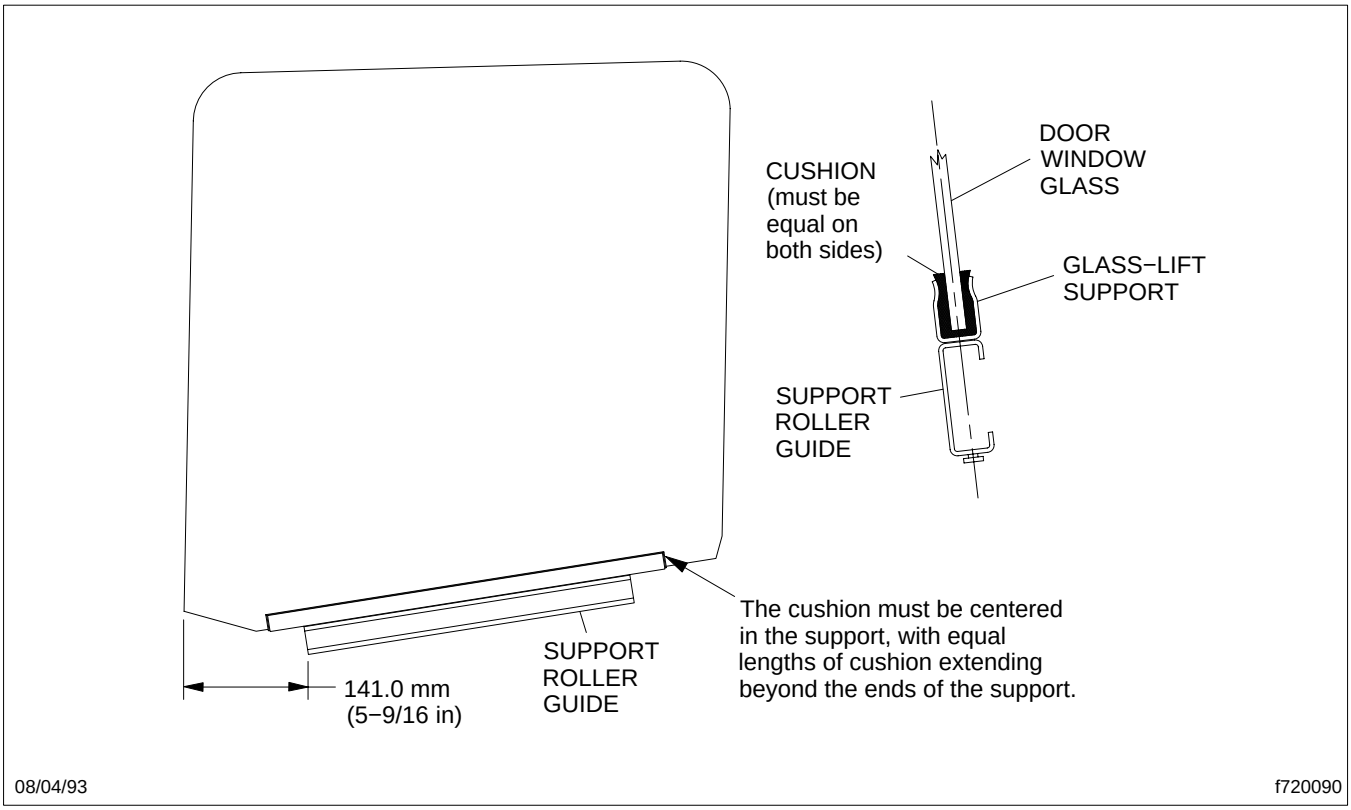


Fig. 6

Roll-Up Window Removal and Installation

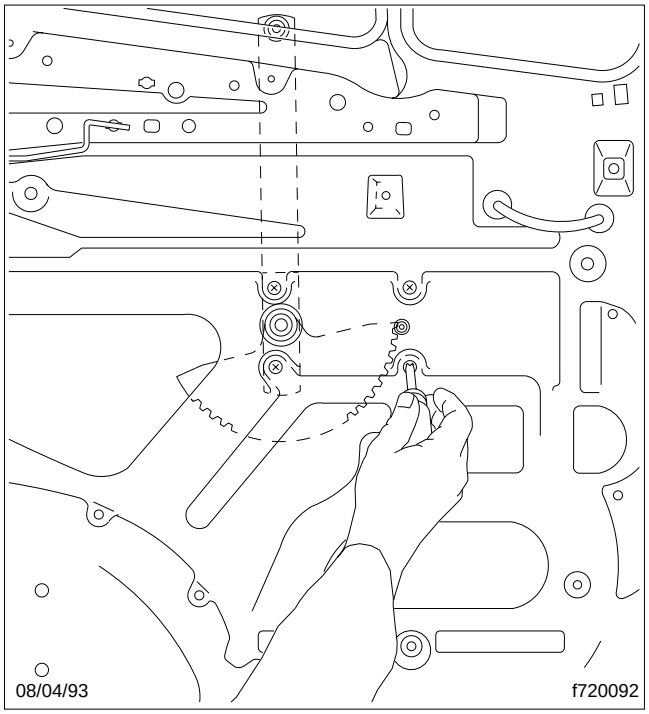


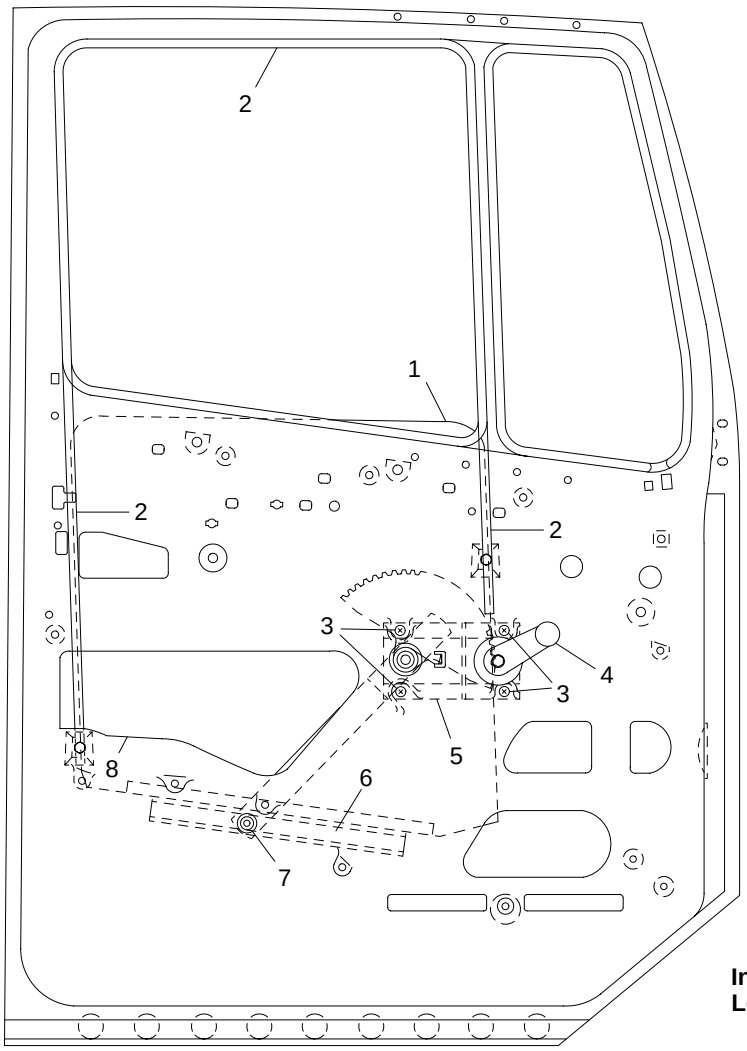
Fig. 7

Regulator Replacement

(Refer to Fig. 1)

1. Remove the roll-up window; **refer to Subject 150.**
2. Leave the regulator roller arm in a vertical position. Remove the four screws that attach the window regulator to the inner door panel. Remove the window regulator.
3. Lubricate the roller of the new window regulator.
4. Place the regulator roller arm in a vertical position, and align the regulator with the screw holes in the inner door panel while installing the four screws. Don't fully tighten the screws at this time.
5. Install the roll-up window; **refer to Subject 150.**

Window Regulator Replacement



1. Roll−Up Window
2. Window−Glass Channel Assembly
3. Regulator Assembly Mounting Screws
4. Window Regulator Crank Arm
5. Sector−Gear−and−Arm Window Regulator Assembly
6. Glass Lift−Support and Roller Guide
7. Regulator Roller
8. Door Panel Opening (Access Hole)

NOTE: Interior door trim panel, inner door handle assembly, and door moulding are not shown.

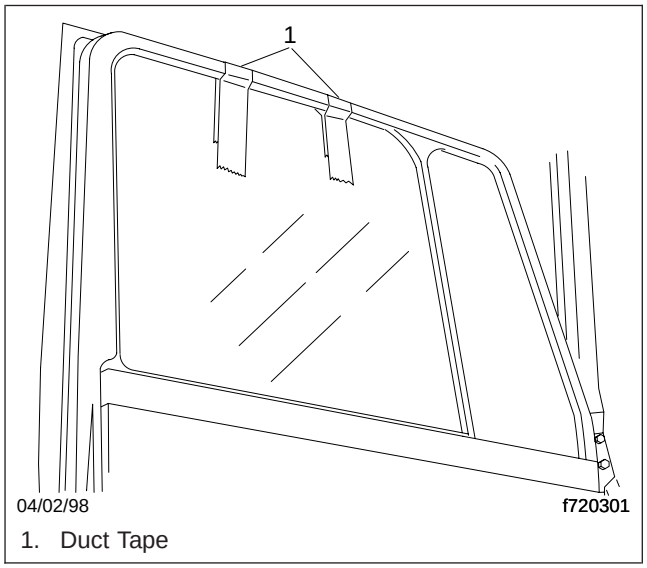
Inside View of Left−Hand Door

08/04/93 f720095

Fig. 1

Regulator Replacement

1. Secure the closed window to the top of the door frame using several pieces of duct tape. See **Fig. 1**.



1. Duct Tape

Fig. 1, Window Secured to Door Frame

2. Remove the inner door handle.

   2.1 Using a small hook, remove the door handle plug from the door handle. See **Fig. 2** .

   2.2 Remove the three screws that attach the door handle to the door.

   2.3 Mark the cable assemblies and switches in the door handle for assembly reference.

   2.4 Disconnect the cable assemblies from the door handle, and remove the door handle.

3. Pull straight out on the door-lock actuator and actuator guide to free the door-lock link lever from the pin on the inner door-latch plate. See **Fig. 3**.

4. Remove the inner door trim panel.

   4.1 Gently insert a straight-blade screwdriver under a corner of the door trim panel, and lift the panel to pull the first quarter-turn fastener out of the door. See **Fig. 4**. Use care not to damage the door trim panel.

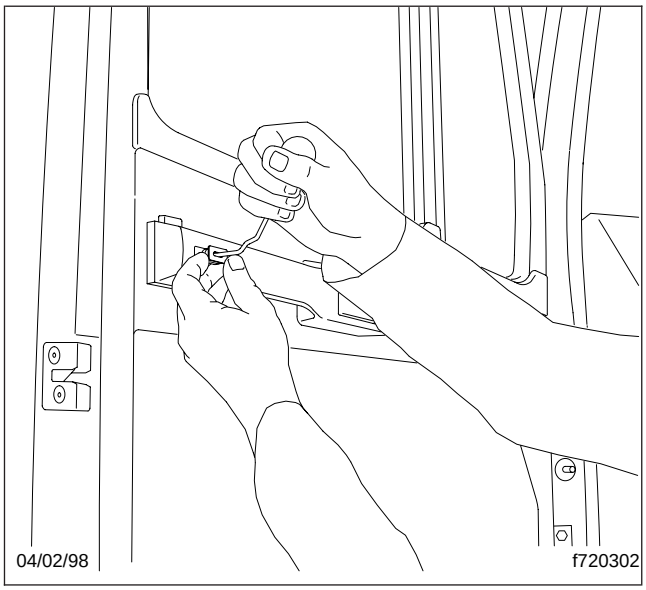
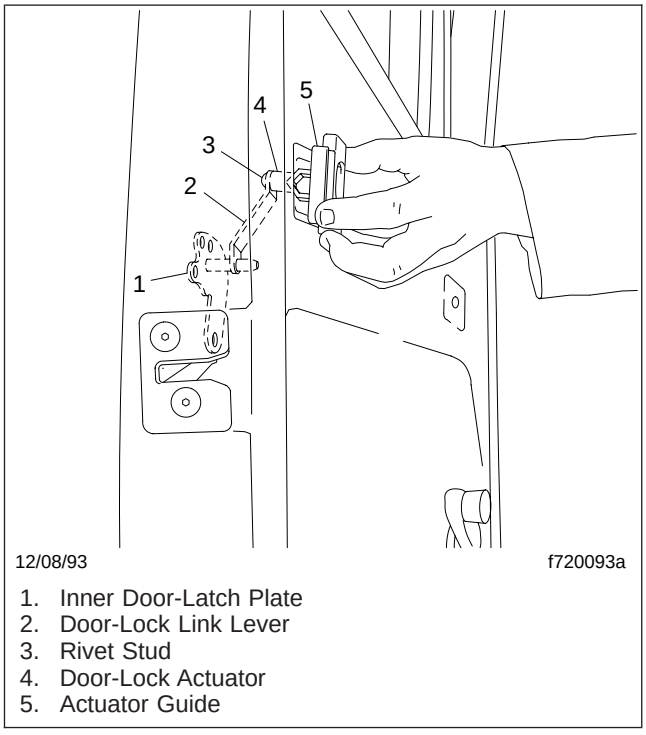


Fig. 2, Removing the Door Handle Plug



1. Inner Door-Latch Plate
2. Door-Lock Link Lever
3. Rivet Stud
4. Door-Lock Actuator
5. Actuator Guide

Fig. 3, Removing the Door-Lock Actuator

Power Window Regulator Replacement

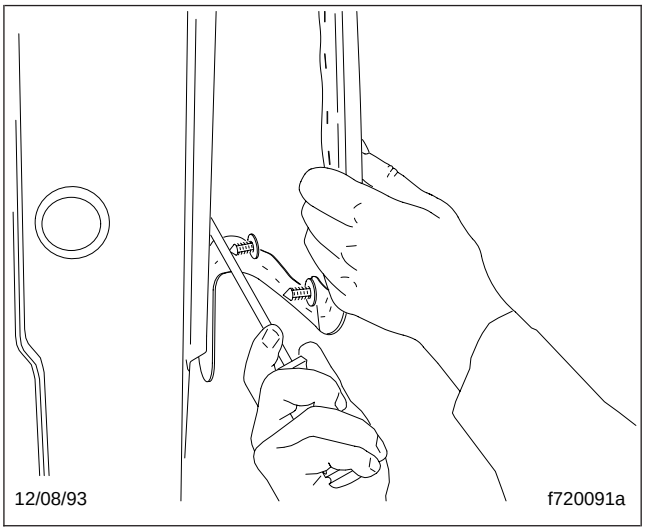


Fig. 4, Removing the Door Trim Panel

4.2 Working around the edge of the panel, pull out each of the quarter-turn fasteners one at a time. If any of the quarter-turn fasteners are damaged, replace them by inserting the head of the new fastener in the backing-board hole, and twist it a quarter turn.

5. Remove the door moulding.

5.1 Remove the four screws and flatwashers that attach the door moulding to the door. See **Fig. 5**.

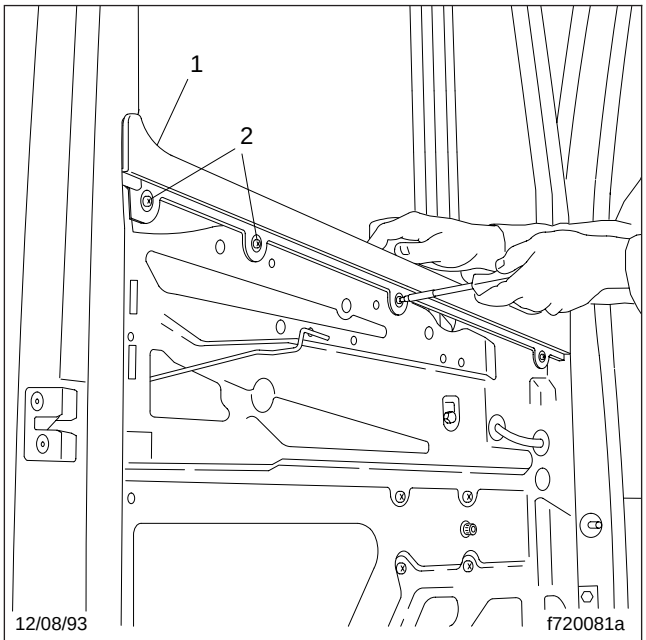
5.2 Remove the door moulding as shown in **Fig. 6**. To prevent damaging the two positioning tabs, turn the rear of the moulding slightly downward, and the front slightly upward, while sliding it forward and off the door.

6. Peel the plastic covering off of the access cutout at the rear of the door. See **Fig. 7**.

7. Remove the regulator.

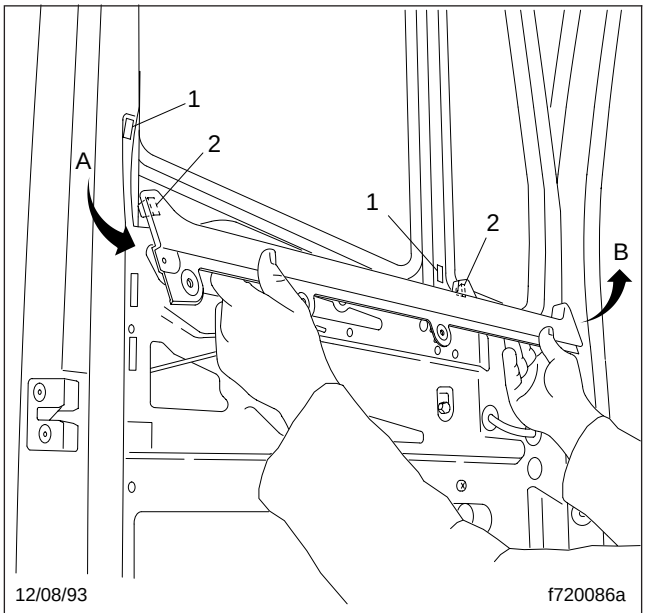
7.1 Remove the four screws that attach the regulator to the door. See **Fig. 7**.

7.2 Remove the plastic fasteners that attach the lower edge of the window to the channel bracket. See **Fig. 8**. Pull the channel bracket and the cushion inside the channel bracket off the window.



1. Door Moulding
2. Screws and Flatwashers

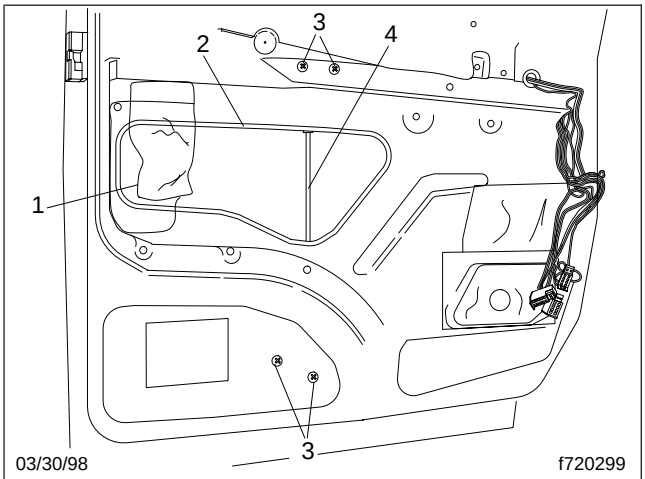
Fig. 5, Door Moulding



A. Move this end forward and down.
B. Move this end forward and up.
1. Positioning Slot 2. Positioning Tab

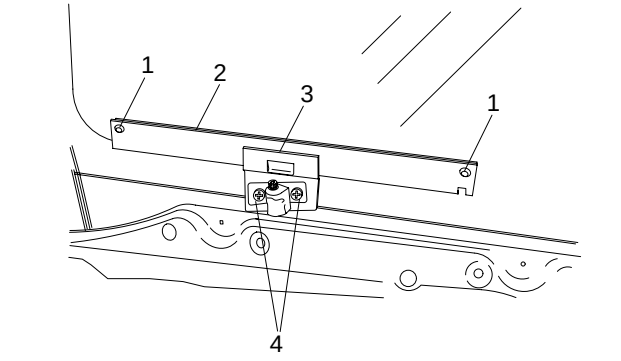
Fig. 6, Removing the Door Moulding

Power Window Regulator Replacement



1. Plastic Covering
2. Access Cutout
3. Screws
4. Regulator

Fig. 7, Rear Access Cutout



1. Plastic Fastener
2. Channel Bracket
3. Regulator Bracket
4. Screws

Fig. 8, Channel Bracket

7.3 Pull the channel bracket up until the bracket at the top of the regulator is above the lower window frame. Remove the two screws that attach the regulator bracket to the channel bracket. See **Fig. 8**.

7.4 Pull the regulator up until you are able to disconnect the cable assembly from the regulator. Disconnect the cable assembly and remove the regulator.

8. Install the new regulator.

8.1 Place the new regulator inside the door through the access cutout, and attach the cable assembly to the regulator.

8.2 Attach the bracket at the top of the regulator to the channel bracket using two screws. Tighten the screws 30 to 35 lbf·in (339 to 395 N·cm).

8.3 Place the cushion along the lower edge of the window; then place the channel bracket over the cushion. Attach the channel bracket to the window using plastic fasteners.

8.4 Attach the upper bracket of the regulator to the door using two screws. Tighten the screws 30 to 35 lbf·in (339 to 395 N·cm).

8.5 Attach the lower bracket of the regulator to the door using two screws. Tighten the screws 30 to 35 lbf·in (339 to 395 N·cm).

9. Press the plastic coverings back over the access cutout on the inner door.

10. Install the door moulding.

10.1 Attach the door moulding to the door. To prevent damaging the two positioning tabs, turn the rear of the moulding upward, and the front slightly downward while sliding it backward and on to the door.

10.2 Install and tighten the four flatwashers and screws that attach the door moulding to the door.

11. Feed the cable assemblies through the hole in the upper, right portion of the door trim panel.

12. Attach the door trim panel to the door only at the top of the panel.

13. Connect the cable assemblies to the switches in the door handle.

14. Install the door handle.

14.1 Install the screws in the two holes toward the front of the door handle. Tighten the screws 30 to 35 lbf·in (339 to 395 N·cm).

14.2 Install the door-lock actuator and actuator guide by placing the door-lock link lever over the pin on the inner door-latch plate. See **Fig. 3**. Hold the door-lock actuator and actuator guide in place while install-

Power Window Regulator Replacement

ing the third screw in the door handle. Tighten the screw 30 to 35 lbf·in (339 to 395 N·cm).

14.3 Press the door handle plug in to the door handle.

15. Attach the sides and lower portion of the door trim panel to the door by pushing in each of the fasteners one at a time.

Specifications

Description	Grade	Size	Torque N·m (lbf·ft)
Door Latch Striker Pin	—	M12	61 (45)
Hinge to Door-Opening-Frame Bolt	10.9	M10	46 (34)
Hinge to Door Bolt	8.8	M8	18 (13)
Window-Channel to Inner-Door-Panel Bolt	8.8	M8	18 (13)

Table 1, Fastener Torques

General Information

VEHICLES WITHOUT INTERMITTENT WIPERS

The windshield wiper and washer are operated by rocker switches. The windshield wiper rocker switch has two speeds: low or high. The windshield washer rocker switch will spray wash fluid on the windshield as long as the switch is depressed.

VEHICLES WITH INTERMITTENT WIPERS WITH ROCKER SWITCH AND SLIDER SWITCH CONTROLS

The windshield wiper and washer are operated by a rocker switch and a slider switch. The windshield wiper rocker switch has two speeds: low or high. The intermittent wipers are turned on by moving the slider switch up to select the desired delay interval between 2 and 10 seconds (2 and 22 seconds on early models). The windshield washer is turned on by pushing the slider switch all the way up.

VEHICLES WITH INTERMITTENT WIPERS WITH A DOUBLE-PADDLE SWITCH

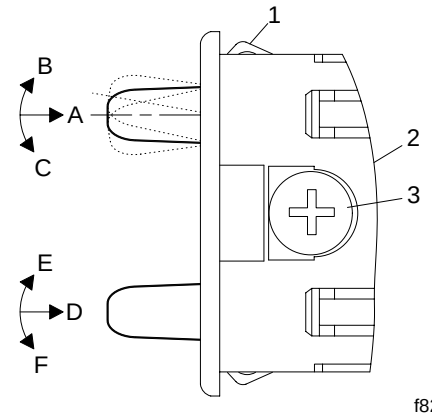
The windshield wiper and washer are operated by a double-paddle switch.

The wipers have five cycles: fast, slow, mist, wash, and delay. There are six delay intervals, three seconds, five seconds (default fast), eight seconds, 12 seconds, 17 seconds (default slow), and 23 seconds. For wiper switch operation, see **Fig. 1**.

The top paddle, when pushed in, turns the wipers on or off. When pushed up, the top paddle switches the wipers to high speed; when it is pushed down, it switches them to low speed.

The bottom paddle, when pushed in momentarily (for less than 1/2 second), turns the wipers on mist (one dry cycle at low speed). When pushed in and held in (for at least 1/2 second), the bottom paddle turns on the washers for a minimum of three cycles after release. For more wash cycles, hold the bottom paddle in longer (but it will always cycle three more times after release).

Pushing the bottom paddle up or down controls the delay cycle of the intermittent wipers. If the wipers



10/06/95 f820178

A. Push in to turn wipers on (low speed) or off.
B. Push up for high speed.
C. Push down for low speed.
D. Push in momentarily for mist cycle. Push in and hold for wash cycle.
E. Push up for fast delay. If already in delay, push up for the next faster delay.
F. Push down for slow delay. If already in delay, push down for the next slower delay.

1. Locking Clip
2. Wiper/Washer Switch
3. Light Bulb Screw

Fig. 1, Wiper/Washer Switch Operation

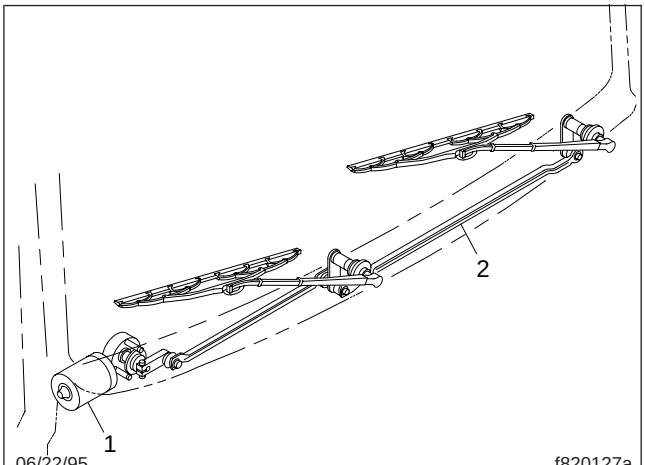
are not in delay, push up for default fast delay (5 seconds) or down for default slow delay (17 seconds). If the wipers are already in delay, push up for the next fastest delay or push down for the next slowest delay.

A linkage assembly joins both wiper arms to a motor that is mounted under the right-side dash panel inside the cab. See **Fig. 2**.

NOTE: Since January 6, 1995, a redesigned Sprague windshield wiper system is being installed in Business Class models. The new Sprague system has latch-mounted wiper blade arms, a higher operating speed, and slightly longer wiper arms. See **Fig. 3**.

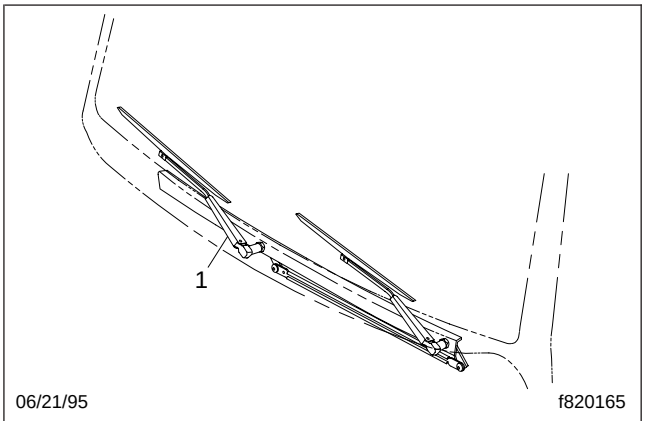
The windshield washer reservoir is located under the cab inside the passenger's side door. See **Fig. 4**. Washer fluid is carried by a tube that runs from the reservoir, along the bottom of the cab, and up the center of each wiper arm; this is known as a wet-arm wiper system. Each tube is attached to a nozzle that is located behind the wiper blade fastening. When the washer pump is turned on, the wash spray at the

General Information



1. Wiper Motor
2. Wiper Linkage Assembly

Fig. 2, Wiper System with Nut-Attached Wiper Blade Arms (before January 6, 1995)



1. Wiper Linkage Assembly

Fig. 3, Wiper System with Latch-Mounted Wiper Blade Arms (from January 6, 1995)

windshield follows the same arc as the wiper arm. There are four jets of spray per wiper arm on the older system, and two jets per wiper arm on the newer system.

NOTE: Repair of all electrical parts in the wiper and washer system is by replacement. The parts of the wiper linkage and bracket assembly can be replaced.

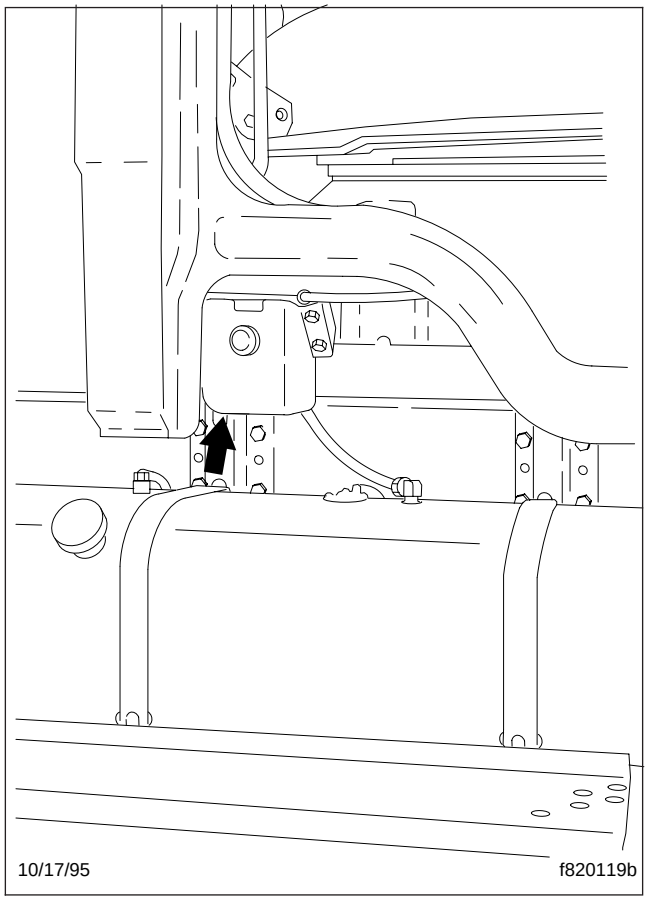


Fig. 4, Windshield Washer Reservoir

On both left-hand drive and right-hand drive vehicles, the wiper motor is installed on the passenger's side. Service procedures are the same for both types.

Wiper Motor Removal and Installation for Systems with Nut-Attached Wiper Blade Arm

Removal

1. Disconnect the batteries.
2. Remove the passenger's side dash panel to gain access to the wiper motor.
   - 2.1 Pull away the extruded rubber trim from the top of the panel.
   - 2.2 Remove the two retaining screws at the top of the panel.
   - 2.3 Lift the panel from the dash.
3. Unplug the multipin connector from the wiper motor harness.
4. Remove the plastic button plug from the access space, located on the passenger's side of the water trough, on the engine side of the firewall.
5. Loosen the pinch-bolt nut at the end of the crank; then unseat the crank from the wiper motor shaft. **See Fig. 1 .**
6. Remove the three nuts from the wiper motor mounting studs.
7. From inside the cab remove the wiper motor.

NOTE: The wiper motor is not a serviceable part.

Installation

1. Position the new wiper motor on the firewall.
2. Install the wiper motor mounting nuts. Tighten them 84 lbf·in (950 N·cm).
3. Plug the multipin connector into the wiper motor harness.
4. Connect the batteries.
5. Run the wiper motor to the park position.
   - 5.1 Turn the key switch on.
   - 5.2 Turn the wiper motor on momentarily then off. The wiper motor should stop in the park position.
   - 5.3 Turn the key switch off.
6. Install the wiper motor crank pointing to the 3 o'clock position as viewed from the engine side of the firewall. **See Fig. 1 .**
7. Tighten the crank pinch-bolt nut securely. Install the plastic button plug into the access space.
8. Test the wiper motor for correct operation.
9. Install the dash panel and retaining screws.
10. Install the extruded rubber trim on top of the panel.

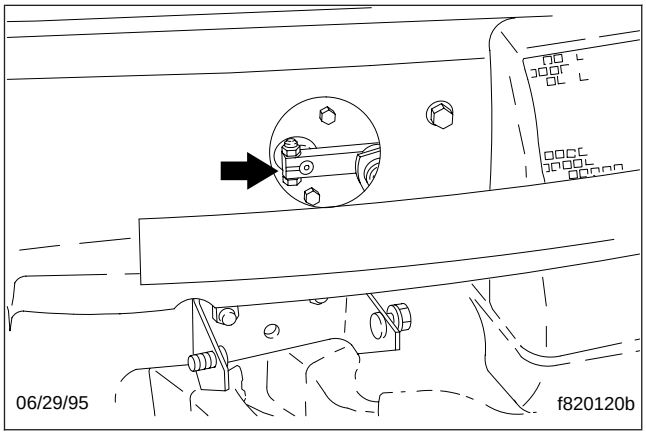


Fig. 1, Pinch Bolt

Wiper Linkage and Support Assembly Removal and Installation for Systems with Nut-Attached Wiper Blade Arm

Removal

1. Lift the wiper arm nut covers for access to the wiper arm nuts.
2. Remove the wiper arm nuts and wiper arms from the splined pivot shafts.

NOTE: Folding the arms out away from the windshield to their over-center position removes the spring tension from the wiper arm hub and eases removal of the wiper arm. **See Fig. 1 .**

3. Remove the wiper arm threaded caps from each pivot arm as shown in **Fig. 2** by turning the caps counterclockwise.
4. Disconnect the wiper washer hose and clamps as necessary to allow removal of the water trough.
5. Remove the cab air intake duct mounting screws. Remove the capscrews and sheet metal screws attaching the water trough to the wiper linkage support bracket and to the firewall. Remove the water trough and cab air duct.
6. Loosen the pinch-bolt nut; then disconnect the wiper motor crank from the wiper motor shaft. **See Fig. 3 .**
7. Remove the capscrews attaching the linkage support bracket to the cowl. **See Fig. 4 .** Remove the wiper linkage assembly. Service as required.

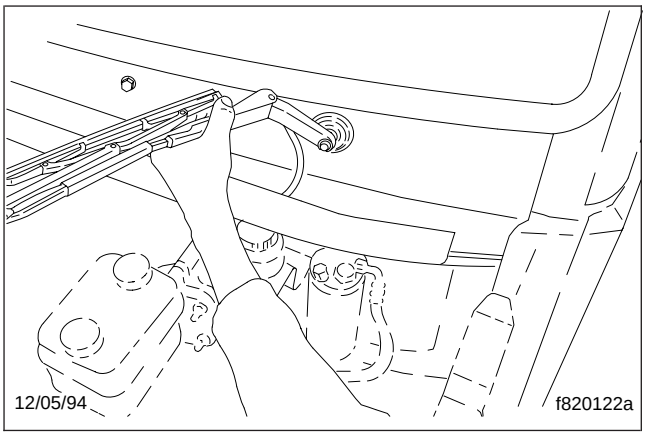


Fig. 1, Wiper Arm Removal

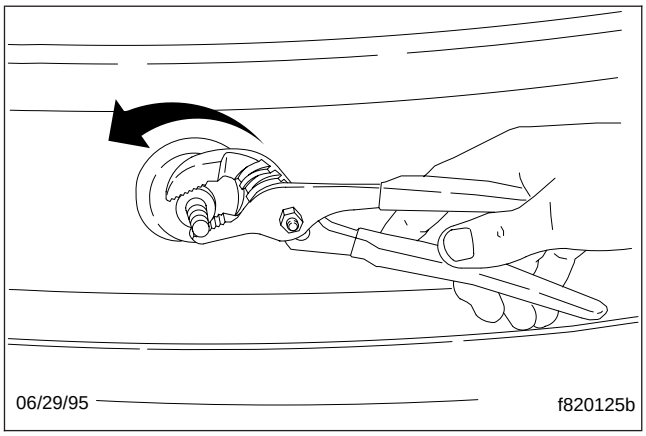


Fig. 2, Turn Caps Counterclockwise

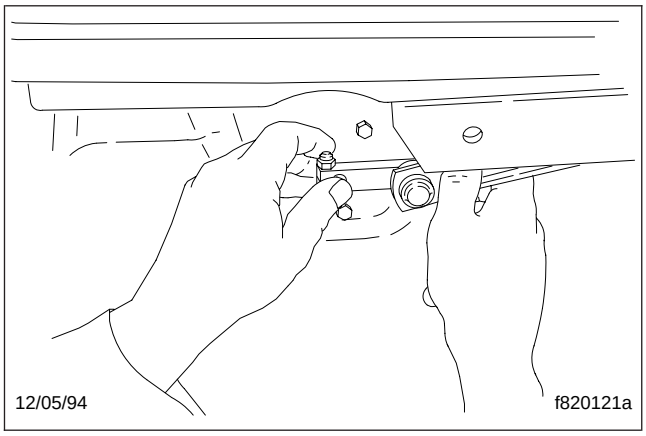


Fig. 3, Disconnect Wiper Motor Crank

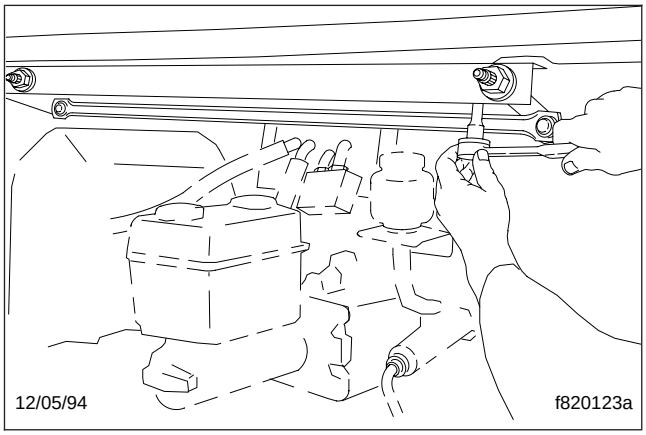


Fig. 4, Capscrew Removal

Wiper Linkage and Support Assembly Removal and Installation for Systems with Nut-Attached Wiper Blade Arm

Installation

1. Install the wiper linkage assembly. Tighten the capscrews 16 lbf·ft (21 N·m).
2. Turn the key switch on; then turn the wiper motor on and then off to position motor in the park position. Turn the key switch off.
3. Install the wiper motor crank pointing to the 3 o'clock position as viewed from the engine side of the firewall. **See Fig. 3 .**
4. Install the cab air intake duct and water trough but do not tighten the fasteners at this time.
5. Use a smooth hooked tool as shown in **Fig. 5** to slip the windshield molding over the upper edge of the water trough. Be careful not to rip the molding. Tighten the water trough capscrews 16 lbf·ft (21 N·m). Tighten the cab air intake duct fasteners. Install the sheet metal screws attaching the water trough to the firewall.
6. Install the wiper arm caps on the pivot arms.
7. With the wiper motor still in the park position, install the wiper arms so that the tips of the wiper blades are 45–55 mm (1–3/4 to 2–1/4 in) from the windshield molding. **See Fig. 6.** Tighten the nuts 13 lbf·ft (18 N·m).
8. Place the wiper arm nut covers over the wiper arm nuts.

NOTE: Conduct the following test on wet glass.

9. Run the wipers at the high speed setting to ensure that the arms do not contact the windshield frame at either end of their stroke. Adjust as necessary.

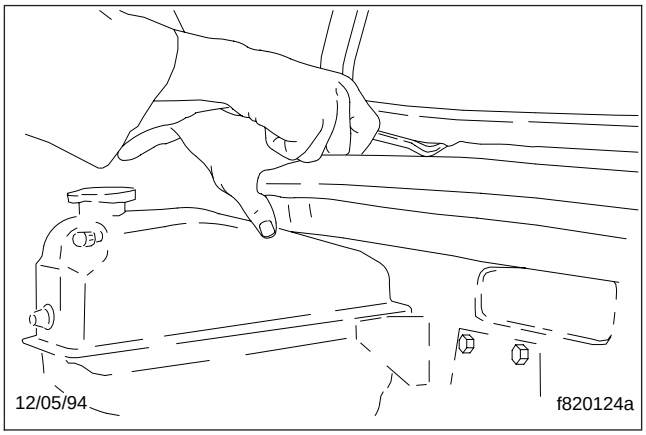
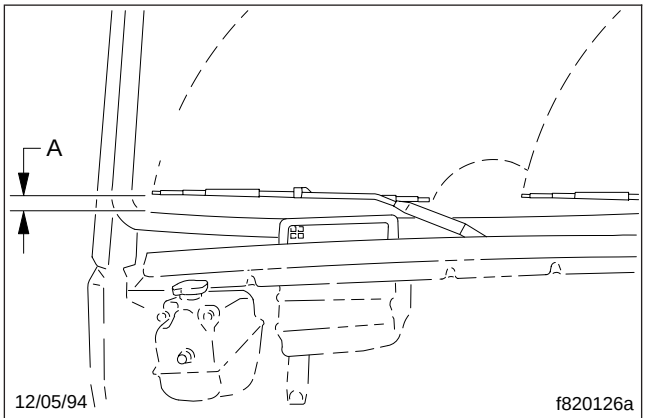


Fig. 5, Installing Windshield Molding



A. 1-3/4" to 2-1/4" (45 to 55 mm)

Fig. 6, Adjusting Wiper Arm Placement

Replacement

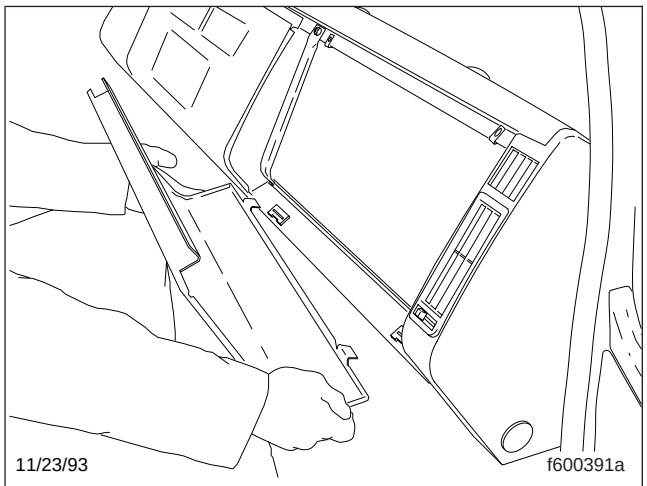
NOTE: To avoid losing washer fluid from the reservoir, you can remove the reservoir and empty it before starting this procedure, or you can place a clean bowl under it before pulling out the pump.

1. Disconnect the electrical connections and washer fluid tubing from the washer pump.
2. Unsnap the pump from the grip of the reservoir body and pull it from the reservoir.
3. Install the new pump.
4. Connect the electrical connections and washer fluid tube.
5. Fill the reservoir.
6. Test the operation of the pump.

Wiper Motor Removal and Installation for Systems with Latch-Mounted Wiper Blade Arms

Removal

1. Disconnect the batteries.
2. Remove the passenger's side dash panel (panel D) to gain access to the wiper motor. See **Fig. 1**.



Left-hand drive shown; right-hand drive opposite

Fig. 1, Removing Panel D

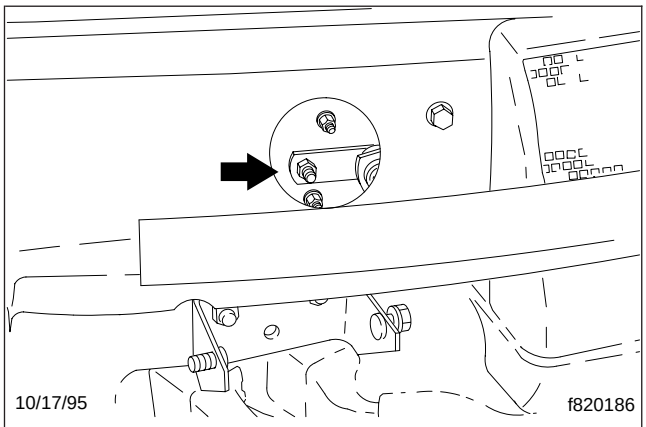
   2.1 Pull away the vinyl extrusion trim from the top of the panel.

   2.2 Remove the two mounting screws at the top of the panel.

   2.3 Lift the panel from the dash.

3. Unplug the multipin connector from the wiper motor harness.
4. Remove the plastic button plug from the access space, located on the passenger's side of the air intake panel on the engine side of the frontwall.
5. Remove the motor crank nut at the end of the motor shaft; then unseat the crank from the wiper motor shaft. See **Fig. 2**.
6. Remove the three nuts from the wiper motor mounting studs.
7. From inside the cab remove the wiper motor.

NOTE: The wiper motor is not a serviceable part.



Left-hand drive shown; right-hand drive opposite

Fig. 2, Motor Crank Nut

Installation

1. Position the new wiper motor on the frontwall.
2. Install the wiper motor mounting nuts. Tighten them 84 lbf·in (950 N·cm).
3. Plug the multipin connector into the wiper motor harness.
4. Connect the batteries.
5. Run the wiper motor to the park position.

   5.1 Turn the ignition keyswitch on.

   NOTE: Ensure the batteries are fully charged.

   5.2 Turn the wiper motor on momentarily, then off. The wiper motor should stop in the park position.

   5.3 Turn the ignition keyswitch off.

6. Install the wiper motor crank pointing to the 3 o'clock position as viewed from the engine side of the frontwall. See **Fig. 2**.
7. Tighten the motor crank nut securely 18 lbf·ft (25 N·m). Install the plastic button plug into the access space.
8. Test the wiper motor for correct operation, and position the wiper arms so that the wiper blades are resting horizontally on the windshield.
9. Install dash panel D and tighten the two mounting screws.

Wiper Motor Removal and Installation for Systems with Latch-Mounted Wiper Blade Arms

10. Install the vinyl extrusion trim on top of the panel.

Wiper Linkage and Support Assembly Removal and Installation for Systems with Latch-Mounted Wiper Blade Arms

Removal

1. Unlatch the wiper arm assembly from the splined pivot shafts.

NOTE: Moving the wiper arms into an unlatched position eases removal of the wiper arms. **See Fig. 1 .**

2. Remove the weather covers from each pivot shaft by turning the weather covers counterclockwise.
3. Disconnect the wiper washer hose and clamps as necessary to allow removal of the air intake panel.
4. Remove the cab air intake duct mounting screws, the capscrews, and the sheet metal screws attaching the air intake panel to the wiper linkage support bracket and to the firewall. Remove the air intake panel and cab air duct.
5. Remove the motor crank nut; then pry the wiper motor crank from the wiper motor shaft. **See Fig. 2 .**
6. Remove the hex capscrews attaching the linkage support bracket to the cowl. **See Fig. 3 .** Remove the wiper linkage assembly. Service as required.

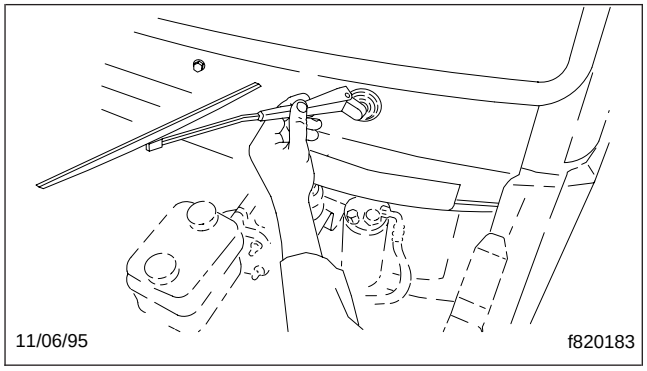


Fig. 1, Wiper Arm Removal

Installation

1. Install the wiper linkage assembly. Tighten the capscrews 16 lbf·ft (21 N·m). **See Fig. 3.**
2. Turn the key switch on; then turn the wiper motor on and then off to position motor in the park position. Turn the key switch off.

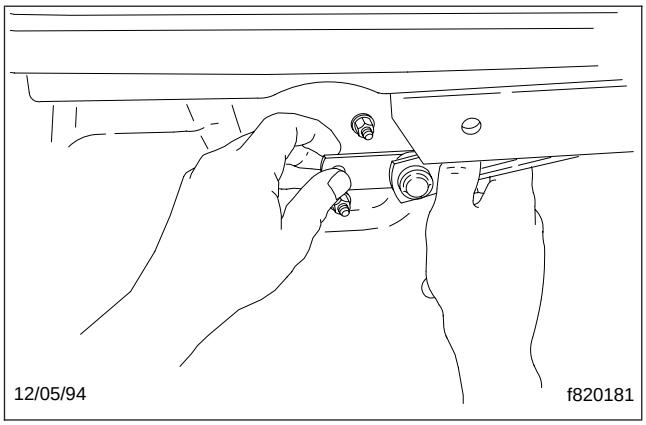


Fig. 2, Disconnect Wiper Motor Crank

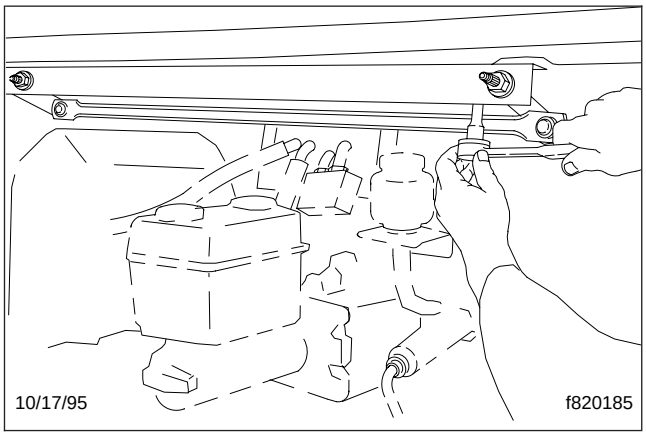


Fig. 3, Capscrew Removal

NOTE: Ensure the battery is fully charged.

3. Install the wiper motor crank pointing to the 3 o'clock position as viewed from the engine side of the firewall. **See Fig. 2 .** Tighten the motor crank nut 18 lbf·ft (25 N·m).
4. Install the cab air intake duct and air intake panel but do not tighten the fasteners at this time.
5. Use a smooth hooked tool as shown in **Fig. 4** to slip the windshield molding over the upper edge of the air intake panel. Be careful not to rip the molding. Tighten the air intake panel capscrews 16 lbf·ft (21 N·m). Tighten the cab air intake duct fasteners. Install the sheet metal screws attaching the air intake panel to the firewall.
6. Install the weather covers on the pivot shafts.

Wiper Linkage and Support Assembly Removal and Installation for Systems with Latch-Mounted Wiper Blade Arms

7. With the wiper motor still in the park position, install the wiper arms so that the wiper blades are resting horizonally on the windshield.

NOTE: Conduct the following test on wet glass.

8. Run the wipers at the high speed setting to ensure that the blades do not contact the windshield moulding or gasket at either end of their stroke. Adjust as necessary.

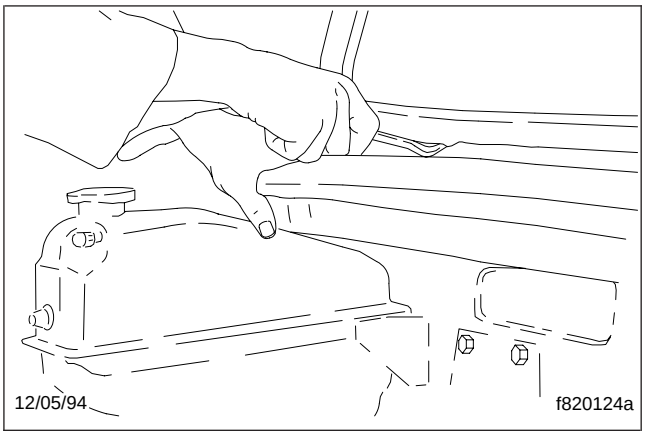


Fig. 4, Installing Windshield Molding

Troubleshooting Tables

VEHICLES WITHOUT INTERMITTENT WIPERS OR VEHICLES WITH INTERMITTENT WIPERS WITH ROCKER SWITCH AND SLIDER SWITCH CONTROLS

Problem—Wipers and Washers Do Not Operate

Problem—Wipers and Washers Do Not Operate	
Possible Cause	**Remedy**
Fuse is blown.	Check fuse. Replace if blown.
Open circuit in power supply (circuits 315 and 305).	With key on, check voltage at wiper and washer switches (circuit 315). If voltage reading is zero, take voltage readings along circuits 315 and 305 back towards ignition switch until open is located. Repair as necessary.

Problem—Washer Motor Inoperable

Problem—Washer Motor Inoperable	
Possible Cause	**Remedy**
Open circuit in switch or between switch and motor.	Make sure there is battery voltage at switch (circuit 315). At motor, check circuit 320 with washer switch closed. Battery voltage should be present. If voltage is not present, locate and repair open circuit or faulty switch.
Faulty motor.	Make sure motor has proper ground; then apply battery voltage to motor (circuit 320). If motor does not work, replace motor.

Problem—Fuses Blow Repeatedly

Problem—Fuses Blow Repeatedly	
Possible Cause	**Remedy**
Incorrect fuse.	Make sure correct fuse is being used. See **Group 54** for circuit breaker and fuse table.
Wiring or switch shorted to ground.	Remove fuse. Unplug wiper motor harness and washer motor power wire. At fuse holder, check continuity between circuit 315 and ground. Check with wiper switch in OFF, LOW and HIGH positions, and with washer switch in OFF and ON positions. Ohmmeter should read infinite in all switch positions. If ohmmeter shows continuity in any switch position, replace grounded component.
Washer motor shorted.	If the above tests reveal no problem, and if fuse blows only when using washers, replace washer motor.
Bind in linkage causing drag on wiper motor.	Disconnect wiper crank from wiper motor. Swing wiper blades away from windshield to their over-center position. Operate wiper linkage by hand. Linkage should operate freely without binding or drag. Repair or replace as necessary.
Wiper motor shorted.	Make sure motor has proper ground. If the above tests reveal no problem, and fuse still blows, replace wiper motor.

Troubleshooting

Problem—Wiper Motor Does Not Work On Low Speed

Problem—Wiper Motor Does Not Work On Low Speed	
Possible Cause	**Remedy**
Open circuit in switch or between switch and motor, or faulty motor.	At motor, check circuit 316 with switch on low speed. Battery voltage should be present. If voltage is not present, locate and repair open circuit or faulty switch. If voltage is present, replace motor.

Problem— Wiper Motor Does Not Work On High Speed

Problem—Wiper Motor Does Not Work On High Speed	
Possible Cause	**Remedy**
Open circuit in switch or between switch and motor, or faulty motor.	At motor, check circuit 318 with switch on high speed. Battery voltage should be present. If voltage is not present, locate and repair open circuit or faulty switch. If voltage is present, replace motor.

Problem—Wiper Motor Inoperable

Problem—Wiper Motor Inoperable	
Possible Cause	**Remedy**
Open in circuit 315 wire or in wiper switch.	At wiper switch, check circuit 315 for battery voltage. Battery voltage should be present. If voltage is not present, locate and repair open circuit. Check circuit 316 (low speed) or 318 (high speed) for voltage with switch in corresponding position. If no voltage, replace wiper switch.
Faulty motor.	Make sure motor has proper ground; then apply battery voltage to motor (circuit 316 for low speed, circuit 318 for high speed). If either speed is not operational, replace motor.

VEHICLES WITH INTERMITTENT WIPERS WITH ROCKER SWITCH AND SLIDER SWITCH CONTROLS

Problem—Wipers Do Not Park and Intermittent Feature Does Not Work Properly

Problem—Wipers Do Not Park and Intermittent Feature Does Not Work Properly	
Possible Cause	**Remedy**
Open circuit in wire 319.	Disconnect the wiper motor connector and check for battery voltage at pin 319. If no voltage, repair the 319 wire.
Open circuit in wire 317, intermittent wiper relay or wiper switch.	Disconnect the wiper motor connector and check for continuity between pin 316 and pin 317 at the harness side of the wiper motor connector. If no continuity, check the 317 wires, wiper switch and the intermittent wiper relay for an open.
Open circuit in wiper motor park switch.	With the wipers at mid stroke, turn the wiper switch and key switch to off. Disconnect the wiper motor connector and check for continuity between pin 317 and pin 319 at the wiper motor. If no continuity, replace the wiper motor.

Problem—Wiper Intermittent Feature Does Not Work Properly, But the Wipers Park Normally

Problem—Wiper Intermittent Feature Does Not Work Properly, But the Wipers Park Normally	
Possible Cause	**Remedy**
Open circuit in wire 319.	Disconnect the intermittent wiper relay and check for battery voltage at pin 319. If no voltage, repair the 319 wire.
Open circuit in wire 315.	Operate the washer switch to prove the 315 wire is good. If the washer does not operate, disconnect the intermittent wiper/washer switch and check for battery voltage at pin 315. If no voltage, repair the 315 wire.
Open circuit in ground wire at the intermittent wiper/washer switch.	Disconnect the intermittent wiper/washer switch and check for continuity to ground at the switch ground terminal. If no continuity, repair the ground wire.
Inoperative intermittent wiper relay or open intermittent wiper relay ground or inoperative intermittent wiper/washer switch.	Perform the above steps before this one. Disconnect the intermittent wiper/ washer switch; and with the key switch on, momentarily jumper wire 315A to wire 315 (battery voltage). If the wipers do make one pass, replace the intermittent wiper/washer switch. If the wipers do not make one pass, check the 315 wire and the intermittent wiper relay ground wire for an open; and then check the intermittent wiper relay for proper operation.

VEHICLES WITHOUT INTERMITTENT WIPERS

Problem—Wipers Do Not Park at Bottom of Stroke

Problem—Wipers Do Not Park at Bottom of Stroke	
Possible Cause	**Remedy**
Wiper crank incorrectly positioned on wiper motor shaft (wipers park in same position each time wiper switch is opened).	Disconnect wiper crank from motor shaft. Turn key switch on; then momentarily turn wiper motor on then off. Wiper motor should be at park position. Turn key switch off. Install wiper crank onto motor shaft pointing to the 3 o'clock position.
Wiper park circuit inoperable (wipers stop immediately when wiper switch is opened).	With wipers at mid-stroke, turn wiper switch and key switch off. Unplug the wiper motor wiring harness. At the wiper motor connector, connect the ground pin to ground and jump pin 316 to 317. Apply battery voltage from fused circuit to pin 319. If motor returns to park, repair open in circuit 319, or circuit 317 or replace switch as necessary. If motor does not return to park, replace motor.

VEHICLES WITH INTERMITTENT WIPERS WITH DOUBLE-PADDLE SWITCH

Problem—Wipers and Washer Not Working

Problem—Wipers and Washer Not Working	
Possible Cause	**Remedy**
The wiring is loose.	Check for and tighten any loose wiring connections.

Troubleshooting

Problem—Wipers and Washer Not Working	
Possible Cause	**Remedy**
An open or short circuit.	Check circuits 315, 315H, 315L, and 315P, the ignition circuit breaker, and both high-speed and low-speed relays. For a wiring diagram, refer to **Specifications 400**.
	Tighten loose wiring connection(s).
	Check and replace the switch.
	Check and replace broken wire(s).
The system is binding.	Free or replace the linkage.
	Free or replace the arm or blade.
The motor does not work.	Replace the motor.

Problem—The Wiper Motor Shaft Turns, But the Wiper Arms Do Not Move

Problem—The Wiper Motor Shaft Turns, But the Wiper Arms Do Not Move	
Possible Cause	**Remedy**
The drive crank is loose or disconnected.	Check the drive crank. If it's loose at the wiper motor drive shaft, clean the drive shaft splines. Replace the crank if necessary. If the crank is disconnected from the drive pivot bar, connect it and line it up correctly. For instructions, refer to **Subject 110**. If the problem persists, replace or repair parts as needed.
The linkage is loose or disconnected.	Check all the linkage connections. Repair or replace parts as needed.

Problem—Wiper Motor High Speed Not Working

Problem—Wiper Motor High Speed Not Working	
Possible Cause	**Remedy**
An open circuit.	Check circuits 315H and 315B for continuity. For a wiring diagram, refer to **Specifications 400**.

Problem—Wiper Motor Low Speed Not Working

Problem—Wiper Motor Low Speed Not Working	
Possible Cause	**Remedy**
An open circuit	Check circuits 315L and 315A for continuity. For a wiring diagram, refer to **Specifications 400**.

Problem—Washers Not Working

Problem—Washers Not Working	
Possible Cause	**Remedy**
Washer tubing disconnected.	Check the washer tubing between the washer pump and the wipers.

Problem—Washers Not Working	
Possible Cause	**Remedy**
An open circuit.	Check circuits 320 and 320A for continuity. Check the ground wire on the switch. For a wiring diagram, refer to **Specifications 400**.

Problem—Circuit Breaker Keeps Tripping

Problem—Circuit Breaker Keeps Tripping	
Possible Cause	**Remedy**
Incorrect circuit breaker installed.	Make sure correct amperage circuit breaker is installed. For the correct amperage, refer to **Specifications 400**.
Wiring is shorted to ground.	Check the wiring and the motor for shorts to ground. For a wiring diagram, refer to **Specifications 400**.
The wiper linkage is binding.	Check the linkage.

Problem—Wipers Do Not Park

Problem—Wipers Do Not Park	
Possible Cause	**Remedy**
The park circuit is not working	Check circuits 315 and 315P (blue) for continuity. Check the ground wire on the switch. For a wiring diagram, refer to **Specifications 400**.

Problem—Intermittent (Delay) Feature Not Working; High and Low Speeds are O.K.

Problem—Intermittent (Delay) Feature Not Working; High and Low Speeds are O.K.	
Possible Cause	**Remedy**
The wiper switch ground circuit is open.	Check the ground wire on the switch. For a wiring diagram, refer to **Specifications 400**.

Problem—Wipers Oversweeping

Problem—Wipers Oversweeping	
Possible Cause	**Remedy**
Worn or broken linkage component.	Replace linkage components as required.
Worn or broken pivot assembly.	Replace the pivot assembly.
Worn or broken wiper arm.	Replace the wiper arm.
The motor assembly is loose.	Secure the motor assembly.
Vehicle voltage too high.	Repair the vehicle electrical system.

Problem—Wipers Oversweeping (for Vehicles With Intermittent Wipers Built From December 5, 1997)

Problem—Wipers Oversweeping (for Vehicles With Intermittent Wipers Built From December 5, 1997)	
Possible Cause	**Remedy**
The motor assembly is loose.	Secure the motor assembly.

Troubleshooting

Problem—Wipers Oversweeping (for Vehicles With Intermittent Wipers Built From December 5, 1997)	
Possible Cause	**Remedy**
Vehicle voltage too high.	Repair the vehicle electrical system.

Specifications

For a schematic of the wiring on non-intermittent wipers, see **Fig. 1**.

For a schematic of the wiring on intermittent wipers for vehicles built before December 5, 1997, see **Fig. 2**.

For a schematic of the wiring on intermittent wipers for vehicles built from December 5, 1997, see **Fig. 3**

For circuit protector identification in the electrical power center, see **Fig. 4**.

For a diagram of the wiper park position for vehicles with left-hand drive, see **Fig. 5**.

For a diagram of the wiper park position for vehicles with right-hand drive, see **Fig. 6**.

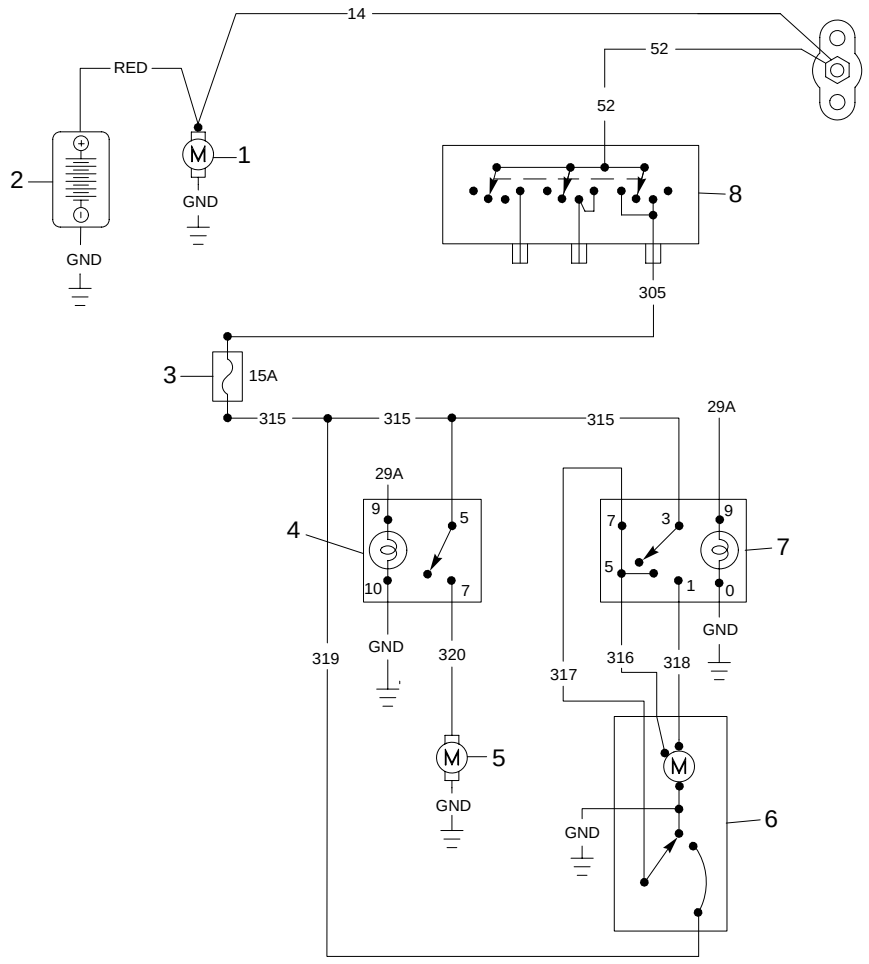
Fastener Torques for Nut-Attached Arm Systems			
Description	**Size**	**Torque**	
		lbf·in (N·cm)	**lbf·ft (N·m)**
Wiper Motor Mounting Nuts	M6	84 (950)	—
Wiper Linkage Assembly Capscrews	M8 x 20	—	16 (21)
Water Trough Capscrews	M8 x 20	—	16 (21)
Wiper Arm Nuts	M8	—	13 (18)

Table 1, Fastener Torques for Nut-Attached Arm Systems

Fastener Torques for Latch-Mounted Arm Systems			
Description	**Size**	**Torque**	
		lbf·in (N·cm)	**lbf·ft (N·m)**
Air Intake Panel Capscrews	M8 x 20	—	16 (21)
Motor Crank Nut	M8	—	18 (25)
Wiper Linkage Assembly Capscrews	M8 x 20	—	16 (21)
Wiper Motor Mounting Nuts	M6	84 (950)	—

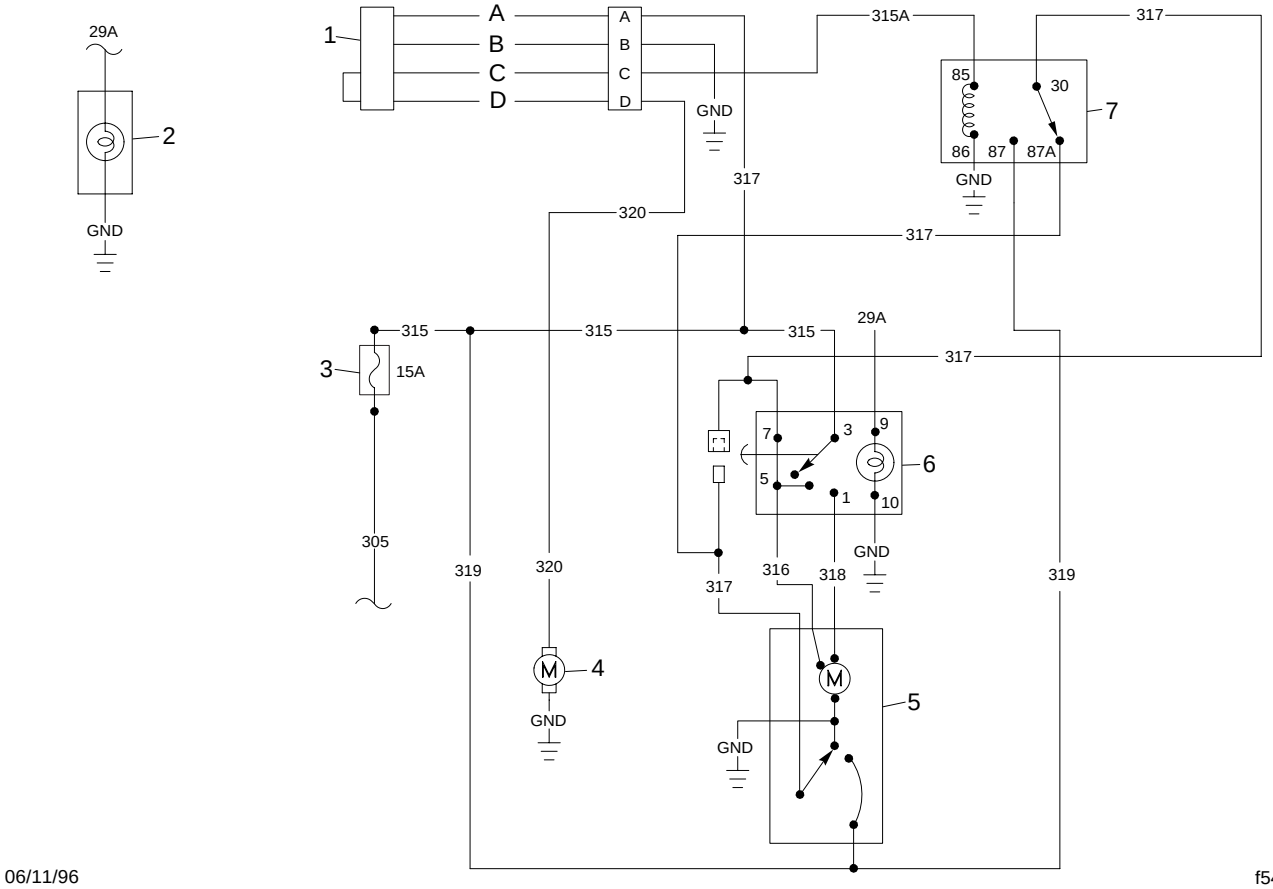
Table 2, Fastener Torques for Latch-Mounted Arm Systems

Specifications



1. 12-Volt Cranking Motor
2. Battery
3. Fuse
4. Washer Switch
5. Washer Motor
6. Wiper Motor
7. Wiper Switch
8. Key Switch

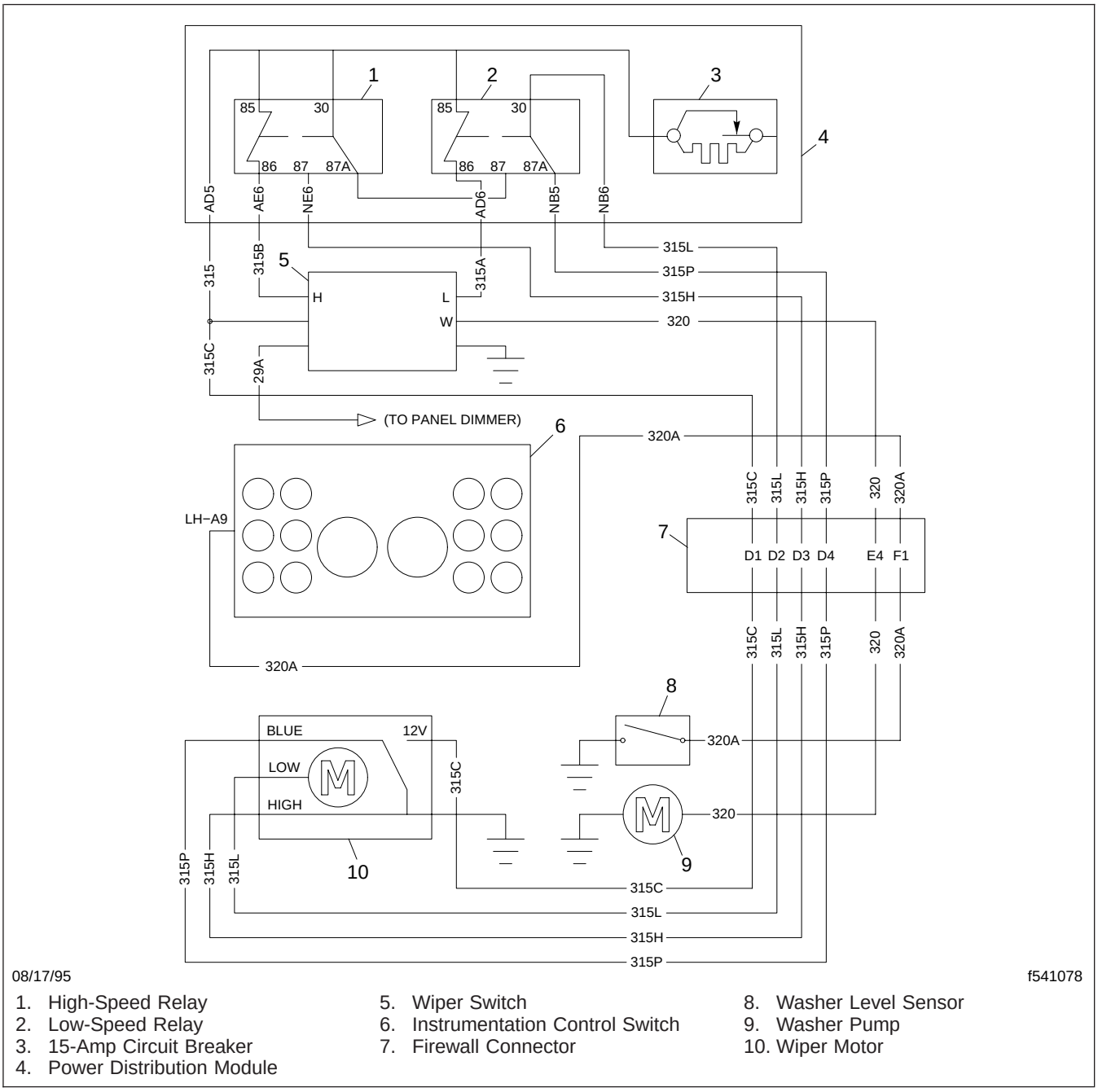
Fig. 1, Non-intermittent Wiper Wiring Diagram



A. Blue (+)
B. Black (–)
1. Intermittent Wiper and Washer Control
2. Wiper/Delay Lamp
3. Circuit Breaker or Fuse
4. Washer Motor
C. Yellow (wiper output)
D. Red (washer)
5. Wiper Motor
6. Wiper Switch
7. Intermittent Wiper Relay

Fig. 2, Intermittent Wiper Wiring Diagram for Vehicles Built Before December 5, 1997

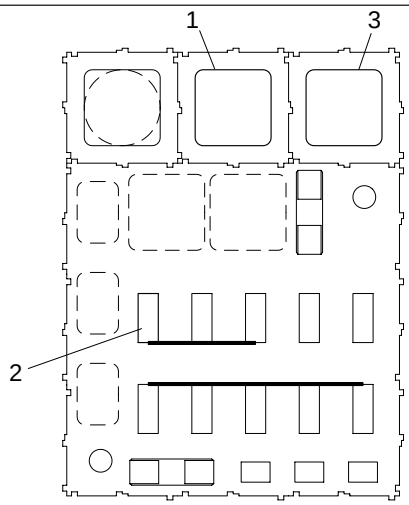
Specifications



08/17/95 f541078

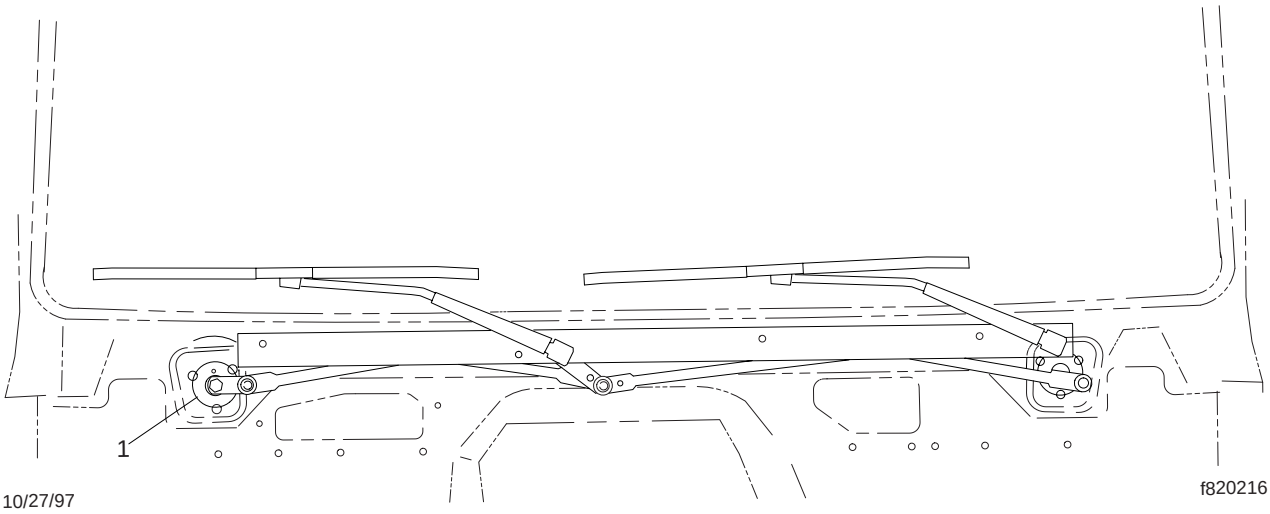
1. High-Speed Relay
2. Low-Speed Relay
3. 15-Amp Circuit Breaker
4. Power Distribution Module
5. Wiper Switch
6. Instrumentation Control Switch
7. Firewall Connector
8. Washer Level Sensor
9. Washer Pump
10. Wiper Motor

Fig. 3, Intermittent Wiper and Washer Wiring Diagram for Vehicles Built From December 5, 1997



1. Intermittent Wiper Relay
2. Washer and Wiper Accessory-Controlled Circuit Breaker or Fuse
3. Intermittent Wiper Relay (for Vehicles Built From December 5, 1997)

Fig. 4, Electrical Power Center, A-Panel

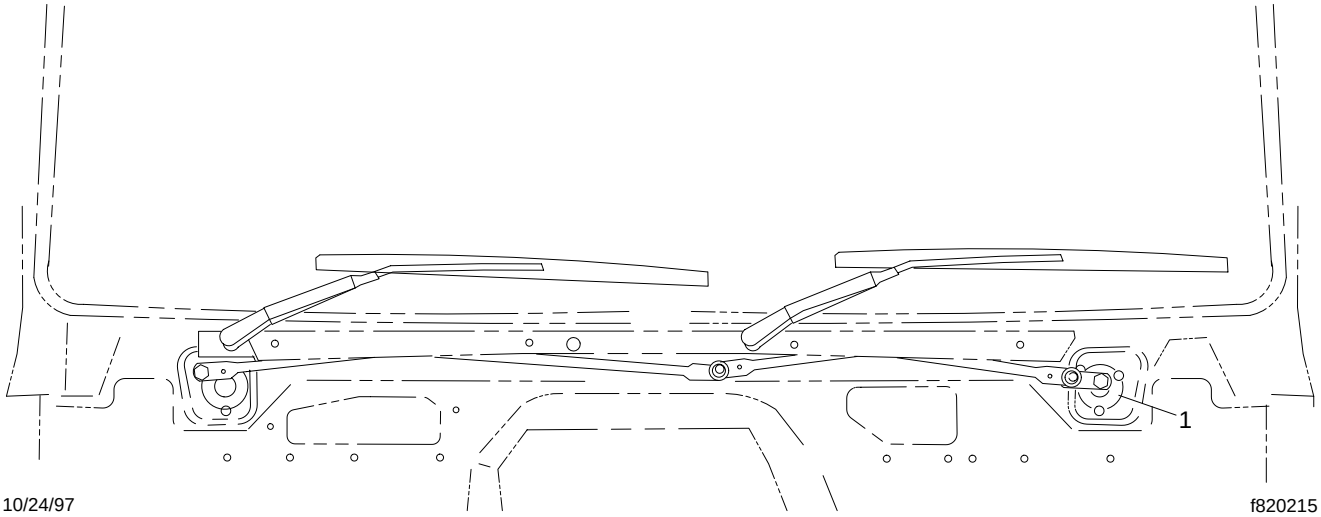


Position the wiper arms so that the wiper blades are resting horizontally on the windshield.

1. Motor

Fig. 5, Wiper Park Position, Left-Hand Drive

Specifications



Position the wiper arms so that the wiper blades are resting horizontally on the windshield.

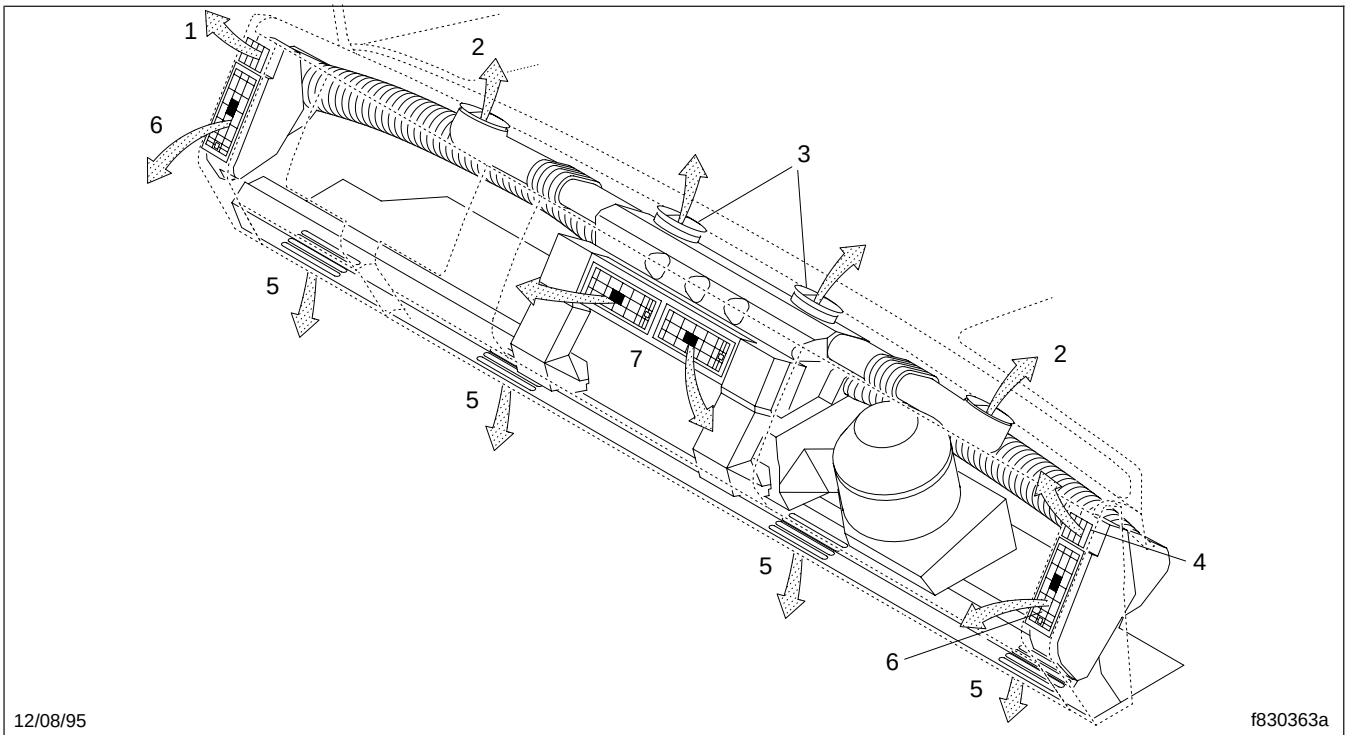
1. Motor

Fig. 6, Wiper Park Position, Right-Hand Drive

General Information, Description of Components, Definition of Terms, and Principles of Operation

General Information

The heater and air conditioner unit uses a common blower motor and duct work to heat or cool the cab. Airflow rate is controlled by a three-speed blower switch. Air outlets are located in the instrument panel, along the bottom of the dash, at the windshield, and also at the side windows. See **Fig. 1**.



1. Driver's Door Window Defrost Outlet
2. Windshield Defrost Outlet
3. Windshield Defrost Outlets
4. Passenger's Door Window Defrost Outlet
5. Floor Outlet
6. Dash/Door Window Vent
7. Center Dash Vents

Fig. 1, Air Outlet System

When equipped with an air conditioner, temperature can be moderated by opening or closing a water regulating valve, which controls the flow of warm engine coolant to the heater core. The temperature of the air inside the cab partly depends on how much coolant is flowing through the heater core, and how much liquid refrigerant is in the evaporator coil.

The air conditioning system also includes a cycling-clutch refrigerant compressor, a condenser, an expansion valve, an evaporator coil, a fixed-temperature thermostatic switch, and mechanically operated controls.

DESCRIPTION OF COMPONENTS

Refrigerant

Refrigerant absorbs heat from the air in the cab and releases it to the air outside the cab.

In an open container, refrigerants boil at temperatures below the freezing point of water; sealing and pressurizing refrigerant in the air conditioning system raises its boiling-point temperature.

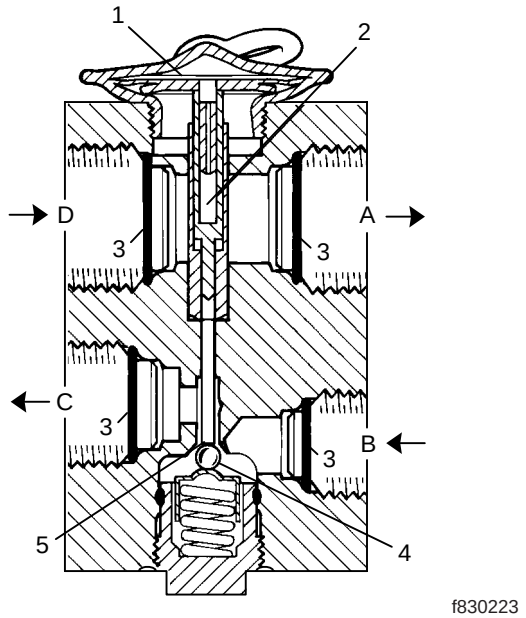
During compressor operation, refrigerant constantly changes from a liquid to a gas. It absorbs heat (boiling) in the low-pressure evaporator coils, and it changes from a gas to a liquid as it releases absorbed heat in the high-pressure condenser.

General Information, Description of Components, Definition of Terms, and Principles of Operation

Expansion Valve

The expansion valve is a dividing point between the high-and low-pressure parts of the refrigerant system. High-pressure liquid refrigerant from the receiver-drier passes through the expansion valve and moves into the low-pressure area of the evaporator coil.

An expansion valve controls the flow rate of refrigerant in proportion to the rate of evaporation in the evaporator. If the amount of liquid in the evaporator drops off, the temperature of the gas going to the compressor rises. This causes a diaphragm in the expansion valve to react, which causes an orifice in the valve to open or close. Refer to **Fig. 2**. Through the orifice, liquid refrigerant is metered into the evaporator, as needed.



A. to compressor.
B. from receiver-drier.
C. to evaporator.
D. from evaporator.
1. Diaphragm
2. Temperature Sensor
3. O-Rings
4. Metering Orifice
5. Ball and Spring

Fig. 2, Expansion Valve

Evaporator Coil

Because the evaporator coil is an area of low pressure in the system, the boiling point of refrigerant lowers, which causes it to absorb heat from the tubing walls and fins of the coils. As it absorbs heat, liquid refrigerant quickly boils and turns into a gas.

As heat is absorbed from the outside surfaces of the evaporator coil, air passing over the unit loses its heat to these cooler surfaces. Moisture in the air condenses on the outside of the coil and drains off as water (the air becomes dehumidified).

Refrigerant Compressor

"Heat" in the low-pressure gas of the evaporator coils is not heat that can be noticed by touch, because liquid refrigerant boils at a temperature much lower than the temperature at which water turns to ice. By touch, the "heated" gas in the coils is very cold. As a result, there is the problem of how to remove heat from subfreezing gas using outside air that may be higher than 100°F (38°C).

With a refrigerant compressor, low-pressure gas from the evaporator can be squeezed into a much smaller space. When the gas is compressed, the heat it contains becomes concentrated. In this way, the gas is made hotter than the outside air, without adding heat.

Another function of the compressor is to move refrigerant through the system.

Condenser

A condenser turns hot refrigerant gas, coming from the compressor, into liquid. Mounted in front of the radiator, it is made up of a coiled tube and a series of fins. Because of its location, the condenser transfers heat to air that is drawn in by the engine fan and by air that is forced into the engine compartment as the vehicle moves forward (ram air).

Receiver-Drier

Used as a reservoir and filter for liquid refrigerant from the condenser, a receiver-drier also removes water and acids from the refrigerant. The water-absorbing material (desiccant) in the unit helps stop blockages from forming in the expansion valve and in other parts of the system.

A moisture indicator shows the amount of water in the refrigerant. A sight glass (aperture) on the unit contains a specially treated element (litmus paper) that changes color, depending on the amount of water in the refrigerant. The indicator changes from a deep cobalt blue (dry) to light greyish-blue (wet) to lilac, lavender, and finally pink (very wet). Any color other than cobalt blue is considered wet. Any time

the system is evacuated (dehydrated), replace the receiver-drier.

Thermostatic Switch

The temperature of the evaporator coil is monitored by a fixed-temperature thermostatic switch.

The probe from the switch extends to the evaporator coil, and the switch is mounted on the right side of the heater and air conditioner housing. This switch disengages the compressor to prevent the evaporator coil from freezing up due to, for example, an expansion valve that is stuck open.

Binary Switch

A binary switch disengages the refrigerant compressor to protect it from harmful operating conditions. It performs two functions:

1. If refrigerant is lost or the outside temperature is too low, the binary switch will keep the compressor from operating. The switch disengages the compressor when falling pressure goes below 26 to 31 psig (179 to 214 kPa); normal compressor operation resumes when rising pressure reaches 0.1 to 3 psig (0.6 to 21 kPa) above shut-off pressure.
2. If the compressor cylinder head pressure increases to unsafe levels above 356 to 413 psig (2454 to 2847 kPa), the binary switch shuts off the compressor. Too much pressure may be caused by blocked air flow through the condenser, a plugged expansion valve or receiver-drier, or too much refrigerant in the system. When pressure falls back 57 to 11 psig (393 to 786 kPa) from shut-off pressure, the compressor resumes operation.

Heater Core

The heater core is a series of fins through which tubing is routed. When the heating system is on, engine coolant flows through the heater core tubes, heating the tubes and fins. The heat is absorbed by air that is forced through the heater core by the blower motor.

Water Regulating Valve

When opened, the water regulating valve allows engine-heated coolant to flow through the heater core.

Air Blower, Resistor Block Assembly

An air blower forces air through the heater core and evaporator coil, and into the cab. The resistor block assembly regulates the voltage to the blower motor. The voltage controls the blower motor speed. The resistor assembly has a thermal cutout which shuts off current to the blower motor in case the motor malfunctions.

DEFINITION OF TERMS

Refer to the following terms for a better understanding of the heater/air-conditioning system.

Air Conditioner A system used to control the temperature, humidity, and movement of air.

Ambient Air Temperature The temperature of air around an object; the outside temperature.

Binary Switch Disengages the refrigerant compressor to protect it from harmful operating conditions.

Blower A motor and fan used to draw air through the evaporator, and force it through the heater core and into the cab.

Blower Resistor Block Assembly Inline resistors that control the amount of voltage going to the blower motor. By controlling the voltage, you can control the fan speed.

Boiling Point The temperature at which a liquid changes to a gas. The boiling point varies with pressure.

Bulk Charging Use of large containers of refrigerant for charging a refrigerant system. Normally used for charging empty systems.

Carbon Dioxide A colorless, odorless, dry, inert gas that can be used to purge light contaminants (for example, dust) from air conditioner parts.

CFM Cubic feet per minute

Charge A specific amount of refrigerant or oil by volume or weight. Also, the act of placing an amount of refrigerant or oil in the air conditioning system.

Clutch Cycling Switch Engages or disengages the compressor depending on changes in system pressure or evaporator temperature.

Cold The absence of heat. (The lowest possible temperature is thought to be –459 °F [–273 °C].)

Compressor A device used to draw low-pressure

General Information, Description of Components, Definition of Terms, and Principles of Operation

refrigerant gas from the evaporator and squeeze it into a high-temperature, high-pressure gas. A second purpose of the compressor is to move refrigerant through the system.

Condensate Water, taken from the air, which forms on the outer surface of the evaporator.

Condenser A heat exchanger that is used to remove heat from the refrigerant, changing it from a high-pressure hot gas to a high-pressure warm liquid.

Condensing Pressure Pressure, as read from the gauge at the discharge service valve; pressure from the discharge side of the compressor into the condenser.

Contaminants Anything other than refrigerant or refrigerant oil in the system. Usually means water in the system. When water and refrigerant mix, corrosive hydrochloric acid forms.

Cycling Clutch System A system which controls compressor clutch operation in order to raise or lower the temperature in the cab.

Dehumidify To remove water from the air, at the evaporator coil.

Dehydrate To remove all traces of moisture from the refrigerant system. Normally called evacuation.

Desiccant A drying agent used in the refrigerant system (in the receiver-drier) to remove water and create an extremely dry condition.

Discharge To bleed some or all of the refrigerant from a system by opening a valve or hose connection and recovering the refrigerant from the system.

Discharge Line Connects the refrigerant compressor outlet to the condenser inlet.

Discharge Pressure Pressure of the refrigerant being discharged from the compressor; high-side pressure.

Drive Pulley A V-pulley attached to the front of the engine crankshaft. It drives the compressor clutch pulley with a belt.

Drying Agent See "Desiccant."

Duct A passageway for the transfer of air from one point to another.

Evacuate To place a high vacuum in the air-conditioning system and dehydrate or remove all traces of wet air.

Evaporate To change state from a liquid to a gas.

Evaporator Coil A component in which liquid refrigerant changes to a gas after it absorbs heat from the air. Also removes some water from the air.

Expansion Valve A device that causes a pressure-drop of the refrigerant and also regulates its flow.

Flooding A condition caused by too much liquid refrigerant going into the evaporator; usually caused by an expansion valve that is stuck open.

Flushing A process of passing liquid refrigerant through an air-conditioner component to remove dirt and water from the part. Liquid refrigerant removes heavy contamination, such as gritty dirt and large dirt build-up, which cannot be removed by purging with a gas.

Foaming Bubbles of oil and refrigerant caused by a rapid boiling out of refrigerant dissolved in the oil when the pressure is suddenly reduced. Foam in the sight glass means a very low refrigerant charge.

Freeze-Up Failure of a unit to operate properly because of ice forming at the expansion valve orifice or on the evaporator coils and fins.

Head Pressure Refrigerant pressure from the discharge side of the compressor to the condenser and expansion valves.

Heater Core A part of the heating system in which hot engine coolant flows to provide heat to the cab or to adjust the temperature produced by the air conditioner.

High-Side Service Valve A device located on the liquid line near the thermostatic expansion valve; it allows high-side pressure to be checked and other service operations to be performed.

Humidity The amount of water vapor in the air.

Hydraulic Lock The return of liquid refrigerant to the compressor, which could destroy the unit.

Hydrochloric Acid A highly corrosive substance that forms when water and refrigerant mix in a refrigerant system.

Hydrofluorocarbon The chemical name for R–134a.

Leak Detector Any device used to detect refrigerant leaks in a refrigerant system.

Liquid Pressure Pressure of refrigerant in the liquid line from the receiver-drier to the thermostatic expansion valve.

General Information, Description of Components, Definition of Terms, and Principles of Operation

Low Head Pressure High-side pressure that is lower than normal due to a system problem.

Low Suction Pressure Low-side pressure that is lower than normal due to a system problem.

Magnetic Clutch An electrical coupling device used to engage or disengage the compressor.

Manifold Device to control refrigerant flow for system test purposes; used with manifold gauges.

Manifold Gauge A calibrated instrument used for measuring system pressures.

Manifold Gauge Set A manifold that is complete with gauges and charging hoses and is used to measure or test pressure.

Micron A metric measurement of mercury; one-tenth of an inch of mercury equals 2540 microns. Measurement in microns is the only accurate way to determine the amount of pressure that is left in a refrigerant system by a high vacuum pump.

Moisture Indicator Litmus paper in a sight glass receiver-drier; shows how much water is in the system.

Nitrogen A colorless, odorless, dry, inert gas that can be used to purge light contaminants (for example, dust) from air conditioner parts.

Opacity A condition that is used to describe contamination of refrigerant oil in the compressor. Fresh refrigerant oil is clear; when contaminated, it appears cloudy or may have fine particles held in suspension.

Overcharge Too much refrigerant or oil in the system.

Phosgene Fumes Poisonous gas produced when refrigerant contacts an open flame or some other source of intense heat.

psia Pounds per square inch, absolute pressure.

psig Pounds per square inch, gauge pressure.

Purge To remove damp air, traces of refrigerant, and loose dirt from a system or part by flushing with a dry, inert gas, such as nitrogen.

Receiver-Drier A combination desiccant, filter, and storage container for liquid refrigerant.

Refrigerant–12 (R–12) A cooling agent used in automotive air conditioning systems. It is being phased out due to environmental concerns.

Refrigeration Cycle The complete circulation of refrigerant through an air conditioning system, accompanied by changes in temperature and pressure.

Refrigerant Oil Highly refined oil compatible with air-conditioning system refrigerants.

Relative Humidity The actual water content of the air in relation to the total water vapor the air can hold at a given temperature.

Resistor A voltage-dropping device, usually wire-wound, for controlling fan speed.

Schrader Valve A spring-loaded valve (similar to but not interchangeable with a tire valve) located inside the compressor service valve fitting to hold refrigerant in the system. Special adaptors must be used with the gauge hose to get into the system.

Sight Glass A window in the receiver-drier (moisture indicator) used to check the refrigerant charge.

Suction Line The line connecting the evaporator outlet to the compressor inlet.

Suction Pressure Compressor inlet pressure (the system's low-side pressure).

Suction Service Valve A device located on the suction hose near the thermostatic expansion valve that allows low-side pressure to be checked and other service operations to be performed.

Suction Side The low-pressure area of the system, extending from the expansion valve to the compressor inlet.

Thermistor A temperature-sensing resistor that is used to measure (in microns) internal system vacuum levels during evacuation.

Thermostatic Switch A temperature-sensitive switch used to control system temperature and prevent evaporator freeze-up; it does this by cycling the compressor's operation.

Thermostatic Vacuum Gauge A high-vacuum gauge sensitive to pressures ranging from atmospheric pressure to less than 1 micron, with scales reading from 25,000 microns to 1 micron.

Undercharge A system low on refrigerant, resulting in lack of cooling and possible compressor damage.

Vacuum Refers to pressure that is less than atmospheric pressure.

Vacuum Pump A mechanical device used to evacuate and place a high vacuum in the refrigerant system.

Vacuum Pump Oil Water soluble oil used in some

General Information, Description of Components, Definition of Terms, and Principles of Operation

vacuum pumps to absorb water from the refrigerant system.

Vapor The gaseous state of a material.

Water Regulating Valve A valve, mechanically operated, for controlling the flow of hot coolant to the heater core.

Principles of Operation

HEATER

Moving the temperature control toward maximum heat opens the water regulating valve, which allows engine-heated coolant to flow through the heater core. Heat absorbed by the air passing over the heater core fins is forced through ducts and into the cab.

AIR CONDITIONER

When the air conditioner is on, the motion of the compressor squeezes the refrigerant into a high-pressure, high-temperature gas. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid. After it is compressed, refrigerant gas moves out of the discharge port of the compressor, and on to the condenser.

At the condenser, air passing over the coil's fins absorbs heat from the hot refrigerant gas and causes it to change into a liquid. The liquid moves to the receiver-drier, which filters it and removes traces of water and acids. The receiver-drier then stores the refrigerant until it is needed by the system.

From the receiver-drier, liquid refrigerant moves to the expansion valve, which meters the flow into the evaporator coil and acts as a boundary between the high-and low-pressure sides of the system. The metered release of the expansion valve greatly drops the liquid's pressure, causing it to expand. The pressure drop lowers the boiling point of the refrigerant, and causes it to evaporate quickly as it absorbs heat from air passing over the coil. The resulting cool air is forced into the cab by the blower; the heated refrigerant gas is drawn back into the compressor, where the cycle is repeated.

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold refrigerant, you must discharge, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the air conditioning system has been discharged to a refrigerant recovery unit through the service valves on the compressor.

Refrigerants are safe when used under the right conditions. Always wear safety goggles and non-leather gloves while discharging, purging, flushing, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

⚠ WARNING

Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should first be treated with a few drops of sterile mineral oil in the eyes, and then rinsed with a weak boric acid solution. Do not rub the eyes. Call a doctor right away.

Refrigerant splashed on the skin should be treated the same as for frostbite: gently pour cool water on the area, but do not rub the skin. Keep the skin warm with layers of soft, sterile cloth. Call a doctor right away.

Even though refrigerant does not burn, when it contacts extreme heat or flame, poisonous phosgene gas is created. This gas also is produced when an open flame leak detector is used. Phosgene fumes have an acrid (bitter) smell.

⚠ WARNING

Do not work in an area where refrigerant may contact an open flame or any burning material, such as a cigarette. When it contacts extreme heat, refrigerant breaks down into poisonous phosgene gas which, if breathed, causes severe respiratory irritation and possible severe injury or death. Do not breathe the fumes from an open flame leak detector.

You must work in an area where there is a constant flow of fresh air when the system is discharged, flushed, charged, and leak tested using an open flame leak detector.

Changes in both federal and state laws will affect the way dealerships service air-conditioning systems. Under current federal laws, refrigerant must be recovered and recycled by all users to protect the environment, and not released into the atmosphere. Many service operations not directly involving the air-conditioning system require the release of the refrigerant charge. Under the new regulations, dealerships not having the required recovery and recycling equipment (and properly trained and certified personnel) will not be allowed to do any of this service work.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant cans from exploding, never expose them to temperatures higher than 125°F (52°C). Never leave refrigerant cans in the sun, and do not store them in sun-exposed areas where heat can build up, such as in gloveboxes, automobile trunks, etc.

Heater Core Removal and Installation

Removal

1. Set the temperature control on the dash to its warmest setting.

⚠ WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

2. Drain the coolant.
3. Disconnect the batteries.
4. Remove the extruded rubber strip at the top of the dashboard. See **Fig. 1**.

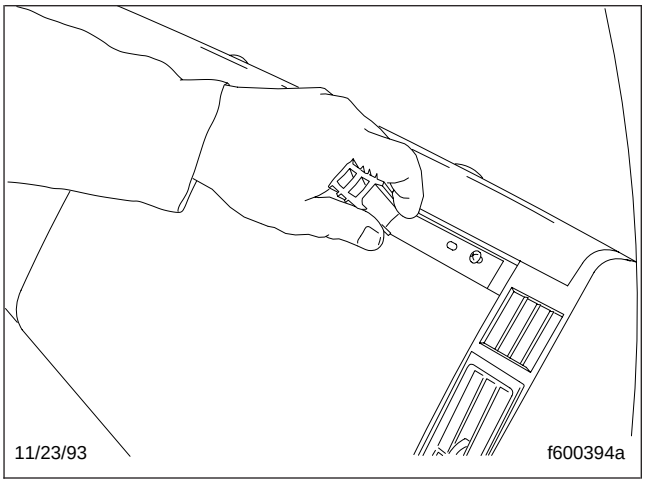


Fig. 1, Remove the Rubber Strip

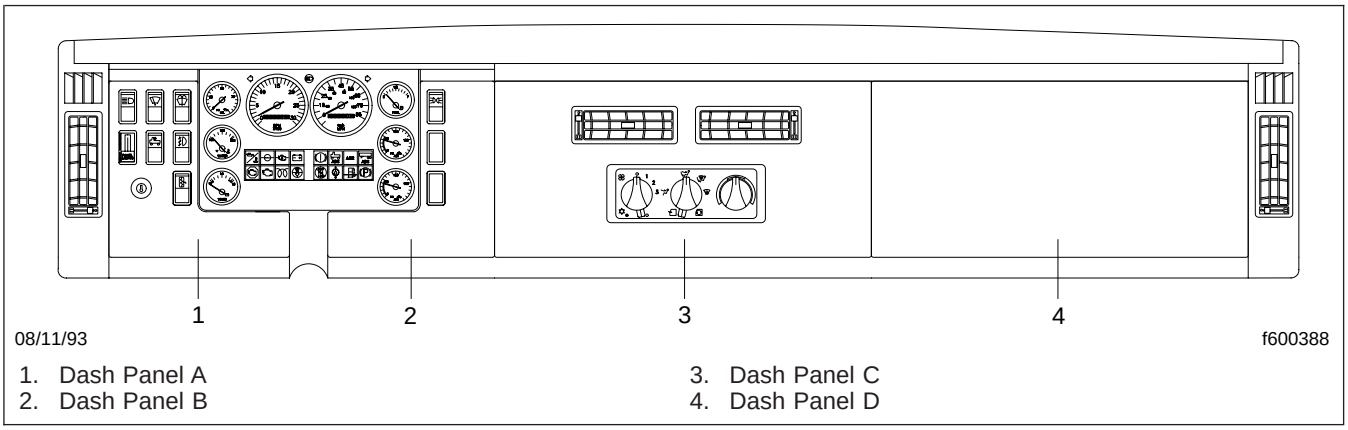
5. Remove dash panel D. See **Fig. 2** and **Fig. 3**.
   - 5.1 Remove the two screws from the top of dash panel D.
   - 5.2 Lift out the dash panel.
6. Pull out the windshield defrost duct. See **Fig. 4**.
7. Remove the parking brake knob and, if so equipped, the trailer brake knob. See **Fig. 5**. Then, remove dash panel B.
8. Remove dash panel C. See **Fig. 2**.
   - 8.1 Remove the bezel around the heater/ air-conditioner control panel.
   - 8.2 Remove the four screws (**Fig. 6**) holding the control panel to dash panel C.
   - 8.3 Remove the two screws from the top of dash panel C.
   - 8.4 Lift out the dash panel and set it aside.
9. Remove the dashboard gauge cover by pushing down on the four locking tabs. See **Fig. 7**.
10. Remove the two screws at the top of dash panel A. See **Fig. 8**.
11. Remove the dash top panel.
    - 11.1 Remove the two screws holding each dash end cap; then remove the end caps. See **Fig. 9**.
    - 11.2 Remove the screws at the base of the windshield holding the dash top panel.
    - 11.3 Remove the screw at the top of the dashboard brace (**Fig. 10**) and the screws at the top of the gauge cluster.
    - 11.4 Lift off the dash top panel. See **Fig. 11**.
12. Remove the dash side vent flexible air ducts. See **Fig. 12**.
13. Remove the air plenum.
    - 13.1 Disconnect the defrost door control cable from the face duct. See **Fig. 13**.
    - 13.2 Remove the face duct.
    - 13.3 Remove the two screws in the air plenum; then, lift out the plenum. See **Fig. 14**.
14. Disconnect the hoses from the heater core. See **Fig. 15**.

⚠ WARNING

Always wear protective gloves when handling the heater core. Failure to do so could result in serious skin cuts from the sharp edges on the heater core fins.

15. Remove the heater core. See **Fig. 16**.

Heater Core Removal and Installation



1. Dash Panel A
2. Dash Panel B
3. Dash Panel C
4. Dash Panel D

Fig. 2, Dash Panel

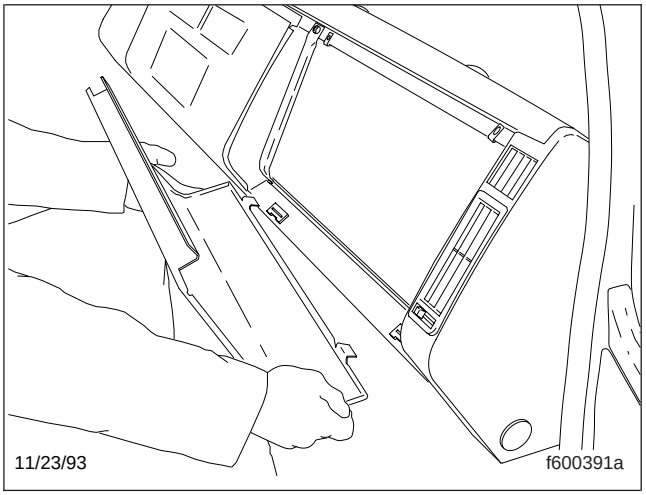


Fig. 3, Remove the Dash Panel

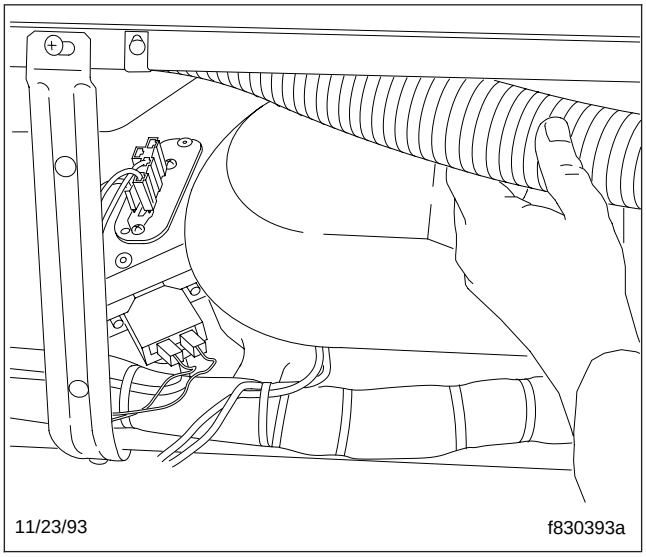


Fig. 4, Remove the Windshield Defrost Duct

Installation

⚠ WARNING

Always wear protective gloves when handling the heater core. Failure to do so could result in serious skin cuts from the sharp edges on the heater core fins.

1. Install the heater core, inserting the pipes through the holes in the firewall. See **Fig. 16**.
2. Connect the hoses to the heater core. See **Fig. 15**.
3. Check the heater core for leaks.
   - 3.1 Connect the batteries.
   - 3.2 Close the radiator drain valve.
   - 3.3 Fill the cooling system with approved coolant. See Group 20 of the *Business Class Trucks Maintenance Manual*.
   - 3.4 Start the engine and set the temperature control to the warmest setting. When the engine thermostat opens, air will be forced from the heater core as the coolant circulates. Check the coolant level again and fill as needed.
   - 3.5 Check the heater core hose connections (**Fig. 15**) for leaks. Tighten the hose clamps if needed.

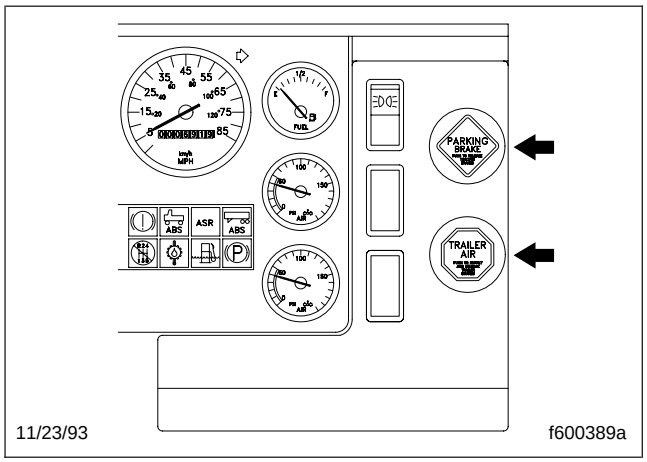


Fig. 5, Parking Brake and Trailer Brake Knobs

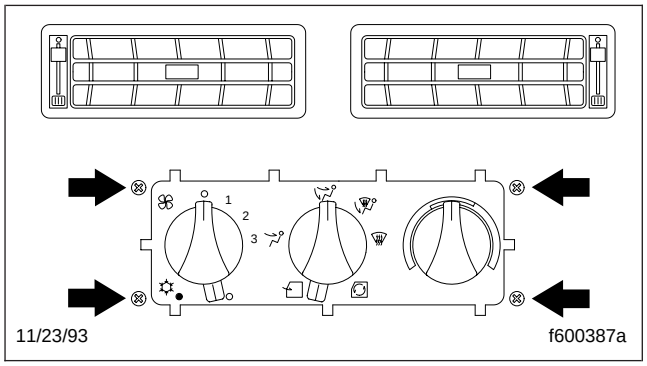
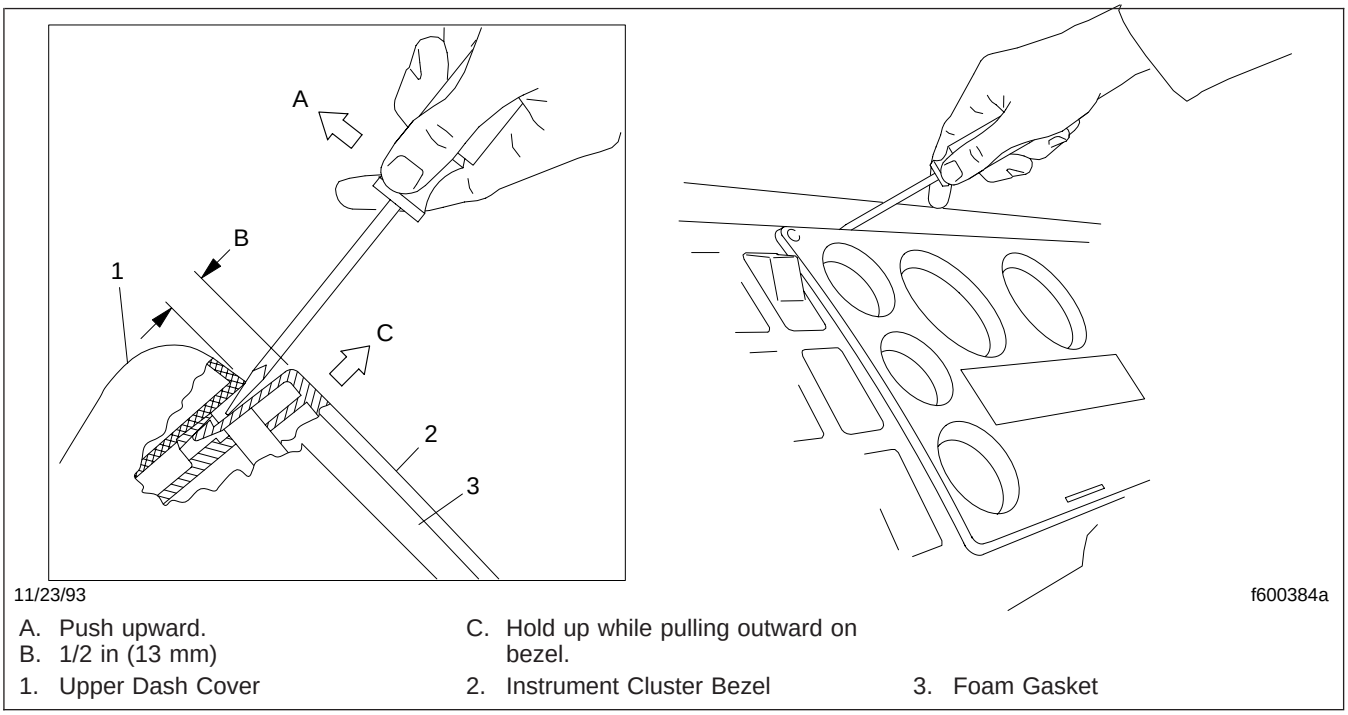


Fig. 6, Control Panel

3.6 Shut down the engine and disconnect the batteries.

4. Install the air plenum. See **Fig. 14**. Install the screws in the plenum.
5. Install the face duct. Connect the defrost door control cable and the cable sheath to the face duct. See **Fig. 13**.
6. Install the flexible air ducts to the dash side vents. See **Fig. 12**.
7. Install the dash top panel (**Fig. 11**) and the screws at the base of the windshield.
8. Install the dash end caps (**Fig. 9**) and their mounting screws (two each).
9. Install the brace screw (**Fig. 10**) and the screws at the top of the gauge cluster.
10. Install dash panel A and its two mounting screws (**Fig. 8**).
11. Install the cover over the dashboard gauges. Make sure the tabs are locked. See **Fig. 7**.
12. Install dash panel C (**Fig. 2**) and its mounting screws.
13. Install dash panel B (**Fig. 2**) and its two mounting screws. If so equipped, install the parking brake knob and the trailer brake knob.
14. Install the windshield defrost duct. See **Fig. 4**.
15. Install dash panel D (**Fig. 2** and **Fig. 3**) and its two mounting screws.
16. Install the extruded rubber strip at the top of the dashboard. See **Fig. 1**.
17. Connect the batteries.

Heater Core Removal and Installation



A. Push upward.
B. 1/2 in (13 mm)
C. Hold up while pulling outward on bezel.
1. Upper Dash Cover
2. Instrument Cluster Bezel
3. Foam Gasket

Fig. 7, Dashboard Gauge Cover

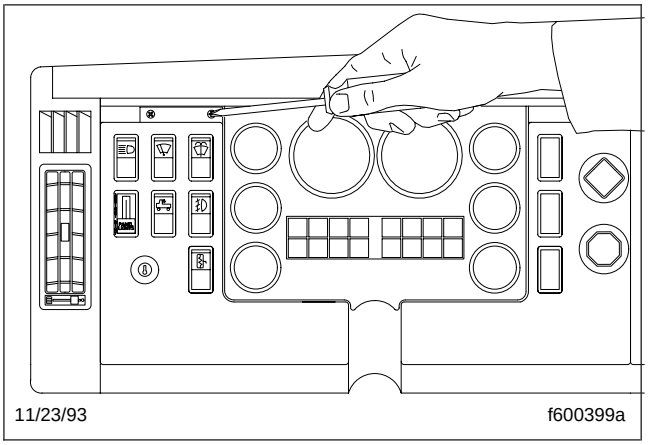


Fig. 8, Dash Panel

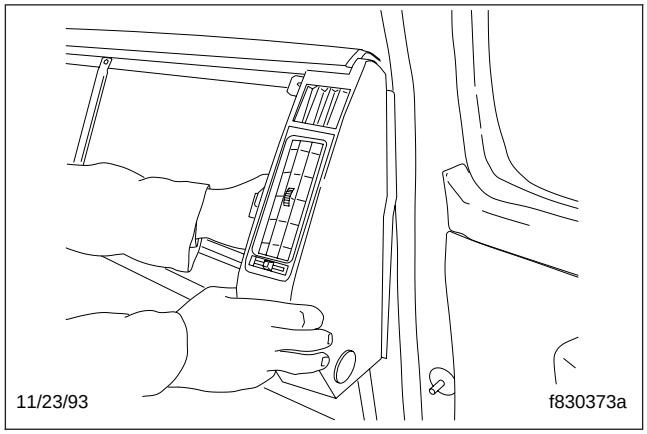


Fig. 9, Remove the Dash End Caps

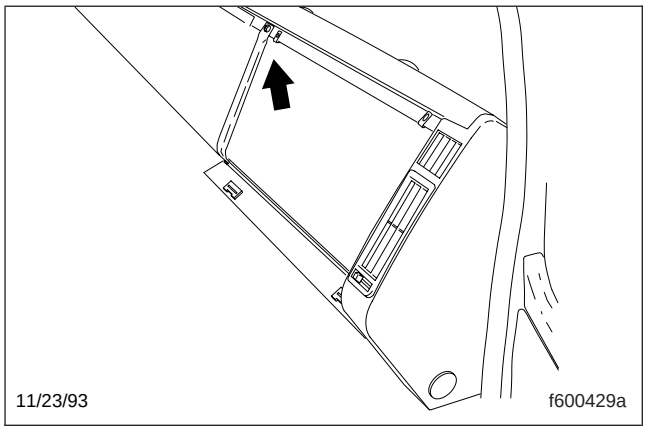


Fig. 10, Dashboard Brace

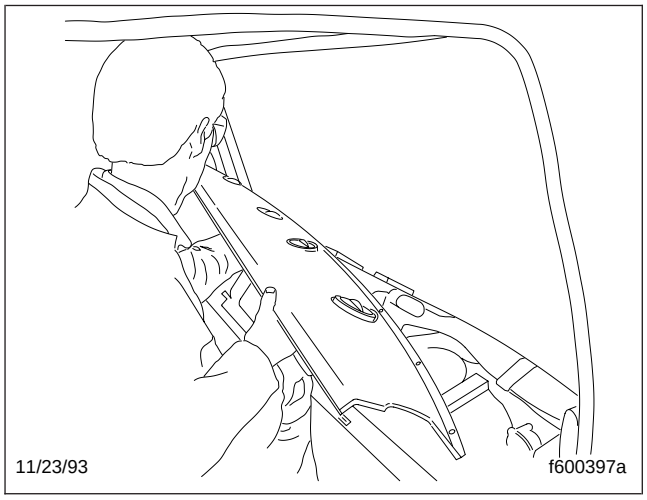


Fig. 11, Remove the Dash Top Panel

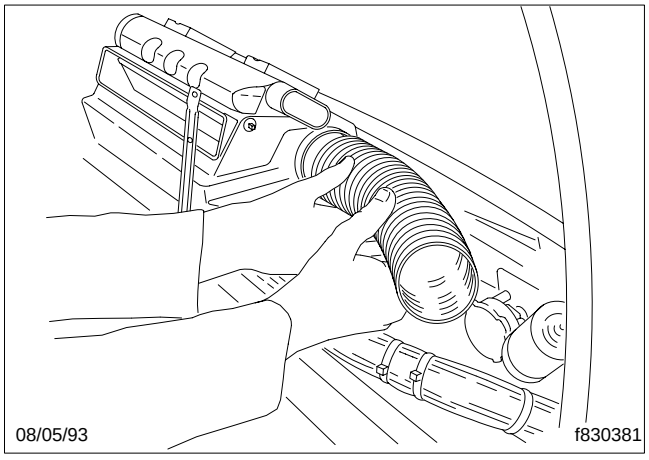
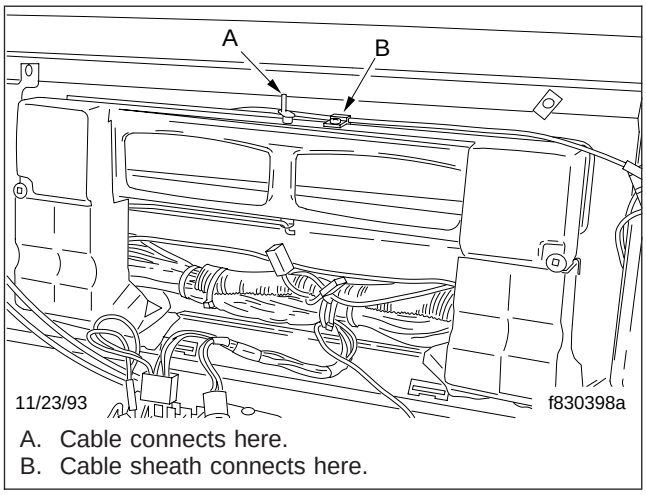


Fig. 12, Dash Side Vent Air Duct



A. Cable connects here.
B. Cable sheath connects here.

Fig. 13, Defrost Door Control Cable

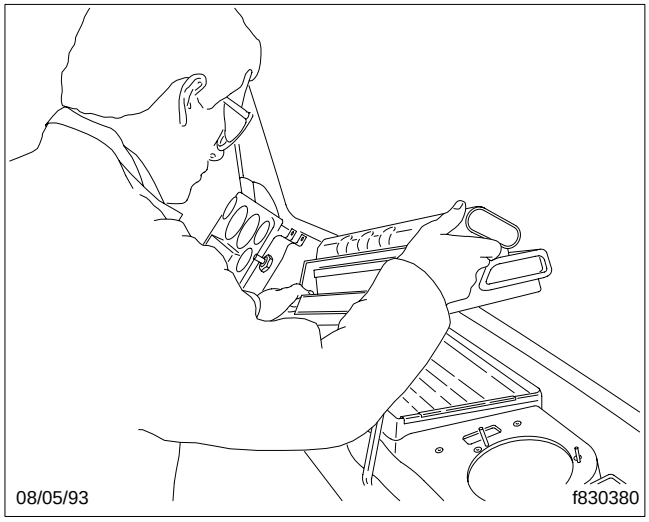
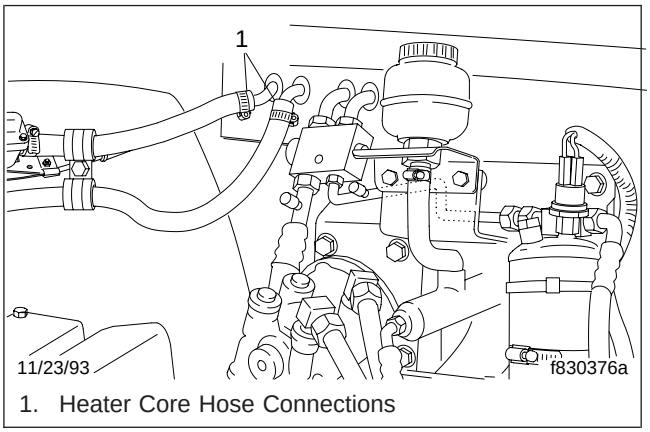


Fig. 14, Remove the Air Plenum

Heater Core Removal and Installation



1. Heater Core Hose Connections

Fig. 15, Heater Core Hose Connections

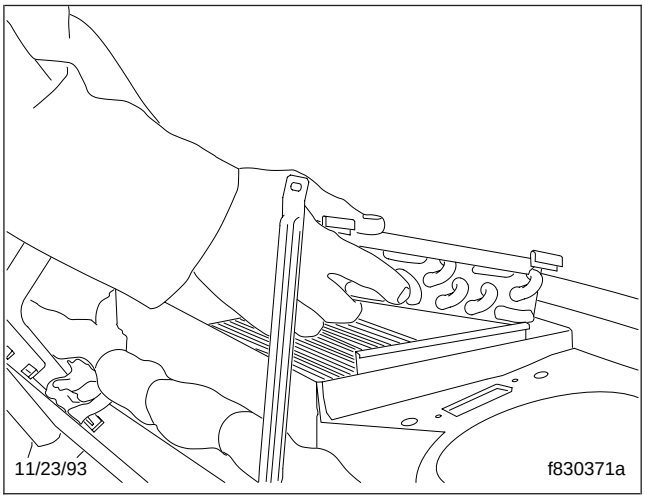


Fig. 16, Remove the Heater Core

Evaporator Coil Removal and Installation

Removal

IMPORTANT: Before replacing any refrigerant parts, read **Subject 220**. Always discharge the system before disconnecting a refrigerant line. If the system is contaminated, purge or flush it before you install replacement parts.

1. Review the information under **Safety Precautions, 100**.

⚠ WARNING

Failure to review the safety precautions, and to be aware of the dangers involved when working with refrigerant, could result in serious personal injury.

2. Disconnect the batteries.
3. Wearing protective goggles and gloves, discharge the refrigerant system. For instructions, refer to **Subject 220**.
4. Remove the heater core. Refer to **Subject 110**.

⚠ CAUTION

Water and dirt can damage the refrigerant system. Five minutes of being uncapped is the limit for any hose or component. Do not blow shop air through the refrigerant hoses; shop air is wet (humid).

5. Disconnect the evaporator coil lines from the expansion valve in the engine compartment. See **Fig. 1**. Save the O-rings if they are in good condition.
6. Cap or plug the evaporator coil lines and the expansion valve ports.

⚠ WARNING

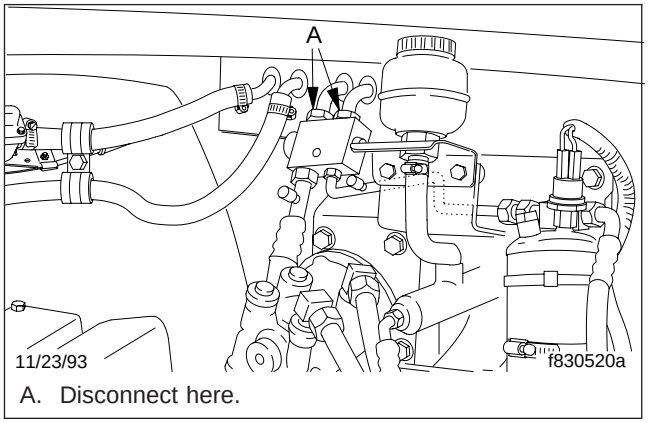
Always wear protective gloves when handling the evaporator coil. Failure to do so could result in serious skin cuts from the sharp edges on the evaporator coil fins.

7. Lift the evaporator coil out of the housing. See **Fig. 2**.

Installation

⚠ WARNING

Always wear protective gloves when handling the evaporator coil. Failure to do so could result in serious skin cuts from the sharp edges on the evaporator coil fins.



A. Disconnect here.

Fig. 1, Evaporator Coil Lines

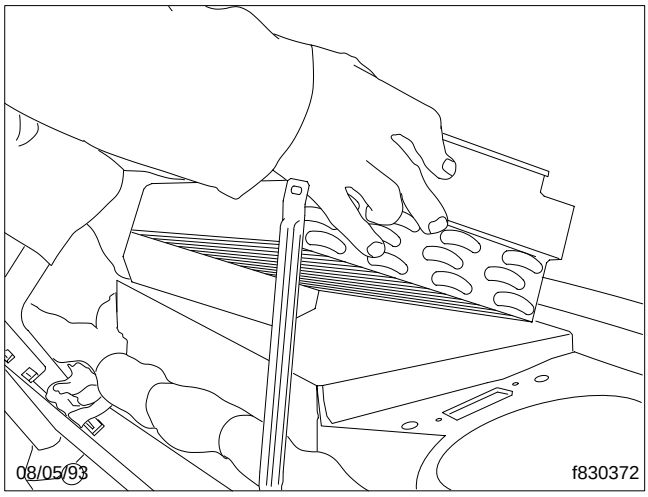


Fig. 2, Remove the Evaporator Coil

1. Wearing protective gloves, place the evaporator coil in the housing. See **Fig. 2** . Make sure the evaporator coil lines extend through the holes in the firewall.
2. Remove the caps or plugs from the evaporator coil lines and the expansion valve ports.

Evaporator Coil Removal and Installation

3. Lubricate the rubber O-rings with refrigerant oil and install them in the fittings.

NOTE: The previously removed O-rings can be used again if they are in good condition.

4. Apply Loctite® 242 or 592 to the male fitting threads; then, connect the evaporator coil

   lines to the expansion valve ports. Tighten the fittings as follows:

   - Large fitting—24 lbf·ft (33 N·m)
   - Small fitting—18 lbf·ft (24 N·m)

5. Evacuate and charge the air conditioning system with refrigerant. For instructions, refer to **Subject 220**. Be sure to add refrigerant oil to the compressor to replace that which was lost when the system was discharged. Refer to the applicable refrigerant compressor section.

NOTE: If the system will not hold a vacuum, check the evaporator coil connections for tightness or check for a missing O-ring.

6. Install the heater core and the other removed components. Refer to **Subject 110** for instructions.

Replacement

1. Disconnect the batteries.
2. Remove the extruded rubber strip at the top of the dashboard. See **Fig. 1**.
3. Remove dash panel D. See **Fig. 2** and **Fig. 3**.
4. If so equipped, remove the parking brake knob and the trailer brake knob. Then, remove dash panel B.
5. Remove dash panel C. See **Fig. 4** .

NOTE: It isn't necessary to remove the control panel from dash panel C or to disconnect the control cables.

6. Remove the thermostatic switch. See **Fig. 5** .
   - 6.1 Disconnect the wires from the thermostatic switch.
   - 6.2 Remove the two allen-head screws holding the thermostatic switch.
   - 6.3 Carefully pull the capillary tube, which extends from the bottom of the thermostatic switch, out of the air duct.
   - 6.4 Remove the thermostatic switch.
7. Install the new thermostatic switch.
   - 7.1 Carefully insert the capillary tube into the hole in the air duct.
   - 7.2 Position the thermostatic switch and secure it with the two allen-head screws.
   - 7.3 Connect the wires to the switch.
8. Install dash panel C and its mounting screws.
9. Install dash panel B and its mounting screws. Install the parking brake knobs.
10. Install dash panel D and its mounting screws.
11. Install the extruded rubber strip at the top of the dashboard.
12. Connect the batteries.

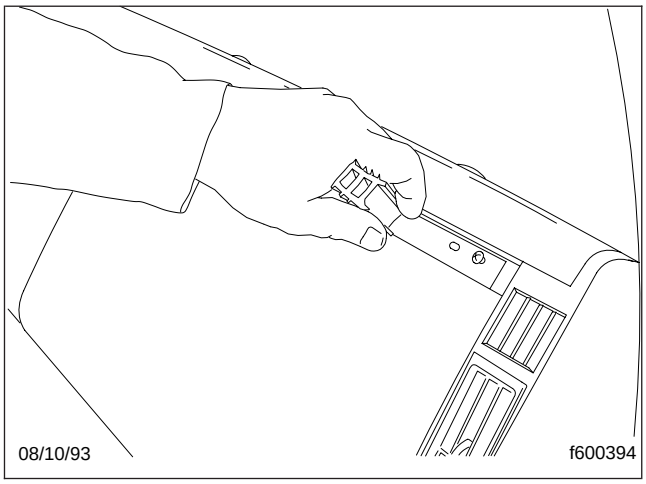
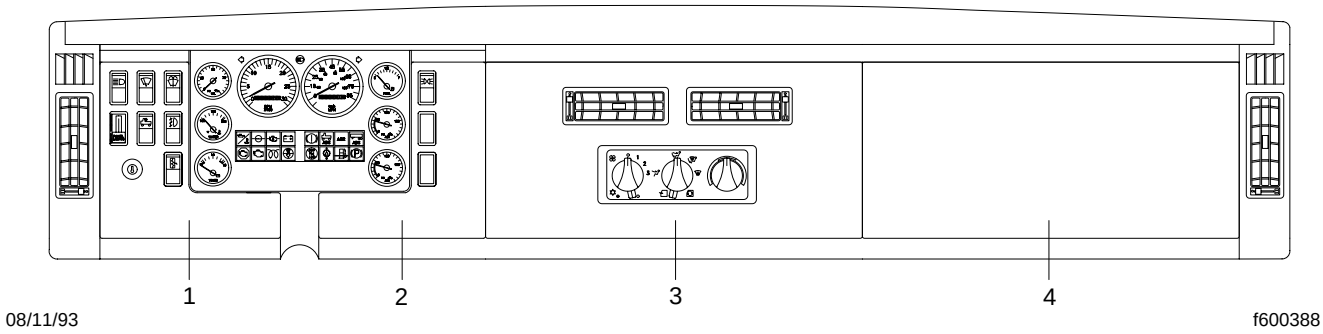


Fig. 1, Remove the Rubber Strip

Thermostatic Switch Replacement



1. Dash Panel A
2. Dash Panel B
3. Dash Panel C
4. Dash Panel D

Fig. 2, Dash Panel

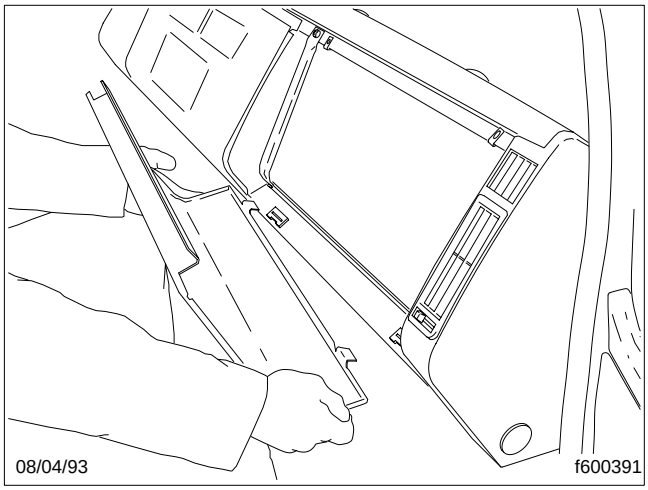


Fig. 3, Remove the Dash Panel

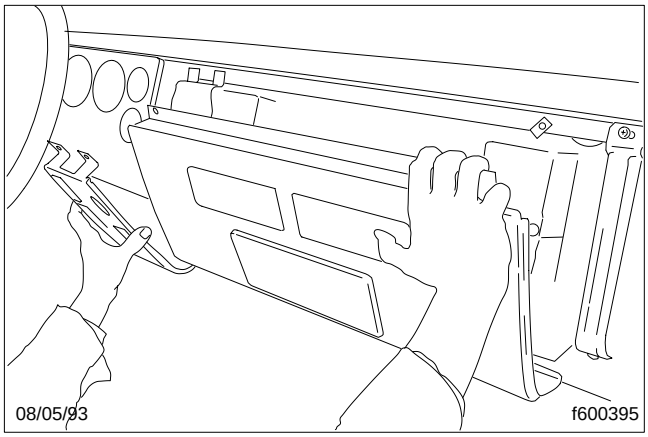
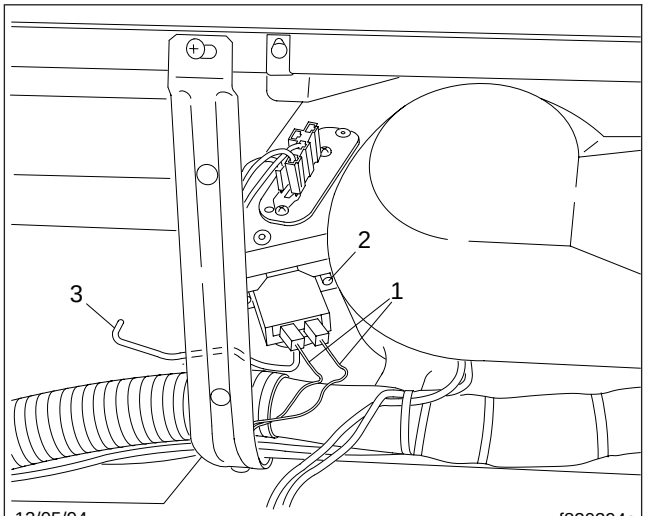


Fig. 4, Remove the Dash Panel



1. Thermostatic Switch Wires
2. Allen-Head Screw
3. Capillary Tube

Fig. 5, Remove the Thermostatic Switch

Replacement

1. Disconnect the batteries.
2. Remove the extruded rubber strip at the top of the dashboard. See **Fig. 1** .
3. Remove dash panel D. See **Fig. 2** and **Fig. 3** .
4. Remove the blower motor cover. See **Fig. 4** .
5. Disconnect the blower motor electrical connector. See **Fig. 5** .
6. Remove the two remaining nuts holding the blower motor (**Fig. 6**); then, lift out the blower motor.
7. Install the new blower motor. Install the two nuts. Tighten them 17 lbf·in (192 N·cm).
8. Connect the blower motor electrical lead (**Fig. 5**).
9. Install the blower motor cover. See **Fig. 4** .
10. Install and tighten the knurled thumb screw on the blower motor cover finger tight.
11. Install dash panel D (**Fig. 3**) and its two mounting screws.
12. Install the extruded rubber strip at the top of the dashboard. See **Fig. 1** .
13. Connect the batteries and check the blower operation. Refer to the vehicle driver's manual for instructions.

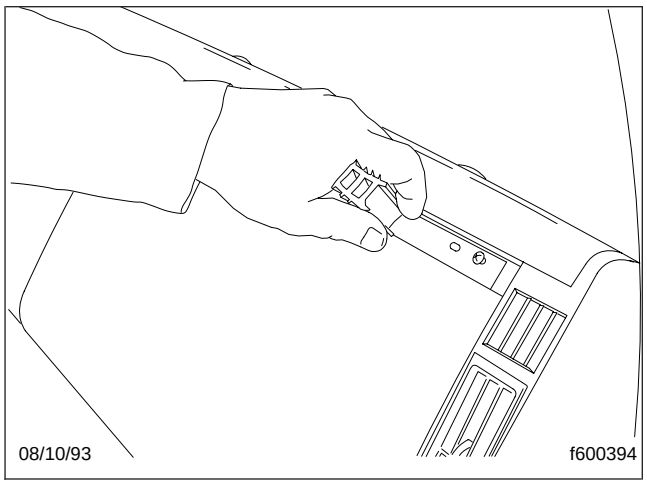
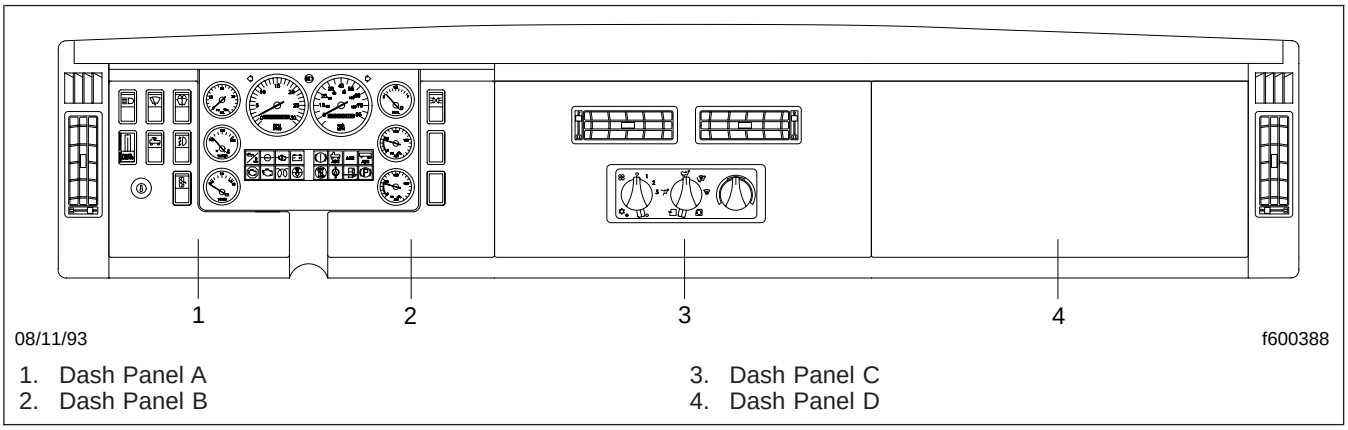


Fig. 1, Remove the Rubber Strip

Blower Motor Replacement



1. Dash Panel A
2. Dash Panel B
3. Dash Panel C
4. Dash Panel D

Fig. 2, Dash Panel

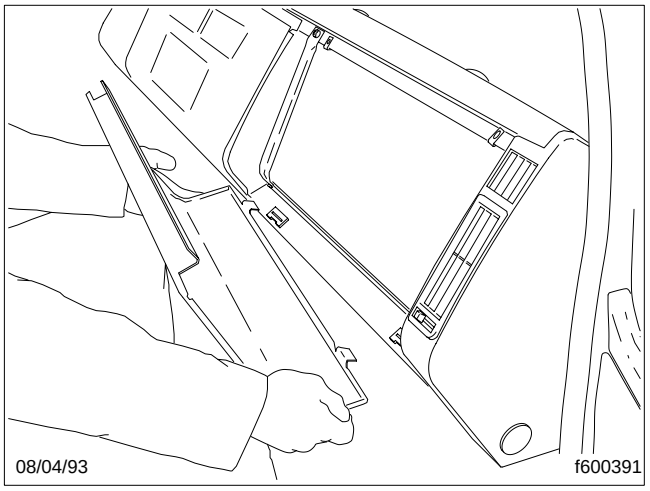


Fig. 3, Remove the Dash Panel

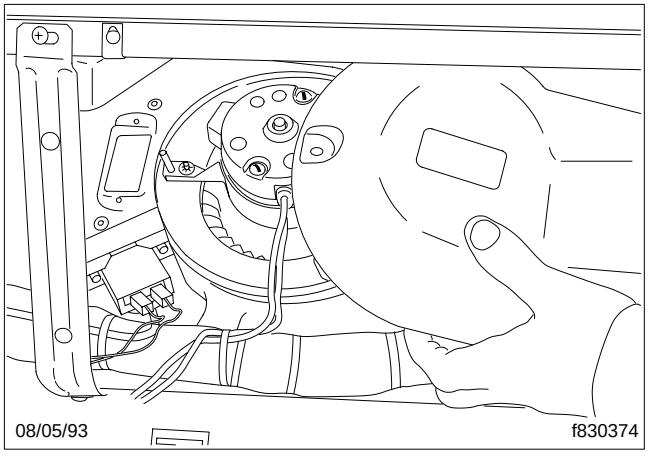


Fig. 4, Remove the Blower Motor Cover

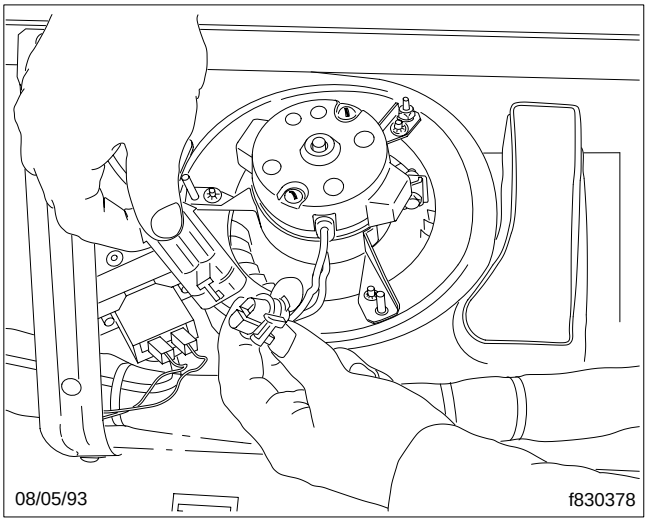


Fig. 5, Disconnect the Blower Motor Electrical Connector

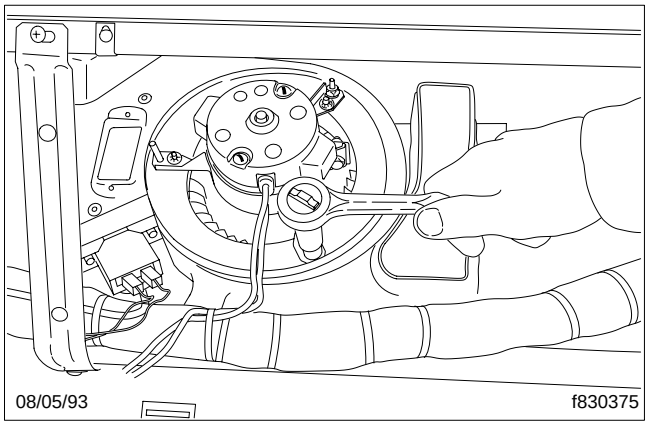


Fig. 6, Remove the Blower Motor Nuts

Replacement

1. Disconnect the batteries.
2. Remove the extruded rubber strip at the top of the dashboard. See **Fig. 1** .
3. Remove the two mounting screws from dash panel D; then, remove the panel. See **Fig. 2** and **Fig. 3** .
4. Remove the resistor block. See **Fig. 4** .
   - 4.1 Unplug the connector from the resistor block.
   - 4.2 Remove the two mounting screws.
   - 4.3 Remove the resistor block.
5. Install the resistor block with the two mounting screws; then, connect the electrical plug.
6. Connect the batteries and check the blower operation.
7. Install dash panel D and the two mounting screws.
8. Install the extruded rubber strip at the top of the dashboard.

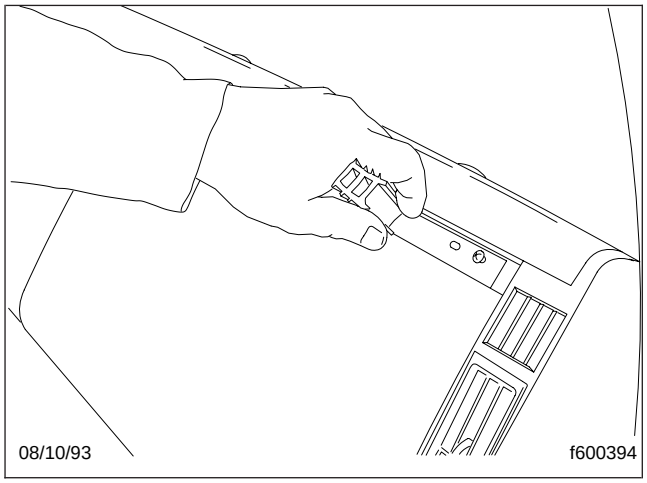
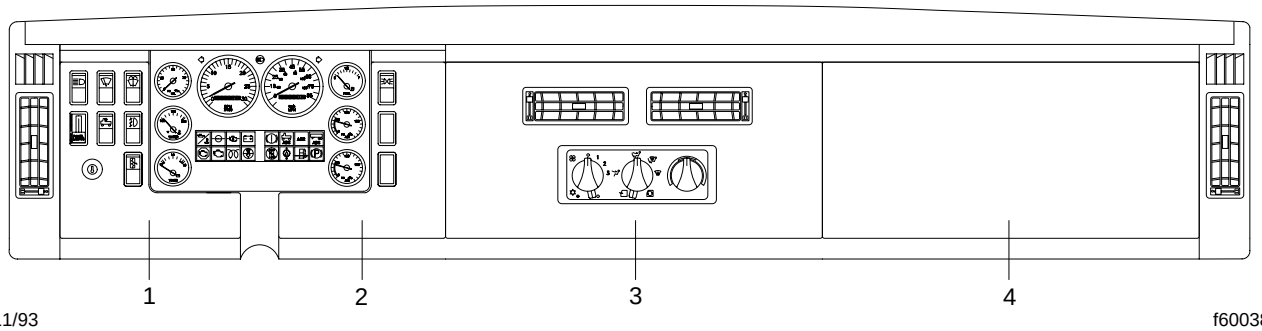


Fig. 1, Remove the Rubber Strip

Resistor Block Replacement



1. Dash Panel A
2. Dash Panel B
3. Dash Panel C
4. Dash Panel D

Fig. 2, Dash Panel

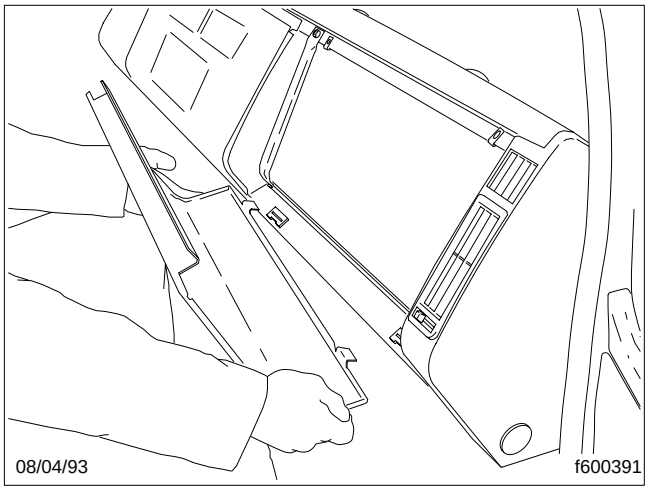
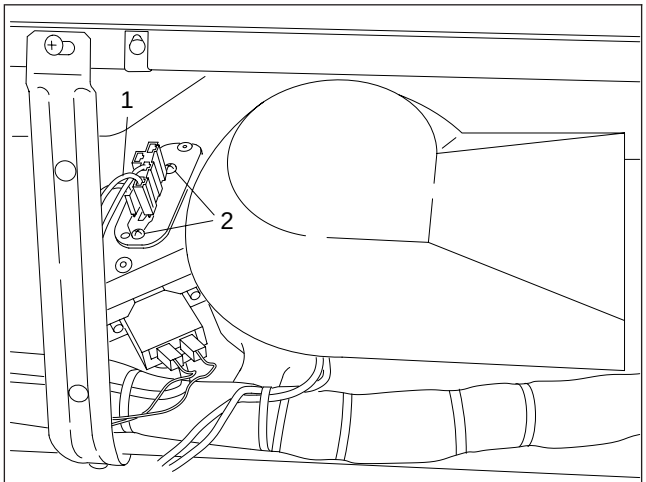


Fig. 3, Remove the Dash Panel



1. Resistor Block Wires
2. Resistor Block Mounting Screws

Fig. 4, Remove the Resistor Block

Water Regulating Valve Replacement

Replacement (See Fig. 1)

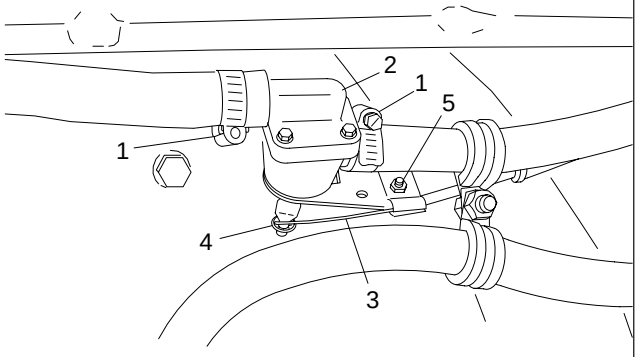
1. Tilt the hood.
2. Set the heater temperature control to the warmest setting.

⚠ WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

3. With the engine cold, drain enough coolant into a clean drain pan to lower the coolant level below the water regulating valve.
4. Remove the screw (Ref. 5) that holds the control cable to the valve base plate.
5. Remove the internal toothed clip (Ref. 4), and detach the control cable (Ref. 3).
6. Disconnect the heater hoses from the valve. Remove and discard the valve.
7. Install the new valve in the heater hoses. Tighten the hose clamps.
8. Slip the end of the control cable over the post on the valve control lever, and install a new internal toothed clip.
9. Adjust the control cable.
   - 9.1 Set the heater temperature control to the coolest position.
   - 9.2 Set the water regulating valve to the closed position.
   - 9.3 Slide the control cable in the clamp until the screw (Ref. 5) in the clamp lines up with the hole in the valve base plate.
   - 9.4 Tighten the screw (Ref. 5) to hold the cable in place.
   - 9.5 Check that the valve closes when the temperature control is at the coolest setting and opens toward the warmest setting.

   NOTE: The valve is fully closed or fully open before it reaches the mechanical stops at either end of its travel. After adjusting for the coolest setting, it is not necessary to adjust for the warmest setting.
10. Fill the cooling system with approved coolant. See Group 20 of the *Business Class Trucks Maintenance Manual* for instructions.
11. Start the engine. When the engine thermostat opens, air will be forced from the heater core as the coolant circulates. Check the coolant level again and fill as needed.
12. Check the valve and the hose connections for leaks. Tighten the hose clamps if needed.
13. Lower the hood.



1. Hose Clamp
2. Valve Body
3. Control Cable
4. Internal Toothed Clip
5. Cable Mounting Screw

Fig. 1, Water Regulating Valve

Replacement (See Fig. 1)

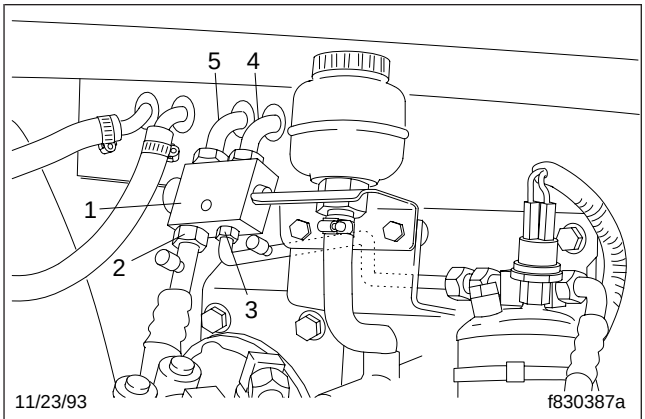
IMPORTANT: Before replacing any refrigerant parts, read **Subject 220**. Always discharge the system at the compressor before disconnecting a refrigerant line. If the system is contaminated, purge or flush it before you install replacement parts.

1. Review the information under **Safety Precautions, 100**.

⚠ WARNING

Failure to review the safety precautions, and to be aware of the dangers involved when working with refrigerant, could result in serious personal injury.

2. Tilt the hood.
3. Wearing protective goggles and gloves, discharge the refrigerant system. For instructions, refer to **Subject 220**.
4. Disconnect the four refrigerant lines from the expansion valve; then, remove and discard the valve. If the O-rings are in good condition, save them for later use.



1. Expansion Valve Body
2. Compressor Line
3. Receive-Drier Line
4. Evaporator Coil Small Line
5. Evaporator Coil Large Line

Fig. 1, Expansion Valve

⚠ CAUTION

Water and dirt can damage the refrigerant system. Five minutes of being uncapped is the limit for any hose or component.

Do not blow shop air through the refrigerant hoses; shop air is wet (humid).

5. Lubricate the rubber O-rings with refrigerant oil and install them in the fittings.

NOTE: The previously removed O-rings can be used again if they are in good condition.

6. Apply Loctite® 242 or 592 to the male fitting threads. Connect the lines from the evaporator coil to the expansion valve ports. Connect the line from the receiver-drier to the expansion valve port and the line that runs from the expansion valve port to the compressor.

   Tighten the connections as follows:

   - Evaporator coil large fitting—24 lbf·ft (33 N·m)
   - Evaporator coil small fitting—18 lbf·ft (24 N·m)
   - receiver-drier line—12 lbf·ft (16 N·m)
   - Compressor line—18 lbf·ft (24 N·m)

7. Evacuate and charge the air conditioning system with refrigerant. For instructions, refer to **Subject 220**. Be sure to add refrigerant oil to the compressor to replace that which was lost when the system was discharged. Refer to the applicable refrigerant compressor section.

NOTE: If the system will not hold a vacuum, check the connections for tightness or check for a missing O-ring.

8. Lower the hood.

Receiver-Drier Replacement

Replacement (See Fig. 1)

IMPORTANT: Before replacing any refrigerant parts, read **Subject 220**. Always discharge the system at the compressor before disconnecting a refrigerant line. If the system is contaminated, purge or flush it before you install replacement parts.

1. Review the information under **Safety Precautions, 100**.

⚠ WARNING

Failure to review the safety precautions, and to be aware of the dangers involved when working with refrigerant, could result in serious personal injury.

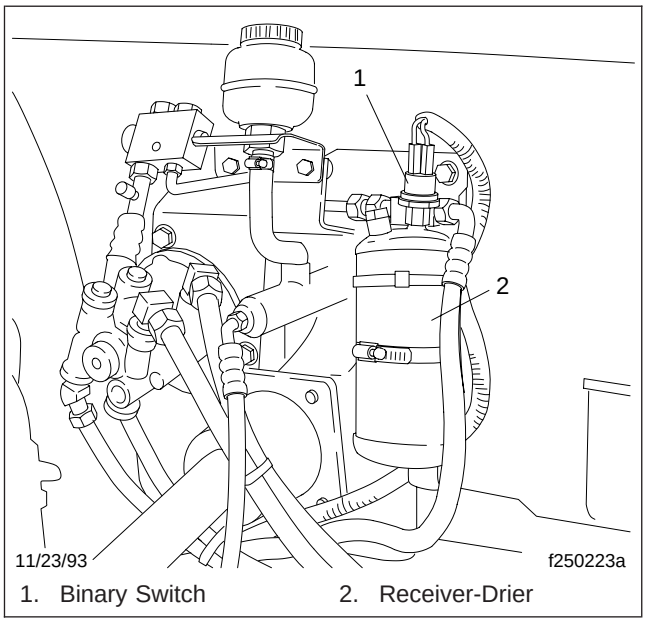
2. Tilt the hood.
3. Wearing protective goggles and gloves, discharge the refrigerant system. For instructions, refer to **Subject 220**.
4. Disconnect the electrical leads from the binary switch.
5. Unscrew the binary switch.
6. Disconnect the inlet and outlet lines. Use two wrenches to avoid twisting the hoses.

⚠ CAUTION

Contaminants, such as water and dirt, can damage the refrigerant system. Five minutes of being uncapped is the limit for any part. Do not blow shop air through the refrigerant hoses since shop air is wet (humid).

IMPORTANT: If the desiccant cartridge inside the old receiver-drier has fallen apart, flush the entire system and replace the expansion valve and the refrigerant compressor. Desiccant matter can't be removed from these parts. A cartridge may fall apart from too much water in the system, because of poor evacuation of the system, or from lack of care.

7. Loosen the clamp that holds the receiver-drier to the bracket on the firewall. Remove and discard the receiver-drier .



1. Binary Switch 2. Receiver-Drier

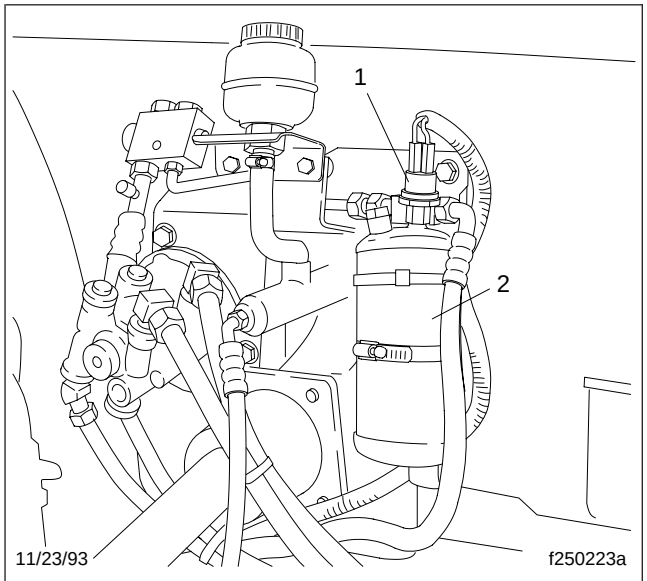
Fig. 1, Receiver-Drier

8. Mount the new receiver-drier and tighten the clamp.
9. Screw the binary switch into the receiver-drier . Tighten the switch 108 lbf·in (1220 N·cm) or one-eighth turn past hand-tight. Connect the electrical leads to the switch.
10. Connect the inlet and outlet lines to the receiver-drier . Tighten the connections 108 lbf·in (45 N·m).
11. Evacuate and charge the air conditioning system with refrigerant. For instructions, refer to **Subject 220**. Be sure to add refrigerant oil to the compressor to replace that which was lost when the system was discharged. Refer to the applicable refrigerant compressor section.
12. Lower the hood.

Replacement (See Fig. 1)

NOTE: A Schrader valve in the receiver-drier prevents loss of refrigerant when removing the binary switch.

1. Tilt the hood.
2. Disconnect the electrical leads from the binary switch.
3. Unscrew the binary switch from the receiver-drier.
4. Screw the new binary switch into the receiver-drier. Tighten the switch 108 lbf·in (1220 N·cm) or one-eighth turn past hand-tight. Connect the electrical leads to the switch.
5. Check the operation of the air-conditioning system.
6. Lower the hood.



1. Binary Switch 2. Receiver-Drier

Fig. 1, Binary Switch

Condenser Replacement

Replacement (See Fig. 1)

IMPORTANT: Before replacing any refrigerant parts, read **Subject 220**. Always discharge the system at the compressor before disconnecting a refrigerant line. If the system is contaminated, purge or flush it before you install replacement parts.

1. Review the information under **Safety Precautions, 100**.

⚠ WARNING

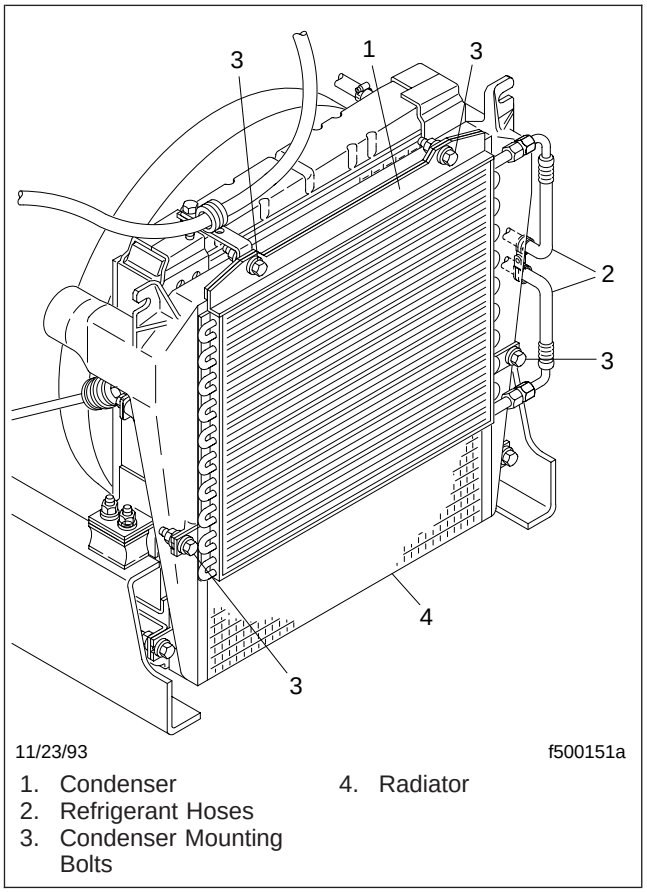
Failure to review the safety precautions, and to be aware of the dangers involved when working with refrigerant, could result in serious personal injury.

2. Tilt the hood.
3. Wearing protective goggles and gloves, discharge the refrigerant system. For instructions, refer to **Subject 220**.
4. Disconnect the refrigerant hoses from the condenser. Use two wrenches to avoid damaging the condenser.

⚠ CAUTION

Contaminants, such as water and dirt, can damage the refrigerant system. Five minutes of being uncapped is the limit for any part. Do not blow shop air through the refrigerant hoses since shop air is wet (humid).

5. Cap the refrigerant hoses.
6. Remove the four condenser mounting bolts.
7. Remove the condenser.
8. Position the condenser on the radiator. Install the capscrews and tighten them 15 lbf·ft (20 N·m).
9. Remove the plugs from the new condenser. Coat the O-rings with refrigerant oil and apply Loctite® 242 or 592 to the male fitting threads.
10. Connect the refrigerant lines to the condenser. Using two wrenches, tighten the fittings 33 lbf·ft (45 N·m). *Be sure to add refrigerant oil to the compressor* , to replace that which was lost in the old condenser. Refer to the applicable compressor section.



1. Condenser
2. Refrigerant Hoses
3. Condenser Mounting Bolts
4. Radiator

Fig. 1, Condenser

11. Charge the system with refrigerant; for instructions, refer to **Subject 220**.
12. Lower the hood.

Replacement

1. Disconnect the batteries.
2. Remove the extruded rubber strip at the top of the dashboard. See **Fig. 1**.

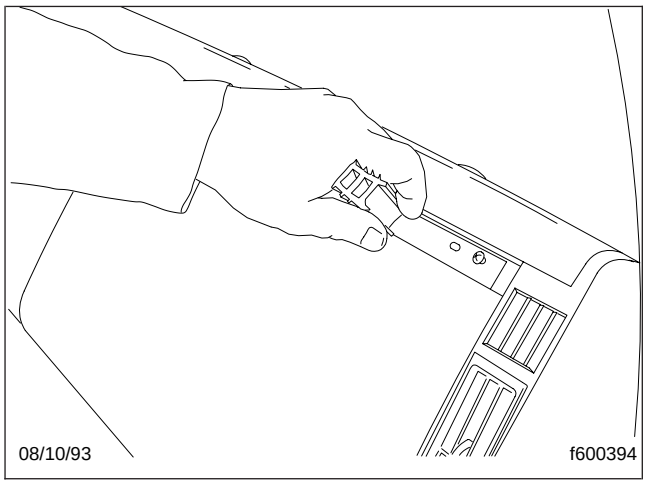


Fig. 1, Remove the Rubber Strip

3. Remove dash panel D. See **Fig. 2** and **Fig. 3**.

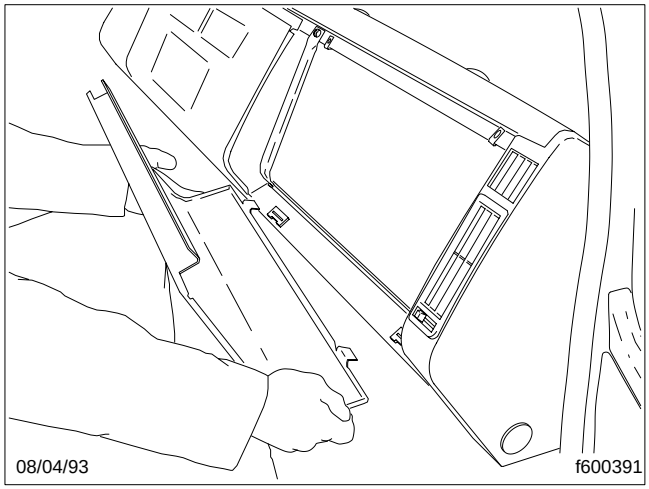
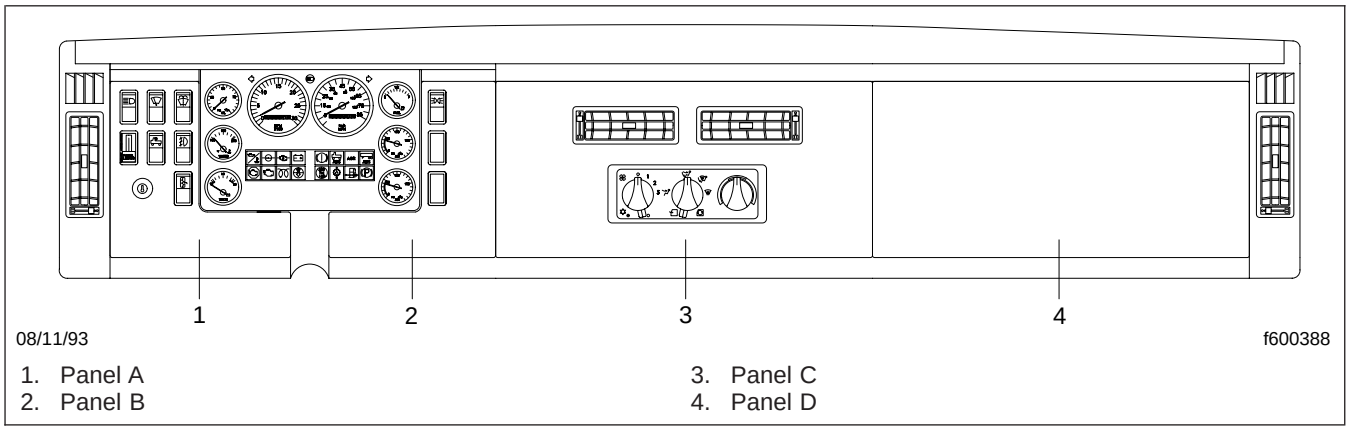


Fig. 3, Remove the Dash Panel

6.1 Gently pry the bezel from the control panel in the center of dash panel C. See **Fig. 4**.

6.2 Remove the panel light and disconnect the electrical connectors from the control panel. Label the connectors so they can be installed in the same positions later.



1. Panel A
2. Panel B
3. Panel C
4. Panel D

Fig. 2, Dash Panel

4. Remove dash panel B. See **Fig. 2**.

4.1 If so equipped, remove the parking brake knob and the trailer brake knob.

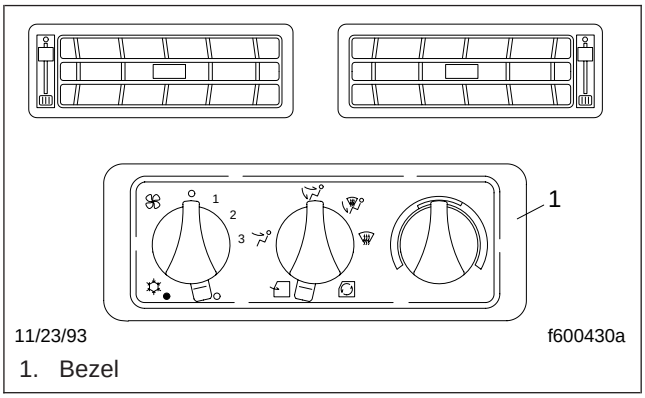
4.2 Lift off the panel.

5. Remove dash panel C.
6. Remove the control panel from dash panel C.

6.3 Label the control cables for later reference. See **Fig. 5**.

6.4 Remove the screws that hold the control cables to the control panel; then, disconnect the cables.

Control Panel Replacement



1. Bezel

Fig. 4, Control Panel

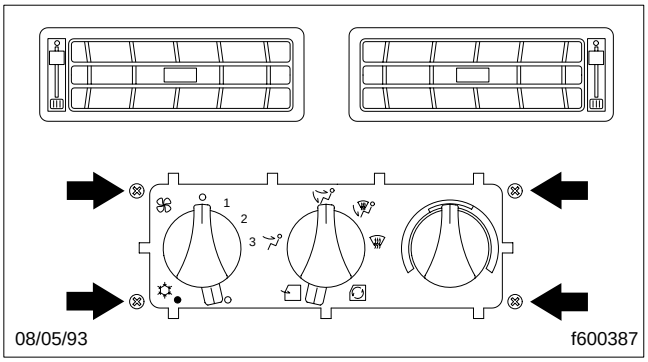
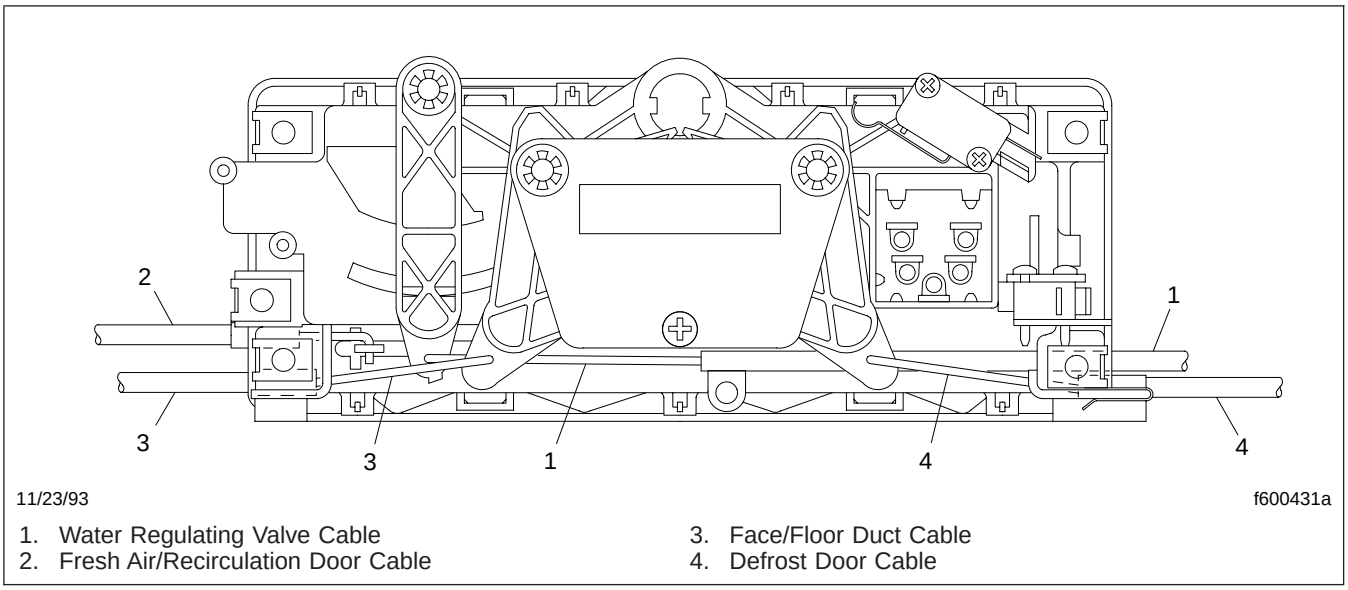


Fig. 6, Control Panel



1. Water Regulating Valve Cable
2. Fresh Air/Recirculation Door Cable
3. Face/Floor Duct Cable
4. Defrost Door Cable

Fig. 5, Control Cables

6.5 Remove the four screws holding the control panel to dash panel C. See **Fig. 6**.

6.6 Lift out the control panel.

7. Install the new control panel in dash panel C.

7.1 Position the control panel and install the four screws that mount it to the dash panel.

7.2 Attach the control cables to the control panel. Install the control cable mounting screws.

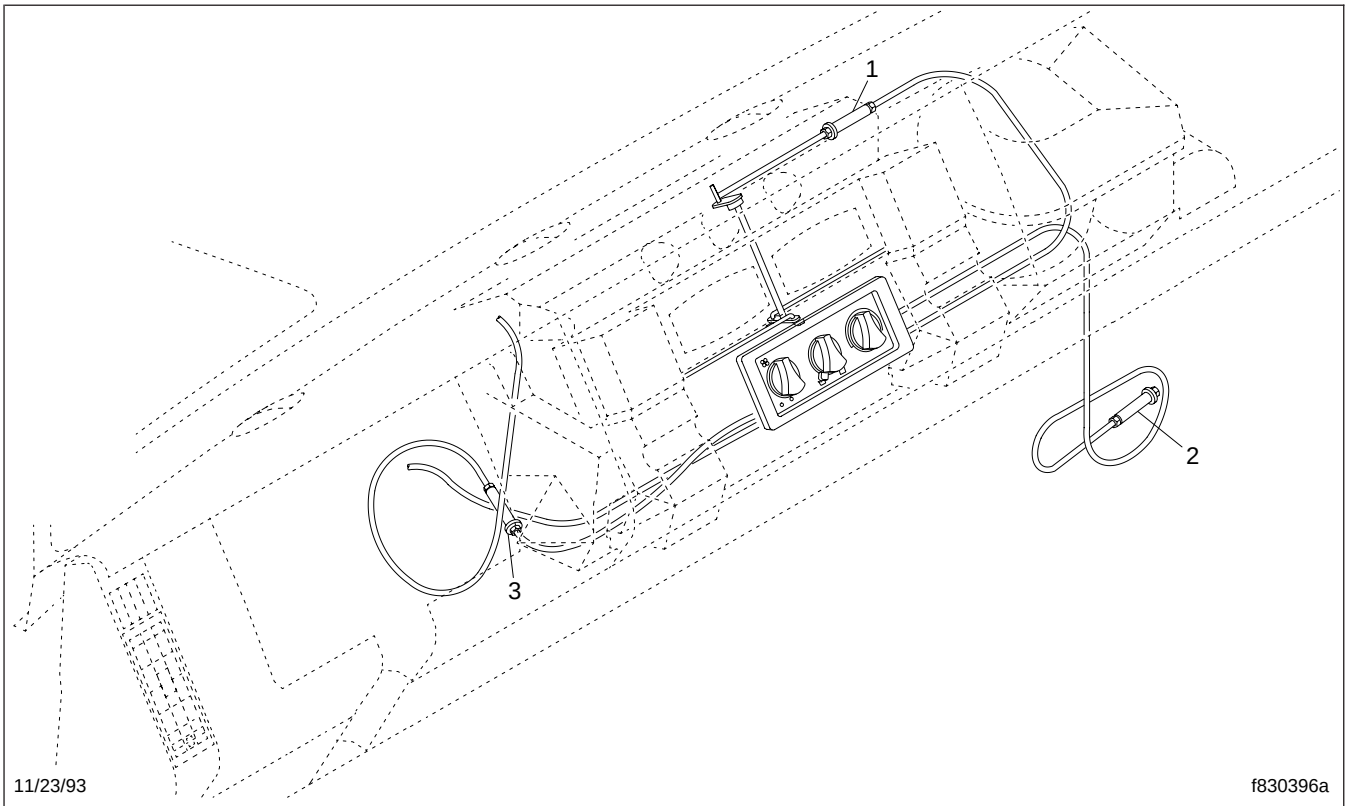
7.3 Insert the panel light and connect the wiring.

7.4 Install the bezel around the control panel.

8. Adjust the control cables. See **Fig. 5** and **Fig. 7**.

8.1 To adjust the cable (**Fig. 5**, Ref. 1) to the water regulating valve, set the dashboard control to the coolest setting (fully counterclockwise). Adjust the turnbuckle until the valve is almost at its mechanical stop in the closed position.

NOTE: The valve is fully closed or fully open before it reaches the mechanical stops at either end of its travel. After adjusting for the coolest setting, it is not necessary to adjust for the warmest setting.



1. Turnbuckle for Face/Floor Duct Door Cable
2. Turnbuckle for Fresh Air/Recirculation Door Cable
3. Turnbuckle for Defrost Duct Door Cable

Fig. 7, Turnbuckles

8.2 To adjust the fresh air/recirculation door cable (**Fig. 5**, Ref. 2), remove the kick panel under the dashboard on the passenger side for access to the door. Move the control lever to the fresh air position. Adjust the turnbuckle (**Fig. 7**, Ref. 2) under the dashboard until the door snaps into the horizontal position and closes off the opening to the cab. Move the lever to the recirculation position and make sure the door snaps open. If necessary, readjust the turnbuckle so the door is in the correct position for each control lever setting.

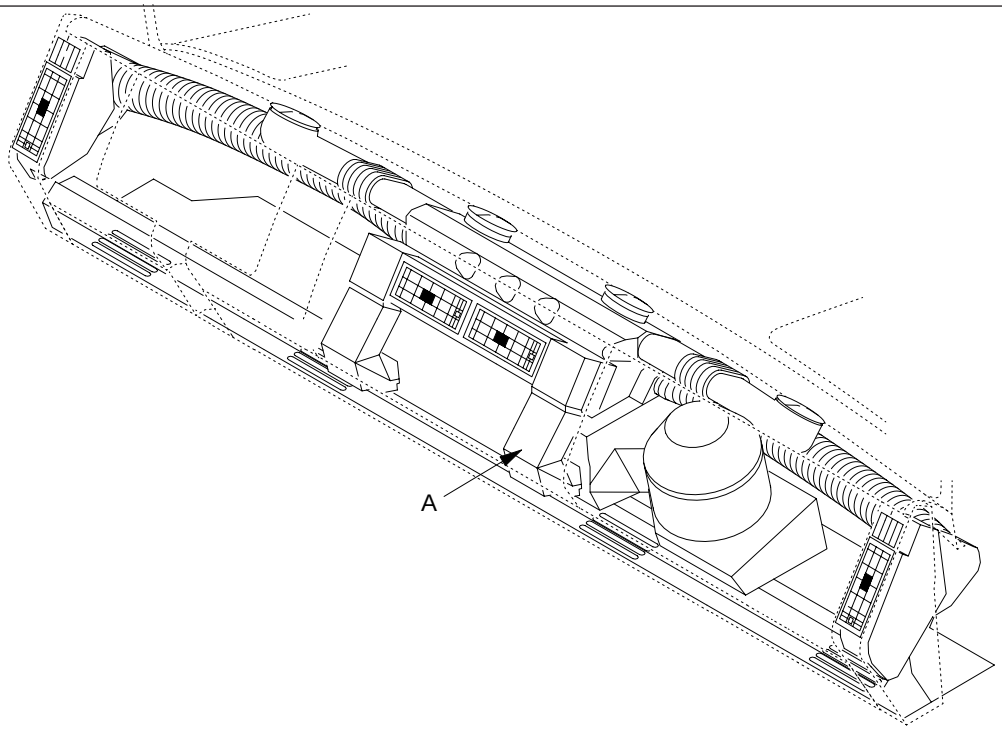
8.3 To adjust the face/floor duct door and defrost duct door cables (**Fig. 5**, Refs. 3 and 4), set the control knob in the twelve o'clock position. Both face/floor duct doors should be open to direct air to the floor, and the defrost duct door should be open to let air out the face ducts. Adjust the turnbuckle (**Fig. 7**, Ref. 3) on the defrost duct door cable if necessary.

Turn the control knob fully counterclockwise; the face/floor duct doors should close. Remove the bottom section of one of the floor ducts to check the door position. See **Fig. 8**. Adjust the turnbuckle (**Fig. 7**, Ref. 1) on the face/floor duct door cable if necessary.

Make sure there is a smooth transition from one cable to the other as the control knob moves through the twelve o'clock position. The defrost duct door cable should move when the control is to the right of the twelve o'clock position; the face/floor duct door cable should move when the control is to the left of the twelve o'clock position. As the control

Control Panel Replacement

knob passes through twelve o'clock, one cable should stop moving and the other cable should start to move. If the cables are adjusted incorrectly, either the control knob will lock up before reaching twelve o'clock or the control knob movement will get very stiff.



11/23/93 f830388a

A. Remove this section of duct to check the door position.

Fig. 8, Check the Door Position

9. Install dash panel C and its mounting screws.
10. Install dash panel B. Install the parking brake knob and, if so equipped, the trailer brake knob.
11. Install dash panel D and its two mounting screws.
12. Install the extruded rubber strip at the top of the dashboard.
13. Connect the batteries.

Discharging, Purging and Flushing, Evacuating, Charging, Charge Checking, and Leak Testing

Discharging

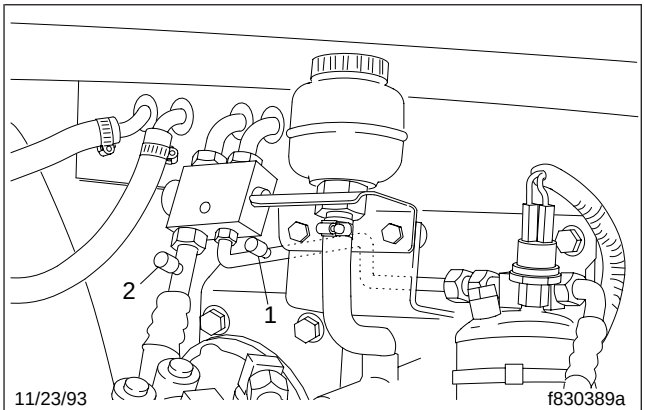
Discharging the air conditioning system removes most of the refrigerant charge in the system.

1. Tilt the hood.

⚠ WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

2. Remove the caps from the suction and discharge service valves. See **Fig. 1**.



1. Discharge Service Valve
2. Suction Service Valve

Fig. 1, Service Valves

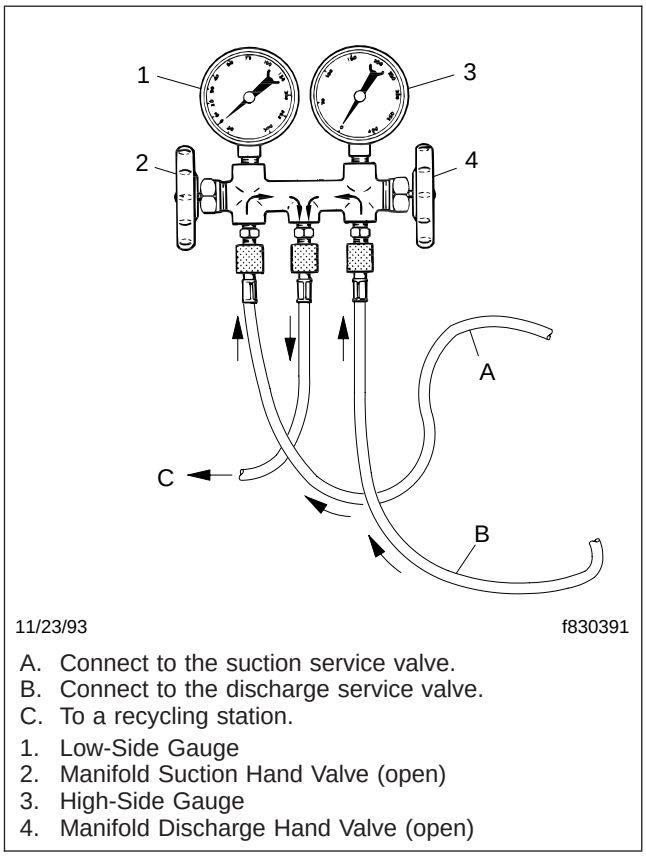
IMPORTANT: The suction and discharge service valves have Schrader valves, which are similar to but not the same as tire valves. Be sure the manifold gauge set has a valve core depressor on the end of each hose.

3. Wearing protective goggles and nonleather gloves, attach a manifold gauge set to the valves. See **Fig. 2**.

   3.1 Close both manifold valves.

   3.2 Connect the manifold high-side hose to the compressor discharge service valve.

   3.3 Connect the manifold low-side hose to the compressor suction service valve.



A. Connect to the suction service valve.
B. Connect to the discharge service valve.
C. To a recycling station.
1. Low-Side Gauge
2. Manifold Suction Hand Valve (open)
3. High-Side Gauge
4. Manifold Discharge Hand Valve (open)

Fig. 2, Discharging Hookup

   3.4 Connect the manifold center hose to an Underwriters Laboratories (U.L.) approved recovery/recycling station.

4. Follow the recovery/recycling station manufacturer's instructions and recover all of the refrigerant from the system.

IMPORTANT: Always comply with all local regulations regarding R–12 disposal. You may be subject to substantial penalties for improper disposal.

5. Measure the oil in the recovery and recycling equipment. The compressor will have to be refilled with the same quantity of new refrigerant oil.

   If the system is contaminated, all of the compressor oil must be replaced with clean oil after purging and flushing the system. If the system is heavily contaminated with desiccant or grit, re-

Discharging, Purging and Flushing, Evacuating, Charging, Charge Checking, and Leak Testing

place the compressor, expansion valve, and receiver-drier.

Purging and Flushing

General Information

⚠ WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

Purging removes damp air, traces of refrigerant, and loose dirt from refrigerant parts by passing a stream of inert, dry gas through the parts. If left in the system, these contaminants would have a bad effect on the life and operation of the air conditioning system.

Flushing removes heavy contamination, such as gritty oil and large dirt buildup, which can't be removed by purging with gas. When a part is flushed, liquid refrigerant is forced through it. The liquid picks up the contaminants and flushes them out.

Whether to purge or flush a part depends on how much contamination there is as described above.

Normally the system always has pressure in it. Some loss of refrigerant from one season to the next is normal and does not mean that the system is dirty. If refrigerant has leaked until the system is nearly empty or if refrigerant parts show signs of internal corrosion and grit, the system is contaminated.

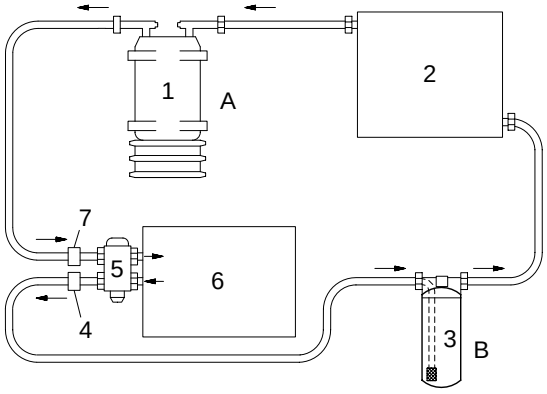
If the system is contaminated with moisture, purge or flush all sections of the system. Then change the oil in the compressor and replace the receiver-drier prior to evacuating and charging the system.

If the system is heavily contaminated or if desiccant has circulated through the system, replace the receiver-drier, expansion valve, and compressor.

Do not purge the receiver-drier or the compressor.

Flush the system in segments to lessen the chance of blowing deposits against a port. See **Fig. 3**.

Purge or flush the system in the opposite direction of refrigerant flow (in other words, backflush the sections).



11/23/93 f830395

NOTE: Arrows denote purge and flush points and direction of flow for gas/liquid.

A. Do not purge; instead, replace.
B. Do not purge; instead, replace.
1. Refrigerant Compressor
2. Condenser
3. Receiver-Drier
4. High-Side Service Valve
5. Expansion Valve
6. Evaporator
7. Suction Service Valve

Fig. 3, Purge and Flush Points

NOTE: Dry nitrogen gas is recommended for purging, but any safe, inert, dry gas, such as carbon dioxide or argon, may be substituted. A pressure regulator is required to regulate from 0 to 200 psi (0 to 1379 kPa). Commercial cylinders of nitrogen contain pressures in excess of 2000 psi (13 790 kPa). This pressure must be reduced to 200 psi (1379 kPa) for purging.

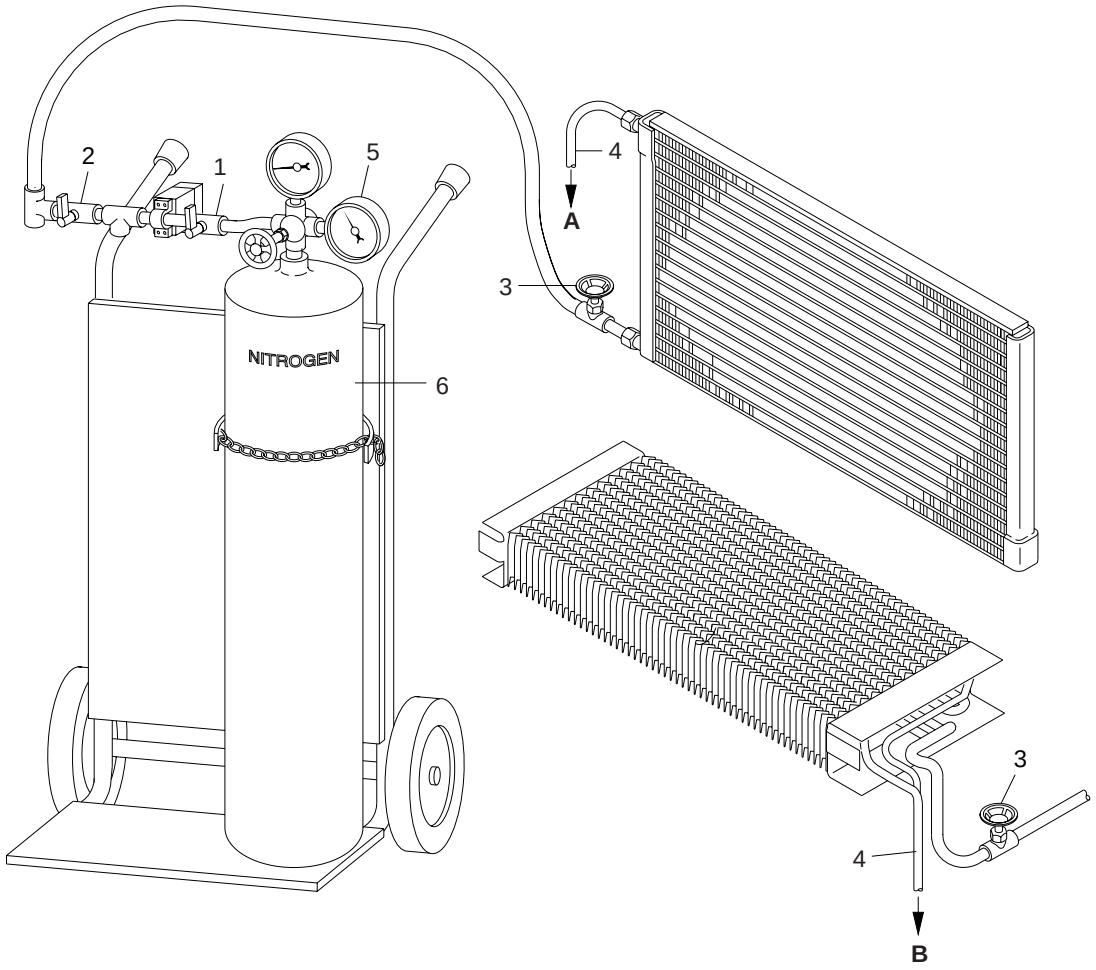
Flushing parts with refrigerant requires a recovery/recycling station.

Purging Procedure

NOTE: Dry nitrogen gas is recommended for purging, but any safe, inert, dry gas, such as carbon dioxide or argon, may be substituted. A pressure regulator is required to regulate from 0 to 200 psi (0 to 1379 kPa). Commercial cylinders of nitrogen contain pressures in excess of 2000 psi (13 790 kPa). This pressure must be reduced to 200 psi (1379 kPa) for purging.

Discharging, Purging and Flushing, Evacuating, Charging, Charge Checking, and Leak Testing

1. Discharge the system.
2. Disconnect both ends of the line or part being purged. Tightly cap the rest of the system.
3. Make sure valves 1, 2, and 3, are closed. See **Fig. 4**.
5. Connect the drain line to the inlet end of the part or line.
6. Place the outlet of the drain line into a recycling system container.
7. Adjust the nitrogen bottle regulator to 200 psi



A. To Waste Container
B. To Recycling System Container
1. Nitrogen Bottle Control Valve
2. Purging Control Valve
3. Supply Line Valve
4. Drain Line
5. Nitrogen Bottle Regulator/Gauge
6. Nitrogen Bottle

Fig. 4, Purging Station

4. Connect the supply line valve to the outlet end of the part or line.

(1379 kPa). Open the nitrogen bottle control valve and the purging control valve. Then slowly

Discharging, Purging and Flushing, Evacuating, Charging, Charge Checking, and Leak Testing

open the supply line valve. Check the drain line for gas flow.

8. Let the nitrogen flow at 200 psi (1379 kPa) for 25 to 30 seconds.
9. Lower the pressure to 4 psi (28 kPa) and let it flow for 1 to 2 minutes. If the line or part was very wet, allow it to flow until there is no trace of refrigerant oil or solid bits of dirt or grit flowing from the drain tube.
10. Close the nitrogen bottle control valve and the purging control valve first, then close the supply line valve.
11. Disconnect the supply line valve and the drain line. Tightly cap both ends of the part or line.

Flushing Procedure

1. Discharge the system.
2. Disconnect both ends of the line or part being flushed. Tightly cap the lines to the rest of the system.
3. Heat R–12 in a dial-a-charge.
4. Connect the dial-a-charge outlet hose to the outlet side of the system. This will ensure that R–12 will flow in the reverse direction of normal flow.
5. Connect a line from the inlet side of the system to a recovery station or a collection bottle.

NOTE: If the system is extremely contaminated, install a receiver-drier inline as a prefilter for the recovery station.

6. Turn on the recovery station and open the outlet valve for the dial-a-charge. Allow about 2 pounds (1 kilogram) of R–12 to flow through the system.
7. Close the supply line valve and wait for the recovery station to shut off.
8. Disconnect the supply line and the drain line from the dial-a-charge and the recovery station. Connect the lines to a nitrogen bottle.
9. Purge the system and check the collection bottle or recovery station for contaminants. Repeat the process if needed.
10. Disconnect the lines from the part and tightly cap both ends of the part.

Evacuating (dehydration)

General Information

Moisture in a Refrigerant System

Moisture damages air conditioning systems in three ways.

First, water forms ice crystals at the thermostatic expansion valve. Ice crystals retard or stop the flow of refrigerant, causing a reduction or complete loss of cooling. As the expansion valve warms due to the lack of refrigerant, the ice melts and passes through the expansion valve. Then refrigerant will flow again until the ice crystals re-form. The result is intermittent cooling.

Second, water causes corrosion. Refrigerants may contain chlorine, which combined with water forms hydrochloric acid. This acid corrodes steel and copper plating.

Third, water mixes with refrigerant oil forming sludge. This reduces the lubricating ability of the oil and can plug the condenser, evaporator, and thermostatic expansion valve.

Effects of Pressure on the Boiling Points of Water

Water boils at 212°F (100°C) at an atmospheric pressure of 14.7 psi (101 kPa) (sea level). At higher elevations the atmospheric pressure is lower which allows water to boil at lower temperatures. See **Table 1** for boiling temperatures of water at converted pressures.

Similarly we can boil and remove water from the air conditioning system by lowering the system pressure to a vacuum to cause the moisture to boil at normal ambient temperatures. A vacuum pump can reduce the pressure in the system. Since the pressure is the lowest at the pump, water vapor is pulled out of the system. See **Fig. 5**. This process is called evacuation or dehydration.

Boiling Temperatures of Water at Converted Pressures		
Boiling Temperature of Water: °F (°C)	**Absolute Pressure: psi (microns)**	**Vacuum: inHg (mmHg)**
212 (100)	14.696 (759993.4)	0 (0)
205 (96)	12.770 (660400.0)	3.92 (99.6)
194 (90)	10.169 (523881.6)	9.22 (234.2)
176 (80)	6.8699 (355269.8)	15.93 (404.6)
158 (70)	4.5207 (233786.7)	20.72 (526.3)
140 (60)	2.8900 (14958.7)	24.04 (610.6)
122 (50)	1.7987 (92555.1)	26.28 (667.5)
104 (40)	1.0700 (55336.4)	27.74 (704.6)
89 (30)	0.61540 (31826.2)	28.67 (728.2)
86 (27)	0.57010 (26220.4)	28.89 (733.8)
76 (24)	0.44435 (22979.9)	29.02 (737.1)
72 (22)	0.38856 (20094.7)	29.13 (739.9)
69 (21)	0.35084 (18143.7)	29.21 (741.9)
64 (18)	0.29505 (15258.5)	29.32 (744.7)
59 (15)	0.24720 (12783.8)	29.42 (747.3)
53 (12)	0.19888 (10285.0)	29.52 (749.8)
45 (7)	0.14746 (7625.8)	29.62 (752.3)
32 (0)	0.08858 (4579.6)	29.74 (755.4)
21 (–6)	0.05293 (2738.1)	29.81 (757.2)
6 (–14)	0.02521 (1304.0)	29.87 (758.7)
–24 (–31)	0.004905 (253.7)	29.911 (759.74)
–35 (–37)	0.002544 (131.6)	29.915 (759.84)
–60 (–51)	0.0004972 (25.7)	29.9200 (759.968)
–70 (–57)	0.0002443 (12.69)	29.92050 (759.9807)
–90 (–68)	0.0000526 (2.72)	29.92089 (759.9906)

Table 1, Boiling Temperatures of Water at Converted Pressures

Vacuum Pump Selection

The purpose of a high-vacuum pump is to reduce and hold a vacuum in the air conditioner system so moisture can be boiled at ambient temperature. For example, a vacuum pump capable of pulling a vacuum of 28.89 inHg (733.8 mmHg), is able to boil water at 80°F (27°C). There are various types of vacuum pumps available. Only some types are recommended for truck air conditioning evacuation.

Air pump-type vacuum pumps are designed to remove large volumes of air but do not develop high vacuum. They cannot pull more than 28 inHg (711 mmHg) which boils water at 100°F (38°C).

Compressor-type vacuum pumps come in two designs: piston-type and rotary-vane type. A piston-type compressor can typically pull a vacuum of 28.2 inHg (716.3 mmHg) which boils water at 96°F (36°C). A rotary-vane type compressor may pull a vacuum of 29.82 inHg (757.4 mmHg) which boils water at 21°F

Discharging, Purging and Flushing, Evacuating, Charging, Charge Checking, and Leak Testing

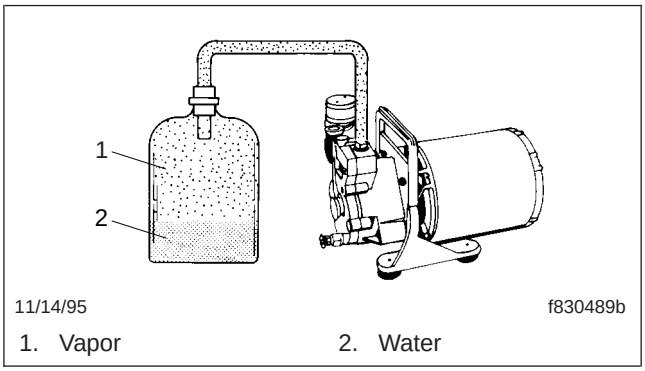


Fig. 5, Water to Vapor

(–6°C), but it is limited to pumping 0.4 to 0.8 cfm, which is too slow to handle truck air conditioners.

High-vacuum pumps are available in single-stage and two-stage models. A single-stage pump is adequate, but a two-stage pump is recommended to save time and assure complete evacuation. See **Fig. 6**.

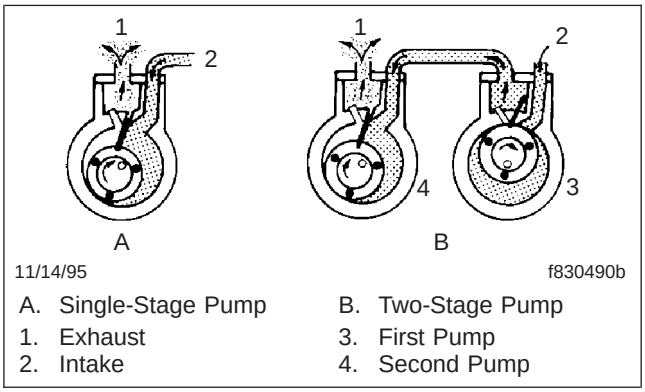


Fig. 6, Vacuum Pumps

Most single-stage high-vacuum pumps with a gas ballast will pull down to about 29.88 inHg (758.95 mmHg) which boils water at 4°F (–16°C).

A two-stage high-vacuum pump features a second pump to reach a higher vacuum than a single-stage pump. In a two-stage pump, the exhaust of the first pump discharges into the intake of the second pump. The second stage pumps at a lower pressure and therefore pulls a higher vacuum on the system than the first pump can by itself.

Two-stage high-vacuum pumps are capable of pulling down to 29.9192 inHg (759.95 mmHg) of vacuum for prolonged periods, which boils water at –60°F (–51°C).

The discharge line restriction is a factor affecting pump-down time. Pump-down time can be significantly reduced by use of larger diameter hoses, as short in length as possible.

Pumping capacity affects pump-down time. It is perfectly acceptable to use a large vacuum pump on a small system. Using too small of a pump on a large system could cause premature pump wear, or require excessive time to pull a vacuum, even though the pump may be able to draw adequate vacuum.

The suggested minimum cfm for pumps on different size air conditioners are listed in **Table 2**.

Minimum CFM for Pumps on Different Size Air Conditioners	
System Size	**Suggested High-Vacuum Pump Size**
Panel Trucks Large Window Units	2.2 cfm
Tractor/Trailers, Buses Rooftop A/C Systems	3.0 cfm
Refrigeration Van	15.0 cfm

Table 2, Minimum CFM for Pumps on Different Size Air Conditioners

Measuring Vacuum

Gauges

Vacuum can be measured with:

- A standard compound gauge;
- A closed-end manometer;
- An electronic thermistor vacuum gauge.

A standard compound gauge reads low pressures in inches of mercury. It is not suitable for measuring high vacuum.

A closed-end U-tube mercury manometer can be read with good accuracy. High vacuum readings can only be read from laboratory-style U-tube manometers.

Electronic thermistor vacuum gauges are designed for use with high vacuum pumps and can accurately

read as low as 100 microns. This gauge can use an analog scale or a digital (LED) display.

Procedure

The location of the vacuum gauge will affect the reading. The closer to the vacuum source, the lower will be the reading.

Isolate the vacuum pump with a good vacuum valve and allow the pressure in the system to stabilize before taking a final reading.

If the pressure will not stabilize, it is an indication of a leak. If it does stabilize at a vacuum which is too high (for example, 1500 microns), it is an indication of moisture and more evacuation is required.

Maintaining the Vacuum Pump

Maintenance is important for high-vacuum pumps. The oil must be changed at regular intervals to prevent moisture buildup which will cause eventual pump failure.

Pumping down for extremely wet air conditioning systems can completely saturate the pump oil.

⚠ CAUTION

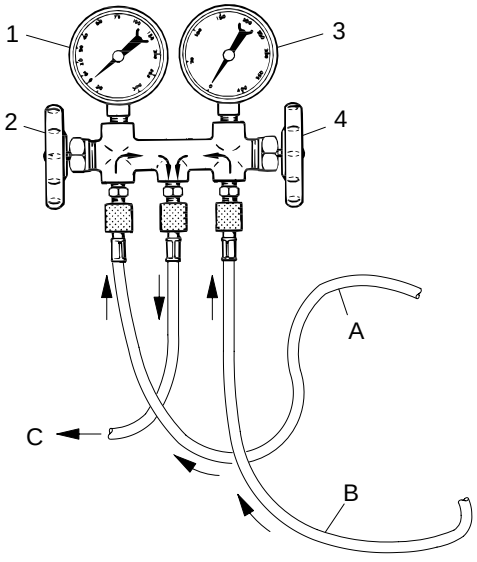
Flush the vacuum pump every fourth time it is used and before storing for long periods of time. Acid will form and corrode the pump if water-laden oil remains in the pump for an extended period.

Vacuum pump oil is water soluble. This aids the pump in reaching a high vacuum by absorbing water and sealing the pump.

Only vacuum pump oil should be used as a flushing agent and lubricant. Do not use any solvent or any other oil. Clean oil should be run through the pump until it runs out clear. Oil should be added to the fill level indicated on the pump. Check the oil level before each use.

Evacuation Procedure

1. The system must be discharged and, if contaminated, purged or flushed and the compressor filled with the correct amount of refrigerant oil. Replace the receiver-drier if the system is opened.
2. Close both manifold hand valves on the manifold gauge set.
3. If using a thermistor vacuum gauge, connect the gauge between the manifold center service hose and the vacuum pump. See **Fig. 7**.



11/23/93 f830391

A. Connect to the suction service valve.
B. Connect to the discharge service valve.
C. To vacuum pump.
1. Low-Side Gauge
2. Manifold Suction Hand Valve (open)
3. High-Side Gauge
4. Manifold Discharge Hand Valve (open)

Fig. 7, Evacuation Hookup

4. Connect the manifold discharge line to the discharge service valve.
5. Connect the manifold suction line to the suction service valve.
6. Connect the center manifold line to the vacuum pump.
7. Open the manifold hand valves.
8. Turn on the vacuum pump, and open the pump control valve.
9. If using a thermistor gauge, open the thermistor gauge valve.

Discharging, Purging and Flushing, Evacuating, Charging, Charge Checking, and Leak Testing

10. Allow the pump to draw to at least 29.90 inHg (759.5 mmHg).
11. Close the pump valves, and turn off the pump.
12. Allow the system to stabilize for five minutes.
13. If not using a thermistor gauge, go to the next step. If using a thermistor gauge, proceed as follows:

    13.1 If the thermistor gauge reading does not rise above 29.85 inHg (758.2 mmHg), the system is okay. Proceed to "Charging."

    13.2 If the thermistor gauge reading rises above 29.85 inHg (758.2 mmHg) and stops, there is moisture in the system. Repeat the steps above beginning with turning on the pump and opening the control valve.

    13.3 If the thermistor gauge reading rises above 29.85 inHg (758.2 mmHg) and continues to rise, add a partial charge of refrigerant and leak test the system. Repair any leaks and reevacuate the system. See "Leak Testing" for instructions.

14. If not using a thermistor gauge, proceed as follows:

    14.1 Note the low pressure gauge needle position.

    14.2 Wait 15 minutes, then check the low pressure gauge needle position again.

    14.3 If the needle has not moved, turn on the vacuum pump and open the pump control valve. Let the pump run for one hour. Go to "Charging."

    IMPORTANT: A gauge reading of over 29.85 inHg (758.2 mmHg) indicates that there is still water in the system.

    14.4 If the needle has moved, add a partial charge of refrigerant and leak test the system. Repair any leaks and reevacuate the system. See "Leak Testing" for instructions.

Charging

General Information

⚠ WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

The recommended way of charging a system is by adding refrigerant as a gas. High-side liquid charging may cause liquid refrigerant to enter the compressor. If this happens, it may cause a hydraulic lock in the compressor and destruction of the unit.

If a charging cylinder is used—one that heats refrigerant and allows the worker to make exact refrigerant measurements—follow the instructions of the equipment manufacturer.

Gas Charging Procedure

NOTE: The system must be evacuated, with the manifold gauge set connected to the compressor, before a full charge can be added to the system.

1. Obtain enough refrigerant to fully charge the system. A full charge is 48 ounces (1362 grams) of refrigerant.

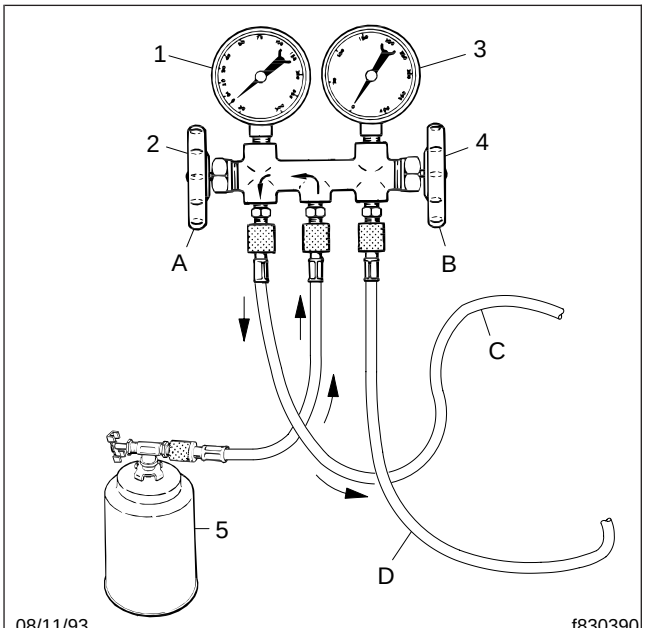
   If a tank (bulk quantity) is used, it should be set on a scale and its weight noted so that the correct amount of refrigerant enters the system. This prevents overcharging, which could damage the compressor.

   If one-pound cans of refrigerant are used, obtain enough to fully charge the system.

NOTE: Each one-pound can actually holds 14 ounces (397 grams) of refrigerant.

2. Close the manifold hand valves.
3. Connect the manifold center service hose to the refrigerant can, as shown in **Fig. 8**. Do not release the refrigerant at this time. Place the can in an upright position so that refrigerant enters the system as a gas. **Do not allow liquid refriger-**

ant to enter the compressor by tipping the refrigerant can.



A. Low-Side Hand Valve
B. High-Side Hand Valve
C. Connect to the suction service valve.
D. Connect to the discharge service valve.
1. Low-Side Gauge
2. Manifold Suction Hand Valve (open)
3. High-Side Gauge
4. Manifold Discharge Hand Valve (closed)
5. Refrigerant

Fig. 8, Gas Charging Hookup

⚠ CAUTION

If the refrigerant can is tilted during service operations, liquid refrigerant could enter the compressor through its suction port, which may damage the unit once it is turned on.

4. With the engine off, open the manifold low-side hand valve. Do not open the manifold high-side hand valve.
5. Open the valve on the refrigerant can to allow the refrigerant vapor to enter the system.

IMPORTANT: On bulk quantity tanks, larger hoses are used. These hoses alone may carry 8 ounces (227 grams) or more of refrigerant.

6. Close the valve on the refrigerant can. If a full charge did not enter the system, the rest will be added while the compressor is on.

⚠ WARNING

Any other way of warming refrigerant, such as using a torch, is dangerous and should never be tried. Using extreme heat on an refrigerant can could cause an explosion and serious bodily injury.

7. Start the engine and run it at 1500 rpm. Set the cab air conditioner controls at maximum cooling and fan speed. The refrigerant compressor must engage. Open the valve on the refrigerant can. Leave the valve open until a full charge of refrigerant has entered the system. Close the valve on the refrigerant can.

   To know when a one-pound can is empty, tap it on the bottom. A hollow ringing will be heard. **Do not tip the refrigerant can.**

NOTE: If refrigerant is slow to enter the system because of low outside temperatures, vaporization can be quickened by placing the refrigerant can in a tub of warm water no warmer than 125°F (52°C).

8. When enough refrigerant has entered the system, look at the sight glass. No frothing or bubbles should appear when the compressor is on. If frothing occurs, leak test the system.
9. While the compressor is engaged, check the operating pressures at the suction and discharge ports. See the applicable compressor section in this manual. If the operating pressures are not acceptable, see **Troubleshooting 300** for possible causes.
10. Shut down the engine. Close both manifold hand valves.
11. All of the manifold gauge hoses are under pressure. Disconnect them from the compressor and the refrigerant can. Install the caps on the compressor service valves.

Liquid Charging Procedure

NOTE: Before charging, the system must be recovered and evacuated with the recovery and

Discharging, Purging and Flushing, Evacuating, Charging, Charge Checking, and Leak Testing

recycling station connected to the service and discharge port connections.

1. Obtain enough refrigerant to fully charge the system. A full charge is 48 ounces (1362 grams) of refrigerant.

   If a tank (bulk quantity) is used, it should be set on a scale and its weight noted so that the correct amount of refrigerant enters the system. This prevents overcharging, which could damage the compressor.

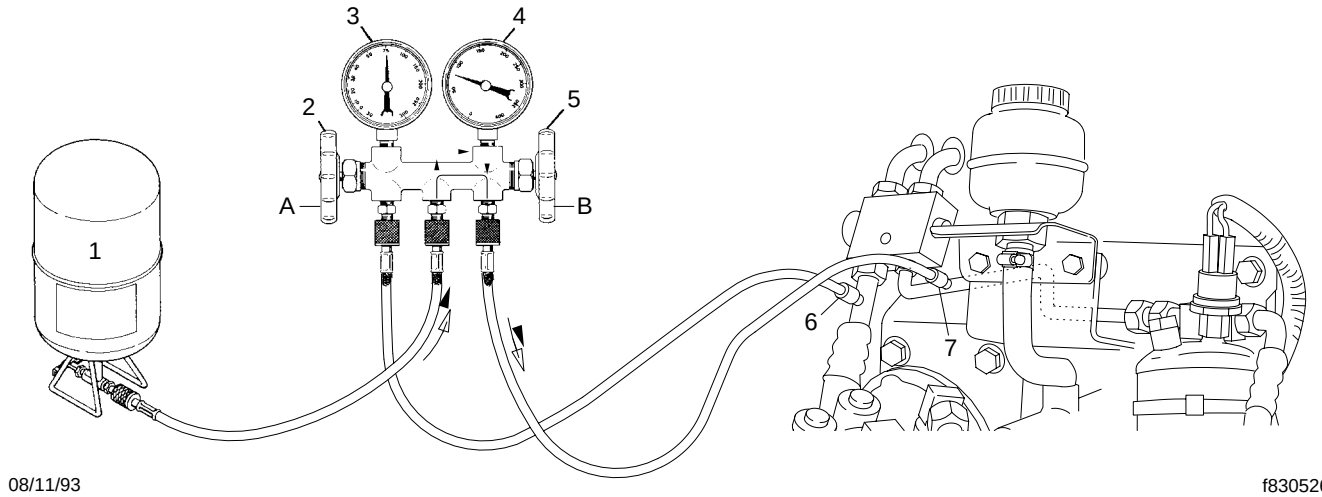
   If one-pound cans of refrigerant are used, obtain enough to fully charge the system.

NOTE: Most one-pound cans actually hold 14 ounces (397 grams) of refrigerant.

2. Close the manifold hand valves.
3. Disconnect the vacuum pump. Connect the manifold center service hose to the refrigerant container and purge the air from the hose.
4. With the engine off, open the manifold high-side hand valve. **Do not** open the manifold low-side hand valve. See **Fig. 9**.
5. If charging from a tank (bulk quantity), turn the tank upside down. Open the valve on the refrigerant container to allow the refrigerant liquid to enter the system.

NOTE: If refrigerant is slow to enter the system because of low outside temperatures, vaporization can be quickened by placing the refrigerant tank in a tub of warm water no warmer than 125°F (52°C).

6. Close the high-side hand valve. If a full charge did not enter the system, the rest will be added while the compressor is on.
7. Start the engine and run it at 1500 rpm. Set the cab air conditioner controls at maximum cooling and fan speed. The refrigerant compressor must engage. If charging from a tank (bulk quantity), place the tank in the upright position. Open the low-side hand valve. Leave the valve open until a full charge of refrigerant has entered the system. Close the valve on the refrigerant container. Close the low-side hand valve. Disconnect the hoses.
8. When enough refrigerant has entered the system, look at the sight glass. No frothing or bubbles should appear when the compressor is on. If frothing occurs, leak test the system.



08/11/93 f830526

A. Manifold Low-Side Hand Valve
B. Manifold High-Side Hand Valve
1. R–12 Bulk Container
2. Closed Manifold Suction Hand Valve
3. Low-Side Gauge
4. High-Side Gauge
5. Open Manifold Discharge Hand Valve
6. Suction Service Valve
7. Discharge Service Valve

Fig. 9, Liquid Charging Hookup

9. While the compressor is engaged, check the operating pressures at the suction and discharge ports. See the applicable compressor section in this manual. If the operating pressures are not acceptable, see **Troubleshooting 300** for possible causes.
10. Shut down the engine.
11. All of the manifold gauge hoses are under pressure. Disconnect them from the service valves. Disconnect the hoses from the refrigerant compressor. Install the caps on the service valves.

Charge Checking

⚠ WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

In a system that is fully charged, some bubbles will show as the compressor cycles. Very high outside temperatures may cause occasional bubbles when the compressor is running; this is normal. For additional information, see "Refrigerant Check" in **Troubleshooting 300**.

Leak Testing

General Information

⚠ WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.

Refrigerant is odorless. As a result, all of it may leak away and not be noticed until the system stops cooling. All vehicle refrigerant systems lose some refrigerant, depending on the condition of the system. High loss rates signal a need to locate and repair the leaks.

Leaks are most often found at the compressor hose connections and at the various fittings and joints in the system. Refrigerant can be lost through hose permeation. Leaks can also be traced to pinholes in the evaporator caused by acid, which forms when water and refrigerant mix.

Leak Detection

There are two ways of finding the locations of leaks:

- sight detection
- electronic leak detection

The electronic leak detection method is the recommended method and the most precise method of detecting leaks.

The sight detection method may be used to find large leaks. Many large leaks will cause oil to escape along with refrigerant at the point of the leak. A deposit of oil may be a sign of a leak. Verification of leaks must be done using the electronic leak detection method.

Freightliner recommends using only the Heated Diode type of electronic leak detector. This type of detector can be identified by its construction and power supply. It has a heated element which requires periodic replacement and uses either a 12V DC or 120V AC power supply, or has a rechargeable battery. The Heated Diode type detector is sensitive only to gases containing halogen, such as R–134a and R–12 refrigerants. It will not detect other substances and is more likely to detect all of the leaks in a system. This type has both visual and audio indicators and self-tests to confirm operation.

Recommended electronic Heated Diode type leak detectors are available from their manufacturers. See **Table 3**.

Another type of detector, the Corona Discharge type, is the kind most commonly found in service and repair shops. This detector requires very little power and can operate on as few as four AA alkaline batteries. The Corona Discharge detector is not sufficiently sensitive and will create false alarms by detecting moisture and antifreeze or solvent vapors. This type of detector is specifically **not recommended**.

When checking for leaks, always focus your attention on the lowest portion of the fitting or part being tested. Refrigerant is heavier than air and will collect at the low point. Oil will also flow toward the low point.

Discharging, Purging and Flushing, Evacuating, Charging, Charge Checking, and Leak Testing

NOTE: Do not try to use a leak tester right after connecting or disconnecting service hoses. Traces of refrigerant at the fittings can falsely signal a leak. Always verify a leak by blowing shop air in to the area of the suspected leak and checking the area again.

Use the following procedures to locate A/C system refrigerant gas leaks using a heated diode type electronic leak detector.

1. Operate the electronic leak detector in accordance with the manufacturer's instructions.
2. Leak test with the engine turned off.
3. Charge the air conditioning system with sufficient refrigerant to indicate a gauge pressure of at least 50 psi (340 kPa) with the system not operating. It may not be possible to produce this amount of pressure and measure leakage if the ambient temperature is less than 59°F (15°C).
4. Be careful not to contaminate the detector probe tip if the part being tested is not clean. Wipe the part off with a dry shop towel or blow it off with shop air. Do not use cleaners or solvents as many detectors are sensitive to their chemical ingredients.
5. Visually inspect the entire refrigerant system. Look for air conditioning lubricant leakage and corrosion or damage to lines, hoses, and all other components. Inspect each questionable location carefully with the detector probe. Check all fittings, couplings, refrigerant controls, service ports (with caps installed), brazed or welded areas, and areas around attachment points and hold-downs.
6. Follow the path of the refrigerant system methodically so that no leaks are missed. If a leak is found, continue to test the rest of the system.
7. Inspect an area of possible leakage slowly and close to the part, moving completely around the part. Move the probe no faster than one to two inches (25 to 50 mm) per second and no farther away than 1/4 inch (6.4 mm) from the part.
8. If a large leak is present in either the system being serviced or the service equipment, the surrounding air will be saturated with refrigerant gas. In this situation the leak detector operates erratically and will indicate leakage without being near a possible leak source. Place a large fan so that a light breeze blows through the work area. Verify a leak by blowing shop air into the area and repeating the inspection. Pinpoint a large leak by blowing out the area often.
9. You may test the evaporator core while it is in its housing. Turn on the blower motor for a minimum of 15 seconds. Shut off the blower and wait for refrigerant gas to accumulate in the housing. Follow the detector instructions for the specific length of time to wait for the gas to accumulate. Insert the detector probe into the blower resistor block, or condensate drain hole if no water is present. If this is not possible insert the probe into the closest opening to the evaporator, such as a heater or vent duct.
10. Leak test the front seal area of the compressor. Blow shop air into the cavities in and around the clutch for at least 15 seconds. Let the compressor stand for one minute and then test for leakage. Inspect rotary type compressors (Sanden or Sel-Tec) by placing the probe near the holes at the front of the clutch. Inspect two-cylinder reciprocating type compressors (Climate Control) by placing the probe between the clutch coil and the compressor.

IMPORTANT: Be careful not to damage the clutch bearing seal with high pressure shop air.

11. Leak test repaired areas of the system after repairs have been performed. Leak test the service ports (with caps installed) after any service which disturbs the refrigerant system.

Discharging, Purging and Flushing, Evacuating, Charging, Charge Checking, and Leak Testing

Electronic Leak Detectors		
Designation	**Manufacturer**	**Comments**
D-TEK	Leybold Inficon 2 Technology Place East Syracuse NY 13057 (315) 434–1144	• Rechargeable battery • Hand-held design • Simple to operate
H–10 Professional	Bacharach Inc. c/o Yokogawa Corp. of America 2 Dart Road Newnan GA 30265 (800) 850–0044	• Rechargeable battery • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Most sensitive available
J 39400	SPX Kent-Moore 28635 Mound Road Warren MI 48092–3499 (800) 328–6657	• 12V DC or 120V AC • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Manual balance control

Table 3, Electronic Leak Detectors

Preliminary Checks

Before testing the operation of the air conditioning system, make the following checks.

1. Make sure the refrigerant compressor drive belt is not damaged and is correctly tensioned. Also check the compressor mountings for tightness. For instructions and other information, see the applicable refrigerant compressor section elsewhere in this group.
2. Using a feeler gauge, check for correct refrigerant compressor clutch clearance. For instructions, see the applicable refrigerant compressor section elsewhere in this group.
3. Check for broken, burst, or cut hoses. Also check for loose fittings on all parts.
4. Check for road debris buildup on the condenser fins. Using air pressure and a whiskbroom or a soapy spray of water, carefully clean off the condenser. Be careful not to bend the fins.
5. Check the moisture indicator sight glass for the moisture content of the refrigerant and the state of the charge. The air conditioner should be on when checking the indicator. You should make this check at the end of a day's run. Replace the charge if it is wet. If there are bubbles in the sight glass, the refrigerant charge could be low. Add more R–12 to the system. See **Subject 220** for instructions.
6. If there is not enough airflow, make sure that leaves or other debris has not entered the fresh air ports under the windshield. If debris has entered, it could clog the fins of the evaporator, and block airflow.

   Also, be sure that all ducts are connected to the dash louvers and that the air-control flaps in the heater housing are moving properly (this requires removal of the right and center dash panel).

Performance Tests

Following is a brief description of symptoms or conditions that will exist if something goes wrong in a refrigerant part.

Cooling Check

When outside temperature and humidity are high, it will take longer to cool the cab, especially if the fresh air vents are left open.

To determine if the air conditioner is cooling enough:

1. Set the engine speed at 1500 rpm.
2. Close the doors and windows.
3. Turn on the air conditioner and set the controls at maximum cooling (recirculated air) and blower speed. The compressor must be engaged during this test.
4. Allow the system to run for at least 10 minutes (longer on hot and humid days).
5. Place a thermometer inside the louver or air duct. Make sure the controls are set so that air flows out of the duct being tested.
6. Compare the measured temperature readings to the readings in **Table 1** below. If the duct's air temperature is higher than normal readings, the system is not cooling enough. For possible causes, see the troubleshooting tables.

Temperature Comparison	
Outside Temperature	**Center Vent Temperature**
60 to 80°F (16 to 27°C)	58°F (14°C) or lower
80 to 90°F (27 to 32°C)	60°F (16°C) or lower
90 to 100°F (32 to 38°C)	64°F (18°C) or lower

Table 1, Temperature Comparison

Refrigerant Check

There are four conditions to look for when checking refrigerant in the sight glass.

1. Bubbles normally show only when the system is started and then disappear after a few seconds. If these bubbles *continue all the time* the system is running, the system is merely low on (not completely out of) refrigerant. Only an occasional bubble should be seen during normal operation.
2. A clear sight glass means that the system has enough refrigerant to work properly, that it is completely out of refrigerant, or that it is overcharged.

3. A cloudy sight glass means that dirt or broken-down bits of desiccant are flowing through the system. This is a serious condition that requires a complete flushing out of the system, installation of a new receiver-drier, expansion valve, and, if the desiccant cartridge of the receiver-drier has fallen apart, installation of a new refrigerant compressor.
4. Oil streaks in the sight glass mean low refrigerant or too much oil in the system.

Receiver-Drier

The receiver-drier is normally at outside temperature. To the touch, the entire length of the unit should be the same temperature. If noticeable cool spots exist, replace the receiver-drier.

A blockage at the inlet of the unit will cause high head pressures. Outlet blockages will cause low head pressures and little or no cooling.

If the moisture indicator is not blue, the receiver-drier is saturated with water and acid, and must be replaced.

Cooling System

Although they are not physically connected, there is a close tie between a vehicle's air conditioner and its cooling system. Poor air conditioner cooling can be the result of a problem in the cooling system.

If the cooling system does not work correctly, the heat of the engine will rise to abnormal levels. The added heat will transfer to the air conditioner, other underhood parts, and maybe make its way into the cab. The added heat makes it necessary for the air conditioner to work harder and, at the same time, it reduces the air conditioner's ability to cool down the air in the cab.

See the engine cooling section for cooling system troubleshooting and to the engine manufacturer's service manual for other details about cooling system problems.

Expansion Valve

Problems that start in the expansion valve show up as follows: when stuck closed, the evaporator and the expansion valve will be at outside temperature. When stuck open, both the coil and the valve will be extremely cold with frost or ice buildup.

Because the expansion valve is very sensitive to contamination, blockages in the system tend to be found here. Usually, the contaminant is water. Less than a drop of water is all it takes to make the valve inoperative. When water reaches the valve, the extreme cold that results from the pressure drop freezes the water, forming a block of ice in the valve. After the system shuts down and the valve warms up, the ice melts, and the valve operates again, only to freeze up when the water returns.

On-and-off operation of the expansion valve means that the receiver-drier is not removing water and acids from the system. These contaminants should cause the moisture indicator's element to turn pink or white.

Refrigerant Compressor

Compressor problems usually show in one of four ways: abnormal noise, seizure, leakage, or low suction and discharge pressures.

Resonant compressor noises are not causes for alarm. Irregular noise or rattles are likely to be caused by broken parts. To check for seizure, de-energize the magnetic clutch and see if the drive plate can be turned. If it will not turn, the compressor has seized.

Low discharge pressure may be caused by not enough refrigerant, not enough belt tension, or a blockage somewhere in the system. These things should be checked before servicing the compressor.

Evaporator

The evaporator is basically trouble-free when airflow over the fins is not blocked. External or, less often, internal blockages will cause low suction pressure as well as little or no cooling.

If hydrochloric acid has formed in the system (the result when refrigerant mixes with water), it may cause pinholes to form in the evaporator. If a leak exists in the system, and it cannot be traced to other parts or fittings, suspect damage to the evaporator.

Condenser

The condenser is also usually trouble-free when road debris, such as leaves or dirt buildup, is removed. If debris cakes up, airflow over the condenser fins is blocked; air is not able to absorb enough heat to turn the hot refrigerant gas into a liquid. High head pres-

sures will result. In these cases, carefully clean off the outer surfaces of the condenser with compressed air or a soap and water solution; be careful not to bend the fins.

High head pressures will also occur if the condenser's tubing is abnormally bent, blocking the flow of refrigerant.

Less common internal blockages, such as bits of foreign material or metallic grit buildup, will stop the flow of refrigerant.

A quick test to check that poor system performance is caused by the condenser is to direct a spray of water onto the condenser while the system is running. If the air conditioner cools better because of the assist provided by the water, it is a sign that the condenser is not working.

When troubleshooting a suspected condenser problem, remember that the problem may be caused by the cooling system transferring high levels of heat to the condenser. See **Group 20** for cooling system troubleshooting and to the engine manufacturer's service manual for other details about cooling system problems.

Thermostatic Switch

Before troubleshooting the thermostatic switch, be sure there is a full charge of refrigerant in the system. The compressor will not operate, or will cycle too often, if there is not enough refrigerant in the system.

Quick or delayed cycling of the compressor may be caused by a thermostatic switch that is working, but is out of adjustment. If, after doing the tests below, the switch seems to be out of adjustment, replace it. The thermostatic switch cannot be recalibrated.

1. Be sure the compressor clutch is operating correctly. See the applicable refrigerant compressor section elsewhere in this group.
2. Expose the evaporator. See **Subject 120** for instructions.
3. Connect the batteries and start the engine. Place the air conditioner control at its coldest setting. Turn on the air conditioner and the fan.
4. Place an accurate thermometer in contact with a tube on the evaporator. Be sure the thermometer is in good contact with the tube, or you will get a wrong reading.

   When the temperature drops below 31° to 36°F (–1° to 2°C), the compressor clutch should disengage and remain this way until the temperature rises to 39° to 44°F (4° to 7°C).
5. If the compressor did not engage when the temperature was above the accepted high range, check the thermostatic switch and its wiring.

   5.1 Connect a voltmeter or a test light from one of the terminals on the thermostatic switch to ground. Repeat this test with the other terminal on the switch.

   5.2 With the engine running and the air conditioner and blower on, both terminals will show voltage when the compressor should be engaged. One terminal will show voltage when the compressor should be disengaged.

   If there is no voltage, there is a problem in the electrical system from the batteries to the thermostatic switch. Check all circuits for the cause, and repair or replace the wiring or parts.

   In all other cases where the compressor is not engaging and disengaging properly, the thermostatic switch is the cause. Replace it with a new switch.
6. Shut down the engine and, to prevent accidental electric shock or shorting during dash assembling, disconnect the batteries.
7. Assemble the dash. See **Subject 120** for instructions.

Line Restrictions

A restricted suction line causes low suction pressure at the compressor and little or not cooling. A restriction in a line between the compressor and the expansion valve can cause high discharge and low suction pressure, and insufficient cooling.

Usually, areas of ice or frost buildup mean a blockage. Parts that often freeze up are probably corroded or inoperative and should be replaced. Parts (such as the expansion valve) that freeze up once in a while may do so because of water in the system, which will cause the moisture indicator element to

turn pink. If this happens, replace the receiver-drier, purge or flush the lines and parts, and recharge the system.

Fault Analysis Flow Chart

Troubleshooting Tables

Problem—Little or No Airflow

Problem—Little or No Airflow	
Possible Cause	**Remedy**
The blower is not operating.	Check for an open circuit breaker. An open circuit breaker indicates a short in the electrical system, which must be located and repaired.
	Check the air conditioner relays for operation. Replace as necessary.
	Make sure the blower motor switch is working. Replace if necessary.
	Check the wiring to the blower motor. If any connections are loose, securely tighten them. Make sure the wiring conforms to the diagram under **Specifications 400** .
	Check the blower motor for operation. Replace if sticking or otherwise inoperative.
	Check the resistor block. Replace if necessary. **CAUTION:** Never try to by pass the fuse in the resistor block. To do so could cause the blower motor to overheat, resulting in serious damage to the heater/ air conditioning system.
There are restrictions or leaks in the air ducts.	Examine all air ducts and remove any blockages. Stop any leaks or replace any portion where the leaks cannot be stopped.
Ice has formed on the evaporator.	Defrost the evaporator before resuming operation of the air conditioner. Review "Performance Tests" in this subject for possible causes and corrective action.

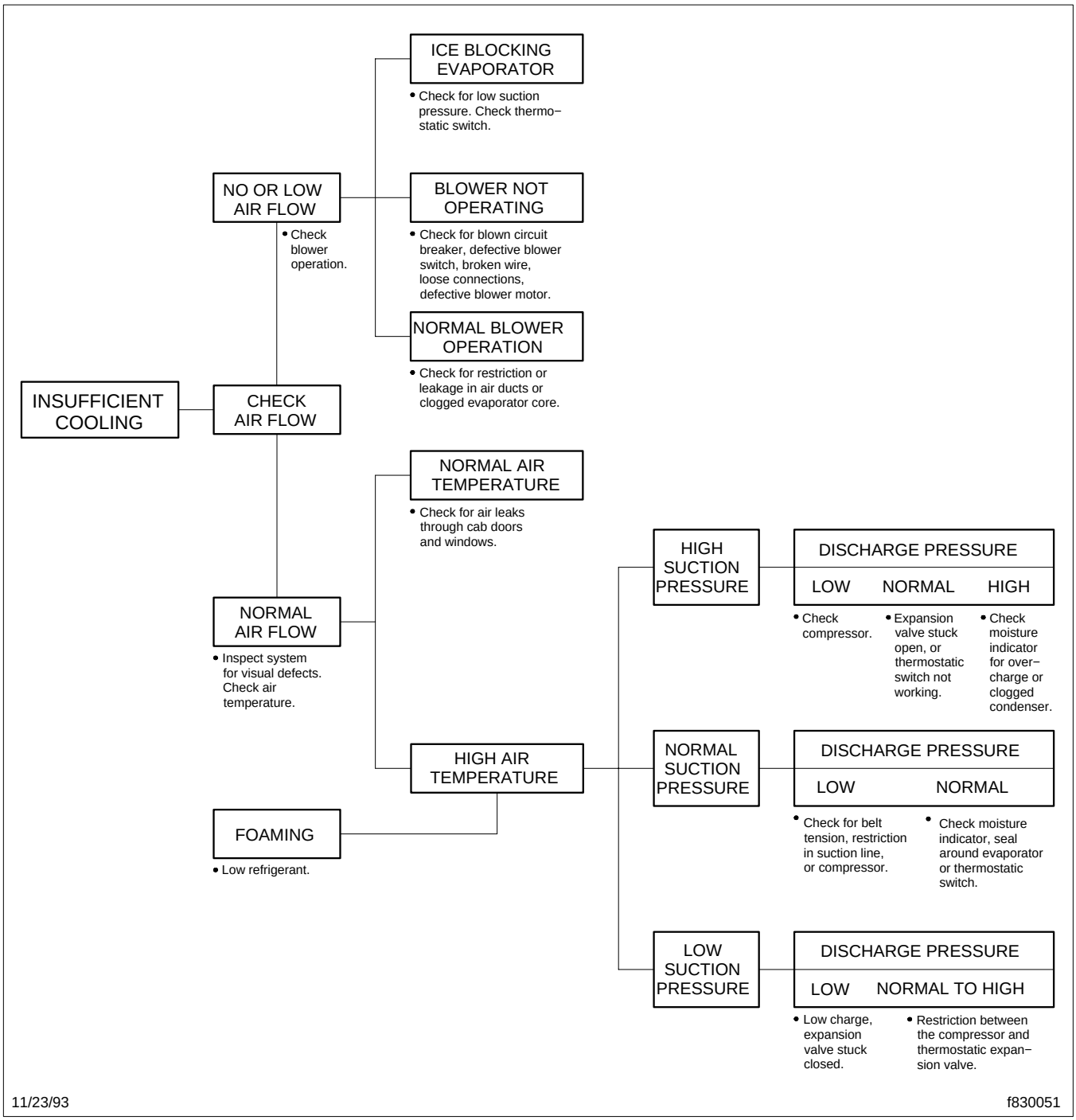


Fig. 1, Fault Analysis Flow Chart

Troubleshooting

Problem—Warm Airflow When the Air Conditioner Is On

Problem—Warm Airflow When the Air Conditioner Is On	
Possible Cause	**Remedy**
There is no refrigerant charge in the system.	Perform a leak test. Repair any leaks, purge the system, replace the receiver-drier, and add a full charge of refrigerant.
Moisture in the system.	If moisture is in the system, ice crystals may form at the expansion valve, blocking the flow of refrigerant (off and on). Discharge the refrigerant charge, purge the system, replace the receiver-drier, and add a full charge of refrigerant.
The refrigerant compressor is not operating.	If the refrigerant charge is low, charge and leak test the system. Repair any leaks.
	The refrigerant compressor clutch or drive belt needs repair or replacement. For instructions, see the refrigerant compressor section elsewhere in this group.
The air-conditioner microswitch is not working.	Replace the microswitch.
Ice has formed on the evaporator.	Defrost the evaporator before resuming operation of the air conditioner. Review "Performance Tests" in this subject for possible causes and corrective action.

Problem—Foaming in the Receiver-Drier Sight Glass

Problem—Foaming in the Receiver-Drier Sight Glass	
Possible Cause	**Remedy**
There is an insufficient refrigerant charge in the system.	Add refrigerant.
There are leaks in the system.	Perform a leak test. Stop all leaks, exhaust the old refrigerant from the system, and add a new charge.
Restriction in the line between the condenser and the receiver-drier is slowing refrigerant flow.	Remove the restrictions from the line. If water or corrosion is present, purge or flush the system, replace the receiver-drier, and add a full charge of refrigerant.

Problem—Low Evaporator Coil Outlet Pressure (Low Compressor Suction Pressure)

Problem—Low Evaporator Coil Outlet Pressure (Low Compressor Suction Pressure)	
Possible Cause	**Remedy**
The expansion valve is not working.	Replace the expansion valve. If moisture or corrosion is present, purge or flush the system, replace the receiver-drier, and add a full charge of refrigerant.
There are restrictions in the line to the expansion valve.	Remove the line restrictions. If moisture or corrosion is present, purge or flush the system, replace the receiver-drier, and add a full charge of refrigerant.
There is an insufficient refrigerant charge in the system.	Add refrigerant.

Problem—High Compressor Discharge Pressure

Problem—High Compressor Discharge Pressure	
Possible Cause	**Remedy**
Airflow through the condenser is restricted.	Remove the debris from the condenser.
There is an internal restriction in the condenser. The return tube bends should all be the same temperature.	Replace the condenser. If water or corrosion is present, evacuate the system, replace the receiver-drier, and add a full charge of refrigerant.
Air is present in the system.	Perform a leak test. Repair any leaks, evacuate the system, and add a full charge of refrigerant.
The system has too much refrigerant.	Drain some of the refrigerant charge at the discharge service valve.
Heavy frosting on the suction line suggests that the evaporator is flooded.	Defrost the evaporator coil before resuming operation of the air conditioner. If the problem recurs, there is probably moisture (ice crystals) blocking the expansion valve. Exhaust the refrigerant charge, purge the system, replace the receiver-drier, and add a full charge of refrigerant.
The engine is over-heated.	Refer to the engine manufacturer's operations manual for corrective measures.
Restriction in the compressor discharge line.	Repair or replace the line.

Problem—Evaporator Outlet Air Temperature Increases as the Compressor Discharge Pressure Drops

Problem—Evaporator Outlet Air Temperature Increases as the Compressor Discharge Pressure Drops	
Possible Cause	**Remedy**
There are leaks in the system.	Leak test the system. Repair any leaks, exhaust the old refrigerant, and add a full charge of refrigerant.
The expansion valve setting is too low.	Replace the expansion valve. Add a full charge of refrigerant.
Too much oil is in the system. An indication of this is clutch or belt slippage at governed engine speed.	Check and remove excess refrigerant oil. For instructions, refer to the refrigerant compressor section elsewhere in this group.

Problem—Compressor Operates Too Often or Continuously

Problem—Compressor Operates Too Often or Continuously	
Possible Cause	**Remedy**
There is too little refrigerant in the system.	Perform a leak test. Repair any leaks and add a full charge of refrigerant.
Ice has formed on the evaporator.	Defrost the evaporator coil before resuming operation of the air conditioner. Check the operation of the thermostatic switch and replace as necessary.
There is a restriction in the refrigerant system.	Remove the restriction from the line. If water or corrosion is present, purge or flush the system, replace the receiver-drier, and add a full charge of refrigerant.
Dirt and debris are clogging the condenser fins.	Remove all dirt and debris from the condenser fins.
The thermostatic switch is not working.	Replace the thermostatic switch.

Troubleshooting

Problem—Quick or Delayed Cycling of the Compressor

Problem—Quick or Delayed Cycling of the Compressor	
Possible Cause	**Remedy**
The thermostatic switch operates, but is out of adjustment.	Replace the thermostatic switch. Do not attempt to adjust it.
Loss of refrigerant is causing a delayed cycling of the compressor.	Leak test and add a full charge of refrigerant.

Problem—Temperature in the Cab Too Low or No Heat

Problem—Temperature in the Cab Too Low or No Heat	
Possible Cause	**Remedy**
The water regulating valve is not opened.	Turn the temperature control knob toward warm.
The water regulating valve is not opening all the way.	Adjust the water regulating valve cable.
The water regulating valve isn't working.	Replace the water regulating valve.
A heater hose is pinched or twisted.	Repair or replace the heater hose.
Coolant is leaking from the system.	Check for leakage at the heater core, and at all hose connections from the heater core to the engine. Check the radiator coolant level, as instructed in the vehicle driver's manual, and add coolant, if necessary. Check and repair any leaks at the radiator.
Dust or dirt is clogging the heater core fins.	Remove and clean the heater core.

Problem—Condensed Water Is Leaking from the Air Conditioner

Problem—Condensed Water Is Leaking from the Air Conditioner	
Possible Cause	**Remedy**
The drain tubes are plugged.	Clean the drain holes and drain tubes.

Specifications

A/C Fitting Torque Specifications*	
Hose Size	**Torque lbf·ft (N·m)**
#6	20–25 (27–34)
#8	30–35 (41–47)
#10 and #12	35–40 (47–54)

* One-inch fittings on the A/C compressor need to be torqued 21 to 27 lbf·ft (28 to 37 N·m) regardless of hose size.

Table 1, A/C Fitting Torque Specifications

3/4- and 5/8-Inch Heater Hose Clamp Torque Values	
Description	**Torque lbf·in (N·cm)**
Standard Hose Clamp	40 (452)
Worm-Gear Hose Clamp	40 (452)
Breeze Constant-Torque Hose Clamp	40 (452)
Oetiker Constant-Torque Hose Clamp	18 (203)

Table 2, 3/4- and 5/8-Inch Heater Hose Clamp Torque Values

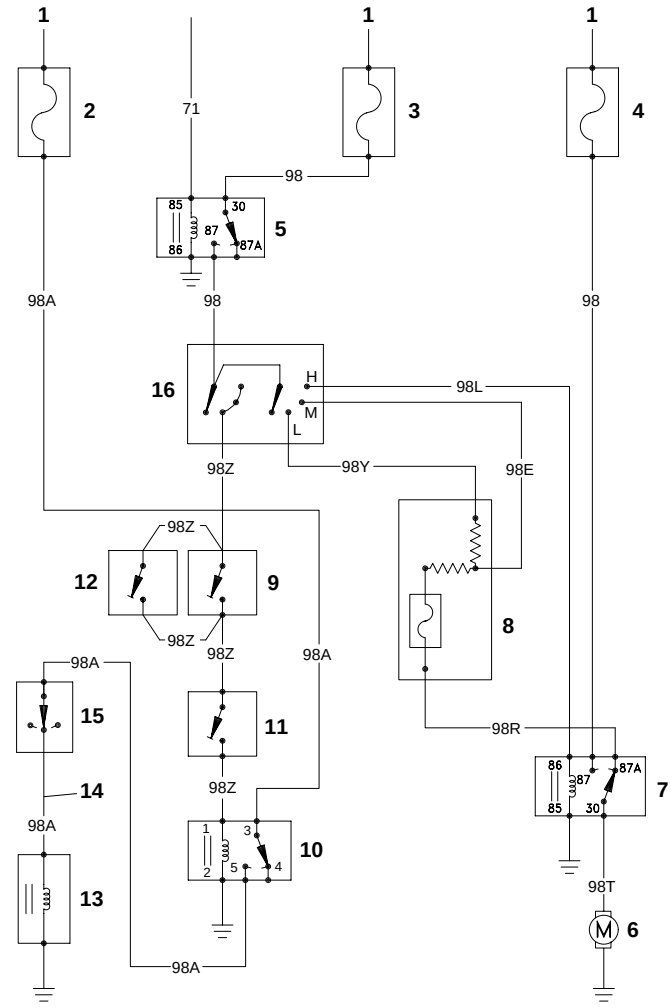
Electronic Leak Detectors		
Designation	**Manufacturer**	**Comments**
D-TEK, D-Tek Select, and TekMate	Leybold Inficon 2 Technology Place East Syracuse, NY 13057 (315) 434–1144	• Rechargeable battery • Hand-held design • Simple to operate
H–10 Professional	Yokogawa Corp. of America 2 Dart Road Newnan, GA 30265 (800) 258–2552	• Rechargeable battery • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Most sensitive available
J 39400	Kent-Moore 29784 Little Mack Roseville, MI 48066–2298 (810) 578–7285	• 12V DC or 120V AC • Carrying case with strap • Calibration leak bottle • Manual sensitivity control • Manual balance control

Table 3, Electronic Leak Detectors

See **Fig. 1** for the air conditioning wiring diagram. See **Fig. 2** for the air conditioning air conditioner plumbing diagram. See **Fig. 3** for the heater plumbing diagram for Cummins B Series engines. See

Specifications

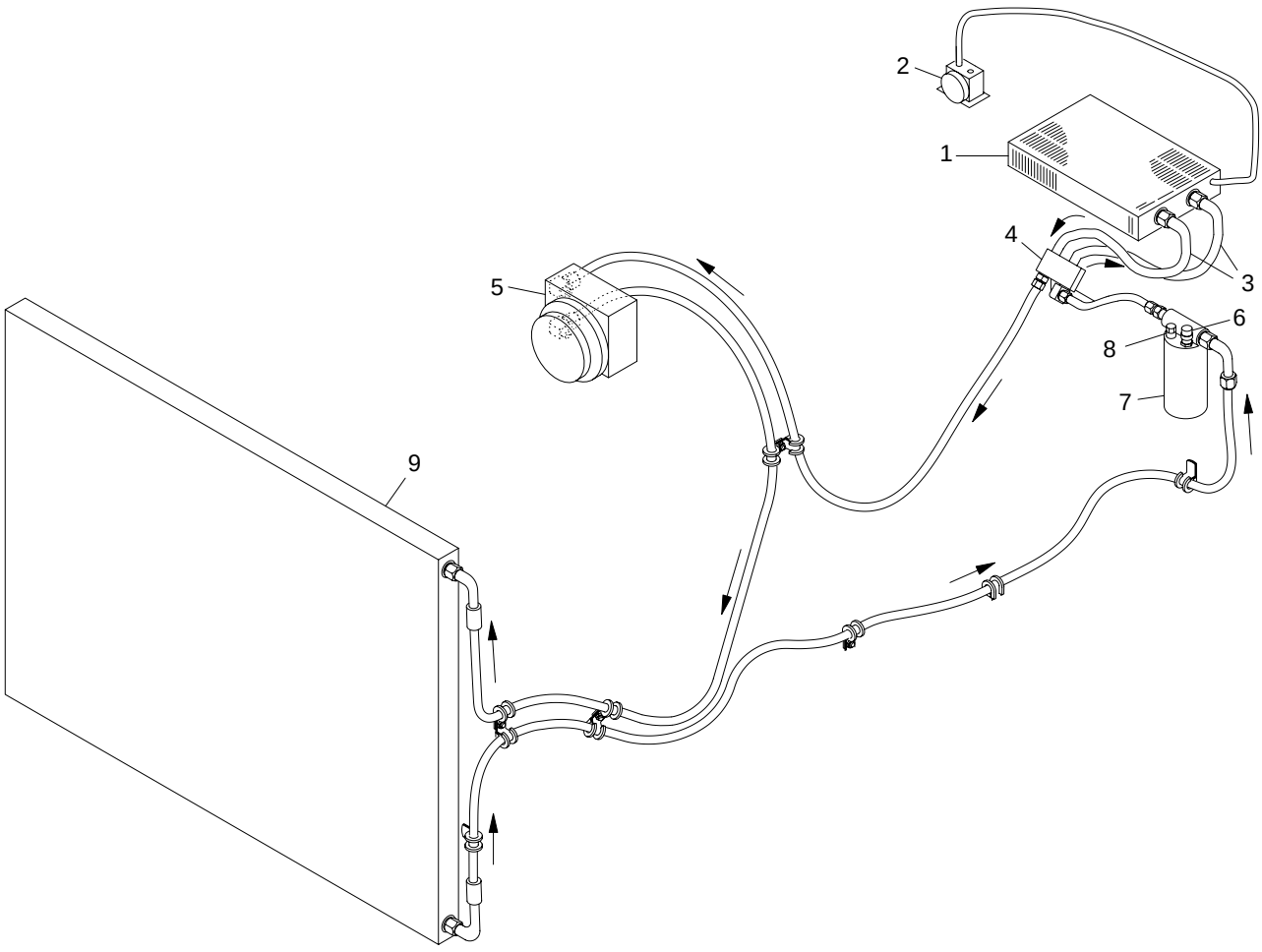
Fig. 4 for the heater plumbing diagram for Cummins C Series engines. See **Fig. 5** for the heater plumbing diagram for Mercedes-Benz OM 366LA engines.



11/23/93 f540349

1. To 14.
2. 10A
3. 15A
4. 40A
5. Heater/Air-Conditioner Relay
6. Blower Motor
7. Heater Blower Relay
8. Resistor
9. Defroster/Dehumidifier Microswitch
10. Compressor Clutch Relay
11. Thermostatic Switch
12. Air Conditioner On/Off Microswitch
13. Air Conditioner Compressor Clutch
14. Black
15. Binary Switch
16. Blower Motor Switch

Fig. 1, Air Conditioning Wiring

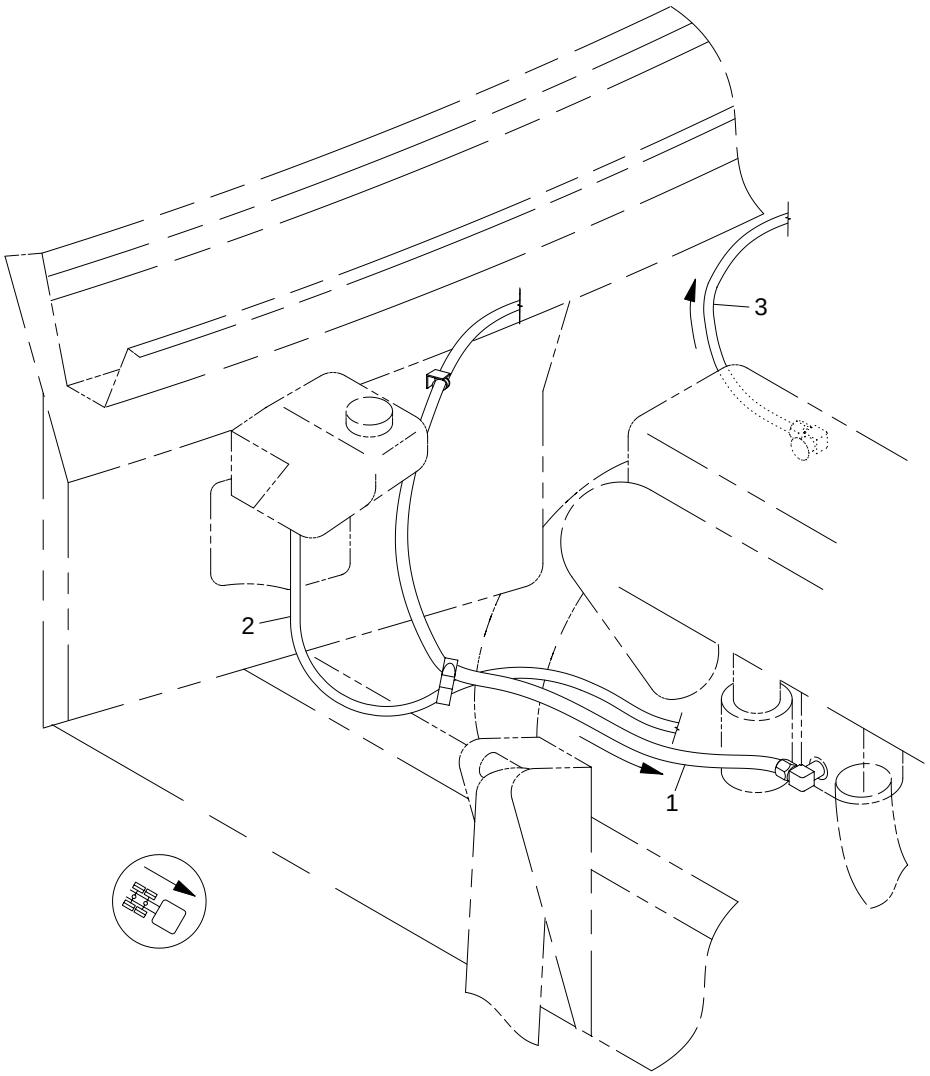


11/23/93 f830370

1. Evaporator Coil
2. Thermostatic Switch
3. Extension Hoses (through firewall)
4. Expansion Valve
5. Refrigerant Compressor
6. Binary Switch
7. Receiver-Drier
8. Moisture Indicator
9. Condenser

Fig. 2, Air Conditioner Plumbing

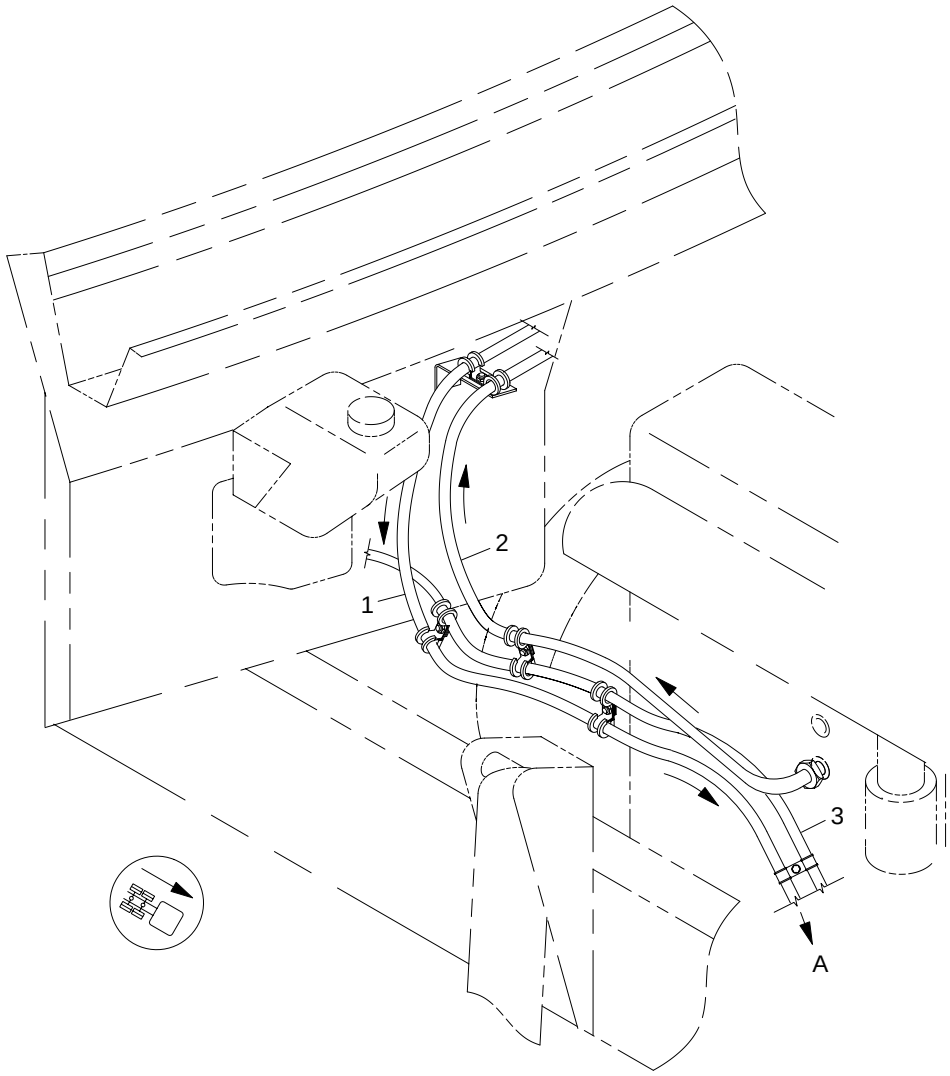
Specifications



11/23/93 f830527

1. Heater Return Line
2. Surge Tank Hose
3. Heater Supply Line

Fig. 3, Heater Plumbing for Cummins B Series Engines



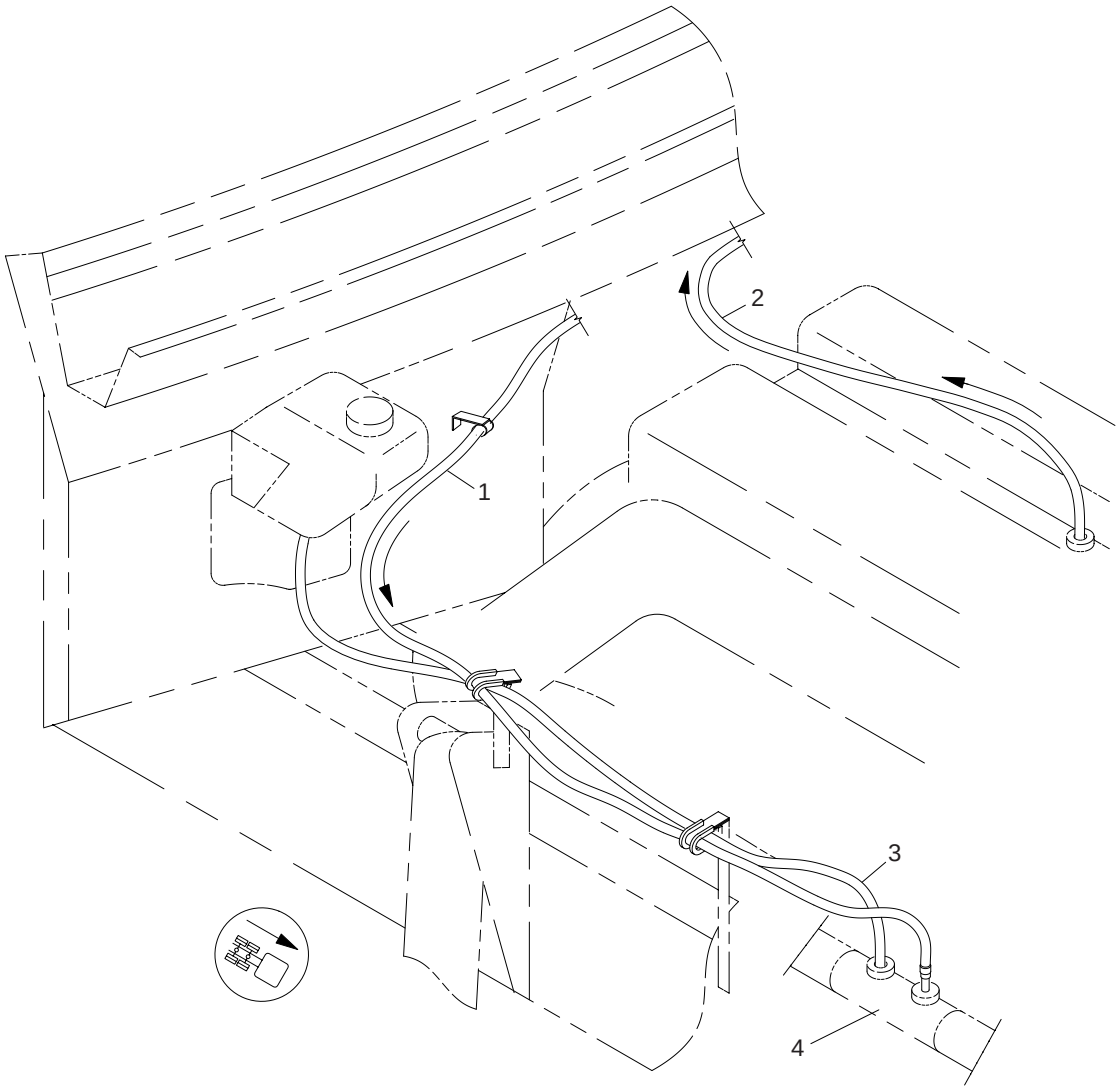
11/23/93 f830528

A. To radiator shunt line.

1. Heater Return Line
2. Heater Supply Line
3. Surge Tank Hose

Fig. 4, Heater Plumbing for Cummins C Series Engines

Specifications



1. Heater Return Line
2. Heater Supply Line
3. Surge Tank Hose
4. Radiator Outlet Hose

Fig. 5, Heater Plumbing for Mercedes-Benz OM 366LA Engines

General Information

The main purpose of the refrigerant compressor **(Fig. 1)** is to draw refrigerant gas from the evaporator and squeeze it into high-pressure gas. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid so that it can be used for cooling again. A second purpose of the compressor is to move refrigerant through the air conditioning system.

The compressor is cycled by a thermostatic switch. When there is enough of a temperature drop in the cab, the switch breaks the circuit to the compressor's clutch. When the clutch is disengaged, its pulley is free-wheeling and the compressor shaft is not turning. When the clutch is engaged, it holds to the pulley, and the turning of the pulley causes the compressor shaft to turn.

Refer to the heater and air conditioner section for more information.

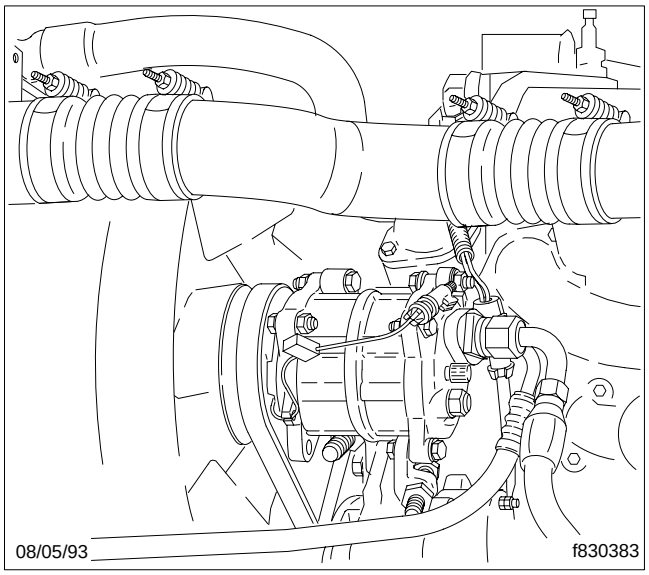


Fig. 1

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold refrigerant, you must discharge, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure. You should disconnect them only after the air conditioning system has been discharged to a refrigerant recovery unit through the service valves.

Refrigerants are safe when used under the right conditions. Always wear safety goggles and non-leather gloves while discharging, purging, flushing, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

⚠ WARNING

WARNING: Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should first be treated with a few drops of sterile mineral oil in the eyes, and then rinsed with a weak boric acid solution. Do not rub the eyes. Call a doctor right away.

Refrigerant splashed on the skin should be treated the same as for frostbite: gently pour cool water on the area, but do not rub the skin. Keep the skin warm with layers of soft, sterile cloth. Call a doctor right away.

Even though refrigerant does not burn, when it contacts extreme heat or flame, poisonous gas is created.

⚠ WARNING

WARNING: Do not work in an area where refrigerant may contact an open flame or any burning material, such as a cigarette. When it contacts extreme heat, refrigerant breaks down into poisonous gas which, if breathed, causes severe respiratory irritation. If an open flame leak detector is used, follow the manufacturer's safety precautions.

If a refrigerant recovery and recycling station is available, discharge the air conditioning system into the station. Refer to the manufacturer's operating instructions.

If a refrigerant recovery and recycling station is not available, check local regulations for disposal methods.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant cans from exploding, never expose them to temperatures higher than 52°C (125°F). Never leave refrigerant cans in the sun, and do not store them in sun-exposed areas where heat can build up, such as in glove boxes, automobile trunks, etc.

Checks

WARNING

WARNING: Before doing any work, read the information under Safety Precautions, 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

Some special tools are needed for doing repair work on the compressor. Tool kits can be bought from the suppliers listed in **Specifications, 400**.

The checks below should be made whenever the air conditioning system is not cooling enough and the causes are unknown.

1. Be sure to check the moisture indicator, to see if moisture is the cause of the problems. The air conditioner should be on when checking the indicator; it is better to check it at the end of a day's run.
2. Check the drive belt and mounting as follows:
   - 2.1 On the drive belt, look for wear, damage, or oil. If worn, oil-soaked, or damaged, remove it and install a new one. Refer to the applicable section in **Group 01** for instructions.
   - 2.2 Check the compressor mounting parts for loose fasteners, cracks, or other damage. Tighten loose fasteners to the torque value in the applicable table in **Specifications, 400**. Repair or replace cracked or damaged brackets.
   - 2.3 Check the tension of the compressor drive belt. Refer to the applicable section in **Group 01** for instructions.
3. Check the wiring and connections to the compressor clutch. Replace damaged wiring and tighten loose connections.
4. Check for road debris build-up on the condenser coil fins. Using air pressure and a whiskbroom or a solution of soap and water, carefully clean the condenser; be careful not to bend the fins.
5. Check the refrigerant charge in the air conditioning system; for instructions, refer to the heater and air conditioner section in this group.
6. Check the suction pressure and discharge pressure of the refrigerant compressor; refer to **Subject 130**.

NOTE: For other possible causes of air conditioner problems, refer to the heater and air conditioner section in this group.

Compressor Suction and Discharge Pressure Checking

Checking

1. Read the information under **"Safety Precautions, 100."**
2. Attach a manifold gauge set to the service ports. Equip the manifold gauge set with a valve core depressor.
   - 2.1 Remove the protector caps from the service valve ports on the firewall. **See Fig. 1.**
   - 2.2 Close both of the valves on the manifold gauge set. Cap the manifold center hose.
   - 2.3 Connect the high-side hose to the discharge service port. The connection should be finger-tight.
   - 2.4 Open the high-side manifold valve one turn. Open the low-side manifold valve just enough to allow refrigerant gas to slowly escape from the low-side hose. Allow gas to escape for three seconds, then close both manifold valves.
   - 2.5 Quickly connect the low-side hose to the suction service port. The connection should be finger-tight.
3. Start the engine and set it to run at 1500 rpm.

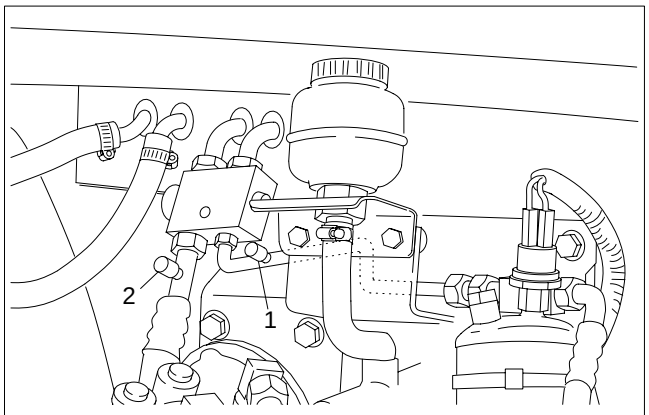


Fig. 1

4. Turn on the heater/air-conditioner blower, and set the air conditioner controls to the coldest setting, so that the compressor is operating. If the outside temperature is cooler than 21°C (70°F), *partially* block the air to the condenser.
5. Look at the manifold suction and discharge pressure gauges. The pressures on the gauges should be within the range listed in the **temperature/pressure specifications table in "Specifications, 400."**
   - 5.1 If the suction pressure is normal and the discharge pressure is too high, skip the following sub-steps and proceed.
   - 5.2 If the suction and discharge pressures are both too high, there is air in the refrigerant, or too much refrigerant in the system; check the charge; for instructions, refer to the heater and air conditioner section in this group.
   - 5.3 If the suction pressure is too high and the discharge pressure is normal, check the wiring to the thermostatic switch beside the blower motor; repair or replace the wiring, as needed. If the wiring is correct and there is power to the switch, check that the probe of the thermostatic switch is correctly installed in the evaporator coil. For instructions, refer to the heater and air conditioner section in this group. If everything checks out okay, replace the thermostatic switch at the climate control panel.
   - 5.4 If the suction pressure is too low and the discharge pressure is normal or too low, check for passage of air through the evaporator coils. If airflow is blocked, remove the blockage. If airflow is satisfactory, check for blockages in the line to the suction side of the compressor.
   - 5.5 If the suction pressure is normal or too high and the discharge pressure is too low, skip the following step and proceed.
6. If the suction pressure is normal and the discharge pressure is too high, airflow through the condenser may not be enough to carry away the heat.

   Check for dirt or debris causing reduced airflow. Also check for a blockage in the refrigerant path indicated by an icy area on the condenser or hoses.

Compressor Suction and Discharge Pressure Checking

6.1 Place a large fan in front of the radiator; place it so that the airflow goes through the condenser. After two minutes of operating the air conditioner and the fan at the same time, look at the manifold pressure gauges again. (One other procedure is to direct a spray of water onto the condenser while the system is running.)

6.2 If the discharge pressure is still too high, the lines between the compressor and the receiver-dryer are restricted, or the condenser is restricted internally. Discharge, flush, evacuate, charge, and leak test the system. If the restriction can't be removed by flushing, replace the restricted line or condenser. After flushing and before placing a vacuum in the system, *be sure to add the correct amount of refrigerant oil to the compressor* . For instructions, **refer to "Oil Check and Adding Oil to the Compressor, 150."**

7. If the suction pressure is normal or too high and the discharge pressure is too low, check for a slipping clutch or wrong-sized clutch pulley or accessory drive pulley. Replace parts as needed.

   If the suction pressure is still normal or too high and the discharge pressure is still too low, the compressor is the problem. Repair or replace the compressor.

Removal

1. Discharge the air conditioning system; for instructions, refer to the heater and air conditioner section in this group.
2. Remove the clamps holding the charge air pipe; then, remove the pipe. See **Fig. 1**.

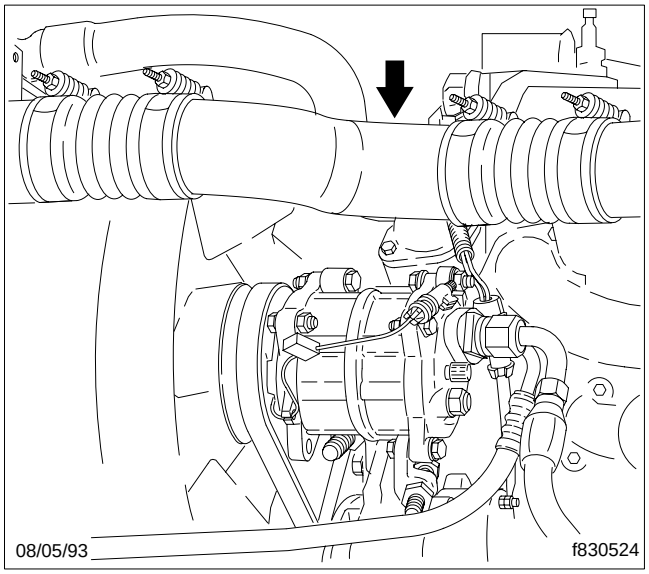


Fig. 1, Charge Air Pipe

3. Thoroughly clean the compressor around the hose connections. Disconnect the suction and discharge hoses from the compressor. Quickly cap the discharge and suction ports and plug the hoses. Under no circumstances should you leave the ports uncapped or the hoses unplugged for longer than a total of five minutes.
4. Disconnect the compressor magnetic clutch electrical wire. See **Fig. 2**.
5. Remove the V-belt.
   - 5.1 Loosen both the adjustment and jam nuts on the compressor lower mounting strut. See **Fig. 3**.
   - 5.2 Loosen the two compressor upper mounting bolts. See **Fig. 4**.
   - 5.3 Pivot the compressor down to relieve the belt tension.
   - 5.4 Remove the V-belt.

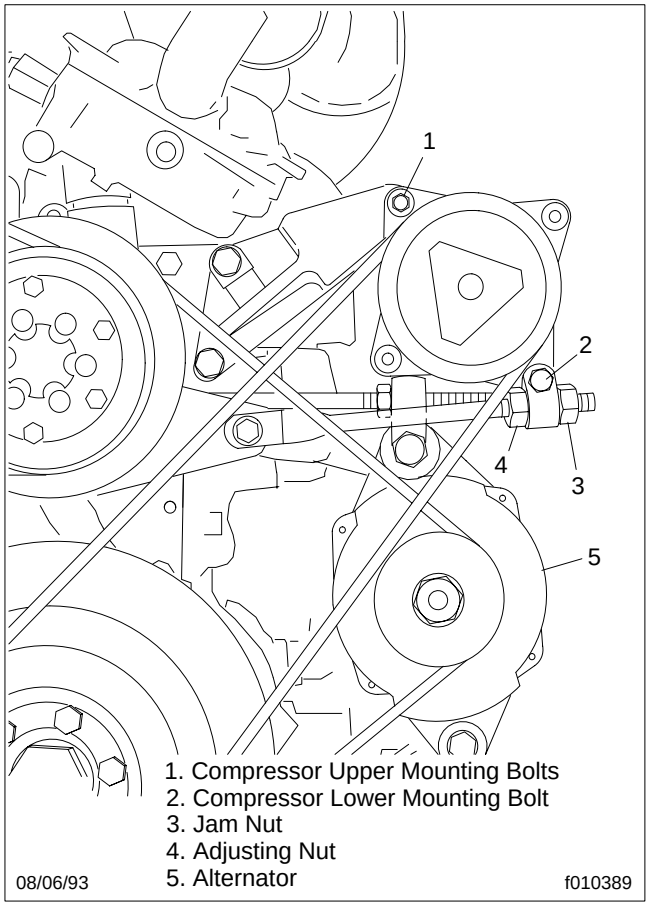


Fig. 2

6. Remove all three compressor mounting bolts (**Fig. 4**) and lift out the compressor.

Installation

IMPORTANT: A new compressor is filled with nitrogen gas and 200 mL (6.8 fl oz) of refrigerant oil. When installing a new compressor on the vehicle, do all of the steps below; if installing a used compressor, skip the following step, and proceed with the installation:

1. Flush a new compressor.
   - 1.1 Slowly release the nitrogen from the discharge side of the compressor. Be careful not to let the oil flow out.
   - 1.2 Turn the compressor several times by hand to expel the oil from the cylinders.

Compressor Removal and Installation

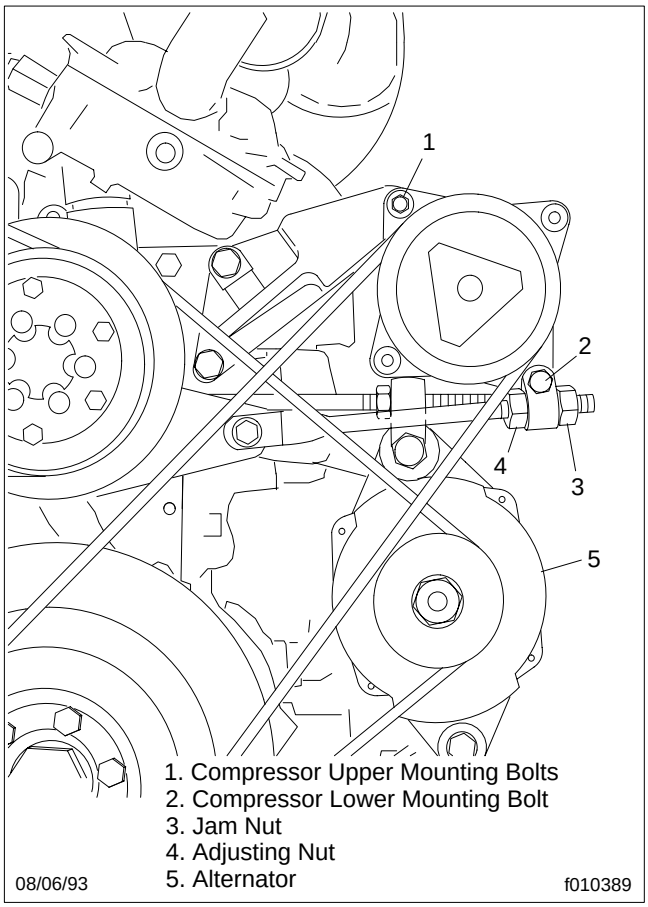


Fig. 3

1.3 When installing the compressor on a completely flushed (cleaned) system, install the compressor as it is; when installing it on a system that has not been flushed, install the compressor after adjusting the amount of oil. For instructions, refer to **Subject 150**.

2. Place the compressor in position against the mounting bracket and install the mounting bolts, washers, and nuts (**Fig. 3**, Refs. 1 and 2).

NOTE: The two long bolts go on top.

3. Hand tighten the nuts.

4. Install the V-belt. Adjust the belt tension. For instructions, the applicable section in **Group 01**.

5. Tighten the compressor mounting bolts 45 N·m (33 lbf·ft).

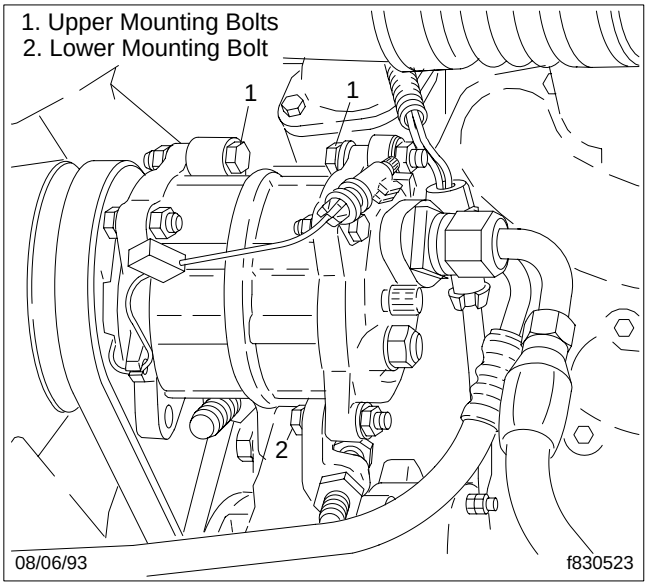


Fig. 4

6. Uncap the suction and discharge ports on the compressor. Unplug the hose connections. Check the hose connections and the surface of the suction and discharge ports. They must be clean and free of nicks, gasket residue, and other foreign material.

IMPORTANT: Under no circumstances should you leave the compressor's ports uncapped or the hoses unplugged for longer than five minutes total.

7. Attach the refrigerant hoses to the system hose connections. Tighten the suction (large) fitting 39 N·m (29 lbf·ft); tighten the discharge (small) fitting 37 N·m (27 lbf·ft).

8. Connect the compressor magnetic clutch electrical wire.

9. Evacuate, charge, and leak test the air conditioning system. For instructions, refer to the heater and air conditioner section in this group.

10. Install the charge air pipe. Tighten the constant torque hose clamps 7 N·m (5 lbf·ft).

Oil Check and Adding Oil to the Compressor

Procedure

IMPORTANT: New compressors are factory-charged with 200 mL (6.8 fl oz) refrigerant oil, which does not require periodic checking. Refrigerant oil circulates through the system with the refrigerant. The oil cannot leave the system except through a leak, when the system is discharged for service, or when a system part is replaced.

Add only FREOL DS-83P refrigerant compressor oil. Oil must be from a container that has not been opened, or that has been tightly sealed since its last use. Tubing, funnels, or other equipment used to transfer the oil should be very clean and dry.

When replacing system parts, add the following amounts of oil to the compressor, to replace that which is lost with the discarded part:

A. *Receiver-dryer*— 80 mL (2.7 fl oz);

B. *Condenser*— 30 mL (1.0 fl oz);

C. *Evaporator coil*— 20 mL (0.7 fl oz) each;

D. *Entire system*— 264 mL (8.9 fl oz). Add this amount of oil to the compressor if the entire system (including the compressor) has been discharged of refrigerant and oil, and all parts and hoses have been flushed.

When handling refrigerant oil:

- The oil should be free of water, dust, metal powder, and other foreign substances.
- Do not mix refrigerant oil with other types or viscosities of oil.
- Refrigerant oil absorbs water when exposed to the air for short periods. After use, quickly seal the oil container.

During normal operation, part of the oil recirculates with the refrigerant in the system. When checking the amount of oil in the system, first run the compressor to return the oil to the compressor.

1. Turn on the air conditioner (the compressor must be engaged), and set the blower fan at high speed.
2. With the compressor engaged, run the engine for at least 20 minutes between 800 and 1200 rpm.
3. After turning off the engine, remove the compressor from the vehicle.
4. Remove the compressor drain plug; then, drain the compressor oil into a clean container. **See Fig. 1.** Rotate the drive plate several times by hand to extract the remaining oil through the discharge-side port. About 30 mL (1 fl oz) of oil will remain in the compressor and cannot be removed without disassembling it.
5. Measure the drained oil with a measuring cylinder.
6. Check the oil for signs of contamination.
   - 6.1 Check for cloudiness or increased opacity.
   - 6.2 Check for a color change to red.
   - 6.3 Check for the presence of foreign particles (metal powder, etc.).

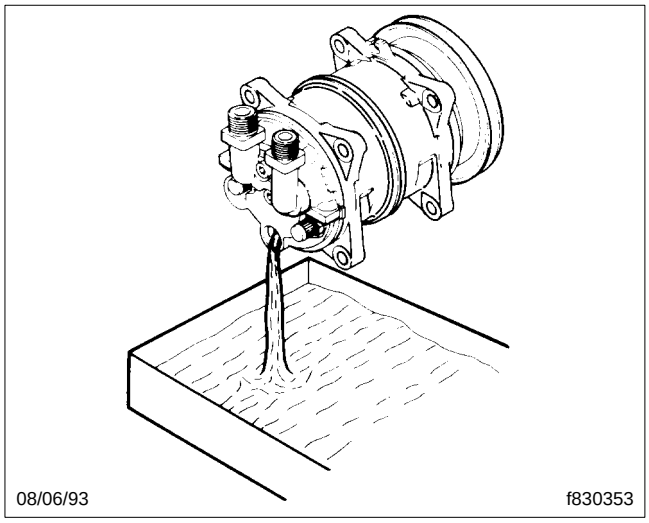


Fig. 1

NOTE: Unlike engine oil, compressor oil contains no added cleaning agent. Even after an entire season of use the oil should not become cloudy, as long as there is nothing wrong with the compressor or the way it is used.

7. If the oil is contaminated, flush all parts of the system and replace the receiver-dryer. For instructions, refer to the heater and air conditioner section in this group.

Oil Check and Adding Oil to the Compressor

8. Install the drain plug and a new O-ring lightly coated with clean compressor oil. Tighten the plug 1280 to 1460 N·cm (113 to 130 lbf·in).
9. Fill the compressor with oil through the suction-side hose fitting. **See Fig. 2. Refer to Table 1** for the charging amount.

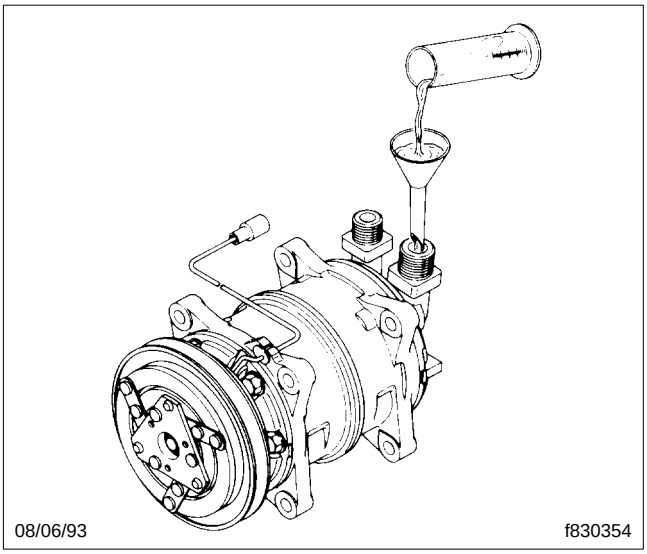


Fig. 2

Collected Amount	Charging Amount
More than 120 mL (4 fl oz)	Same as collected amount; do not exceed 264 mL (8.9 fl oz)
Less than 120 mL (4 fl oz)	120 mL (4 fl oz)

Table 1

10. If an oil return operation (above) could not be done, check the compressor oil as follows:
    - 10.1 Remove the damaged compressor from the vehicle.
    - 10.2 Remove the drain plug, and drain the oil.
    - 10.3 Using a measuring cylinder, measure the drained oil.
    - 10.4 Check the oil for contamination.
    - 10.5 Fill the new compressor with oil through the suction-side connector. Refer to the table above for the correct amount of oil.
    - 10.6 Install the new compressor on the vehicle.
    - 10.7 Perform the oil return operation.
    - 10.8 Remove the compressor and check the amount of oil again.
    - 10.9 Fill the compressor with oil again. **Refer to Table 1** for the correct amount of oil.

Magnetic Clutch Assembly Removal, Inspection, and Installation

Removal

See **Fig. 1**.

NOTE: The special tools available from independent suppliers may look different from those shown in the figures below, but they are functionally identical.

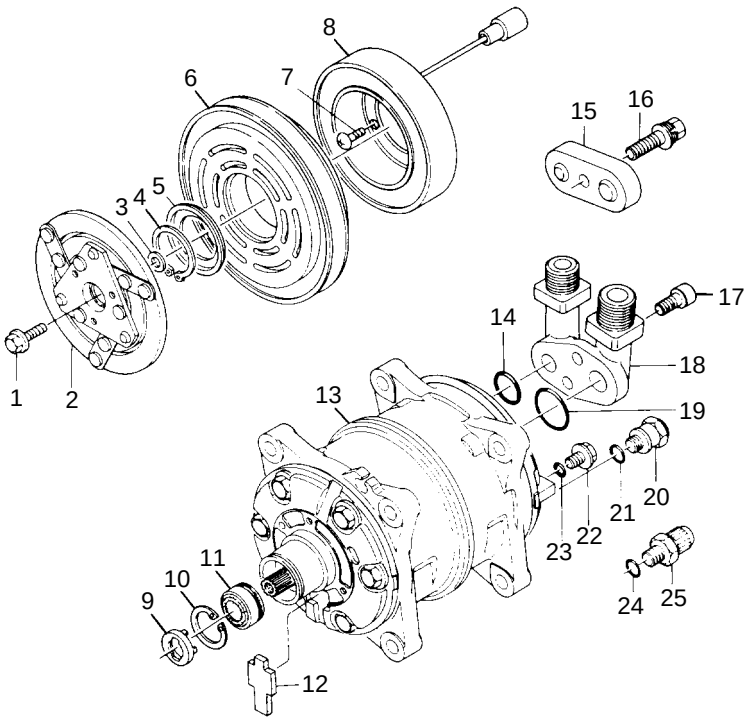
1. Remove the compressor from the vehicle. For instructions, **refer to "Compressor Removal and Installation, 140."**
2. Remove the center bolt using the drive plate holder [1]to prevent drive-plate rotation. **See Fig. 2.**
3. Using the drive-plate puller [1], remove the drive plate. **See Fig. 3.** Then, remove the shims from either the driveshaft or the drive plate.
4. Using external snap-ring pliers, remove the snap ring; then, remove the cover. **See Fig. 4.**
5. Using the pulley puller and the spacer [1] positioned on the cylinder head hub, remove the pulley assembly. **See Fig. 5.**

NOTE: To avoid damaging the pulley groove, the puller claws should be hooked into (not under) the pulley groove.

6. Remove the coil's lead wire from the wire holder on the compressor; then, remove the three screws and the coil. **See Fig. 6.**

CAUTION

CAUTION: Do not hold the coil by the lead wire. This could damage the coil.



1. Bolt
2. Drive Plate
3. Shim
4. Snap Ring
5. Cover
6. Pulley Assembly
7. Screw
8. Field Coil
9. Shaft Seal Cover
10. Snap Ring
11. Shaft Seal
12. Felt
13. Compressor Housing
14. O−Ring
15. Plate
16. Bolt
17. Bolt
18. Connector
19. O−Ring
20. Relief Valve
21. O−Ring
22. Drain Plug
23. O−Ring
24. O−Ring
25. Service Valve

Fig. 1

[1] **Refer to "Specifications, 400"** for suppliers of the special tools.

Magnetic Clutch Assembly Removal, Inspection, and Installation

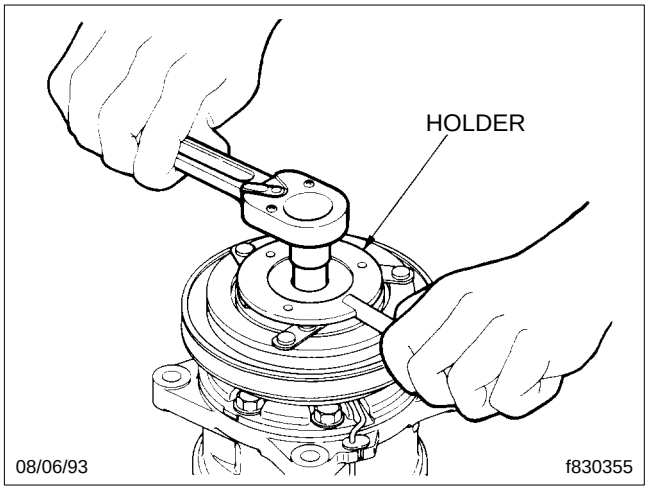


Fig. 2

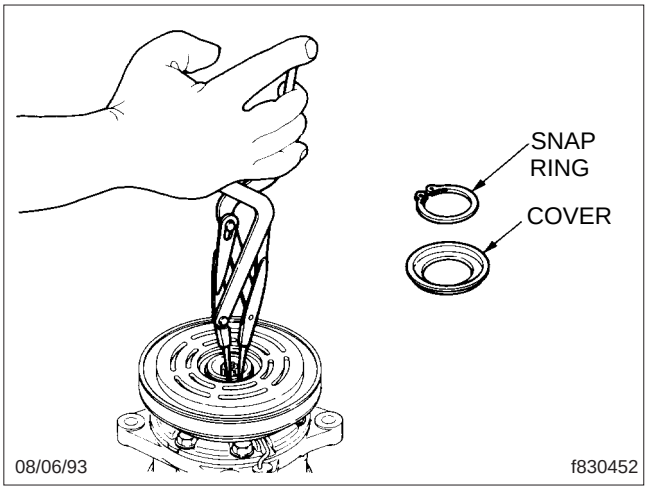


Fig. 4

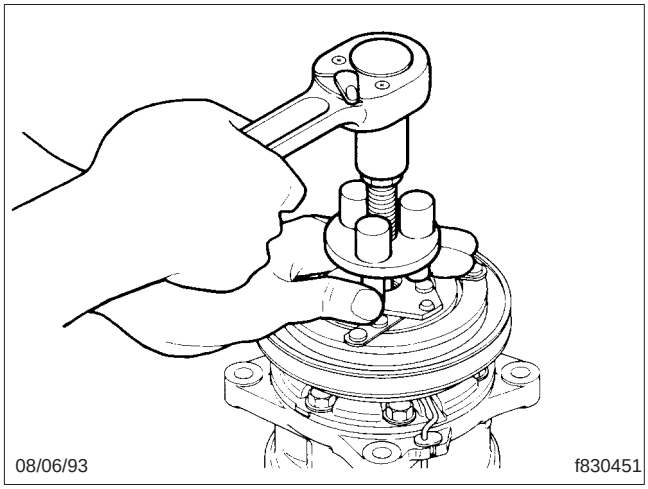


Fig. 3

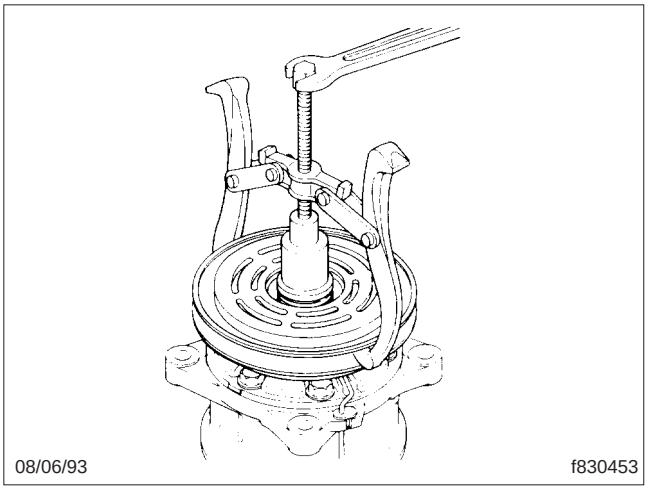


Fig. 5

Inspection (Refer to Fig. 7)

1. Inspect the drive plate. If the frictional surface shows signs of damage due to too much heat, replace the drive plate and pulley assembly.
2. Check the appearance of the pulley assembly. If the frictional surface of the pulley shows signs of too much grooving due to slippage, replace both the pulley and drive plate. Clean the frictional surfaces of the pulley assembly before installing it.
3. Check the coil for a loose connector and for cracked insulation. Replace it if necessary.

Installation

1. Make sure the felt is installed on the front cylinder head. **See Fig. 8.**
2. Install the coil on the compressor (lead wire on top).
3. Make sure the concave portion of the coil is aligned with the felt; then, tighten the mounting screws 400 to 580 N·cm (35 to 52 lbf·in). **See Fig. 8.**
4. Install the lead wire in the wire holder on the compressor.

Magnetic Clutch Assembly Removal, Inspection, and Installation

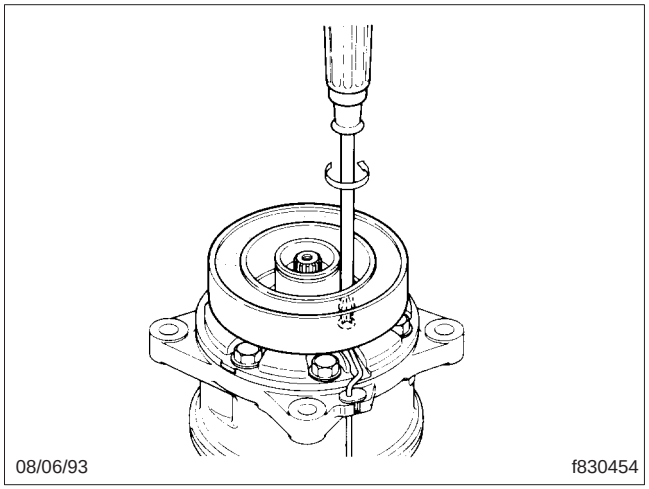


Fig. 6

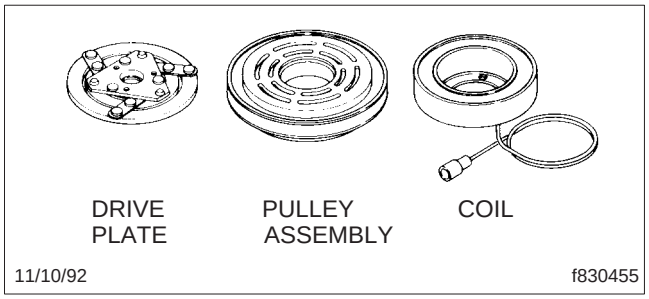


Fig. 7

5. Using the installation tool [1] and a hand press, install the pulley assembly. **See Fig. 9.** Install the bearing cover and the snap ring. **See Fig. 10.**

NOTE: The chamfered edge of the snap ring should face upward.

6. Install the drive plate on the compressor drive-shaft, together with the original shim(s). **See Fig. 11.** Press the drive plate down by hand.

7. Using the clutch holder [1] to prevent drive-plate rotation, tighten the bolt 1180 to 1360 N·cm (104 to 121 lbf·in).

NOTE: After tightening the bolt, check that the pulley turns smoothly.

8. Using a feeler gauge, check that the clutch clearance is 0.3 to 0.6 mm (0.01 to 0.02 inch). **See Fig. 12.** Adjust the clearance using shims, as necessary. Adjusting shims are available in the following thicknesses: 0.1 mm; 0.3 mm; 0.5 mm; 0.8 mm; and 2.2 mm.

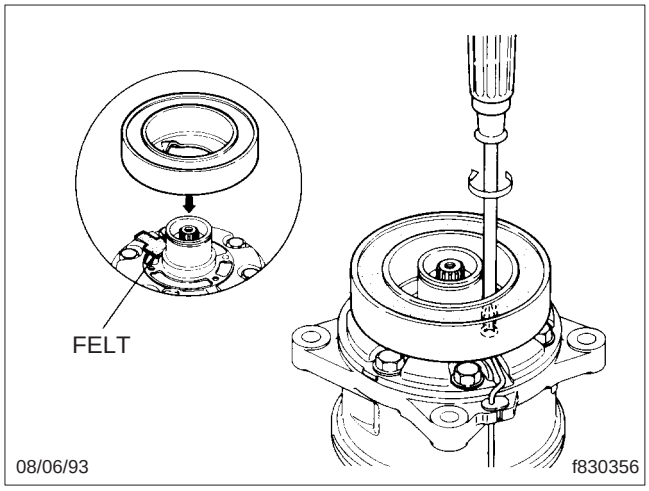


Fig. 8

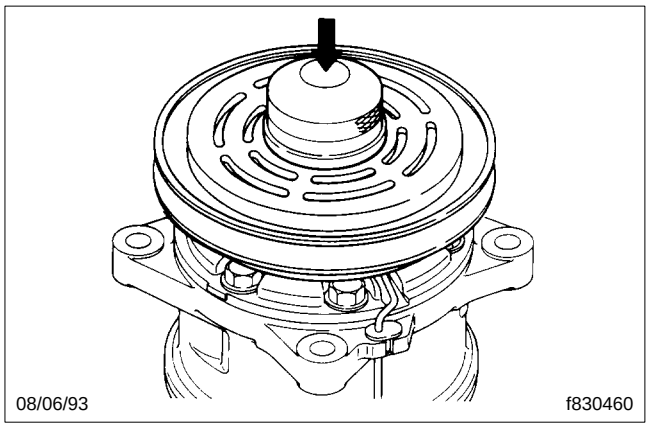


Fig. 9

9. Install the compressor on the vehicle. For instructions, **refer to "Compressor Removal and Installation, 140."**

10. Perform a running-in operation on the clutch. For instructions, **refer to "Running-In Operations, 180."**

Magnetic Clutch Assembly Removal, Inspection, and Installation

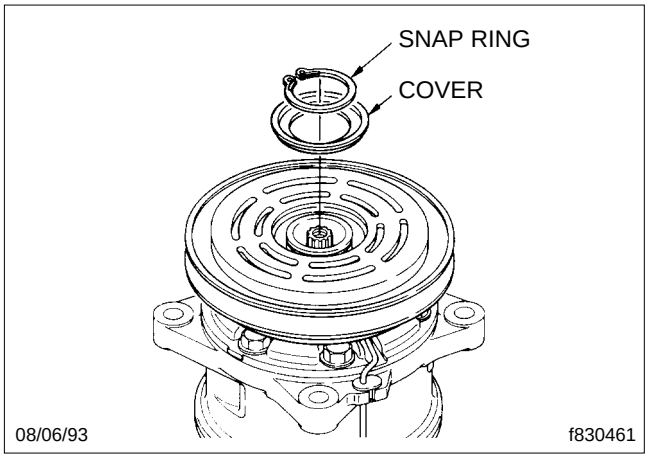


Fig. 10

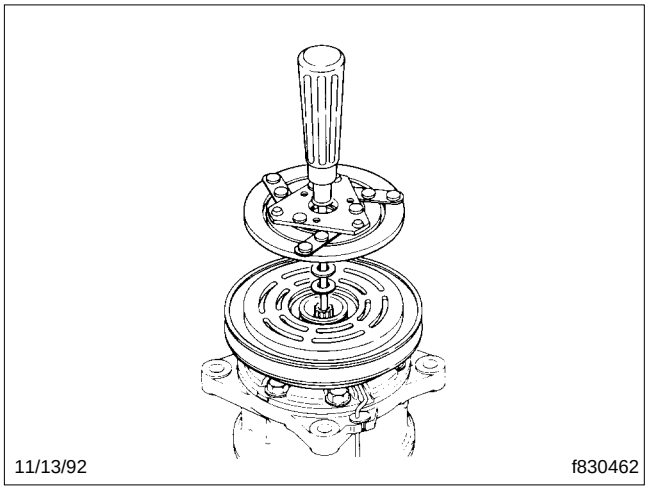


Fig. 11

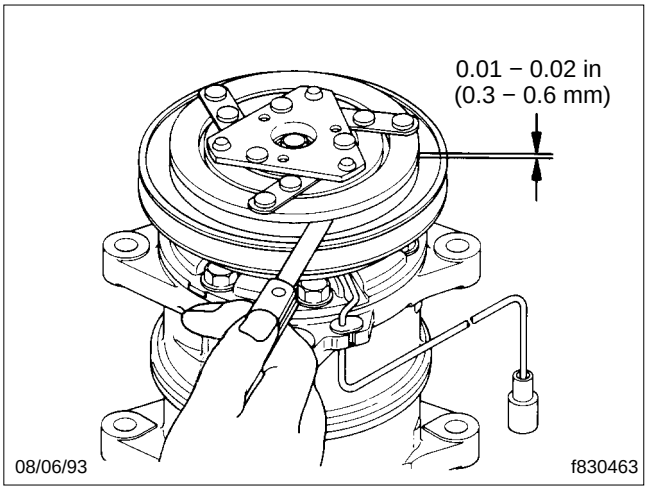


Fig. 12

Replacement

NOTE: The special tools available from independent suppliers may look different from those shown in the figures below, but they are functionally identical.

1. Remove the magnetic clutch assembly, as described in **"Magnetic Clutch Removal, Inspection, and Installation: Removal, 160."**
2. Remove the felt. **See Fig.1.**
3. Using the remover [1], remove the shaft seal cover by engaging the hook on the remover with the hook on the shaft seal cover and slowly drawing out the cover. **See Fig.1.** Discard the shaft seal cover.
4. Using internal snap-ring pliers, remove the snap ring. **See Fig.2.**
5. Using the remover [1], remove the shaft seal by engaging the hook on the remover with the hook on the shaft seal and slowly drawing out the shaft seal. **See Fig.3.**

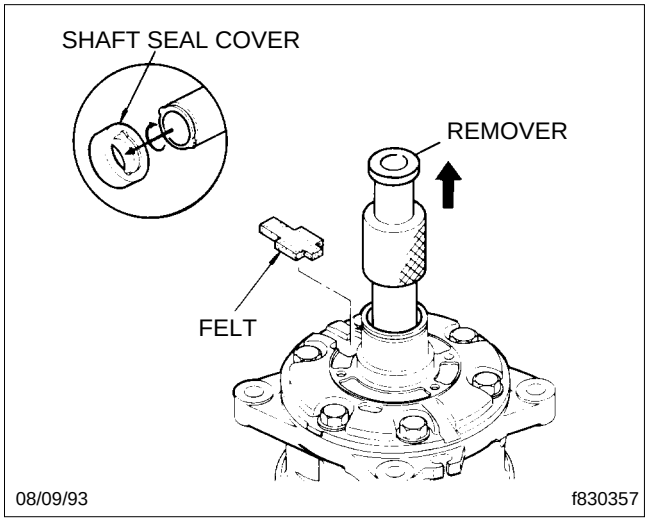


Fig. 1

NOTE: The shaft seal and shaft seal cover should not be re-used. Always use a new seal kit. Be very careful that the lip of the shaft seal to be installed is not scratched or damaged in any way. Make sure the shaft seal is free of lint and dirt, which could damage the shaft seal surface.

6. Clean the sealed section of the front cylinder head.
7. Apply clean compressor oil to the new shaft seal and to the front cylinder head. If the slip faces are dirty, clean them with thinner, dry them, and apply clean compressor oil to them.
8. Install the guide [1] onto the end of the driveshaft. **See Fig.4.**
9. Insert the shaft seal over the guide into the front cylinder head. **See Fig.5.**

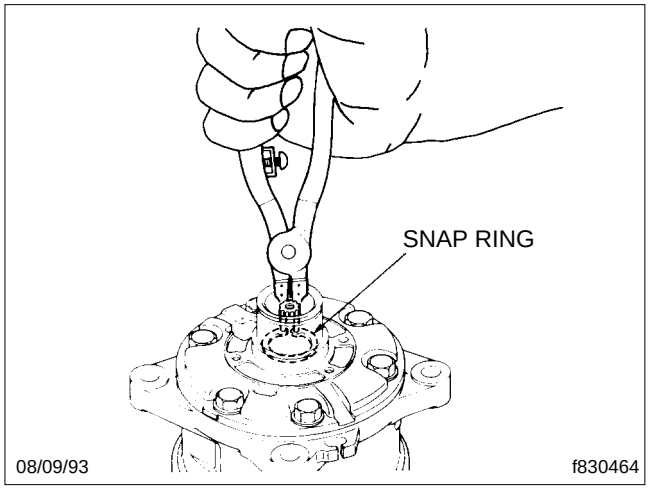


Fig. 2

10. Using the installing end of the remover [1], install the shaft seal as far as possible into the front cylinder head. **See Fig.6.** Remove the guide installed earlier from the driveshaft.
11. Using internal snap-ring pliers, install the snap ring. **See Fig.7.** Press the snap ring using the installing end of the remover [1] until a click is heard.

NOTE: When installing the snap ring, the round edge of the snap ring must face downward, **as shown in Fig.8.**

12. Fit the guide [1] onto the end of the driveshaft. **See Fig.9.** Using the installing end of the remover [1], install the shaft seal cover.

[1] **Refer to "Specifications, 400"** for suppliers of the special tools.

Shaft Seal Replacement

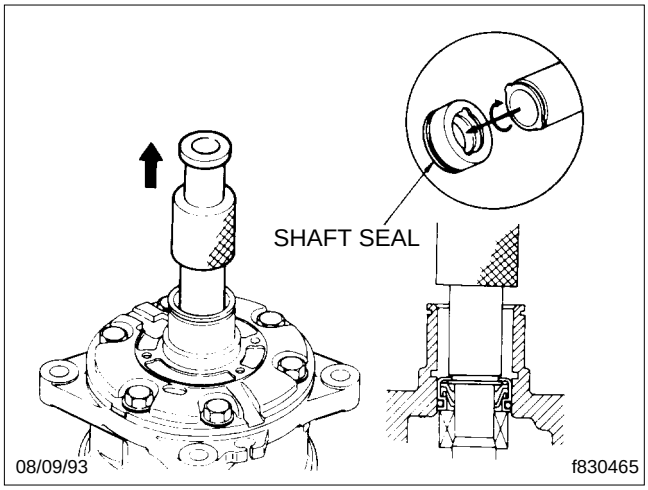


Fig. 3

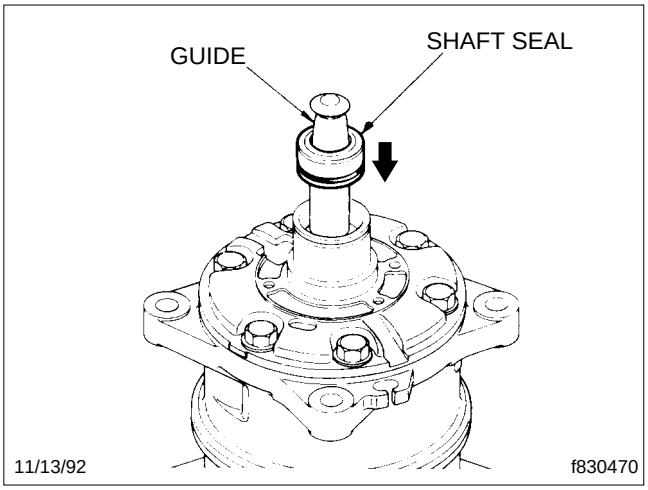


Fig. 5

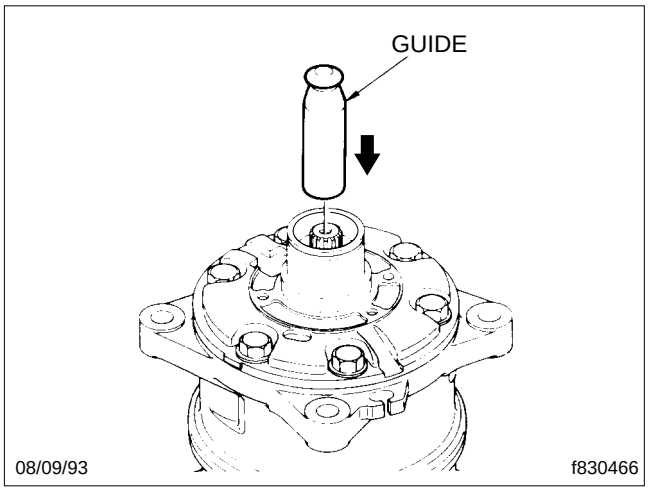


Fig. 4

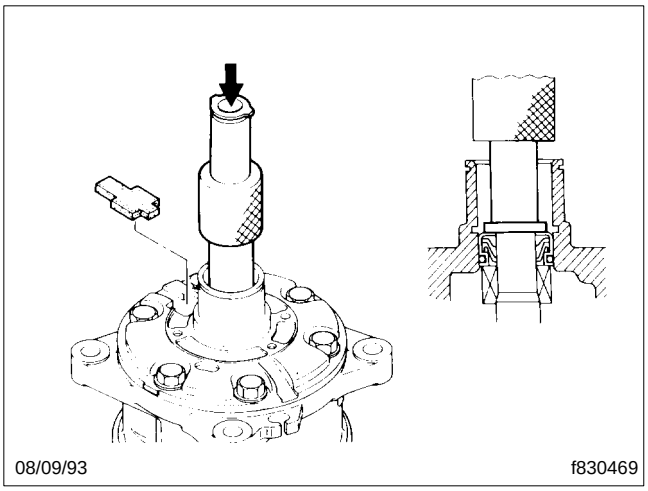


Fig. 6

NOTE: The installation position of the shaft seal cover is shown **in Fig.10.**

13. Install a new felt. **See Fig.10.**
14. Install the magnetic clutch assembly, as described in **"Magnetic Clutch Removal, Inspection, and Installation, 160."**

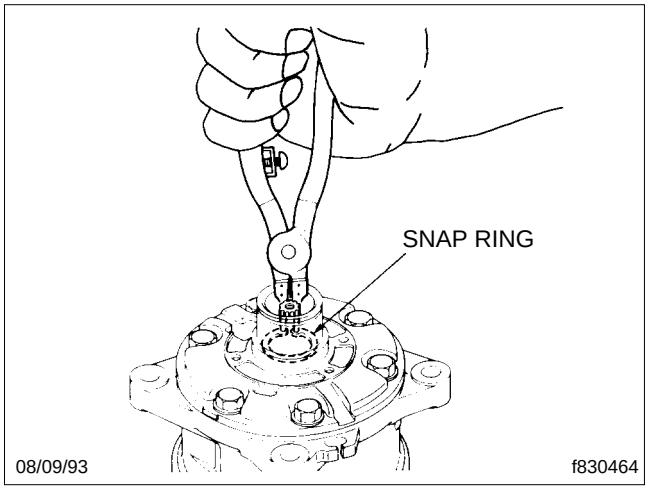


Fig. 7

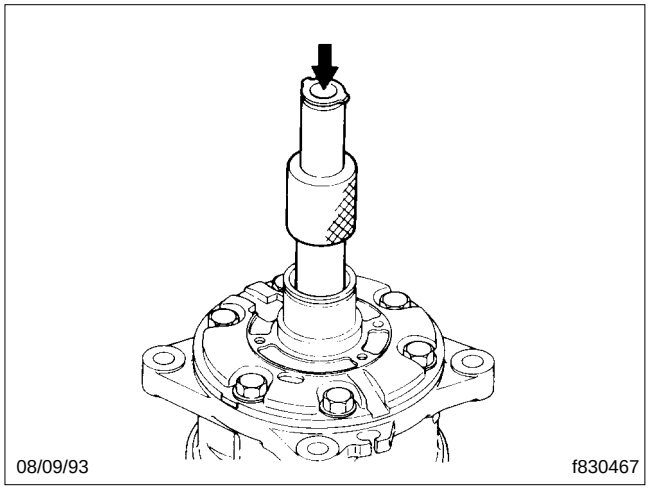


Fig. 9

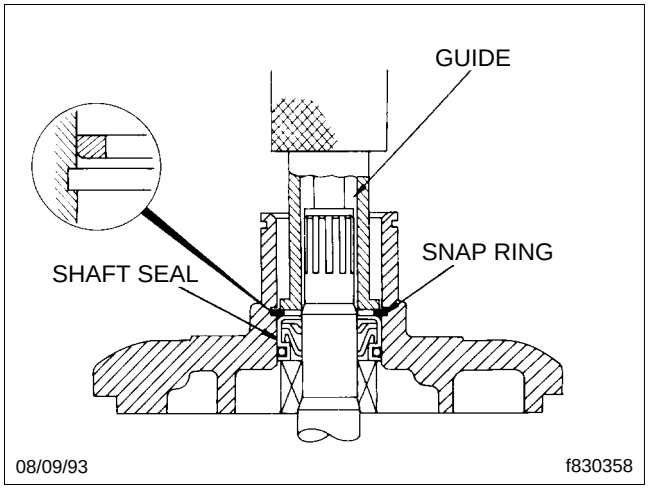


Fig. 8

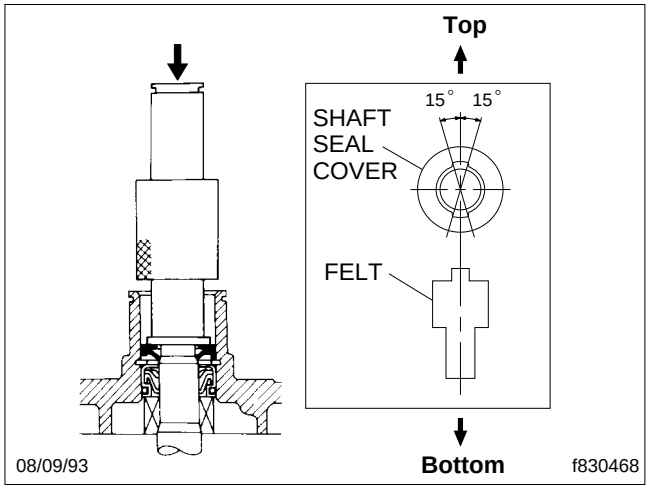


Fig. 10

Leak Test

Check the compressor for refrigerant leaks after it is repaired, as follows:

1. Install blanking caps in the suction and discharge fittings on the compressor.
2. Connect a manifold gauge set to the compressor's service ports. Close the discharge hand valve on the manifold. Fill refrigerant gas through the service port on the suction side fitting, raising the pressure to at least 482 kPa (70 psi).
3. Check the compressor for leakage using a leak detector.
4. Slowly release the refrigerant from the compressor. Remove the caps just before connecting the hoses to the compressor.

Magnetic Clutch Running-In

1. Install the compressor on the vehicle, and charge the system with refrigerant.
2. Turn on the engine and the air conditioner. Keep the compressor's speed at 500 rpm.
3. Operate the air conditioner switch on the climate control panel through the on and off cycle at least 50 times (on for 10 seconds; off for 10 seconds).

Storing a Repaired Compressor

Procedure

If it is necessary to store a repaired compressor for some time before installation, evacuate the compressor and fill refrigerant through the service port on the suction side fitting to raise the refrigerant pressure to 482 kPa (70 psi).

Special tools can be purchased from the following independent suppliers:

Classic Tool Design
31 Walnut St.
New Windsor, NY 12550
(914) 562-8700

Mastercool USA Inc.
216 Route 10, Bldg. 3
Randolph, NJ 07869
(201) 366-1101

Description	Torque	
	N·cm (lbf·in)	N·m (lbf·ft)
Adjusting Rod Jam Nut	—	190 (140)
Compressor Mounting Nuts	—	45 (33)
Compressor Clutch Coil Mounting Screws	400–580 (35–52)	—
Clutch Assembly Bolt	1180–1360 (104–121)	—
Oil Drain Plug	1280–1460 (113–130)	—

Table 1, Torque Values, DKS–15CH

Model	Refrigerant Oil
DKS–15CH	FREOL DS-83P

Table 2, Refrigerant Oil Specifications

Outside Temperature °C (°F)	Maximum Center Vent Temperature °C (°F)	Operating Suction Pressure (Low Side) kPa (psig)	Maximum Liquid Line Pressure (High Side) kPa (psig)
16 to 27 (60 to 80)	14 (58)	55–103 (8–15)	1138 (165)
27 to 32 (80 to 90)	16 (60)	83–124 (12–18)	1276 (185)
32 to 38 (90 to 100)	18 (64)	103–138 (15–20)	1413 (205)

Table 3, Temperature/Pressure Specifications

General Information

The main purpose of the refrigerant compressor is to draw refrigerant gas from the evaporator and squeeze it into high-pressure gas. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid so that it can be used for cooling again. A second purpose of the compressor is to move refrigerant through the air conditioner system.

The compressor is cycled by a thermostatic switch, which is located on the blower motor housing in the cab. When there is enough of a temperature drop in the cab, the switch breaks the circuit to the compressor's magnetic clutch. When the clutch is disengaged, its pulley is free-wheeling and the compressor shaft is not turning. When the clutch is engaged, it holds to the pulley, and the turning of the pulley causes the compressor shaft to turn.

The Climate Control compressor is a two-piston design. The pistons are driven by a crankshaft and connecting rods. Refer to the heater and air conditioner section in this group for other information.

Safety Precautions

CAUTION

CAUTION: Different refrigerant oils are used in compressors on R–12 and R–134a air conditioning systems. Always use the correct refrigerant oil and never mix oils. If the wrong oil is used, or if oils are mixed, the compressor could seize due to improper lubrication.

Refrigerant R–134a Air Conditioning Systems

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and non-leather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

WARNING

WARNING: Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure. However, it can be combustible at pressures as low as 139 kPa absolute (5.5 psig) at 177°C (350°F) when mixed with air concentrations that are greater than 60 percent.

WARNING

WARNING: R–134a air conditioning systems should not be pressure tested or leak tested with compressed air (R–134a may be safely pressured with dry nitrogen). Combustible mixtures of air and R–134a may form, resulting in a fire or explosion, which could cause personal injury or property damage.

You must work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R-134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 52°C (125°F).

On R–134a refrigerant systems, polyalkylene glycol (PAG) or polyol ester (POE) oil is used in the compressor. When handling these oils, observe the following:

- keep the oil free of contaminants
- do not expose the a/c system or the oil container to air for long periods of time; PAG and POE oils have a high moisture absorption capacity
- use care when handling: painted surfaces, plastic parts, and other components (drive belts) could be damaged if the oil is spilled on them
- never mix the oils with other types of refrigerant oil

Safety Precautions

Refrigerant R–12 Air Conditioning Systems

Whenever repairs are made to any air conditioner parts that hold refrigerant, you must discharge, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the air conditioning system has been discharged to a refrigerant recovery unit through the service valves on the compressor.

Refrigerants are safe when used under the right conditions. Always wear safety goggles and non-leather gloves while discharging, purging, flushing, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

⚠ WARNING

WARNING: Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should first be treated with a few drops of sterile mineral oil in the eyes, and then rinsed with a weak boric acid solution. Do not rub the eyes. Call a doctor right away.

Refrigerant splashed on the skin should be treated the same as for frostbite: gently pour cool water on the area, but do not rub the skin. Keep the skin warm with layers of soft, sterile cloth. Call a doctor right away.

Even though refrigerant does not burn, when it contacts extreme heat or flame, poisonous phosgene gas is created. This gas also is produced when an open flame leak detector is used. Phosgene fumes have an acrid (bitter) smell.

⚠ WARNING

WARNING: Do not work in an area where refrigerant may contact an open flame or any burning material, such as a cigarette. When it contacts extreme heat, refrigerant breaks down into poisonous phosgene gas which, if breathed, causes severe respiratory irritation. Do not breathe the fumes from an open flame leak detector.

You must work in an area where there is a constant flow of fresh air when the system is discharged, flushed, charged, and leak tested using an open flame leak detector.

Changes in both federal and state laws will affect the way dealerships service air-conditioning systems. Under current federal laws, refrigerant R–12 must be recovered and recycled by all users to protect the environment, and not released into the atmosphere. Many service operations not directly involving the air-conditioning system require the release of the refrigerant charge. Under the new regulations, dealerships not having the required recovery and recycling equipment (and properly trained and certified personnel) will not be allowed to do any of this service work.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant cans from exploding, never expose them to temperatures higher than 52°C (125°F). Never leave refrigerant cans in the sun, and do not store them in sun-exposed areas where heat can build up, such as in gloveboxes, automobile trunks, etc.

Pre-Service Checks

WARNING

WARNING: Before doing any work, read the information under Safety Precautions, 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

CAUTION

CAUTION: Determine if the air conditioning system is charged with refrigerant R–134a or R–12. Check the label on the radiator shroud (the side the compressor is on), the compressor identification tag, and the caution labels on system components, for verification. Service procedures are different for these refrigerant systems. Failure to properly identify the refrigerant system prior to servicing could cause component malfunction and system contamination.

Some special tools are needed for doing repair work on the compressor. Refer to **Specifications, 400.**

The checks below should be made whenever the air conditioning system is not cooling enough and the causes are unknown.

1. Be sure to check the moisture indicator, to see if moisture is the cause of the problems. The air conditioner should be on when checking the indicator; it is better to check it at the end of a day's run.
2. Check the drive belt and mounting as follows:
   - 2.1 On the drive belt, look for wear, damage, or oil. If worn, oil-soaked, or damaged, remove it and install a new one. Refer to **Group 01** in this manual for instructions.
   - 2.2 Check the compressor mounting parts for loose fasteners, cracks, or other damage. Tighten loose fasteners to the following torque values:
     - Compressor Mounting bolt, 3/8–16: 47 N·m (35 lbf·ft)
     - Compressor mounting bracket pivot bolt, 1/2–13: 81 N·m (60 lbf·ft)
   - 2.3 Repair or replace cracked or damaged brackets.
   - 2.4 Check the tension of the compressor drive belt. Refer to **Group 01** in this manual for instructions.
3. Check the wiring and connections to the compressor clutch. Replace damaged wiring and tighten loose connections.
4. Check for road debris build-up on the condenser coil fins. Using air pressure and a whiskbroom or a solution of soap and water, carefully clean the condenser; be careful not to bend the fins.
5. Check the refrigerant charge in the air conditioning system; for instructions, refer to the applicable heater and air conditioner section in this group.
6. Check the suction pressure and discharge pressure of the refrigerant compressor; refer to **Subject 120.**

NOTE: For other possible causes of air conditioner problems, refer to the applicable heater and air conditioner section in this group.

Compressor Suction and Discharge Pressure Checking

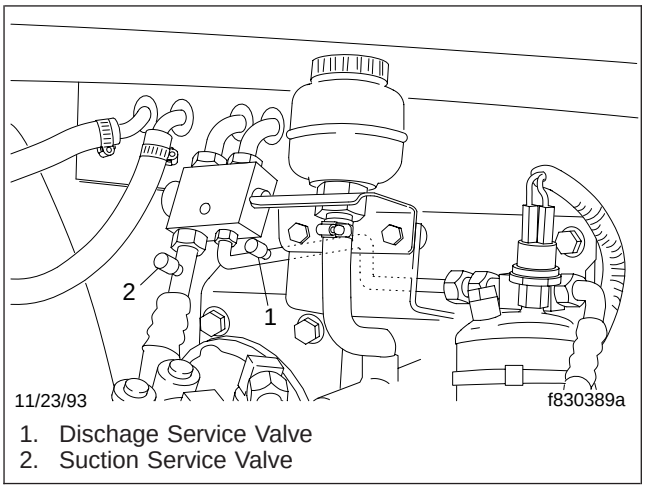
Checking

WARNING

WARNING: Before doing any of the work below, read the information under Safety Precautions, 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

1. Attach a manifold gauge set to the service ports. Make sure that the manifold gauge set is equipped with a valve core depressor.

   1.1 Remove the protector caps from the service valve ports on the compressor (R–12 systems), or at the firewall (R–134a systems). **See Fig. 1.**



1. Dischage Service Valve
2. Suction Service Valve

Fig. 1, Service Port Locations, R–134a System

   1.2 Make sure that the valves on the recovery and recycling station are closed. Cap the manifold center hose.

   1.3 Connect the red high-side hose to the discharge service valve, and the blue low-side hose to the suction service valve.

2. Start the engine and set it to run at 1500 rpm.

3. Turn on the heater-air conditioner blower, and set the air conditioner controls to the coldest setting, so that the compressor is operating. If the outside temperature is cooler than 70°F (21°C), *partially* block the air to the condenser.

4. Look at the manifold suction and discharge pressure gauges. The pressure on the gauges should be within the range in **Table 1** or **Table 2.**

   4.1 If the suction and discharge pressures are both too high, there is air in the refrigerant, or too much refrigerant in the system; check the charge; for instructions, refer to the applicable heater and air conditioner section in this group.

   4.2 If the suction pressure is too high and the discharge pressure is normal, check the wiring to the thermostatic switch on the blower motor housing; repair or replace the wiring, as needed. If the wiring is correct and there is power to the switch, check that the probe of the thermostatic switch is correctly installed in the evaporator coil. Refer to the applicable heater and air conditioner section in this group for instructions. If everything checks out okay, but the problem persists, replace the thermostatic switch at the climate control panel.

   4.3 If the suction pressure is too low and the discharge pressure is normal or too low, check for passage of air through the evaporator coils. If airflow is blocked, remove the blockage. If airflow is satisfactory, check for blockages in the line to the suction side of the compressor.

5. If the suction pressure is normal and the discharge pressure is too high, airflow through the condenser may not be enough to carry away the heat.

   5.1 Place a large fan in front of the radiator, so that the airflow goes through the condenser. After two minutes of operating the air conditioner and the fan at the same time, look at the manifold pressure gauges again. (One other procedure is to direct a spray of water onto the condenser while the system is running.)

   5.2 If the discharge pressure is still too high, the lines between the compressor and the receiver-drier are blocked, or the condenser is blocked internally. Discharge, flush, evacuate, charge, and leak test the system. If the blockage can't be removed by flushing, replace the blocked line or

Compressor Suction and Discharge Pressure Checking

blocked condenser. After flushing and before placing a vacuum in the system, *be sure to add the correct amount of refrigerant oil to the compressor.* For instructions, refer to **Subject 140.**

6. If the suction pressure is normal or too high and the discharge pressure is too low, check for a slipping clutch or wrong-sized clutch pulley or accessory drive pulley. Replace parts as needed.

   If the suction pressure is still normal or too high and the discharge pressure is still too low, the compressor is the problem. Repair or replace the compressor.

Outside Temperature °C (°F)	Maximum Center Vent Temperature °C (°F)	Low Pressure (suction) kPa (psi)	High Pressure (discharge) kPa (psi)
16 to 27 (60 to 80)	14 (58)	41–103 (6–15)	1138 (165)
27 to 32 (80 to 90)	16 (60)	69–124 (10–18)	1276 (185)
32 to 38 (90 to 100)	18 (64)	83–138 (12–20)	1413 (205)

Table 1, Temperature/Pressure Specifications, R–12 Systems

Relative Humidity	Outside Temperature °C (°F)	Maximum Center Vent Temperature °C (°F)	Low Pressure (suction) kPa (psi)	High Pressure (discharge) kPa (psi)
Low (40%)	24 (75)	4 (39)	97 (14)	965 (140)
	29 (85)	4 (39)	103 (15)	1145 (166)
	38 (100)	5 (40)	110 (16)	1503 (218)
High (90%)	24 (75)	3 (38)	97 (14)	896 (130)
	29 (85)	4 (39)	110 (16)	1103 (160)
	38 (100)	5 (40)	124 (18)	1517 (220)

Table 2, Temperature/Pressure Specifications, R–134a Systems

Removal

1. Recover the refrigerant from the air conditioning system; for instructions, refer to the applicable heater and air conditioner section in this group.
2. Disconnect the suction and discharge hose fittings at the compressor. **See Fig.1.**

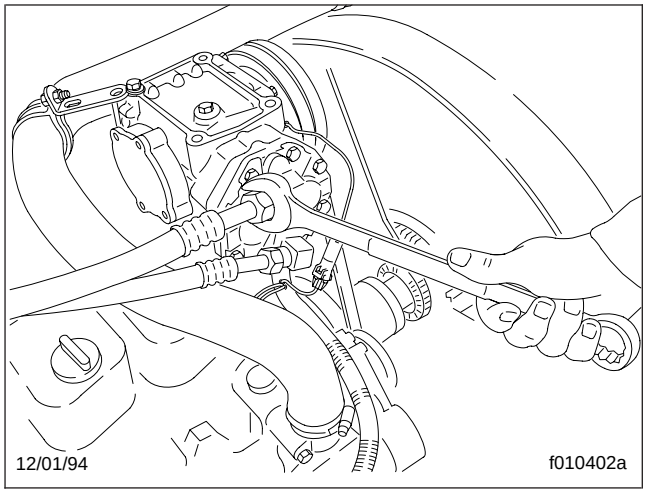


Fig. 1, Disconnect the Suction and Discharge Hose Fittings

3. Plug the hoses to prevent contamination.
4. Disconnect the compressor magnetic clutch electrical connection. **See Fig.2.**

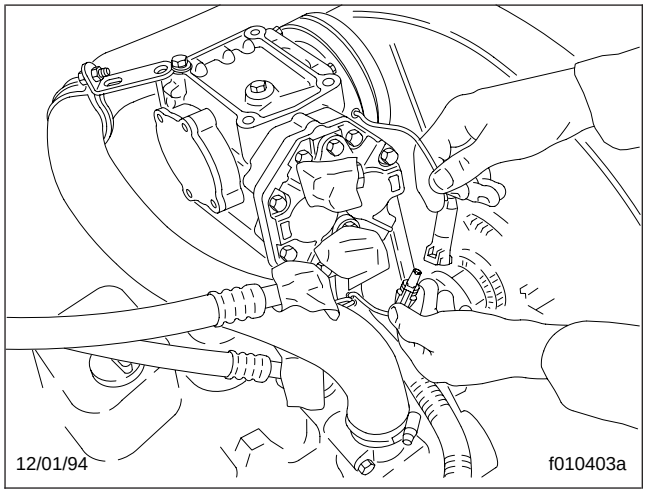
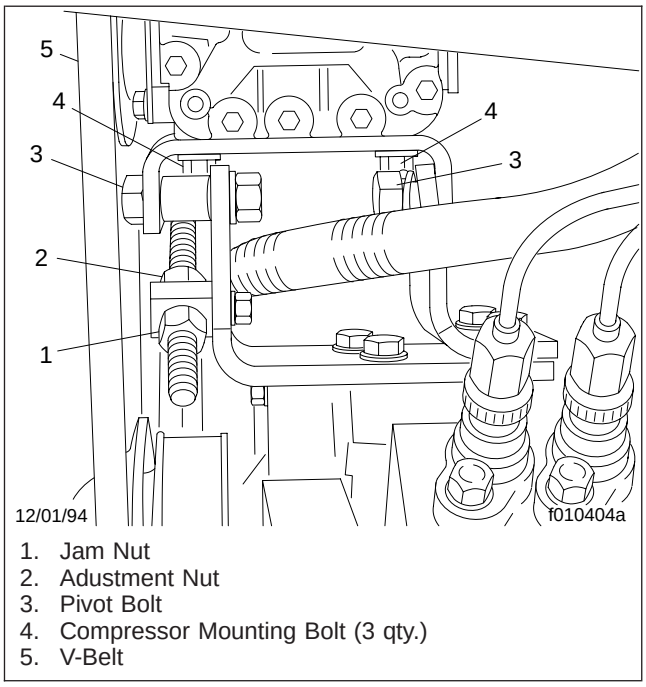


Fig. 2, Disconnect the Electrical Connection

5. Remove the V-belt. **See Fig.3,Fig. 4,or Fig.5.**



1. Jam Nut
2. Adustment Nut
3. Pivot Bolt
4. Compressor Mounting Bolt (3 qty.)
5. V-Belt

Fig. 3, Compressor Mounting on Cummins B Series Engines (earlier installations)

5.1 Loosen the compressor pivot bolts (Ref. 3).

5.2 Loosen the adjusting rod jam nut (Ref. 1), then back off the adjustment nut (Ref. 2) until the belt can be removed.

5.3 Remove the belt. Don't pry or roll it off the pulleys.

6. Remove the compressor.

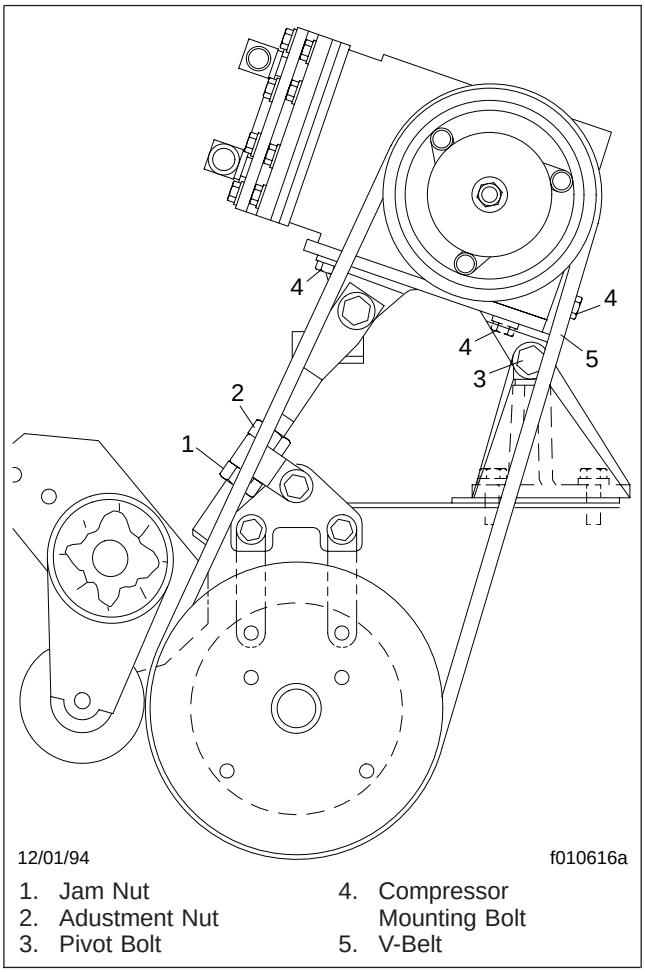
6.1 Pivot the compressor mounting bracket for access to the three compressor mounting bolts (**Fig.3**, Ref. 4).

6.2 Remove the three compressor mounting bolts (Ref. 4).

On Cummins C Series engines, remove the bolt (**Fig.5**, Ref. 6) that attaches the adjusting rod to the compressor support bracket (Ref. 7).

6.3 Remove the compressor.

Compressor Removal and Installation



1. Jam Nut
2. Adustment Nut
3. Pivot Bolt
4. Compressor Mounting Bolt
5. V-Belt

Fig. 4, Compressor Mounting on Cummins B Series Engines (current installations)

Installation

IMPORTANT: A new compressor is filled with refrigerant oil and nitrogen gas. When installing a new compressor on the vehicle, do all of the steps below; if installing a used compressor, position the compressor on the mounting bracket, and begin installation.

1. To prepare a new compressor for installation, gently release the nitrogen gas from the discharge side of the compressor; be careful not to let the oil flow out. Turn the compressor shaft several times by hand to distribute oil which has settled in the cylinder.
2. Position the compressor against the mounting bracket.
3. On Cummins B Series engines, install the mounting bolts and washers to hold the compressor in place. Tighten the nuts 47 N·m (35 lbf·ft).

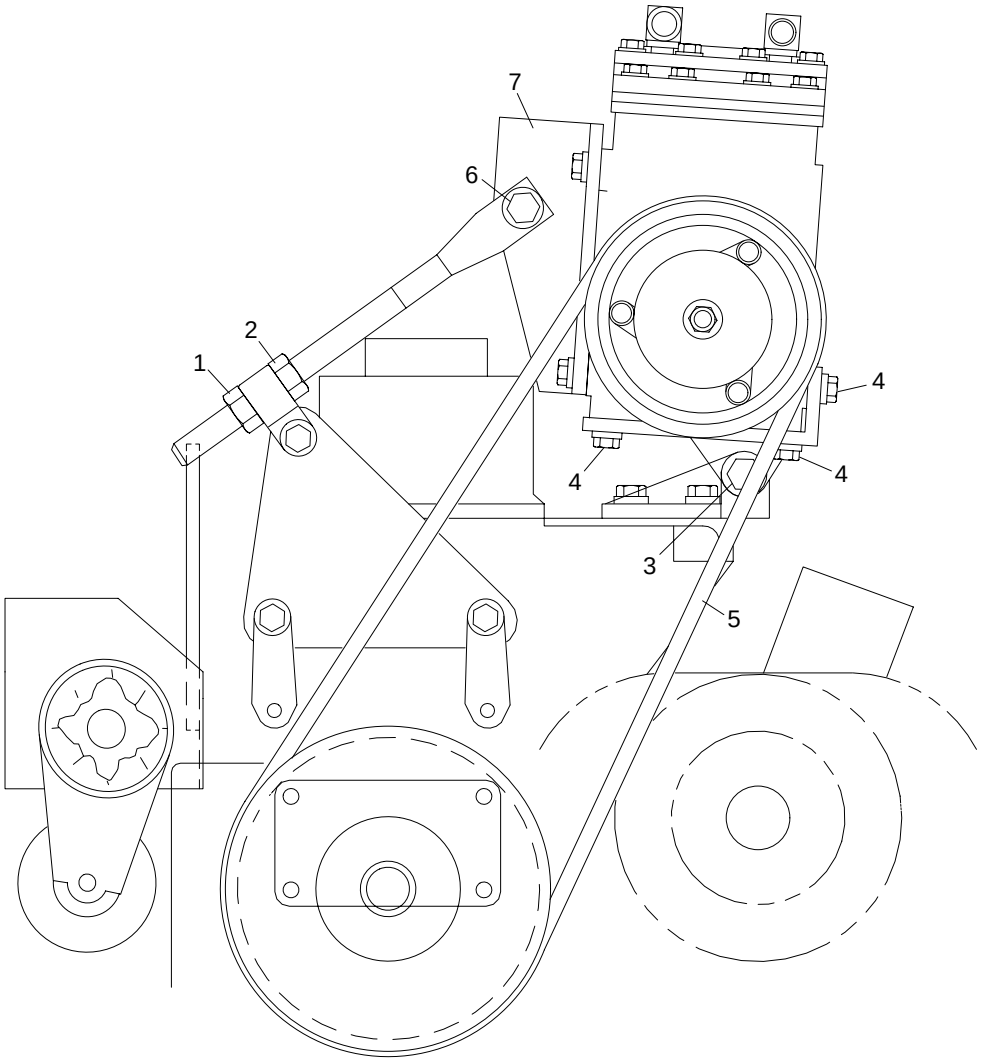
   On Cummins C Series engines, install the adjusting rod attachment bolt. Tighten the bolt 87 N·m (64 lbf·ft).
4. Install the V-belt.

   4.1 Position the V-belt over the pulleys.

   4.2 Adjust the V-belt tension by screwing the adjustment nut on the lower mounting strut in or out. Refer to **Group 01** in this manual for instructions.
5. Tighten the compressor pivot bolts 87 N·m (64 lbf·ft).
6. Uncap the discharge and suction ports. Unplug the suction and discharge hose connections. Check the hose connections and the surface of the discharge and suction ports. Surfaces must be clean and free of nicks, gasket residue, and other foreign matter.

IMPORTANT: Under no circumstances should you leave the compressor's ports uncapped for longer than five minutes total.

7. Connect the refrigerant hoses to the compressor. Tighten the fittings 45 N·m (33 lbf·ft).
8. Connect the electrical wire to the compressor magnetic clutch.
9. Replace the receiver-drier.
10. Check the oil in the compressor as specified in **Subject 140.**
11. Evacuate, charge, and leak test the refrigerant system. For instructions, refer to the applicable heater and air conditioner section in this manual.



1. Jam Nut
2. Adustment Nut
3. Pivot Bolt
4. Compressor Mounting Bolt
5. Fan Belt
6. Adjusting Rod Attaching Bolt
7. Compressor Support Bracket

Fig. 5, Compressor Mounting on Cummins C Series Engines

Oil Check and Adding Oil

⚠ CAUTION

Different refrigerant oils are used in compressors on R–12 and R–134a air conditioning systems. Always use the correct refrigerant oil and never mix oils. If the wrong oil is used, or if oils are mixed, the compressor could seize due to improper lubrication.

IMPORTANT: On R–12 air conditioning systems, new compressors are factory-charged with about 12.2 oz (360 mL) of refrigerant oil. On R–134a air conditioning systems, new compressors are factory-charged with about 14 oz (414 mL) of refrigerant oil. Some refrigerant oil is circulated through the system with the refrigerant, and cannot leave the system except through a leak, when the system is discharged or recovered, or when a system part is replaced.

Oil must be from a container that has not been opened, or that has been tightly sealed since its last use. Check the labelling on the compressor to determine the recommended refrigerant oil. Tubing, funnels, or other equipment used to transfer the oil should be very clean and dry.

When handling refrigerant oil:

- The oil should be free of water, dust, metal powder, and other foreign substances.
- Don't mix refrigerant oil with other types or viscosities of oil.
- Refrigerant oil absorbs moisture when exposed to the air for any period of time. After use, quickly seal the oil container.

IMPORTANT: Add the same amount of oil that is removed when the system is discharged or recovered, or when a system part is replaced. The two lists that follow provide approximate refill amounts for R–12 and R–134a air conditioning systems. Make sure you use the correct list.

The following is for R–12 air conditioning systems only:

A. Refrigerant charge—0.7 fl oz (20 mL): This amount of oil may be removed from the system each time the system loses its charge, due to routine discharging or due to a slow leak; no other parts of the system have been purged, flushed, or replaced.

IMPORTANT: The items below list oil quantities that include the amounts that are lost during discharging. Do not add an additional 0.7 fl oz (20 mL)—the amount described in the item above—to the quantities listed.

B. Receiver-drier—2.7 fl oz (80 mL);

IMPORTANT: A new receiver-drier may contain 3.4 fl oz (100 mL) of refrigerant oil, eliminating the need to add oil before installation. Confirm the oil level in a new receiver-drier; don't add any oil if it already contains 3.4 fl oz (100 mL).

C. Condenser—1.0 fl oz (30 mL);

D. Evaporator coil—0.7 fl oz (20 mL);

E. Entire system—15 fl oz (450 mL) with or without an auxiliary heater/air-conditioner. Add this amount of oil to the compressor if the entire system (including the compressor) has been discharged of refrigerant and oil, and all parts and hoses have been flushed.

The following is for R–134a air conditioning systems only:

A. Oil charge—the entire system should have *about* 14 fl oz (414 mL) of refrigerant oil. There should be 10 fl oz (296 mL) in the compressor. Each major component has *about* 2.0 fl oz (59 mL) of oil (this amount has been rounded off for ease of adding oil to the compressor). Therefore, additional oil must be added to the compressor when a major component is replaced.

NOTE: As an example, if the condenser and the receiver-drier are to be replaced, first check the oil level of the compressor. The compressor should have 10 fl oz (296 mL). Add oil if needed. Then, after replacing the condenser and the receiver-drier, add an additional 4.0 fl oz (118 mL) of oil to the compressor. The entire system should then have about 14 fl oz (414 mL).

IMPORTANT: Replacing only the amount of oil that is removed during evacuation may result in the wrong oil charge because the oil charge may have been incorrect prior to evacuation.

Oil Check and Adding Oil to the Compressor

The only way to ensure the proper oil charge is to check the oil level of the compressor with a dipstick.

B. Receiver-drier—when the receiver-drier is replaced, *about* 2.0 fl oz (59 mL) must be added to the compressor in addition to the 10 fl oz (296 mL) that the compressor requires).

IMPORTANT: A new receiver-drier does not contain any refrigerant oil.

C. Condenser—when the condenser is replaced, *about* 2.0 fl oz (59 mL) must be added to the compressor in addition to the 10 fl oz (296 mL) that the compressor requires.

D. Evaporator coil—when the evaporator coil is replaced, *about* 2.0 fl oz (59 mL) must be added to the compressor in addition to the 10 fl oz (296 mL) that the compressor requires.

IMPORTANT: Check the compressor oil level whenever the system has been opened.

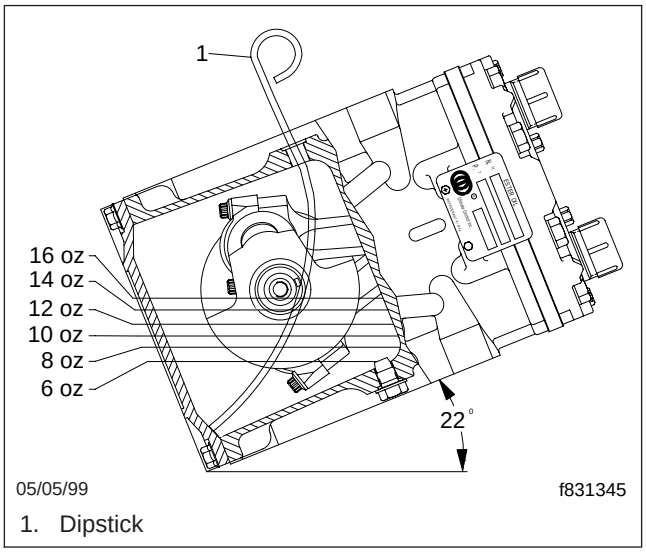
⚠ WARNING

Don't remove the oil fill plug without first recovering or discharging the system. Failure to recover or discharge the system could cause uncontrolled release of high-pressure refrigerant, which can freeze skin and eye tissue causing serious injury or blindness.

1. Remove the oil fill plug and O-ring.
2. Check the oil level with the dipstick. When the compressor is mounted vertically, use either plug; when mounted in any other orientation, use the upper plug. **Figure 1** shows the oil level with the refrigerant compressor mounted at 22 degrees. **Figure 2** shows the oil level with the refrigerant compressor mounted at 45 degrees.

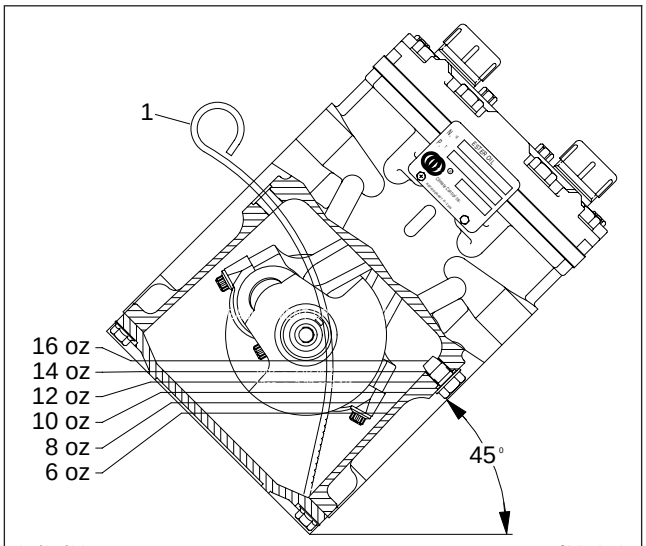
   If the dipstick bottoms out before going in more than 3 inches (75 mm), it is hitting the compressor crankshaft. Rotate the drive plate by hand and insert the dipstick again until it contacts the bottom of the sump. See **Table 1** to determine the oil quantity. Add or remove oil from the compressor so that the oil charge is 10 fl oz (296 mL).

NOTE: A dipstick can be made locally or purchased from a special tools supplier. Refer to the special tools table in **Specifications 400**. If made locally, it can be formed from 1/8-inch diameter by 8-5/16 inch long stock. See **Fig. 3**. Use a nonferrous material that is not subject to corrosion. Notching the end makes it easier to see the oil depth.



1. Dipstick

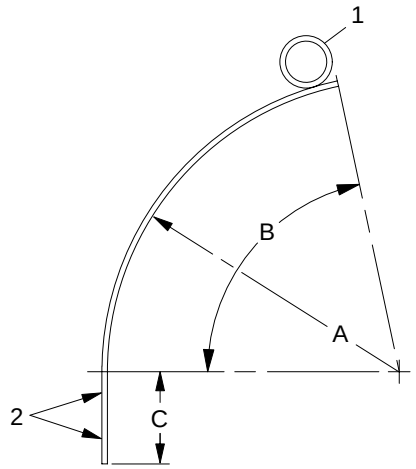
Fig. 1, Oil Level With Refrigerant Compressor Mounted at 22 Degrees



1. Dipstick

Fig. 2, Oil Level With Refrigerant Compressor Mounted at 45 Degrees

3. Being careful not to twist the O-ring, slip it over the oil fill plug threads. Insert the plug in the oil fill opening and tighten it until snug. If the plug leaks, don't attempt to stop the leak by overtightening. Leaks may be caused by dirt under the O-ring, dirt on the seat, a broken O-ring, or a damaged seat on the oil fill plug or opening. Correct the problem and install a new O-ring.



NOTE: Left-Hand Mounting: Check oil when shaft key is down. Right-Hand Mounting: Check oil when shaft key is up.

A. 4-3/4 Inches (121 mm) Radius
B. 78°
C. 1-1/2 Inches (38 mm)
1. Finger Ring
2. 12 Notches, 1/8 Inch (3.2 mm) Apart

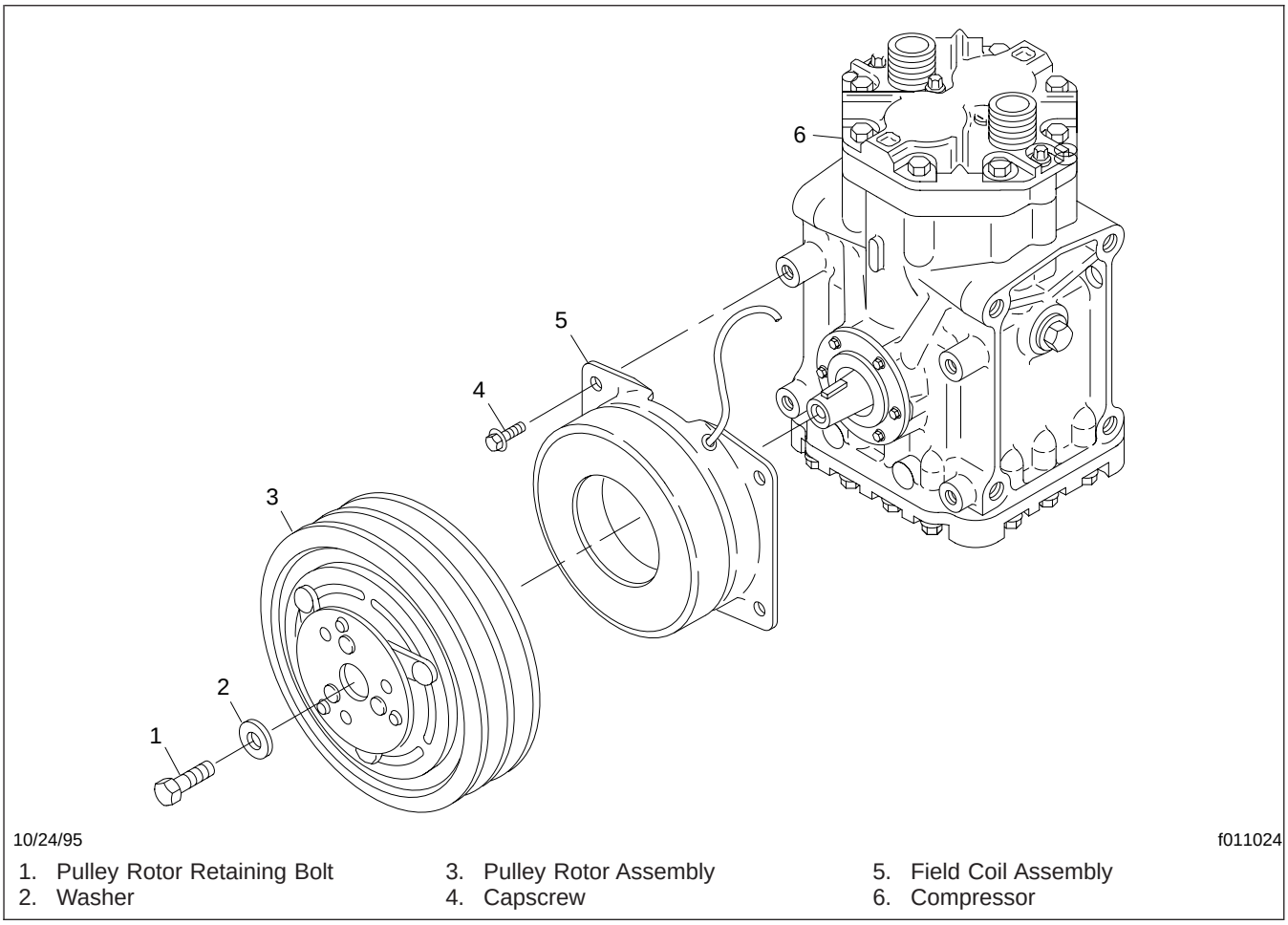
Fig. 3, Dipstick Specifications

Oil Quantity at Various Dipstick Depths				
Dipstick Depth				Oil Quantity fl oz (mL)
0-Degree Mount (horizontal) inches (mm)	22-Degree Mount inches (mm)	45-Degree Mount inches (mm)	90-Degree Mount (vertical) inches (mm)	
13/16 (20.6)	1-3/4 (44.5)	1-5/8 (41.3)	7/8 (22.2)	6 (177)
1 (25.4)	2-1/16 (52.4)	1-13/16 (46)	1 (25.4)	8 (237)
1-3/16 (30.2)	2-5/16 (58.7)	2 (50.8)	1-1/8 (28.6)	10 (296)
1-5/8 (41.3)	2-9/16 (65.1)	2-1/4 (57.2)	1-7/16 (36.5)	12 (355)
1-13/16 (46)	2-7/8 (73)	2-7/16 (61.9)	1-11/16 (43)	14 (414)
1-15/16 (49.2)	3-1/8 (79.4)	2-5/8 (66.7)	1-7/8 (47.6)	16 (473)

Table 1, Oil Quantity at Various Dipstick Depths

Magnetic Clutch Removal, Inspection, and Installation

Removal (See Fig. 1)



1. Pulley Rotor Retaining Bolt
2. Washer
3. Pulley Rotor Assembly
4. Capscrew
5. Field Coil Assembly
6. Compressor

Fig. 1, Pulley Rotor and Field Coil Assemblies

1. Remove the pulley rotor assembly.
   - 1.1 Remove the 5/16-inch pulley rotor retaining bolt from the center of the pulley rotor.
   - 1.2 Install a 5/8–11 capscrew in the hub of the pulley rotor assembly.
   - 1.3 Tighten the screw to pull the pulley rotor assembly off the compressor shaft.

⚠ CAUTION

CAUTION: Do not try to remove the pulley rotor assembly by prying or hammering. This can damage the assembly.

2. Remove the field coil assembly.
   - 2.1 Disconnect the field coil electrical lead wire.
   - 2.2 Remove the four 1/4–20 capscrews holding the field coil assembly to the compressor housing.

Inspection

1. Inspect the drive plate. If the friction surface shows signs of damage due to too much heat, replace the drive plate and pulley assembly.

Magnetic Clutch Removal, Inspection, and Installation

2. Check the pulley assembly. If the friction surface of the pulley shows signs of too much grooving due to slippage, replace both the pulley and drive plate. Clean the friction surfaces of the pulley assembly before installing it.
3. Check the coil for a loose connector and for cracked insulation. Replace it, if necessary.

Installation

1. Position the field coil assembly on the compressor housing with the four screw mounting holes aligned with the bosses on the housing.
2. Apply Loctite® 262 or 680 to the four 1/4–20 capscrews (on those threads that do not already have dry Loctite on them).
3. Install the capscrews and gradually tighten them to align the coil assembly. Final torque should be 20 N·m (15 lbf·ft).
4. Taking care to properly align and seat the shaft and hub keyways, attach the pulley rotor assembly to the compressor shaft.
5. Install the 5/16–24 center bolt and washer. Tighten the bolt about 27 N·m (20 lbf·ft).
6. Turn the pulley rotor assembly by hand to make sure it moves freely without interference with the field coil assembly.
7. Connect the lead wire from the field coil to the vehicle electrical circuit.
8. Engage and disengage the clutch several times to check for correct operation.

Replacement (See Fig. 1)

1. Remove the compressor from the vehicle. For instructions, see **Subject 130**.

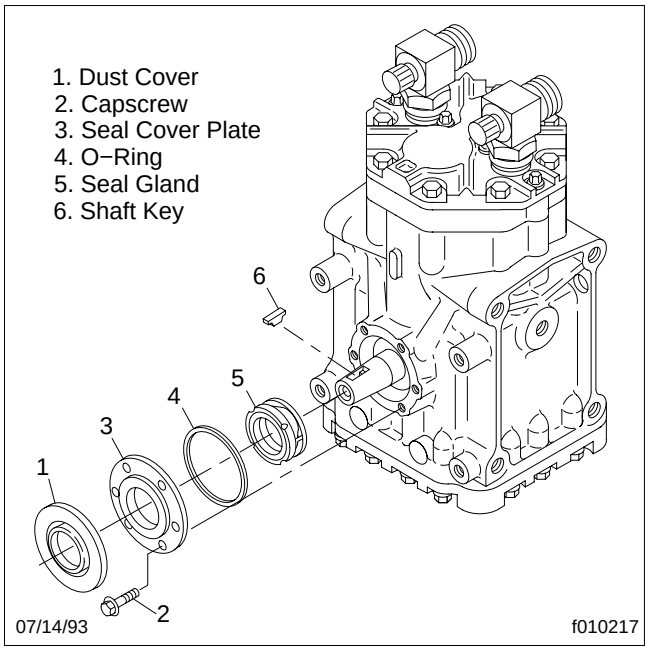


Fig. 1

2. Remove the clutch. For instructions, see **Subject 150**.
3. Remove the seal.
   - 3.1 Remove the dust cover if present.
   - 3.2 Remove the seal cover plate. Using the seal puller, pull out and discard the seal gland. Do not use a screwdriver to pry the seal gland from the compressor shaft; this could damage the shaft. Discard all seal parts including the O-ring.
4. Clean the shaft and seal cavity with a clean lint-free cloth.
5. Install the new seal.
   - 5.1 Dip the new seal gland assembly (**Fig. 1**, Ref. 5) in refrigerant oil.
   - 5.2 Remove the carbon ring from the seal gland assembly; then, push the assembly over the end of the shaft. Make sure the carbon ring retainer is facing out. Use the seal installer tool to move the seal gland assembly into position on the shaft.
   - 5.3 Place the carbon ring in the ring retainer so the lapped surface is facing out. The indentations in the outside edge of the carbon ring must engage the driving lugs and be firmly seated in the retainer.
   - 5.4 Coat a new O-ring with refrigerant oil so it will stick; then, install it in the seal cover plate groove.
   - 5.5 Install the seal cover plate so there is equal clearance around the shaft. Install the capscrews, and tighten them 60 to 84 lbf·in (680 to 940 N·cm) in the sequence shown in **Fig. 2**.
   - 5.6 Place the dust cover on the shaft before inserting the shaft key. As the clutch bolt is tightened, the dust cover will be drawn into the proper position.
6. Install the clutch. For instructions, see **Subject 150**.

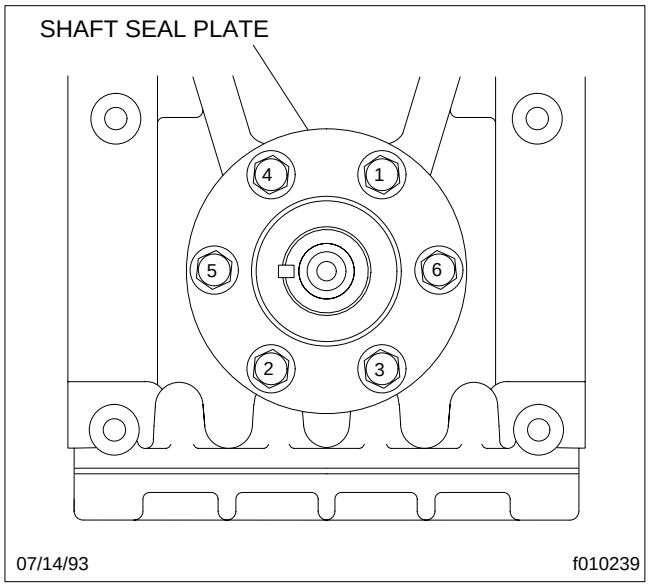
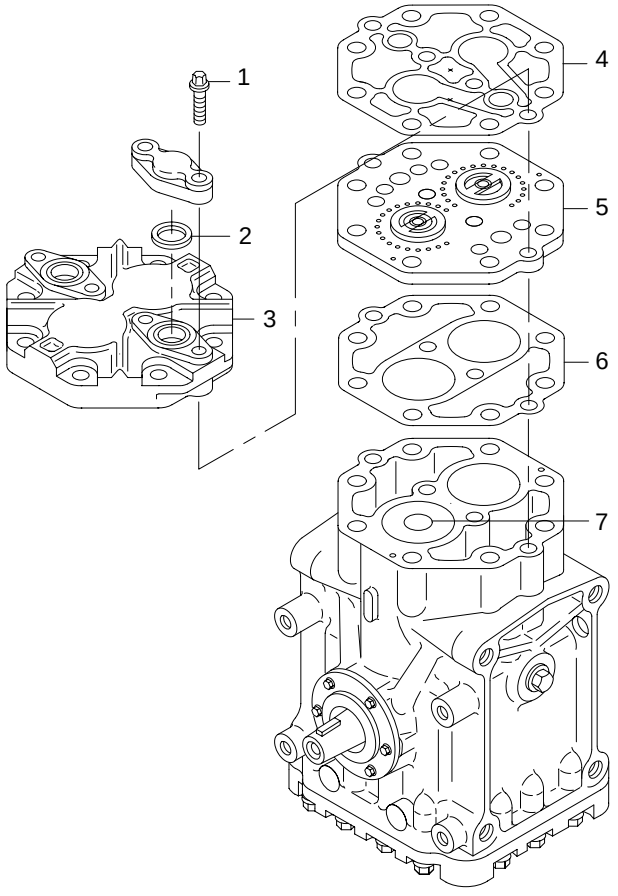


Fig. 2, Tightening Sequence

Removal (See Fig. 1)



1. Capscrew
2. O-Ring
3. Cylinder Head
4. Cylinder Head Gasket
5. Valve Plate
6. Cylinder Gasket
7. Piston

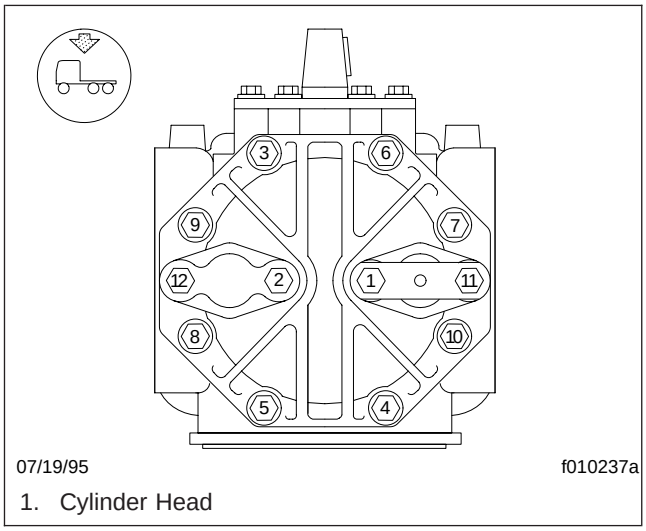
Fig. 1, Compressor Head and Valve Plate Assembly

NOTE: Before doing any work on the head and valve plate, open both service valves to release any gas pressure in the compressor. The cylinder head is made of aluminum; be careful when removing it not to damage the sealing surfaces.

1. Remove the screws from the service valves. **See Fig. 2**, Refs. 1, 2, 11, and 12.

   If equipped with flanged-type service valves, these four screws are longer than the remaining head screws.

   If equipped with Rotalock or Tube-O type valves, remove them by loosening the hexnuts which are part of the valve assembly.



1. Cylinder Head

Fig. 2, Cylinder Head Capscrew Tightening Sequence

2. Remove the remaining screws from the head.
3. Remove the valve plate and head from the cylinder by prying or tapping under the ears extending from the valve plate. If the head and valve plate adhere, hold the head and tap the valve plate ears away from the head with a soft hammer.

CAUTION

CAUTION: Do not hit or tap the head to separate it from the valve plate. Damage to the head may result.

4. Being careful not to scratch or nick the machined sealing surfaces, remove all gasket material adhering to the head, valve plate, or cylinder.

Installation

NOTE: Valves and valve plates are furnished only as a complete assembly.

Head and Valve Plate Removal and Installation

CAUTION

CAUTION: Different refrigerant oils are used in compressors on R–12 and R–134a air conditioning systems. Always use the correct refrigerant oil and never mix oils. If the wrong oil is used, or if oils are mixed, the compressor could seize due to improper lubrication.

1. Apply a thin film of clean refrigerant oil to the area of the crankcase to be covered by the cylinder gasket. Place the cylinder gasket in position on the cylinder so the dowel pins in the crankcase pass through the dowel pin holes in the cylinder gasket.
2. Apply a thin film of clean refrigerant oil to the top and bottom valve plate areas to be covered by gaskets. Place the valve plate in position on the cylinder gasket so the discharge valve assemblies are facing up and the locating dowel pins go through the dowel pin holes in the valve plate. The discharge valve assemblies are the smaller diameter ones with the restrainer over the valve reed.
3. Place the head gasket in position on the valve plate so the dowel pins go through the dowel pin holes in the gasket.
4. Apply a light film of clean refrigerant oil to the machined surface of the cylinder head which contacts the head gasket. Place the head on the cylinder head gasket so the dowel pins go into the dowel pin holes in the head.
5. Apply a thin film of clean refrigerant oil to the service valve flanges. Place a service valve gasket in position on the cylinder head service valve flanges. Place the service valves in position on the proper service valve ports (suction or discharge) and insert the four longer screws through the service valve mounting pads, the head, the valve plate, and into the crankcase.

   If equipped with Rotalock or Tube-O type valves, insert the longer screws on the inside of the service valve ports and the shorter screws on the outside.

   Insert the remaining head screws and tighten all the screws until the heads make contact.
6. Tighten the head and service valve screws 23 to 34 N·m (17 to 25 lbf·ft) in sequence. **See Fig. 2.**

Pistons, Connecting Rods, Crankshaft, and Bearing Removal and Installation

Piston and Connecting Rod Removal

The pistons and connecting rods are easily accessible after removing the head, valve plate assembly, and base plate. If the connecting rods will be reused, mark the rod, cap and crankshaft throw so the rod can be installed in exactly the same position on the crank pin.

Crankshaft and Bearing Removal

NOTE: When replacing the crankshaft, both the front (seal end) and rear main bearings should also be replaced since they may be damaged during removal.

1. Remove the four capscrews from the rear bearing cover plate.
2. Remove the cover plate by gently prying it loose from the crankcase, being careful that the housing is pulled parallel to the bearing surface.
3. Remove all components down to the crankcase, crankshaft, and seal end main bearing assembly.
4. Wash this assembly in an OSHA-approved solvent to remove all traces of oil and grease. Allow it to dry.
5. Heat the assembly in an oven set to 150°C (300°F).

CAUTION

CAUTION: Heat the complete assembly evenly in an oven. Localized heating may crack the crankcase.

6. Remove the crankshaft and ball bearing assembly from the crankcase.
7. If the crankshaft is reusable, remove the ball bearing assembly. Hold the crankshaft vertically in a vise with the flywheel end up, gripping the shaft at the unmachined center throw. Using two large screwdrivers as a pry under the bearing race, force the bearing upward and remove it from the shaft.

Crankshaft and Bearing Installation

1. Press the rear ball bearing onto the crankshaft by exerting pressure on the bearing inner race.
2. Make sure that the shaft, bearing, and recess in the crankcase are clean and free of burrs.
3. Heat the crankcase in an oven set to 150°C (300°F).

CAUTION

CAUTION: Heat the complete assembly evenly in an oven. Localized heating may crack the crankcase.

4. Using the opening in the bottom of the crankcase as a point of entry, place the seal end bearing in the recess. If necessary, apply force to the outer race to be sure that it is seated in the bottom of the recess.
5. Allow the crankcase to cool. Install the crankshaft through the rear bearing cover plate opening, and guide the flywheel end through the inner race of the ball bearing.
6. Place the crankcase so that it is completely supported on the ball bearing inner race. Then, press the shaft into place until the shaft boss contacts the inner bearing race.

CAUTION

CAUTION: If the housing is not completely supported by the inner bearing race, the bearing may be destroyed.

7. Install the rear bearing cover plate with the O-ring in the crankcase. A slight force may be required due to the small clearances between the outer race of the ball bearing and the bearing cover plate recess.
8. Install the four capscrews and tighten them 1220 to 2300 N·cm (108 to 204 lbf·in) in the sequence **shown in Fig. 1.**

Pistons, Connecting Rods, Crankshaft, and Bearing Removal and Installation

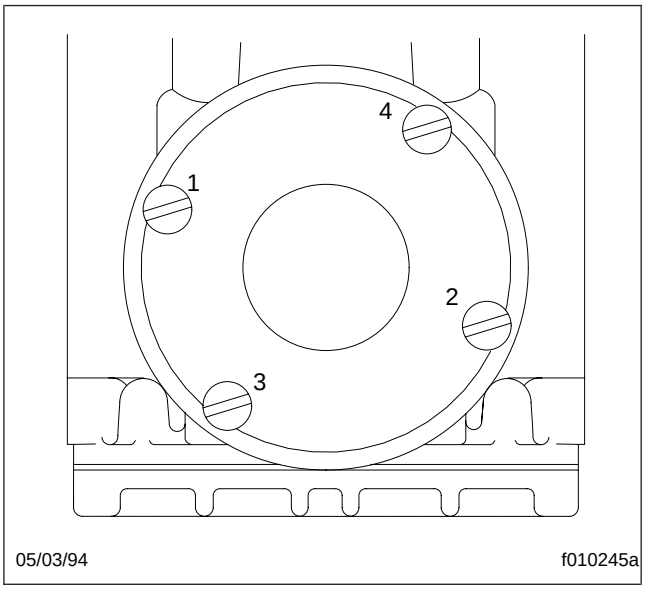


Fig. 1, Rear Bearing Cover Plate Capscrew Tightening Sequence

Piston and Connecting Rod Installation

CAUTION

CAUTION: Different refrigerant oils are used in compressors on R–12 and R–134a air conditioning systems. Always use the correct refrigerant oil and never mix oils. If the wrong oil is used, or if oils are mixed, the compressor could seize due to improper lubrication.

NOTE: When installing either the original or a new piston and connecting rod assembly, coat all bearing surfaces with clean oil of the same brand used in the crankcase.

When installing the assembly into the cylinder, the wrist pin roll pin must be positioned toward the center of the compressor. If positioned toward the outside, the roll pin may hit the crankshaft when the piston is at bottom dead center.

When installing a used connecting rod, match up the marks made during removal. When installing a new connecting rod, the dowel pins in the bearing cap must be positioned to enter the holes in the rod.

1. Install the piston and connecting rod assemblies.
2. Install the connecting rod capscrews and tighten them 16 to 22 N·m (12 to 16 lbf·ft).
3. Wipe all parts with a lint free cloth to make sure they are clean.
4. Install the base plate. Tighten the capscrews 16 to 24 N·m (12 to 18 lbf·ft) in sequence. **See Fig. 2.**

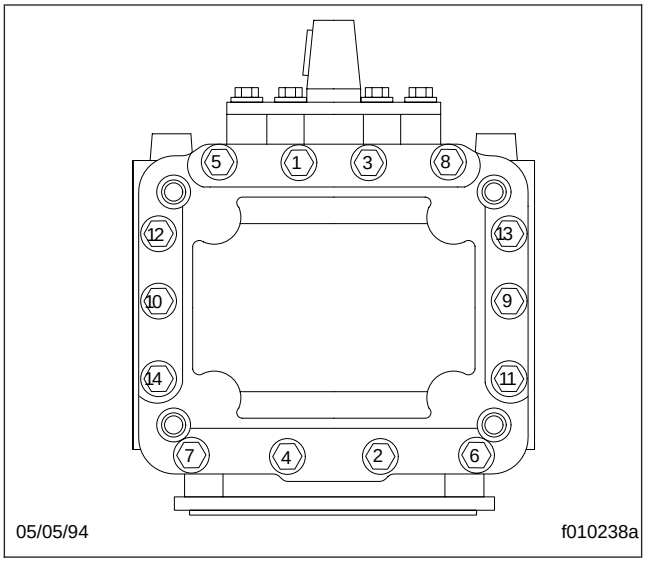


Fig. 2, Baseplate Capscrew Tightening Sequence

5. Install the head and valve plate assembly. For instructions, **Subject 170.**
6. Check the labelling on the compressor to determine the recommended refrigerant oil. Fill the crankcase with the recommended oil.
7. Close all openings to prevent the entrance of foreign material.

Specifications

Special tools can be ordered from your local tool supplier.

Torque Specifications				
Location	Thread	Head Type	Torque	
			lbf·ft (N·m)	lbf·in (N·cm)
Base Plate	1/4–20	Hex	10–16 (14–22)	—
Connecting Rod	1/4–20	12 point	12–16 (16–22)	—
Rear Bearing Cover Plate	1/4–20	Flat	10–16 (14–22)	—
Cylinder Head	5/16–18	Hex	17–25 (23–34)	—
Seal Plate	10–24	Hex	—	60–84 (680–940)
Flange Valve	5/16–18	Hex	17–25 (23–34)	—
Tube-O Valve	1–14	Hex	35–40 (47–54)	—
Rotalock Valve	1–14	Hex	35–40 (47–54)	—
Mounting Screw	3/8–16	Hex	35 (47)	—
Oil Fill Plug	3/8–24	Hex	—	60–120 (680–1360)
Clutch Bolt	5/16–24	Hex	20 (27)	—

Table 1, Torque Specifications

Temperature/Pressure Specifications, R-12 Systems			
Outside Temperature °F (°C)	Maximum Center Vent Temp. °F (°C)	Low Pressure (suction) psi (kPa)	High Pressure (discharge) psi (kPa)
60–80 (16–27)	58 (14)	6–15 (41–103)	165 (1138)
80–90 (27–32)	60 (16)	10–18 (69–124)	185 (1276)
90–100 (32–38)	64 (18)	12–20 (83–138)	205 (1413)

Table 2, Temperature/Pressure Specifications, R-12 Systems

Temperature/Pressure Specifications, R-134a Systems						
Ambient Air Temperature °F (°C)	Humidity		Dash Louver Temperature °F (°C) †	Service Port Pressures * †		A/C Compressor Cycling On?
	Target	Actual (Relative Humidity)		High (psi)	Low (psi)	
70 (21)	Low	25%	44 (6)	144	20.1	Yes
70 (21)	High	55%	45 (7)	146.6	21.6	Yes
80 (27)	Low	25%	46 (8)	164.4	20.1	Yes
80 (27)	High	55%	51 (11)	201.8	24.4	No
90 (32)	Low	25%	49 (9)	219.8	22.6	No
90 (32)	High	55%	60 (16)	242.1	31.5	No

Specifications

Temperature/Pressure Specifications, R-134a Systems						
Ambient Air Temperature °F (°C)	Humidity		Dash Louver Temperature °F (°C) †	Service Port Pressures * †		A/C Compressor Cycling On?
	Target	Actual (Relative Humidity)		High (psi)	Low (psi)	
100 (38)	Low	25%	57 (14)	261.3	29.5	No
100 (38)	High	55%	68 (20)	309.3	42.5	No

* Service port pressures recorded with A/C compressor running.

† Fresh air mode in use.

Table 3, Temperature/Pressure Specifications, R-134a Systems

Recommended Refrigerant Oils, R-12 Systems	
Manufacturer	Type
Texaco	Capella WF100
Suniso	No. 5
FREOL	DS83P

Table 4, Recommended Refrigerant Oils, R-12 Systems

Recommended Refrigerant Oils, R-134a Systems*		
Description	Part Number	Compressor Manufacture Date
Polyalkylene Glycol (PAG)	ABP N83 326055	Prior to May 5, 1995, and from July 2002
Polyol Ester (POE)	ABP N83 326008	May 5, 1995, through July 2002

* Look at the identification tag on the refrigerant compressor to determine the type of refrigerant oil that should be used in the air conditioning system. If the type of oil is not specified on the identification tag, use the compressor manufacture date to determine the type of oil to use.

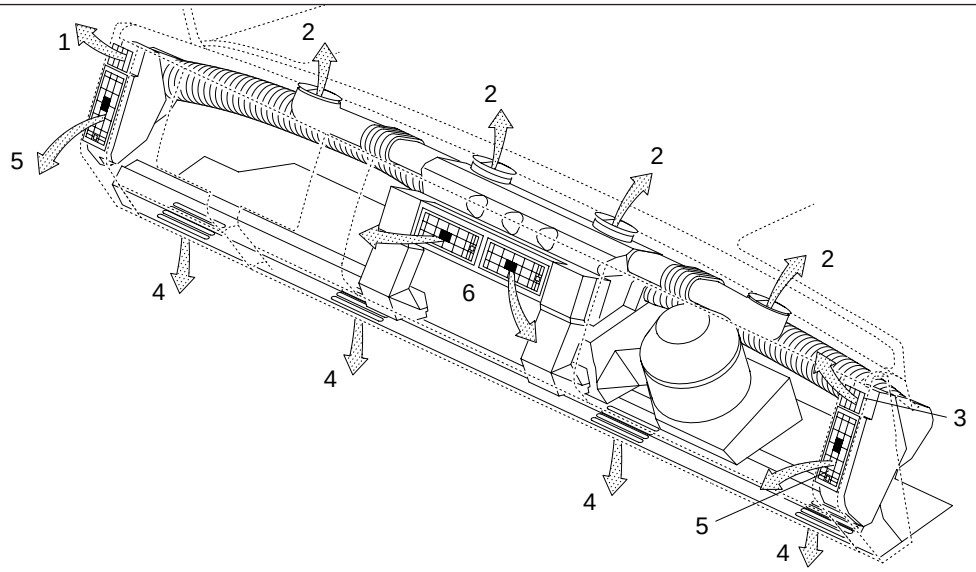
Table 5, Recommended Refrigerant Oils, R-134a Systems

Torque Specifications for Fittings on Reciprocating Refrigerant Compressors		
Outside Diameter of Metal Tube (inches)	Torque for Steel Tubes lbf·ft (N·m)	Torque for Aluminum or Copper Tubes lbf·in (N·cm) or lbf·ft (N·m)
1/4	10–15 (14–20)	60–80 lbf·in (680–900 N·cm)
3/8	30–35 (41–47)	11–13 lbf·ft (15–18 N·m)
1/2	30–35 (41–47)	15–20 lbf·ft (20–27 N·m)
5/8	30–35 (41–47)	21–27 lbf·ft (28–37 N·m)
3/4	30–35 (41–47)	28–33 lbf·ft (38–45 N·m)

Table 6, Torque Specifications for Fittings on Reciprocating Refrigerant Compressors

General Description

The heating, ventilation, and air conditioning (HVAC) unit uses a common blower motor and duct work to heat or cool the cab. Airflow rate is controlled by a three-speed blower switch. Air outlets are located in the instrument panel, along the bottom of the dash, at the windshield, and also at the side windows. See **Fig. 1**.



Left-hand drive shown; right-hand drive opposite

1. Driver's Door Window Defrost Outlet
2. Windshield Defrost Outlets
3. Passenger's Door Window Defrost Outlet
4. Floor Outlet
5. Dash/Door Window Vent
6. Center Dash Vents

Fig. 1, Air Outlet System

Both left-hand drive (LH DR) and right-hand drive (RH DR) vehicles use the same HVAC unit. On RH DR, components are moved to the opposite side of the cab. The blower motor, on the right-hand (passenger's) side on LH DR, moves to the left-hand (passenger's) side on RH DR.

When equipped with an air conditioner, temperature can be moderated by opening or closing a water regulating valve, which controls the flow of warm engine coolant to the heater core. The temperature of the air inside the cab partly depends on how much coolant is flowing through the heater core, and how much liquid refrigerant is in the evaporator coil.

The air conditioning system also includes a cycling-clutch refrigerant compressor, a condenser, an expansion valve, an evaporator coil, a fixed-temperature thermostatic switch, and mechanically operated controls.

Description of Components

Refrigerant

Refrigerant absorbs heat from the air in the cab and releases it to the air outside the cab.

In an open container, refrigerants boil at temperatures below the freezing point of water; sealing and pressurizing refrigerant in the air conditioning system raises its boiling-point temperature.

During compressor operation, refrigerant constantly changes from a liquid to a gas. It absorbs heat (boiling) in the low-pressure evaporator coils, and it changes from a gas to a liquid as it releases absorbed heat in the high-pressure condenser.

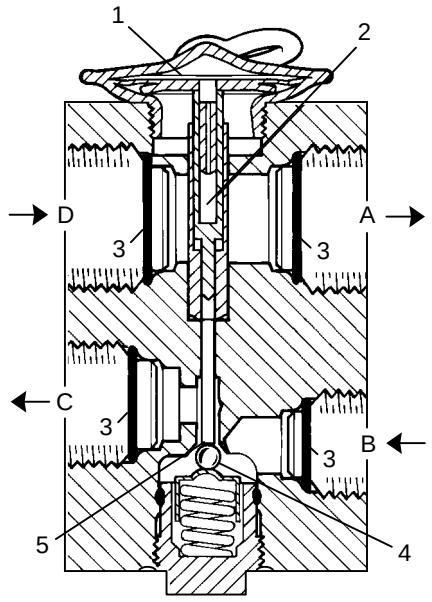
Expansion Valve

The expansion valve is a dividing point between the high- and low-pressure parts of the refrigerant system. High-pressure liquid refrigerant from the

General Information

receiver-drier passes through the expansion valve and moves into the low-pressure area of the evaporator coil.

An expansion valve controls the flow rate of refrigerant in proportion to the rate of evaporation in the evaporator. If the amount of liquid in the evaporator drops off, the temperature of the gas going to the compressor rises. This causes a diaphragm in the expansion valve to react, which causes an orifice in the valve to open or close. See **Fig. 2**. Through the orifice, liquid refrigerant is metered into the evaporator, as needed.



10/17/94 f830223

A. To compressor
B. From receiver-drier
C. To evaporator
D. From evaporator
1. Diaphragm
2. Temperature Sensor
3. O-Ring
4. Metering Orifice
5. Ball and Spring

Fig. 2, Expansion Valve

Evaporator Coil

Because the evaporator coil is an area of low pressure in the system, the boiling point of refrigerant lowers, which causes it to absorb heat from the tubing walls and fins of the coils. As it absorbs heat, liquid refrigerant quickly boils and turns into a gas.

As heat is absorbed from the outside surfaces of the evaporator coil, air passing over the unit loses its heat to these cooler surfaces. Moisture in the air condenses on the outside of the coil and drains off as water (the air becomes dehumidified).

Refrigerant Compressor

"Heat" in the low-pressure gas of the evaporator coils is not heat that can be noticed by touch, because liquid refrigerant boils at a temperature much lower than the temperature at which water turns to ice. By touch, the "heated" gas in the coils is very cold. As a result, there is the problem of how to remove heat from subfreezing gas using outside air that may be higher than 38°C (100°F).

With a refrigerant compressor, low-pressure gas from the evaporator can be squeezed into a much smaller space. When the gas is compressed, the heat it contains becomes concentrated. In this way, the gas is made hotter than the outside air, without adding heat.

Another function of the compressor is to move refrigerant through the system.

Condenser

A condenser turns hot refrigerant gas, coming from the compressor, into liquid. Mounted in front of the radiator, it is made up of a coiled tube and a series of fins. Because of its location, the condenser transfers heat to air that is drawn in by the engine fan and by air that is forced into the engine compartment as the vehicle moves forward (ram air).

Receiver-Drier

Used as a reservoir and filter for liquid refrigerant from the condenser, a receiver-drier also removes water and acids from the refrigerant. The water-absorbing material (desiccant) in the unit helps stop blockages from forming in the expansion valve and in other parts of the system.

A moisture indicator shows the amount of water in the refrigerant. A sight glass (aperture) on the unit contains a specially treated element (litmus paper) that changes color, depending on the amount of water in the refrigerant. The indicator changes from a deep cobalt blue (dry) to light greyish-blue (wet) to lilac, lavender, and finally pink (very wet). Any color other than cobalt blue is considered wet. Any time the system is evacuated (dehydrated), replace the receiver-drier.

Thermostatic Switch

The temperature of the evaporator coil is monitored by a fixed-temperature thermostatic switch.

The probe from the switch extends to the evaporator coil, and the switch is mounted on the right side of the heater and air conditioner housing. This switch disengages the compressor to prevent the evaporator coil from freezing up due to, for example, an expansion valve that is stuck open.

Fan Cycle Switch (On-Off Fan Only)

Located on the receiver-drier, the fan cycle switch activates a solenoid to turn the fan on or off, depending on refrigerant pressure.

On vehicles built before November 1994, the fan will come on if refrigerant pressure is greater than 260 ± 10 psi (1800 kPa). The fan turns off when pressure drops below 174 ± 10 psi (1200 kPa).

On vehicles built from November 1994, the fan will come on if refrigerant pressure is greater than 300 ± 10 psi (2070 kPa). The fan turns off when pressure drops below 250 ± 10 psi (1725 kPa).

Binary Switch

A binary switch disengages the refrigerant compressor to protect it from harmful operating conditions. It performs two functions:

1. If refrigerant is lost or the outside temperature is too low, the binary switch will keep the compressor from operating. The switch disengages the compressor when falling pressure goes below 26 to 31 psig (180 to 215 kPa); normal compressor operation resumes when rising pressure reaches 0.1 to 3.0 psig (0.6 to 21.0 kPa) above shutoff pressure.
2. If the compressor cylinder head pressure increases to unsafe levels above 356 to 413 psig (2455 to 2845 kPa), the binary switch shuts off the compressor. Too much pressure may be caused by blocked air flow through the condenser, a plugged expansion valve or receiver-drier, or too much refrigerant in the system. When pressure falls back 57 to 114 psig (395 to 785 kPa) from shutoff pressure, the compressor resumes operation.

Heater Core

The heater core is a series of fins through which tubing is routed. When the heating system is on, engine coolant flows through the heater core tubes, heating the tubes and fins. The heat is absorbed by air that is forced through the heater core by the blower motor.

Water Regulating Valve

When opened, the water regulating valve allows engine-heated coolant to flow through the heater core.

Air Blower, Resistor Block Assembly

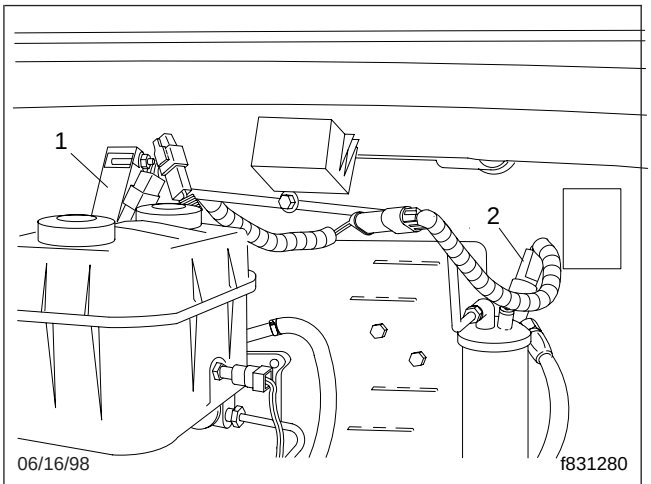
An air blower forces air through the heater core and evaporator coil, and into the cab. The resistor block assembly regulates the voltage to the blower motor. The voltage controls the blower motor speed. The resistor assembly has a thermal cutout which shuts off current to the blower motor in case the motor malfunctions.

Air Conditioning Protection and Diagnostics System (APADS™)

The APADS™ control and diagnostics system is designed to increase the life of the air conditioning system components, reduce air conditioning maintenance, and aid the diagnosis of system faults. The APADS™ control system consists of an electronic control module, high and low pressure switches, and an evaporator thermostat. The electronic control module actively monitors system conditions and controls the operation of the refrigerant compressor and the fan clutch. Refer to Principles of Operation for more information on this system.

Located under the hood on the left-hand side of the frontwall, the electronic control module registers fault codes that warn of existing or impending problems in the air conditioning system. See **Fig. 3**. Diagnostic information and system status are communicated by red and green light emitting diodes (LEDs) built into the electronic control module. Since only one blink code can be displayed, the fault code of highest priority takes precedence. For more information on fault codes, see **Troubleshooting 300**.

General Information



1. Electronic Control Module
2. High Pressure Switch

Fig. 3, APADS Control Module

APADS™ High Pressure Switch

Located on the discharge side of the refrigerant compressor, the high pressure switch signals the electronic control module to turn the fan on and to prevent operation of the refrigerant compressor in the event of a high pressure condition. When the pressure increases above 290 to 310 psi (1999 to 2137 kPa) on vehicles built before December 11, 1998 or 340 to 375 psi (2344 to 2586 kPa) on vehicles built from December 11, 1998 the electronic control module shuts down the refrigerant compressor if necessary, and turns the fan on. When the pressure returns to 250 to 270 psi (1724 to 1862 kPa), the compressor resumes normal operation and the electronic control module turns the fan off.

APADS™ Low Pressure Switch

Located on the suction side of the refrigerant compressor, the low pressure switch signals the electronic control module to shut down the refrigerant compressor in extremely cold temperatures, or if there is a loss of charge. When the pressure falls below 10 psi (69 kPa) the electronic control module shuts down the refrigerant compressor. When the pressure is above 34 psi (234 kPa) the compressor resumes normal operation.

APADS™ Evaporator Thermostat

The evaporator thermostat is the main air conditioning system control. The evaporator thermostat is wired in series with the air conditioning system on/off switch. It opens at 32°F (0°C) or below, and closes at 38°F (3°C) or above.

Definition of Terms

Refer to the following terms for a better understanding of the heater/air-conditioning system.

Air Conditioner A system used to control the temperature, humidity, and movement of air in the cab.

Air Conditioning Protection and Diagnostics System (APADS™) A system that actively monitors air conditioner conditions and controls the refrigerant compressor and the on/off fan drive. Existing or impending problems are registered as fault codes on the electronic control module.

Ambient Air Temperature The temperature of air around an object; the outside temperature.

Binary Switch Disengages the refrigerant compressor to protect it from harmful operating conditions.

Blower A motor and fan used to draw air through the evaporator, and force it through the heater core and into the cab.

Blower Resistor Block Assembly In line resistors that control the amount of voltage going to the blower motor. By controlling the voltage, you can control the fan speed.

Boiling Point The temperature at which a liquid changes to a gas. The boiling point varies with pressure.

Bulk Charging Use of large containers of refrigerant for charging a refrigerant system. Normally used for charging empty systems.

Carbon Dioxide A colorless, odorless, dry, inert gas that can be used to purge light contaminants (for example, dust) from air conditioner parts.

CFM Cubic feet per minute.

Charge A specific amount of refrigerant or oil by volume or weight. Also, the act of placing an amount of refrigerant or oil in the air conditioning system.

Clutch Cycling Switch (Thermostatic Switch) Engages or disengages the compressor depending on changes in system pressure or evaporator temperature.

Cold The absence of heat. The lowest possible temperature is thought to be –459°F (–273°C).

Compressor A device used to draw low-pressure refrigerant gas from the evaporator and squeeze it into a high-temperature, high-pressure gas. A second purpose of the compressor is to move refrigerant through the system.

Condensate Water, taken from the air, which forms on the outer surface of the evaporator.

Condenser A heat exchanger that is used to remove heat from the refrigerant, changing it from a high-pressure hot gas to a high-pressure warm liquid.

Condensing Pressure Pressure, as read from the gauge at the discharge service valve; pressure from the discharge side of the compressor into the condenser.

Contaminants Anything other than refrigerant or refrigerant oil in the system. Usually means water in the system. When water and refrigerant mix, corrosive hydrochloric acid forms.

Cycling Clutch System A system which controls compressor clutch operation in order to raise or lower the temperature in the cab.

Dehumidify To remove water from the air, at the evaporator coil.

Dehydrate To remove all traces of moisture from the refrigerant system. Normally called evacuation.

Desiccant A drying agent used in the refrigerant system (in the receiver-drier) to remove water and create an extremely dry condition.

Discharge Line Connects the refrigerant compressor outlet to the condenser inlet.

Discharge Pressure Pressure of the refrigerant being discharged from the compressor; high-side pressure; condensing pressure.

Drive Pulley A V-pulley attached to the front of the engine crankshaft. It drives the compressor clutch pulley with a belt.

Drying Agent See "Desiccant."

Duct A passageway for the transfer of air from one point to another.

Evacuate To place a high vacuum in the air-conditioning system and dehydrate or remove all traces of moisture.

Evaporate To change state from a liquid to a gas.

Evaporator Coil A component in which liquid refrigerant changes to a gas after it absorbs heat from the air. Also removes some moisture from the air.

Evaporator Thermostat (APADS™) The evaporator thermostat is the main air conditioning system control. It is used to turn off the refrigerant compressor whenever frost begins to form on the evaporator.

Expansion Valve A device that causes a pressure-drop of the refrigerant and also regulates its flow.

Flooding A condition caused by too much liquid refrigerant going into the evaporator; usually caused by an expansion valve that is stuck open.

Flushing A process of passing liquid refrigerant through an air-conditioner component to remove dirt and water from the part. Liquid refrigerant removes heavy contamination, such as gritty dirt and large dirt buildup.

Freeze-Up Failure of a unit to operate properly because of ice forming at the expansion valve orifice or on the evaporator coils and fins.

Heater Core A part of the heating system in which hot engine coolant flows to provide heat to the cab or to adjust the temperature produced by the air conditioner.

High-Side Service Valve A device located on the liquid line near the thermostatic expansion valve; it allows high-side pressure to be checked and other service operations to be performed.

High Pressure Switch (APADS™) Located on the discharge side of the refrigerant compressor, the high pressure switch signals the electronic control module to turn the fan on and to prevent operation of the refrigerant compressor in the event of a high pressure condition.

Humidity The amount of water vapor in the air.

Hydraulic Lock The return of liquid refrigerant to the compressor, which could destroy the unit.

Leak Detector Any device used to detect refrigerant leaks in a refrigerant system.

Liquid Pressure Pressure of refrigerant in the liquid line from the receiver-drier to the thermostatic expansion valve.

Low Pressure Switch (APADS™) Located on the suction side of the refrigerant compressor, the low pressure switch signals the electronic control module to shut down in extremely cold temperatures, or if there is a loss of charge.

Low-Air Pressure Switch An air operated electrical

General Information

switch that is normally open, but closes when the system pressure rises to 65 to 75 psi (450 to 515 kPa). Its purpose is to prevent the refrigerant compressor from turning on if the vehicle's air system pressure is too low to activate the cooling fan.

Low Head Pressure High-side pressure that is lower than normal due to a system problem.

Low Suction Pressure Low-side pressure that is lower than normal due to a system problem.

Magnetic Clutch An electrical coupling device used to engage or disengage the compressor.

Manifold Device to control refrigerant flow for system test purposes; used with manifold gauges.

Manifold Gauge A calibrated instrument used for measuring system pressures.

Manifold Gauge Set A manifold that is complete with gauges and charging hoses and is used to measure or test pressure.

Micron A metric unit of length equal to one-millionth of a meter; used to measure vacuum drawn from a refrigerant system by a vacuum pump.

Moisture Indicator Litmus paper in a sight glass receiver-drier; shows how much moisture is in the system.

Nitrogen A colorless, odorless, dry, inert gas that can be used to purge light contaminants (for example, dust) from air conditioner parts.

Opacity A condition that is used to describe contamination of refrigerant oil in the compressor. Fresh refrigerant oil is clear; when contaminated, it appears cloudy or may have fine particles held in suspension.

Overcharge Too much refrigerant or oil in the system.

Polyalkylene Glycol (PAG) and Polyol Ester (POE-) Highly refined synthetic oils that are used in R–134a air conditioning systems.

psia Pounds per square inch. Pressure exerted by the air at sea level. Atmospheric pressure is usually measured with a mercury barometer.

psig Pounds per square inch, gauge pressure. Any pressure above normal atmospheric pressure (14.7 psi) is referred to as gauge pressure.

Purge To remove damp air, traces of refrigerant, and loose dirt from a system or part by flushing with a dry, inert gas, such as nitrogen.

Receiver-Drier A combination desiccant, filter, and storage container for liquid refrigerant.

Recovery Removal of the refrigerant from air conditioning systems.

Recycling Removal of contaminants and moisture from R–134a using a recovery and recycling station.

Refrigerant–134a (R–134a) The cooling agent used in automotive air conditioning systems. The chemical name for R–134a is Tetrafluoroethane.

Refrigeration Cycle The complete circulation of refrigerant through an air conditioning system, accompanied by changes in temperature and pressure.

Relative Humidity The actual water content of the air in relation to the total water vapor the air can hold at a given temperature.

Resistor A voltage-dropping device, usually wire-wound, for controlling fan speed.

Suction Line The line connecting the evaporator outlet to the compressor inlet.

Suction Pressure Compressor inlet pressure (the system's low-side pressure).

Suction Service Valve A device located on the suction hose near the thermostatic expansion valve that allows low-side pressure to be checked and other service operations to be performed.

Suction Side The low-pressure area of the system, extending from the expansion valve to the compressor inlet.

Thermistor A vacuum pressure sensor that is used to measure (in microns of mercury) internal system vacuum levels after evacuation.

Thermostatic Switch A temperature-sensitive switch used to control system temperature and prevent evaporator freeze-up; it does this by cycling the compressor's operation.

Thermostatic Vacuum Gauge A high-vacuum gauge sensitive to pressures ranging from atmospheric pressure to less than 1 micron of mercury, with scales reading from 25,000 microns to 1 micron of mercury.

Undercharge A system low on refrigerant, resulting in lack of cooling and possible compressor damage.

Vacuum Refers to pressure that is less than atmospheric pressure.

Vacuum Pump A mechanical device used to evacu-

ate and place a high vacuum in the refrigerant system.

Vacuum Pump Oil Water soluble oil used in some vacuum pumps to absorb moisture from the refrigerant system.

Vapor The gaseous state of a material.

Water Regulating Valve A valve, mechanically operated, for controlling the flow of hot coolant to the heater core.

Principles of Operation

Heater

Moving the temperature control toward maximum heat opens the water regulating valve, which allows engine-heated coolant to flow through the heater core. Heat absorbed by the air passing over the heater core fins is forced through ducts and into the cab.

Air Conditioner

When the air conditioner is on, the motion of the compressor squeezes the refrigerant into a high-pressure, high-temperature gas. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid. After it is compressed, refrigerant gas moves out of the discharge port of the compressor, and on to the condenser.

At the condenser, air passing over the coil's fins absorbs heat from the hot refrigerant gas and causes it to change into a liquid. The liquid moves to the receiver-drier, which filters it and removes traces of moisture and acids. The receiver-drier then stores the refrigerant until it is needed by the system.

From the receiver-drier, liquid refrigerant moves to the expansion valve, which meters the flow into the evaporator coil and acts as a boundary between the high- and low-pressure sides of the system. The metered release of the expansion valve greatly drops the liquid's pressure, causing it to expand. The pressure drop lowers the boiling point of the refrigerant, and causes it to evaporate quickly as it absorbs heat from air passing over the coil. The resulting cool air is forced into the cab by the blower; the heated refrigerant gas is drawn back into the compressor, where the cycle is repeated.

Air Conditioning Protection and Diagnostics System (APADS™)

After the engine is started, the electronic control module prevents operation of the refrigerant compressor for 15 seconds. After the 15 second delay, the compressor comes on for 15 seconds. This start-up cycle is accomplished with the control module ignoring all input from the thermostat. The purpose of engaging the compressor is to circulate lubricant within the compressor, which is beneficial to the system especially when it is not used frequently. If the high or low pressure switches indicate out of bound or fault conditions, the compressor is turned off after the initial 15 seconds.

The evaporator thermostat is the primary control of the air conditioning system. The refrigerant compressor will cycle at the frequency governed by the thermostat, but is limited to a maximum of one cycle per 15 seconds.

When the high pressure switch indicates a high pressure condition, the refrigerant compressor is allowed to stay on for an algorithmically determined variable period, limited to 10 seconds. The compressor is allowed to turn on after the high pressure switch resets, and the maximum cycle rate of the compressor is limited to once every 15 seconds as governed by the control logic.

When the low pressure switch indicates a low pressure condition, the refrigerant compressor is turned off. The compressor is allowed to turn on after the low pressure switch resets, and the maximum cycle rate of the compressor is limited to once every 15 seconds as governed by the control logic.

Additional air conditioning system controls performed by APADS™ include shut down of the refrigerant compressor if the supply voltage drops below 11 volts. It is allowed to turn on again after there has been a sufficient rise in system voltage. The refrigerant compressor is shut down until the next ignition cycle if any of the following faults occur:

- high pressure
- open clutch
- shorted clutch

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and non-leather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

⚠ WARNING

WARNING: Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure. However, it can be combustible at pressures as low as 5.5 psig (139 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

⚠ WARNING

WARNING: R–134a air conditioning systems should not be pressure tested or leak tested with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion, which could cause personal injury or property damage. R–134a may be safely pressured with dry nitrogen.

You must work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R-134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

On R–134a refrigerant systems, polyalkylene glycol (PAG), or polyol ester (POE) oil is used in the compressor. When handling these oils, observe the following:

- keep the oil free of contaminants
- do not expose the a/c system or the oil container to air for long periods of time; PAG and POE oils absorb moisture quickly
- use care when handling: painted surfaces, plastic parts, and other components (drive belts) could be damaged if the oil is spilled on them
- never mix the oils with other types of refrigerant oil

Heater Core Removal and Installation

Removal

⚠ WARNING

Before doing any of the work below, read the information under Subject 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

1. Disconnect the batteries.
2. Set the temperature control on the dash to its warmest setting.

⚠ WARNING

Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

3. Drain the coolant.
4. Remove the vinyl extrusion trim at the top of the dash. See **Fig. 1**.

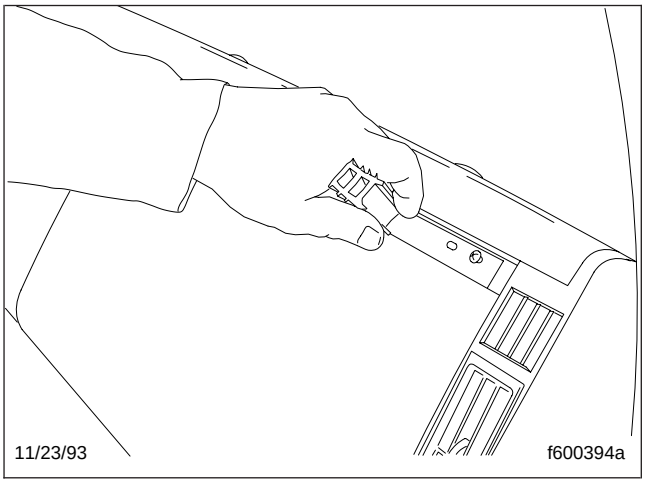


Fig. 1, Removing the Vinyl Extrusion Trim

5. Remove dash panel D. See **Fig. 2** and **Fig. 3**.
   - 5.1 Remove the two screws from the top of dash panel D.
   - 5.2 Lift out the dash panel. Set it and the two mounting screws aside.
6. Pull out the windshield defrost duct. See **Fig. 4**.

NOTE: On vehicles with right-hand drive, loosen panel B. On these vehicles, the panel has enough slack that it does not need to be removed.

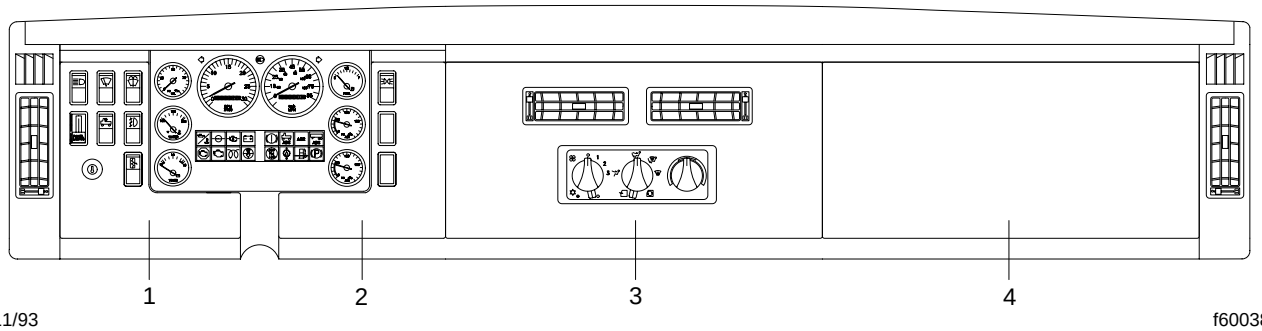
7. Remove dash panel B.
   - 7.1 Remove the knobs from the parking brake air valve and the trailer brake air valve, if so equipped. See **Fig. 5**.
   - 7.2 Remove the two mounting screws.
   - 7.3 Lift out the dash panel. Set it and the two mounting screws aside.
8. Remove dash panel C. See **Fig. 2**.
   - 8.1 Remove the bezel around the HVAC control panel.
   - 8.2 Remove and set aside the four screws (see **Fig. 6**) holding the control panel to dash panel C.
   - 8.3 Remove the two screws from the top of dash panel C.
   - 8.4 Lift out the dash panel. Set it and the two mounting screws aside.

NOTE: On vehicles with right-hand drive, loosen the instrument panel. On these vehicles, the panel has enough slack that it does not need to be removed.

9. Remove the instrument panel. See **Fig. 7**.
   - 9.1 On vehicles built after late January/early February 1997, remove the four spring-loaded Torx®-head screws.

     On vehicles built earlier, insert a screwdriver in the locking tabs and push upward to release.
   - 9.2 Pull out the panel and disconnect all the electrical connectors.
   - 9.3 Disconnect the two air pressure lines.
   - 9.4 Disconnect the oil pressure line.
10. Remove and set aside the two screws at the top of dash panel A. See **Fig. 8**.
11. Remove the upper dash cover.
    - 11.1 Disconnect the harness for the turn signal switch.

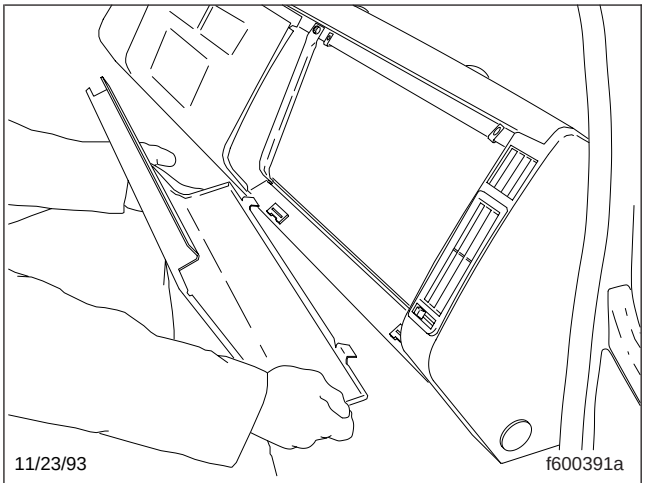
Heater Core Removal and Installation



Left-hand drive shown; right-hand drive opposite

1. Panel A
2. Panel B
3. Panel C
4. Panel D

Fig. 2, Dash Panels



Left-hand drive shown; right-hand drive opposite

Fig. 3, Removing Panel D

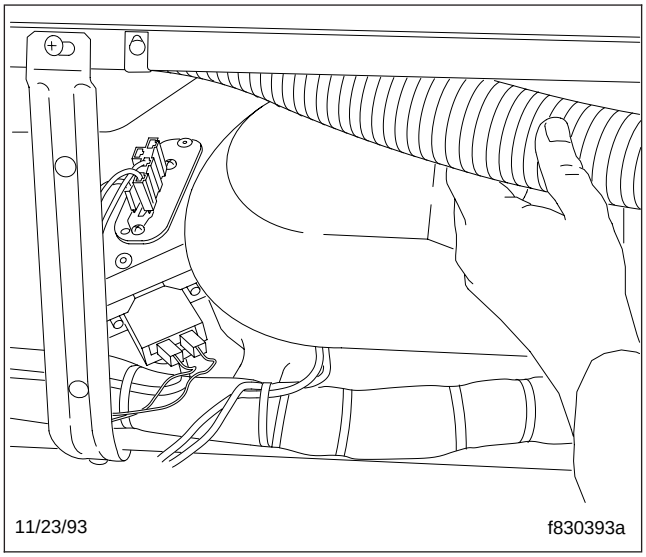


Fig. 4, Pulling Out the Windshield Defrost Duct

11.2 Pull dash panel A forward. Remove the screws holding each dash end cap; pull the end caps forward and out of the way. See **Fig. 9**.

11.3 Remove the screws at the base of the windshield holding the upper dash cover.

11.4 Remove the screw at the top of the dash brace (see **Fig. 10**) and the screws at the top of the gauge cluster.

11.5 Lift off the upper dash cover. See **Fig. 11**.

12. Disconnect the defrost door control cable from the face duct. See **Fig. 12**.

13. Remove the face duct.

14. Remove the four fasteners from the heater top cover, then set the cover aside.

15. Disconnect the hoses from the heater core. See **Fig. 13**.

⚠ WARNING

Always wear protective gloves when handling the heater core. Failure to do so could result in serious skin cuts from the sharp edges on the heater core fins.

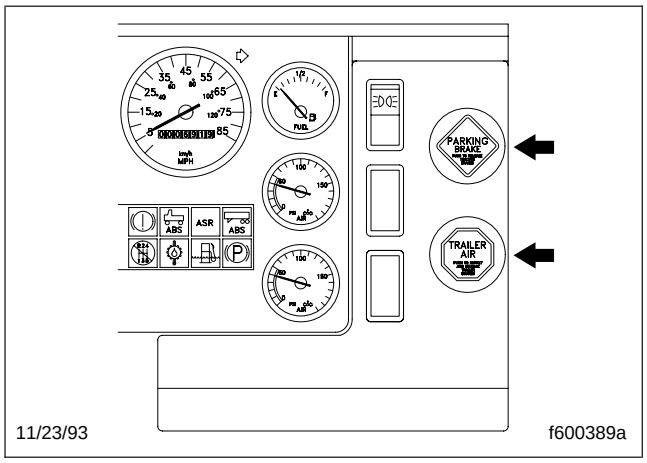


Fig. 5, Air Valve Knobs

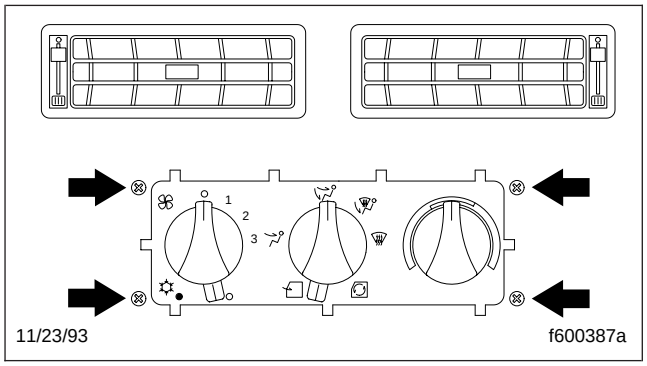


Fig. 6, HVAC Control Panel

16. Remove the heater core. See **Fig. 14**.

Installation

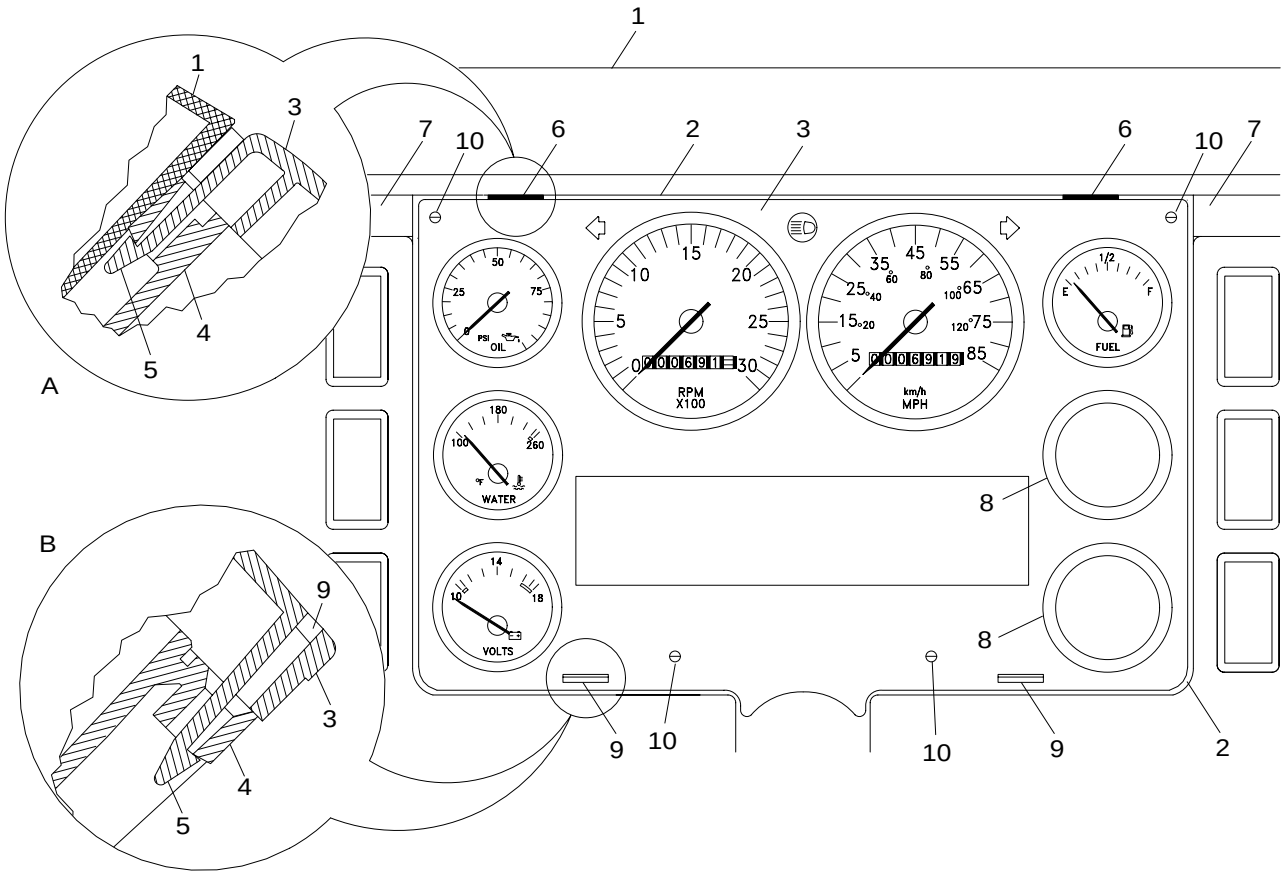
WARNING

Always wear protective gloves when handling the heater core. Failure to do so could result in serious skin cuts from the sharp edges on the heater core fins.

1. Install the heater core, inserting the pipes through the holes in the frontwall. See **Fig. 14**.
2. Connect the hoses to the heater core. See **Fig. 13**.
3. Check the heater core for leaks.
   - 3.1 Connect the batteries.
   - 3.2 Close the radiator drain valve.
   - 3.3 Fill the cooling system with approved coolant. See the vehicle maintenance manual.
   - 3.4 Start the engine and set the temperature control to the warmest setting. When the engine thermostat opens, air will be forced from the heater core as the coolant circulates. Check the coolant level again and fill as needed.
   - 3.5 Check the heater core hose connections (see **Fig. 13**) for leaks. Tighten the hose clamps if needed.
   - 3.6 Shut down the engine and disconnect the batteries.
4. Install the heater top cover.
5. Install the face duct. Connect the defrost door control cable and the cable sheath to the face duct. See **Fig. 12**.
6. Install the upper dash cover (see **Fig. 11**) and tighten the screws at the base of the windshield.
7. Install the dash end caps (see **Fig. 9**) and their mounting screws (two each).
8. Install the brace screw (see **Fig. 10**) and the screws at the top of the gauge cluster.
9. Install dash panel A and tighten its two mounting screws (see **Fig. 8**).
10. Install the instrument panel, as removed. See **Fig. 7**.
    - 10.1 Connect the oil pressure line (brown).
    - 10.2 Connect the two air pressure lines (green on top).
    - 10.3 Connect all the electrical connectors.
    - 10.4 On vehicles built after late January/early February 1997, install the four spring-loaded Torx®-head screws.

      On vehicles built earlier, insert the locking tabs into the slots in the panel and push inward until they click into place. Make sure the tabs are locked.
11. Install dash panel C and tighten its two mounting screws (see **Fig. 2**).

Heater Core Removal and Installation



09/16/97 f600386a

On vehicles built after late January/early February 1997, remove the four spring-loaded Torx®-head screws. On vehicles built earlier, insert a screwdriver in the locking tabs and push upward to release.

A. Sectional Detail (top)
1. Upper Dash Cover
2. Foam Gasket
3. Instrument Panel
4. Gauge Housing

B. Sectional Detail (bottom)
5. Panel Locking Tab
6. Opening in Foam Gasket
7. Vinyl Extrusion Trim
8. Gauge Blank (block-off plug)
9. Slot in Panel
10. Torx-Head Screw

Fig. 7, Instrument Panel Removal

12. Install dash panel B and tighten its two mounting screws (see **Fig. 2**). Install the knobs on the parking brake air valve and the trailer brake air valve, as removed.
13. Install the windshield defrost duct. See **Fig. 4**.
14. Install dash panel D and tighten its two mounting screws (see **Fig. 2** and **Fig. 3**).
15. Install the vinyl extrusion trim at the top of the dash. See **Fig. 1**.
16. Connect the wiring harness to the turn signal switch.
17. Connect the batteries.

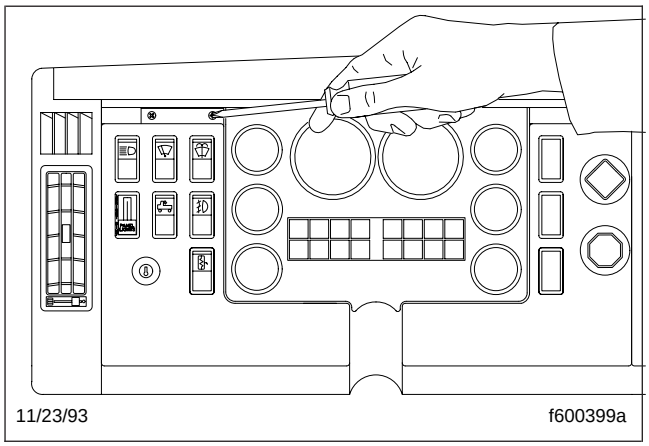
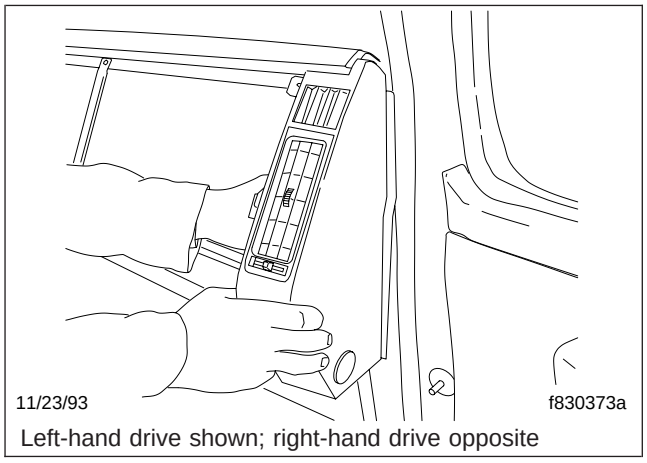
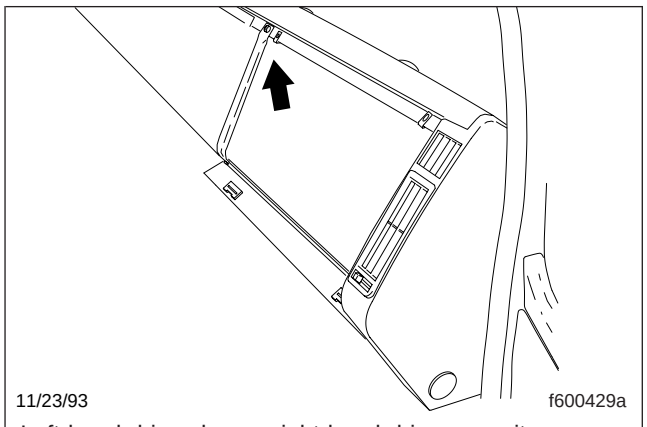


Fig. 8, Removing the Fasteners on Panel A



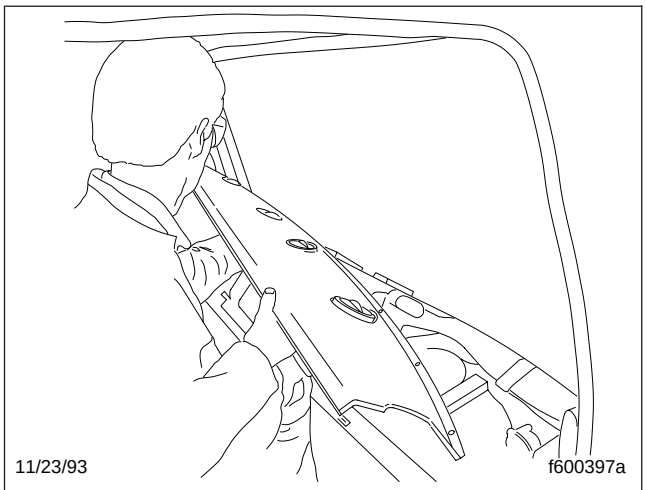
Left-hand drive shown; right-hand drive opposite

Fig. 9, Removing the Dash End Caps



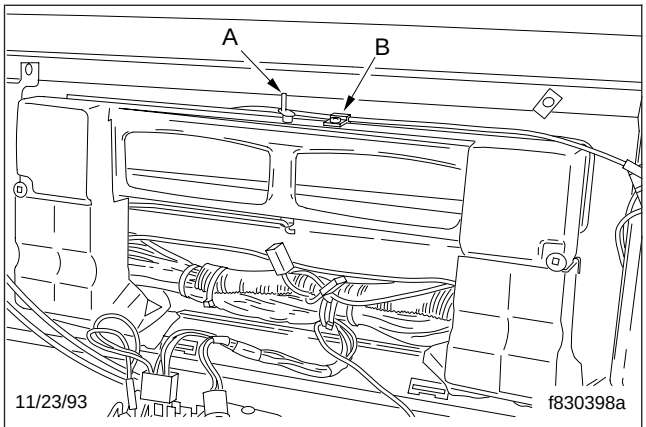
Left-hand drive shown; right-hand drive opposite

Fig. 10, Dash Brace Top Screw



Left-hand drive shown; right-hand drive opposite

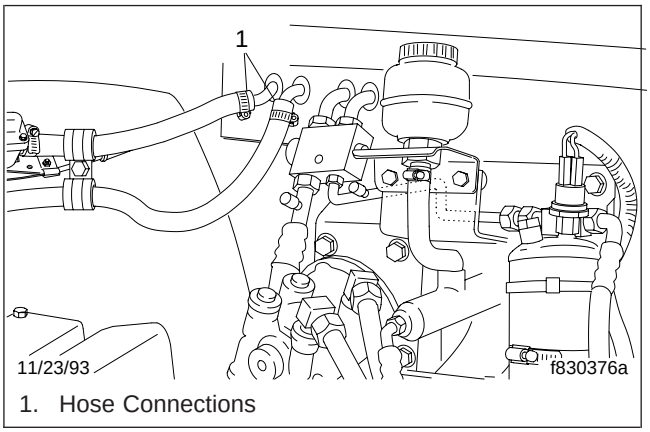
Fig. 11, Lifting Off the Upper Dash Cover



A. Cable connects here.
B. Cable sheath connects here.

Fig. 12, Defrost Cable Connections

Heater Core Removal and Installation



1. Hose Connections

Fig. 13, Heater Core Hoses

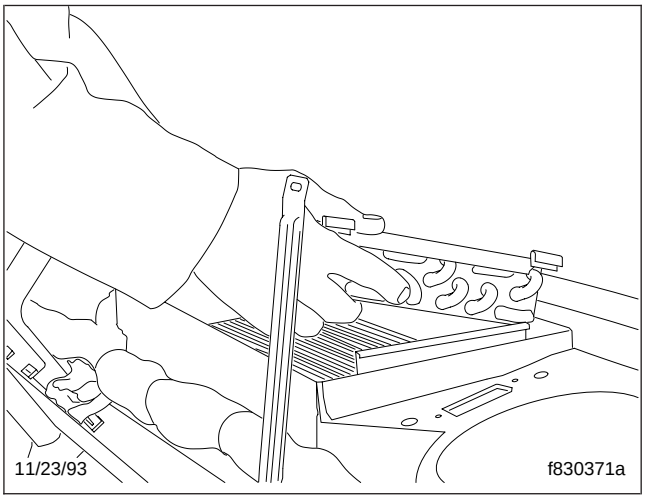


Fig. 14, Removing the Heater Core

Evaporator Coil Removal and Installation

Removal

WARNING

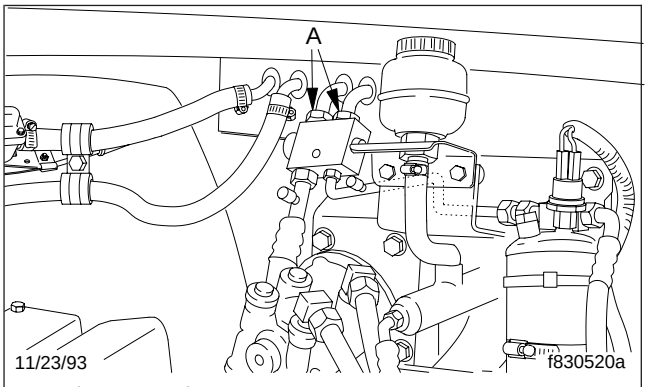
WARNING: Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to personal injury.

1. Disconnect the batteries.
2. Wearing protective goggles and gloves, recover the refrigerant system. For instructions, refer to **Subject 220.**
3. Remove the heater core. For instructions, refer to **Subject 110.**

CAUTION

CAUTION: Water and dirt can damage the refrigerant system. Five minutes of being uncapped is the limit for any hose or component. Do not blow shop air through the refrigerant hoses; shop air is wet (humid).

4. Disconnect the evaporator coil lines from the expansion valve in the engine compartment. **See Fig. 1.** Save the O-rings if they are in good condition.



A. Disconnect here.

Fig. 1, Disconnect the Evaporator Coil Lines

5. Cap or plug the evaporator coil lines and the expansion valve ports.

WARNING

WARNING: Always wear protective gloves when handling the evaporator coil. Failure to do so could result in serious skin cuts from the sharp edges on the evaporator coil fins.

6. Lift the evaporator coil out of the housing. **See Fig. 2.**

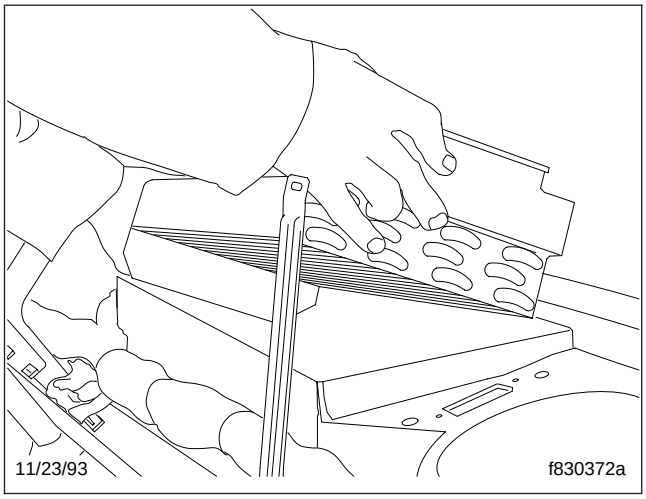


Fig. 2, Lift out the Evaporator Coil

Installation

WARNING

WARNING: Always wear protective gloves when handling the evaporator coil. Failure to do so could result in serious skin cuts from the sharp edges on the evaporator coil fins.

1. Wearing protective gloves, place the evaporator coil in the housing. **See Fig. 2.** Make sure the evaporator coil lines extend through the holes in the firewall.
2. Remove the caps or plugs from the evaporator coil lines and the expansion valve ports.
3. Lubricate the rubber O-rings with mineral oil and install them in the fittings.

NOTE: The previously removed O-rings can be used again if they are in good condition.

Evaporator Coil Removal and Installation

4. Apply Loctite 242 or 592 to the male fitting threads; then, connect the evaporator coil lines to the expansion valve ports. Tighten the fittings as follows:
    - Large fitting—33 N·m (24 lbf·ft)
    - Small fitting—24 N·m (18 lbf·ft)
5. Evacuate and charge the air conditioning system with refrigerant. For instructions, refer to **Subject 220**. Be sure to add refrigerant oil to the compressor to replace that which was lost when the system was discharged. Refer to the applicable refrigerant compressor section elsewhere in this group.

NOTE: If the system will not hold a vacuum, check the evaporator coil connections for tightness or check for a missing O-ring.

6. Install the heater core and the other removed components. For instructions, refer to **Subject 110.**
7. Connect the batteries.

Replacement

1. Disconnect the batteries.
2. Remove the vinyl extrusion trim at the top of the dash. See **Fig. 1**.

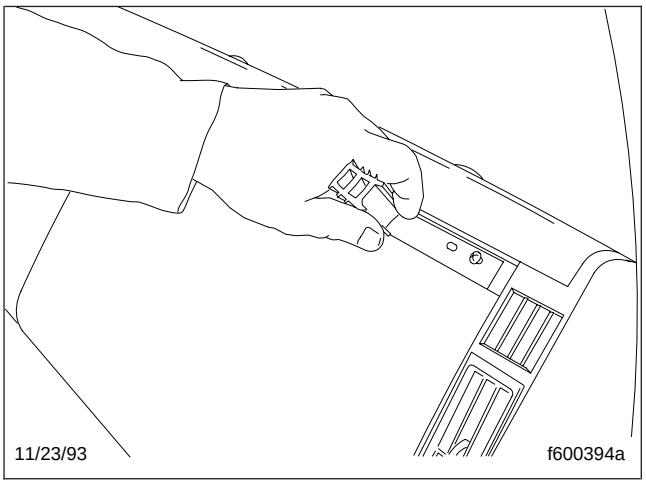


Fig. 1, Removing the Vinyl Extrusion Trim

3. Remove dash panel D and set it and the two mounting screws aside. See **Fig. 2** and **Fig. 3**.

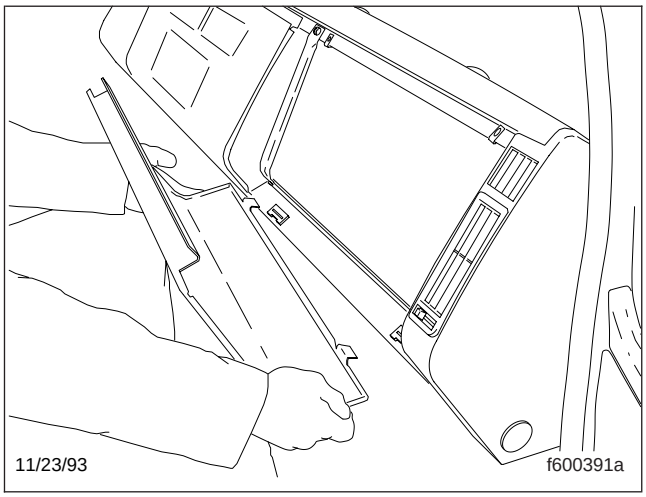
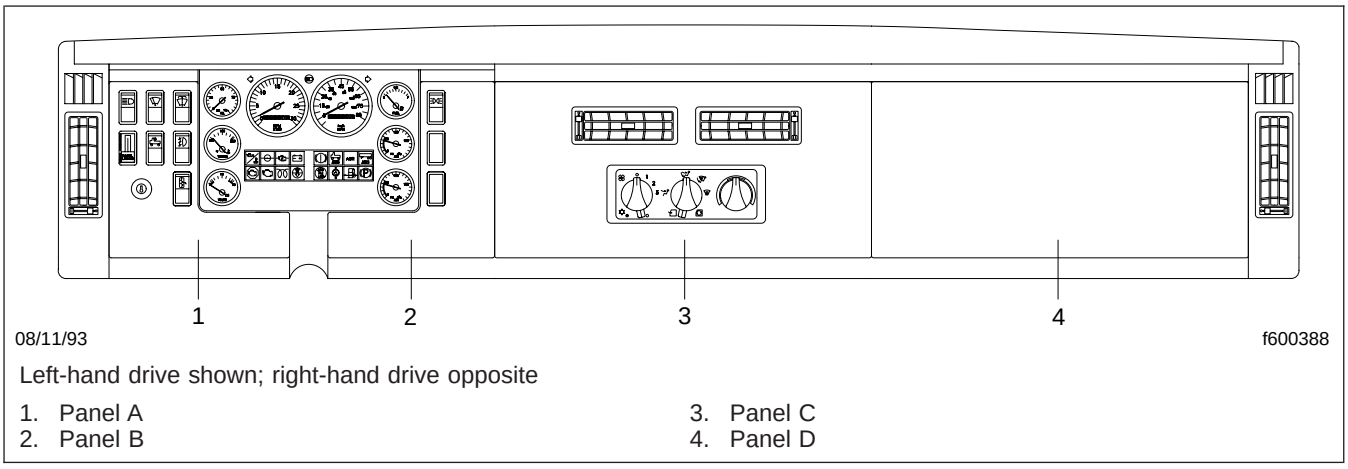


Fig. 3, Removing Panel D

4.3 If necessary in order to remove panel B, loosen the fasteners on the instrument panel. For detailed instructions, see **Subject 110**.

4.4 Lift off the dash panel. Set it and the two mounting screws aside.

5. Remove dash panel C and set it and the two mounting screws aside. See **Fig. 4**.



Left-hand drive shown; right-hand drive opposite

1. Panel A
2. Panel B
3. Panel C
4. Panel D

Fig. 2, Dash Panels

4. Remove dash panel B.

4.1 Remove the knobs from the parking brake air valve and the trailer brake air valve, if so equipped.

4.2 Remove the two mounting screws.

NOTE: It isn't necessary to remove the control panel from dash panel C or to disconnect the control cables.

Thermostatic Switch Replacement

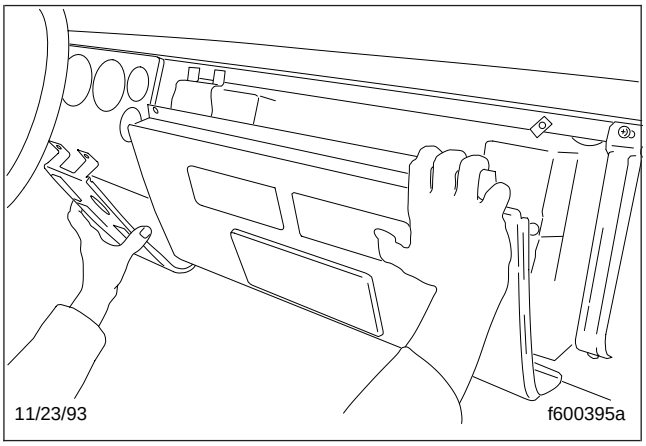
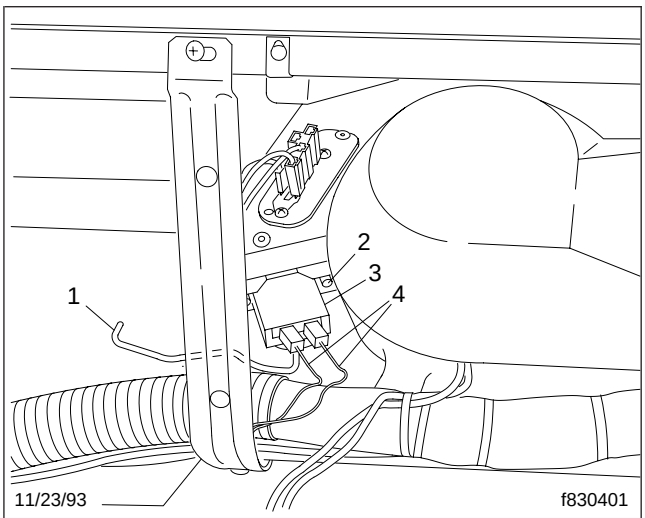


Fig. 4, Removing Panel C

6. On right-hand drive (RH DR) vehicles, detach the ignition keyswitch from panel A.
7. Remove the two screws holding the thermostatic switch to the ducting. Remove the thermostatic switch from the vehicle. See **Fig. 5**.



1. Capillary Tube
2. Allen-Head Screw
3. Thermostatic Switch
4. Thermostatic Switch Wires

Fig. 5, Thermostatic Switch

7.1 Disconnect the wires from the thermostatic switch.

7.2 Remove the two capscrews holding the thermostatic switch.

7.3 Move the air duct to access the capillary tube. Carefully pull the capillary tube, which extends from the bottom of the thermostatic switch, out of the air duct.

7.4 Remove the thermostatic switch.

8. Install the new thermostatic switch.

8.1 Carefully insert the capillary tube into the hole in the air duct.

8.2 Position the thermostatic switch and secure it to the ducting using the two screws, as removed.

8.3 Connect the wires to the switch.

8.4 Move the air duct into position.

9. On RH DR, attach the ignition keyswitch to panel A.
10. Install dash panel C and tighten its two mounting screws.
11. Install dash panel B and tighten its two mounting screws. Install the knobs for the parking brake air valve and the trailer brake air valve, as removed.
12. Install dash panel D and tighten its two mounting screws.
13. Install the vinyl extrusion trim at the top of the dashboard.
14. Connect the batteries.

Replacement

1. Disconnect the batteries.
2. Remove the vinyl extrusion trim at the top of the dash. See **Fig. 1**.

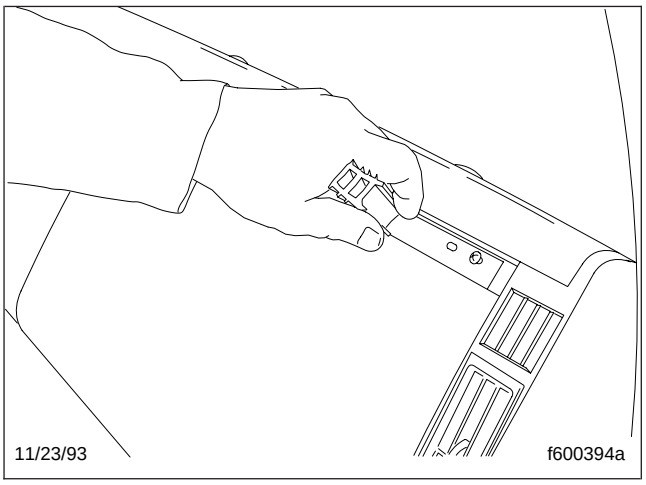


Fig. 1, Removing the Vinyl Extrusion Trim

3. Remove dash panel D and set it and the two mounting screws aside. See **Fig. 2** and **Fig. 3**.

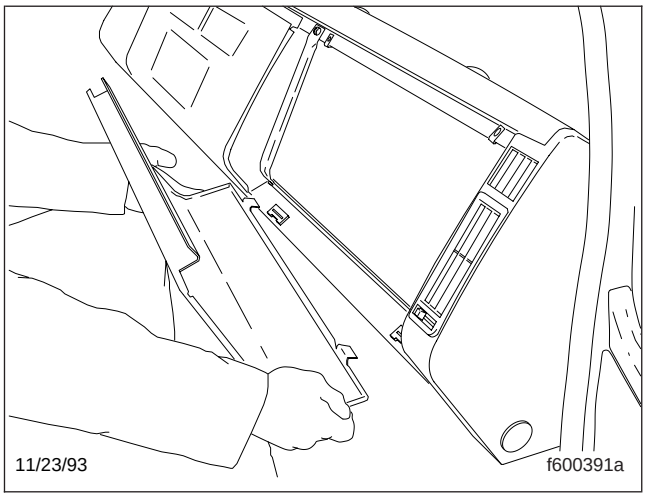
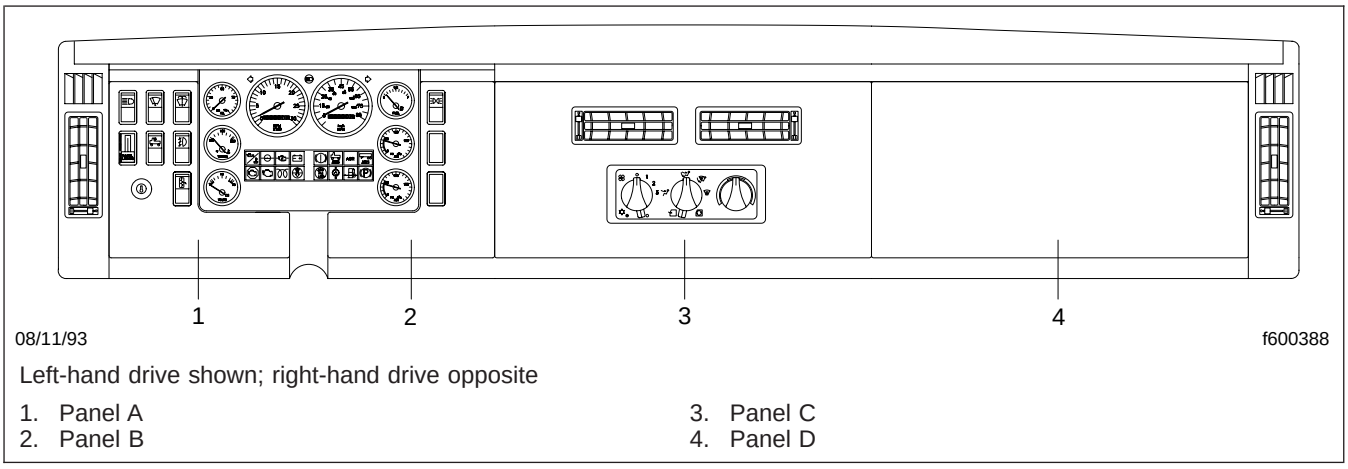


Fig. 3, Removing Panel D

7. Remove the three mounting nuts holding the blower motor (see **Fig. 6**); then, lift out the blower motor and remove it from the dash.
8. Position the new blower motor in the dash. Install the three mounting nuts and tighten them 17 lbf·in (192 N·cm).
9. Connect the blower motor electrical connector



Left-hand drive shown; right-hand drive opposite

1. Panel A
2. Panel B
3. Panel C
4. Panel D

Fig. 2, Dash Panels

4. On right-hand drive (RH DR) vehicles, remove the upper dash cover.
5. Remove the blower motor cover. See **Fig. 4**.
6. Disconnect the blower motor electrical connector. See **Fig. 5**.

(see **Fig. 5**).

10. Install the blower motor cover. See **Fig. 4**.
11. Install the knurled thumb screw on the blower motor cover finger-tight.
12. On RH DR vehicles, install the upper dash cover.

Blower Motor Replacement

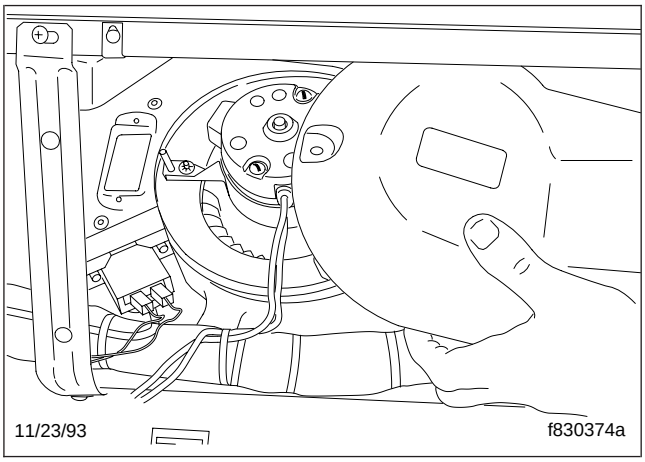


Fig. 4, Removing the Blower Motor Cover

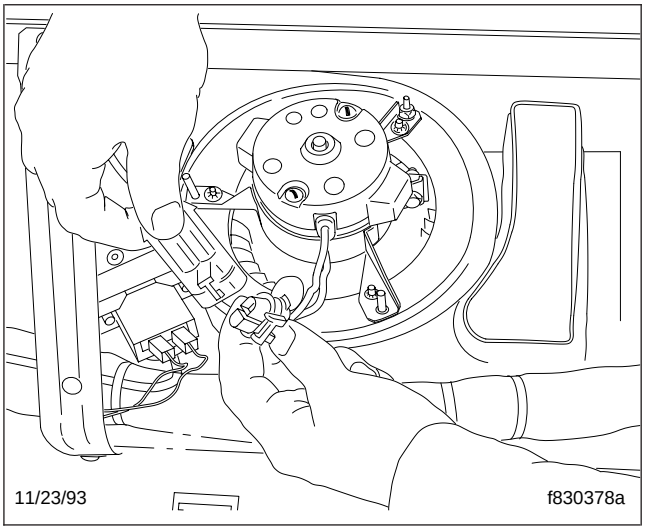


Fig. 5, Disconnecting the Electrical Connector

13. Install dash panel D (see **Fig. 3**) and tighten the two mounting screws.
14. Install the vinyl extrusion trim at the top of the dash. See **Fig. 1**.
15. Connect the batteries and check the blower operation. See the vehicle driver's manual for instructions.

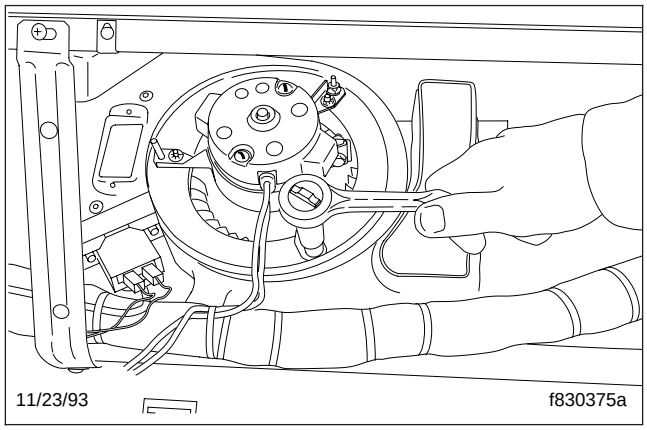


Fig. 6, Removing the Blower Motor

Replacement

1. Disconnect the batteries.
2. Remove the extruded rubber strip at the top of the dashboard. **See Fig. 1.**

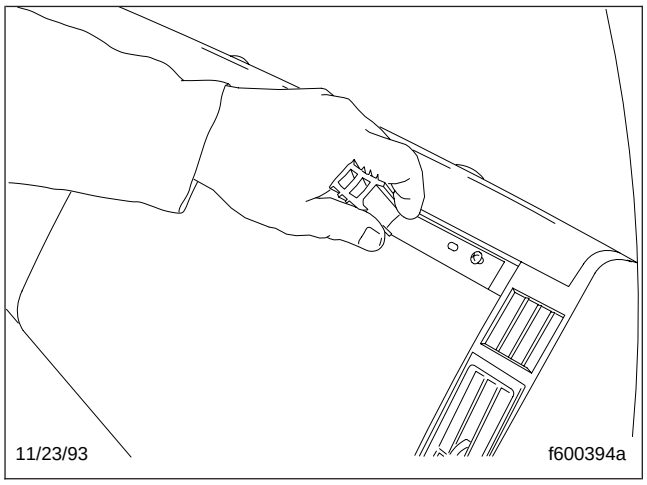


Fig. 1

3. Remove the two mounting screws from dash panel D; then, remove the panel. See **Fig. 2** and **Fig. 3.**

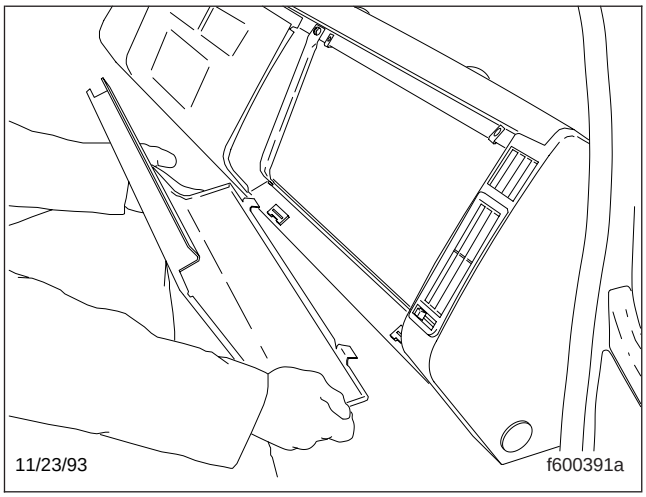
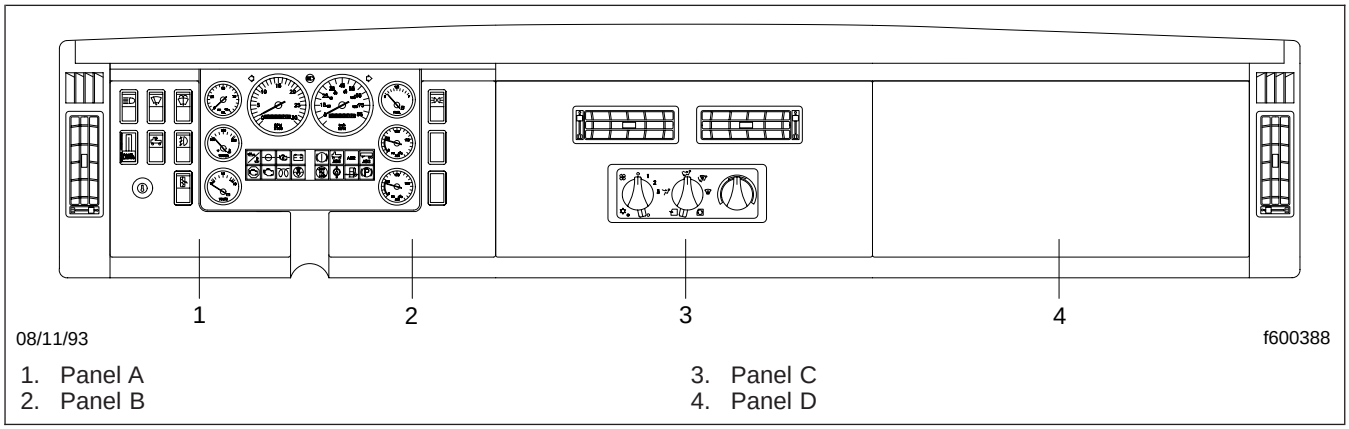


Fig. 3

5. Install the resistor block with the two mounting screws; then, connect the electrical plug.
6. Connect the batteries and check the blower operation.
7. Install dash panel D and the two mounting screws.
8. Install the extruded rubber strip at the top of the dashboard.

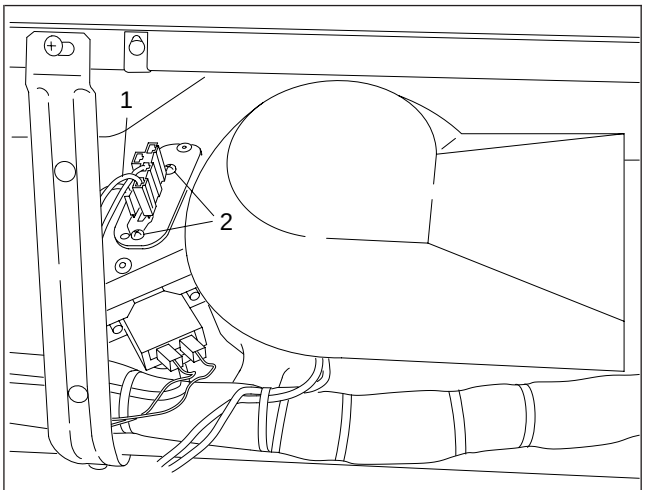


1. Panel A
2. Panel B
3. Panel C
4. Panel D

Fig. 2

4. Remove the resistor block. **See Fig. 4.**
   - 4.1 Unplug the connector from the resistor block.
   - 4.2 Remove the two mounting screws.
   - 4.3 Remove the resistor block.

Resistor Block Replacement

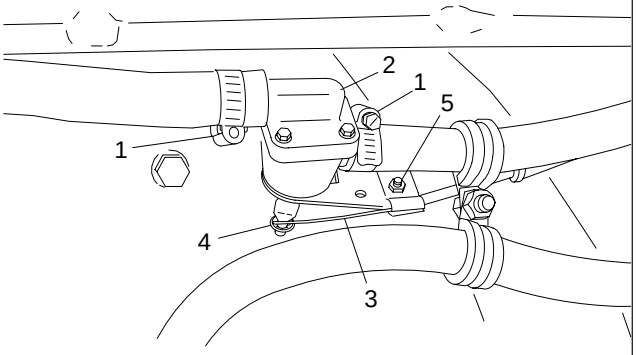


1. Resistor Block Wires
2. Resistor Block Mounting Screws

Fig. 4

Replacement (See Fig. 1)

1. Tilt the hood.



1. Hose Clamp
2. Valve Body
3. Control Cable
4. Internal Toothed Clip
5. Cable Mounting Screw

Fig. 1

2. Set the heater temperature control to the warmest setting.

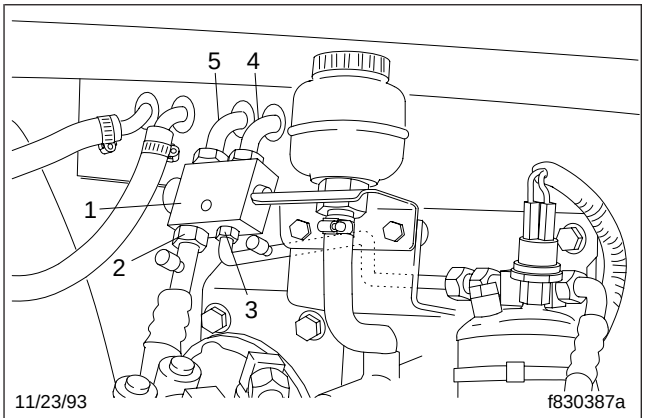
⚠ WARNING

WARNING: Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.

3. With the engine cold, drain enough coolant into a clean drain pan to lower the coolant level below the water regulating valve.
4. Remove the screw (Ref. 5) that holds the control cable to the valve base plate.
5. Remove the internal toothed clip (Ref. 4), and detach the control cable (Ref. 3).
6. Disconnect the heater hoses from the valve. Remove and discard the valve.
7. Install the new valve in the heater hoses. Tighten the hose clamps.
8. Slip the end of the control cable over the post on the valve control lever, and install a new internal toothed clip.
9. Adjust the control cable.
   - 9.1 Set the heater temperature control to the coolest position.
   - 9.2 Set the water regulating valve to the closed position.
   - 9.3 Slide the control cable in the clamp until the screw (Ref. 5) in the clamp lines up with the hole in the valve base plate.
   - 9.4 Tighten the screw (Ref. 5) to hold the cable in place.
   - 9.5 Check that the valve closes when the temperature control is at the coolest setting and opens toward the warmest setting.

   NOTE: The valve is fully closed or fully open before it reaches the mechanical stops at either end of its travel. After adjusting for the coolest setting, it is not necessary to adjust for the warmest setting.
10. Fill the cooling system with approved coolant. Refer to the vehicle maintenance manual.
11. Start the engine. When the engine thermostat opens, air will be forced from the heater core as the coolant circulates. Check the coolant level again and fill as needed.
12. Check the valve and the hose connections for leaks. Tighten the hose clamps if needed.
13. Lower the hood.

Replacement (See Fig. 1)



1. Expansion Valve Body
2. Compressor Line
3. Receiver-Drier Line
4. Evaporator Coil (small line)
5. Evaporator Coil (large line)

Fig. 1, Expansion Valve

⚠ WARNING

WARNING: Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

1. Tilt the hood.
2. Wearing protective goggles and gloves, recover the refrigerant system. For instructions, refer to **Subject 220.**
3. Disconnect the four refrigerant lines from the expansion valve; then, remove and discard the valve and the O-rings.

⚠ CAUTION

CAUTION: Water and dirt can damage the refrigerant system. Five minutes of being uncapped is the limit for any hose or component.

Do not blow shop air through the refrigerant hoses; shop air is wet (humid).

4. Lubricate the new rubber O-rings with mineral oil and install them in the fittings.
5. Apply Loctite 242 or 592 to the male fitting threads. Connect the lines from the evaporator coil to the expansion valve ports. Connect the line from the receiver-drier to the expansion valve port and the line that runs from the expansion valve port to the compressor.

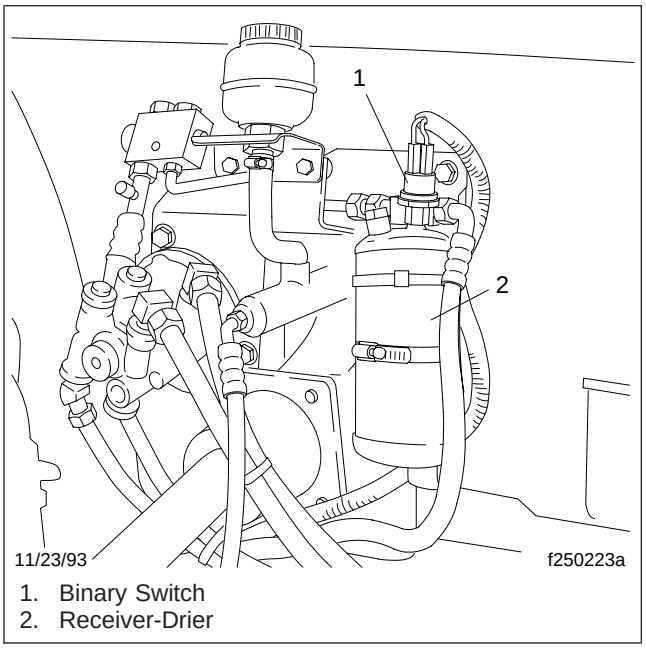
   Tighten the connections as follows:

   - Evaporator coil large fitting—33 N·m (24 lbf·ft)
   - Evaporator coil small fitting—24 N·m (18 lbf·ft)
   - Receiver-drier line—16 N·m (12 lbf·ft)
   - Compressor line—24 N·m (18 lbf·ft)
6. Evacuate and charge the air conditioning system with refrigerant. For instructions, refer to **Subject 220.** Be sure to add refrigerant oil to the compressor to replace that which was lost when the system was discharged. Refer to the applicable refrigerant compressor section in this group.

NOTE: If the system will not hold a vacuum, check the connections for tightness or check for a missing O-ring.

7. Lower the hood.

Replacement (See Fig. 1)



1. Binary Switch
2. Receiver-Drier

Fig. 1, Receiver-Drier Installation

⚠ WARNING

WARNING: Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

1. Tilt the hood.
2. Wearing protective goggles and gloves, recover the refrigerant system. For instructions, refer to **Subject 220.**
3. Disconnect the electrical leads from the binary switch and the fan control switch (if equipped).
4. Disconnect the inlet and outlet lines. Use two wrenches to avoid twisting the hoses.

⚠ CAUTION

CAUTION: Contaminants, such as water and dirt, can damage the refrigerant system. Five minutes of being uncapped is the limit for any part. Do not blow shop air through the refrigerant hoses since shop air is wet (humid).

IMPORTANT: If the desiccant cartridge inside the old receiver-drier has fallen apart, flush the entire system and replace the expansion valve and the refrigerant compressor. Desiccant matter can't be removed from these parts. A cartridge may fall apart from too much moisture in the system, because of poor evacuation of the system, or from lack of care.

5. Loosen the clamp that holds the receiver-drier to the bracket on the firewall. Remove and discard the receiver-drier.
6. Unscrew the binary switch. Remove the fan control switch (if equipped).
7. Mount the new receiver-drier and tighten the clamp.
8. If equipped with a fan cycle switch:

   On vehicles built before November 1994, apply Loctite 242 or 592 to the male threads of the coupling. Install the fan cycle switch, and tighten it 108 lbf·in (1220 N·cm) or one-eighth turn past hand-tight.

   On vehicles built from November 1994, lubricate a new O-ring with mineral oil, then install it over the male threads of the receiver-drier coupling. Install the fan cycle switch and tighten it 20 to 25 lbf·ft (27 to 34 N·m).

   Connect the wiring harness to the switch.
9. On vehicles built before November 1994, apply Loctite 242 or 592 to the male threads of the binary switch coupling. Install the binary switch, and tighten it 108 lbf·in (1220 N·cm) or one-eighth turn past hand-tight.

   On vehicles built from November 1994, lubricate a new O-ring with mineral oil, then install it over the male threads of the receiver-drier coupling. Install the binary switch and tighten it 20 to 25 lbf·ft (27 to 34 N·m).

   Connect the wiring harness to the switch.
10. Connect the inlet and outlet lines to the receiver-drier. Tighten the connections 45 N·m (33 lbf·ft).
11. Evacuate and charge the air conditioning system with refrigerant. For instructions, refer to **Sub-**

Receiver-Drier Replacement

ject 220. Be sure to add refrigerant oil to the compressor to replace that which was lost when the system was discharged. Refer to the applicable refrigerant compressor section in this group.

12. Lower the hood.

Replacement

⚠ WARNING

WARNING: Before doing any of the work below, read the information under Safety Precautions, 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

1. Tilt the hood.
2. Disconnect the harness connectors and unscrew the switch from its coupling on the receiver-drier. **See Fig. 1.**

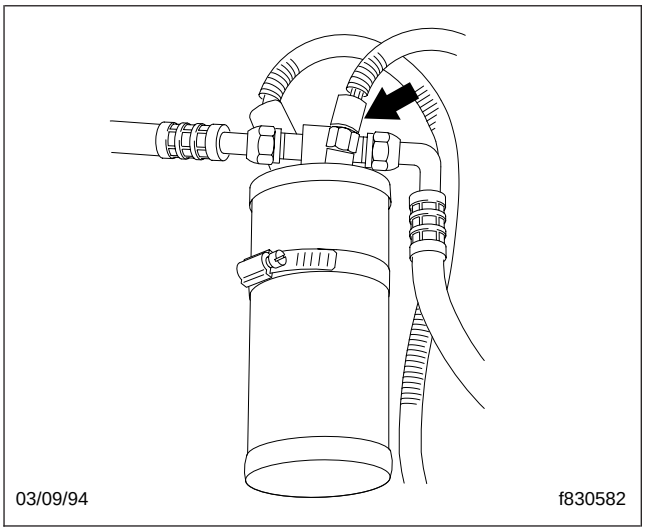
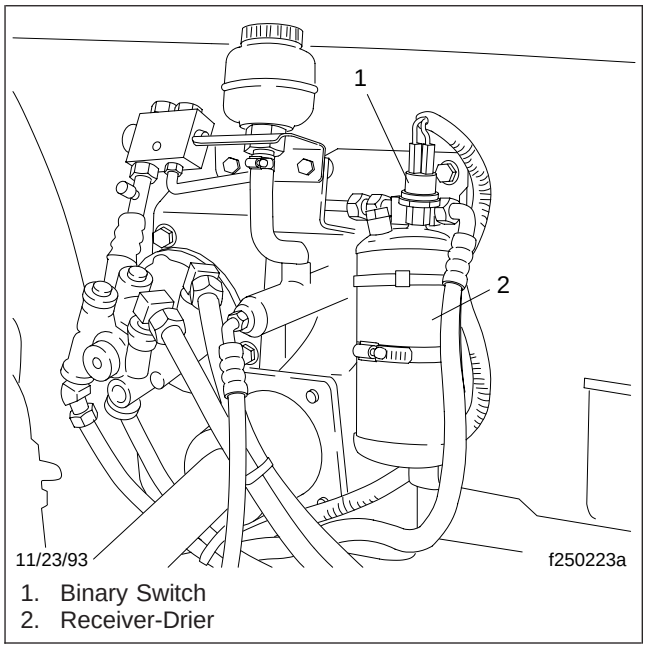


Fig. 1, Fan Cycling Switch

3. On vehicles built before November 1994, apply Loctite 242 or 592 to the male threads of the coupling. Install the fan cycle switch, and tighten it 108 lbf·in (1220 N·cm) or one-eighth turn past hand-tight.

   On vehicles built from November 1994, lubricate a new O-ring with mineral oil, then install it over the male threads of the receiver-drier coupling. Install the fan cycle switch and tighten it 20 to 25 lbf·ft (27 to 34 N·m).
4. Connect the wiring harness to the switch.
5. Check the system charge and charge the system with refrigerant if needed. Refer to **Subject 220** for instructions.
6. Lower the hood.

Replacement (See Fig. 1)



1. Binary Switch
2. Receiver-Drier

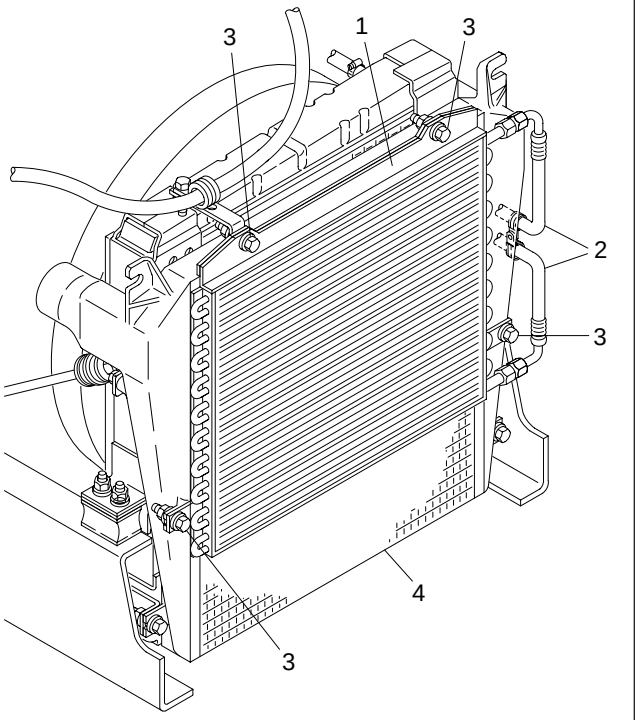
Fig. 1, Binary Switch Installation

NOTE: A Schrader valve in the receiver-drier prevents loss of refrigerant when removing the binary switch.

1. Tilt the hood.
2. Disconnect the electrical leads from the binary switch.
3. Unscrew the binary switch from the receiver-drier.
4. On vehicles built before November 1994, apply Loctite® 242 or 592 to the male threads of the binary switch coupling. Install the binary switch, and tighten it 108 lbf·in (1220 N·cm) or one-eighth turn past hand-tight.

   On vehicles built from November 1994, lubricate a new O-ring with mineral oil, then install it over the male threads of the receiver-drier coupling. Install the binary switch and tighten it 20 to 25 lbf·ft (27 to 34 N·m).
5. Check the operation of the air-conditioning system.
6. Lower the hood.

Replacement (See Fig. 1)



11/23/93 f500151a

1. Condenser
2. Refrigerant Hoses
3. Condenser Mounting Bolt
4. Radiator

Fig. 1, Condenser Installation

⚠ WARNING

WARNING: Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

1. Tilt the hood.
2. Wearing protective goggles and gloves, recover the refrigerant system. For instructions, refer to **Subject 220.**
3. Disconnect the refrigerant hoses from the condenser. Use two wrenches to avoid damaging the condenser.

⚠ CAUTION

CAUTION: Contaminants, such as water and dirt, can damage the refrigerant system. Five minutes of being uncapped is the limit for any part. Do not blow shop air through the refrigerant hoses since shop air is wet (humid).

4. Cap the refrigerant hoses.
5. Remove the four condenser mounting bolts.
6. Remove the condenser.
7. Position the condenser on the radiator. Install the capscrews and tighten them 20 N·m (15 lbf·ft).
8. Remove the plugs from the new condenser. Coat the O-rings with mineral oil and apply Loctite 242 or 592 to the male fitting threads.
9. Connect the refrigerant lines to the condenser. Using two wrenches, tighten the fittings 45 N·m (33 lbf·ft). *Be sure to add refrigerant oil to the compressor*, to replace that which was lost in the old condenser. Refer to the applicable compressor section in this group.
10. Charge the system with refrigerant; for instructions, refer to **Subject 220.**
11. Lower the hood.

Replacement

1. Disconnect the batteries.
2. Remove the vinyl extrusion trim at the top of the dash. See **Fig. 1**.

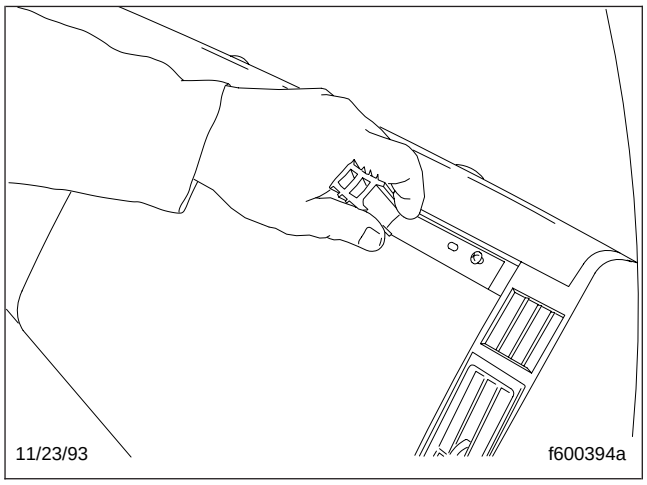
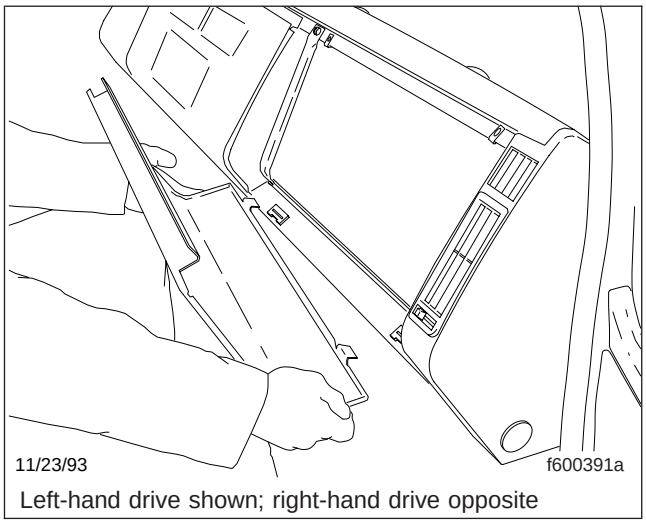


Fig. 1, Removing the Vinyl Extrusion Trim

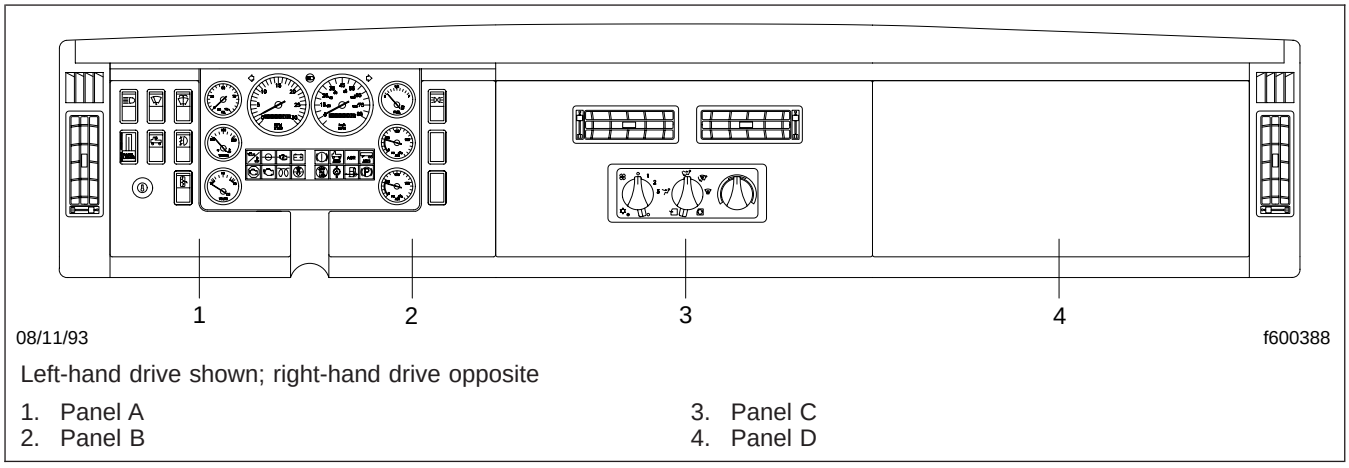
3. Remove dash panel D. Set it and its two mounting screws aside. See **Fig. 2** and **Fig. 3**.



Left-hand drive shown; right-hand drive opposite

Fig. 3, Removing Panel D

4. Remove dash panel B. See **Fig. 2**.
   - 4.1 If so equipped, remove the knobs from the parking brake air valve and the trailer brake air valve.
   - 4.2 If necessary in order to remove panel B, loosen the fasteners on the instrument panel. For detailed instructions see **Subject 110**.
   - 4.3 Lift off the panel. Set it and its two mounting screws aside.
5. Remove dash panel C.



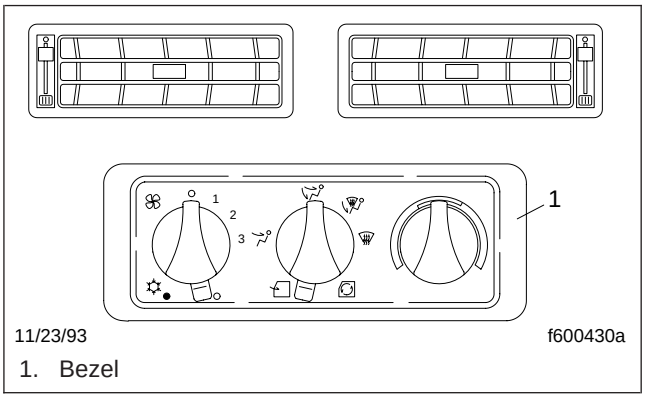
Left-hand drive shown; right-hand drive opposite

1. Panel A
2. Panel B
3. Panel C
4. Panel D

Fig. 2, Dash Panels

   - 5.1 Gently pry the bezel from the control panel in the center of dash panel C. See **Fig. 4**.
   - 5.2 Remove and set aside the four screws holding the control panel to dash panel C. See **Fig. 5**.

Control Panel Replacement



1. Bezel

Fig. 4, HVAC Control Panel

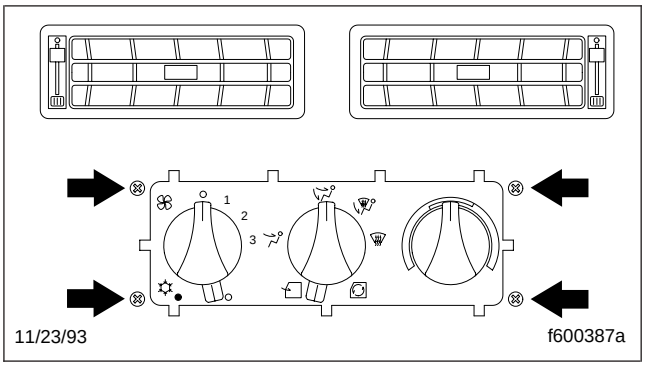


Fig. 5, Control Panel Mounting Screws

5.3 Remove the two mounting screws from the top of dash panel C.

5.4 Lift out the dash panel. Set it and the two mounting screws aside.

6. Remove the old control panel.

6.1 Remove the panel light and disconnect the electrical connectors from the control panel. Label the connectors so they can be installed in the same positions later.

6.2 Label the control cables for later reference. See **Fig. 6**.

6.3 Remove the screws that hold the control cables to the control panel; then, disconnect the cables.

6.4 Lift out the control panel.

7. Install the new control panel.

7.1 Position the control panel and install the four screws that mount it to the dash panel.

7.2 Attach the control cables to the control panel. Install the control cable mounting screws.

7.3 Insert the panel light and connect the wiring.

7.4 Install the bezel around the control panel.

8. Adjust the control cables. See **Fig. 6** and **Fig. 7**.

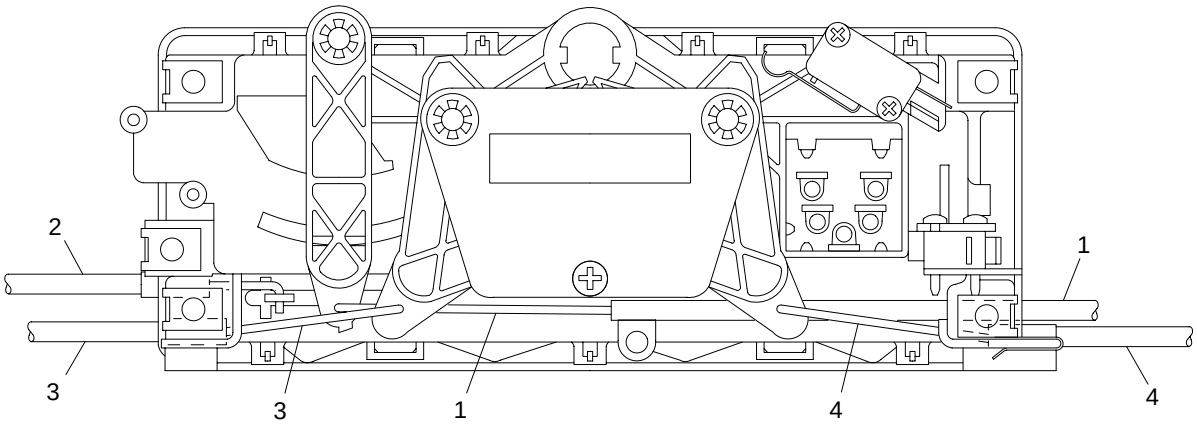
8.1 To adjust the cable (**Fig. 6**, Ref. 1) to the water regulating valve, set the dashboard control to the coolest setting (fully counterclockwise). Adjust the turnbuckle until the valve is almost at its mechanical stop in the closed position.

NOTE: The valve is fully closed or fully open before it reaches the mechanical stops at either end of its travel. After adjusting for the coolest setting, it is not necessary to adjust for the warmest setting.

8.2 To adjust the fresh air/recirculation door cable (**Fig. 6**, Ref. 2), remove the kick panel under the dashboard on the passenger side for access to the door. Move the control lever to the fresh air position. Adjust the turnbuckle (**Fig. 7**, Ref. 2) under the dashboard until the door snaps into the horizontal position and closes off the opening to the cab. Move the lever to the recirculation position and make sure the door snaps open. If necessary, readjust the turnbuckle so the door is in the correct position for each control lever setting.

8.3 To adjust the face/floor duct door and defrost duct door cables (**Fig. 6**, Refs. 3 and 4), set the control knob in the twelve o'clock position. Both face/floor duct doors should be open to direct air to the floor, and the defrost duct door should be open to let air out the face ducts. Adjust the turnbuckle (**Fig. 7**, Ref. 3) on the defrost duct door cable if necessary.

Turn the control knob fully counterclockwise; the face/floor duct doors should close. Remove the bottom section of one



1. Water Regulating Valve Cable
2. Fresh Air/Recirculation Door Cable
3. Face/Floor Duct Cable
4. Defrost Door Cable

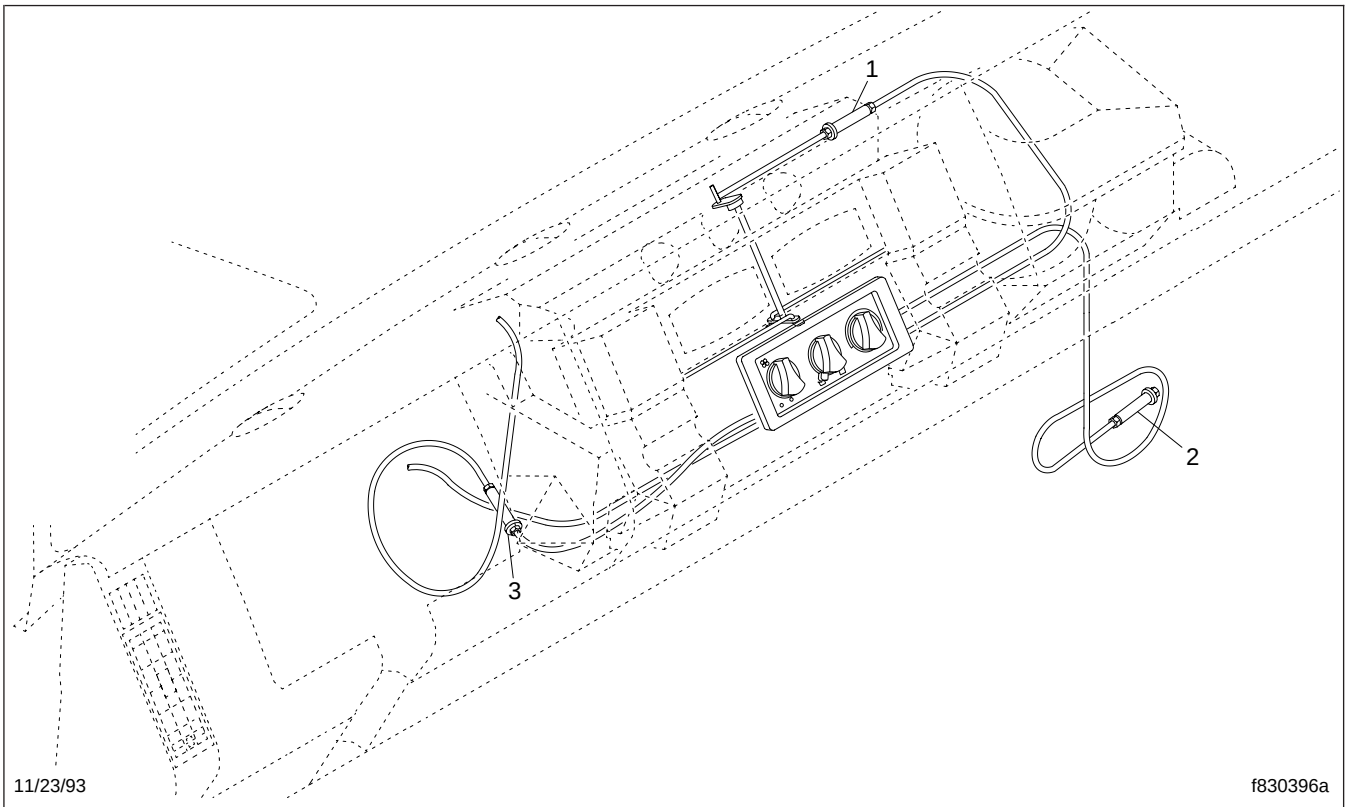
Fig. 6, HVAC Control Cables

of the floor ducts to check the door position. See **Fig. 8**. Adjust the turnbuckle (**Fig. 7**, Ref. 1) on the face/floor duct door cable if necessary.

Make sure there is a smooth transition from one cable to the other as the control knob moves through the twelve o'clock position. The defrost duct door cable should move when the control is to the right of the twelve o'clock position; the face/floor duct door cable should move when the control is to the left of the twelve o'clock position. As the control knob passes through twelve o'clock, one cable should stop moving and the other cable should start to move. If the cables are adjusted incorrectly, either the control knob will lock up before reaching twelve o'clock or the control knob movement will get very stiff.

9. Install dash panel C and tighten its two mounting screws.
10. Install dash panel B and tighten its two mounting screws. Install the knobs on the parking brake air valve and the trailer brake air valve, as removed.
11. If loosened, tighten the fasteners on the instrument panel. For detailed instructions, see **Subject 110**.
12. Install dash panel D and tighten its two mounting screws.
13. Install the vinyl extrusion trim at the top of the dash.
14. Connect the batteries.

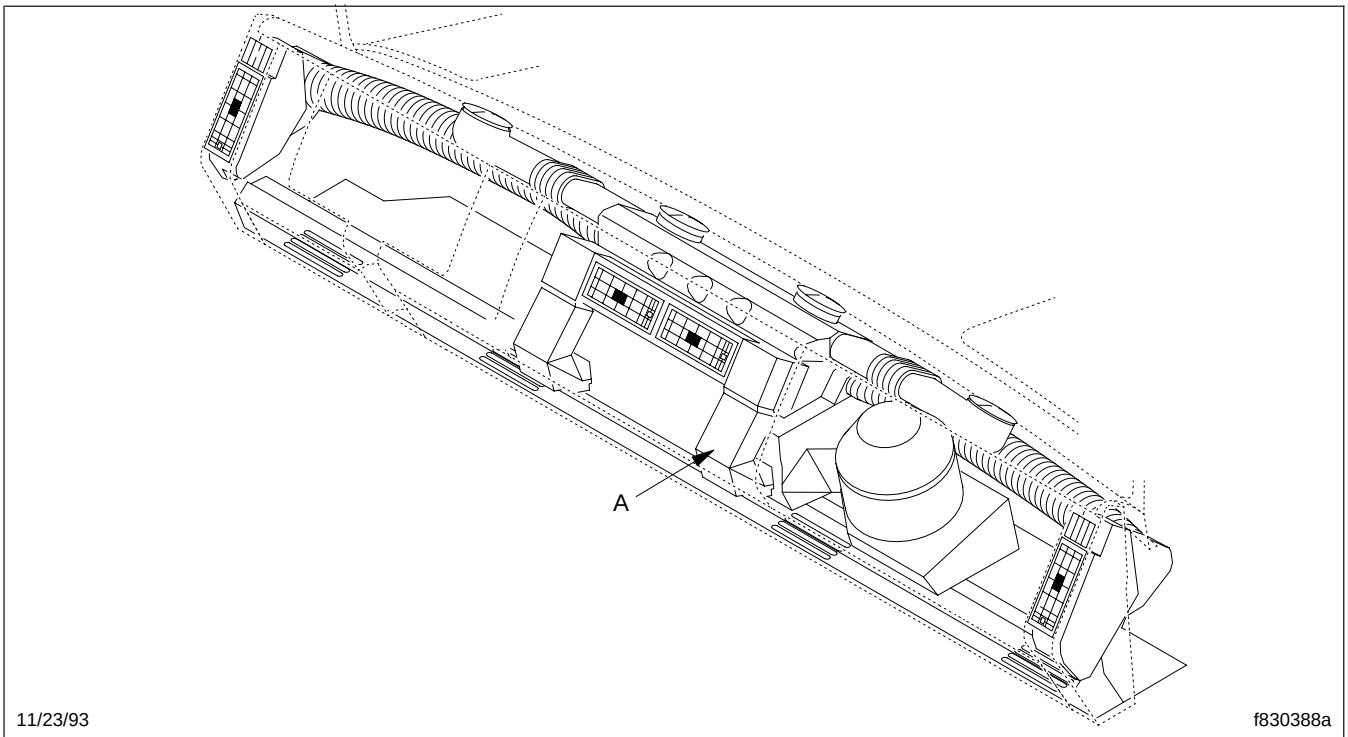
Control Panel Replacement



Left-hand drive shown; right-hand drive opposite

1. Turnbuckle for Face/Floor Duct Door Cable
2. Turnbuckle for Fresh Air/Recirculation Door Cable
3. Turnbuckle for Defrost Duct Door Cable

Fig. 7, Control Cable Adjustment



Left-hand drive shown; right-hand drive opposite

A. Remove this section of duct to check the door position.

Fig. 8, Duct Door Position Adjustment

Recovery, Evacuating/Recycling, Purging and Flushing, Charging, and Leak Testing

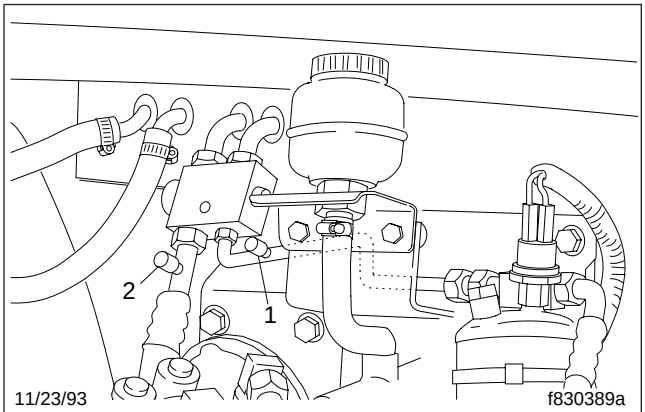
Recovery

⚠ WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

The recovery process removes most of the refrigerant charge in the system.

1. Tilt the hood.
2. If equipped with a swashplate-type compressor, start the engine and run the air conditioning system for 5 minutes. Shut down the engine.
3. Remove the caps from the suction and discharge service valves. See **Fig. 1**.



1. Discharge Service Valve
2. Suction Service Valve

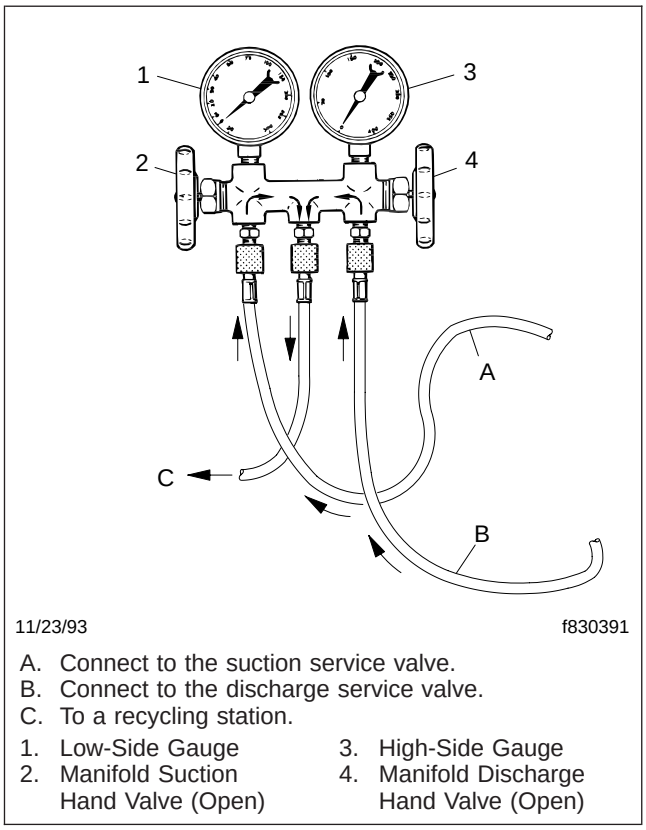
Fig. 1, Service Valves

4. Wearing protective goggles and nonleather gloves, attach the recover/recycling station's hoses to the valves. See **Fig. 2**.

   IMPORTANT: Push down firmly on the hose connectors until a clicking sound is heard. This will ensure that the coupler is locked.

   4.1 Make sure that the recovery and recycling station's valves are closed.

   4.2 Connect the red high-side hose to the discharge service valve.



A. Connect to the suction service valve.
B. Connect to the discharge service valve.
C. To a recycling station.

1. Low-Side Gauge
2. Manifold Suction Hand Valve (Open)
3. High-Side Gauge
4. Manifold Discharge Hand Valve (Open)

Fig. 2, Discharging Hookup

   4.3 Connect the blue low-side hose to the suction service valve.

   4.4 Turn the knob clockwise on each coupler to open the Schrader valves.

5. Follow the recovery and recycling station manufacturer's instructions and recover all of the refrigerant from the system.

IMPORTANT: Always comply with all local regulations regarding refrigerant disposal. You may be subject to substantial penalties for improper disposal.

6. Measure the oil recovered during this procedure. The compressor will have to be refilled with the same quantity of new refrigerant oil.

   If the system is contaminated with moisture, all of the compressor oil must be replaced with clean oil. If the system is heavily contaminated with desiccant or grit, replace the compressor, expansion valve, and receiver-drier.

Recovery, Evacuating/Recycling, Purging and Flushing, Charging, and Leak Testing

Evacuating (Recycling)

GENERAL INFORMATION

Moisture in a Refrigerant System

Water forms ice crystals at the thermostatic expansion valve. Ice crystals retard or stop the flow of refrigerant, causing a reduction or complete loss of cooling. As the expansion valve warms, due to the lack of refrigerant, the ice melts and passes through the expansion valve. Then refrigerant will flow again until the ice crystals reform. The result is intermittent cooling.

Refrigerant oil has an extremely high moisture absorption capacity. This reduces the lubricating ability of the oil, which could damage the compressor and other system components.

Effects of Pressure on the Boiling Points of Water

Water boils at 212°F (100°C) at an atmospheric pressure of 14.7 psi (sea level). At higher elevations the atmospheric pressure is lower which allows water to boil at lower temperatures. See **Table 1** for boiling temperatures of water at converted pressures.

Boiling Temperatures of Water at Converted Pressures

Boiling Temperature of Water °F (°C)	Absolute Pressure psi (microns Hg)	Vacuum inHg (mmHg)
212 (100)	14.696 (759993.4)	0 (0)
205 (96)	12.770 (660400.0)	3.92 (99.6)
194 (90)	10.169 (523881.6)	9.22 (234.2)
176 (80)	6.8699 (355269.8)	15.93 (404.6)
158 (70)	4.5207 (233786.7)	20.72 (526.3)
140 (60)	2.8900 (14958.7)	24.04 (610.6)
122 (50)	1.7987 (92555.1)	26.28 (667.5)
104 (40)	1.0700 (55336.4)	27.74 (704.6)
89 (30)	0.61540 (31826.2)	28.67 (728.2)
86 (27)	0.57010 (26220.4)	28.89 (733.8)
76 (24)	0.44435 (22979.9)	29.02 (737.1)
72 (22)	0.38856 (20094.7)	29.13 (739.9)
69 (21)	0.35084 (18143.7)	29.21 (741.9)
64 (18)	0.29505 (15258.5)	29.32 (744.7)
59 (15)	0.24720 (12783.8)	29.42 (747.3)
53 (12)	0.19888 (10285.0)	29.52 (749.8)
45 (7)	0.14746 (7625.8)	29.62 (752.3)
32 (0)	0.08858 (4579.6)	29.74 (755.4)
21 (–6)	0.05293 (2738.1)	29.81 (757.2)
6 (–14)	0.02521 (1304.0)	29.87 (758.7)
–24 (–31)	0.004905 (253.7)	29.911 (759.74)
–35 (–37)	0.002544 (131.6)	29.915 (759.84)
–60 (–51)	0.0004972 (25.7)	29.9200 (759.968)
–70 (–57)	0.0002443 (12.69)	29.92050 (759.9807)

Boiling Temperatures of Water at Converted Pressures		
Boiling Temperature of Water °F (°C)	**Absolute Pressure psi (microns Hg)**	**Vacuum inHg (mmHg)**
–90 (–68)	0.0000526 (2.72)	29.92089 (759.9906)

Table 1, Boiling Temperatures of Water at Converted Pressures

Similarly we can boil and remove water from the air conditioning system by lowering the system pressure to a vacuum to cause the moisture to vaporize at normal ambient temperatures. A vacuum pump can reduce the pressure in the system. Since the pressure is the lowest at the pump, water vapor is pulled out of the system. See **Fig. 3**. This process is called evacuation or dehydration. Also, most recover and recycling stations automatically recycle refrigerant during this process to ensure the system will be charged with the cleanest refrigerant possible.

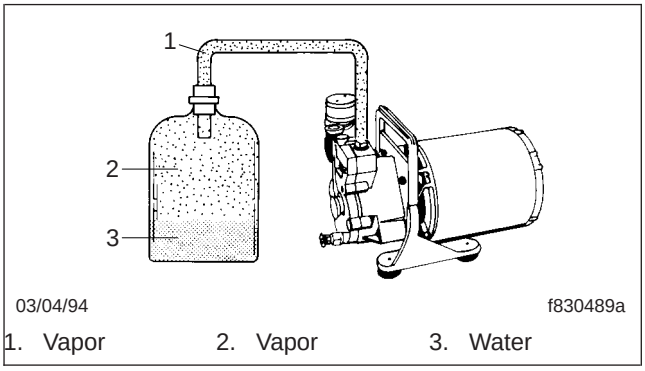


Fig. 3, Water to Vapor

Vacuum Pump Selection

The purpose of a high-vacuum pump is to reduce and hold a vacuum in the air conditioner system so moisture can be boiled at ambient temperature. For example, a vacuum pump capable of pulling a vacuum of 28.89 inHg (734 mmHg), is able to boil water at 80°F (27°C). There are various types of vacuum pumps available. Only some types are recommended for truck air conditioning evacuation.

Air pump-type vacuum pumps are designed to remove large volumes of air but do not develop high vacuum. They cannot pull more than 28 inHg (711 mmHg) which boils water at 100°F (38°C).

Compressor-type vacuum pumps come in two designs: piston-type and rotary-vane type. A piston-type compressor can typically pull a vacuum of 28.2 inHg (716.3 mmHg) which boils water at 96°F (36°C). A rotary-vane type compressor may pull a vacuum of 29.82 inHg (757 mmHg) which boils water at 21°F (–6°C), but it is limited to pumping 0.4 to 0.8 CFM, which is too slow to handle truck air conditioners.

High-vacuum pumps are available in single and two-stage models. A single-stage pump is adequate, but a two-stage pump is recommended to save time and ensure complete evacuation. See **Fig. 4**.

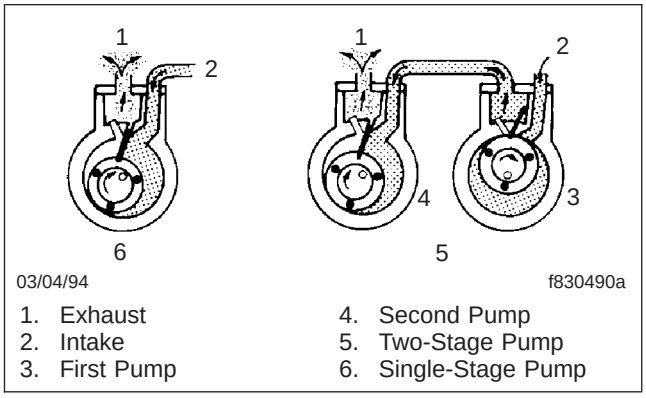


Fig. 4, Vacuum Pumps

Most single-stage high-vacuum pumps with a gas ballast will pull down to about 29.88 inHg (758.95 mmHg) which boils water at 4°F (–16°C).

A two-stage high-vacuum pump features a second pump to reach a higher vacuum than a single-stage pump. In a two-stage pump, the exhaust of the first pump discharges into the intake of the second pump. The second stage pumps at a lower pressure and therefore pulls a higher vacuum on the system than the first pump can by itself.

Two-stage high-vacuum pumps are capable of pulling down to 29.9192 inHg (759.95 mmHg) of vacuum for prolonged periods, which boils water at –60°F (–51°C).

The discharge line restriction is a factor affecting pump-down time. Pump-down time can be signifi-

cantly reduced by use of larger diameter hoses, as short in length as possible.

Pumping capacity affects pump-down time. It is perfectly acceptable to use a large vacuum pump on a small system. Using too small of a pump on a large system could cause premature pump wear, or require excessive time to pull a vacuum, even though the pump may be able to draw adequate vacuum.

The suggested *minimum* CFMs for pumps on different size air conditioners are listed in **Table 2**.

Minimum CFMs for Pumps on Different Size Air Conditioners	
System Size	**Suggested High-Vacuum Pump Size**
Panel Trucks Large Window Units	2.2 CFM
Tractor/Trailers, Buses Rooftop A/C systems	3.0 CFM
Refrigeration Van	15.0 CFM

Table 2, Minimum CFMs for Pumps on Different Size Air Conditioners

MEASURING VACUUM

Gauges

Vacuum can be measured with:

1. *Standard compound gauge.*

   A standard compound gauge reads low pressures in inches of mercury. It is not suitable for measuring high vacuum.

2. *Closed end manometer.*

   A closed end U-tube mercury manometer can be read with good accuracy. High vacuum readings can only be read from laboratory-style U-tube manometers (which are not practical for service shops).

3. *Electronic thermistor vacuum gauge.*

   An electronic thermistor vacuum gauge is designed for use with high vacuum pumps and can accurately read as low as 100 microns. This gauge can use an analog scale, a digital or LED display.

Procedure

The location of the vacuum gauge will affect the reading. The closer to the vacuum source, the lower will be the reading.

Isolate the vacuum pump with a good vacuum valve and allow the pressure in the system to stabilize before taking a final reading.

If the pressure will not stabilize, it is an indication of a leak. If it does stabilize at a vacuum which is too high (for example, 1500 microns), it is an indication of moisture, and more evacuation is required.

MAINTAINING THE VACUUM PUMP

Maintenance is important for high-vacuum pumps. The oil must be changed at regular intervals to prevent moisture buildup which will cause eventual pump failure.

Pumping down for extremely wet air conditioning systems can completely saturate the pump oil.

⚠ CAUTION

Flush the vacuum pump every fourth time it is used and before storing for long periods of time.

Vacuum pump oil is water soluble. This aids the pump in reaching a high vacuum by absorbing water and sealing the pump.

⚠ CAUTION

Acid will form and corrode the pump if water-laden oil remains in the pump for an extended period.

Only vacuum pump oil should be used as a lubricant. Do not use any solvent or any other oil. Clean oil should be run through the pump until it runs out clear. Oil should be added to the fill level indicated on the pump. Check the oil level before each use.

EVACUATION PROCEDURE

1. The system must have been recovered and the compressor filled with the correct amount of refrigerant oil. Replace the receiver-drier if the system is opened.

2. Wearing protective goggles and nonleather gloves, attach the recovery/recycling station's hoses to the valves (see **Fig. 1**).

   IMPORTANT: Push down firmly on the hose connectors until a clicking sound is heard. This will ensure that the coupler is locked.

   2.1 Make sure that the recovery and recycling station's valves are closed.

   2.2 Connect the red high-side hose to the discharge service valve.

   2.3 Connect the blue low-side hose to the suction service valve.

   2.4 Turn the knob clockwise on each coupler to open the Schrader valves.

3. Follow the recovery and recycling station manufacturer's instructions and evacuate/recycle the refrigerant system.

Purging and Flushing

GENERAL INFORMATION

⚠ WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

Purging removes damp air, traces of refrigerant, and loose particles from refrigerant parts by passing a stream of inert, dry nitrogen gas through the parts. If left in the system, these contaminants adversely affect the life and operation of the air conditioning system.

Flushing removes heavy contamination, such as gritty oil and large dirt buildup, which can't be removed by purging with gas. When a part is flushed, liquid refrigerant is forced through it; the liquid picks up the contaminants and flushes them out.

Whether to purge or flush a part depends on how much contamination there is, as described above.

Normally, the system always has pressure in it. Some loss of refrigerant from one season to the next is normal, and does not mean that the system is dirty. If refrigerant has leaked until the system is nearly empty, or if refrigerant parts show signs of internal corrosion and grit, the system is contaminated.

If the system is contaminated with moisture, purge all sections of the system. Then change the oil in the compressor and replace the receiver-drier prior to evacuating and charging the system.

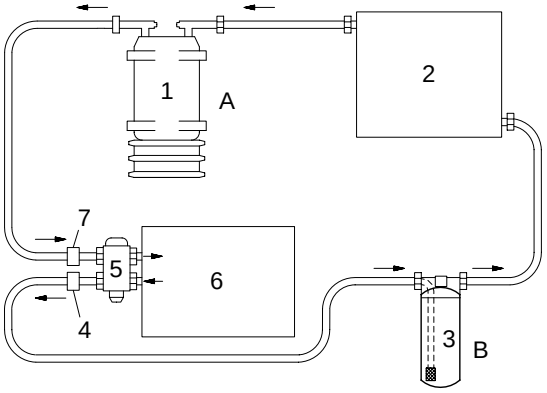
If the system is heavily contaminated, or if desiccant has circulated through the system, replace the receiver-drier, expansion valve, and compressor.

Do not purge the receiver-drier or the compressor.

Flush the system in segments to lessen the chance of blowing deposits against a port. See **Fig. 5**.

Purge or flush the system in the opposite direction of refrigerant flow (in other words, backflush the sections).

Flushing parts with refrigerant requires a recovery and recycling station.



11/23/93 f830395

NOTE: Arrows denote purge and flush points and direction of flow for gas/liquid.

A. Do not purge; instead, replace.
B. Do not purge; instead, replace.
1. Refrigerant Compressor
2. Condenser
3. Receiver-Drier
4. High-Side Service Valve
5. Expansion Valve
6. Evaporator
7. Suction Service Valve

Fig. 5, Purge and Flush Points

Recovery, Evacuating/Recycling, Purging and Flushing, Charging, and Leak Testing

PURGING PROCEDURE

(See Fig. 6)

NOTE: Dry nitrogen gas is recommended for purging. A pressure regulator is required to regulate between 0 to 200 psi. Commercial cylinders of nitrogen contain pressures in excess of 2000 psi (13 780 kPa); This pressure must be reduced to 200 psi (1378 kPa) for purging.

1. Recover the system refrigerant.
2. Disconnect both ends of the line or part being purged. Tightly cap the rest of the system.
3. Make sure valves 1, 2, and 3 are closed.
4. Connect the supply line valve to the outlet end of the part or line.
5. Connect the drain line to the inlet end of the part or line.
6. Place the outlet of the drain line into a recycling system container.
7. Adjust the nitrogen bottle regulator to 200 psi (1378 kPa). Open the nitrogen bottle control valve and the purging control valve. Then, slowly open the supply line valve. Check the drain line for gas flow.
8. Let the nitrogen flow at 200 psi (1378 kPa) for 25 to 30 seconds.
9. Lower the pressure to 4 psi (28 kPa) and let it flow for 1 to 2 minutes. If the line or part was very wet, allow it to flow until there is no trace of refrigerant oil or solid bits of dirt or grit flowing from the drain tube.
10. Close the nitrogen bottle control valve and the purging control valve first, then close the supply line valve.
11. Disconnect the supply line valve and the drain line. Tightly cap both ends of the part or line.

FLUSHING PROCEDURE

1. Recover the system refrigerant.
2. Disconnect both ends of the line or part being flushed. Tightly cap the lines to the rest of the system.
3. Heat R–134a in a charging cylinder or pressurize the refrigerant as recommended by the manufacturer.
4. Connect the charging cylinder outlet hose to the outlet side of the system (this will ensure that R–134a will flow in the reverse direction of normal flow).
5. Connect a line from the inlet side of the system to a recovery/recycling station.

NOTE: If the system is extremely contaminated, install a receiver-drier inline as a prefilter for the recovery/recycling station.

6. Turn on the recovery/recycling station and open the outlet valve for the charging cylinder. Allow about 2 pounds (1 kilogram) of R–134a to flow through the system.
7. Close the supply line valve and wait for the recovery station to shut off.
8. Disconnect the supply line and the drain line from the charging cylinder and the recovery station. Connect the lines to a nitrogen bottle.
9. Purge the system and check the collection bottle for contaminants. Repeat the process if needed.
10. Disconnect the lines from the part and tightly cap both ends of the part.

Charging

⚠ WARNING

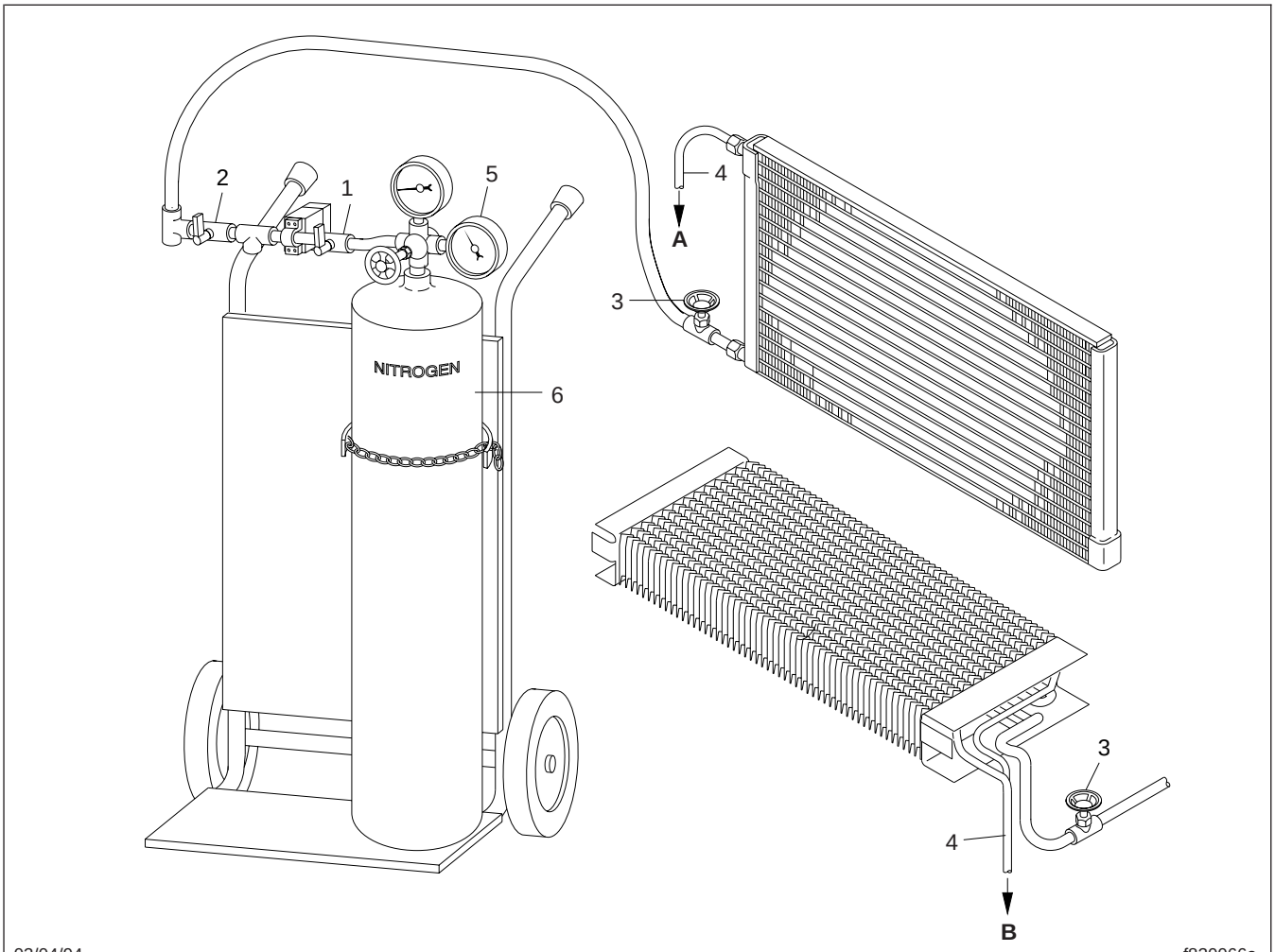
Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

NOTE: Before charging, the system must be recovered and evacuated with the recovery and recycling station connected to the service and discharge port connections.

1. Obtain 52 oz (1.47 kg) of refrigerant to fully charge the system.

   Set the tank on a scale and weigh it so that the correct amount of refrigerant enters the system.

Recovery, Evacuating/Recycling, Purging and Flushing, Charging, and Leak Testing



A. To Waste Container
B. To Recycling System Container
1. Nitrogen Bottle Control Valve
2. Purging Control Valve
3. Supply Line Valve
4. Drain Line
5. Nitrogen Bottle Regulator/Gauge
6. Nitrogen Bottle

Fig. 6, Purging Station

This prevents overcharging, which could damage the compressor.

2. Charge the refrigerant system.

   NOTE: If equipped with a recovery, recycling, and recharging station, charge the system on the high side following the manufacturer's instructions. If charging from a bulk container, do the following.

   2.1 Turn the tank (bulk container) upside down. With the engine off, open the high-side hand valve. *Do not* open the low-side hand valve

   2.2 Allow refrigerant to enter the system until the correct charge (by weight) has entered. Then, close the high-side hand valve.

Recovery, Evacuating/Recycling, Purging and Flushing, Charging, and Leak Testing

2.3 Start the engine and run it at 1500 rpm. Set the cab air conditioner controls at maximum cooling and fan speed; the refrigerant compressor must engage.

2.4 If a full charge did not enter the system, place the tank (bulk container) in the upright position, then open the *low-side valve* to draw vapor into the system; leave the valve open until the correct weight of refrigerant has entered the system, then close the low-side valve.

NOTE: If refrigerant is slow to enter the system because of low outside temperatures, vaporization can be quickened by placing the refrigerant tank in a tub of warm water, no warmer than 125°F (52°C).

3. While the compressor is engaged, check the operating pressures at the suction and discharge ports; see the applicable compressor section in this manual. If the operating pressures are not acceptable, see **Troubleshooting 300** for possible causes.
4. Disconnect the high-side hose. With the engine running, open the low-side and high-side hose valves to recover the refrigerant from the lines.
5. Shut down the engine.

Leak Testing

GENERAL INFORMATION

⚠ WARNING

Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

Refrigerant is odorless; as a result, all of it may leak away and not be noticed until the system stops cooling. All vehicle refrigerant systems lose some refrigerant, depending on the condition of the system. Higher loss rates signal a need to locate and repair the leaks.

Leaks are most often found at the compressor hose connections and at the various fittings and joints in the system. If unapproved replacement hoses are installed, refrigerant can be lost through hose permeation.

METHODS OF LEAK DETECTION

When checking for leaks, always focus your attention on the lowest portion of the fitting or part being tested. Refrigerant is heavier than air and will collect at the low point. Oil will also flow toward the low point. Listed in sequence from least precise to most precise, the methods for locating leaks are:

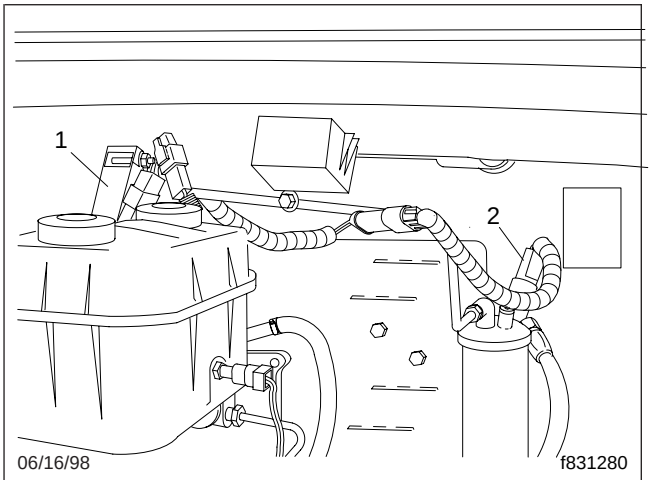
1. *Soapsuds solution*. A solution of soap and water can be squirted onto a suspected fitting or part. If the leak is large enough it will cause bubbles to form in the soapy solution at the point of the leak.
2. *Electronic leak detectors*. Electronic leak detectors are battery or 115-volt powered and rely on a very sensitive signal when a leak is found. In addition to being very precise, electronic leak detectors can be used in tight places.

NOTE: Do not try to use a leak tester right after connecting or disconnecting service hoses. Traces of refrigerant at the fittings can falsely signal a leak.

Air Conditioning Protection and Diagnostics System Electronic Control Module Replacement

Replacement

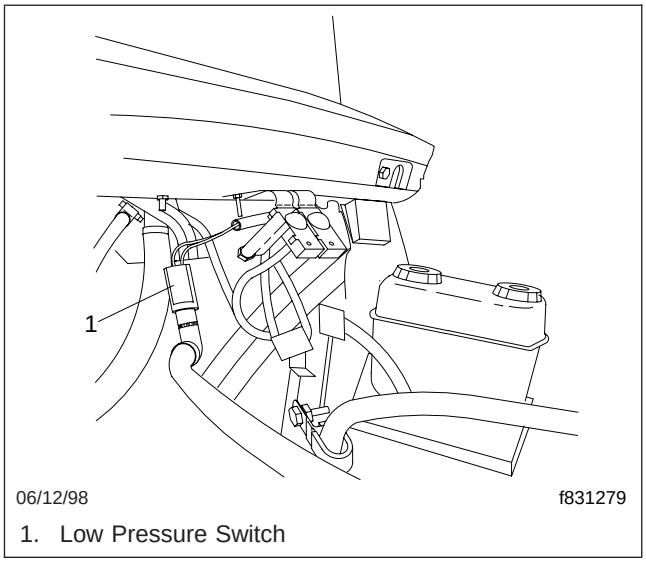
1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Open the hood.
4. Disconnect the high and low pressure switch harnesses on the Air Conditioning Protection and Diagnostics System (APADS™) electronic control module. See **Fig. 1** and **Fig. 2**.



1. Electronic Control Module
2. High Pressure Switch

Fig. 1, APADS™ Electronic Control Module

5. Remove the two bolts, washers, and nuts that fasten the APADS™ electronic control module to the mounting bracket. Keep the fasteners for installation.
6. Attach the new APADS™ electronic control module to the mounting bracket using the bolts, washers, and nuts. Tighten the bolts securely.
7. Connect the high and low pressure switch harnesses to the connectors.
8. Close the hood.
9. Connect the batteries.
10. Remove the chocks from the tires.



1. Low Pressure Switch

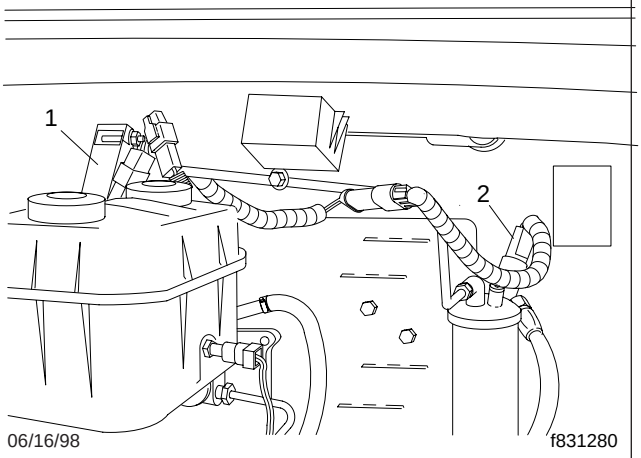
Fig. 2, APADS™ Low Pressure Switch

Air Conditioning Protection and Diagnostics System Pressure Switch Replacement

Replacement

NOTE: This procedure can be used for replacing both the low pressure switch and the high pressure switch.

1. Turn off the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries.
3. Open the hood.
4. Disconnect the pressure switch harness on the Air Conditioning Protection and Diagnostics System (APADS™) electronic control module. See **Fig. 1** and **Fig. 2**.



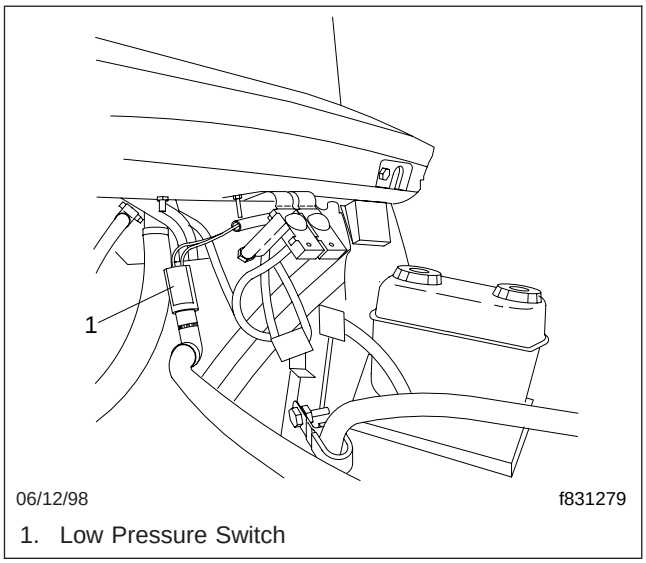
1. Electronic Control Module
2. High Pressure Switch

Fig. 1, APADS™ High Pressure Switch

5. Remove the pressure switch from its port on the refrigerant line.
6. Lubricate a new O-ring with mineral oil, and place it on the coupling on the refrigerant line.
7. Attach the pressure switch to the port and tighten 20 to 25 lbf·ft (27 to 34 N·m).

IMPORTANT: After replacing the high pressure switch, clear the blink code by cycling the ignition switch—one cycle on, one cycle off—for four consecutive cycles.

8. Connect the pressure switch harness to the connector.



1. Low Pressure Switch

Fig. 2, APADS™ Low Pressure Switch

9. Close the hood.
10. Connect the batteries.
11. Remove the chocks from the tires.

Preliminary Checks

Before testing the operation of the air conditioning system, make the following checks.

1. Make sure the refrigerant compressor's drive belt is not damaged and is correctly tensioned. Also check the compressor mountings for tightness. For instructions and other information, see the applicable refrigerant compressor section elsewhere in this group.
2. Using a feeler gauge, check for correct refrigerant compressor clutch clearance. For instructions, see the applicable refrigerant compressor section elsewhere in this group.
3. Check for broken, burst, or cut hoses; also check for loose fittings on all parts.
4. Check for road debris buildup on the condenser coil fins. Using air pressure and a whiskbroom or a soapy spray of water, carefully clean off the condenser; be careful not to bend the fins.
5. Check the color of the moisture indicator sight glass. If the color is a deep cobalt blue, the refrigerant charge is dry. If the indicator is *not* blue, the system is contaminated with moisture; recover the refrigerant, evacuate the system, replace the receiver-drier, and add a full refrigerant charge.
6. If there is not enough airflow, make sure that leaves or other debris has not entered the fresh air ports under the windshield. If debris has entered, it could clog the fins of the evaporator coils, and block airflow.

   Also, be sure that all ducts are connected to the dash louvers and that the air-control flaps in the heater housing are moving properly (this requires removal of the right and center dash panel).

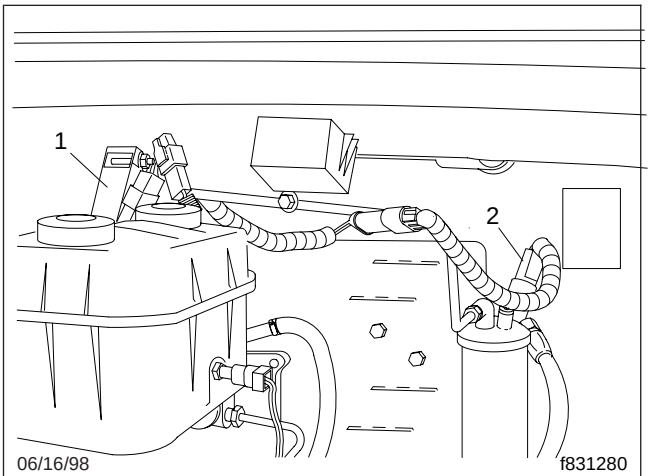
Performance Tests

Following is a brief description of symptoms or conditions that will exist if something goes wrong in a refrigerant part.

AIR CONDITIONING PROTECTION AND DIAGNOSTICS SYSTEM (APADS™)

The Air Conditioning Protection and Diagnostics System consists of an electronic control module, high and low pressure switches, and an evaporator thermostat. The electronic control module actively monitors system conditions and controls the operation of the refrigerant compressor and the fan clutch.

Located under the hood on the left-hand side of the frontwall (**Fig. 1**), the electronic control module registers fault codes that warn of existing or impending problems in the air conditioning system. Diagnostic information is provided by blinking red and green LEDs (light emitting diodes) built into the electronic control module. Since only one blink code can be displayed, the fault code of highest priority takes precedence. See **Table 1** for the fault code order of priority. Only the highest priority fault code is held in memory. Once the fault code is cleared, a new fault must occur to initiate a new blink code.



1. Electronic Control Module
2. High Pressure Switch

Fig. 1, APADS Control Module and Pressure Switch

A "blink" is approximately 1/4 second in duration. Once the number of blinks has been broadcast, there is a delay time of two seconds before the blink code is repeated. See **Table 2** for a description of blink codes.

The blink code is cleared by two methods:

Troubleshooting

- Cycle the ignition switch—one second on, one second off—for four consecutive cycles.
- Self-clearing based on the persistence of the fault. If a fault condition occurs once and does not repeat, the fault code is held for an extended period of time and then cleared. If the fault is repetitive, it will always be retained in memory until the problem is fixed.

For APADS™ troubleshooting information, see **Table 3**.

APADS™ Fault Code Order of Priority			
Priority	**Fault Code Name**	**Fault Description**	**LED Blinks**
1	Static low pressure	Full loss of charge	1
2	Dynamic low pressure	Partial loss of charge	1
3	High pressure	Overcharge, blocked condenser	2
4	Open clutch	Clutch wire open	3
5	Shorted clutch	Shorted clutch coil	3
6	Low pressure switch open	Cut wire to low pressure switch	4
7	High pressure switch open	Cut wire to high pressure switch	4
8	Low voltage	Low battery voltage	Rapid Green
9	No faults	No faults, module functional	Red off, Green slow blink

Table 1, APADS Fault Code Order of Priority

APADS™ Blink Codes	
Condition	**Description**
Slow Green	Unit is functioning properly
Fast Green	Low system voltage
One Red Blink	Loss of refrigerant
Two Red Blinks	Fan failure or external condenser blockage
Three Red Blinks	Voltage drop out, open or shorted wire to compressor clutch
Four Red Blinks	Open wire in pressure switch circuit

Table 2, APADS Blink Codes

APADS™ Troubleshooting Table			
Condition	**Definition**	**Possible Cause**	**Action**
Slow flashing green light.	Two seconds on, 1/2 second off.	Unit is functioning properly.	No action is needed.
Rapid flashing green light.	Low system voltage, indicates low supply voltage condition. Voltage has dropped below 11.0 volts.	Possibly caused by a damaged alternator, discharged batteries, poor ground, or an excessive electrical load.	Check voltage at the control harness by probing pins 4 (ground) and 2 (power). If voltage is less than 11.0 volts, start checking for voltage drops or a poor ground.

APADS™ Troubleshooting Table			
Condition	**Definition**	**Possible Cause**	**Action**
Ignition on, LEDs not flashing on control module or no lights on module.	Control module not receiving battery voltage.	Fuse or circuit breaker is blown.	Repair the fuse or reset the circuit breaker.
		Broken power or ground wire to control module.	Repair the wiring.
		Damaged control module.	Replace the APADS™ electronic control module, or retrofit the APADS with a binary switch. For instructions, see Service Bulletin 83–74.
Red light flashing one blink in sequence.	Low pressure fault. This is detected by monitoring the ambient temperature and switching activity of the low pressure switch.	Partial or total loss of refrigerant.	Install service gauges and the check system for leaks.
		A damaged low pressure switch.	Disconnect the low-side pressure switch connector and measure the resistance value of the switch. If the resistance shows 2.49k ohms, the switch is operating properly. If the resistance shows less than 5 ohms, replace the switch. NOTE: This check must be done with the switch installed on the vehicle, and the ignition in the off position and proper charge.
Red light flashing two blinks in sequence.	High pressure fault. The system is exhibiting abnormal high pressure activity.	Fan drive failure.	Inspect proper operation of the solenoid valve, relay, and/or related components.
		Blocked air flow through the condenser.	Remove the restriction from the condenser.
Red light flashing three blinks in sequence.	Open wire to A/C clutch. Detected by inadequate current through the compressor clutch. If no current is sensed when the A/C drive is turned on, an open connection to the clutch coil is indicated.	A break in the wiring between the control module and the A/C compressor clutch, or a break in the clutch coil.	With the use of an ohmmeter, check the resistance of the clutch coil. If the reading is less than 2.8 ohms, replace the clutch.
	Shorted wire or shorted A/C clutch. Detected by excessive current through the compressor clutch.	This indicates either a shorted clutch coil or shorted wiring to the clutch.	Locate and repair the shorted or frayed wiring between the control module and the A/C clutch.
	Fluctuating battery voltage.	Fluctuation of greater than one volt caused by a damaged voltage regulator.	Replace the alternator.

Troubleshooting

APADS™ Troubleshooting Table			
Condition	**Definition**	**Possible Cause**	**Action**
Red light flashing four blinks in sequence.	Opening in wiring harness to high or low pressure switches.	Unseated connector.	Check the connectors at the module and the pressure switch for loose pins.
		Break between wiring harness and pressure switch.	With the use of an ohmmeter, probe the yellow and yellow/black pins of the module harness. Resistance should read less than 5 ohms.
		Moisture intrusion into the connectors or switch.	Check the seals and inspect the wires for continuity.
		The use of a non-Index pressure switch.	Install the correct pressure switch.
A/C clutch is not engaging during the first 15 seconds after the ignition is turned on.	—	Unit is working. Regardless of A/C system state at start-up, the A/C clutch is disengaged for the first 15 seconds.	—
When the engine is turned on, and the A/C controls are set to the on position, the compressor is off for 15 seconds, on for 15 seconds, and then remains off indefinitely.	No voltage going to A/C compressor clutch.	Unsatisfactory A/C input signal.	Check for a break in the wiring between A/C clutch and the A/C controls.
			Check for a bad A/C on/off control switch.
			Check for a bad A/C relay.
At start-up, after 15 seconds, compressor clutch doesn't engage, but engine fan engages.	Control module sensing an opening in the high pressure switch circuit.	High-side pressure switch failure.	Check the switch by measuring the resistance value across the leads. If the resistance shows less than 1k ohms, the switch is functioning properly. If resistance is greater than 100 ohms, replace the switch.
Slow flashing green, compressor is on for a short period of time, off for 15 seconds in a repetitive sequence.	Indicates that the system is exhibiting abnormal high or low pressure activity.	Blockage on the high side of the system or in the condenser.	Repair the restriction.
		Partial loss of refrigerant.	Check the system for loss of refrigerant.
Slow flashing green light, not engaging in defrost mode or in cold weather.	—	The unit is more than likely functioning correctly. If the ambient temperature is too low, the compressor clutch is not allowed to engage because of low system pressure.	—

APADS™ Troubleshooting Table			
Condition	**Definition**	**Possible Cause**	**Action**
Slow flashing green, clutch is engaged, A/C is not cooling.	—	Inoperative blower motor.	Check for proper operation of the blower motors.
		Loose or broken compressor belts.	Tighten or replace the compressor belts.

Table 3, APADS Troubleshooting Table

COOLING CHECK

When outside temperature and humidity are high, it will take longer to cool the cab, especially if the fresh air vents are left open.

To determine if the air conditioner is cooling enough:

1. Set the engine speed at 1500 rpm.
2. Close the doors and windows.
3. Turn on the air conditioner. Set the controls at maximum cooling (recirculated air) and blower speed. The compressor must be engaged during this test.
4. Allow the system to run for at least 10 minutes (longer on hot and humid days).
5. Place a thermometer inside the louver or air duct; make sure the controls are set so that air flows out of the duct being tested.
6. Compare the measured temperature readings to the readings in **Table 4**. If the duct's air temperature is higher than normal readings, the system isn't cooling enough. For possible causes, see the troubleshooting tables.

RECEIVER-DRIER

The receiver-drier is normally at outside temperature. To the touch, the entire length of the unit should be the same temperature. If noticeable cool spots exist, replace the receiver-drier.

A blockage at the inlet of the unit will cause high head pressures; outlet blockages will cause low head pressures and little or no cooling.

If the moisture indicator is pink or white (showing that the system is wet), the receiver-drier is saturated with moisture and must be replaced.

Temperature/Pressure Specifications						
Ambient Air Temperature °F (°C)	**Humidity**		**Dash Louver Temperature °F (°C) †**	**Service Port Pressures * †**		**A/C Compressor Cycling On?**
	Target	**Actual (Relative Humidity)**		**High (psi)**	**Low (psi)**	
70 (21)	Low	25%	44 (6)	144	20.1	Yes
70 (21)	High	55%	45 (7)	146.6	21.6	Yes
80 (27)	Low	25%	46 (8)	164.4	20.1	Yes
80 (27)	High	55%	51 (11)	201.8	24.4	No
90 (32)	Low	25%	49 (9)	219.8	22.6	No
90 (32)	High	55%	60 (16)	242.1	31.5	No
100 (38)	Low	25%	57 (14)	261.3	29.5	No
100 (38)	High	55%	68 (20)	309.3	42.5	No

* Service port pressures recorded with A/C compressor running.
† Fresh air mode in use.

Table 4, Temperature/Pressure Specifications

Troubleshooting

COOLING SYSTEM

Although they are not physically connected, there is a close tie between a vehicle's air conditioner and its cooling system. Poor air conditioner cooling can be the result of a problem in the cooling system.

If the cooling system does not work correctly, the heat of the engine will rise to abnormal levels. The added heat will transfer to the air conditioner, other underhood parts, and maybe make its way into the cab. The added heat makes it necessary for the air conditioner to work harder and, at the same time, it reduces the air conditioner's ability to cool down the air in the cab. Also, if the water regulating valve isn't closing all the way, heat will enter the cab, giving the impression that the air conditioning system is not working.

See **Group 20** of this manual for cooling system troubleshooting and to the engine manufacturer's service manual for other details about cooling system problems.

EXPANSION VALVE

Problems that start in the expansion valve show up as follows: when stuck closed, the evaporator coil and the expansion valve will be at outside temperature; when stuck open, both the coil and the valve will be extremely cold with frost or ice buildup.

Because the expansion valve is very sensitive to contamination, blockages in the system tend to be found here. Usually, the contaminant is water; less than a drop of water is all it takes to make the valve inoperative. When water reaches the valve, the extreme cold that results from the pressure drop freezes the water, forming a block of ice in the valve. After the system shuts down and the valve warms up, the ice melts, and the valve operates again, only to freeze up when the moisture returns.

On-and-off operation of the expansion valve means that the receiver-drier is not removing moisture from the system. This should cause the moisture indicator's element to turn white and then pink.

REFRIGERANT COMPRESSOR

Compressor problems usually show in one of four ways: abnormal noise; seizure; leakage; or low suction and discharge pressures.

Resonant compressor noises are not causes for alarm; irregular noise or rattles are likely to be caused by broken parts. To check for seizure, de-energize the magnetic clutch and see if the drive plate can be turned. If it won't turn, the compressor has seized.

Low discharge pressure may be caused by not enough refrigerant, not enough belt tension, or a blockage somewhere in the system. These things should be checked before servicing the compressor.

EVAPORATOR

The evaporator coils are basically trouble-free when airflow over the fins is not blocked. External or, less often, internal blockages will cause low suction pressure as well as little or no cooling.

If a leak exists in the system, and it cannot be traced to other parts or fittings, suspect damage to one of the evaporator coils.

CONDENSER

The condenser is also usually trouble-free when road debris, such as leaves or dirt buildup, is removed. If debris cakes up, airflow over the condenser fins is blocked; air is not able to absorb enough heat to turn the hot refrigerant gas into a liquid. High head pressures will result. In these cases, carefully clean off the outer surfaces of the condenser with compressed air or a soap and water solution; be careful not to bend the fins.

High head pressures will also occur if the condenser's tubing is abnormally bent, blocking the flow of refrigerant. Frost will appear at the point where the flow is restricted.

Less common internal blockages (bits of foreign material or metallic grit buildup) will stop the flow of refrigerant.

A quick test to check that poor system performance is caused by the condenser is to direct a spray of water onto the condenser while the system is running. If the air conditioner cools better because of the assist provided by the water, it is a sign that the condenser is not working.

When troubleshooting a suspected condenser problem, remember that the problem may be caused by the cooling system transferring high levels of heat to the condenser. See **Group 20** of this manual for cooling system troubleshooting and to the engine manufacturer's service manual for other details about cooling system problems.

THERMOSTATIC SWITCH

Before troubleshooting the thermostatic switch, be sure there is a full charge of refrigerant in the system. The compressor will not operate, or will cycle too often, if there is not enough refrigerant in the system.

Quick or delayed cycling of the compressor may be caused by a thermostatic switch that is working, but is out of adjustment. If, after doing the tests below, the switch seems to be out of adjustment, replace it (the thermostatic switch cannot be recalibrated).

NOTE: If the thermostatic switch is removed, it must be inserted at the same location of depth.

1. Be sure the compressor clutch is operating correctly. See the applicable refrigerant compressor section elsewhere in this group.
2. Expose the evaporator coil. See **Subject 120** for instructions.
3. Start the engine. Place the air conditioner control at its coldest setting. Turn on the air conditioner and the fan.
4. Place an accurate thermometer in contact with a tube on the evaporator coil. Be sure the thermometer is in good contact with the tube, or you will get a wrong reading.

   When the temperature drops below 31° to 36°F (–1° to 2°C), the compressor clutch should disengage and remain this way until the temperature rises to 39° to 44°F (4° to 7°C).
5. If the compressor did not engage when the temperature was above the accepted high range, check the thermostatic switch and its wiring.

   5.1 Connect a voltmeter or a test light from one of the terminals on the thermostatic switch to ground. Repeat this test with the other terminal on the switch.

   5.2 With the engine running and the air conditioner and blower on, both terminals will show voltage when the compressor should be engaged; one terminal will show voltage when the compressor should be disengaged.

   If there is no voltage, there is a problem in the electrical system from the batteries to the thermostatic switch. Check all circuits for the cause, and repair or replace the wiring or parts.

   In all other cases where the compressor is not engaging and disengaging properly, the thermostatic switch is the cause. Replace it with a new switch.
6. Shut down the engine and, to prevent accidental electric shock or shorting during dash assembling, disconnect the batteries.
7. Assemble the dash; see **Subject 120** for instructions.

LINE RESTRICTIONS

A restricted suction line causes low suction pressure at the compressor and little or no cooling. A restriction in a line between the compressor and the expansion valve can cause high discharge and low suction pressure, and insufficient cooling.

Usually, areas of ice or frost buildup mean a blockage. Parts that often freeze up are probably corroded or inoperative and should be replaced. Parts (such as the expansion valve) that freeze up once in a while may do so because of moisture in the system, which will cause the moisture indicator's element to turn white or pink; if this happens, recover the refrigerant charge, evacuate/recycle the system refrigerant, replace the receiver-drier, and install a new charge.

Fault Analysis Flow Chart

See **Fig. 2** for the fault analysis flow chart.

Troubleshooting Tables

Troubleshooting

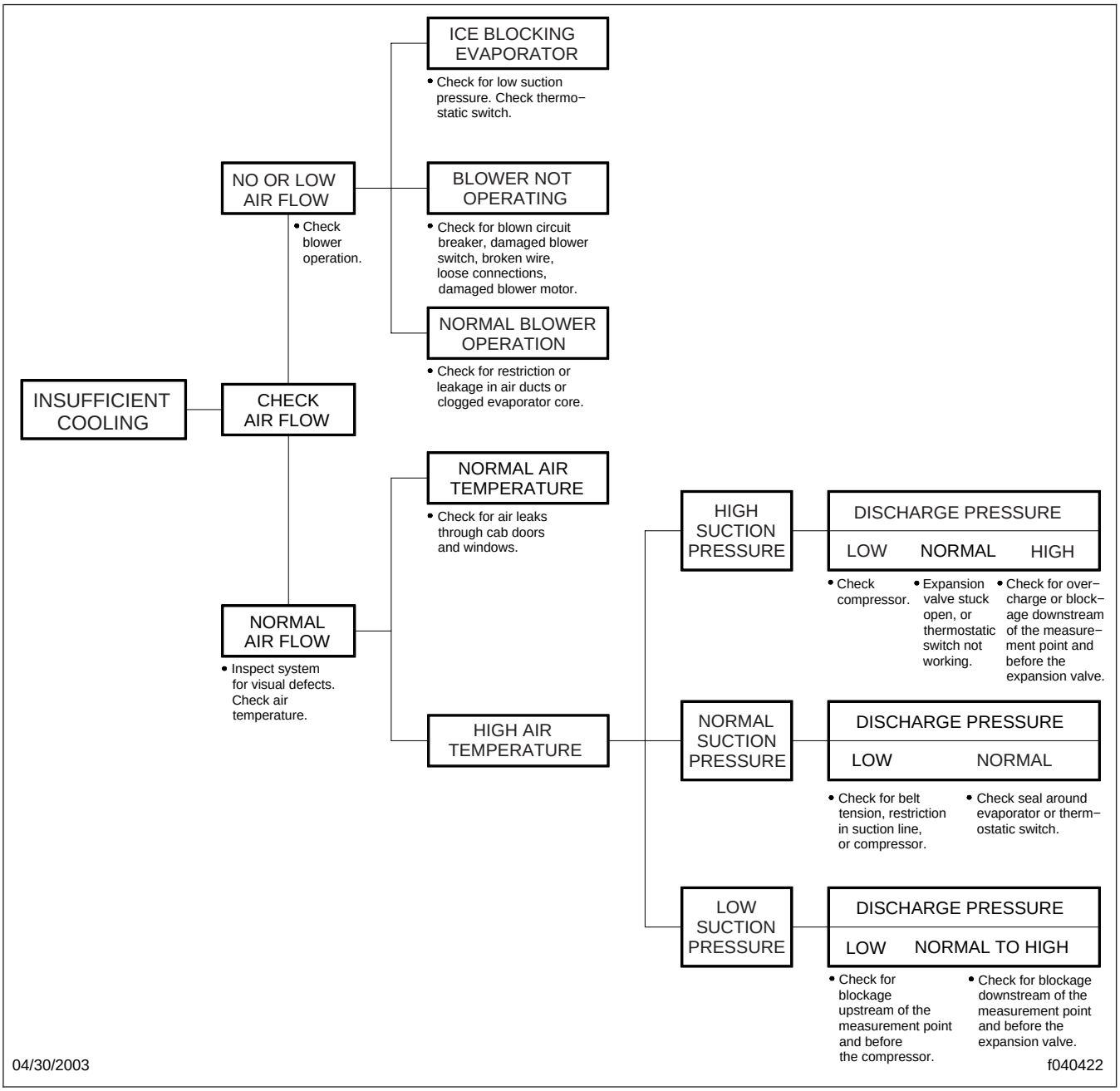


Fig. 2, Fault Analysis Flow Chart

Problem—Little or No Airflow

Problem—Little or No Airflow	
Possible Cause	**Remedy**
The blower is not operating.	Check for an open circuit breaker. An open circuit breaker indicates a short in the electrical system, which must be located and repaired.
	Check the air conditioner relays for operation. Replace, as necessary.
	Make sure the blower motor switch is working. Replace, if necessary.
	Check the wiring to the blower motor. If any connections are loose, securely tighten them. Make sure the wiring conforms to the diagram under **Specifications, 400.**
	Check the blower motor for operation. Replace if sticking or otherwise inoperative.
	Check the resistor block. Replace, if necessary. **CAUTION** **Never try to by-pass the fuse in the resistor block. To do so could cause the blower motor to overheat, resulting in serious damage to the heater/ air-conditioning system.**
There are restrictions or leaks in the air ducts.	Examine all air ducts and remove any blockages. Stop any leaks or replace any portion where the leaks cannot be stopped.
Ice has formed on the evaporator coil.	Defrost the evaporator coil before resuming operation of the air conditioner. Review "Performance Tests" in this subject for possible causes and corrective action.

Problem—Warm Airflow When the Air Conditioner Is On

Problem—Warm Airflow When the Air Conditioner Is On	
Possible Cause	**Remedy**
There is no refrigerant charge in the system.	Perform a leak test. Repair any leaks, evacuate the system, replace the receiver-drier, and add a full charge of refrigerant.
Moisture in the system.	If moisture is in the system, ice crystals may form at the expansion valve, blocking the flow of refrigerant (off and on). Recover the refrigerant charge, replace the receiver-drier, evacuate the system, and add a full charge of refrigerant.
The refrigerant compressor is not operating.	If the refrigerant charge is low, charge and leak test the system. Repair any leaks.
	The refrigerant compressor clutch or drive belt needs repair or replacement. For instructions, see the refrigerant compressor section elsewhere in this group.
The air-conditioner microswitch is not working.	Replace the microswitch.
Ice has formed on the evaporator coil.	Defrost the evaporator coil before resuming operation of the air conditioner. Review "Performance Tests" in this subject for possible causes and corrective action.

Troubleshooting

Problem—Low Evaporator Coil Outlet Pressure (Low Compressor Suction Pressure)

Problem—Low Evaporator Coil Outlet Pressure (Low Compressor Suction Pressure)	
Possible Cause	**Remedy**
The expansion valve is not working.	Replace the expansion valve.
There are restrictions in the line to the expansion valve.	Remove the line restrictions.
There is an insufficient refrigerant charge in the system.	Locate the leak. Recover the charge, replace the receiver-drier, and add a full refrigerant charge.

Problem—High Compressor Discharge Pressure

Problem—High Compressor Discharge Pressure	
Possible Cause	**Remedy**
Airflow through the condenser is restricted.	Remove the debris from the condenser.
There is an internal restriction in the condenser. (Ice buildup on the condenser or a cool spot on the line from the condenser to the receiver-drier).	Replace the condenser.
Air is present in the system.	Perform a leak test. Repair any leaks, evacuate the system, and add a full charge of refrigerant.
Heavy frosting on the suction line suggests that the evaporator coil is flooded.	Defrost the evaporator coil before resuming operation of the air conditioner.
The engine is over-heated.	See the engine manufacturer's operations manual for corrective measures.
Restriction in the compressor discharge line.	Repair or replace the line.

Problem—Evaporator Outlet Air Temperature Increases as the Compressor Discharge Pressure Drops

Problem—Evaporator Outlet Air Temperature Increases as the Compressor Discharge Pressure Drops	
Possible Cause	**Remedy**
There are leaks in the system.	Leak test the system.
The expansion valve setting is too low.	Replace the expansion valve. Add a full charge of refrigerant.
Too much oil is in the system. An indication of this is clutch or belt slippage at governed engine speed.	Check and remove excess refrigerant oil. For instructions, see the refrigerant compressor section elsewhere in this group.

Problem—Compressor Operates Too Often or Continuously

Problem—Compressor Operates Too Often or Continuously	
Possible Cause	**Remedy**
There is too little refrigerant in the system.	Perform a leak test. Repair any leaks, and add a full charge of refrigerant.
Ice has formed on the evaporator coil.	Defrost the evaporator coil before resuming operation of the air conditioner. Check the operation of the thermostatic switch, and replace as necessary.

Problem—Compressor Operates Too Often or Continuously	
Possible Cause	**Remedy**
There is a restriction in the refrigerant system.	Remove the restriction from the line.
Dirt and debris are clogging the condenser fins.	Remove all dirt and debris from the condenser fins.
The thermostatic switch isn't working.	Replace the thermostatic switch.

Problem—Quick or Delayed Cycling of the Compressor

Problem—Quick or Delayed Cycling of the Compressor	
Possible Cause	**Remedy**
The thermostatic switch operates, but is out of adjustment.	Replace the thermostatic switch. Do not attempt to adjust it.
Loss of refrigerant is causing a delayed cycling of the compressor.	Leak test and add a full charge of refrigerant.

Problem—Temperature in the Cab Too Low or No Heat

Problem—Temperature in the Cab Too Low or No Heat	
Possible Cause	**Remedy**
The water regulating valve is not opened.	Turn the temperature control knob toward "warm."
The water regulating valve is not opening all the way.	Adjust the water regulating valve cable.
The water regulating valve isn't working.	Replace the water regulating valve.
A heater hose is pinched or twisted.	Repair or replace the heater hose.
Coolant is leaking from the system.	Check for leakage at the heater core, and at all hose connections from the heater core to the engine. Check the radiator coolant level, as instructed in the vehicle driver's manual, and add coolant, if necessary. Check and repair any leaks at the radiator.
Dust or dirt is clogging the heater core fins.	Remove and clean the heater core.

Problem—Condensed Water Is Leaking from the Air Conditioner

Problem—Condensed Water Is Leaking from the Air Conditioner	
Possible Cause	**Remedy**
The drain tubes are plugged.	Clean the drain holes and drain tubes.

Specifications

WARNING

R–134a is the only refrigerant that is approved for use on Freightliner LLC vehicles. Several companies offer less expensive, hydrocarbon-based refrigerants, such as propane and methane. Use of these refrigerants will void the warranty on the vehicle's air conditioning system, cause damage to the air conditioning system, and possibly result in personal injury or property damage. Leaking air conditioning systems charged with hydrocarbon-based refrigerants pose a serious risk of fire or explosion under the hood, or inside the passenger compartment. Regardless of what the refrigerant supplier states, no vehicle built by Freightliner LLC can be safely charged with hydrocarbon-based refrigerants.

When servicing an air conditioning system, be sure to use a refrigerant identifier to ensure that the system has not been charged with something other than R–134a. This should be standard practice since there is no way to tell what services have been previously performed. Identification by service technicians will help to avoid the risk of explosion and guard against contamination of equipment when refrigerant is recovered and recycled.

See **Fig. 1** for the air conditioning wiring diagram.

See **Fig. 2** for the air conditioning plumbing diagram.

See **Fig. 3** for the heater plumbing diagram for Cummins B Series engines.

See **Fig. 4** for the heater plumbing diagram for Cummins C Series engines.

See **Fig. 5** for the heater plumbing diagram for Mercedes-Benz OM 366LA engines.

See **Fig. 6** for the heater plumbing diagram for Dodge Magnum engines.

See **Fig. 7** for the APADS™ electronic control module wiring diagram.

See **Fig. 8** for the Cummins mechanical engine and APADS™ schematic.

Torque Values		
Description	**Torque**	
	lbf·ft (N·m)	**lbf·in (N·cm)**
Expansion Valve Fittings:		
Evaporator Large Line	24 (33)	—
Evaporator Small Line	18 (24)	—
Receiver-Drier Line	12 (16)	—
Refrigerant Compressor Line	18 (24)	—
Blower Motor Mounting Nuts	—	17 (192)
Condenser Mounting Bolts	15 (20)	—
Condenser Refrigerant Line Fittings	33 (45)	—
Receiver-Drier Fittings	33 (45)	—
Binary Switch	—	108 (1220)

Table 1, Torque Values

Specifications

Temperature/Pressure Specifications						
Ambient Air Temperature °F (°C)	Humidity		Dash Louver Temperature °F (°C) †	Service Port Pressures * †		A/C Compressor Cycling On?
	Target	Actual (Relative Humidity)		High (psi)	Low (psi)	
70 (21)	Low	25%	44 (6)	144	20.1	Yes
70 (21)	High	55%	45 (7)	146.6	21.6	Yes
80 (27)	Low	25%	46 (8)	164.4	20.1	Yes
80 (27)	High	55%	51 (11)	201.8	24.4	No
90 (32)	Low	25%	49 (9)	219.8	22.6	No
90 (32)	High	55%	60 (16)	242.1	31.5	No
100 (38)	Low	25%	57 (14)	261.3	29.5	No
100 (38)	High	55%	68 (20)	309.3	42.5	No

* Service port pressures recorded with A/C compressor running.

† Fresh air mode in use.

Table 2, Temperature/Pressure Specifications

3/4- and 5/8-Inch Heater Hose Clamp Torque Values	
Description	Torque lbf·in (N·cm)
Standard Hose Clamp	40 (452)
Worm-Gear Hose Clamp	40 (452)
Breeze Constant-Torque Hose Clamp	40 (452)
Oetiker Constant-Torque Hose Clamp	18 (203)

Table 3, 3/4- and 5/8-Inch Heater Hose Clamp Torque Values

APADS™ Parametric Specifications *				
Parameter	Minimum	Typical	Maximum	Units †
Supply Voltage (continuous operation)	10.0	13.5	16.0	Volts
Supply Voltage (absolute maximum, two minute duration)			24.0	Volts
Supply Current (no load)			50.0	mAmps
Load (AC clutch drive)	3.0	4.0		Ohms
Load (AC clutch drive)		0.1	0.20	Henries
Load Energy $\frac{1}{2}LI^2$			1.5	Joules
Relay Contact Voltage Drop		0.04	0.10	Volts
Load (fan actuator circuit)	13.0			Ohms
Load (fan actuator circuit)			80.0	mHenries
Input Debounce Delay	0.3		1.1	Seconds

Specifications

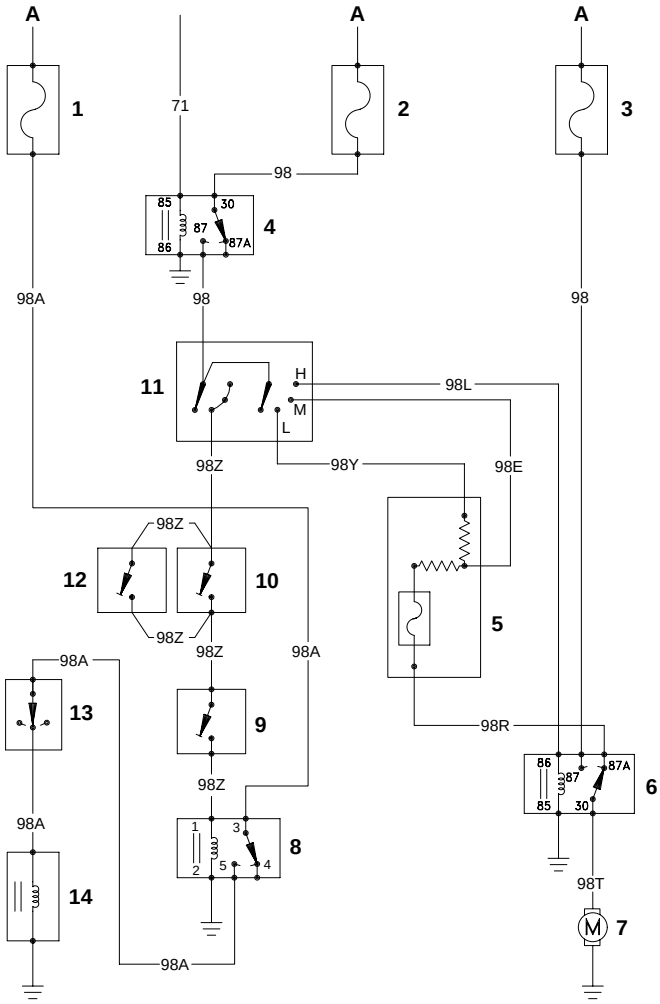
APADS™ Parametric Specifications *				
Parameter	**Minimum**	**Typical**	**Maximum**	**Units †**
Open Clutch Sense Current	0.15	0.5	1.27	Amps
Shorted Clutch Cut Out Resistance	1.7		2.4	Ohms
Voltage Cut Out Off Threshold	10.8	11.0	11.2	Volts
Evaporator Thermostat On Range	5.0		VIGN	Volts
Evaporator Thermostat Off Range	0		1.0	Volts

* Applicable over the full operating range: –40° to 212°F (–40° to 100°C)

† All voltages referenced are to ground lead of the device.

Table 4, APADS Parametric Specifications

Specifications



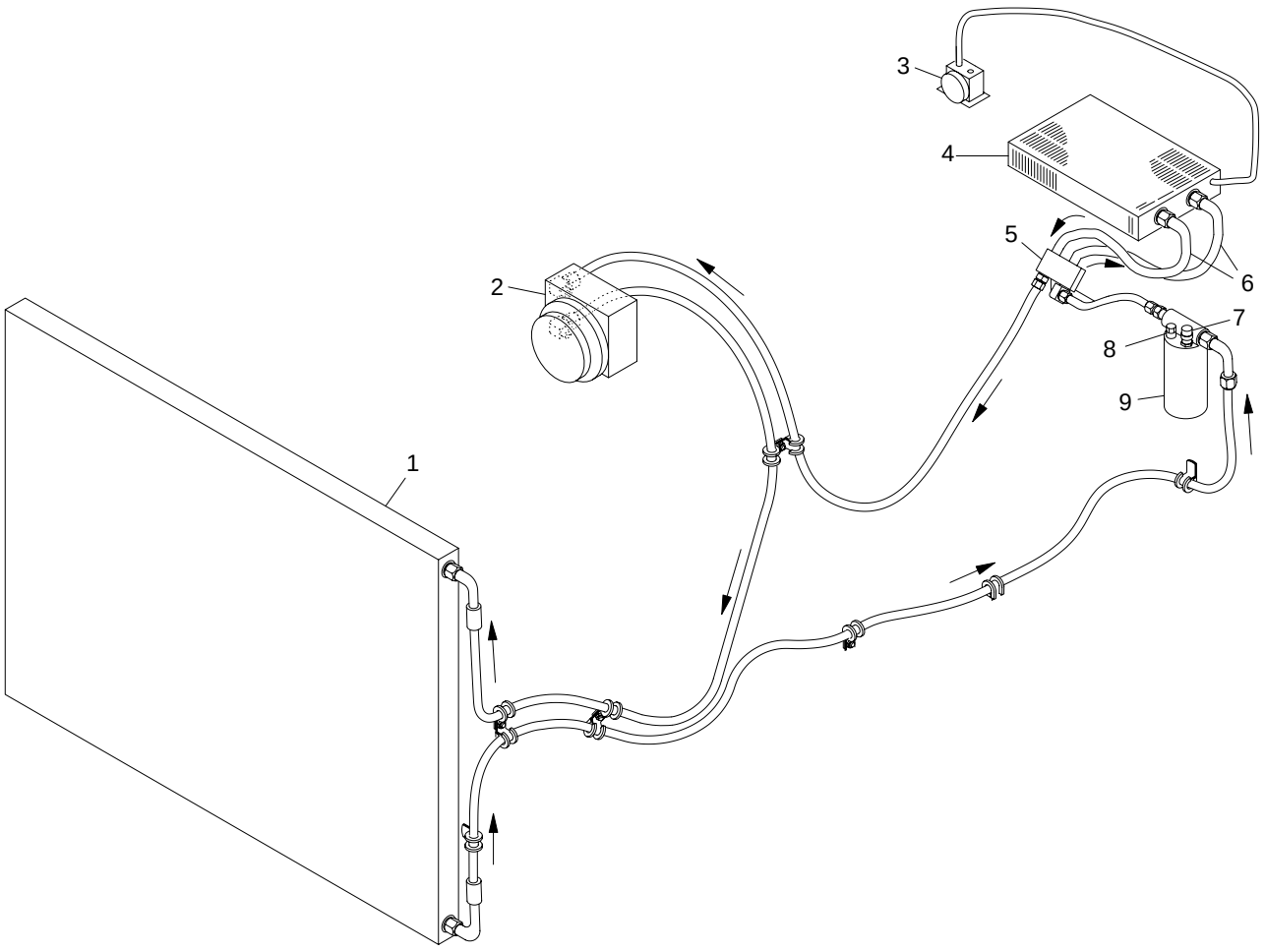
04/15/94 f540349a

NOTE: For the specific location of each circuit breaker/fuse/relay in the electrical center, refer to the Wiring Diagram and Circuits, Vehicle section in **Group 54**.

A. To circuit 14

1. 10A
2. 15A
3. 40A
4. Heater/Air-Conditioner Relay
5. Resistor
6. Heater Blower Relay
7. Blower Motor
8. Compressor Clutch Relay
9. Thermostatic Switch
10. Defroster/Dehumidifier Microswitch
11. Blower Motor Switch
12. Air Conditioner On/Off Microswitch
13. Binary Switch
14. Air Conditioner Compressor Clutch

Fig. 1, Air Conditioning Wiring

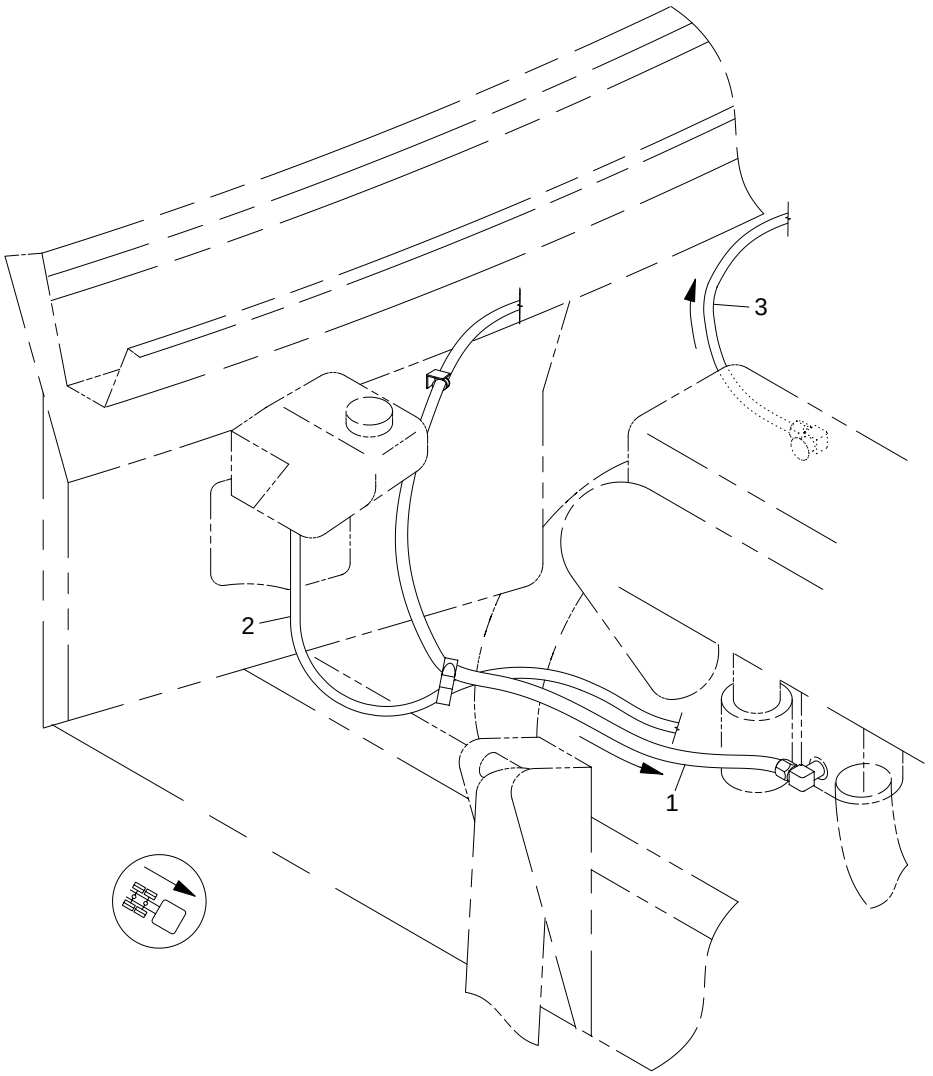


04/15/94 f830370a

1. Condenser
2. Refrigerant Compressor
3. Thermostatic Switch
4. Evaporator Coil
5. Expansion Valve
6. Extension Hoses (through frontwall)
7. Binary Switch
8. Moisture Indicator
9. Receiver-Drier

Fig. 2, Air Conditioner Plumbing

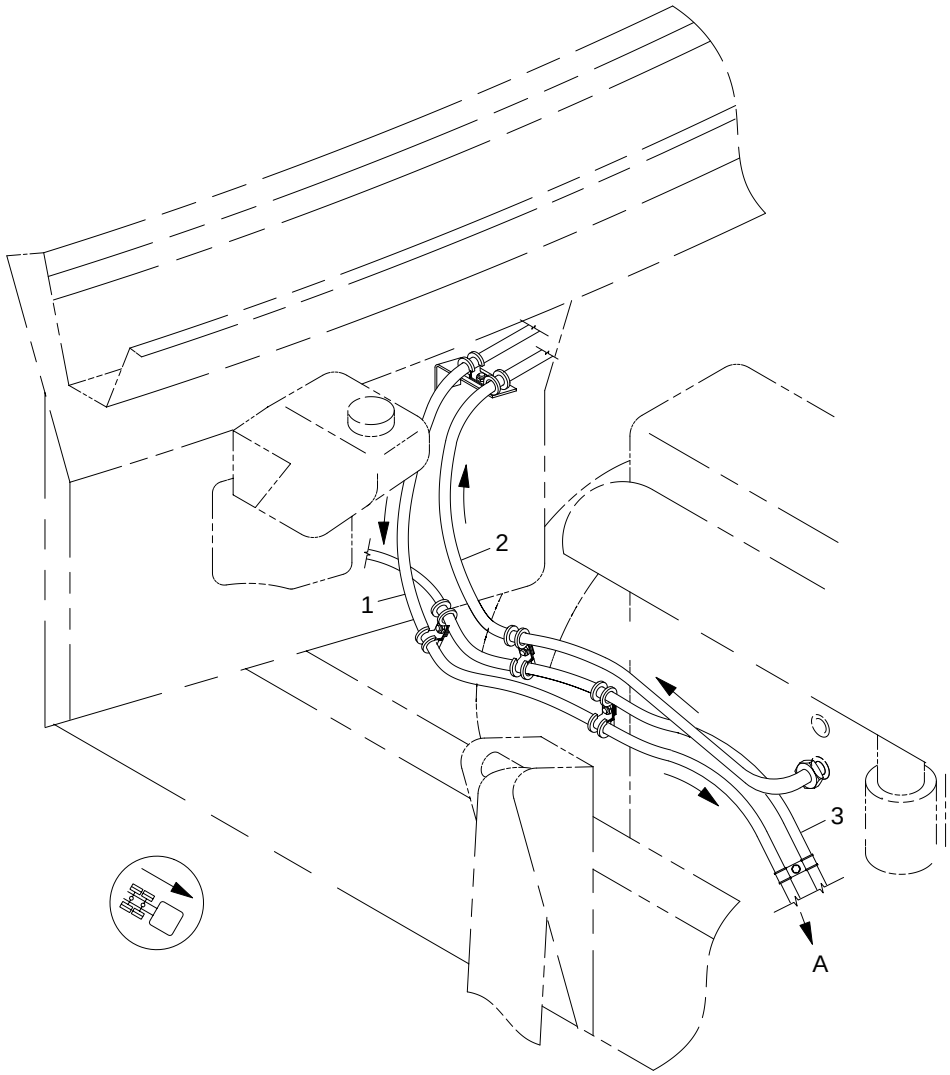
Specifications



11/23/93 f830527

1. Heater Return Line
2. Surge Tank Hose
3. Heater Supply Line

Fig. 3, Heater Plumbing for Cummins B Series Engines



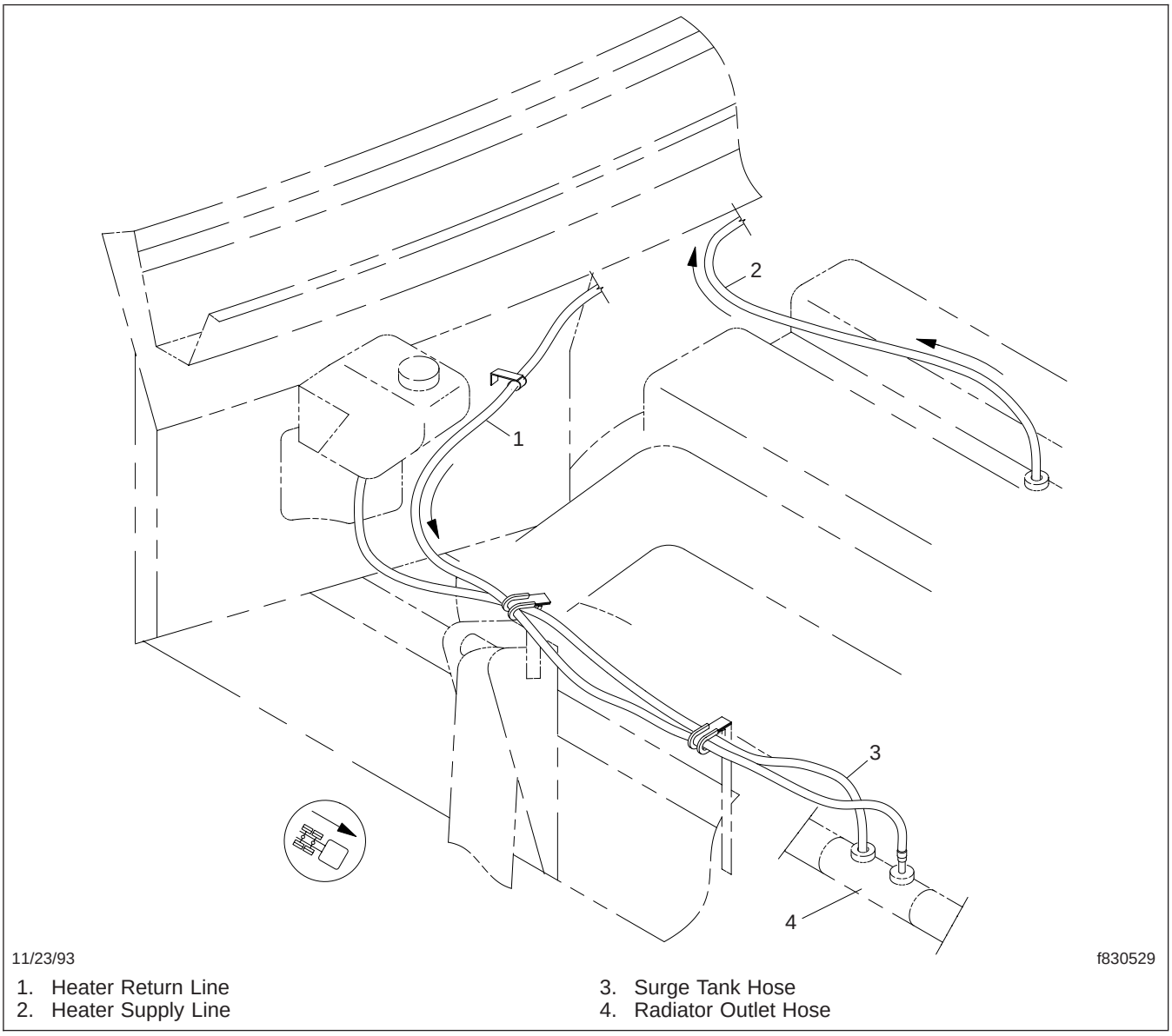
11/23/93 f830528

A. To radiator shunt line.

1. Heater Return Line
2. Heater Supply Line
3. Surge Tank Hose

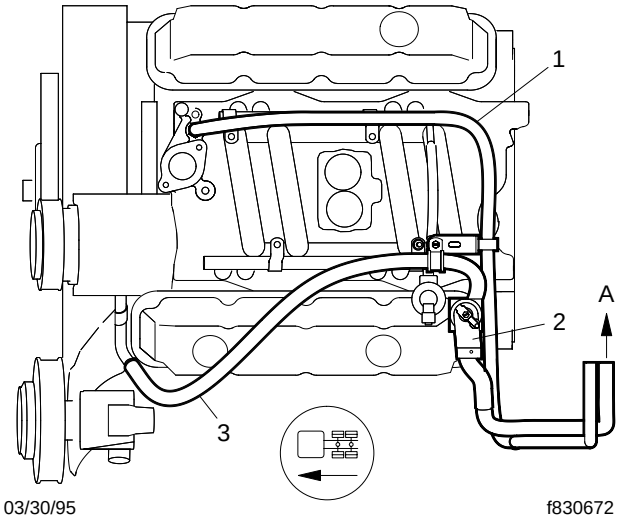
Fig. 4, Heater Plumbing for Cummins C Series Engines

Specifications



1. Heater Return Line
2. Heater Supply Line
3. Surge Tank Hose
4. Radiator Outlet Hose

Fig. 5, Heater Plumbing for Mercedes-Benz OM 366LA Engines



A. To the heater.
1. Heater Supply Line
2. Water Regulating Valve
3. Heater Return Line

Fig. 6, Heater Plumbing for Dodge Magnum Engines

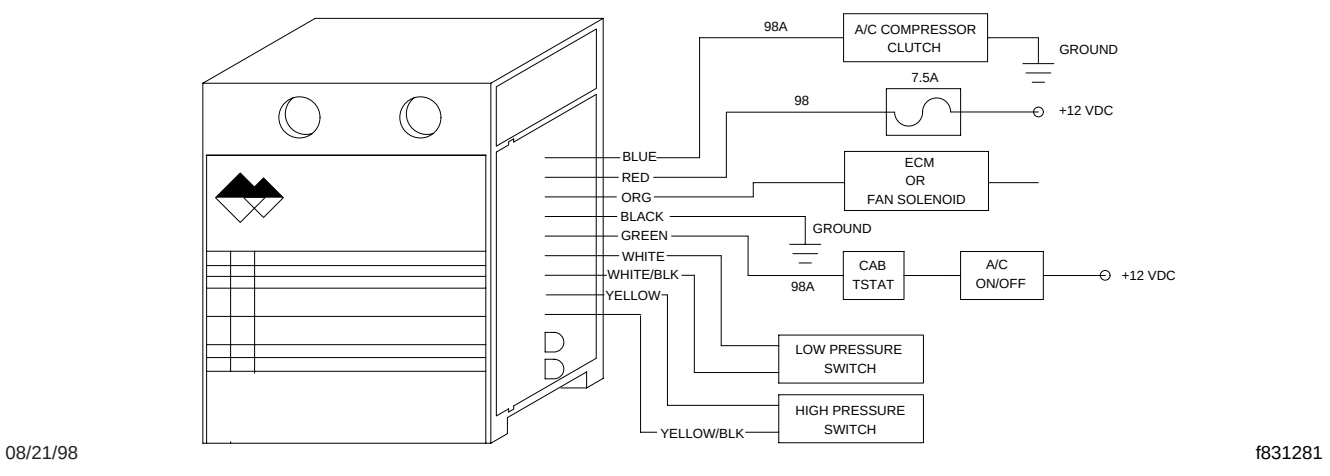


Fig. 7, APADS Electronic Control Module Wiring Diagram

Specifications

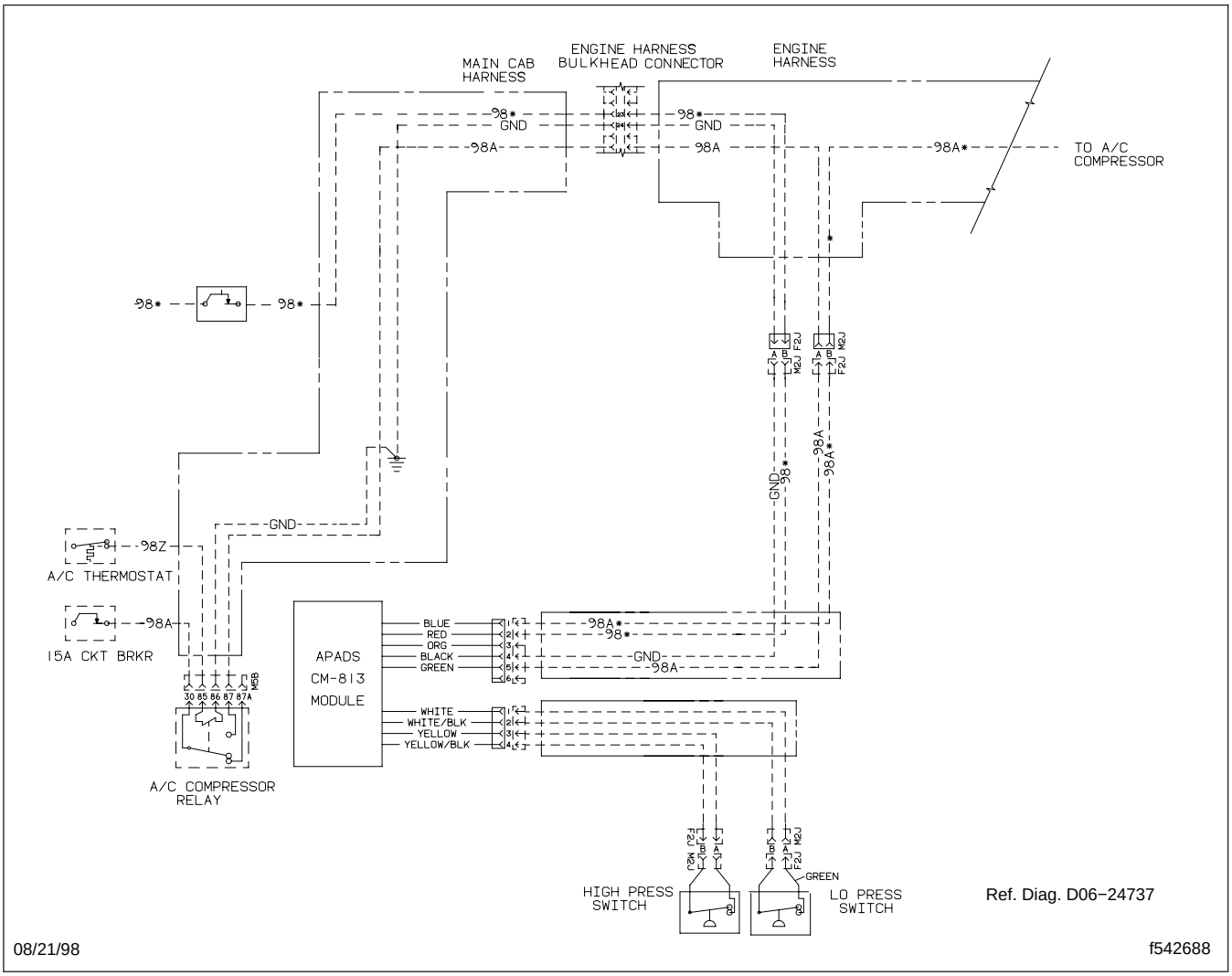


Fig. 8, Cummins Mechanical Engine and APADS Schematic

General Information (See Fig. 1 or Fig. 2)

The main purpose of the refrigerant compressor is to draw refrigerant gas from the evaporator and squeeze it into high-pressure gas. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid so that it can be used for cooling again. A second purpose of the compressor is to move refrigerant through the air conditioning system.

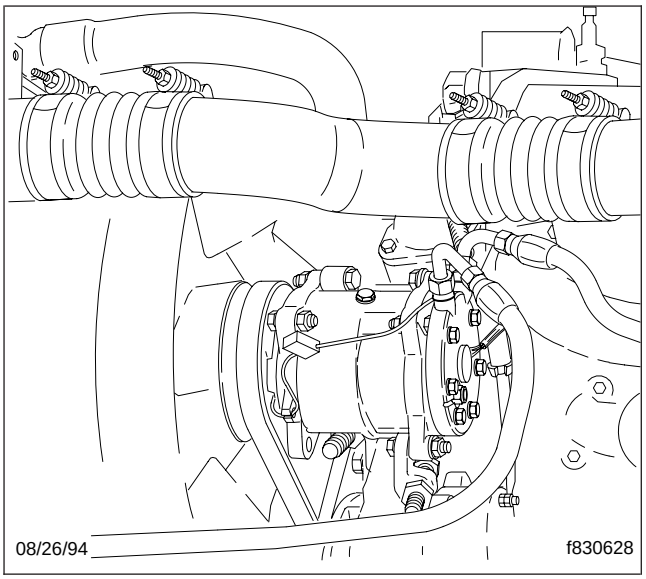


Fig. 1, OM 366LA Engine Mounting

The compressor is cycled by a thermostatic switch. When there is enough of a temperature drop in the cab, the switch breaks the circuit to the compressor's clutch. When the clutch is disengaged, its pulley is free-wheeling and the compressor shaft is not turning. When the clutch is engaged, it holds to the pulley, and the turning of the pulley causes the compressor shaft to turn.

Refer to the cab air conditioner section in this group for more information.

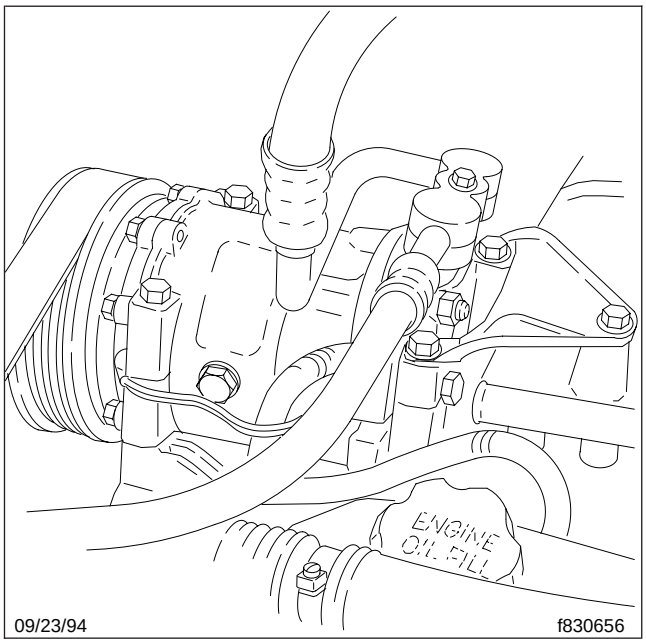


Fig. 2, Dodge Magnum Engine Mounting

Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and non-leather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

⚠ WARNING

WARNING: Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure. However, it can be combustible at pressures as low as 139 kPa absolute (5.5 psig) at 177°C (350°F) when mixed with air concentrations that are greater than 60 percent.

⚠ WARNING

WARNING: R–134a air conditioning systems should not be pressure tested or leak tested with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion, which could cause personal injury or property damage. R–134a may be safely pressured with dry nitrogen.

Always work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 52°C (125°F).

On R–134a refrigerant systems, polyalkylene glycol (PAG) oil is used in the compressor. When handling PAG oil, observe the following:

- keep the oil free of contaminants
- do not expose the a/c system or the PAG oil container to air; PAG oil has a high moisture absorption capacity and the oil container should be immediately sealed after each use.
- use care when handling: painted surfaces, plastic parts, and other components (drive belts) could be damaged if PAG oil is spilled on them
- never mix PAG oil with other types of refrigerant oil

Pre-Service Checks

⚠ WARNING

WARNING: Before doing any work, read the information under Safety Precautions, 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

⚠ CAUTION

CAUTION: Determine whether the air conditioning system is charged with refrigerant R–134a or with R–12. Check the label on the radiator shroud (the side the compressor is on), the compressor identification tag, and the caution labels on system components for verification. Service procedures are different for these refrigerant systems. Failure to properly identify the refrigerant system prior to servicing could cause component malfunction and system contamination.

Some special tools are needed for doing repair work on the compressor. Refer to the special tools table in **Specifications 400.** Tool kits can be bought from the distributor listed under the special tools table in **Specifications 400.**

NOTE: Compressor problems usually show in one of four ways: abnormal noise; seizure; leakage; or low suction and discharge pressures. Resonant compressor noises are not causes for alarm; irregular noise or rattles are likely to be caused by broken parts. To check for seizure, de-energize the magnetic clutch and see if the drive plate can be turned. If it won't turn, the compressor has seized.

Do the following checks whenever the air conditioner system is not cooling enough and the causes are unknown.

1. Be sure to check the moisture indicator, to see if moisture is the cause of the problems. The air conditioner should be on when checking the indicator; it is better to check it at the end of a day's run.
2. Check the drive belt and mounting:
   - 2.1 On the drive belt, look for wear, damage, or oil. If worn, oil-soaked, or damaged, remove it and install a new one. Refer to the drive belt section in **Group 01** of this manual for instructions.
   - 2.2 Check the compressor mounting parts for loose fasteners, cracks, or other damage. Tighten loose fasteners to the torque value in the torque specifications table under **Specifications 400.** Repair or replace cracked or damaged brackets.
   - 2.3 Check the tension of the compressor drive belt. Refer to the drive belt section in **Group 01** of this manual for instructions.
   - 2.4 Check the compressor oil level. **Refer to Subject 140** for instructions.
3. Check the wiring and connections to the compressor clutch. Replace damaged wiring and tighten loose connections.
4. Check for road debris build-up on the condenser coil fins. Using air pressure and a whiskbroom or a solution of soap and water, carefully clean the condenser; be careful not to bend the fins.
5. Check the refrigerant charge in the air conditioner system; for instructions, refer to the section on R–134a heater and air conditioner systems in this group.
6. Check the suction pressure and discharge pressure of the refrigerant compressor; **refer to Subject 120**.
7. Check the valve plate and cylinder gasket (**Subject 170**), and the shaft seal (**Subject 160**) for damage. Replace as needed.

NOTE: For other possible causes of air conditioner problems, refer to the section on R–134a heater and air conditioner systems in this group and to the applicable fan clutch section in **Group 20** of this manual.

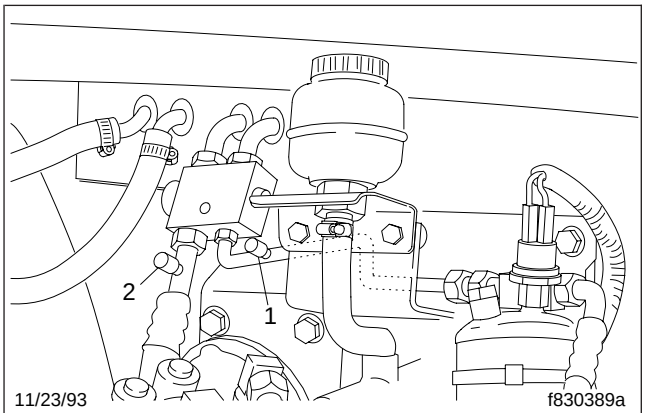
Checking

⚠ WARNING

WARNING: Before doing any of the work below, read the information under Safety Precautions, 100. Failure to read the safety precautions, and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.

1. Attach a manifold gauge set to the service ports. Make sure that the manifold gauge set is equipped with a valve core depressor.

   1.1 Remove the protector caps from the service valve ports. **See Fig. 1.**



1. Discharge Service Valve
2. Suction Service Valve

Fig. 1

IMPORTANT: Push down firmly on the hose connectors until a clicking sound is heard. This will ensure that the coupler is locked.

   1.2 Make sure that the valves on the recovery and recycling station are closed. Cap the manifold center hose.

   1.3 Connect the red high-side hose to the discharge service valve, and the blue low-side hose to the suction service valve.

2. Start the engine and set it to run at 1500 rpm.

3. Turn on the heater-air conditioner blower, and set the air conditioner controls to the coldest setting, so that the compressor is operating. If the outside temperature is cooler than 21°C (70°F), *partially* block the air to the condenser.

4. Look at the manifold suction and discharge pressure gauges. The pressure on the gauges should be within the range in the temperature/pressure specifications table in **Specifications 400.**

   4.1 If the suction and discharge pressures are both too high, there is air in the refrigerant, or too much refrigerant in the system; check the charge; for instructions, refer to the section on R–134a heater and air conditioner systems in this group.

   4.2 If the suction pressure is too high and the discharge pressure is normal, check that the probe of the thermostatic switch is correctly installed in the evaporator coil. Refer to the section on R–134a heater and air conditioner systems in this group for instructions.

   4.3 If the suction pressure is too low and the discharge pressure is normal or too low, check for passage of air through the evaporator coils. If airflow is blocked, remove the blockage. If airflow is satisfactory, check for blockages in the line to the suction side of the compressor.

5. If the suction pressure is normal and the discharge pressure is too high, airflow through the condenser may not be enough to carry away the heat.

   5.1 Place a large fan in front of the radiator; place it so that the airflow goes through the condenser. After two minutes of operating the air conditioner and the fan at the same time, look at the manifold pressure gauges again. (One other procedure is to direct a spray of water onto the condenser while the system is running.)

   5.2 If the discharge pressure is still too high, the line between the compressor and the receiver-drier is blocked, or the condenser is blocked internally. Recover, flush, evacuate, charge, and leak test the system. If the blockage can't be removed by flushing, replace the blocked line or blocked condenser. After flushing and before placing a vacuum in the system, *be sure to add the correct amount of refriger-*

Compressor Suction and Discharge Pressure Checking

ant oil to the compressor. For instructions, refer to **Subject 140.**

6. If the suction pressure is normal or too high and the discharge pressure is too low, check for a slipping clutch or wrong-sized clutch pulley or accessory drive pulley. Replace parts as needed.

   If the suction pressure is still normal or too high and the discharge pressure is still too low, the compressor is the problem. Repair or replace the compressor.

Removal

1. Recover the refrigerant from the air conditioning system; for instructions, refer to the section on R–134a heater and air conditioner systems in this group.
2. If equipped with an OM 366LA engine do the following. If equipped with a Dodge Magnum engine, go to the next step.
   - 2.1 Remove the clamps holding the charge air pipe; then, remove the pipe. **See Fig. 1.**

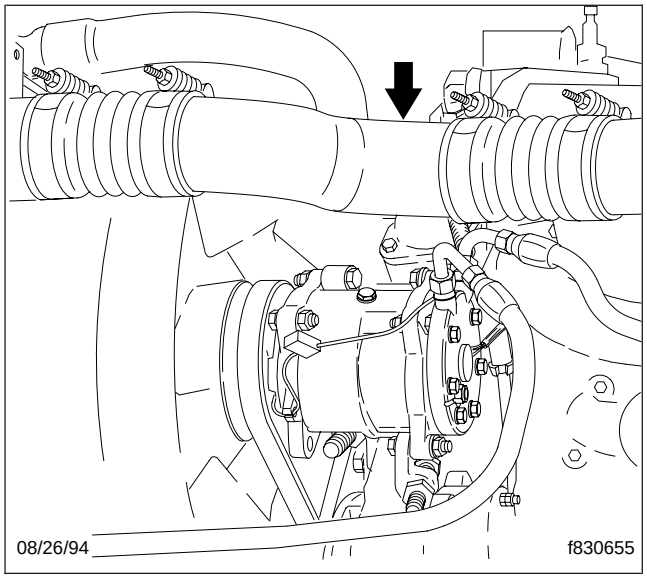


Fig. 1, Charge Air Pipe

   - 2.2 Clean the compressor around the hose connections. Disconnect all of the lines from the compressor. Quickly cap the discharge and suction ports and plug the hoses.
   - 2.3 Disconnect the compressor clutch electrical wire. **See Fig. 2.**
   - 2.4 Loosen both the adjusting and jam nuts on the compressor lower mounting strut. **See Fig. 3**, Refs. 13 and 11.
   - 2.5 Loosen the two compressor upper mounting bolts.
   - 2.6 Pivot the compressor down to relieve the belt tension.

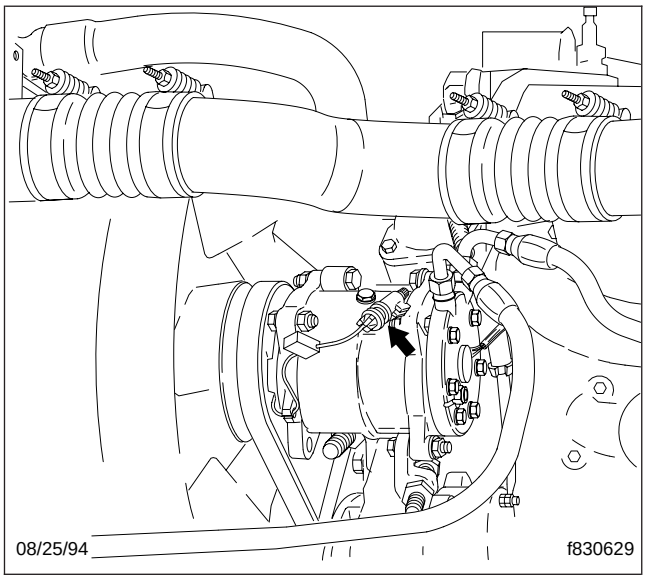


Fig. 2

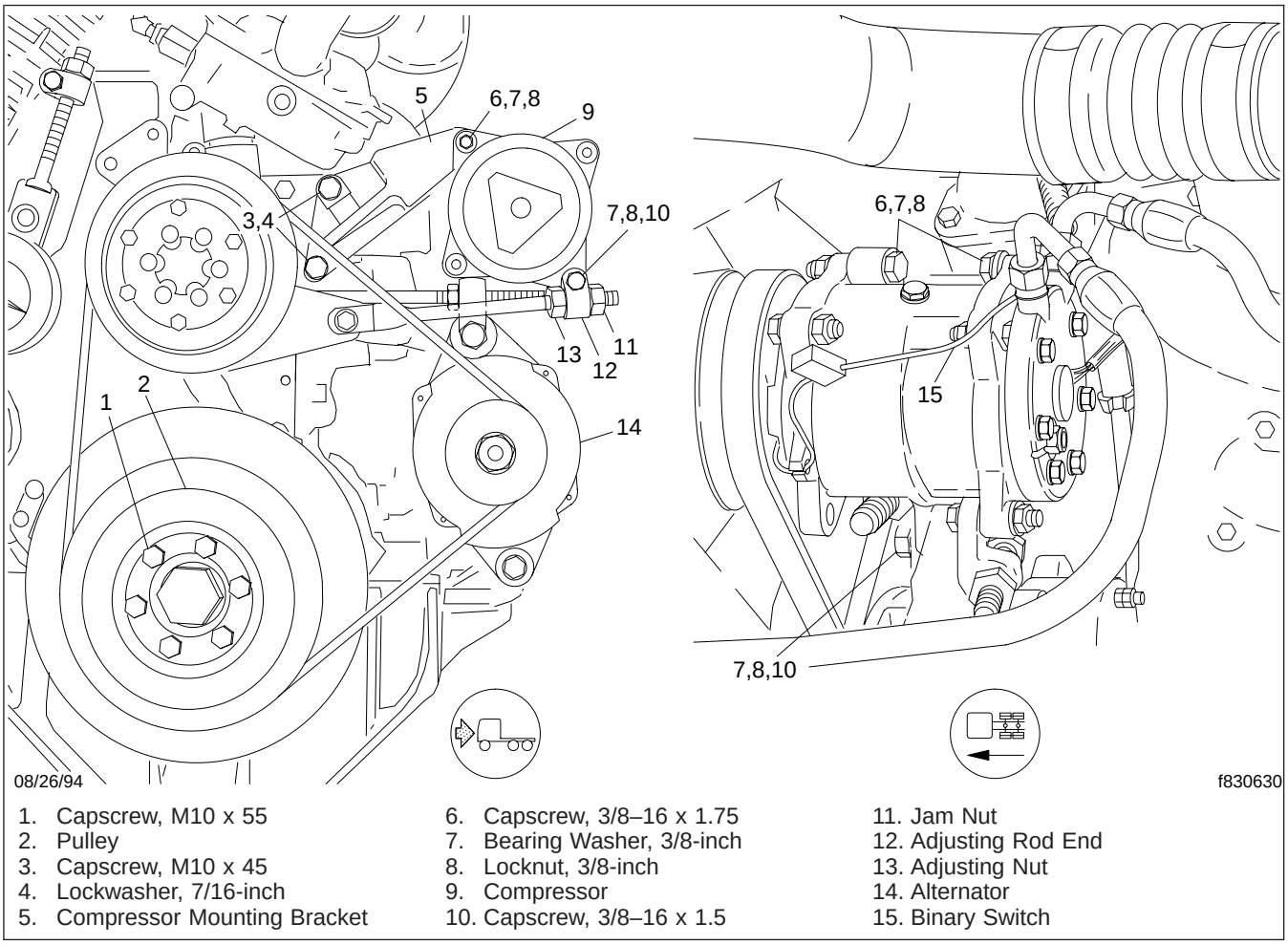
   - 2.7 Remove the V-belt.
   - 2.8 Remove all three compressor mounting bolts and lift out the compressor.
3. If equipped with a Dodge Magnum engine, remove the compressor. **See Fig. 4.**
   - 3.1 Turn the belt tensioner counterclockwise to loosen the drive belt.
   - 3.2 Remove the fastener from the junction block assembly. Move the junction block assembly out of the way. Quickly cap the discharge and suction ports and plug the hoses.
   - 3.3 Cut the tie strap that secures the clutch wiring. Disconnect the wiring.
   - 3.4 Remove the five mounting fasteners, then remove the compressor.

Installation

IMPORTANT: A new compressor is filled with nitrogen gas and 200 mL (6.8 fl oz) of refrigerant oil. When installing a new compressor on the vehicle, do all of the steps below; if installing a used compressor, skip the following step, and proceed with the installation:

1. Prepare a new compressor.

Compressor Removal and Installation



1. Capscrew, M10 x 55
2. Pulley
3. Capscrew, M10 x 45
4. Lockwasher, 7/16-inch
5. Compressor Mounting Bracket
6. Capscrew, 3/8–16 x 1.75
7. Bearing Washer, 3/8-inch
8. Locknut, 3/8-inch
9. Compressor
10. Capscrew, 3/8–16 x 1.5
11. Jam Nut
12. Adjusting Rod End
13. Adjusting Nut
14. Alternator
15. Binary Switch

Fig. 3

1.1 Slowly release the nitrogen from the discharge side of the compressor. Be careful not to let the oil flow out.

1.2 Turn the compressor shaft several times by hand to distribute oil which has settled in the cylinders.

2. If equipped with an OM 366LA engine, install the compressor as follows. If equipped with a Dodge Magnum engine, go to the next step.

2.1 Place the compressor in position against the mounting bracket and install the mounting bolts, washers, and nuts.

NOTE: The two long bolts go on top.

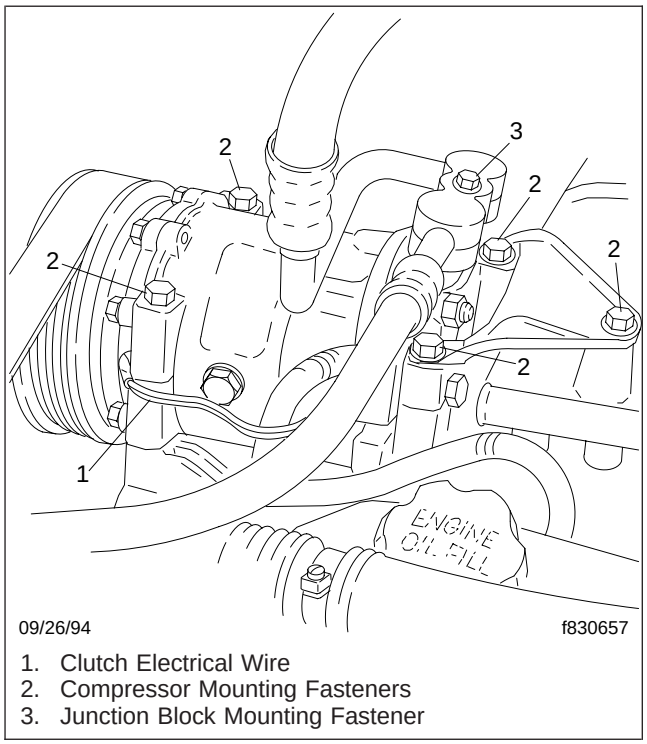
2.2 Hand tighten the nuts.

2.3 Install the V-belt. Adjust the belt tension. For instructions, refer to the applicable section in **Group 01.**

2.4 Tighten the compressor mounting bolts 45 N·m (33 lbf·ft).

2.5 Uncap the suction and discharge ports on the compressor. Unplug the hose connections. Check the hose connections and the surface of the suction and discharge ports. They must be clean and free of nicks, gasket residue, and other foreign material.

IMPORTANT: Under no circumstances should you leave the compressor's ports un-



1. Clutch Electrical Wire
2. Compressor Mounting Fasteners
3. Junction Block Mounting Fastener

Fig. 4

capped or the hoses unplugged for longer than five minutes total.

2.6 Attach the refrigerant hoses to the system hose connections. Tighten the suction (large) fitting 39 N·m (29 lbf·ft); tighten the discharge (small) fitting 37 N·m (27 lbf·ft).

2.7 Connect the compressor clutch electrical wire.

2.8 Install the charge air pipe. Tighten the constant torque hose clamps 680 N·cm (60 lbf·in).

3. If equipped with a Dodge Magnum engine, install the compressor.

3.1 Position the compressor on the mounting block.

3.2 Position the retaining bracket at the rear of the compressor.

3.3 Install the five mounting fasteners and tighten them 27 N·m (20 lbf·ft).

3.4 Uncap the suction and discharge ports on the compressor. Unplug the hose connections. Check the hose connections and the surface of the suction and discharge ports. They must be clean and free of nicks, gasket residue, and other foreign material. Replace both O-rings, then install the block assembly on the compressor. Tighten the fastener 25 N·m (19 lbf·ft).

IMPORTANT: Under no circumstances should you leave the compressor's ports uncapped or the hoses unplugged for longer than five minutes total.

3.5 Turn the belt tensioner counterclockwise and slip the belt over the pulley.

4. Evacuate, charge, and leak test the air conditioning system. For instructions, refer to the section on R–134a heater and air conditioner systems in this group.

General Information

⚠ CAUTION

Different refrigerant oils are used in compressors on R–12 and R–134a air conditioning systems. Always use the correct refrigerant oil and never mix oils. If the wrong oil is used, or if oils are mixed, the compressor could seize due to improper lubrication.

IMPORTANT: New compressors are factory-charged with about 6.8 oz (200 mL) of refrigerant oil. Some refrigerant oil is circulated through the system with the refrigerant, and cannot leave the system except through a leak, when the system is recovered, or when a system part is replaced.

Oil must be from a container that has not been opened, or that has been tightly sealed since its last use. For R–134a systems, order Sanden oil SKI/7803-1997 from your local Freightliner parts distribution center. Tubing, funnels, or other equipment used to transfer the oil should be very clean and dry.

IMPORTANT: Add the same amount of oil that is removed when the system is discharged or recovered, or when a system part is replaced. The list below contains approximate refill amounts for R–134a air conditioning systems.

A. Refrigerant charge—0.7 fl oz (20 mL): This amount of oil may be lost from the system each time the system loses its charge, due to routine recovery or due to a slow leak; no other parts of the system have been replaced.

IMPORTANT: The items below list oil quantities that include the amounts that are lost during recovery. Do not add an additional 0.7 fl oz (20 mL)—the amount described in the item above—to the quantities listed.

B. Receiver-drier—2.7 fl oz (80 mL);

IMPORTANT: A new receiver-drier does not contain any refrigerant oil.

C. Condenser—1.0 fl oz (30 mL);

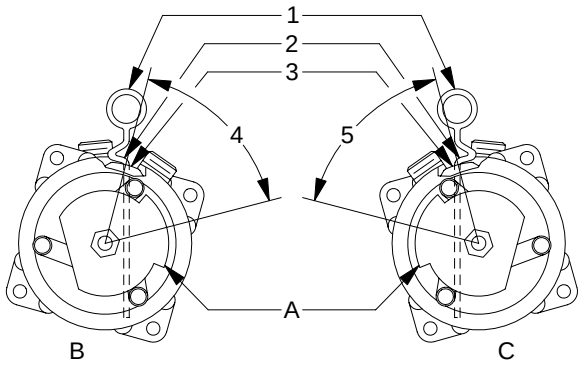
D. Evaporator coil—0.7 fl oz (20 mL);

E. Entire system—14 fl oz (414 mL) with or without an auxiliary heater/air-conditioner. Add this amount of oil to the compressor if the entire system (including the compressor) has been recovered of refrigerant and oil, and if the system has been evacuated.

When handling refrigerant oil:

- The oil should be free of water, dust, metal powder, and other foreign substances.
- Don't mix refrigerant oil with other types or viscosities of oil.
- Refrigerant oil absorbs moisture when exposed to the air for any period. After use, quickly seal the oil container.

IMPORTANT: Check the compressor oil level at the time of installation and whenever a loss of refrigerant oil has occurred.



A. Position of counterweight.
B. Mounting angle right.
C. Mounting angle left.

1. Dipstick
2. Dipstick Stop
3. Oil Fill Hole
4. 2 o'Clock
5. 10 o'Clock

Fig. 1, Checking the Oil Level

⚠ WARNING

Don't remove the oil fill plug without first recovering the system. Failure to recover the system could cause uncontrolled release of high-pressure refrigerant, which can freeze skin and eye tissue causing serious injury or blindness.

1. Run the compressor for 10 minutes with the engine at idle. Shut down the engine.

Oil Check and Adding Oil to the Compressor

2. Recover all of the refrigerant from the system.
3. Determine the mounting angle of the compressor from horizontal (oil fill plug on top).
4. Remove the oil fill plug. Using a socket wrench on the armature retaining nut, turn the shaft clockwise until the counterweight is positioned correctly. See **Fig. 1**.
5. Check the oil level with the dipstick. Make sure the angle of the dipstick stop is pointing in the right direction. See **Fig. 1**.

   Remove the dipstick and count the number of notches covered by the oil. If the number of notches covered by oil does not match the specifications for the appropriate mounting angle in **Table 1**, add or subtract oil to the midrange value. For example, if the mounting angle is zero degree, add oil until 6 notches on the dipstick are covered by oil.

Oil Specifications at Various Mounting Angles	
Mounting Angle	**Number of Notches Covered by Oil**
0°	5 to 7
10°	6 to 8
20°	7 to 9
30°	8 to 10
40°	9 to 11
50°	10 to 12
60°	11 to 13
90°	16 to 18

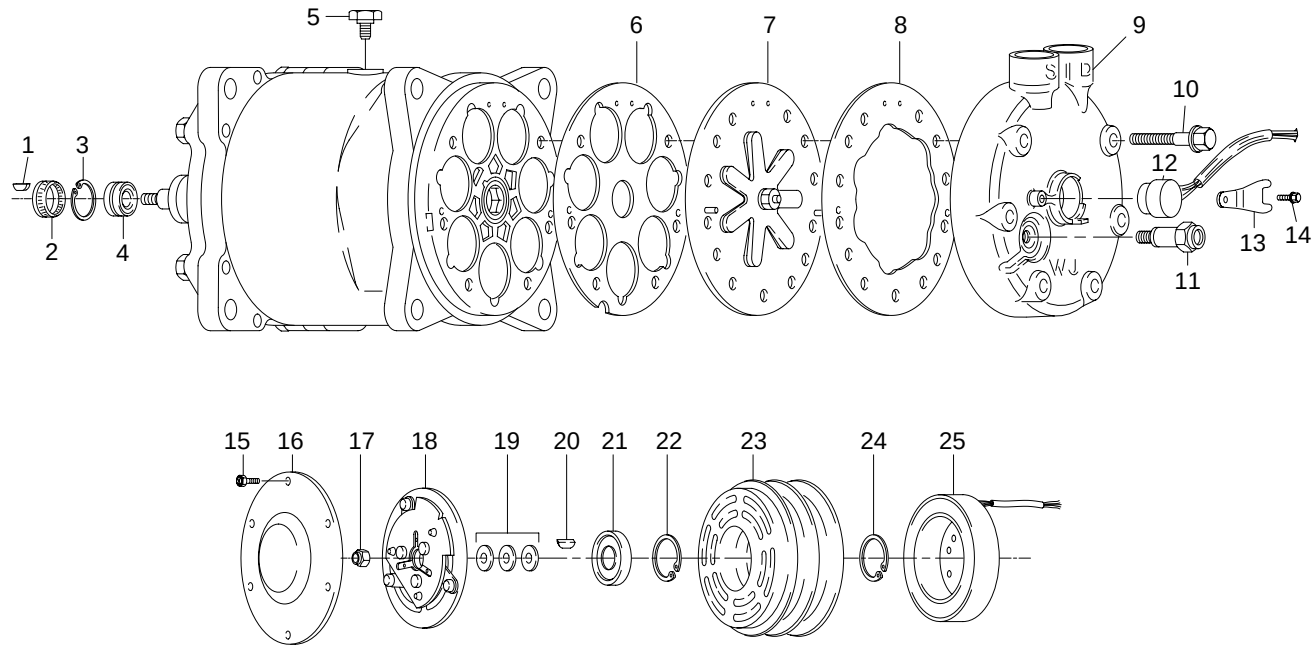
Table 1, Oil Specifications at Various Mounting Angles

NOTE: A dipstick can be made locally or purchased from a special tools supplier. Refer to the list of special tool suppliers in **Specifications 400**.

6. Being careful not to twist the O-ring, insert the plug in the oil fill opening. Tighten the plug 11 to 19 lbf·ft (15 to 25 N·m).

Clutch Assembly Removal, Inspection, and Installation

Removal (See Fig. 1)



1. Shaft Key
2. Felt Ring
3. Shaft Seal Snap Ring
4. Shaft Seal (with O-ring)
5. Oil Plug
6. Block Gasket
7. Valve Plate Assembly
8. Head Gasket
9. Cylinder Head
10. Cylinder Head Bolt
11. Pressure Relief Valve
12. Thermal Protector Switch, TPS (optional)
13. TPS Clip (optional)
14. TPS Screw (optional)
15. Bolt
16. Drive Plate Cover
17. Shaft Nut
18. Drive Plate
19. Clutch Shims
20. Shaft Key
21. Pulley Bearing Dust Cover
22. Pulley Snap Ring
23. Pulley Assembly
24. Field Coil Assembly Snap Ring
25. Field Coil Assembly

Fig. 1, Sanden SD7 Series Refrigerant Compressor

1. Remove the compressor from the vehicle. For instructions, refer to **Subject 130**.
2. Remove the six bolts that attach the drive plate cover and remove the cover.
3. Insert the pins of the drive plate spanner into the threaded holes of the drive plate. Hold the drive plate securely while removing the retaining nut. See **Fig. 2**.
4. Using the drive-plate puller, thread the three puller bolts into the drive plate. Turn the center screw clockwise to loosen and remove the drive plate. See **Fig. 3**.
5. Remove the pulley bearing dust cover (if equipped), the shaft key, and the clutch shims. Use a slotted screwdriver and hammer to tap the shaft key loose. See **Fig. 4**.
6. Using external snap-ring pliers, remove the pulley assembly snap ring.
7. Remove the pulley assembly.
   - 7.1 Insert the lip of the pulley puller jaws into the snap ring groove. See **Fig. 5**.
   - 7.2 Place the puller shaft protector over the exposed shaft.

Clutch Assembly Removal, Inspection, and Installation

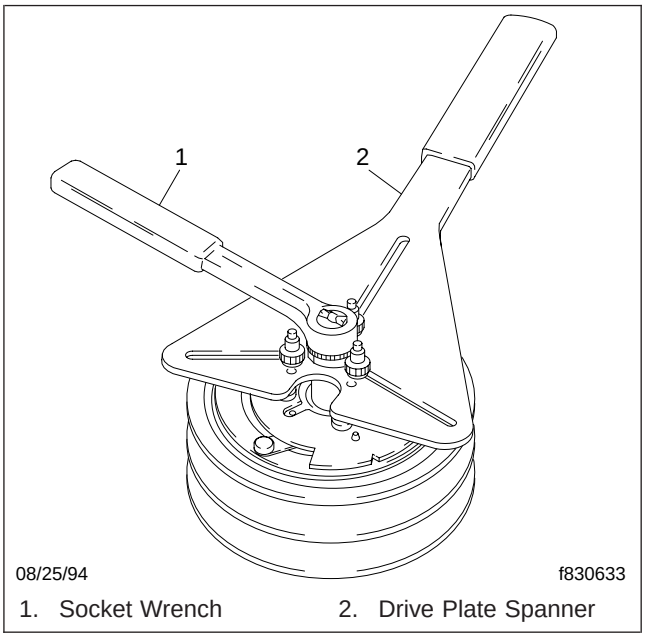


Fig. 2, Remove the Retainer Nut

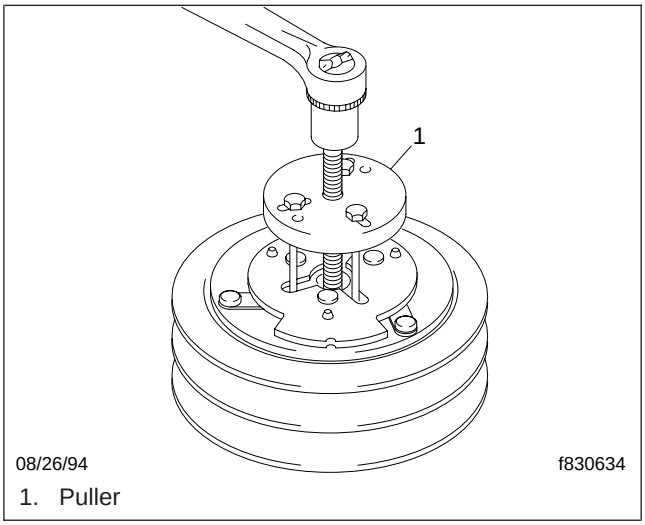


Fig. 3, Remove the Drive Plate

7.3 Align the thumb screws to the puller jaws. Tighten the screws finger tight.

7.4 Using a socket wrench, turn the puller center bolt clockwise and remove the pulley.

8. Remove the coil assembly.

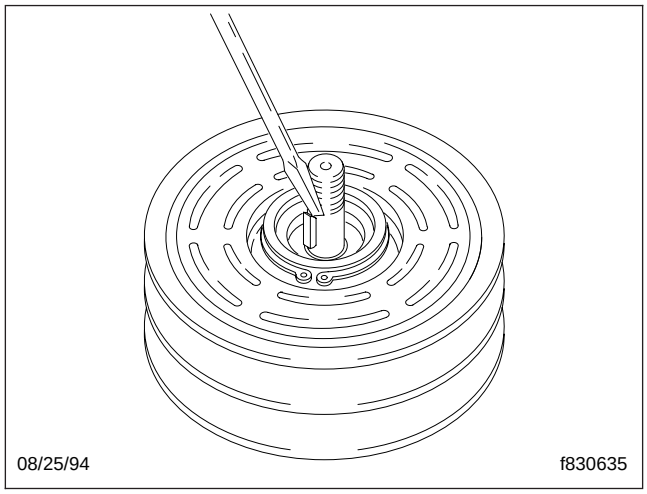


Fig. 4, Tap the Shaft Key Loose

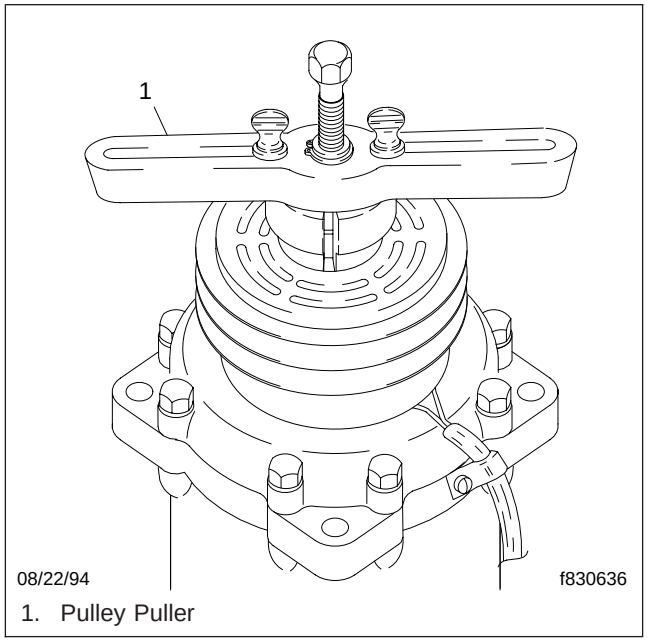


Fig. 5, Pulley Assembly

8.1 Remove the coil's lead wire from the wire holder on the compressor.

8.2 Disconnect the wiring harness.

8.3 Remove the snap ring (**Fig. 6**); then, remove the coil assembly.

Clutch Assembly Removal, Inspection, and Installation

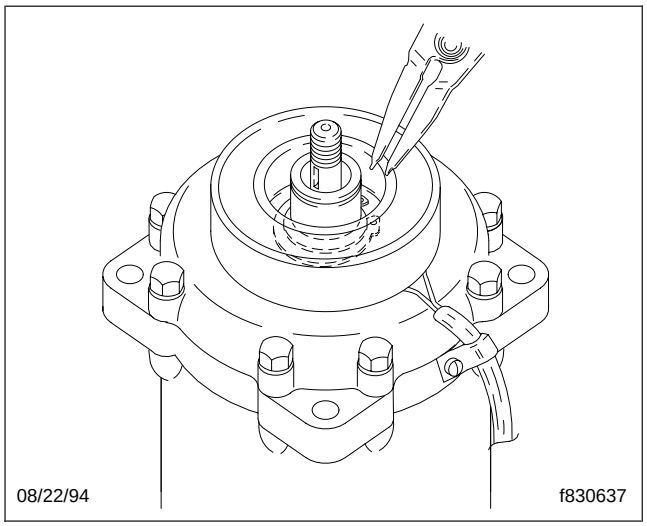


Fig. 6, Coil Assembly

Inspection

1. Inspect the drive plate. If the frictional surface shows signs ofdamage due to too much heat, replace the drive plate and pulley assembly.
2. Check the appearance of the pulley assembly. If the friction surface of the pulley shows signs of too much grooving due to slippage, replace both the pulley and drive plate. Clean the friction surfaces of the pulley assembly before installing it.
3. Check the coil for a loose connector and for cracked insulation.Replace it if necessary.

Installation

NOTE: When supporting the compressor in a vise, clamp only on the mounting ears, never on the body of the compressor.

1. Install the coil assembly.
   - 1.1 Position the coil assembly on the compressor.
   - 1.2 Install the snap ring.
   - 1.3 Attach the coil's lead wire to the wire holder on the compressor.
   - 1.4 Connect the wiring harness.
2. Install the pulley assembly.
   - 2.1 Position the pulley over the boss of the front housing.
   - 2.2 Place the pulley installer ring into the bearing bore. Make sure that the edge rests only on the inner race of the bearing, not on the seal, pulley, or outer race of the bearing.
   - 2.3 Place the driver into the ring. Using a hammer or arbor press, drive the pulley down against the front housing step. See **Fig. 7**.

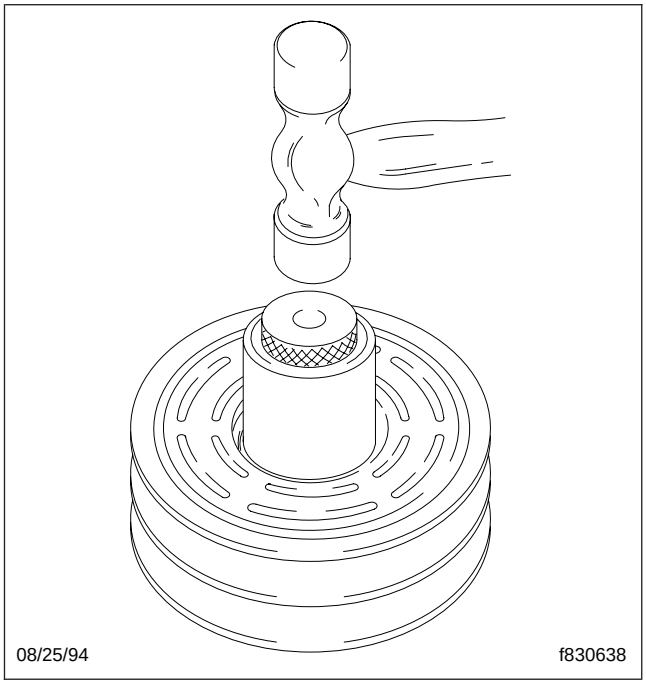


Fig. 7, Drive the Pulley Down

   - 2.4 Using internal snap ring pliers, install the pulley bearing snap ring.
   - 2.5 Using external snap ring pliers, install the pulley snap ring. If a bevel is present on the snap ring, make sure that it is facing up (away from the body of the compressor).
   - 2.6 Install the pulley bearing dust cover by gently tapping it into place.
3. Install the drive plate assembly.
   - 3.1 Using pliers, install the shaft key. See **Fig. 8**.

Clutch Assembly Removal, Inspection, and Installation

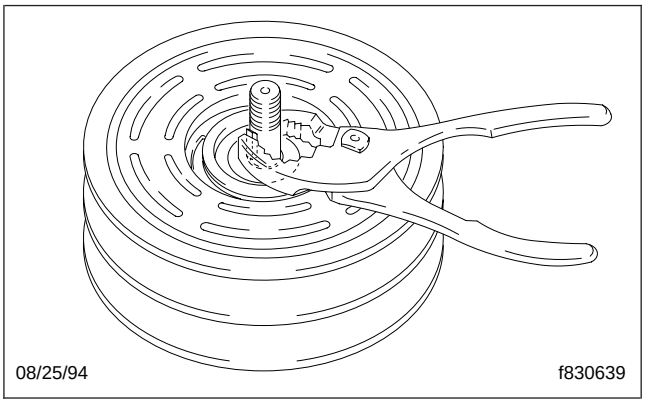


Fig. 8, Install the Shaft Key

3.2 Install the shims.

3.3 Align the keyway in the drive plate assembly with the shaft key. Using a driver, and a hammer or an arbor press, drive the assembly down over the shaft until it bottoms on the shims. See **Fig. 9**.

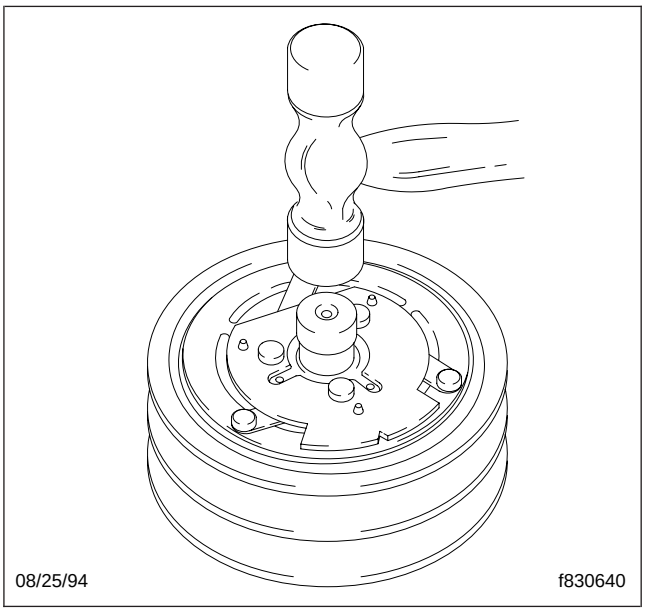


Fig. 9, Drive Plate Assembly

3.4 Install the retaining nut. Tighten the nut to the torque in **Specifications 400**.

4. Using a feeler gauge, check that the clutch clearance is 0.4 to 0.8 mm (0.02 to 0.03 inch). See **Fig. 10**. Adjust the clearance by gently tapping down on the front plate at the high spots, or gently prying up at the low spots.

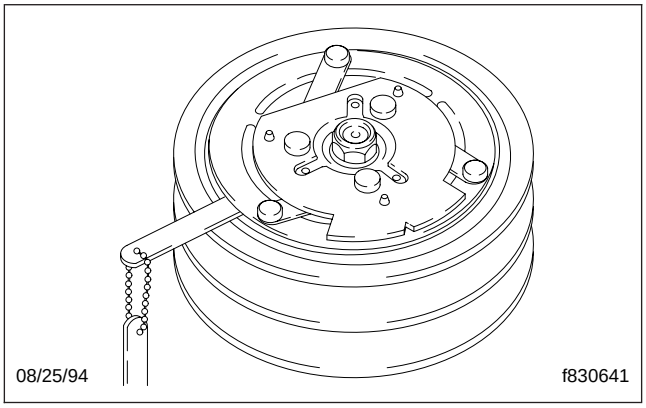


Fig. 10, Check the Clutch Clearance

5. Install the drive plate cover. Tighten the bolts to the torque in **Specifications 400**.

6. Install the compressor on the vehicle. For instructions, refer to **Subject 130**.

Replacement

1. Remove the drive plate and pulley assemblies. For instructions, refer to **Subject 150.**
2. Using snap ring pliers, remove the felt ring retainer. **See Fig. 1.** Then remove the felt ring.

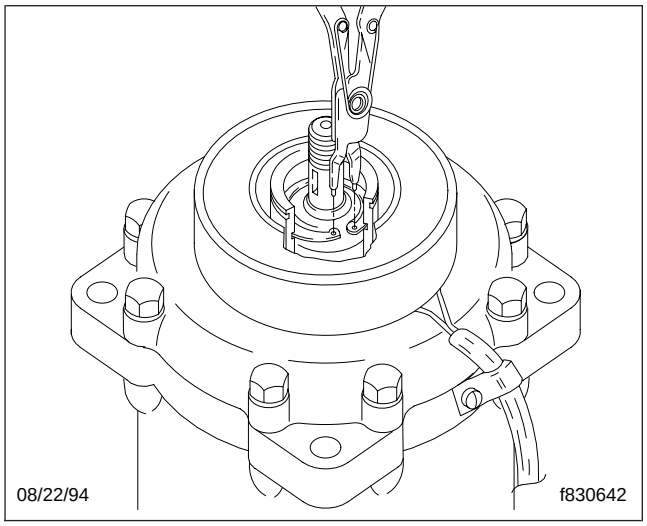
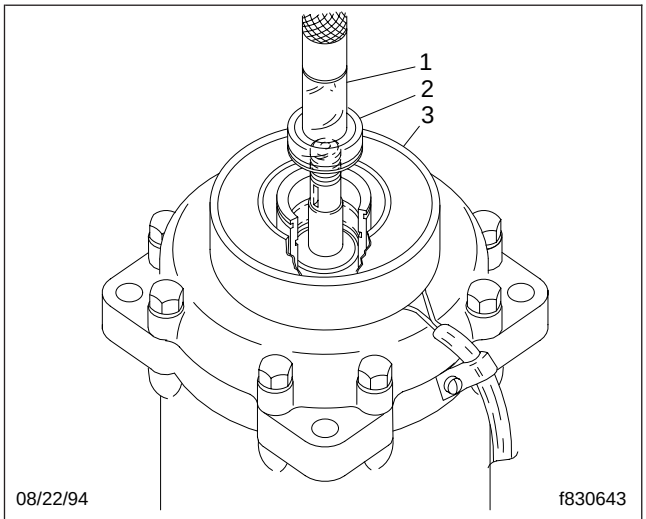


Fig. 1

3. Using snap ring pliers, remove the shaft seal snap ring.
4. Position the shaft seal removal and installation tool on the shaft seal. Twist the tool until the hooks on the tool engage the slots in the shaft seal housing, then pull the seal out with a twisting motion. **See Fig. 2.**

NOTE: The shaft seal and felt ring should not be reused. Always use a new seal kit. Be very careful that the lip of the shaft seal to be installed is not scratched or damaged in any way. Make sure the shaft seal is free of lint and dirt, which could damage the shaft seal surface.

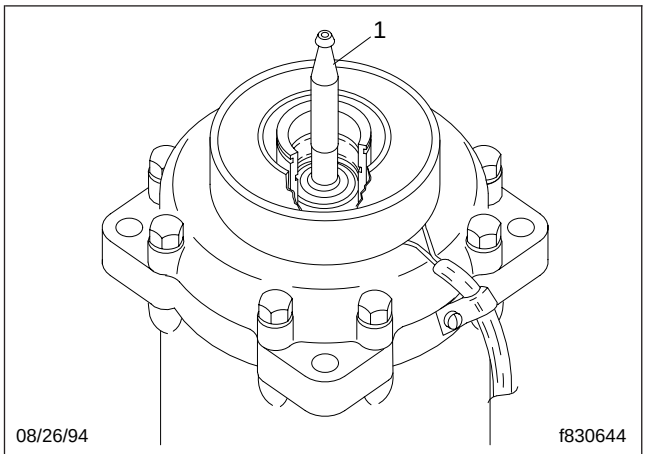
5. Using a non-petroleum based solvent and a lint-free cloth, clean the shaft seal cavity. Then, use dry compressed air to blow out the shaft seal cavity.
6. Position the shaft seal protective sleeve over the compressor shaft. **See Fig. 3** . Make sure that the sleeve has no scratches so that the shaft seal will not be damaged. Also, make sure that



1. Shaft Seal Removal and Installation Tool
2. Shaft Seal
3. Coil Assembly

Fig. 2

there is no gap between the end of the sleeve and the seal surface of the shaft.



1. Protective Sleeve

Fig. 3

7. Position the shaft seal removal and installation tool until the hooks on the tool engage the slots in the new shaft seal housing.
8. Place the entire assembly into clean 5GS refrigerant oil. **See Fig. 4.**
9. Insert the shaft seal over the protective sleeve, then press it down as far as possible. Twist the

Shaft Seal Replacement

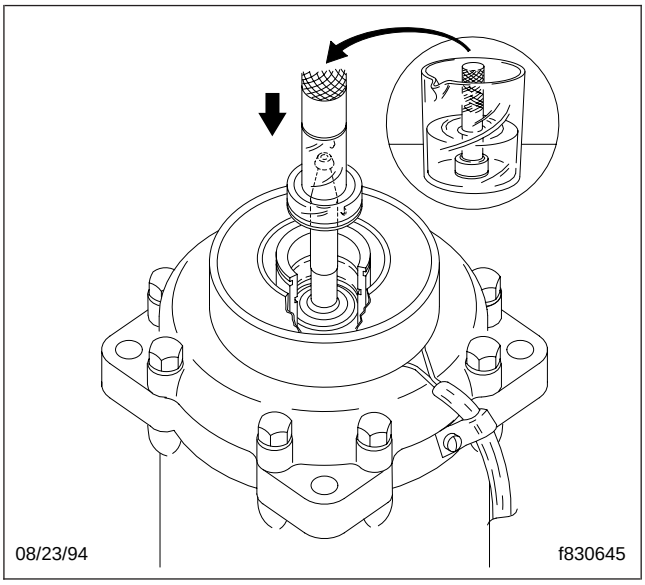


Fig. 4

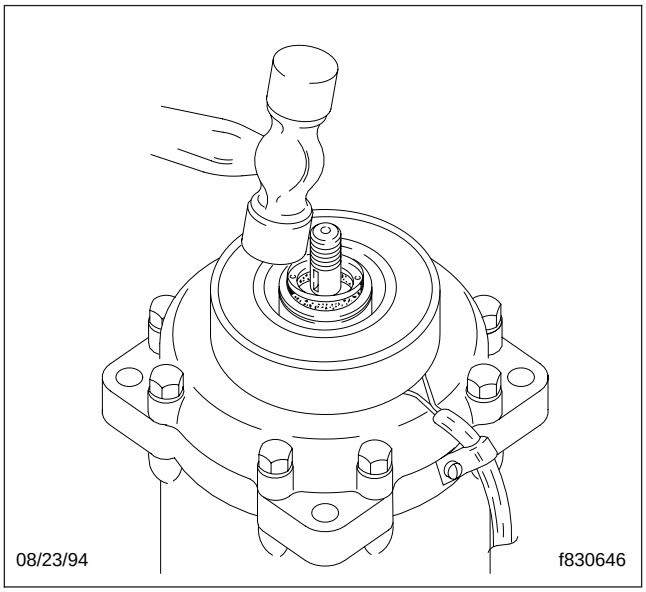


Fig. 5

removal and installation tool to remove it from the seal. Remove the tool and the protective sleeve.

10. Using internal snap-ring pliers, install the snap ring. **See Fig. 1.** If needed, gently tap the snap ring to ensure that it is seated in the groove.

NOTE: When installing the snap ring, the beveled end of the snap ring must face away from the compressor body.

11. Gently tap the new felt ring in place. **See Fig. 5.**
12. Install the drive plate and pulley assemblies. For instructions, refer to **Subject 150.**

Head and Valve Plate Removal and Installation

Removal

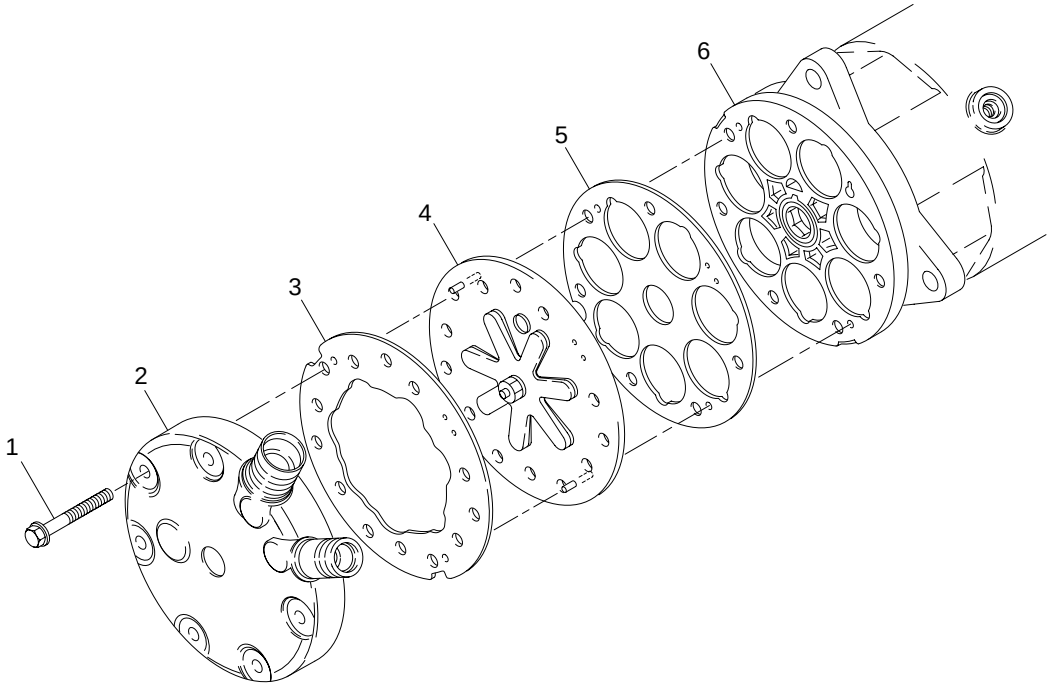
NOTE: Before doing any work on the head and valve plate, open both service valves to release any gas pressure in the compressor.

1. Remove the bolts from the cylinder head. **See Fig. 1.**

⚠ CAUTION

CAUTION: Do not hit or tap the head to separate it from the valve plate. Damage to the head may result.

NOTE: It is recommended that the head gasket (located between the cylinder head and the valve plate) and the block gasket (located between the valve plate and the cylinder block) be replaced any time the cylinder head is removed.



1. Cylinder Head Bolt
2. Cylinder Head
3. Head Gasket
4. Valve Plate Assembly
5. Block Gasket
6. Compressor Body

Fig. 1

2. Remove the valve plate assembly and the cylinder head from the compressor. Use a gasket scraper to separate the cylinder head from the valve plate. **See Fig. 2**. Use care not to scratch the gasket surface of the cylinder head.
3. Being careful not to scratch or nick the machined sealing surfaces, remove all gasket material adhering to the head, valve plate, or compressor block.

Head and Valve Plate Removal and Installation

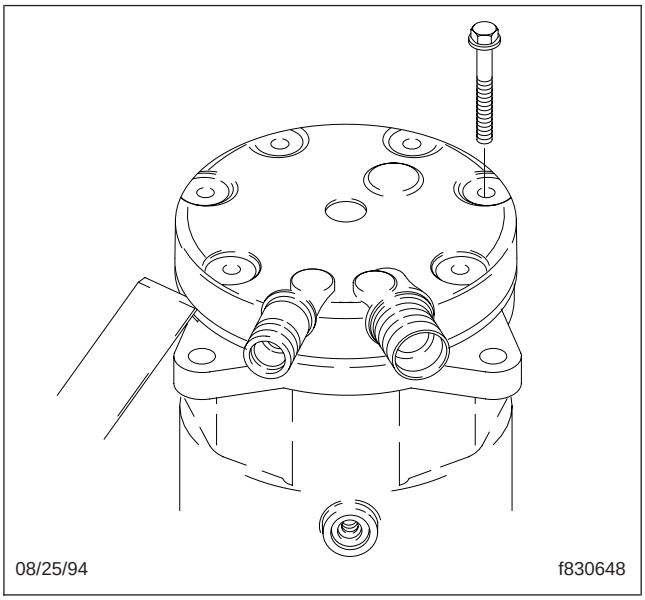


Fig. 2

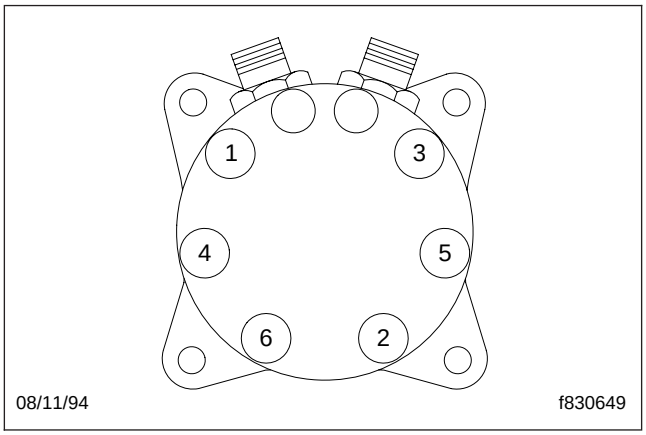


Fig. 3

Installation

1. Apply a thin film of clean 5GS refrigerant oil to the new block gasket. Place the block gasket in position on the compressor so that the pin holes in the compressor block line up with the pin holes in the block gasket.
2. Place the valve plate assembly in position on the block gasket so that the discharge valve, retainer, and the nut are facing up (away from the cylinder block). Make sure that the locating pins on the valve plate go through the pin holes in the gasket.
3. Remove all residual oil from each bolt hole on the cylinder block.
4. Apply a thin film of clean 5GS refrigerant oil to the new head gasket. Place the gasket in position over the valve plate locating pins. Make sure that the locating pins on the valve plate go through the pin holes in the gasket.
5. Place the head on the cylinder head gasket so that the dowel pins go into the dowel pin holes in the head.
6. Install the head bolts. Tighten the bolts in sequence to the values given in **Subject 400**. **See Fig. 3** for the tightening sequence.

Special tools can be purchased from the following independent suppliers:

Classic Tool Design
31 Walnut St.
New Windsor, NY 12550
(914) 562-8700

Mastercool USA Inc.
216 Route 10, Bldg. 3
Randolph, NJ 07869
(201) 366-1101

Description	Torque	
	N·cm (lbf·in)	N·m (lbf·ft)
Adjusting Rod Jam Nut	—	190 (140)
Compressor Mounting Fasteners:		
OM 366LA Engine	—	38 (28)
Dodge Magnum Engine	—	27 (20)
Clutch Retaining Nut (1/2")	—	30 (22)
Clutch Retaining Nut (M8)	—	18 (13)
Oil Drain Plug	—	20 (15)
Cylinder Head Bolts, M6	—	14 (10)
Cylinder Head Bolts, M8	—	34 (25)
Pressure Relief Valve	120 (11)	—
Dust Cover Screws, M5	880 (78)	—
Clutch Lead Wire Clamp Screw	1500 (132)	—
Rotalock Valve	—	37 (27)

Table 1, Torque Values

Outside Temp. °C (°F)	Maximum Center Vent Temp. °C (°F)	Operating Suction Pressure (Low Side) kPa (psi)	Maximum Liquid Line Pressure (High Side) kPa (psi)
16–27 (60–80)	14 (58)	55–103 (8–15)	1138 (165)
27–32 (80–90)	16 (60)	83–124 (12–18)	1276 (185)
32–38 (90–100)	18 (64)	103–138 (15–20)	1413 (205)

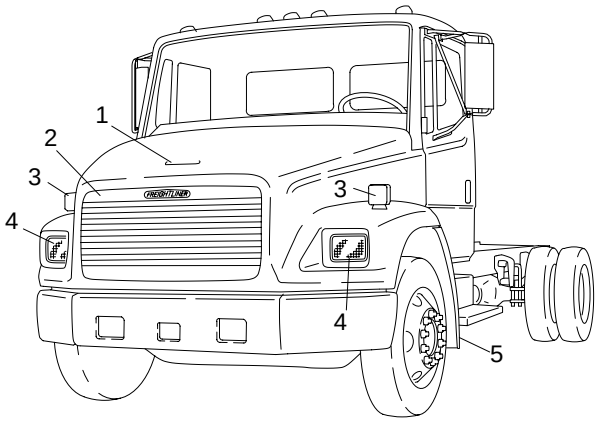
Table 2, Temperature/Pressure Specifications

General Information

All Freightliner Business Class Trucks have a molded, fiberglass-reinforced-plastic (FRP) hood and fender assembly, and molded FRP half-fenders that mount to the cab sides. Several reinforcing members are bonded to the engine side of the hood. The argent-colored front grille is made of injection-molded plastic.

A recess in the hood, above the grille, provides the handle for hood tilting. **See Fig. 1** and **Fig. 2 .**

Most Business Class Trucks are equipped with a one-piece hood that tilts forward to allow engine access. On these one-piece hoods, the grille is mounted to the front of the hood and moves forward with the hood when the hood is tilted.



04/22/93 f000448

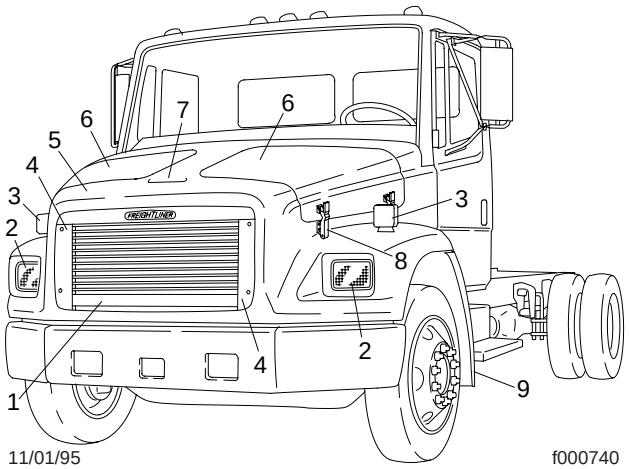
1. Recessed Hood-Tilt Handle
2. Injection-Molded Plastic Hood-Mounted Grille
3. Turn-Signal/Parking Lights
4. Recessed Single Headlight
5. Cab-Mounted Half-Fender

Fig. 1, Hood Features, With Hood-Mounted Grille

Less common are special application Business Class Trucks equipped with fixed-grille hoods, and trucks having fixed-grille hoods with dual engine access (butterfly) doors.

On these trucks, the grille mounts to the radiator support and does not move when the hood is tilted forward. This design provides engine access without interference problems from front-mounted sirens, lights, winches, etc.

On snow plow-equipped vehicles, the plow assembly often makes hood tilting impossible. The dual access door hood, with a hinged panel on each side of the vehicle, allows routine underhood service on these vehicles, even while the plow is installed. **See Fig. 2.**



11/01/95 f000740

1. Injection-Molded Plastic Radiator-Mounted Grille
2. Recessed Single Headlight
3. Turn-Signal/Parking Lights
4. Grille Trim
5. Hood
6. Engine Access "Butterfly" Door
7. Recessed Hood-Tilt Handle
8. Access Door Latch
9. Cab-Mounted Half-Fender

Fig. 2, Hood Features, With Radiator-Mounted (fixed) Grille and Dual Engine Access (butterfly) Doors

The hood and half-fenders are compression molded using the preform molding process. The first step in this process is to produce a preform by spraying chopped glass fibers and resin binder in a controlled manner onto a screen that's the same shape as the male moulding die. The preform is then heated to cure the resin binder. Next, the preform is moved to a compression molding press. Resin is dispersed onto the preform; then the preform is placed onto the male half of a matched metal mold. As the halves of the mold close, the resin is distributed throughout the part, and is cured under heat and pressure.

After molding, the hood (or half-fender) is trimmed and prepared for painting. Before priming, the fiberglass reinforcements and metal parts are bonded to the hood.

General Information

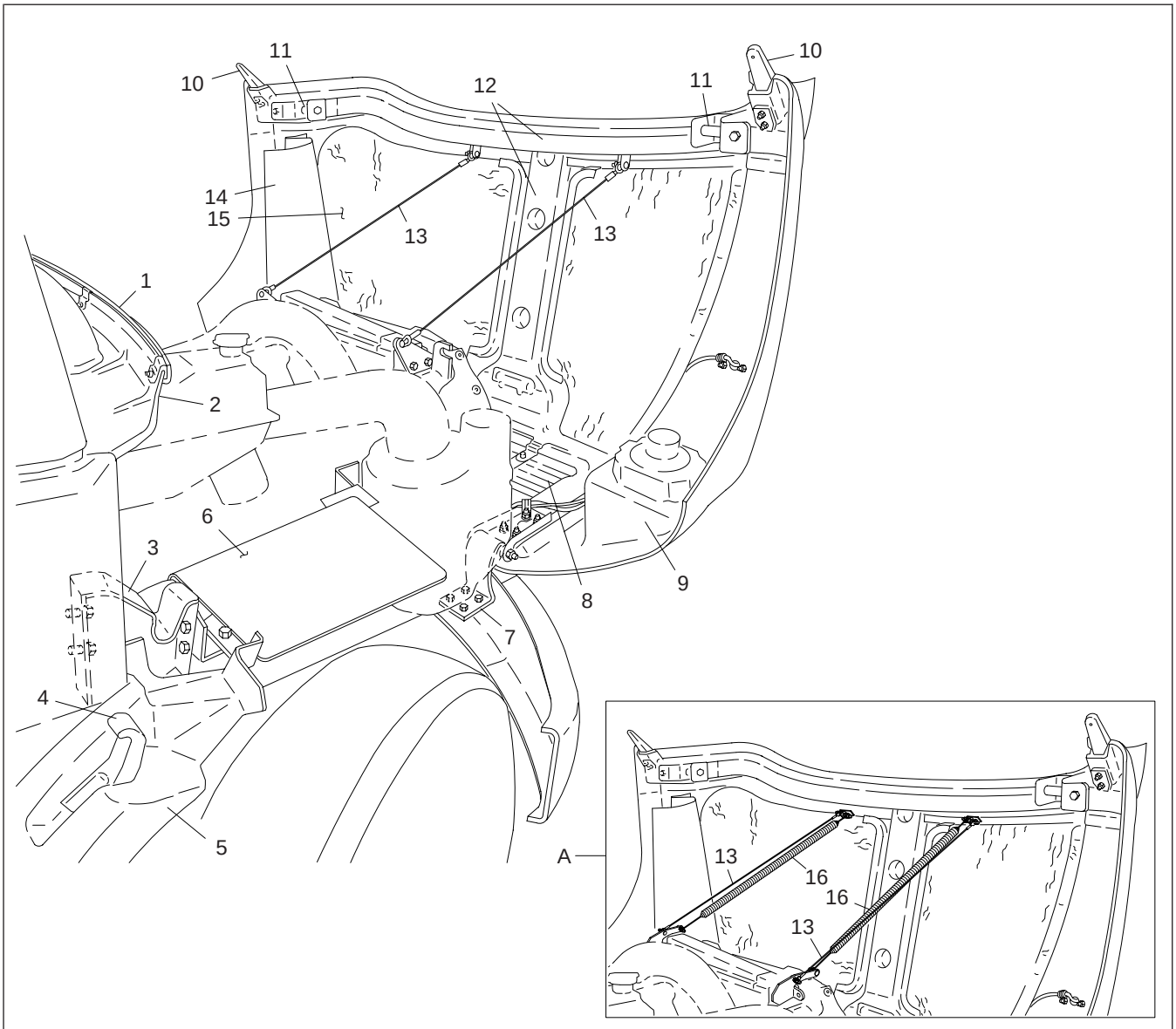
At the front of the hood, brackets mounted directly behind the front bumper, at the outside of each frame rail, support the hood-hinge pivots. Stop cables limit forward travel of the hood. Newer production vehicles have a tilt-assist assembly in addition to the stop cables. **See Fig. 3.**

When in the operating position, the hood is supported at the front by the hood-hinge pivots and at the rear by hood support brackets which are attached to the cab. A groove in each bracket mates with pins attached to the inside of the hood, near each upper rear corner. The hood is held down with two rubber over-center latches, with part of the latch attached to the hood, and the other part attached to each half-fender. To prevent warm, under-hood air from entering the cab through the air conditioner/heater air-inlet, a hood seal attaches to the cowl panel, ahead of the windshield.

Both the front hood-hinge pivots and the rear hood support brackets are adjustable forward and backward, and up and down. The front pivots are also adjustable right and left.

Splash shields under the hood extend to the inboard side of the tires. The left-hand splash shield attaches to the hood, and the right-hand shield attaches to the frame and the cab bulkhead.

On the underside of the hood are several 1-inch-thick (25 mm) polyester polyurethane foam hood liners, with a polymer-film facing. The liners reduce engine noise emissions.



04/27/93 f880207

A. Equipped with Tilt Assist

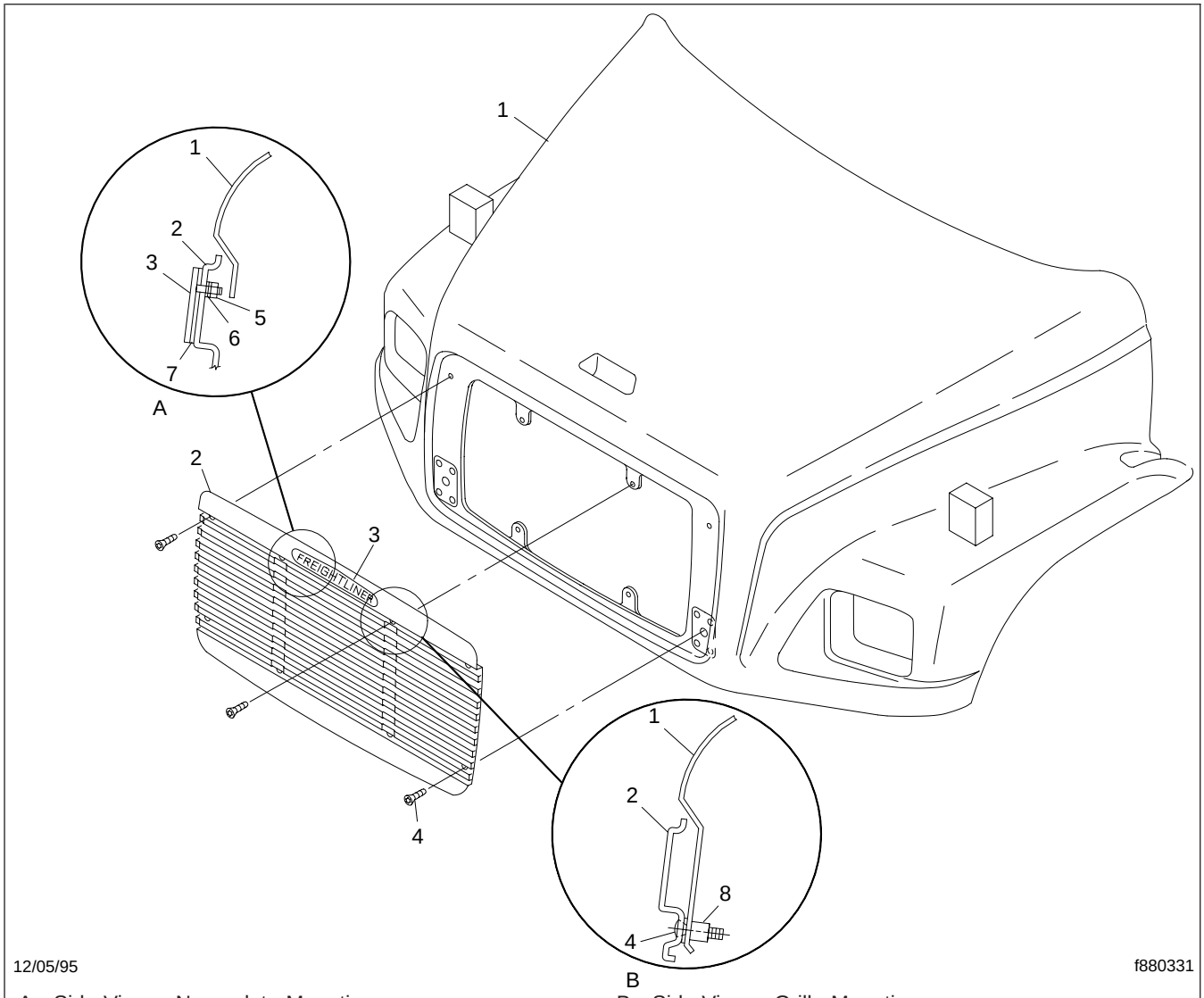
1. Hood Seal
2. Air-Inlet Panel
3. Rear Hood Support Bracket
4. Hood Latch Bracket
5. Half-Fender
6. Right-Hand Splash Shield
7. Hood Hinge
8. Grille
9. Headlight Housing
10. Hood Latch
11. Rear Hood Support Assembly
12. Hood Reinforcements
13. Hood-Stop Cable Assembly
14. Left-Hand Splash Shield
15. Hood Liner Panel
16. Hood Tilt-Assist Assembly

Fig. 3, Hood Components

Grille Removal and Installation

The grille is made of injection-molded, argent colored plastic. The removal and installation method depends on whether the grille is hood-mounted or radiator-mounted.

Hood-Mounted Grille (See Fig. 1)



A. Side View – Nameplate Mounting
B. Side View – Grille Mounting

1. Hood
2. Grille
3. Nameplate
4. T30 Torx Screw
5. Self-Threading Hexnut
6. Flatwasher
7. Nameplate Gasket
8. Well Nut

Fig. 1, Hood-Mounted Grille Installation

Grille Removal and Installation

REMOVAL

1. Apply the parking brakes.
2. With the hood in the normal, driving position, use a Torx screwdriver (T30) to remove the grille-to-hood screws.
3. Remove the grille.

INSTALLATION

NOTE: If the grille is being replaced, transfer the nameplate and gasket to the new grille.

1. Place the grille in the hood opening and align the screw holes.
2. Install the screws and use a Torx screwdriver (T30) to tighten them securely.

Radiator-Mounted (Fixed) Grille (See Fig. 2)

REMOVAL

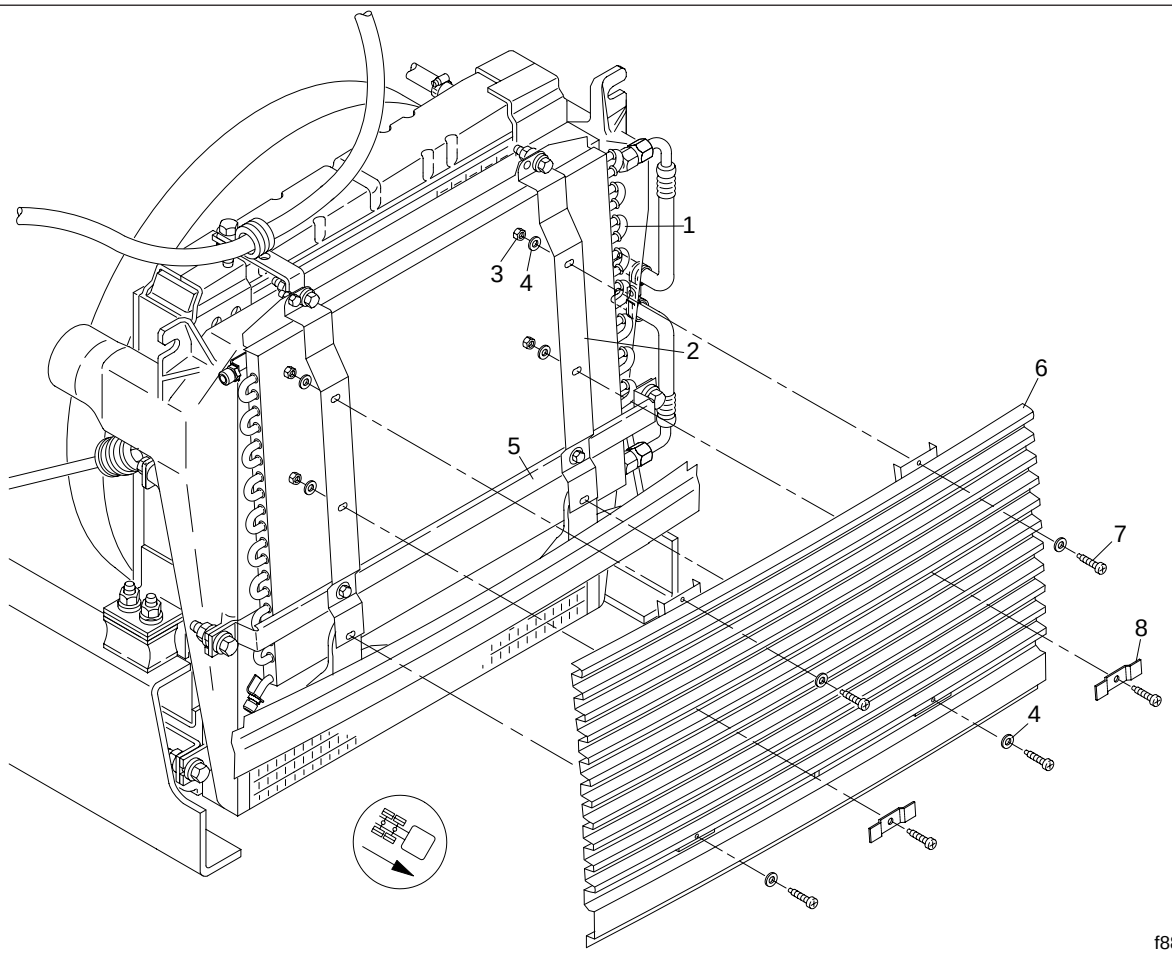
NOTE: The hood must be tilted forward to access grille fasteners. If equipment mounted on the front of the vehicle interferes with hood tilting, that equipment must be removed before attempting grille removal.

1. Apply the parking brakes.
2. Tilt the hood forward.
3. Loosen the grille retaining screws using a Phillips screwdriver, while holding the retaining screw nuts with a box wrench.
4. Remove the screws, grille retainer brackets, flatwashers, and nuts.
5. Remove the grille.

INSTALLATION

1. Position the grille against its mounting brackets and align the screw holes.
2. Insert the grille retaining screws, making sure to install flatwashers on the screws at the four corner positions and retainer brackets on the screws at the middle positions.
3. Install flatwashers and nuts on the retaining screws and tighten the screws securely using a Phillips screwdriver.

Grille Removal and Installation



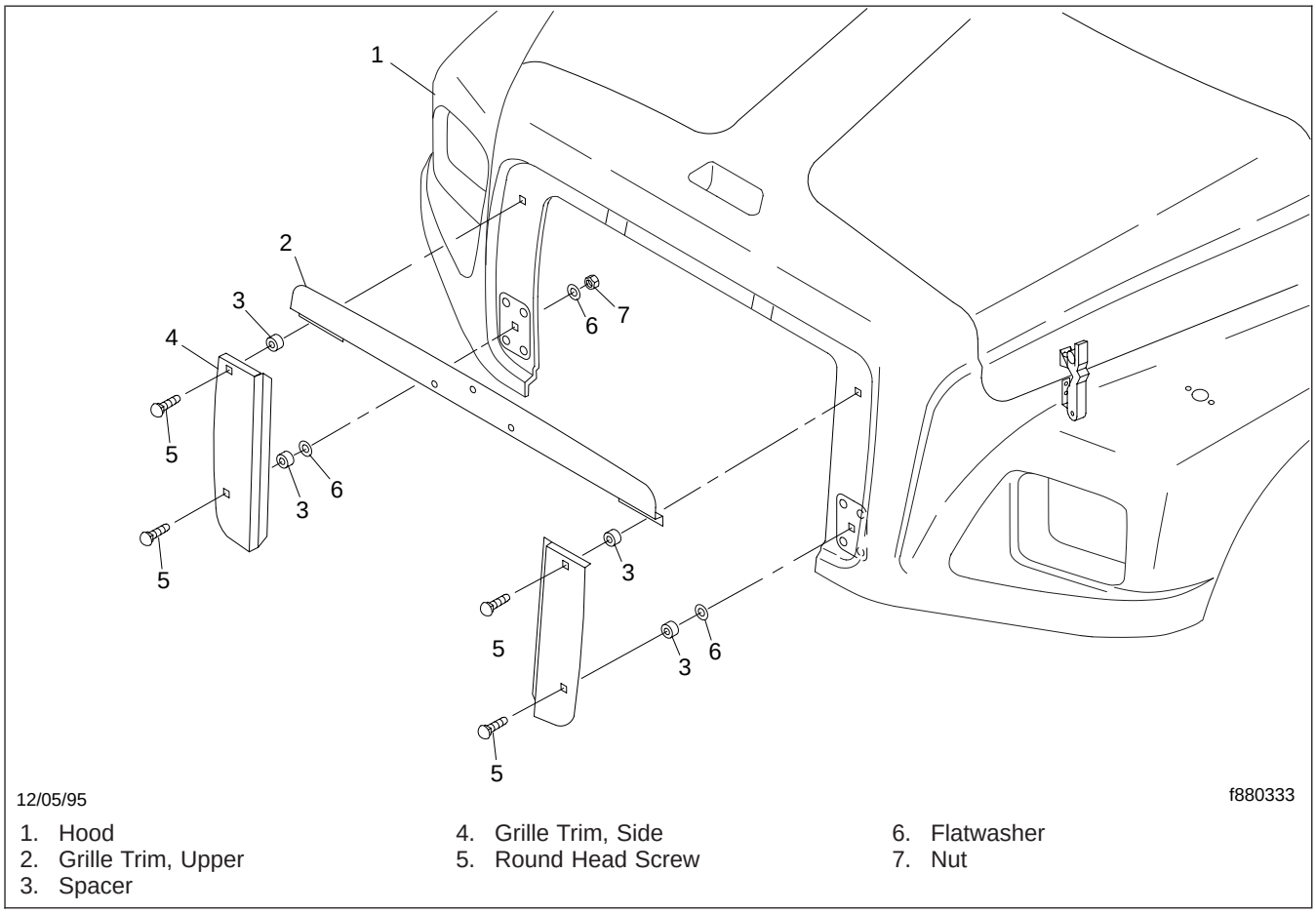
NOTE: Hood assembly removed for clarity. Also, grille shown is for vehicles without front PTO. On PTO-equipped vehicles, the grille is shorter.

1. A/C Condenser
2. Grille Mounting Bracket
3. Self-Locking Hexnut
4. Flatwasher
5. Channel
6. Grille
7. Phillips Screw
8. Grille Retainer Bracket

Fig. 2, Radiator-Mounted (fixed) Grille Installation

Grille Trim Removal and Installation (Fixed-Grille Models)

On fixed-grille versions of the Business Class Truck, three pieces of argent colored trim border the top and sides of the grille. These trim pieces are made of formed sheet steel and mount to the hood assembly. **See Fig. 1.**



1. Hood
2. Grille Trim, Upper
3. Spacer
4. Grille Trim, Side
5. Round Head Screw
6. Flatwasher
7. Nut

Fig. 1, Radiator-Mounted (fixed) Grille Trim Installation

Removal

NOTE: The hood must be tilted forward to access grille trim fasteners. If equipment mounted on the front of the vehicle interferes with hood tilting, that equipment must be removed before attempting grille trim removal.

1. Apply the parking brakes.
2. Tilt the hood forward.
3. Loosen the grille trim retaining nuts using a socket wrench, while holding the retaining screw head against the grille trim piece with your hand. (The round-head retaining screws have square shanks, which mate with square holes in the trim pieces.)
4. Remove the screws, spacers, flatwashers, and nuts.
5. Remove the grille trim.

Installation

NOTE: If the upper trim piece is being replaced, transfer the nameplate and gasket to the new trim piece.

Grille Trim Removal and Installation (Fixed-Grille Models)

1. Insert the round-head screws in the side trim pieces, and install spacers and flatwashers on the screws. **See Fig. 1.**
2. Position the upper trim piece against the hood and align the screw holes.
3. Install the grille trim side pieces on the hood.
4. Install flatwashers and nuts on the retaining screws and tighten the nuts securely using a socket wrench.

Splash Shield Removal and Installation

Removal

1. Apply the parking brakes and chock the rear tires.
2. Tilt the hood.
3. To remove the *right-hand splash shield*, remove the 1/4-turn stud that attaches the rear of the shield to its bracket on the rear hood-support bracket. See **Fig. 1**. Lift the rear of the shield about 1 in (25 mm), then pull it rearward about 1 in (25 mm). Lift it over the tire.

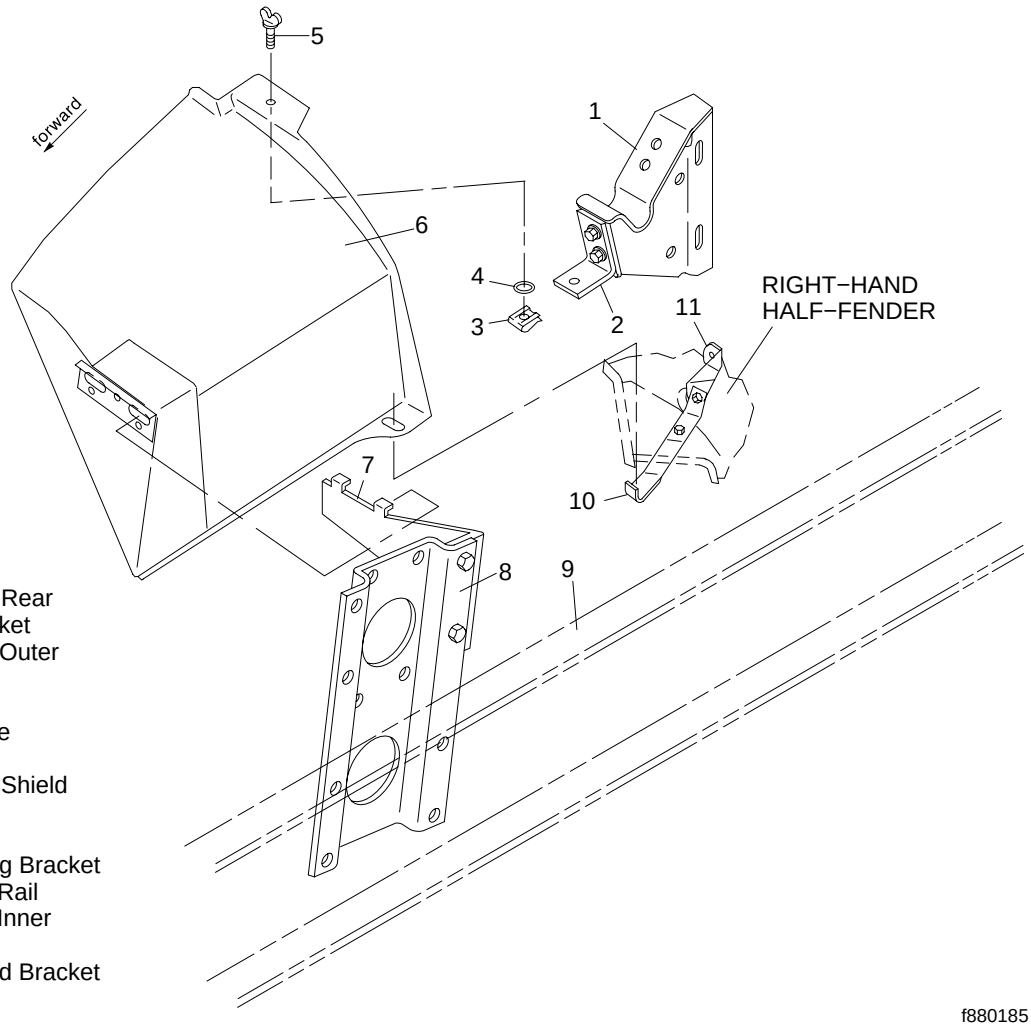
   To remove the *left-hand splash shield*, pull the upper edge of the splash shield sound-absorbent liner down far enough to access the splash shield rivets. Then use a drill and bit to remove the rivets and fender washers that attach the shield to the hood. See **Fig. 2**. Remove the shield.

Installation

1. To install the *right-hand splash shield*, position the tabs on the front mounting bracket in the slots in the front of the splash shield, then lower the rear of the shield until the tab on the rear inner mounting bracket is installed in the slot in the lower edge of the shield. See **Fig. 1**. Install the 1/4-turn stud.

   To install the *left-hand splash shield*, position the shield against the reinforcement under the hood, and align the rivet holes. See **Fig. 2**. At each of the six holes, position the fender washer, then install a pop rivet to attach the shield to the reinforcement. Push the splash shield sound-absorbent liner into place.
2. Lower the hood, and remove the chocks.

Splash Shield Removal and Installation



1. Bulkhead−Mounted Rear Hood−Support Bracket
2. Splash Shield Rear Outer Mounting Bracket
3. Split Ring Retainer
4. 1/4−Turn Receptacle
5. 1/4−Turn Stud
6. Right−Hand Splash Shield
7. Splash Shield Front Mounting Bracket
8. Air Cleaner Mounting Bracket
9. Right−Hand Frame Rail
10. Splash Shield Rear Inner Mounting Bracket
11. Half−Fender Forward Bracket

08/09/93 f880185

Fig. 1

Splash Shield Removal and Installation

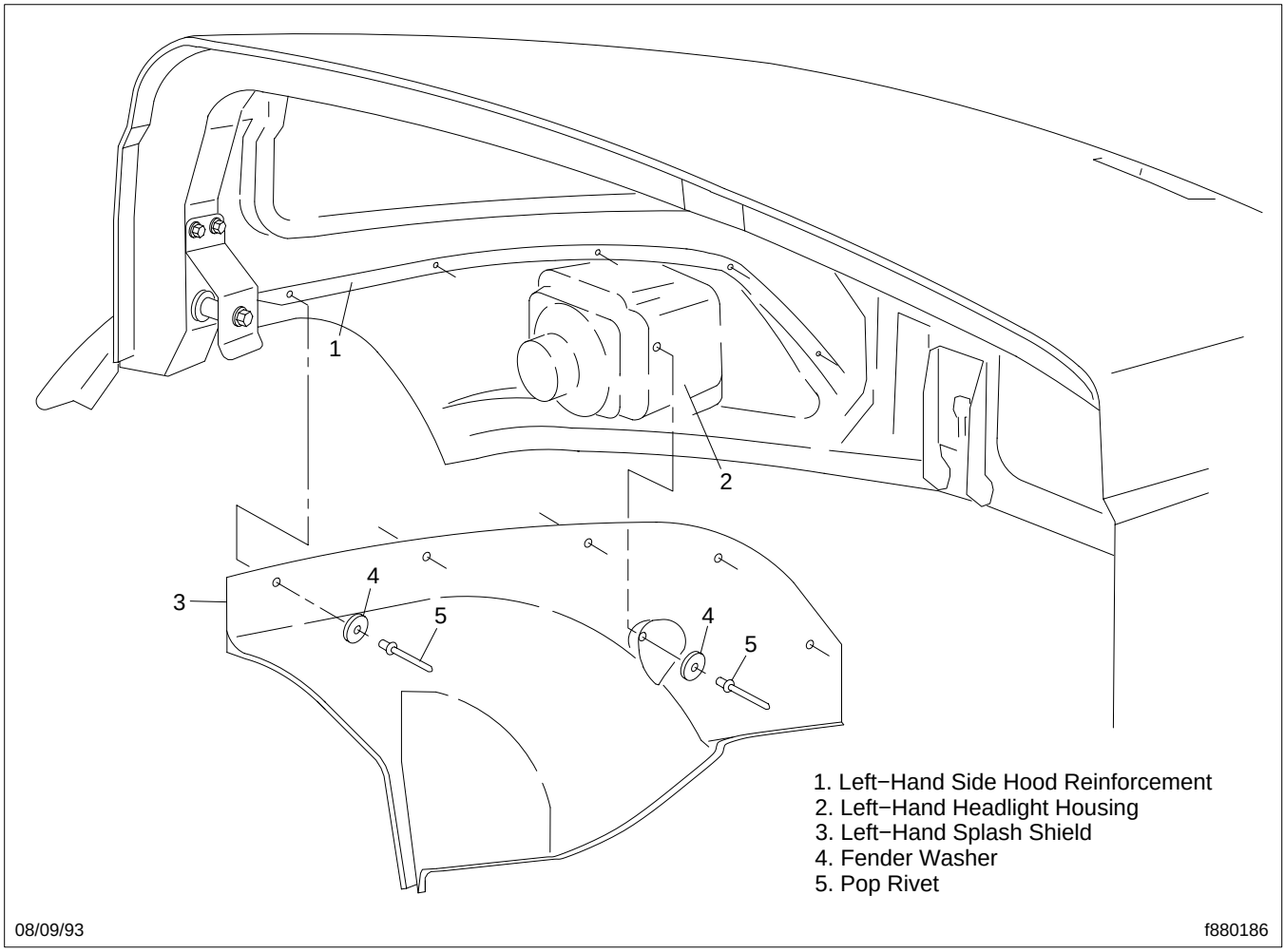


Fig. 2

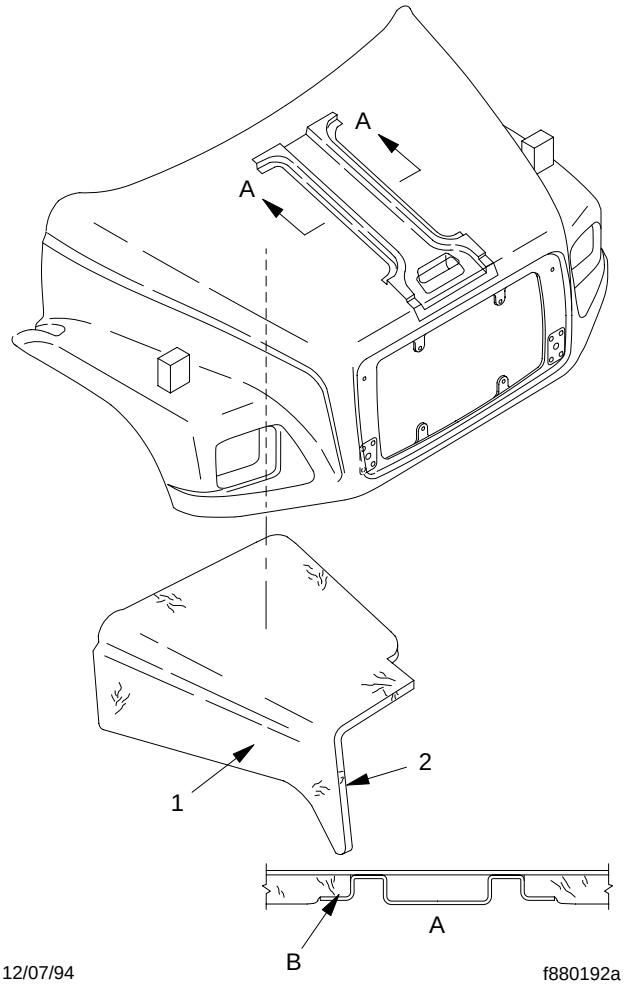
Hood Liner Replacement
(See Fig. 1 and Fig. 2)

Some Business Class Trucks equipped with diesel engines have noise insulation liners fitted to the underside of the hood. The liners are made of 1-inch-thick (25 mm) foam and have a polymer facing on both sides.

On vehicles equipped with a one-piece hood, 2 liners are attached to the underside of the hood.

On vehicles equipped with a dual access door hood, a liner is fitted to each access door.

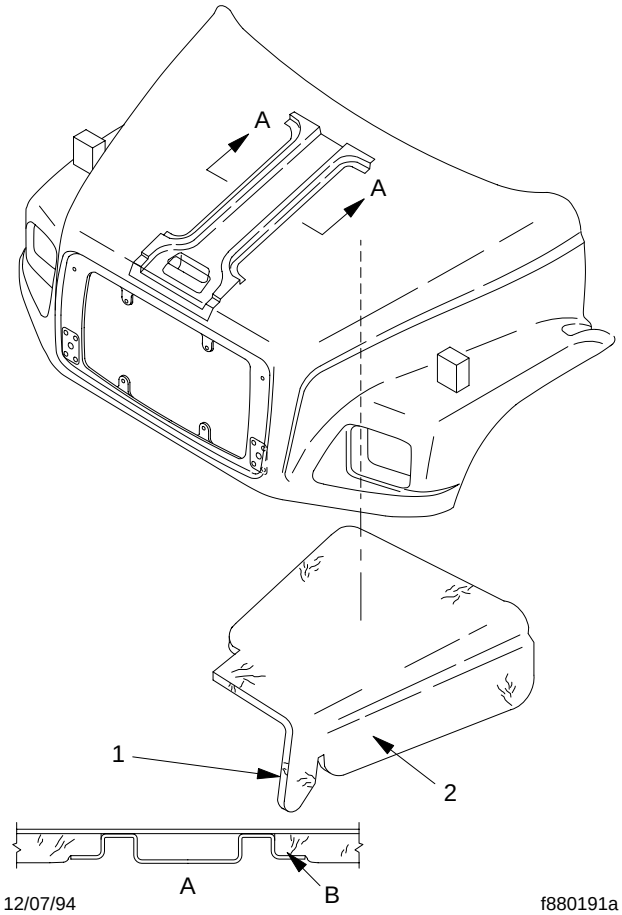
1. Apply the parking brakes and chock the rear tires.
2. If replacing either side hood liner **(see Fig. 1 or Fig. 2),** remove the grille; if necessary, refer to **Subject 100.**
3. Tilt the hood.
4. Remove the entire liner that is being replaced.
5. Use a wire brush to clean the area that was covered by the liner; then, thoroughly steam clean the area, and allow it to air dry.
6. Push the pressure-sensitive-adhesive side of the new liner into place, starting at one edge and working the liner into place from that edge toward the opposite edge. If installing either side hood liner, start by pushing the inboard edge of the liner into the center hood reinforcement. **See Fig. 1** or **Fig. 2,** Section A-A.
7. Lower the hood. If it was removed, install the grille; refer to **Subject 100** for information.
8. Remove the chocks from the tires.



A. Cross-section view, hood center reinforcement
B. First, push the inboard edge of the liner into the center hood reinforcement.
1. Pressure-Sensitive Adhesive Backing
2. Polymer Film Facing

Fig. 1, Right-Hand Side Hood Liner

Hood Liner Replacement



A. Cross-section view, hood center reinforcement
B. First, push the inboard edge of the liner into the center hood reinforcement.
1. Polymer Film Facing
2. Pressure-Sensitive Adhesive Backing

Fig. 2, Left-Hand Side Hood Liner

Removal (See Fig. 1 and Fig. 2)

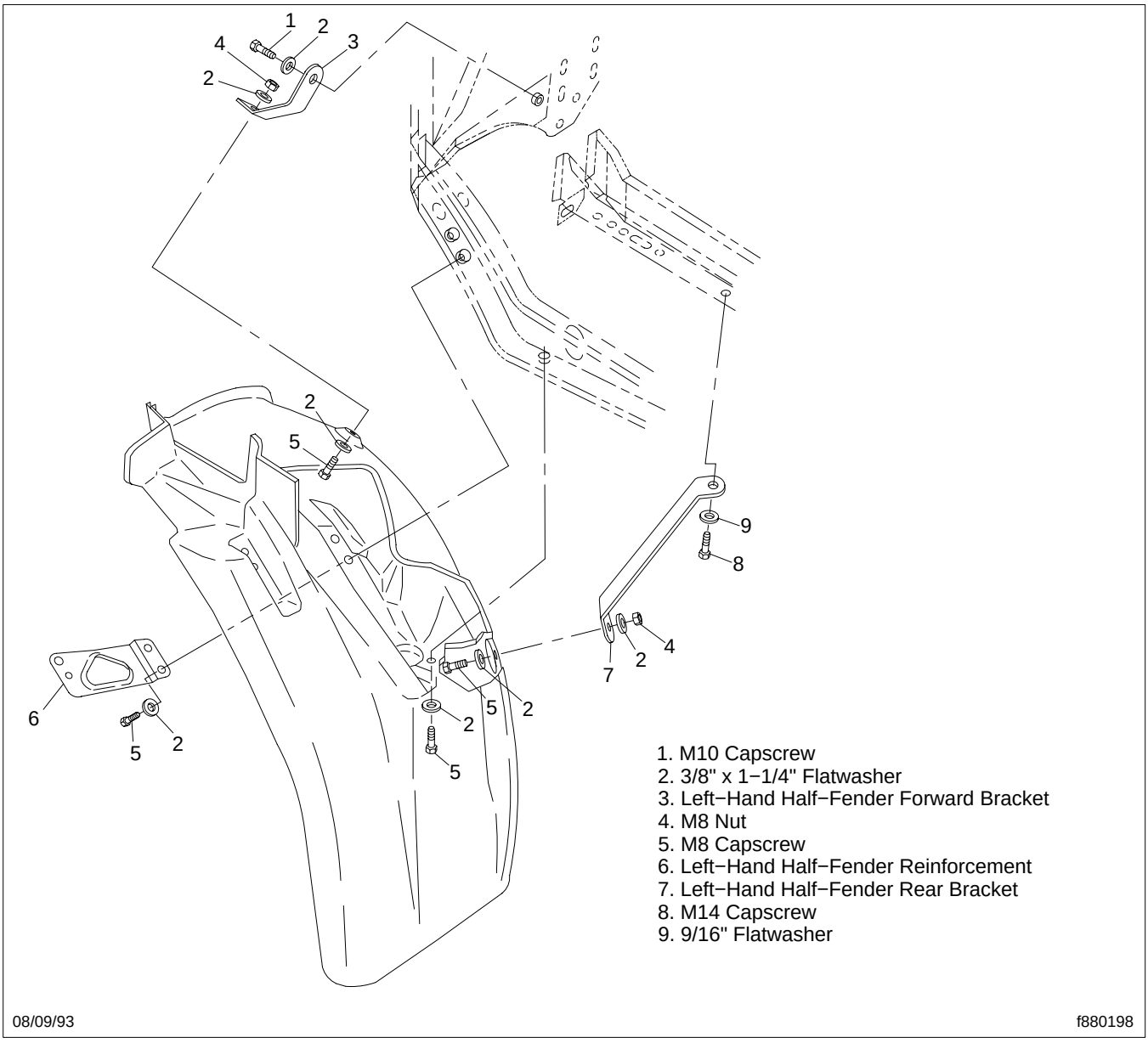


Fig. 1, Left-Hand Half-Fender Installation

1. Apply the parking brakes and chock the rear tires.
2. Tilt the hood.
3. Remove the fasteners that attach the half-fender to the forward and rear brackets.
4. Remove the fasteners that attach the half-fender to the cab. Remove the half-fender.

Half-Fender Removal and Installation

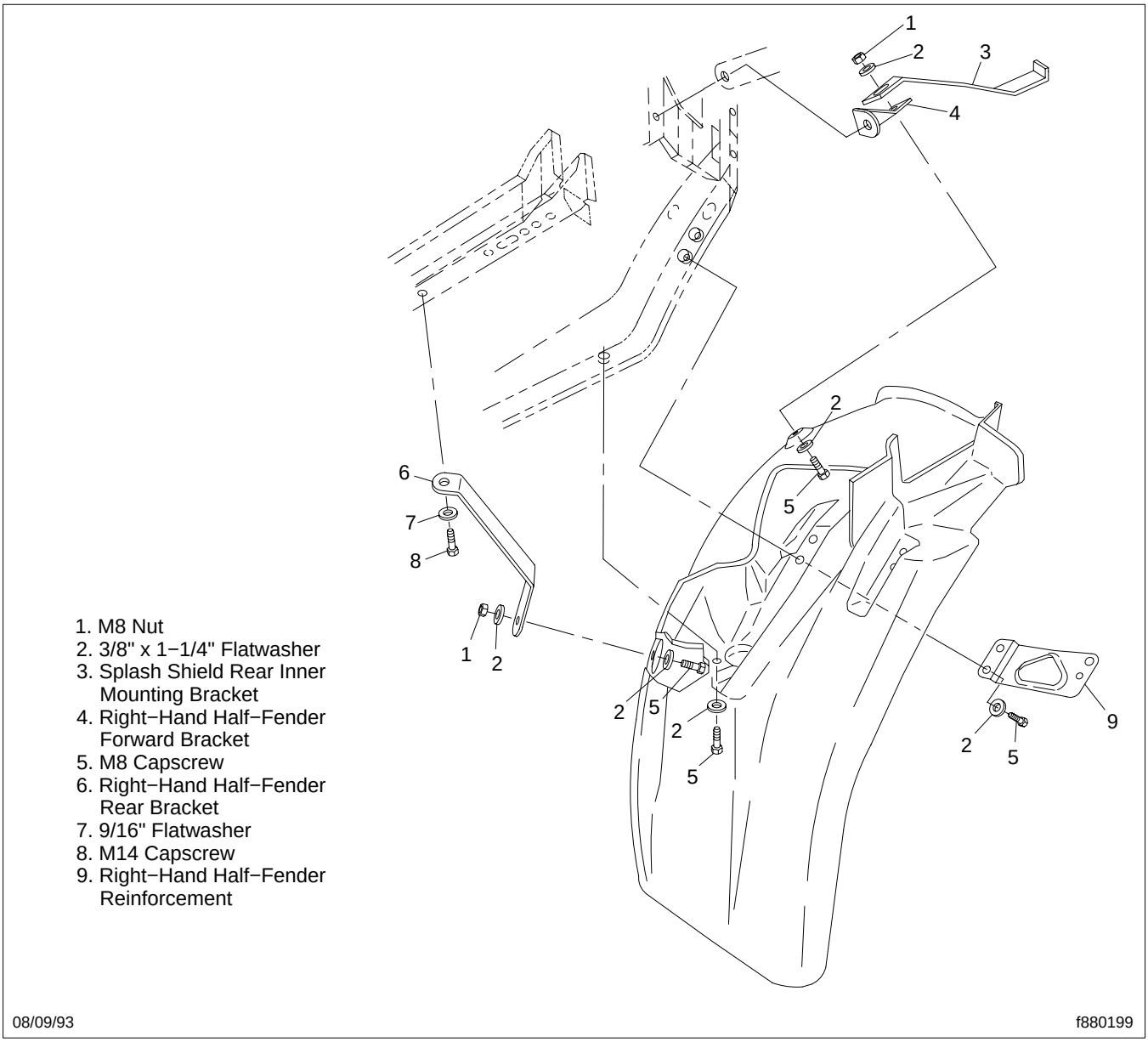


Fig. 2, Right-Hand Half-Fender Installation

5. If the half-fender is being replaced, remove the hood latch bracket and half-fender reinforcement for installation on the new half-fender. Also, if replacing a right-hand half-fender, remove and save the splash shield rear inner mounting bracket.

Installation (See Fig. 1 and Fig. 2)

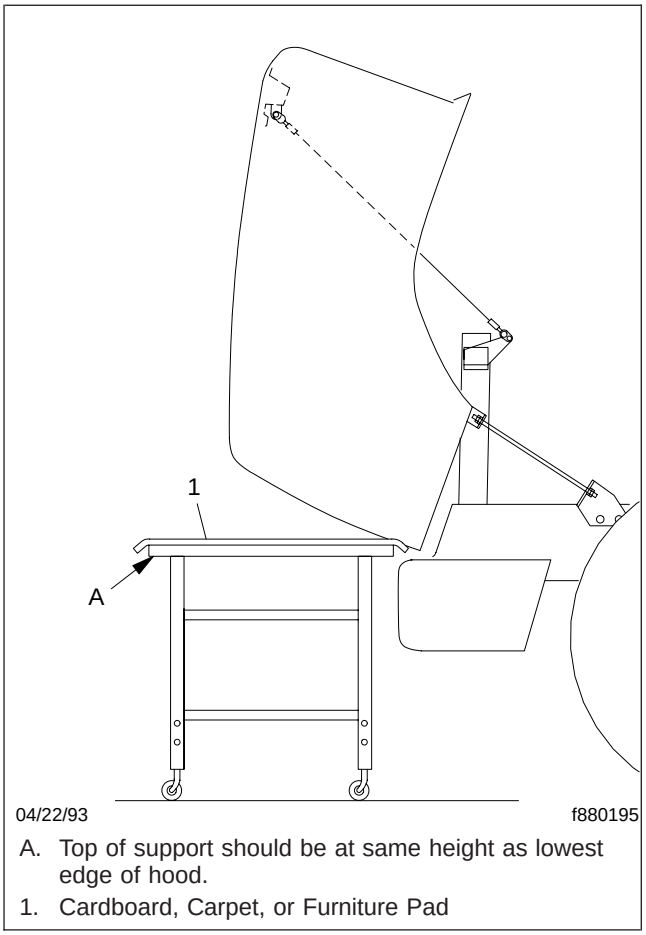
1. If the half-fender was replaced, install the hood latch bracket, half-fender reinforcement, and (if so equipped) the splash shield rear inner mounting bracket on the new half-fender. Tighten the 1/4–20 locknuts 1080 N·cm (96 lbf·in).

2. Position the new half-fender against the cab, and install, finger-tight, the fasteners that attach the fender and fender reinforcement to the cab.
3. Install the fasteners that attach the half-fender to the forward and rear brackets.
4. Tighten all M8 capscrews and nuts 21 N·m (16 lbf·ft).
5. Lower the hood, and remove the chocks.

Removal

1. Apply the parking brakes and chock the rear tires.
2. Tilt the hood.
3. Place a support between the floor and the front of the hood. See **Fig. 1**.

   The support should be as wide and as long as the front of the hood, and should be the same height as the lowest edge of the hood. Place cardboard, carpet, rags, or other padding on top of the support to protect the hood.



A. Top of support should be at same height as lowest edge of hood.
1. Cardboard, Carpet, or Furniture Pad

Fig. 1

4. Disconnect the headlight and turn-signal/parking light connectors behind the bumper on both sides of the vehicle. See **Fig. 2**.

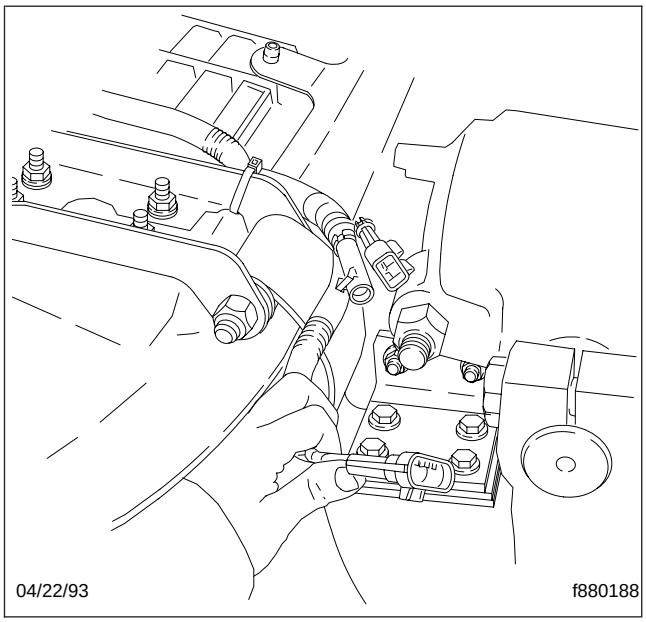


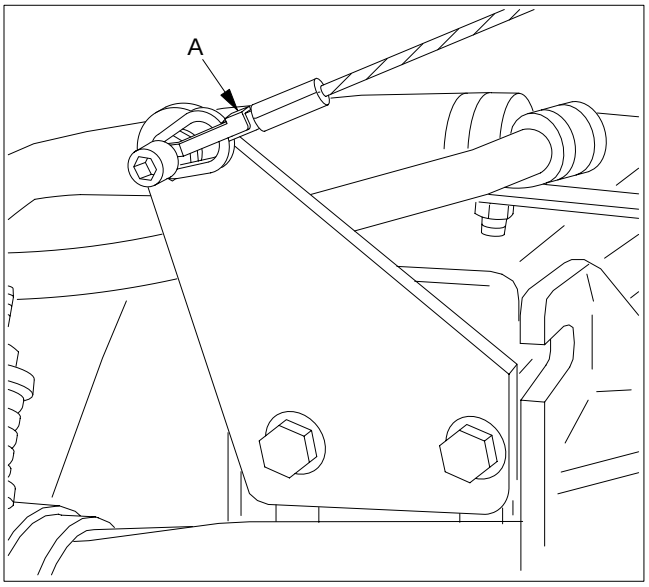
Fig. 2

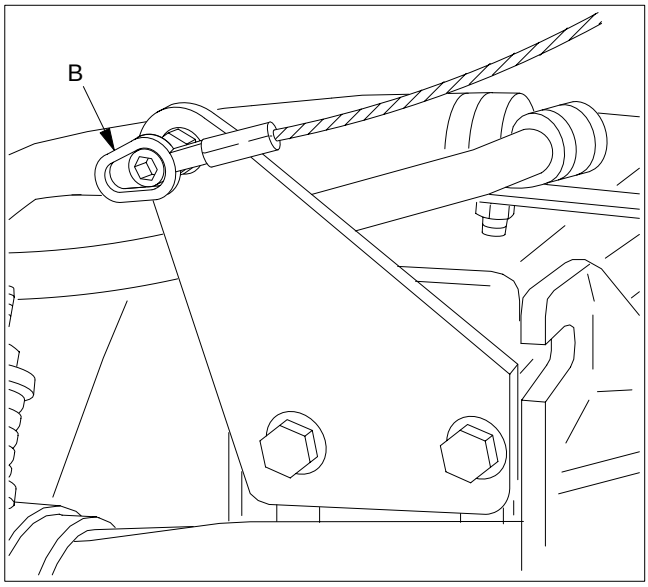
5. Lower the hood until it is balanced over the pivots to relieve tension on the stop cables (and, if so equipped, the tilt-assist assemblies). Have a co-worker hold the hood in this position.
6. Disconnect the stop cables, and if so equipped, the tilt-assist assemblies from the brackets on the radiator. See **Fig. 3** and **Fig. 4**.
7. Carefully tilt the hood onto the support.
8. Remove the prevailing torque locknuts from the hood-pivot bolts. See **Fig. 5**. Drive out both hood-pivot bolts.
9. Carefully roll or slide the hood support away from the vehicle; don't try to lift the hood.

Installation

1. With the hood in the forward-tilt position and resting on the support at about the same height as the top of the bumper, move the support and hood into alignment with the front of the vehicle. Don't try to lift the hood.
2. Align the bolt holes of the hood hinge brackets with those in the lower hood hinges. Push the hood-pivot bolts into place from the inboard side. See **Fig. 5**. Install the prevailing torque locknuts, then tighten them 130 lbf·ft (176 N·m).

Hood Removal and Installation



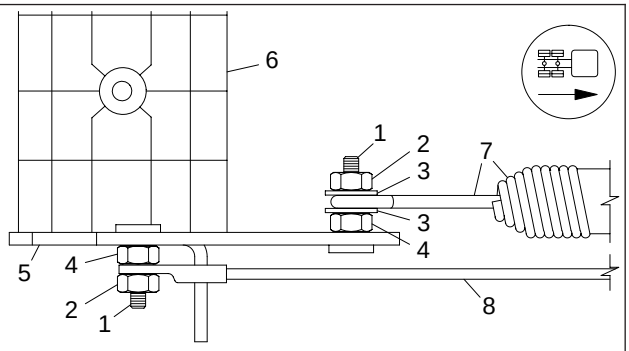


04/22/93 f880189

A. Remove this keeper.

B. Remove the cable eye from the allen-head bolt.

Fig. 3



04/27/93 f880264

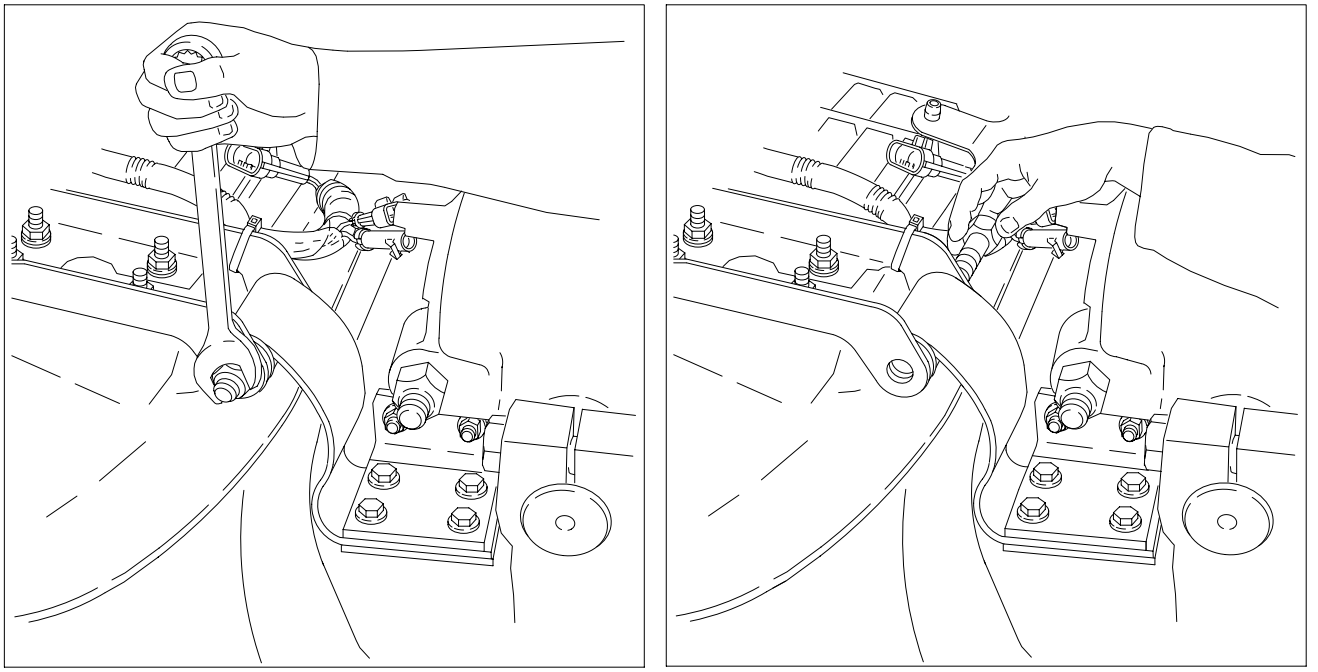
1. Stud
2. Locknut
3. Washers
4. Nut
5. Bracket
6. Radiator
7. Tilt-Assist Assembly
8. Stop Cable

Fig. 4, Top View

3. Lower the hood until it is balanced over the pivots, then have a co-worker hold the hood in this position.
4. Connect the stop-cable assemblies to the brackets on top of the radiator. If so equipped, install the keepers to prevent the cable eyes from coming off the ends of the allen-head bolts. See **Fig. 3**.

   If equipped with tilt-assist assemblies, install each stop cable on the stud farthest back on the radiator bracket. Install locknuts (**Fig. 4**), tighten them until all the parts are flush against each other, then back off the locknuts 1/4 turn.

   Install each tilt-assist assembly to the forward stud on the radiator side-channel brackets, using a washer on each side of the tilt-assist cable hook, then a locknut. See **Fig. 4**. Tighten the locknuts until all the parts are flush against each other, then back off the locknuts 1/4 turn.
5. Remove the hood support from the front of the vehicle and tilt the hood all the way open.
6. Connect the headlight and turn-signal/parking light cables on both sides of the vehicle.
7. Lower the hood. Check the hood adjustment, and adjust the hood if needed. See **Subject 150** for instructions.
8. Remove the chocks from the tires.

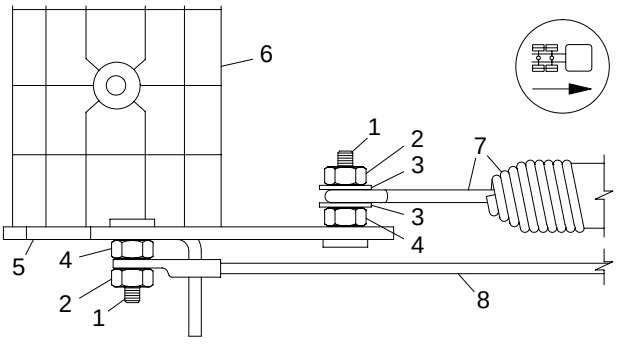


04/22/93 f880190

Fig. 5

Replacement

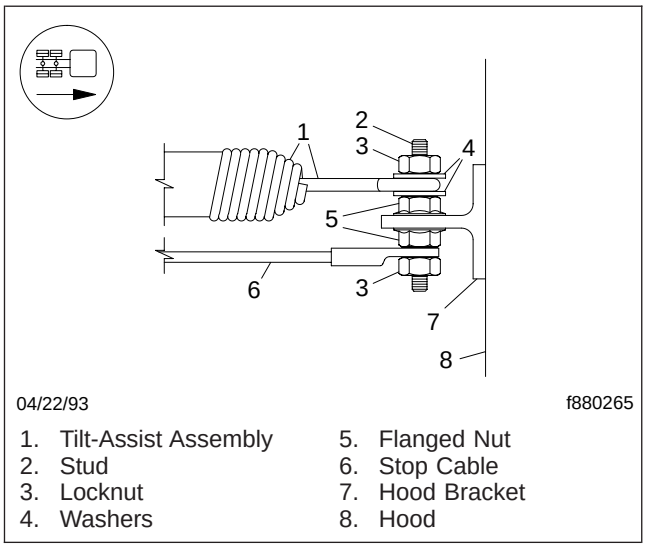
1. Apply the parking brakes and chock the rear tires.
2. Tilt the hood.
3. Remove the tilt-assist assembly.
   - 3.1 Loosen and remove the locknut and washer holding the tilt-assist assembly to the bracket on the radiator side-channel. See **Fig. 1**.
   - 3.2 Loosen and remove the locknut holding the tilt-assist assembly to the stud on the hood bracket. See **Fig. 2**.
4. Remove the old tilt-assist assembly from the vehicle.



1. Stud
2. Locknut
3. Washers
4. Nut
5. Bracket
6. Radiator
7. Tilt-Assist Assembly
8. Stop Cable

Fig. 1, Top View

5. Install the new tilt-assist assembly.
   - 5.1 If there is none present, install a washer on the forward stud on the radiator side-channel bracket. Hook one end of the new tilt-assist assembly over the stud. See **Fig. 1**.
   - 5.2 Install a second washer and locknut on the stud; then tighten the locknut until all parts are flush against each other. Back off the nut 1/4 turn, to allow the tilt-assist assembly to rotate.
   - 5.3 If there is none present, install a washer on the stud in the hood bracket. Hook the other end of the tilt-assist assembly over the stud .See **Fig. 2**.
   - 5.4 Install a second washer and locknut on the stud; then tighten the locknut until all the parts are flush against each other. Back off the nut 1/4 turn to allow the hood tilt-assist assembly to rotate.
6. If replacing both tilt-assist assemblies, repeat the procedure for the other side of the vehicle.
7. Lower the hood. Check the hood adjustment, and adjust the hood if needed. See **Subject 150** for instructions.
8. Remove the chocks from the tires.



1. Tilt-Assist Assembly
2. Stud
3. Locknut
4. Washers
5. Flanged Nut
6. Stop Cable
7. Hood Bracket
8. Hood

Fig. 2, Top View

Adjustment

1. Drive the vehicle back and forth to settle the frame and suspension. Park the vehicle on a flat, level surface.
2. With the hood in the operating position, and both hood latches latched, check the gap between the top of the bumper and the bottom edge of the hood on both sides. The edges should be parallel. **See Fig. 1.**

   If the edges *are parallel*, proceed to the next step.

   If the edges are *not* parallel, adjust the height of the front of the hood.

   2.1 With the hood latched, on the side of the hood that's low, loosen the two sets of locknuts and capscrews that attach the hood-pivot support bracket to the frame rail. **Refer to Fig. 2** , Refs. 3 and 9.

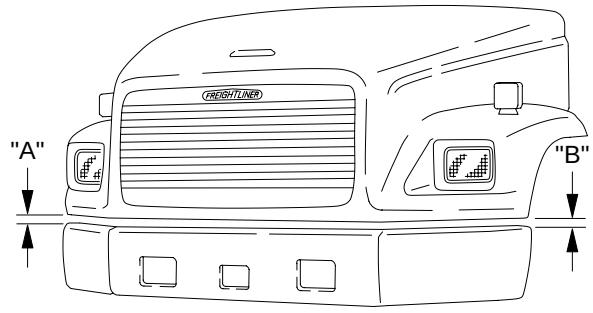
   2.2 Raise that side of the hood until both sides are parallel. From its lowest to its highest position, each hood-pivot support bracket will adjust 9.0 mm (11/32 in). Tighten the fasteners 95 N·m (70 lbf·ft).

   2.3 If you can't move that side up enough to make both sides parallel, loosen the hood-pivot support bracket fasteners on the other side of the hood, and lower that side of the hood until both sides are parallel. Tighten the fasteners 95 N·m (70 lbf·ft).

   Go to the next step.
3. With the hood in the operating position, and both hood latches latched, measure the gap between the rear vertical edge of the hood and the front outer vertical edge of the cowl at both sides of the vehicle. **Refer to Fig. 3 .** The gap should be between 10 and 16 mm (3/8 to 5/8 in).

   If the gap on both sides is within specifications, go to the step for checking the alignment of the hood/cab character lines.

   If the gap is *not* within specifications on one or both sides, adjust the fore-and-aft position of the hood.



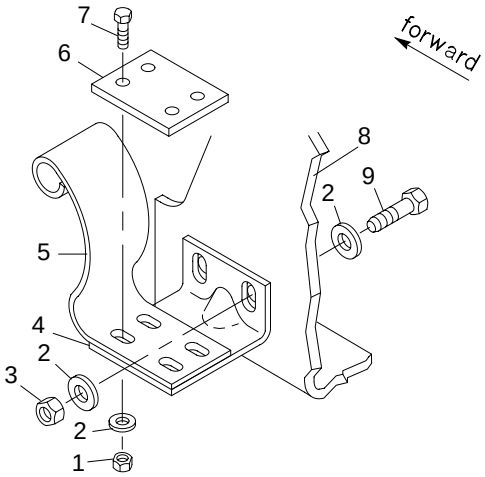
"A" must equal "B"

08/09/93 f880183

Fig. 1

3.1 Determine the amount that the hood must be moved at one or both sides, to correct the gap.

3.2 Unlatch and tilt the hood.



1. Lower Hood−Hinge Pivot Locknut
2. Flatwasher
3. Hood−Pivot Support Bracket Locknut
4. Hood−Pivot Support Bracket
5. Lower Hood−Hinge Pivot
6. Lower Hood−Hinge Reinforcement
7. 3/8−16 Capscrew
8. Frame Rail
9. 1/2−13 Capscrew

08/09/93 f880184

Fig. 2

3.3 At the side(s) of the hood that must be moved, loosen the three capscrews that attach the rear hood support assembly to

Hood Alignment Adjustment

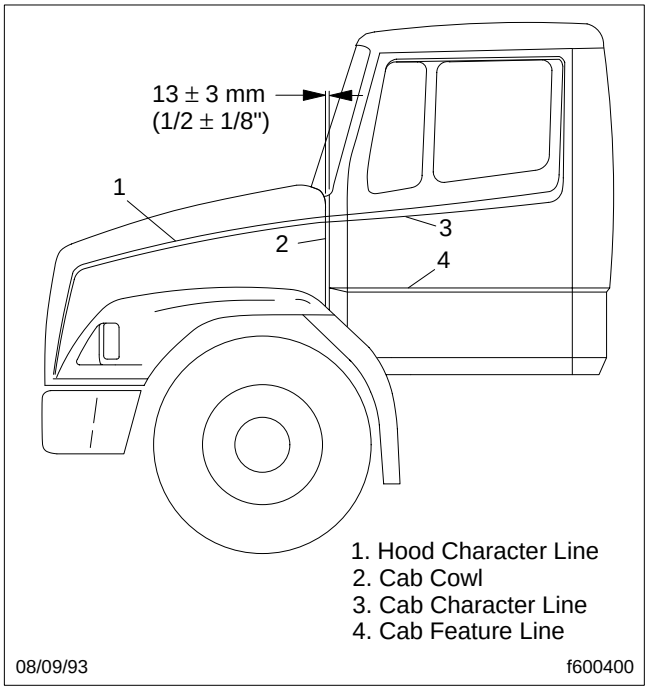


Fig. 3

the hood, just enough to allow the hood to slide fore and aft for adjustment. **Refer to Fig. 4** , Ref 3.

On the side(s) to be moved, loosen the four locknuts and capscrews that attach the lower hood-hinge pivot to the hood-pivot support bracket. **Refer to Fig. 2** , Refs. 1 and 7. Slide that side(s) of the hood fore or aft the amount determined earlier.

Tighten the lower hood-hinge pivot locknuts 55 N·m (40 lbf·ft).

3.4 Return the hood to the operating position, and fasten the latches.

3.5 Again, check the gap at both sides of the hood. **Refer to Fig. 3 .**

If the gap is *not* within specifications, repeat the above procedure.

When the gap is within specifications at both sides of the hood, go to the next step.

4. With the hood in the operating position, and both hood latches latched, check alignment of the cab and hood character lines. **Refer to Fig. 3 .** Or, if so equipped, check alignment of the cab and hood paint stripes.

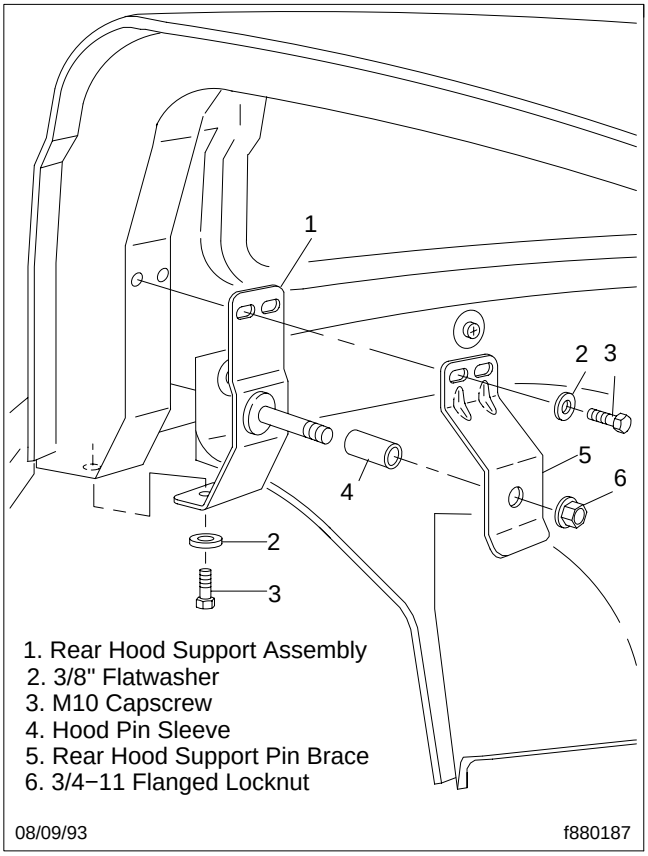


Fig. 4

If the character lines (or paint stripes) are aligned, go to the step for tightening the rear hood assembly capscrews.

If the character lines (or paint stripes) are misaligned, adjust the up-and-down position of the rear of the hood.

4.1 Unlatch and tilt the hood.

4.2 If not already done, at the side(s) of the hood that must be moved, loosen the three capscrews that attach the rear hood support assembly to the hood, just enough to allow the hood support assembly to slide fore and aft for adjustment. **Refer to Fig. 4 .**

NOTE: Complete the steps for up-and-down adjustment of one side, before doing the other side.

4.3 At the side of the hood that must be moved, loosen the capscrews that attach the rear hood support bracket and hood support brace to the bulkhead. Also, loosen the locknut that attaches the hood support brace to the rear hood support bracket. **Refer to Fig. 5 .**

4.4 Push the rear hood support bracket upward as far as it will go.

4.5 Return the hood to the operating position, but latch only the side that is *not* being adjusted.

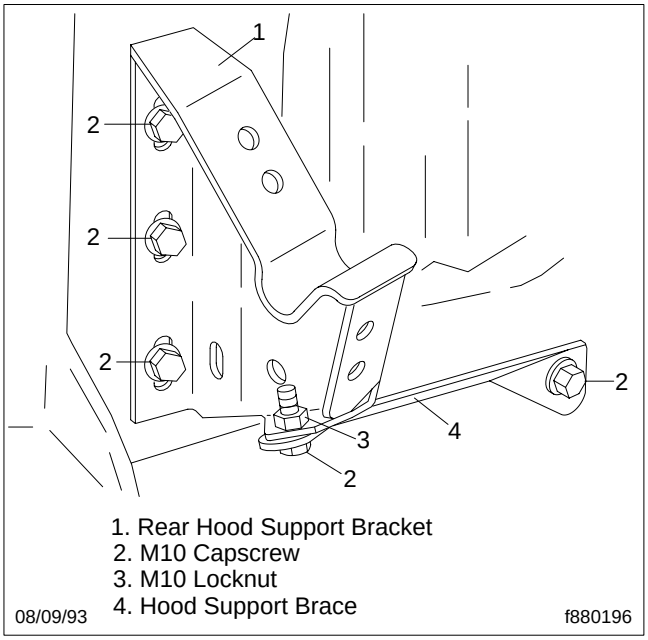
4.6 At the side of the hood that's being adjusted, push down on the top of the hood until the character lines (or paint stripes) are aligned.

4.7 Carefully tilt the hood, without changing the position of the rear hood support bracket. Tighten 55 N·m (40 lbf·ft) the capscrews and locknuts for the rear hood support bracket and the hood support brace. **Refer to Fig. 5 .**

NOTE: If the other side of the hood needs to be adjusted, repeat required steps for up-and-down adjustment.

4.8 Go to the next step.

5. If loosened, tighten the capscrews that attach the rear hood support assembly to the hood 55 N·m (40 lbf·ft). **Refer to Fig. 4 .**



1. Rear Hood Support Bracket
2. M10 Capscrew
3. M10 Locknut
4. Hood Support Brace

Fig. 5

Repair Safety Precautions

Before performing any fiberglass repairs, read the following precautions. Observe any additional precautions given by the manufacturers of the repair materials used.

1. All of the raw materials used in repairing fiberglass are harmful to the eyes and could cause blindness. Wear goggles or other protective eye shields to reduce the chances of splash contacting your eyes.
2. Wear protective gloves, as some people may have skin sensitivity to resin. Also, don't allow the hardener to contact your skin; the hardener can be a skin irritant.

IMPORTANT: In case the hardener or resin contacts your skin, wash with soap and water. If the hardener or resin should contact your eyes, rinse with plenty of water (15 minutes), and call a doctor.

3. When working with fiberglass materials, wear old clothing, since the resin may damage the cloth. Wash the clothing before wearing it again.
4. Most of the liquids involved in fiberglass repair and cleanup (especially when using acetone as a solvent) are flammable; some are also toxic. Don't perform repairs in areas where exposed (or stored) flammable liquids may contact an open flame or any burning material, such as a cigarette. Don't perform repairs in areas that are not well ventilated.

⚠ WARNING

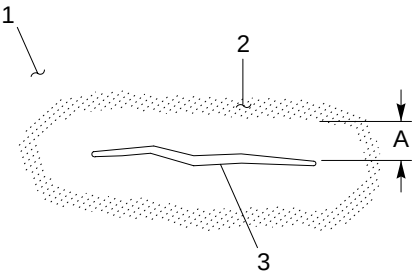
WARNING: Do fiberglass repairs in a safe workshop area to prevent severe personal injury due to explosion of flammable liquids or breathing of toxic fumes.

5. Do not use electric tools when the fumes of flammable solvents are present. The heat or sparks generated by the tools could create a fire hazard.
6. When grinding or sanding fiberglass surfaces, wear goggles or other protective eye shields, and also use an air purifying respirator, either a throwaway type or one with a replaceable particulate filter(s). Don't breathe grinding dust or particles, otherwise irritation may occur. Also, during grinding and sanding operations, wear a disposable (paper) shop coat to keep dust and fiber slivers off your clothing.
7. Because fiberglass dust can shorten the life of electrical units, air-powered tools are preferred (for frequent use).
8. Unless fiberglass repairs are done on a regular (daily) basis, don't save leftover liquids. If liquids must be saved, store them in cool, dark areas, away from direct sunlight.

Surface Damage Repair

Surface damage refers to scratches, chips, or nicks on the outer surface of the hood or half-fender. Use the following instructions to repair surface damage:

1. Examine the damaged area. If there are cracks, see if they go all the way through the hood or half-fender. If they do, see "Structural Damage Repair" for instructions.
2. Clean the area with xylene, acetone, or an equivalent grease- and wax-removing solvent. Inspect the area closely.
3. Using 220-grit or finer sandpaper, remove all of the paint around the damaged area to a distance of about 1-1/2 inches (4 cm). See **Fig. 1**.



A. Remove paint and primer 1-1/2 inches (4 cm) around the damaged area. Use 220-grit or finer sandpaper.

1. Paint
2. Primer
3. Scratch

Fig. 1, Damaged Area with Paint and In-Mold Coating Removed

4. Using an air nozzle, blow off all dust.

5. Apply Ashland Pliogrip 7775L self-leveling urethane adhesive over the non-coated area and spread a thin layer using a squeegee applicator. Cover the entire damaged area, overlapping onto the painted surface. Leave a crowned excess of adhesive, slightly higher than the painted surface.

NOTE: When using Ashland Pliogrip 7775L, dispense the required adhesive from the cartridge in a continuous bead of uniform size and a uniform green color. Discard the initial few inches of discolored bead.

6. After the adhesive dries (about 50 minutes), sand it with a hand-held disc pad. Use 320-grit or finer sandpaper. Feather the edges of the fill so there are no visible sharp edges.
7. Clean the area with compressed air. Mask the area, then spot prime and paint it. Use Sherwin Williams BB–11 black conductive primer. See **Group 98** for spot-painting instructions.

Structural Damage Repair

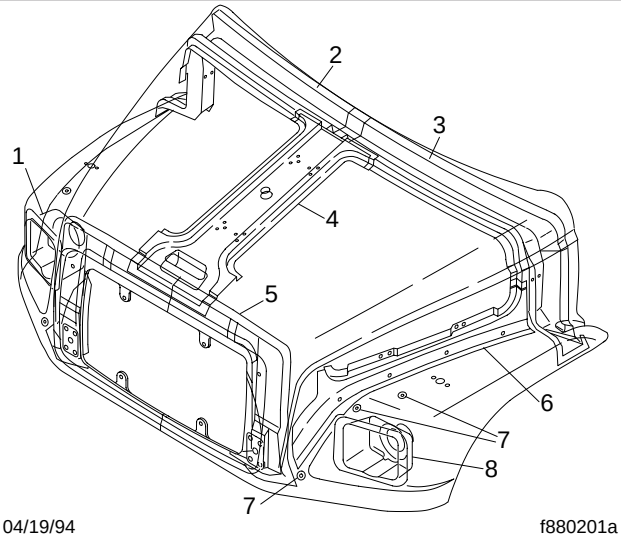
The Preform FRP (fiberglass reinforced plastic) hood consists of a one-piece hood and fender assembly. Inner reinforcements are bonded to the engine-side of the hood with a structural adhesive. See **Fig. 2**. If the hood is damaged, determine which parts are affected.

If there is damage to any of the reinforcements, the damage is not repairable. For example, if the grille area of the hood is damaged so badly that the reinforcement bonded inside the grille area is also damaged, replace the entire hood assembly.

If a joint between two reinforcements, or between a reinforcement and the hood skin, has separated and there is no damage at the joint area, the parts can be rebonded. Or, if a part of the hood skin is damaged and its adjoining reinforcement(s) aren't damaged, the reinforcement can be separated from the damaged part, the damaged part can be patched, and the reinforcement(s) rebonded in place.

If a half-fender has a small crack or hole, it can be repaired; if it has a puncture or large fracture, it must be replaced.

For rebonding parts, see "Hood Reinforcement Rebonding."



04/19/94 f880201a

1. Right-Hand Headlight Housing
2. Right-Hand Rear Hood Reinforcement
3. Left-Hand Rear Hood Reinforcement
4. Center Hood Reinforcement
5. Front Hood Reinforcement
6. Left-Hand Side Hood Reinforcement
7. Bonded Fasteners
8. Left-Hand Headlight Housing

Fig. 2, Hood Assembly Components

For damage in the form of a crack or small hole, see "Crack or Small Hole Repair."

For larger damaged areas, see "Puncture or Large Fracture Repair."

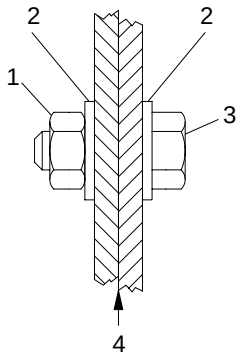
HOOD REINFORCEMENT REBONDING

1. If rebonding a joint that has partially separated, completely separate the reinforcement from the hood using a heat gun and putty knife. Remove as much of the old adhesive as possible. The heat gun will soften the adhesive and allow it to be peeled off the FRP.

   If the parts cannot be separated, work folded medium-grit sandpaper or a section of a steel hacksaw blade between the two surfaces to remove the old adhesive.
2. Scuff the surfaces with 80- to 220-grit sandpaper.
3. Clean the surfaces to be bonded with Ashland 6036 solvent or methylene chloride. Inspect the

area closely to be sure all of the old adhesive, dirt, water, grease, and oils are removed.

4. If replacing a large part, align the part on the hood and clamp it in place. Drill holes through the bonding surfaces and install clamping bolts in the holes. Use two washers, one on each side of the joint. See **Fig. 3**. There should be enough clamping bolts to hold the hood in place and keep the bonding surfaces together, or at least one bolt every 12 to 18 inches (30 to 45 cm). Remove the part for application of adhesive.



1. Nut
2. Washers
3. Bolt
4. Bond Joint

Fig. 3, Clamping Bolt at Bond Joint

5. Following the manufacturer's instructions, use enough adhesive to bond the parts together. Use Ashland Pliogrip urethane cartridge materials 7773 or 7779.

NOTE: When using Ashland Pliogrip 7773 or 7779, insert the two tubes of adhesive into the applicator and dispense a 3/8-inch (10 mm) diameter bead of uniform green-colored adhesive at the bonding surface. Discard any adhesive that does not show this uniform green color.

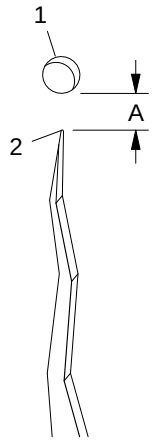
6. Within three and one half minutes (7773) or within 10 minutes (7779) of applying the bead, align the part on the hood and clamp it firmly in place. If it is a large part install the clamping bolts. Tighten the clamps or clamping bolts just enough to ensure that a uniform amount of pressure is applied along the seam. Ideally, the adhesive should be compressed to form a bondline one inch (25 mm) wide and 0.030 inch (0.76 mm) thick. This thickness can be ensured by sprinkling 0.030 inch (0.76 mm) glass beads into the adhesive before mating the parts.
7. Before it cures, remove any excess adhesive that squeezes out the edges of the bond.
8. Remove the clamps after the adhesive has cured for 30 minutes (7773) or for 60 minutes (7779).
9. If holes were drilled for clamping bolts, repair them using the instructions under "Crack or Small Hole Repair."
10. If necessary, prime and paint the repair area using the instructions under "Surface Damage Repair."

CRACK OR SMALL HOLE REPAIR

A crack (fracture) or small hole through the laminate requires repair with a fiberglass-reinforced patch.

1. Examine the damage to the hood or half-fender. Apply hand pressure all around the damaged area to check for any concealed damage.
2. If a sound-absorbent liner is present on the underside of the damaged area, peel away the liner to provide an adequate working area.
3. Clean the damaged area on both sides of the hood or half-fender with xylene, acetone, or equivalent grease- and wax-removing solvent. Inspect the area closely. All dirt, water, grease, and oils must be removed.
4. If repairing a crack, use a 1/8-inch (3-mm) diameter bit to drill a hole completely through the uncracked laminate 1/8 inch (3 mm) from each end of the crack, to prevent the crack from lengthening. See **Fig. 4**.
5. On the engine side of the hood (or underside of the half-fender), use a router bit (on a grinder or a drill) to grind away a shallow recess one-quarter the depth of the laminate and extending 1/2 inch (13 mm) outward from all sides of the damage. Taper the outside edge of the ground area. See **Fig. 5**.

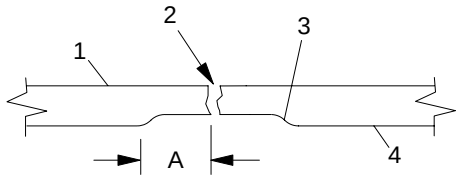
   If repairing a crack, grind outward to the drilled hole at the end of the crack, but not beyond. See **Fig. 6**, Ref. A.
6. Use 80- to 220-grit sandpaper to scuff an area at least one inch (25 mm) away from the fracture on all sides. Be sure to scuff thoroughly, since



05/04/94 f880222b

A. 1/8 inch (3 mm)
1. Drilled 1/8-inch (3-mm) Hole
2. End of Crack

Fig. 4, Drilling a Hole to Prevent the Crack From Lengthening



05/04/94 f880227b

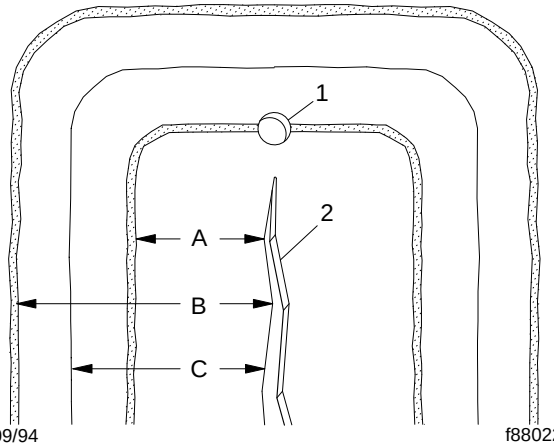
A. Grind a shallow recess one-quarter the depth of the laminate and extending 1/2 inch (13 mm) outward in all directions from the damaged area.
1. Laminate
2. Crack
3. Slight Taper
4. Engine Side of Hood (or underside of half-fender)

Fig. 5, Recessed Area (cross-sectional view)

this will give the patch a surface to which it can stick. See **Fig. 6**, Ref. B.

7. Blow the dust away with compressed air and wipe the area with a clean cloth.

8. If necessary, align the panel sections on both sides of the crack, using weights or clamps to re-establish the original panel profile.



02/09/94 f880223a

A. Use a router to grind away a shallow recess one-quarter the depth of the laminate and extending 1/2 inch (13 mm) outward from the damage. If repairing a crack, don't grind past the hole drilled at the end of the crack.
B. Use 80- to 220-grit sandpaper to scuff the area one inch (25 mm) around the damage.
C. Cut the fiberglass cloth to fully cover the damage, and overlay about 3/4 inch (20 mm).
1. Hole 2. Crack

Fig. 6, Preparing the Damaged Area on the Engine Side of the Hood

9. With a razor-blade knife, cut a section of woven fiberglass cloth to fully cover the crack and to overlay about 3/4 inch (20 mm). See **Fig. 6**, Ref. C.

10. To bond the fiberglass cloth to the damaged panel, use Ashland Pliogrip 7775L urethane adhesive.

NOTE: When using Ashland Pliogrip 7775L, dispense the required adhesive from the cartridge in a continuous bead of uniform size and a uniform green color. Discard the initial few inches of discolored bead.

11. Lay the cut section of fiberglass cloth on the repair area, centered over the damage. Using a fiberglass roller, press the cloth down firmly into the layer of adhesive to completely saturate the glass fibers.

12. Apply another layer of adhesive over the glass cloth. Spread the adhesive evenly using the fiberglass roller.

13. After two to five minutes, the adhesive will start to jell. It may take more time when cool, less when warm.

IMPORTANT: To avoid pre-jelling or skin-over, mate the FRP parts to be bonded within one to four minutes after dispensing the adhesive.

NOTE: To get a smoother surface, press a piece of masking tape, wider than the repair, directly over the wet adhesive and smooth it before it hardens. The tape can be removed after five minutes when the adhesive has set.

14. The patch should be hard enough in 50 minutes to allow sanding to a smooth flat surface if required.

15. Repair the damage on the outside surface of the hood or half-fender, using the instructions in "Surface Damage Repair." Prime and paint both surfaces, using the instructions in **Group 98**.

PUNCTURE AND LARGE FRACTURE REPAIR (SECTION REPLACEMENT)

If a half-fender has a puncture or large fracture, replace the half-fender.

On very large damaged areas (for example, structural damage on the side surface of the hood covering an area of a square foot or more) it may be easier to do a section replacement rather than make a patch. Fenders and headlight reinforcements may be used in section replacements. Also, a second damaged hood with the needed section intact may be available as scrap.

IMPORTANT: A piece of Preform FRP laminate from a Short Conventional hood must be used for section replacement. Use of any other material may not allow the necessary bonding for the repair.

1. Push in on the area immediately surrounding and underneath the damaged area to determine the extent of damage.

2. If a sound-absorbent liner is present on the underside of the damaged area, peel away the liner to provide an adequate working area.

3. Clean the damaged area on both sides of the hood with xylene, acetone, or an equivalent grease- and wax-removing solvent. Inspect the area closely. All dirt, water, grease, and oils must be removed.

4. Using a sabre saw, cut out a large, straight-sided panel containing the damaged area. See **Fig. 7**, Ref. A.

   If the damage extends to a joint where a reinforcement is bonded to the hood, completely separate the reinforcement with a heat gun and putty knife before cutting. See "Hood Reinforcement Rebonding" for instructions.

⚠ WARNING

WARNING: Wear goggles and an air purifying respirator when grinding, cutting, or sanding during all fiberglass repairs. The ground dust and particles could cause temporary or permanent damage to your eyes and, if inhaled, could cause throat or lung irritation.

5. From a scrap hood, cut a section replacement panel from the same area, only slightly larger than the cut-out in the damaged hood. See **Fig. 7**, Ref. B. Then, trim the section replacement to fit both the size and contour of the original cutout.

   If the damage is next to a headlight reinforcement, but doesn't include the reinforcement, remove the headlight reinforcement from the replacement section (scrap hood), not the damaged hood.

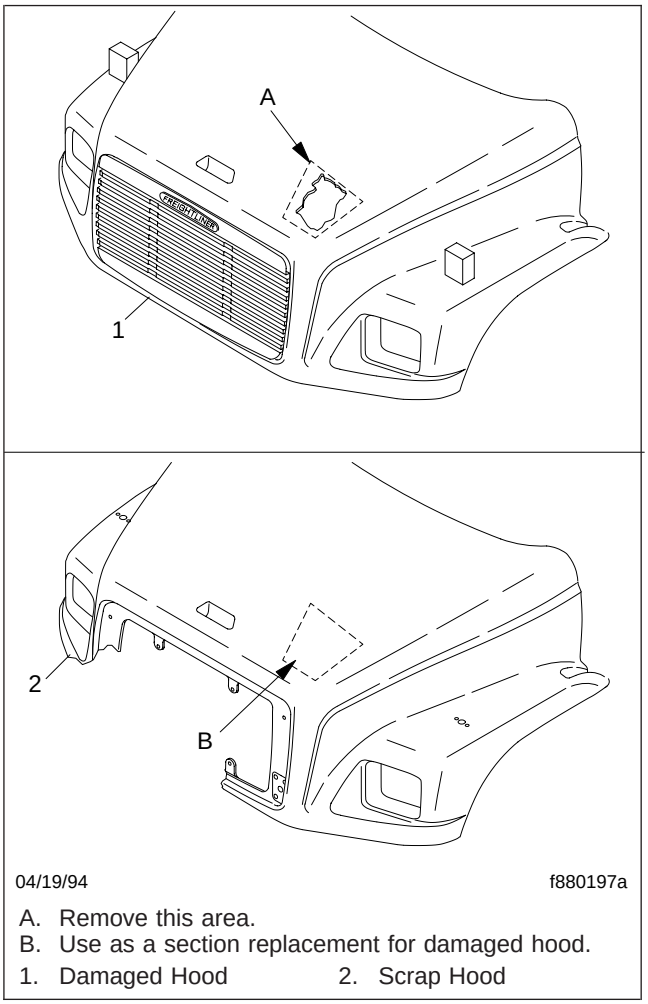
6. After the trimming is completed, sand the edges to allow a 1/16- to 1/8-inch (2- to 3-mm) gap around the cutout.

7. On the engine side of the hood, use a router bit (on a grinder or drill) to grind away a shallow recess one-quarter the depth of the laminate and extending 1/2 inch (13 mm) outward from all sides of the cutout area. See **Fig. 8**, Ref. A.

   Also, grind 1/2 inch (13 mm) inward from all edges on the engine side of the section replacement. See **Fig. 8**, Ref. C.

   Slightly taper the outside edge of the ground area on the hood and the inside edge of the ground area on the section replacement. See **Fig. 9**, Ref. 3.

Hood and Half-Fender Repair



A. Remove this area.
B. Use as a section replacement for damaged hood.
1. Damaged Hood
2. Scrap Hood

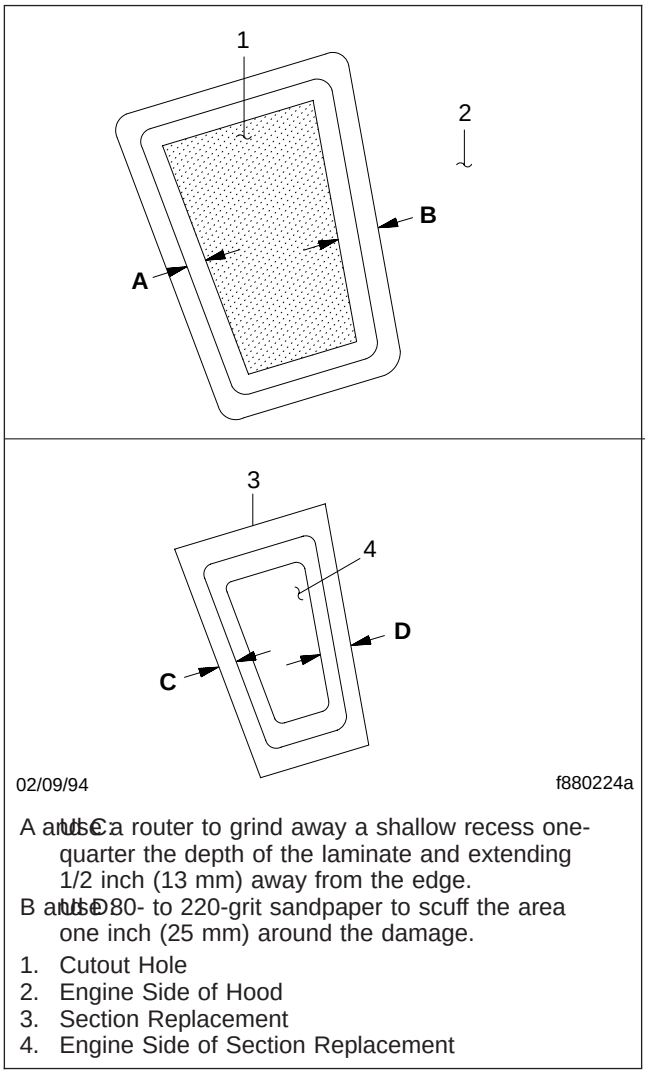
Fig. 7, Section Replacement of a Damaged Fiberglass Hood

8. Use 80- to 220-grit sandpaper to scuff an area at least one inch (25 mm) out from all sides of the cutout area. See **Fig. 8**, Ref. B.

   Also, scuff at least one inch (25 mm) in from all sides of the section replacement. See **Fig. 8**, Ref. D.

   Scuff thoroughly, since this will give the section replacement a surface to which it can stick. Be sure to completely sand off any undercoating sprayed on these areas.

9. On the outer sides of both the cutout and the section replacement, bevel the edges about 45 degrees. See **Fig. 10**.



A and C. Use a router to grind away a shallow recess one-quarter the depth of the laminate and extending 1/2 inch (13 mm) away from the edge.
B and D. Use 80- to 220-grit sandpaper to scuff the area one inch (25 mm) around the damage.
1. Cutout Hole
2. Engine Side of Hood
3. Section Replacement
4. Engine Side of Section Replacement

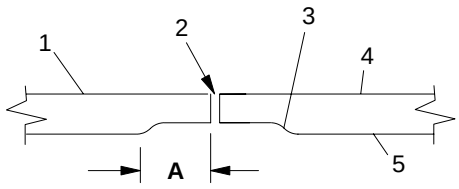
Fig. 8, Preparing the Section Replacement and Hood Cutout on the Unexposed Side

10. Gently feather the outer painted surfaces back about 1/2 inch (13 mm) beyond the edges of the repair areas (on both the cutout and the section replacement), using 220-grit or finer sandpaper.

11. Blow the dust away with compressed air, and wipe the area with a clean cloth.

12. If the section replacement is close enough to an edge, use clamps to temporarily secure it during the repair.

    If the replacement is too far from an edge to use clamps, use bond strips. See **Fig. 11**.

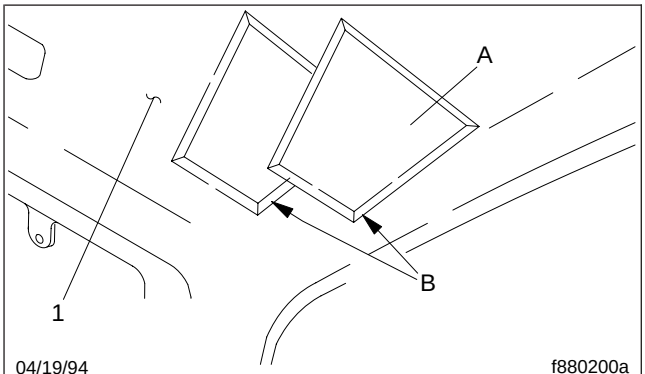


05/04/94 f880226b

A. Grind a shallow recess one-quarter the depth of the laminate and extending 1/2 inch (13 mm) outward in all directions from the damaged area.

1. Section Replacement
2. Gap
3. Slight Taper
4. Hood
5. Engine Side of Hood

Fig. 9, Cutout Area (cross-sectional view)



04/19/94 f880200a

A. Insert section replacement.
B. Bevel outer surface edges on all sides.

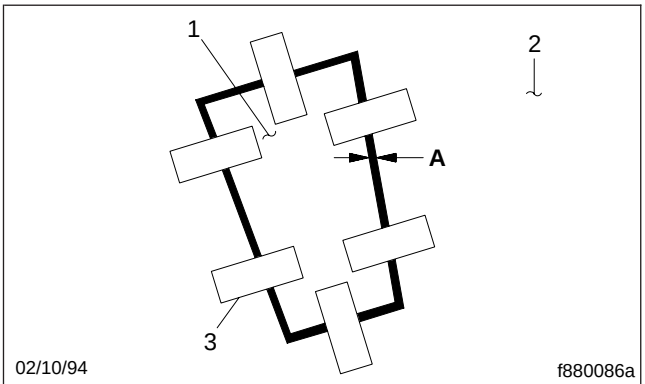
1. Exposed Side of Hood

Fig. 10, Areas to be Beveled

12.1 Cut some scrap FRP into strips. Make enough strips to hold the section replacement in position; about one every six inches (15 cm). If the surface of the replacement panel is contoured or curved, use many small bond strips; larger strips could deform the curves.

12.2 On the engine side of the repair, use 220-grit sandpaper to scuff sand the areas on the hood and section replacement panels where you plan to bond the strips.

12.3 If a joint between the hood and a reinforcement was separated for the repair, rebond the joint. See "Hood Reinforcement Rebonding" for instructions.



02/10/94 f880086a

A. Gap of 1/16 inch to 1/8 inch (2 to 3 mm)

1. Section Replacement
2. Engine Side of Hood
3. Bond Strip

Fig. 11, Securing the Section Replacement to the Hood Using Bond Strips

12.4 Holding the section replacement in position, bond the strips to both hood and replacement panels in the area already scuffed. Use Ashland Pliogrip 7773 to bond the strips.

NOTE: When using Ashland Pliogrip 7773, dispense the required adhesive from the cartridge in a continuous bead of uniform size and a uniform green color. Discard the initial few inches of discolored bead.

12.5 After the adhesive has hardened, use 80- to 220-grit sandpaper to scuff the bond strips.

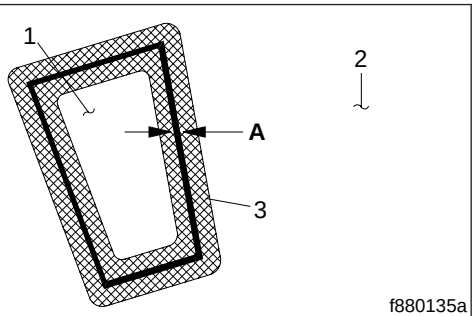
12.6 Blow the dust away with compressed air, and wipe the area with a clean cloth.

13. With a razor-blade knife, cut sections of woven fiberglass cloth to fully cover the gap between the cutout and the section replacement, all the way around the damaged area. The cloth should overlay about 3/4 inch (20 mm) on both sides of the gap. See **Fig. 12**.

14. To bond the fiberglass cloth to the damaged panel, use Ashland Pliogrip 7775L urethane adhesive.

NOTE: When using Ashland Pliogrip 7775L, dispense the required adhesive from the cartridge in a continuous bead of uniform size and a uni-

Hood and Half-Fender Repair



NOTE: The fiberglass cloth should overlay about 3/4 inch (20 mm) on both sides of the gap.

A. Gap of 1/16 inch to 1/8 inch (2 to 3 mm)
1. Section Replacement
2. Engine Side of Hood
3. Fiberglass Cloth

Fig. 12, Overlaying the Gap with Fiberglass Cloth

form green color. Discard the initial few inches of discolored bead.

15. Use a plastic or metal device to spread a thin layer of adhesive over the scuffed area.
16. Lay the cut sections of fiberglass cloth on the repair area, centered over the damage. Using a fiberglass roller, press the cloth down firmly into the layer of adhesive to completely saturate the glass fibers.
17. Apply another layer of adhesive over the glass cloth. Spread the adhesive evenly using the fiberglass roller.
18. After two to five minutes, the adhesive will start to jell. It may take more time when cool, less when warm.

IMPORTANT: To avoid pre-jelling or skin-over, the FRP parts to be bonded should be mated within one to four minutes after the adhesive is dispensed.

NOTE: To get a smoother surface, press a piece of masking tape, wider than the repair, directly over the wet adhesive and smooth it before it hardens. The tape can be removed after five minutes when the adhesive has set.

19. The patch should be hard enough in 50 minutes to allow sanding to a smooth flat surface, if desired.
20. Repair the damage on the outside surface of the hood and paint the surface on both sides, using the instructions in "Surface Damage Repair."

Engine Access Door Removal and Installation

Some Severe-Duty Business Class Trucks are fitted with front mounted PTOs, snow plows, etc. which limit or prevent hood opening. A hood with dual access doors is available for these applications to allow routine engine maintenance and service without requiring PTO or plow removal. This hood is sometimes referred to as the butterfly hood. **See Fig. 1.**

The access doors are made of the same fiberglass reinforced plastic (FRP) as the main hood and are attached to the hood along its centerline by piano-type hinges.

Two rubber over-center latches are fitted to each door to hold it in the closed position. A prop rod, fastened to the inside of each door, can be unclipped and used to hold the door open.

Access Door Removal

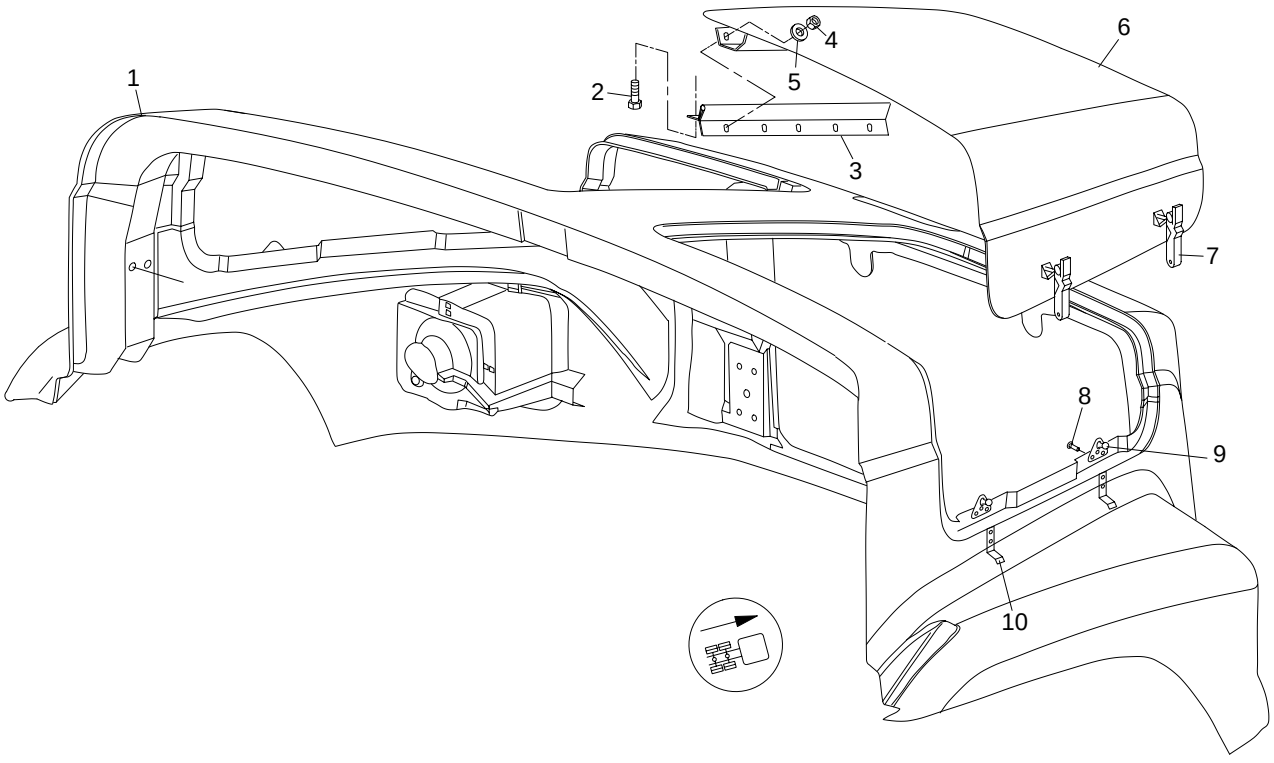
1. Apply the parking brakes and chock the rear tires.
2. Unlatch, but do not open, the door that is being removed.
3. Unlatch, open, and prop up the door that is *not* being removed.
4. Working through the open access door, remove the five bolts that secure the door hinge to the hood center reinforcement for the door that is being removed.
5. Remove the access door.

Access Door Installation

NOTE: If the access door is being replaced, transfer all mounting and latching hardware to the new door before installing it.

1. Place the access door in the hood opening.
2. Position the door, as necessary, to line up the door stop brackets and latch components.
3. Connect the latches to hold the door in place.
4. Working through the open door on the other side of the vehicle, install the five bolts that secure the door hinge to the hood center reinforcement.
5. Unlatch the newly installed door and open it to check the adjustment.
6. Remove the chocks from the tires.

Engine Access Door Removal and Installation



10/27/95 f880332

1. Butterfly Hood
2. Hinge Mounting Bolt
3. Hinge
4. Nut
5. Flatwasher
6. Engine Access Door, Right-Hand
7. Rubber Latch
8. Rivet
9. Door Stop Bracket
10. Latch Hook

Fig. 1, Engine Access Door Components

Repair Tools and Materials List

SURFACE DAMAGE REPAIR

The following are required for surface damage repair:

- Xylene, acetone, or equivalent solvent
- Hand-held disc pad
- Self-leveling adhesive [1]
- Applicator squeegee
- 220- or finer grit sandpaper
- 320- or finer grit sandpaper
- Primer [2]

HOOD REINFORCEMENT REBONDING

The following are required for hood reinforcement rebonding:

- Heat gun
- Putty knife
- Hacksaw blade
- 80- to 220-grit sandpaper
- Solvent [3]
- Adhesive [4]
- Clamps, clamping bolts with washers
- Primer [2]
- 0.030 in (0.76 mm) glass beads (if needed)

CRACK OR SMALL HOLE REPAIR

The following are required for repair of cracks or small holes:

- Xylene, acetone, or equivalent solvent
- Drill and 1/8-inch (3-mm) diameter bit
- Router bit and grinder, or drill
- 80- to 220-grit sandpaper
- 220- or finer grit sandpaper
- 320- or finer grit sandpaper
- Woven fiberglass cloth
- Wooden stir stick
- Clamps
- Self-leveling adhesive [1]
- Applicator squeegee
- Hand-held disc pad
- Razor-blade knife
- Primer [2]

PUNCTURE OR LARGE FRACTURE REPAIR

The following are required for repair of punctures or large fractures:

- Suitable section of Preform FRP from scrap hood
- Xylene, acetone, or equivalent solvent
- Sabre saw
- Heat gun
- Putty knife
- Router bit and grinder, or drill
- 80- to 220-grit sandpaper
- 220- or finer grit sandpaper
- Solvent [3]
- Adhesive [4]
- Razor-blade knife
- Woven fiberglass cloth
- Wooden stir stick
- Self-leveling adhesive [1]
- Applicator squeegee
- Hand-held disc pad
- Clamps
- Primer [2]

[1] Use Ashland Pliogrip 7775L self-leveling urethane adhesive. Premeasured tubes of adhesive, mixing nozzles, and caulking gun applicators are available through Freightliner PDCs. See **Table 2** and **Table 3**.
[2] Use Sherwin Williams BB–-11 black conductive primer. Contact your local Sherwin Williams automotive paint distributor to purchase this primer.
[3] Use Ashland 6036 solvent or methylene chloride. Contact Ashland Merchandising Group, telephone (419) 289-9588, to purchase this solvent.
[4] Use Ashland Pliogrip 7700 series adhesives. Part numbers 7773 and 7779 are those products refered to in the instructions above. Part numbers 7771 and 7770 may be substituted. A heat gun or paint oven may be used to speed curing times but do not heat these adhesives above 180°F (82°C). These products are available through Freightliner PDCs. See **Table 2**.

Specifications

Fastener Torques				
Description	Size	Grade	Torque	
			lbf·in (N·cm)	lbf·ft (N·m)
Hood Latch Locknuts	1/4–20	B	96 (1080)	–
Half-Fender Capscrews	M8	8.8	—	16 (21)
Half-Fender Locknuts	M8	—	—	16 (21)
Hood-Pivot Bolt Locknuts	9/16–18	C	—	130 (176)
Hood-Pivot Support Bracket Locknuts	1/2–13	C	—	70 (95)
Lower Hood-Hinge Pivot Locknuts	3/8—16	C	—	40 (55)
Rear Hood Support Assembly Capscrews	M10	10.9	—	40 (55)
Rear Hood Support Bracket Capscrews	M10	10.9	—	40 (55)
Rear Hood Support Brace Locknuts and Capscrews	M10	10.9	—	40 (55)

Table 1, Fastener Torques

NOTE: Ashland Pliogrip 7700 and 8000 Series repair adhesives and accessories are available through Freightliner PDCs. The 7700 Series two-part urethane adhesives are specially formulated and packaged for repair of hoods and other fiber-reinforced plastics. Ashland Pliogrip 8000 Series two-part urethane adhesives are also available for those who prefer to use these earlier generation adhesives. The 7775L adhesive is a self-leveling mixture that is appropriate when a surface filler or glass fabric reinforcement repair is required.

The descriptions, working times, and curing times (sanding and repainting) of the different adhesives are shown below. See **Table 2** and **Table 4**. All working and curing times correspond to an ambient temperature of 73°F (23°C) in the workshop. Curing times may be shortened by using a heat gun or paint oven. Humidity does not affect these adhesives. All the adhesives develop the same bonding strength. Substitutions can be made to change working times.

See **Table 3** and **Table 5** for Ashland adhesive accessories.

IMPORTANT: To ensure a successful repair, do not heat these adhesives above 180°F (82°C).

7700 Series Adhesives				
Description	Part Number	Working Time in Minutes	Curing Time in Minutes	Curing Time in Hours
Adhesive, two 50 ml Cartridges, 3.4 oz (100 ml)	ACA 7771	1.5	10	—
Adhesive, two 50 ml Cartridges, 3.4 oz (100 ml)	ACA 7773	3.5	30	—
Adhesive, two 300 ml Cartridges, 20 oz (600 ml)	ACA 7773 300	3.5	30	—
Adhesive, two 50 ml Cartridges, 3.4 oz (100 ml)	ACA 7775L	5.0	50	—
Adhesive, two 50 ml Cartridges, 3.4 oz (100 ml)	ACA 7779	10	—	1.0
Adhesive, two 300 ml Cartridges, 20 oz (600 ml)	ACA 7779 300	10	—	1.0
Adhesive, two 50 ml Cartridges, 3.4 oz (100 ml)	ACA 7770	35	—	3.0

Specifications

7700 Series Adhesives				
Description	**Part Number**	**Working Time in Minutes**	**Curing Time in Minutes**	**Curing Time in Hours**
Adhesive, two 300 ml Cartridges, 20 oz (600 ml)	ACA 7770 300	35	—	3.0

Table 2, 7700 Series Adhesives

7700 Series Accessories	
Description	**Part Number**
Manual Applicator Gun for 300 ml Cartridges	ACA TS526C
1/4-in Mixing Nozzles for 50 ml Cartridges (100/box) *	ACA 583 238
Pneumatic Applicator Gun for 300 ml Cartridges	ACA TS525
3/8-in Mixing Nozzles for 300 ml Cartridges (100/box) *	ACA F 771072

* Each adhesive cartridge comes with two mixing nozzles. Once mixed, the adhesive in the nozzle will harden by the end of its working time. If making several small repairs, have extra nozzles on hand.

Table 3, 7700 Series Accessories

8000 Series Adhesives				
Description	**Part Number**	**Working Time in Minutes**	**Curing Time in Minutes**	**Curing Time in Hours**
Adhesive, Supermix 4:1, 12 oz (355 ml)	ACA 8104	4.0	30	—
Adhesive, Supermix 4:1, 12 oz (355 ml)	ACA 8110	10	—	1.0
Adhesive, Supermix 4:1, 12 oz (355 ml)	ACA 8145	50	—	8.0

Table 4, 8000 Series Adhesives

8000 Series Accessories	
Description	**Part Number**
Pneumatic Applicator Gun for 355 ml Cartridges	ACA 582 2241
3/8-in Mixing Nozzles for 8000 Series Cartridges (100/box) *	ACA F 771072

* Each adhesive cartridge comes with two mixing nozzles. Once mixed, the adhesive in the nozzle will harden by the end of its working time. If making several small repairs, have extra nozzles on hand.

Table 5, 8000 Series Accessories

General Information

NOTE: The information in this section applies only to FL112 vehicles.

The hoods on these vehicles are made of fiberglass, and are manufactured by the spray-up process.

The materials used in fiberglass spray-up hoods are a combination of glass filaments, resin (the binder), catalysts (to initiate the cure), and weather resistance additives. The filaments of pure glass provide strength, dimensional stability, and heat resistance. The resin is a liquid plastic that hardens when combined with another substance, the catalyst. The resin acts as a binder to hold the filaments together; it supplies only a limited amount of additional strength to the structure.

HOOD MOUNTING AND COMPONENTS

The hood assembly mounts at the front to two hood pivot brackets, located on the outside of the frame rails, attached to the front cross-member extension. The hood pivots work in conjunction with the torsion bar tilt-assist mechanism. Two retaining straps allow a forward hood tilt adequate for vehicle service.

In the operating position, the rear of the hood is supported by hood support brackets, which are attached to the cab. These rear brackets hold the hood in the correct position for operation. The hood is held in place with latches, one on each side.

The hood pivot brackets are adjustable forward and backward and side to side. The rear hood support brackets are adjustable up and down.

Each hood assembly is equipped with an injection-molded, argent-colored grille. The grille is attached to the hood with eight fasteners. The hood is also equipped with a headlight bezel assembly, which features a headlight and turn signal/parking light combination, along with side-marker lights, on each fender.

Hood Removal, Installation, and Adjustment

Removal

1. Park the vehicle on a flat, level surface. Chock the tires.

⚠ WARNING

Do not attempt to lift the hood; it weighs about 150 lbs (68 kg). Lifting the hood could result in personal injury or damage to the hood assembly and other components.

2. Remove the grille. For removal instructions, see **Subject 110**.
3. Tilt the hood to the fully-open position.
4. Place a support between the floor and the front of the hood. The support should be as wide and as long as the front of the hood, and should be the same height as the lowest edge of the hood. Place cardboard, carpet, rags, or other padding on top of the support to protect the hood.
5. Disconnect the two headlight bezel wiring connectors at the bumper and the single connector at the side-marker light, from both sides of the hood.
6. Disconnect the two tilt-limiting assist straps by removing the fasteners attached to the inside surface of the hood. Move the hood to a less than full-tilt position to provide some slack in the straps.
7. Remove the torsion bar tilt-assist mechanism. For removal instructions, see **Subject 120**.
8. Remove the shoulder bolts from the hood hinge brackets while continuing to support the hood in position. Use a punch and hammer to tap out the shoulder bolts.
9. Carefully roll or slide the hood support away from the vehicle.

Installation

1. Position the disconnected electrical wiring out of the way to avoid interference during installation.

⚠ WARNING

Do not attempt to lift the hood; it weighs about 150 lbs (68 kg). Lifting the hood could result in personal injury or damage to the hood assembly and other components.

2. With the hood in the forward-tilt position and resting on the support at about the same height as the top of the bumper, move the support and hood into alignment with the front of the vehicle.
3. Apply a lubricant to the shoulder bolts and ensure that the hood pivot bushings are in position.
4. Insert the shoulder bolts and tap them into place with a mallet. Attach the nuts to the bolts. Torque the nuts to 28 lbf·ft (38 N·m).
5. Install the torsion bar tilt-assist mechanism. For installation instructions, see **Subject 120**.
6. Lower the hood until it is balanced over the pivots, then have a co-worker hold the hood in this position.
7. Connect the two tilt-limiting assist straps attached to the inside surface of the hood.
8. Tilt the hood to a full-tilt position.
9. Connect the electrical connectors to the headlight bezel assemblies.
10. Place the hood into the operating position. Latch the hood.
11. Install the grille. For instructions, see **Subject 110**.
12. Remove the chocks from the tires.

Adjustment

NOTE: If the vehicle has had damage to the chassis, the frame must be straightened before adjusting the hood.

1. Drive the vehicle back and forth to settle the frame and suspension. Park the vehicle on a flat, level surface. Chock the tires.
2. Determine whether hood adjustment is necessary by checking, with the hood in the operating position and the hood latches latched, the alignment of the hood character line with the cab

Hood Removal, Installation, and Adjustment

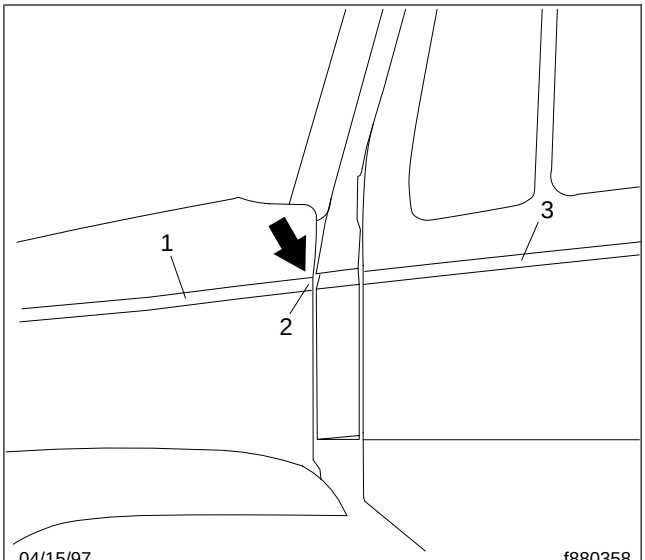
character line. **See Fig. 1.** The two lines should approximately match.

3. If it is determined that the hood needs to be vertically adjusted, follow these steps:

   3.1 Take note of the difference in the alignment of the character lines on the left and the right sides.

   3.2 Tilt the hood to the fully-open position.

   3.3 Slightly loosen the bolts securing one of the rear hood support brackets, which are attached to the cab frontwall. **See Fig. 2.**



1. Hood Character Line
2. Adjustment Point
3. Cab Character Line

Fig. 1, Hood Adjustment Point

   3.4 Loosen the support brace bolts at the hood support bracket.

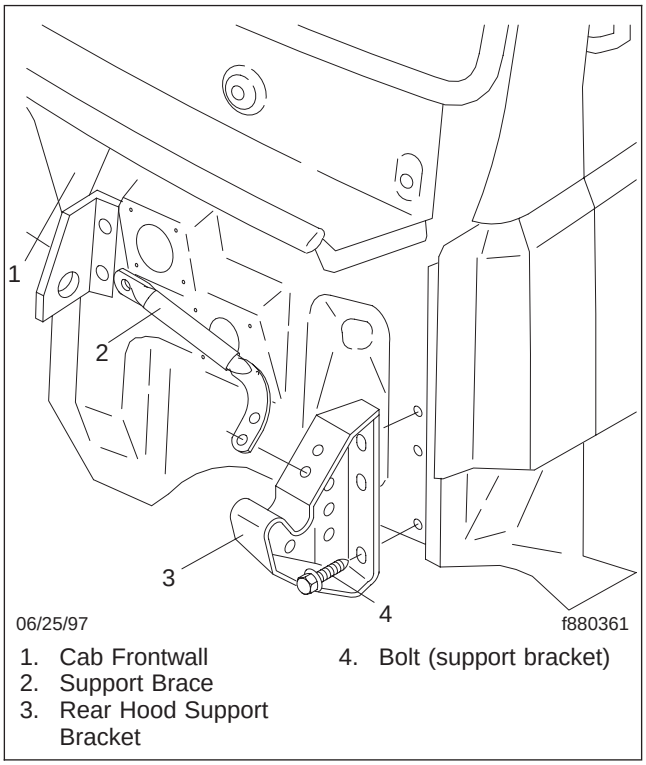
   3.5 Loosen the support brace bolts at the cab frontwall.

   NOTE: It is also necessary to loosen or disconnect the radiator strut rod.

   3.6 Either raise or lower the bracket an amount equal to the difference in the character lines.

   3.7 Snug down the bracket mounting bolts.

   3.8 Close and latch the hood.



1. Cab Frontwall
2. Support Brace
3. Rear Hood Support Bracket
4. Bolt (support bracket)

Fig. 2, Rear Hood Support Bracket

   3.9 Inspect the alignment. If necessary, repeat the procedure until the lines are approximately the same.

   3.10 Unlatch and tilt the hood to the fully-open position.

   3.11 Tighten the mounting bolts on the rear hood support bracket, which was just adjusted, and torque them to 29 lbf·ft (40 N·m).

   3.12 Tighten the support brace bolts at the support bracket and torque them to 34 lbf·ft (46 N·m).

   3.13 Securely tighten the support brace bolts at the cab frontwall.

   3.14 Ensure that the radiator strut rod is connected to the rear hood support bracket and that the fasteners are tightened to the proper torque value. See **Section 20.01** in this manual.

   3.15 The vertical alignment adjustment should be complete.

3.16 Lower the hood and fasten the hood latches.

NOTE: The forward and aft adjustment of the hood should be not necessary as the hoods are manufactured to be adjustment-free. However, this adjustment can be performed by loosening the bolts securing the hood pivot brackets to the front crossmember extension and adjusting the position of the pivots.

Removal

1. From the front side of the grille, remove the eight Torx® head fasteners that hold the grille to the hood. **See Fig. 1.**

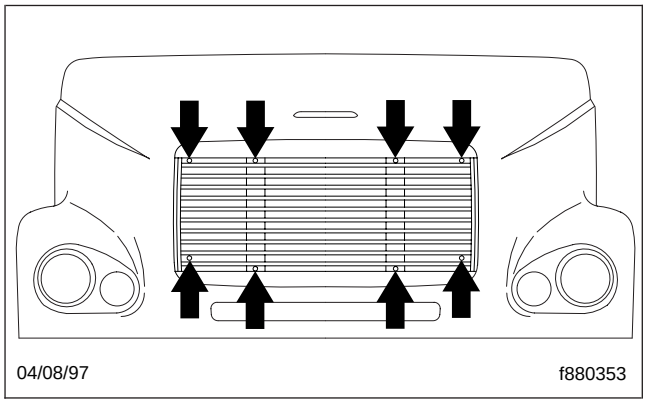


Fig. 1, Location of Grille Fasteners

2. Remove the grille from the hood.

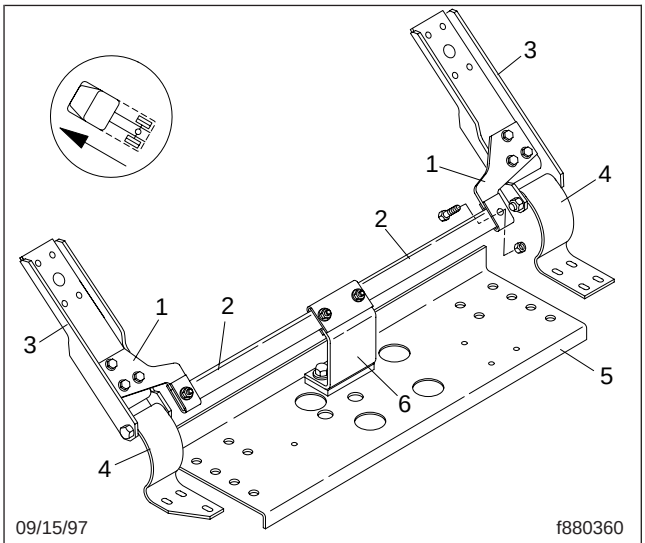
Installation

1. Place the grille in position on the hood with the grille fastener holes lined up with the holes on the hood.
2. Install the eight fasteners into the threaded isolators.
3. Tighten the fasteners 96 lbf·in (1080 N·cm).

Hood Torsion Bar Tilt-Assist Mechanism Removal and Installation

Removal

1. Apply the parking brakes, and chock the tires.
2. Remove the grille. See **Subject 110** for removal instructions.
3. Release the hood latches, and tilt the hood completely open.
4. Remove the three bolts in both torsion bar outer brackets. See **Fig. 1**.



1. Torsion Bar Outer Bracket
2. Torsion Bar
3. Hood Hinge Bracket
4. Hood Hinge Pivot
5. Front Closing Crossmember
6. Inner Torsion Bar Bracket

Fig. 1, Torsion Bar Tilt-Assist Mechanism

5. Loosen the bolts and nuts securing the torsion bar outer slotted ends to the outer brackets. Disconnect the outer brackets from the torsion bars.
6. Remove the bolts and nuts securing both torsion bars to the inner torsion bar bracket.
7. Remove the torsion bars.

Installation

NOTE: Tilt and support the hood at an angle of approximately 50 degrees to ease the installation of the torsion bars and the outer brackets.

1. Insert the torsion bars (drilled ends) into the inner torsion bar bracket and install the inner torsion bar bolts and nuts.
2. Attach the slotted outer ends of the torsion bars to the outer brackets.
3. Align the holes in the outer torsion bar brackets with the holes in the hood hinge brackets and install the three bolts on each side.
4. Torque the inner torsion bar bolts and nuts to 37 lbf·ft (50 N·m), the outer torsion bar bolts and nuts to 26 lbf·ft (36 N·m), and the outer bracket bolts to 37 lbf·ft (50 N·m).
5. Return the hood to the operating position and fasten both hood latches.
6. Install the grille. See **Subject 110** for installation instructions.
7. Remove the chocks from the tires.

NOTE: The torsion bar tilt-assist mechanism is not adjustable.

Repair Safety Precautions

Before performing any fiberglass repairs, read the following precautions. Observe any additional precautions given by the manufacturers of the repair materials used.

1. All of the raw materials used in repairing fiberglass are harmful to the eyes and could cause blindness. Wear goggles or other protective eye shields to reduce the chances of splash contacting your eyes.
2. Wear protective gloves, as some people may have skin sensitivity to urethane adhesives.

IMPORTANT: In case the hardener or resin contacts your skin, wash with soap and water. If the hardener or resin should contact your eyes, rinse with plenty of water (15 minutes), and call a doctor.

3. When working with fiberglass materials, wear old clothing, since the resin may damage the cloth. Wash the clothing before wearing it again.
4. Most of the liquids involved in fiberglass repair and cleanup (especially when using acetone as a solvent) are flammable; some are also toxic. Don't perform repairs in areas where exposed (or stored) flammable liquids may contact an open flame or any burning material, such as a cigarette. Don't perform repairs in areas that are not well ventilated with fans or an exhaust system.

⚠ WARNING

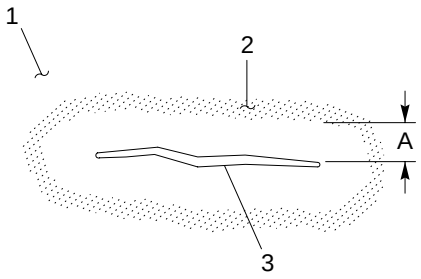
Do fiberglass repairs in a safe workshop area to prevent severe personal injury due to explosion of flammable liquids or breathing of toxic fumes.

5. Do not use electric tools when the fumes of flammable solvents are present. The heat or sparks generated by the tools could create a fire hazard.
6. When grinding or sanding fiberglass surfaces, wear goggles or other protective eye shields, and also use an air purifying respirator, either a throwaway type or one with a replaceable particulate filter(s). Don't breathe grinding dust or particles, otherwise irritation may occur. Also, during grinding and sanding operations, wear a disposable (paper) shop coat to keep dust and fiber slivers off your clothing.
7. Because fiberglass dust can shorten the life of electrical units, air-powered tools are preferred (for frequent use).

Surface Damage Repair

Surface damage refers to scratches, chips, or nicks on the outer surface of the hood or half-fender. Use the following instructions to repair surface damage:

1. Examine the damaged area. If there are cracks, see if they go all the way through the hood or half-fender. If they do, see "Structural Damage Repair" for instructions.
2. Clean the area with xylene, acetone, or an equivalent grease- and wax-removing solvent. Inspect the area closely.
3. Using 220-grit or finer sandpaper, remove all of the paint around the damaged area to a distance of about 1-1/2 inches (4 cm). See **Fig. 1**.



A. Remove paint and primer 1-1/2 inches (4 cm) around the damaged area. Use 220-grit or finer sandpaper.
1. Paint
2. Primer
3. Scratch

Fig. 1, Damaged Area with Paint and In-Mold Coating Removed

4. Using an air nozzle, blow off all dust.
5. Apply Ashland Pliogrip 7775L self-leveling urethane adhesive over the non-coated area and spread a thin layer using a squeegee applicator. Cover the entire damaged area, overlapping onto the painted surface. Leave a crowned excess of adhesive, slightly higher than the painted surface.

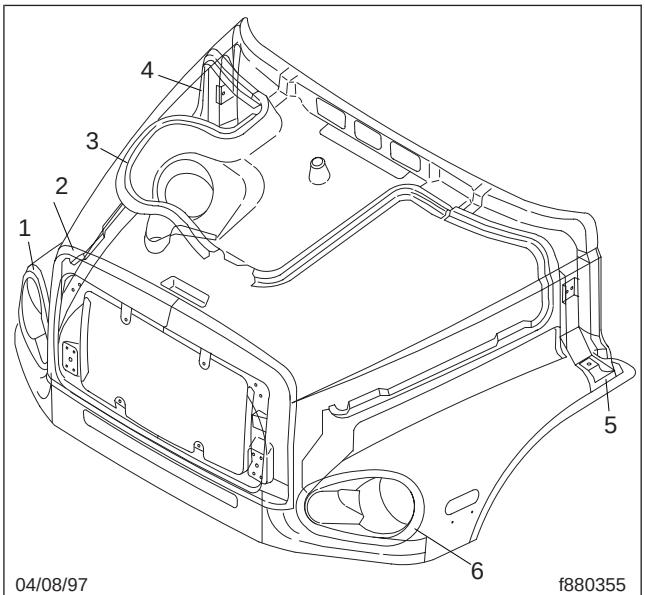
NOTE: When using Ashland Pliogrip 7775L, dispense the required adhesive from the cartridge

in a continuous bead of uniform size and a uniform green color. Discard the initial few inches of discolored bead.

6. After the adhesive dries (about 50 minutes), sand it with a hand-held disc pad. Use 320-grit or finer sandpaper. Feather the edges of the fill so there are no visible sharp edges.
7. Clean the area with compressed air. Mask the area, then spot prime and paint it. Use Sherwin Williams BB–11 black conductive primer. See **Group 98** for spot-painting instructions.

Structural Damage Repair

The Preform FRP (fiberglass reinforced plastic) hood consists of a one-piece hood and fender assembly. Inner reinforcements are bonded to the engine-side of the hood with a structural adhesive. See **Fig. 2**. If the hood is damaged, determine which parts are affected.



1. Right-Hand Headlight Housing
2. Front Hood Reinforcement
3. Rear Air Plenum Reinforcement
4. Right-Hand Side Reinforcement
5. Left-Hand Side Reinforcement
6. Left-Hand Headlight Housing

Fig. 2, Hood Assembly Components

If there is damage to any of the reinforcements, the damage is not repairable. For example, if the grille area of the hood is damaged so badly that the reinforcement bonded inside the grille area is also damaged, replace the entire hood assembly.

If a joint between two reinforcements, or between a reinforcement and the hood skin, has separated and there is no damage at the joint area, the parts can be rebonded. Or, if a part of the hood skin is damaged and its adjoining reinforcement(s) aren't damaged, the reinforcement can be separated from the damaged part, the damaged part can be patched, and the reinforcement(s) rebonded in place.

If a half-fender has a small crack or hole, it can be repaired; if it has a puncture or large fracture, it must be replaced.

For rebonding parts, see "Hood Reinforcement Rebonding."

For damage in the form of a crack or small hole, see "Crack or Small Hole Repair."

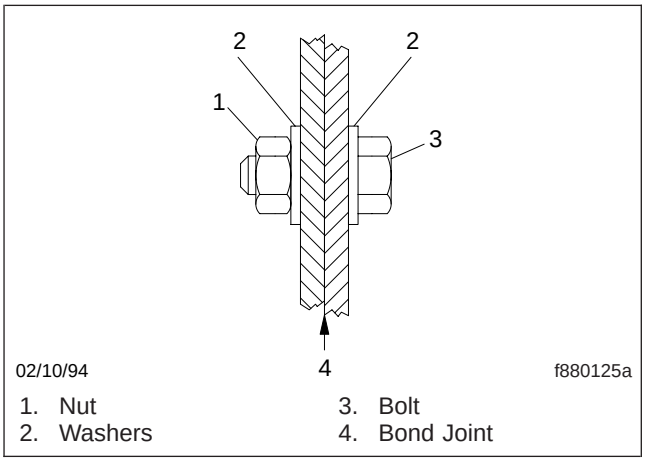
For larger damaged areas, see "Puncture or Large Fracture Repair."

HOOD REINFORCEMENT REBONDING

1. If rebonding a joint that has partially separated, completely separate the reinforcement from the hood using a heat gun and putty knife. Remove as much of the old adhesive as possible. The heat gun will soften the adhesive and allow it to be peeled off the FRP.

   If the parts cannot be separated, work folded medium-grit sandpaper or a section of a steel hacksaw blade between the two surfaces to remove the old adhesive.
2. Scuff the surfaces with 80- to 220-grit sandpaper.
3. Clean the surfaces to be bonded with Ashland 6036 solvent or methylene chloride. Inspect the area closely to be sure all of the old adhesive, dirt, water, grease, and oils are removed.
4. If replacing a large part, align the part on the hood and clamp it in place. Drill holes through the bonding surfaces and install clamping bolts in the holes. Use two washers, one on each side of the joint. See **Fig. 3**. There should be enough clamping bolts to hold the hood in place and keep the bonding surfaces together, or at least

one bolt every 12 to 18 inches (30 to 45 cm). Remove the part for application of adhesive.



1. Nut
2. Washers
3. Bolt
4. Bond Joint

Fig. 3, Clamping Bolt at Bond Joint

5. Following the manufacturer's instructions, use enough adhesive to bond the parts together. Use Ashland Pliogrip urethane cartridge materials 7773 or 7779.

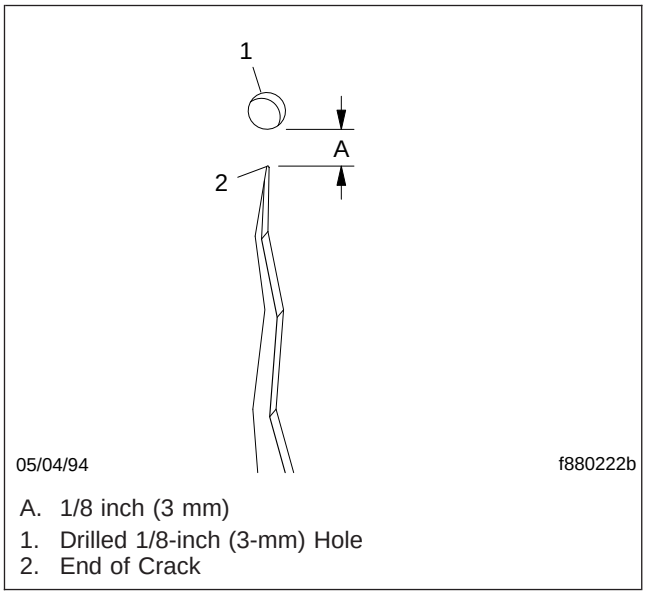
NOTE: When using Ashland Pliogrip 7773 or 7779, insert the two tubes of adhesive into the applicator and dispense a 3/8-inch (10-mm) diameter bead of uniform green-colored adhesive at the bonding surface. Discard any adhesive that does not show this uniform green color.

6. Within three and one half minutes (7773) or within 10 minutes (7779) of applying the bead, align the part on the hood and clamp it firmly in place. If it is a large part, install the clamping bolts. Tighten the clamps or clamping bolts just enough to ensure that a uniform amount of pressure is applied along the seam. Ideally, the adhesive should be compressed to form a bondline one inch (25 mm) wide and 0.030 inch (0.76 mm) thick. This thickness can be ensured by sprinkling 0.030 inch (0.76 mm) glass beads into the adhesive before mating the parts.
7. Before it cures, remove any excess adhesive that squeezes out the edges of the bond.
8. Remove the clamps after the adhesive has cured for 30 minutes (7773) or for 60 minutes (7779).
9. If holes were drilled for clamping bolts, repair them using the instructions under "Crack or Small Hole Repair."
10. If necessary, prime and paint the repair area using the instructions under "Surface Damage Repair."

CRACK OR SMALL HOLE REPAIR

A crack (fracture) or small hole through the laminate requires repair with a fiberglass-reinforced patch.

1. Examine the damage to the hood or half-fender. Apply hand pressure all around the damaged area to check for any concealed damage.
2. If a sound-absorbent liner is present on the underside of the damaged area, peel away the liner to provide an adequate working area.
3. Clean the damaged area on both sides of the hood or half-fender with xylene, acetone, or equivalent grease- and wax-removing solvent. Inspect the area closely. All dirt, water, grease, and oils must be removed.
4. If repairing a crack, use a 1/8-inch (3-mm) diameter bit to drill a hole completely through the uncracked laminate 1/8 inch (3 mm) from each end of the crack, to prevent the crack from lengthening. See **Fig. 4**.



A. 1/8 inch (3 mm)
1. Drilled 1/8-inch (3-mm) Hole
2. End of Crack

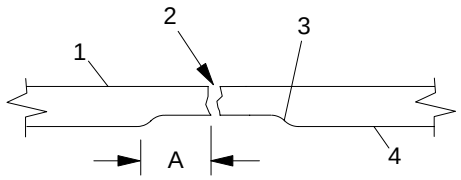
Fig. 4, Drilling a Hole to Prevent the Crack From Lengthening

5. On the engine side of the hood (or underside of the half-fender), use a router bit (on a grinder or a drill) to grind away a shallow recess one-

Hood and Half-Fender Repair

quarter the depth of the laminate and extending 1/2 inch (13 mm) outward from all sides of the damage. Taper the outside edge of the ground area. See **Fig. 5**.

If repairing a crack, grind outward to the drilled hole at the end of the crack, but not beyond. See **Fig. 6**, Ref. A.



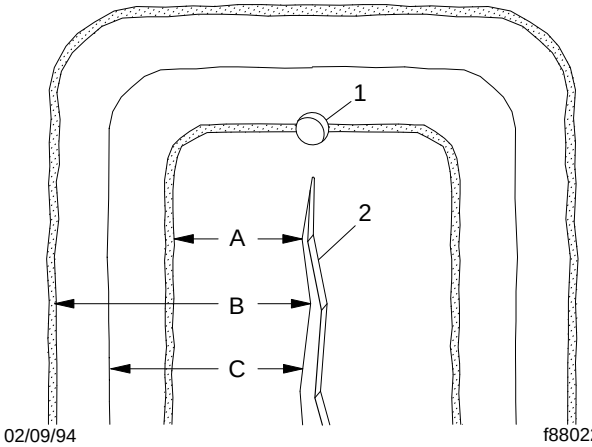
05/04/94 f880227b

A. Grind a shallow recess one-quarter the depth of the FRP and extending 1/2 inch (13 mm) outward in all directions from the damaged area.
1. FRP
2. Crack
3. Slight Taper
4. Engine Side of Hood (or underside of half-fender)

Fig. 5, Recessed Area (cross-sectional view)

6. Use 80- to 220-grit sandpaper to scuff an area at least one inch (25 mm) away from the fracture on all sides. Be sure to scuff thoroughly, since this will give the patch a surface to which it can stick. See **Fig. 6**, Ref. B.
7. Blow the dust away with compressed air and wipe the area with a clean cloth.
8. If necessary, align the panel sections on both sides of the crack, using weights or clamps to re-establish the original panel profile.
9. With a razor-blade knife, cut a section of woven fiberglass cloth to fully cover the crack and to overlay about 3/4 inch (20 mm). See **Fig. 6**, Ref. C.
10. To bond the fiberglass cloth to the damaged panel, use Ashland Pliogrip 7775L urethane adhesive.

NOTE: When using Ashland Pliogrip 7775L, dispense the required adhesive from the cartridge in a continuous bead of uniform size and a uniform green color. Discard the initial few inches of discolored bead.



02/09/94 f880223a

A. Use a router to grind away a shallow recess one-quarter the depth of the FRP and extending 1/2 inch (13 mm) outward from the damage. If repairing a crack, don't grind past the hole drilled at the end of the crack.
B. Use 80- to 220-grit sandpaper to scuff the area one inch (25 mm) around the damage.
C. Cut the fiberglass cloth to fully cover the damage, and overlay about 3/4 inch (20 mm).
1. Hole
2. Crack

Fig. 6, Preparing the Damaged Area on the Engine Side of the Hood

11. Lay the cut section of fiberglass cloth on the repair area, centered over the damage. Using a fiberglass roller, press the cloth down firmly into the layer of adhesive to completely saturate the glass fibers.
12. Apply another layer of adhesive over the glass cloth. Spread the adhesive evenly using the fiberglass roller.
13. After two to five minutes, the adhesive will start to jell. It may take more time when cool, less when warm.

IMPORTANT: To avoid pre-jelling or skin-over, mate the FRP parts to be bonded within one to four minutes after dispensing the adhesive.

NOTE: To get a smoother surface, press a piece of masking tape, wider than the repair, directly over the wet adhesive and smooth it before it hardens. The tape can be removed after five minutes when the adhesive has set.

14. The patch should be hard enough in 50 minutes to allow sanding to a smooth flat surface if required.
15. Repair the damage on the outside surface of the hood or half-fender, using the instructions in "Surface Damage Repair." Prime and paint both surfaces, using the instructions in **Group 98**.

PUNCTURE AND LARGE FRACTURE REPAIR (SECTION REPLACEMENT)

If a half-fender has a puncture or large fracture, replace the half-fender.

On very large damaged areas (for example, structural damage on the side surface of the hood covering an area of a square foot or more) it may be easier to do a section replacement rather than make a patch. Fenders and headlight reinforcements may be used in section replacements. Also, a second damaged hood with the needed section intact may be available as scrap.

IMPORTANT: A piece of Preform FRP from another FL112 vehicle hood must be used for section replacement. Use of any other material may not allow the necessary bonding for the repair.

1. Push in on the area immediately surrounding and underneath the damaged area to determine the extent of damage.
2. If a sound-absorbent liner is present on the underside of the damaged area, peel away the liner to provide an adequate working area.
3. Clean the damaged area on both sides of the hood with xylene, acetone, or an equivalent grease- and wax-removing solvent. Inspect the area closely. All dirt, water, grease, and oils must be removed.
4. Using a sabre saw, cut out a large, straight-sided panel containing the damaged area. See **Fig. 7**, Ref. A.

   If the damage extends to a joint where a reinforcement is bonded to the hood, completely separate the reinforcement with a heat gun and putty knife before cutting. See "Hood Reinforcement Rebonding" for instructions.

⚠ WARNING

Wear goggles and an air purifying respirator when grinding, cutting, or sanding during all fiberglass repairs. The ground dust and particles could cause temporary or permanent damage to your eyes and, if inhaled, could cause throat or lung irritation.

5. From a scrap hood, cut a section replacement panel from the same area, only slightly larger than the cut-out in the damaged hood. See **Fig. 7**, Ref. B. Then, trim the section replacement to fit both the size and contour of the original cutout.

   If the damage is next to a headlight reinforcement, but doesn't include the reinforcement, remove the headlight reinforcement from the replacement section (scrap hood), not the damaged hood.
6. After the trimming is completed, sand the edges to allow a 1/16- to 1/8-inch (2- to 3-mm) gap around the cutout.
7. On the engine side of the hood, use a router bit (on a grinder or drill) to grind away a shallow recess one-quarter the depth of the laminate and extending 1/2 inch (13 mm) outward from all sides of the cutout area. See **Fig. 8**, Ref. A.

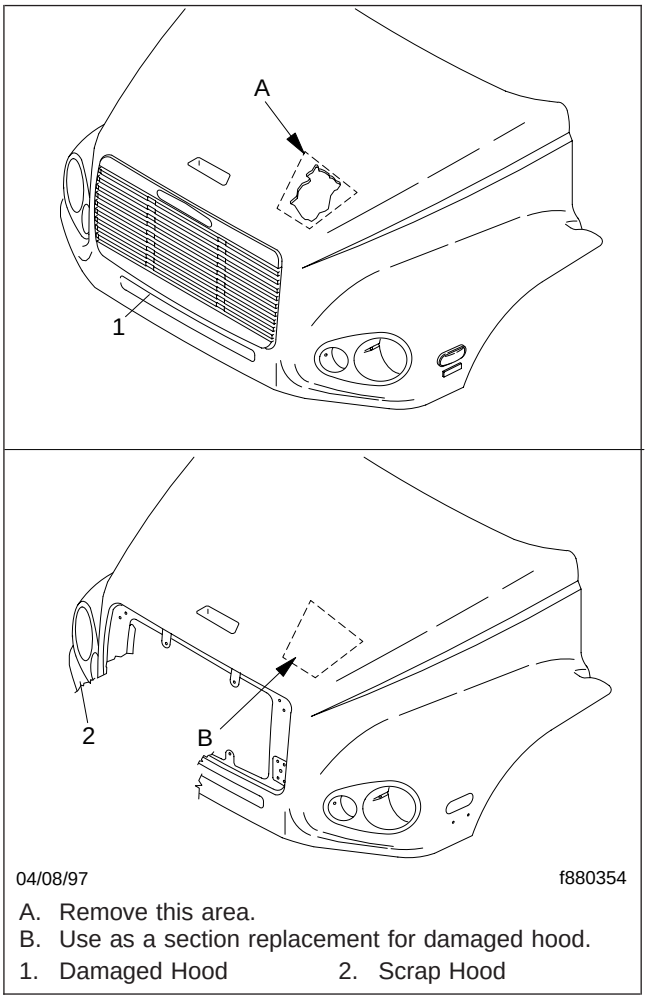
   Also, grind 1/2 inch (13 mm) inward from all edges on the engine side of the section replacement. See **Fig. 8**, Ref. C.

   Slightly taper the outside edge of the ground area on the hood and the inside edge of the ground area on the section replacement. See **Fig. 9**, Ref. 3.
8. Use 80- to 220-grit sandpaper to scuff an area at least one inch (25 mm) out from all sides of the cutout area. See **Fig. 8**, Ref. B.

   Also, scuff at least one inch (25 mm) in from all sides of the section replacement. See **Fig. 8**, Ref. D.

   Scuff thoroughly, since this will give the section replacement a surface to which it can stick. Be sure to completely sand off any undercoating sprayed on these areas.

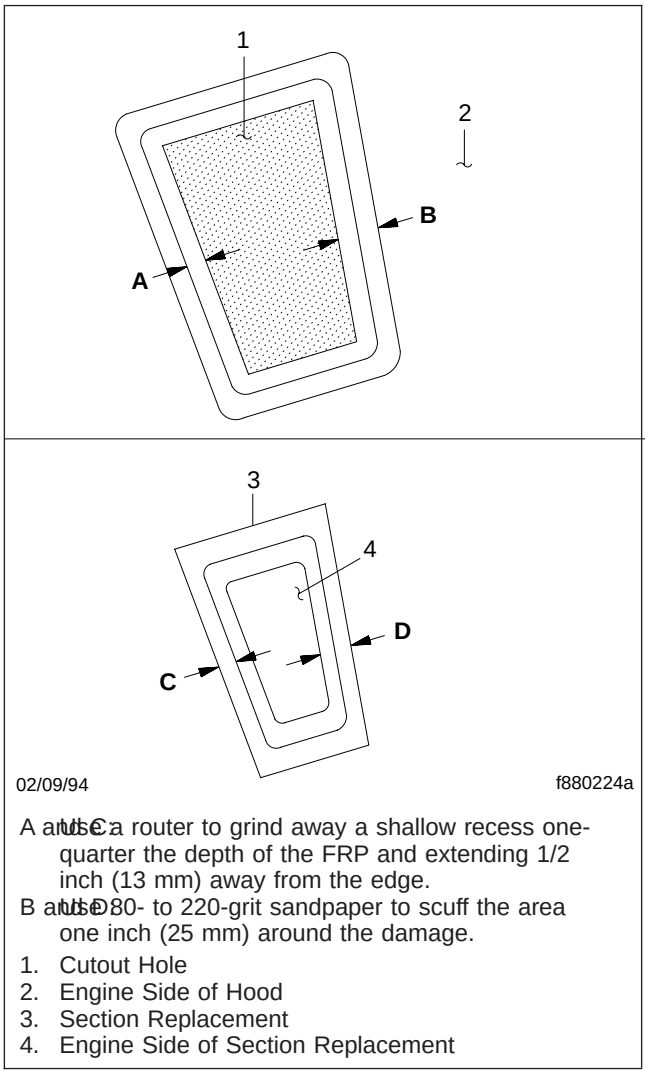
Hood and Half-Fender Repair



A. Remove this area.
B. Use as a section replacement for damaged hood.
1. Damaged Hood
2. Scrap Hood

Fig. 7, Section Replacement of a Damaged Fiberglass Hood

9. On the outer sides of both the cutout and the section replacement, bevel the edges about 45 degrees. See **Fig. 10**.
10. Gently feather the outer painted surfaces back about 1/2 inch (13 mm) beyond the edges of the repair areas (on both the cutout and the section replacement), using 220-grit or finer sandpaper.
11. Blow the dust away with compressed air, and wipe the area with a clean cloth.
12. If the section replacement is close enough to an edge, use clamps to temporarily secure it during the repair.



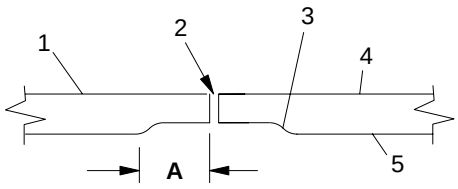
A and C. Use a router to grind away a shallow recess one-quarter the depth of the FRP and extending 1/2 inch (13 mm) away from the edge.
B and D. Use 80- to 220-grit sandpaper to scuff the area one inch (25 mm) around the damage.
1. Cutout Hole
2. Engine Side of Hood
3. Section Replacement
4. Engine Side of Section Replacement

Fig. 8, Preparing the Section Replacement and Hood Cutout on the Unexposed Side

If the replacement is too far from an edge to use clamps, use bond strips. See **Fig. 11**.

12.1 Cut some scrap FRP into strips. Make enough strips to hold the section replacement in position; about one every six inches (15 cm). If the surface of the replacement panel is contoured or curved, use many small bond strips; larger strips could deform the curves.

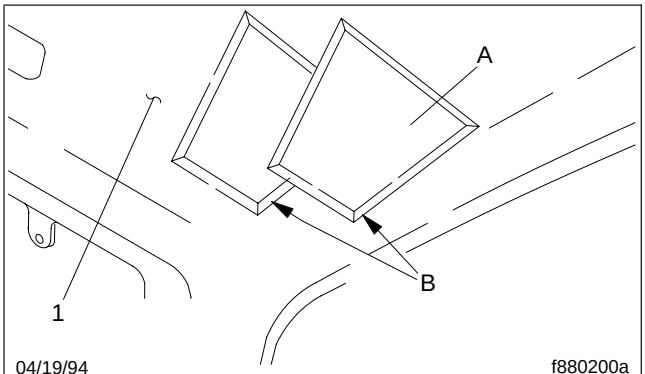
12.2 On the engine side of the repair, use 220-grit sandpaper to scuff sand the areas on



05/04/94 f880226b

A. Grind a shallow recess one-quarter the depth of the FRP and extending 1/2 inch (13 mm) outward in all directions from the damaged area.
1. Section Replacement
2. Gap
3. Slight Taper
4. Hood
5. Engine Side of Hood

Fig. 9, Cutout Area (cross-sectional view)



04/19/94 f880200a

A. Insert section replacement.
B. Bevel outer surface edges on all sides.
1. Exposed Side of Hood

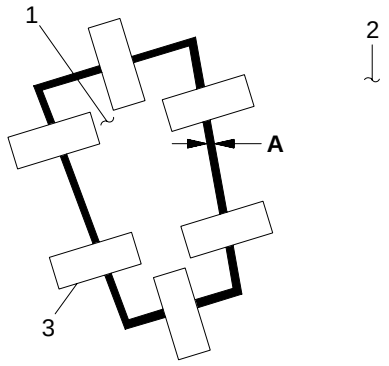
Fig. 10, Areas to be Beveled

the hood and section replacement panels where you plan to bond the strips.

12.3 If a joint between the hood and a reinforcement was separated for the repair, rebond the joint. See "Hood Reinforcement Rebonding" for instructions.

12.4 Holding the section replacement in position, bond the strips to both hood and replacement panels in the area already scuffed. Use Ashland Pliogrip 7773 to bond the strips.

NOTE: When using Ashland Pliogrip 7773, dispense the required adhesive from the cartridge in a continuous bead of uniform size



02/10/94 f880086a

A. Gap of 1/16 inch to 1/8 inch (2 to 3 mm)
1. Section Replacement
2. Engine Side of Hood
3. Bond Strip

Fig. 11, Securing the Section Replacement to the Hood Using Bond Strips

and a uniform green color. Discard the initial few inches of discolored bead.

12.5 After the adhesive has hardened, use 80- to 220-grit sandpaper to scuff the bond strips.

12.6 Blow the dust away with compressed air, and wipe the area with a clean cloth.

13. With a razor-blade knife, cut sections of woven fiberglass cloth to fully cover the gap between the cutout and the section replacement, all the way around the damaged area. The cloth should overlay about 3/4 inch (20 mm) on both sides of the gap. See **Fig. 12**.

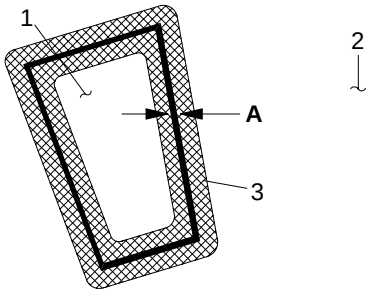
14. To bond the fiberglass cloth to the damaged panel, use Ashland Pliogrip 7775L urethane adhesive.

NOTE: When using Ashland Pliogrip 7775L, dispense the required adhesive from the cartridge in a continuous bead of uniform size and a uniform green color. Discard the initial few inches of discolored bead.

15. Use a plastic or metal device to spread a thin layer of adhesive over the scuffed area.

16. Lay the cut sections of fiberglass cloth on the repair area, centered over the damage. Using a fiberglass roller, press the cloth down firmly into

Hood and Half-Fender Repair



NOTE: The fiberglass cloth should overlay about 3/4 inch (20 mm) on both sides of the gap.

A. Gap of 1/16 inch to 1/8 inch (2 to 3 mm)

1. Section Replacement
2. Engine Side of Hood
3. Fiberglass Cloth

Fig. 12, Overlaying the Gap with Fiberglass Cloth

the layer of adhesive to completely saturate the glass fibers.

17. Apply another layer of adhesive over the glass cloth. Spread the adhesive evenly using the fiberglass roller.
18. After two to five minutes, the adhesive will start to jell. It may take more time when cool, less when warm.

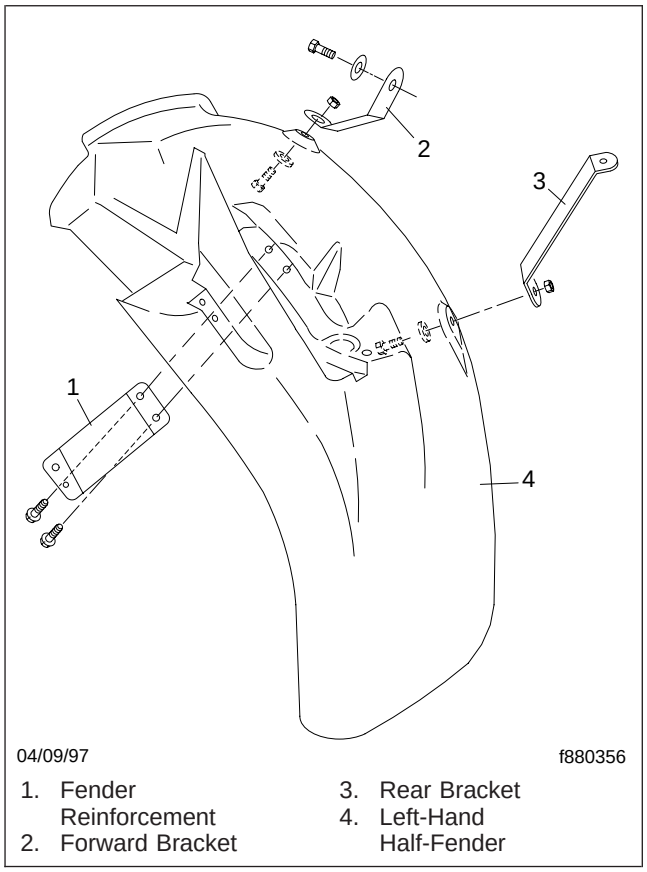
IMPORTANT: To avoid pre-jelling or skin-over, the FRP parts to be bonded should be mated within one to four minutes after the adhesive is dispensed.

NOTE: To get a smoother surface, press a piece of masking tape, wider than the repair, directly over the wet adhesive and smooth it before it hardens. The tape can be removed after five minutes when the adhesive has set.

19. The patch should be hard enough in 50 minutes to allow sanding to a smooth flat surface, if desired.
20. Repair the damage on the outside surface of the hood and paint the surface on both sides, using the instructions in "Surface Damage Repair."

Half-Fender Removal and Installation

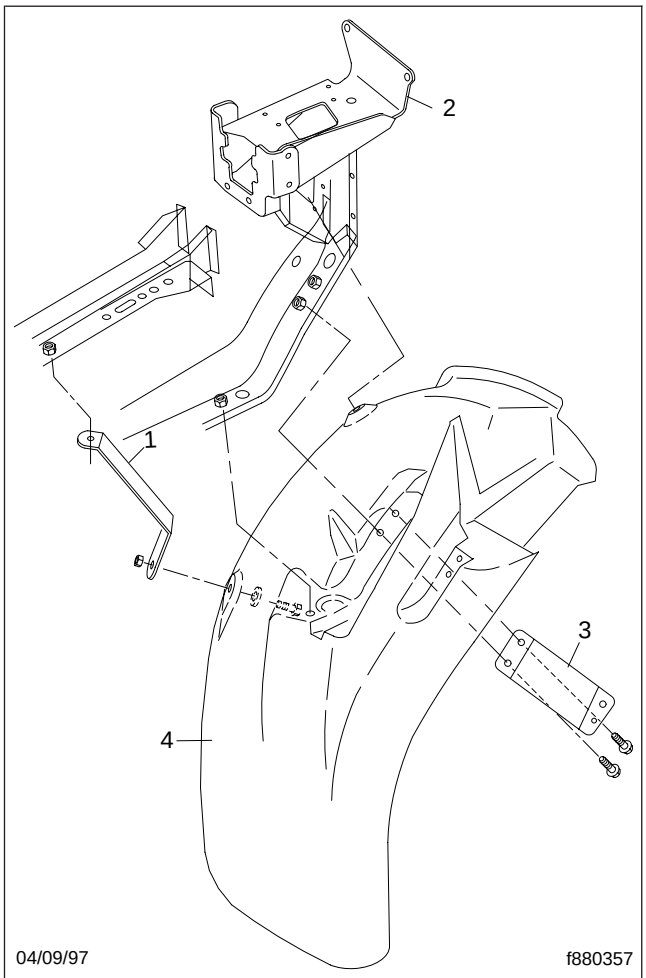
Removal (See Fig. 1 and Fig. 2)



1. Fender Reinforcement
2. Forward Bracket
3. Rear Bracket
4. Left-Hand Half-Fender

Fig. 1, Left-Hand Half-Fender Installation

1. Apply the parking brakes and chock the tires.
2. Tilt the hood.
3. Remove the two quarter-turn fasteners and the splash shield.
4. Remove the fasteners attaching the half-fender to the forward (lower air cleaner bracket on the right-hand side) and rear brackets.
5. Remove the fasteners attaching the half-fender to the cab, which extend through the fender reinforcements.
6. If the half-fender is being replaced, remove the hood latch bracket and half-fender reinforcement for installation on the new half-fender.



1. Rear Bracket
2. Lower Air Cleaner Bracket
3. Fender Reinforcement
4. Right-Hand Half-Fender

Fig. 2, Right-Hand Half-Fender Installation

NOTE: If replacing a half-fender, remove and save the splash shield rear inner mounting bracket.

7. Remove the vertical fastener in the approximate center of the half-fender, attaching the half-fender to the cab. Remove the half-fender.

NOTE: This vertical fastener is not visible unless viewed directly from below.

Half-Fender Removal and Installation

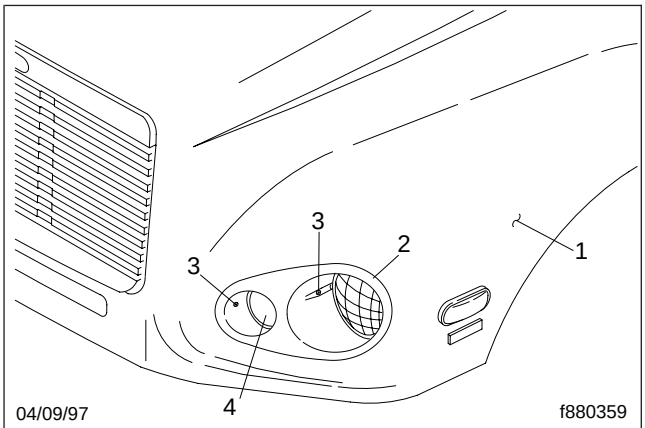
Installation (See Fig. 1 and Fig. 2)

1. If the half-fender was replaced, install the hood latch bracket, half-fender reinforcement, and the splash shield rear inner mounting bracket onto the new half-fender. Tighten the 1/4–20 locknuts 96 lbf·in (1080 N·cm).
2. Position the new half-fender against the cab. Install the fasteners which attach the fender to the cab, finger-tight only.
3. Install the fasteners that attach the half-fender to the forward bracket (lower air cleaner bracket on the right-hand side) and rear bracket.
4. Torque all the half-fender retaining M8 bolts and nuts to 14 lbf·ft (20 N·m).
5. Install the splash shield and the two quarter-turn fasteners.
6. Lower the hood, and remove the chocks.

Headlight Bezel Assembly Removal and Installation

Removal

1. Remove the two screws (**Fig. 1**) that attach the headlight bezel assembly to the hood.
2. Withdraw the bezel assembly from its opening in the hood and disconnect the turn signal harness connector.
3. Remove the headlight bezel assembly from the hood.



1. Hood
2. Headlight Bezel
3. Mounting Screw
4. Turn Signal

Fig. 1, Headlight Bezel Assembly-to-Hood Attachment

Installation

1. Connect the turn signal harness connector to the turn signal.
2. Place the headlight bezel assembly in position in its opening in the hood.
3. Install and tighten the two screws until snug.

Repair Tools, Materials

SURFACE DAMAGE

Required tools and materials:

- Xylene, acetone, or equivalent solvent
- 220- or finer grit sandpaper
- 320- or finer grit sandpaper
- Hand-held disc pad
- Self-leveling adhesive [1]
- Applicator squeegee
- Primer [2]

STRUCTURAL DAMAGE

Section Replacement (Punctures and Large Fractures)

Required tools and materials:

- Scrap FRP from a damaged hood
- Xylene, acetone, or equivalent solvent
- Saber saw
- Router bit
- Razor-blade knife
- Woven fiberglass cloth
- Clamps
- 80- to 220-grit sandpaper
- 220- or finer grit sandpaper
- 320- or finer grit sandpaper
- Hand-held disc pad
- Adhesive for bonding strips (if needed) [3]
- Self-leveling adhesive [1]
- Applicator squeegee
- Primer [2]

Crack or Small Hole

Required tools and materials:

- Xylene, acetone, or equivalent solvent
- 1/8-inch diameter drill bit
- Router bit
- Razor-blade knife
- Woven fiberglass cloth
- 80- to 220-grit sandpaper
- 220- or finer grit sandpaper
- 320- or finer grit sandpaper
- Hand-held disc pad
- Self-leveling adhesive [1]
- Applicator squeegee
- Primer [2]

HOOD COMPONENT REBONDING

Required tools and materials:

- Solvent [4]
- 80- to 220-grit sandpaper
- Clamps, clamping bolts with washers
- 0.030" (0.76 mm) diameter glass beads
- Adhesive [3]
- Primer [2]
- Heat gun
- Putty knife, hacksaw blade

Torque Values (standard and metric fasteners)				
Description	**Size**	**Grade**	**Torque lbf·ft (N·m)**	**Torque lbf·in (N·cm)**
Hood Pivot Shoulder Bolt Locknuts	3/8–16	C	28 (38)	–
Inner Torsion Bar Locknuts and Bolts	3/8–16	8	37 (50)	–

[1] Use Ashland Pliogrip 7775L self-leveling urethane adhesive. 7775L has no sag resistance and, therefore, is useful for filling cracks and channels, and for bonding glass-fiber reinforcing fabrics. Ashland products are available through Freightliner dealers. See **Table 2** and **Table 3**.
[2] Use Sherwin Williams BB–11 black conductive primer. Contact your local Sherwin Williams automotive paint distributor to purchase this primer.
[3] Ashland Pliogrip 7773 or 7779 adhesives are recommended for this application, but 7771 and 7770 may be substituted. A heat gun may be used to speed curing times. Ashland products are available through Freightliner dealers. See **Table 2**.
[4] Use Ashland 6036 primer or methylene chloride. Contact Ashland Merchandising Group, telephone (419) 289–9588, to purchase this primer.

Specifications

Torque Values (standard and metric fasteners)				
Description	**Size**	**Grade**	**Torque lbf·ft (N·m)**	**Torque lbf·in (N·cm)**
Outer Bracket to Hood Hinge Bracket Bolts	3/8–16	8	37 (50)	–
Outer Torsion Bar Locknuts and Bolts	3/8–16	5	26 (36)	–
Torsion Bar Inner Bracket Locknuts and Bolts	1/2–13	8	68 (92)	–
Grille Mounting Screws	1/4–20	—	–	96 (1080)
Hood Support Bracket Bolts	M10 X 1.5	9.8	29 (40)	–
Brace Rod Locknuts and Bolts	M10 X 1.5	10.9	34 (46)	–
Half-Fender Locknuts and Bolts	M8 X 1.25	8.8	14 (20)	–

Table 1, Torque Values (standard and metric fasteners)

NOTE: Ashland Pliogrip 7700 and 8000 Series adhesives and accessories are available through Freightliner dealers and PDCs. The 7700 Series adhesives are two-part urethane adhesives, specially formulated and packaged for repair of hoods and other fiber-reinforced plastics. Adhesive 7775L is a self-leveling mixture that is appropriate when a surface filler or glass fabric reinforcement repair is required. The 8000 Series adhesives are also two-part urethane adhesives, available for those who prefer to use these earlier-generation adhesives. Descriptions, working times, and curing times (sanding and repainting) for the various adhesives are shown below in **Table 2** and **Table 4**.

Ashland adhesive accessories are listed in **Table 3** and **Table 5**.

NOTE: All of the adhesives develop the same bonding strength; specific adhesives may be preferred to change working times.

NOTE: All working and curing times correspond to an ambient temperature of 73°F (23°C) in the workplace; humidity level will NOT affect working or curing times.

IMPORTANT: While a heat gun may be used to speed adhesive curing time, do not overheat the adhesive. The maximum allowable temperature is 180°F (82°C).

Working and Curing Times for 7700 Series Adhesives				
Description	**Part Number**	**Working Time in Minutes**	**Curing Time in Minutes**	**Curing Time in Hours**
Adhesive, two 1.7 oz (50 ml) cartridges, 3.4 oz (100 ml)	ACA 7771	1.5	10.0	—
Adhesive, two 1.7 oz (50 ml) cartridges, 3.4 oz (100 ml)	ACA 7773	3.5	30.0	—
Adhesive, two 10 oz (300 ml) cartridges, 20 oz (600 ml)	ACA 7773 300	3.5	30.0	—
Adhesive, two 1.7 oz (50 ml) cartridges, 3.4 oz (100 ml)	ACA 7775L	5.0	50.0	—
Adhesive, two 1.7 oz (50 ml) cartridges, 3.4 oz (100 ml)	ACA 7779	10.0	—	1.0
Adhesive, two 10 oz (300 ml) cartridges, 20 oz (600 ml)	ACA 7779 300	10.0	—	1.0
Adhesive, two 1.7 oz (50 ml) cartridges, 3.4 oz (100 ml)	ACA 7770	35.0	—	2.5–3.0
Adhesive, two 10 oz (300 ml) cartridges, 20 oz (600 ml)	ACA 7770 300	35.0	—	2.5–3.0

Table 2, Working and Curing Times for 7700 Series Adhesives

Specifications

7700 Series Accessories	
Description	**Part Number**
Manual Applicator Gun for 10 oz (300 ml) Cartridges	ACA TS526C
1/4" Mixing Nozzles for 1.7 oz (50 ml) Cartridges (100/box) *	ACA 583 238
Pneumatic Applicator Gun for 10 oz (300 ml) Cartridges	ACA TS525
3/8" Mixing Nozzles for 10 oz (300 ml) Cartridges (100/box) *	ACA F 771072

* These are additional mixing nozzles. Each adhesive cartridge comes with two mixing nozzles.

Table 3, 7700 Series Accessories

Working and Curing Times for 8000 Series Adhesives				
Description	**Part Number**	**Working Time in Minutes**	**Curing Time in Minutes**	**Curing Time in Hours**
Adhesive, Supermix 4:1, 12 oz (355 ml)	ACA 8104	4	30	—
Adhesive, Supermix 4:1, 12 oz (355 ml)	ACA 8110	10	—	1
Adhesive, Supermix 4:1, 12 oz (355 ml)	ACA 8145	50	—	5–8

Table 4, Working and Curing Times for 8000 Series Adhesives

8000 Series Accessories	
Description	**Part Number**
Pneumatic Applicator Gun for 12 oz (355 ml) Cartridges	ACA 582 2241
3/8" Mixing Nozzles for 8000 Series Cartridges (100/box) *	ACA F 771072

* These are additional mixing nozzles. Each adhesive cartridge comes with two mixing nozzles.

Table 5, 8000 Series Accessories

General Description

The Twinflow midship-mounted fire pump is a centrifugal pumping system designed to deliver large volumes of water under pressure. See **Fig. 1**.

Generally, the pump consists of the following major components:

- cast-iron pump body
- bronze impeller(s) and a stainless steel shaft
- pump gear box
- priming system
- pressure control device
- valves

There are numerous other components, such as the AutoLube and the mechanical seal.

Pump type is determined by the number of impellers on a common shaft. The impeller, which is mounted on a shaft rotated by the vehicle's engine via the driveline, provides velocity to the water causing it to build enough pressure and volume to be used for firefighting applications. See **Fig. 2**.

Bearings support and align the impeller shaft and other components. The bearings must be maintained on a scheduled basis.

The pump body is split horizontally in two sections for the ease of removal of the impeller assembly, including the bearings and the clearance rings.

The pump gear box and the impeller assembly are removable from the bottom of the vehicle in order to avoid interference with the pump plumbing and control mechanisms.

The pump has two large suction inlets, one on each side of the vehicle, though other inlets may be present. The inlets and the internal pump outlets are on opposite sides of the pump to balance forces caused by the intake and the discharge of water.

The AutoLube is built into the pump assembly to continuously force oil to the impeller shaft bushing to lubricate and cool the impeller bushing.

Principles of Operation

A centrifugal pump such as the Twinflow fire pump operates on the principle wherein centrifugal force is created by a rapidly spinning disk, or impeller. Water is routed to the center of the impeller, which throws the water outward from the center of the impeller. When water is confined in a closed container, in this instance, the pump body, the water pressure increases. The pressure level depends on how fast the impeller is rotating.

Water enters the spinning impeller at the intake and is confined by shrouds and vanes in the impeller, which, in turn, builds pressure.

The vanes guide the water away from the inlet to the discharge to reduce the water's turbulence and to move the water toward the outer edge of the impeller.

The shrouds serve as the sides of the impeller and confine the water to the centrifugal acceleration.

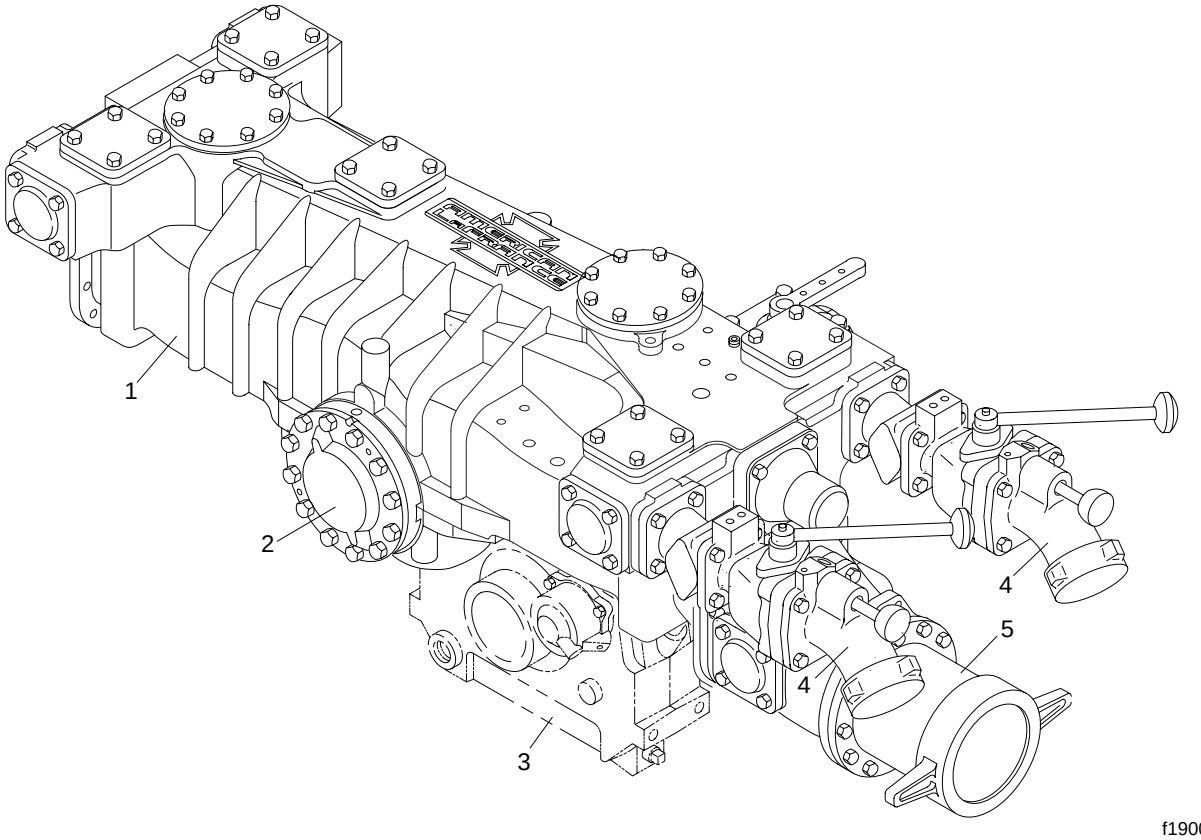
Single-stage pumps provide the same operating and rating-test pressures as a two-stage pump, but the two-stage pump offers additional operating (water) pressure.

The primary difference between a single-stage and a two-stage pump is that the single-stage has only one impeller and no transfer valve to switch between volume and pressure operation. A transfer valve is a two-position valve that permits the impellers in a two-stage pump to operate in parallel (volume) or series (pressure).

In two-stage pumps, the volume operation results in the pressure at the pump intake being added to the equal pressure developed by the impellers, and the amount of water sent to the discharge being the sum of the flows of the two impellers. The pressure operation features the impellers operating in series, or the output of the primary impeller supplied from the pump intake is supplied to the input of the secondary impeller. Thus, the pressure at the pump discharge is the sum of the pressures of the two impellers plus the pressure at the intake. The flow is then half of the volume operation.

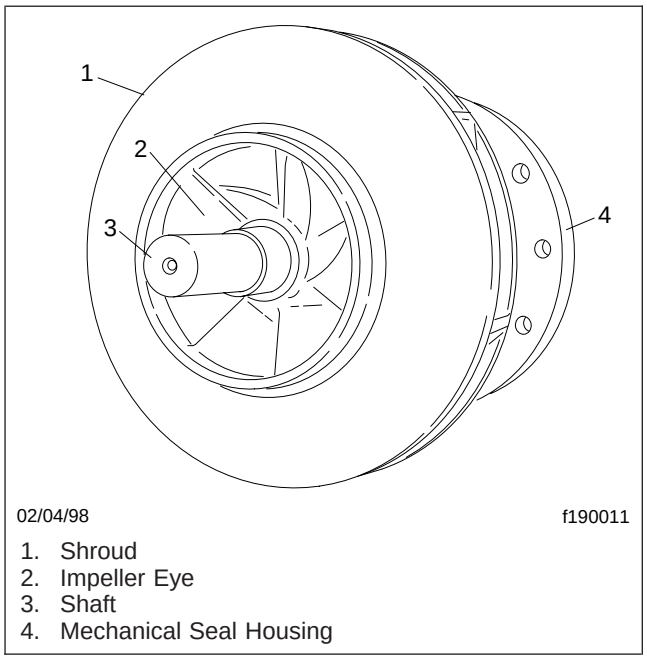
In both types of pumps, the pressurized water is prevented from returning to the intake of the impeller(s) by clearance rings. Centrifugal pumps have clearance rings mounted between the spinning impeller and the pump body. Clearance rings and the hubs of the impeller(s) will, over time, become worn or pitted and may need to be replaced or machined to a smaller diameter.

General Information



1. Pump Body
2. AutoLube
3. Gear Box
4. Discharge
5. Intake

Fig. 1, Twinflow Fire Pump (single-stage shown)



1. Shroud
2. Impeller Eye
3. Shaft
4. Mechanical Seal Housing

Fig. 2, Twinflow Fire Pump Gear Box

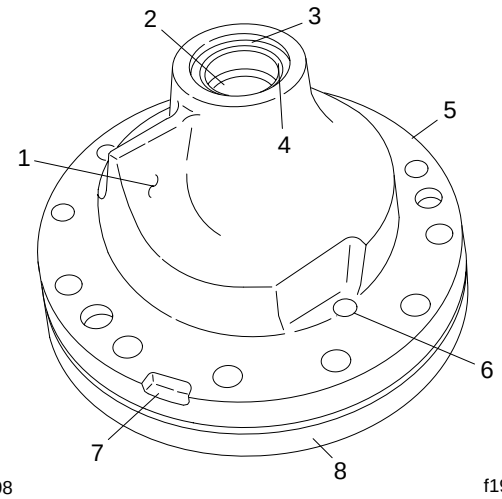
Replacement

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Drain the water from the pump.
3. Remove the fill and drain plugs from the AutoLube reservoir and drain the oil.
4. Use a center punch to mark the AutoLube cover and the front bearing housing for proper alignment during assembly.

CAUTION

Do not use a chisel to separate the AutoLube from the pump body because the mating surfaces may be scratched or gouged, which could result in a leak. The AutoLube is manufactured from cast metal and if it becomes necessary to pry the AutoLube apart from the pump body, pry between the AutoLube and the pump body or at the AutoLube notches.

5. Remove the 1/2–13 x 2 capscrews attaching the AutoLube to the pump body and gently pry the AutoLube from the pump body and impeller shaft.
6. Place the AutoLube face down on a work bench and remove the two 3/8–16 x 3/4 allen-head capscrews from the impeller side. Separate the two halves and remove the diaphragm.
7. Remove the seal lock ring.
8. Remove the oil seal from the inner half of the AutoLube.
9. Check the impeller shaft bushing for wear.
10. Clean the inner and outer halves of the AutoLube.
11. Clean the gasket surfaces of the AutoLube and the pump body.
12. Check for restrictions in the water passages to the rear half of the AutoLube.
13. If it is necessary to replace the impeller shaft bushing, press the bushing from the inner side of the inner half of the AutoLube (on the side opposite of the impeller). Install the bushing from the impeller side of the inner half of the AutoLube. See **Fig. 1**.



1. Cut Water
2. Bushing
3. Lock Ring
4. Seal
5. Front Bearing Housing
6. Water Passage
7. Pry Notches
8. AutoLube Cover

Fig. 1, Impeller Shaft Bushing

CAUTION

The impeller shaft bushing seats against a shoulder in the inner half of the AutoLube and can only be removed and installed as described or the AutoLube may be damaged.

14. Install the new oil seal in the inner half of the AutoLube.
15. Install the seal lock ring.
16. Position the diaphragm on the inner half of the AutoLube.
17. Line up the marks and place the outer half of the AutoLube onto the inner half. Apply Loctite® 242 to the two 3/8–16 x 3/4 allen-head capscrews. Tighten 30 lbf·ft (41 N·m).
18. Install the new gasket on the AutoLube and position the assembly (with the top up) onto the impeller shaft. Attach the AutoLube with 1/2–13 x 2 capscrews and tighten 80 lbf·ft (108 N·m).

AutoLube Seal Replacement

CAUTION

Do not damage the oil seal. A damaged oil seal could result in damage to the AutoLube assembly as well as the pump.

19. To fill the AutoLube with 90w oil, pump the oil in from the bottom plug opening until the oil spills from the top opening. This eliminates air pockets and false readings.

CAUTION

Purge the air from the AutoLube while filling it with oil or a "false-fill" situation will develop, which could cause damage to the AutoLube and other components.

20. Add water to the pump.
21. Operate the fire pump and check the AutoLube for water or oil leaks.
22. Remove the tire chocks.

Fire Pump Gearbox Removal, Disassembly, Assembly, and Installation

Removal

NOTE: For an exploded view of the fire pump body assembly, see **Fig. 1**.

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Drain the water from the pump.
3. Drain the gearbox lubricant to prevent contamination.
4. Disconnect the pressure lubrication line to the gearbox cover. Keep the line primed with lubricant.
5. Disconnect the drive shafts from the gearbox.
6. Disconnect the electrical switches and the air lines. Mark the switches and air lines for assembly.
7. Disconnect the pump gearbox cooling lines.

⚠ WARNING

The gearbox is heavy. Support the gearbox with a lifting or supporting device while removing it from the pump body. Failure to do so could result in the gearbox falling, which could result in personal injury or property damage.

NOTE: Before removing the gearbox, use a center punch to mark the rear bearing housing, the mechanical seal housing, the oil pump cover and the pump body to ensure proper alignment during reassembly.

8. Support the gearbox with an appropriate device.
9. Remove the six 1/2–13 x 1-3/4 capscrews that attach the gearbox cover to the top of the gearbox.
10. Remove the 7/16–14 x 1-1/4 capscrews that attach the gearbox to the rear bearing housing.
11. Lower the gearbox. Be sure to balance the gearbox so that it does not tip from the lowering device. See **Fig. 2**.
12. Remove the gearbox cover.

NOTE: The threaded holes may need to be cleaned.

Disassembly

1. Remove and disassemble the intermediate shaft assembly.

   1.1 Disconnect the oil suction line from the lubrication pump.

   1.2 Remove the capscrews attaching the front bearing housing to the lubrication pump. Then, remove the housing and pump assembly.

   NOTE: The rear bearing housing has threaded holes for 1/4–20 jackscrews to assist in removal.

   1.3 Remove the capscrews attaching the rear bearing housing to the lubrication pump.

   1.4 Reach into the top of the gearbox housing and remove the intermediate gear and shaft assembly. The bearing inner cups are pressed onto the shaft, so care must be taken not to damage the cups during removal.

   1.5 Using a bearing splitter, clamp the halves of the splitter onto the back edge of the intermediate shaft bearing cup. Attach a crossbar puller to the bearing splitter halves and remove the cup. Care must be taken when removing the cup to not damage the lubrication pump spline in the center of the intermediate shaft. Repeat the procedure for the opposite-side bearing cup.

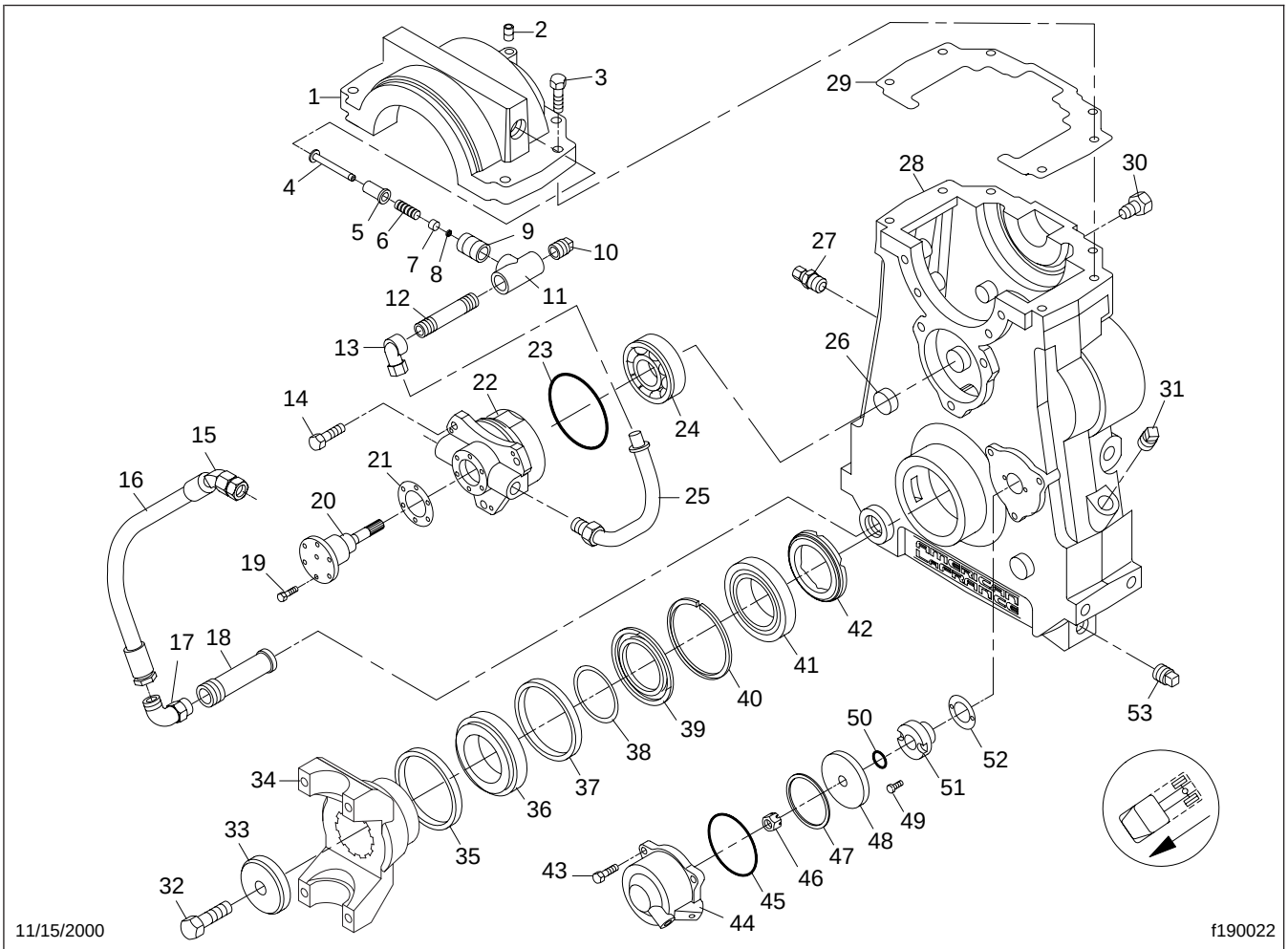
   1.6 Using a gear puller with reversed jaws, remove the intermediate shaft bearing cone from the intermediate shaft rear cover.

⚠ CAUTION

Lubrication pump impeller vanes are fragile, and may break or chip. Impeller vanes are installed only one way. If removal of the vanes is necessary, note the installation direction of the vanes (rounded edge). Failure to install the vanes properly will result in pump gearbox failure.

   1.7 When disassembling the lubrication pump, be sure to note the number of gas-

Fire Pump Gearbox Removal, Disassembly, Assembly, and Installation



1. Gearbox Cover
2. Air Vent
3. Capscrew, 1/2–13 x 1-3/4
4. Oil Spray Valve
5. Bushing
6. Oil Spray Bar Spring
7. Retainer Spring
8. External Retaining Ring
9. Close Nipple, 3/4 NPT
10. Plug, 1/2 NPT
11. Branch Tee, 1/2 x 1/2 x 3/4
12. Nipple, 1/2 NPT x 3 1/2
13. Compression Elbow, 1/2 NPT x 1/2
14. Capscrew, 7/16–14 x 1-1/4
15. JIC 90 Elbow, 1/2 NPT x 12
16. Oil Suction Line
17. JIC 45 Elbow, 1/2 NPT x 12
18. Gearbox Lubrication Oil Filter
19. Capscrew, 1/4–20 x 5/8
20. Lubrication Oil Pump Cover
21. Lubrication Oil Pump Cover Gasket
22. Lubrication Oil Pump
23. Intermediate Ring and Oil Seal
24. Intermediate Bearing
25. Pressure Lubrication Hose, 1/2 ID
26. Plug, 1/2 NPT
27. Hard Copper Tube Fitting, 1/2 NPT x 3/8
28. Gearbox Assembly
29. Gearbox Cover Gasket
30. Gearbox Oil Level Indicator
31. Plug, 3/4 NPT
32. Capscrew, 3/4–10 x 1 1/2
33. Yoke Washer
34. Driveline Yoke
35. Oil Seal
36. Bearing and Race
37. Preload Spacer
38. Preload Shim
39. Snap Ring Lock
40. Snap Ring
41. Bearing and Race
42. Input Shaft Thrust Spacer
43. Capscrew, 5/16–18 x 1
44. Air Shift Cylinder
45. Shift Cylinder Seal
46. Hex Locking Nut, 1/2–13
47. Piston Seal Ring
48. Air Shift Piston
49. Capscrew, 1/4–20 x 1-5/8
50. Vee Block Seal
51. Air Cylinder Bushing
52. Shifter Bushing Gasket
53. Magnetic Plug, 3/4 NPT

Fig. 1, Fire Pump Body Assembly (exploded view)

Fire Pump Gearbox Removal, Disassembly, Assembly, and Installation

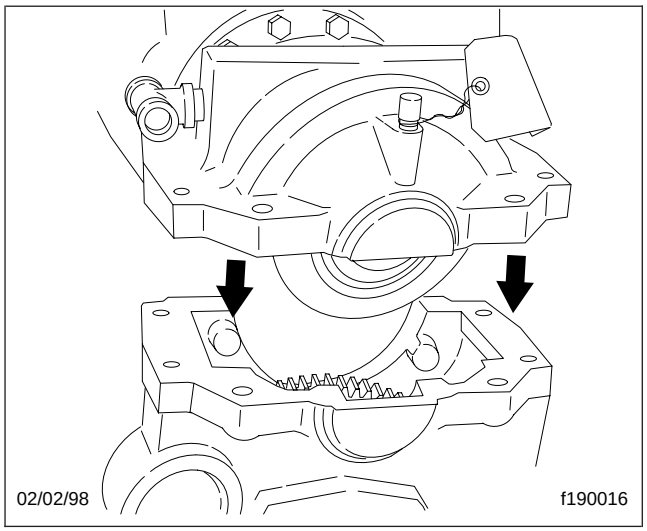


Fig. 2, Lowering the Fire Pump gearbox

kets and shims that are under the cover. Set these components aside for reassembly.

1.8 Using a centerpunch, mark the lubrication pump position, and remove the six 1/4–20 x 5/8 capscrews.

1.9 Remove the lubrication pump cover.

1.10 Remove the lubrication pump impeller and the shaft, being careful not to damage the impeller vanes.

1.11 Using a gear puller with reversed jaws, remove the intermediate shaft bearing cone from the intermediate shaft front cover. Care must be taken when removing the cup so as not to damage the lubrication pump spline in the center of the intermediate shaft cover.

2. Remove and disassemble the output shaft assembly. See **Fig. 3**.

2.1 Remove the manual shift eye from the rear of the shift yoke shaft.

2.2 Remove the detent allen-head screw, spring and detent ball from the top of the output shaft housing.

2.3 Remove the shift and interlock switches on the output shaft housing.

2.4 Remove the 7/16–14 x 2-1/4 capscrews retaining the output shaft and the housing to the gearbox housing. Carefully remove the output shaft housing by sliding the housing from the shift yoke shaft.

2.5 Remove the input shaft pilot bearing from the output shaft.

2.6 Remove the 3/4–10 x 1-1/2 capscrew retaining the rear driveline yoke to the output shaft and remove the yoke.

2.7 Remove the output shaft seal.

2.8 Remove the output shaft by sliding it from the output shaft housing from the rear to the front. Use caution when sliding the output shaft through the bearing cones and spacer(s).

⚠ CAUTION

Bearing cups, cones and spacers are factory pre-set for end play, and are only provided as a matched set. It is important that bearing cups, bearing cones and spacers, when removed, be kept together in matched sets. Input and output shaft bearing and spacer sets are different. Failure to keep matched sets together or to not use factory pre-set and matched bearing and spacer sets will void warranty and may result in gearbox failure.

2.9 Remove the inner and outer bearing cones.

2.10 Using a brass drift, carefully drive out the outer bearing cup from the inside out. Remove the internal retaining ring and then the spacer(s).

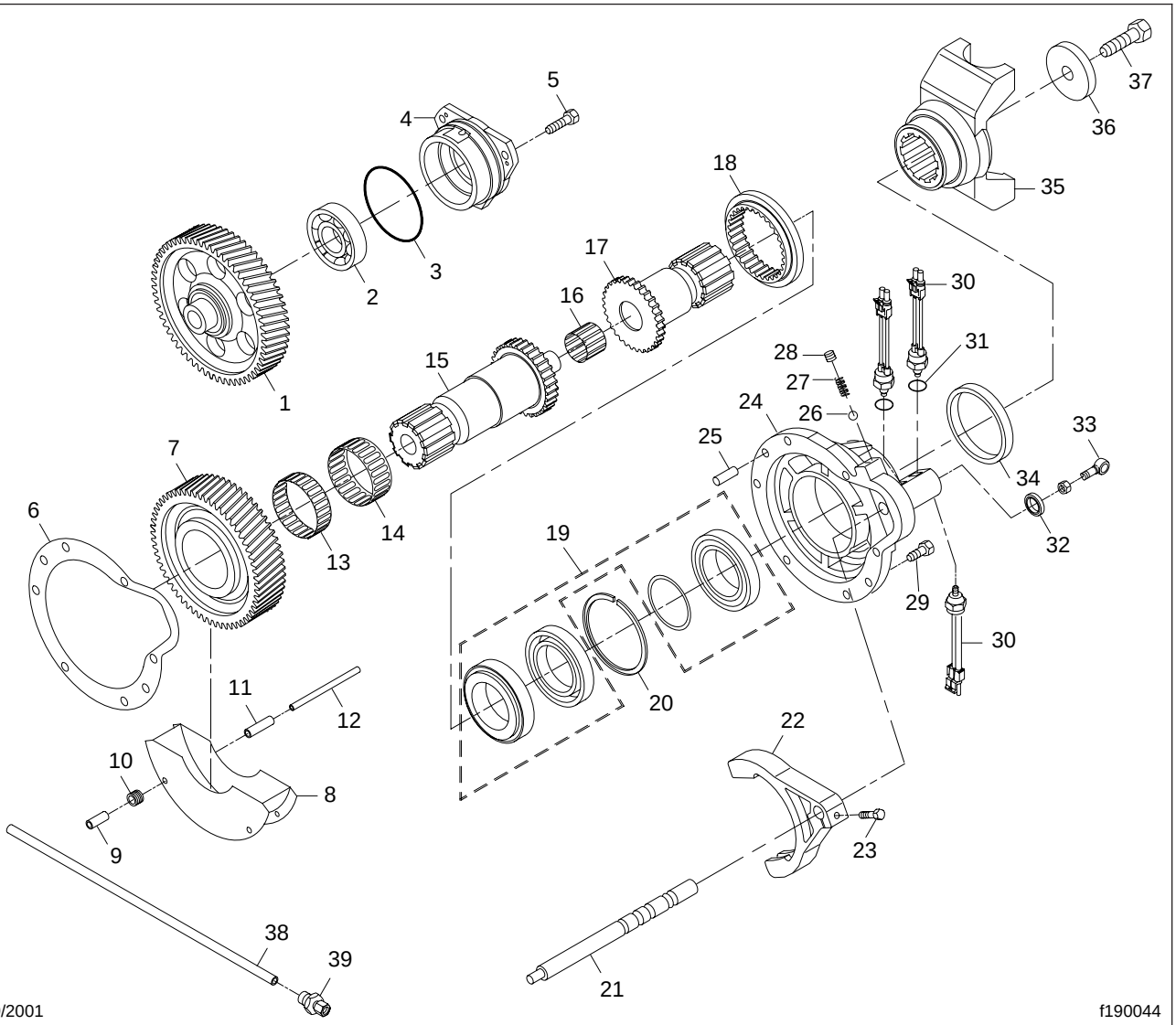
2.11 Using a brass drift, carefully drive out the inner bearing cup from the outside in.

2.12 Remove the shaft seal from the output shaft housing.

3. Remove and disassemble the input shaft assembly.

3.1 Remove the three 5/16–18 x 1 capscrews from the shift cylinder, and then carefully slide the shift cylinder from the piston.

Fire Pump Gearbox Removal, Disassembly, Assembly, and Installation



1. Intermediate Gear Assembly
2. Intermediate Bearing
3. Intermediate Shaft Bearing Cover Oil Seal
4. Intermediate Shaft Bearing Cover
5. Screw, 7/16–14 x 1/8 Hex Nylock
6. Bearing Cover Gasket
7. Input Gear
8. Windage Tray
9. Spacer
10. Windage Tray Spring
11. Spacer
12. Windage Tray Rod
13. Short Caged Roller Bearing
14. Long Caged Roller Bearing
15. Input Shaft
16. Input Shaft Needle Bearing
17. Output Shaft
18. Shifting Collar
19. Rear Bearing Shims/Spacers Assembly
20. Internal Retaining Ring
21. Shifting Shaft
22. Shift Fork
23. Screw, 3/8–16 x 1-1/4 Hex Nylock G8
24. Output Shaft Housing
25. Gearbox Dowl Pin
26. Gearshift Shaft Ball
27. Compression Spring
28. Hex Socket Setscrew, HD, Selflock
29. Screw, 7/16–14 x 1-3/4 Hex Nylock
30. Gearshift Switch
31. Switch Seal Ring
32. Wiper/Scraper Seal
33. Manual Shift Eye
34. Lip Seal
35. Driveline Yoke
36. Yoke Washer
37. Capscrew, 3/4–10 x 1-1/2 Hex HD
38. Gearbox Cooling Tube
39. Cooling Tube Connector

Fig. 3, Rear Gearbox Assembly (exploded view)

3.2 Remove the nut and then remove the piston from the shift shaft. Remove the seal ring from the piston.

⚠ CAUTION

Do not remove the piston from the shift yoke shaft unless it is damaged (and replacement is mandatory). When installing a new piston, replace the locknut and tighten snugly, but do not overtighten as the nut can become distorted, which can cause shift failures.

3.3 Remove the shift shaft, the shift fork, and the shift ring assembly from the gearbox. Make sure the shift ring does not get dropped or damaged.

3.4 Note the location and orientation of the shift fork on the shaft, then remove the 3/8–16 x 1-1/4 screw from the shift fork and remove the fork from the shift shaft.

3.5 Remove the shift shaft support block. Then remove the seal from the support block.

NOTE: One ear of the shift yoke is machined and will fit one way. Make a note of the location of the machined ear when removing the shift yoke.

3.6 Remove the 3/4–10 x 1-1/2 capscrew attaching the front driveline yoke to the input shaft. Remove the yoke.

3.7 Remove the input shaft by sliding the input shaft from the output shaft housing opening at the rear of the gearbox. Use caution when sliding the input shaft through the bearing cones, the thrustwasher and the drive gear. Place wooden blocks to support the drive gear and to protect the windage tray, and force the shaft loose.

⚠ CAUTION

Bearing cups, cones and spacers are factory preset for end play, and are only provided as a matched set. It is important that bearing cups, bearing cones and spacers, when removed, be kept together in matched sets. Input and output shaft bearing and spacer sets are different. Failure to keep matched sets together or to not use factory pre-set and matched bearing and spacer sets will void warranty and may result in gearbox failure.

There are two bearings of different widths supporting the drive gear on the input shaft. It is important that these bearings be installed in the drive gear in the proper location. Note the location of the bearings when removed. Failure to install the bearings properly can result in gearbox failure.

3.8 Reaching through the top of the gearbox housing, carefully remove the drive gear, the inner bearing cone, and thrustwasher. Remove the drive gear bearings.

3.9 Using a magnet, remove the positioning pins from the windage tray. Then, remove the windage tray and the positioning springs.

3.10 Remove the input shaft seal.

3.11 Remove the outer bearing cone.

3.12 Using a brass drift, carefully drive out the outer bearing cup from the inside out. Remove the internal retaining ring and the spacer(s).

3.13 Using a brass drift, carefully drive out the inner bearing cup from the outside in.

4. Inspect the cooling tube for damage and leaks.
5. Remove the gearbox lubrication oil filter from the suction inlet on the gearbox housing.
6. Clean and inspect each component of the gearbox assembly. Inspect the bearing cups and the cones for wear, pitting and damage. Inspect the gear tooth surfaces for wear damage and pitting. Inspect the shift shaft block for wear. Inspect the gasket surfaces for nicks and gouges. Replace all components that are worn, damaged or pitted.

Assembly

1. Install a new transmission lubrication oil filter.
2. Assemble and install the input shaft assembly.

Fire Pump Gearbox Removal, Disassembly, Assembly, and Installation

⚠ CAUTION

Bearing cups, cones and spacers are factory pre-set for end play, and are only provided as a matched set. It is important that bearing cups, bearing cones and spacers, when removed, be kept together in matched sets. Input and output shaft bearing and spacer sets are different. Failure to keep matched sets together or to not use factory pre-set and matched bearing and spacer sets will void warranty and may result in transmission failure.

2.1 Using a brass drift or a bearing cup installation tool, install the inner bearing cup from the inside out. Then install the spacer(s) and insert the retaining ring.

2.2 Using a brass drift or a bearing cup installation tool, install the outer bearing cup from the outside in.

2.3 Coat the outer bearing cone with oil. Install the outer bearing cone.

2.4 Install the input shaft seal.

2.5 Install the windage tray positioning springs and windage tray. While holding the windage tray in place against the positioning springs, install the windage tray positioning pins.

⚠ CAUTION

There are two bearings of different widths supporting the drive gear on the input shaft. It is important that these bearings be installed in the drive gear in the proper location. The location of the bearings should have been noted when removed from the assembly. Make sure that the lubrication holes are aligned in the center of the larger bearing. Failure to install the bearings properly may result in transmission failure.

2.6 Coat the new drive bearings with oil and install in the drive gear.

2.7 Coat the inner bearing cone with oil and install. Then, install the thrustwasher.

2.8 Reaching through the top of the transmission housing, install the drive gear into position against the thrustwasher, being careful not to dislodge the windage tray.

2.9 Slide the input shaft through the output shaft housing opening at the rear of the transmission through the drive gear, the thrustwasher, and the bearing cones and spacer(s).

2.10 Install the front driveline yoke on the input shaft, being careful not to damage the input shaft seal. Apply Loctite® 242 to the 3/4–10 x 1-1/2 yoke retaining capscrew. Then install the capscrew and washer and tighten 225 lbf·ft (305 N·m).

NOTE: Apply a coat of Loctite® to all screws prior to reassembly.

NOTE: One ear of the shift yoke is machined, and it will only fit one way. Make sure the yoke is oriented on the shaft in the position noted during disassembly.

2.11 Make sure the shift fork is properly aligned (the machined side should be toward the threaded end of the shift shaft) and slide the new shift fork on the shift shaft. Align the shift fork with the groove in the shaft and secure the shift fork in place with a 3/8–16 x 1-1/4 screw. Tighten the screw 33 lbf·ft (45 N·m).

2.12 Install a new seal on the shift shaft support block. Install a new gasket on the shift shaft support block. Install the shift shaft support block and gasket in the gearbox using two 1/4–20 x 5/8 capscrews. Tighten the capscrews 96 lbf·in (1085 N·cm).

2.13 Place the shift ring into the shift fork grooves. While holding the shift ring in place, insert the shift shaft into the gearbox through the bushing. Make sure the teeth on the shift shaft ring line up with the teeth on the input shaft and gear.

2.14 Apply a light coating of grease to the new seal ring, then install the seal ring on the shift piston. Install the piston on the shift shaft end.

⚠ CAUTION

When installing the piston, use a new locknut and tighten snugly but do not overtighten. Over-

tightening the locknut may distort the piston and cause shift failures.

2.15 Secure the piston in place with a new locknut.

2.16 Apply a light coating of grease to the shift cylinder seal and install the seal in the groove on the shift cylinder.

2.17 Install the shift cylinder using three 5/16–18 x 1 screws. Tighten the screws 17 lbf·ft (23 N·m).

3. Assemble and install the output shaft assembly.

3.1 Install a new shift shaft seal in the output shaft housing.

⚠ CAUTION

Bearing cups, cones and spacers are factory pre-set for end play, and are only provided as a matched set. It is important that bearing cups, bearing cones and spacers, when removed, be kept together in matched sets. Input and output shaft bearing and spacer sets are different. Failure to keep matched sets together or to not use factory pre-set and matched bearing and spacer sets will void warranty and may result in transmission failure.

3.2 Using a brass drift or a bearing cup installation tool, install the inner bearing cup from the inside out. Install the spacer(s). Then install the retaining ring.

3.3 Using a brass drift or a bearing cup installation tool, install the outer bearing cup from the outside in.

3.4 Coat the outer bearing cone with oil and then install it.

3.5 Install the output shaft seal.

3.6 Apply a coating of oil to the inner bearing cone, and install.

3.7 Apply a coating of oil to the input shaft pilot bearing and then install the bearing into the output shaft.

3.8 Install the output shaft by sliding the shaft in through the output shaft housing from the front to the rear. Be careful when sliding the output shaft through the bearing cones and spacer(s).

3.9 Install the rear driveline yoke on the output shaft, taking care not to damage the output shaft seal. Apply Loctite® 242 to the 3/4–10 x 1-1/2 capscrew. Then, install the capscrew and washer and tighten 225 lbf·ft (305 N·m).

3.10 Install a new gasket onto the output shaft housing.

3.11 Apply Loctite® 242 to the two 7/16–14 x 2-1/4 and the four 7/16–14 x 1-3/4 capscrews. Then, install the output shaft and housing, sliding the housing onto the shift yoke shaft. Install and tighten the 2-1/4-inch capscrews 50 lbf·ft (68 N·m) and the 1-3/4-inch capscrews 53 lbf·ft (72 N·m).

3.12 Install the shift and interlock switches on the output shaft housing.

3.13 Apply Loctite® 242 to the detent allen-head screw, and install the detent ball, spring and allen-head screw.

3.14 Install the manual shift eye from the rear of the shift yoke shaft.

3.15 Rotate the input shaft to check for proper movement.

4. Assemble and install the intermediate shaft assembly.

4.1 Press a new bearing cone into the intermediate shaft rear cover, coat the cone with oil and install a new cover seal.

4.2 Press a new bearing cone into the intermediate shaft front cover, coat the cone with oil and install a new cover seal.

⚠ CAUTION

Lubrication pump impeller vanes are fragile, and may break or chip. Impeller vanes are installed only one way. If removal of the vanes is necessary, note the installation of the vanes. Failure to install the vanes properly will result in transmission failure.

IMPORTANT: To ensure proper operation of the oil pump, use the same number of gaskets and shims that were removed when the oil pump was disassembled.

Fire Pump Gearbox Removal, Disassembly, Assembly, and Installation

4.3 Install the lubrication pump impeller assembly, vanes and shaft into the front cover, aligning matchmarks. Apply Loctite® 242 to the six 1/4–20 x 5/8 capscrews and tighten 8 lbf·ft (11 N·m).

4.4 Press the new bearing cups onto the intermediate shaft, one on each side of the intermediate gear.

4.5 Reaching through the top of the transmission housing, install the intermediate gear and shaft assembly, taking care not to damage the bearing cups.

4.6 Holding the intermediate gear assembly in place, install the rear intermediate shaft cover. Apply Loctite® 242 to the three 7/16–14 x 1-1/4 capscrews and install but do not torque.

4.7 Install the front intermediate shaft cover, aligning the lubrication pump shaft spline with the intermediate shaft spline. Apply Loctite® 242 to the three 7/16–14 x 1-1/4 capscrews and tighten all six capscrews 53 lbf·ft (72 N·m).

4.8 Connect the oil suction line to the lubrication pump.

4.9 Rotate the input shaft and manually shift the transmission to check for proper movement and operation.

Installation

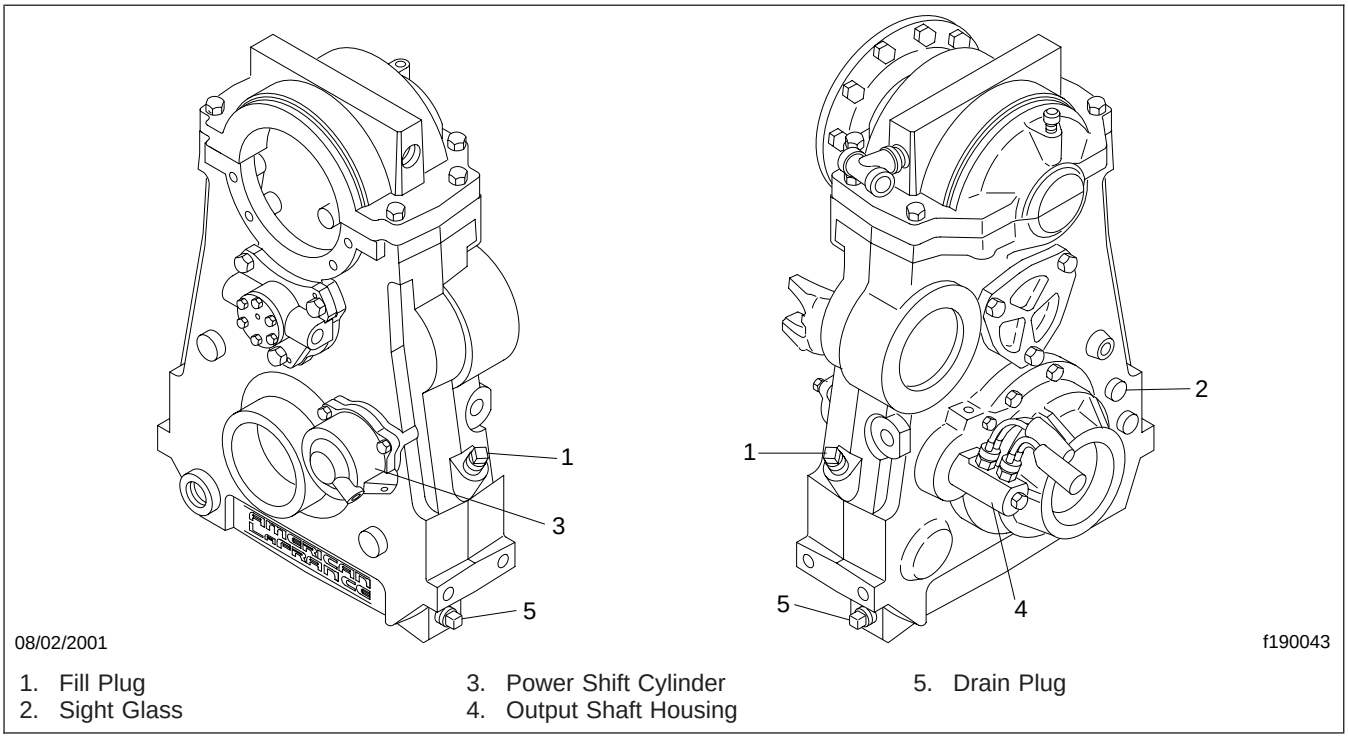
1. Install a new gasket on the seating surface of the rear bearing housing.

⚠ CAUTION

Properly align the rear bearing housing. If the rear bearing housing is not aligned with the matchmarks, the gear tooth mesh could be incorrect and may result in damage to the gearbox.

2. Using a lifting device, lift the gearbox into position (around the rear bearing housing). Apply Loctite® 242 to the six 1/2–13 x 1-3/4 capscrews, and attach the gearbox cover to the gearbox. Tighten finger-tight, but do not torque.
3. Apply Loctite® 242 to the twelve 7/16–14 x 1-1/4 capscrews, and insert the capscrews through the rear bearing housing cover and gasket into the gearbox. Tighten 53 lbf·ft (72 N·m).
4. Tighten the six 1/2–13 x 1-3/4 capscrews 65 lbf·ft (88 N·m).
5. Connect the pump gearbox cooling lines.
6. Connect the air lines and electrical switches.
7. Connect the drive shafts. Tighten the yoke fasteners 225 lbf·ft (305 N·m), and tighten the bearing retaining strap capscrews 40 to 48 lbf·ft (54 to 65 N·m).
8. Connect the lubrication line to the gearbox cover.
9. Fill the gearbox with the necessary lubricant. See **Fig. 4**.
10. Operate the pump and check for leaks. Verify the oil pressure at 25 to 35 psi (172 to 241 kPa) at the oil injection point.
11. Remove the chocks from the front and rear tires.

Fire Pump Gearbox Removal, Disassembly, Assembly, and Installation



1. Fill Plug
2. Sight Glass
3. Power Shift Cylinder
4. Output Shaft Housing
5. Drain Plug

Fig. 4, Fire Pump Gear Box Lubrication and Fluid Change Locations

Replacement

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Drain the water from the pump.

⚠ WARNING

The gearbox assembly is heavy. Support the lower gearbox assembly with a lifting device. Failure to do so could result in the assembly falling, which could result in personal injury or property damage.

3. Remove the gearbox. See **Subject 110** for information.
4. Remove the 5/8–11 x 1-1/4 capscrew and bearing retaining washer from the end of the impeller shaft.
5. Remove the twelve 1/2–13 x 1-3/4 capscrews that attach the rear bearing housing to the pump body.
6. Install two 1/2–13 x 3 jackscrews into the 1/2–13 threaded holes provided in the rear bearing housing. See **Fig. 1**.
7. Use a centerpunch to mark the rear bearing housing, the mechanical seal housing, and the pump body so that the components are properly aligned during assembly.
8. Turn the two jack screws evenly, clockwise, to push the rear bearing housing from the impeller shaft and pump body.

NOTE: To prevent damage to components as the rear bearing housing is pushed from the impeller shaft, place your hands under the gear opening to catch the gear, key, and bearings.

NOTE: It may be necessary to use pry bars to gently assist in removing the inner bearings and gear.

9. Remove the jack bolts.
10. Remove the slinger from the impeller shaft.
11. Remove the four 7/16–14 x 1-1/4 capscrews from the mechanical seal cover. See **Fig. 2**. Use a center punch to mark the seal cover for proper alignment during installation.
12. Use pry bars if necessary in the provided slots to loosen the mechanical seal cover from the impeller shaft and the pump body.
13. Remove the old mechanical seal, being careful not to damage the impeller shaft. Use two small hook-tools positioned about 180 degrees apart to pull the mechanical seal from the seal cavity if necessary.
14. Clean the seal cavity and the impeller shaft.
15. Inspect the retaining ring on the shaft.
16. Remove the burrs at the gear key slot and the bearing lands, and remove the oil seal in the rear bearing housing. See **Fig. 3**.

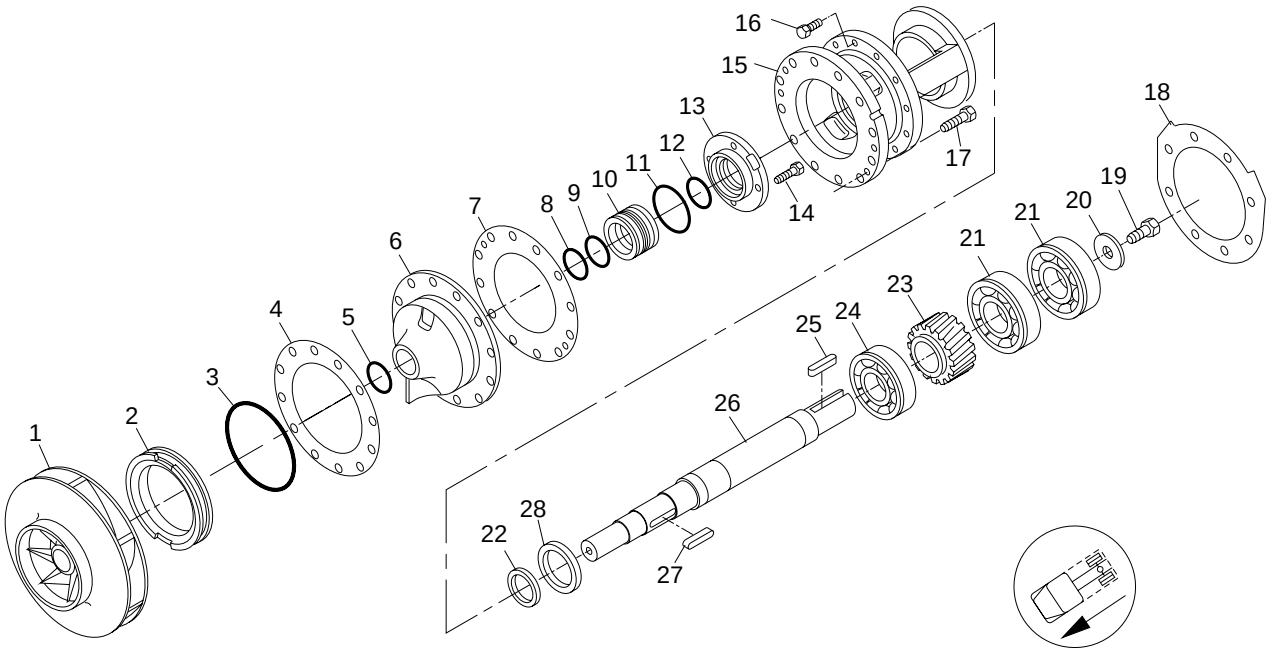
IMPORTANT: Always replace the entire mechanical seal with a new Twinflow mechanical seal assembly.

⚠ CAUTION

When installing a new mechanical seal do not touch the sealing surface of the carbon seal ring or the metal seat while handling or installing. Oil and grease can damage the bellows of the mechanical seal. Use only a soap-and-water solution to lubricate the mechanical seal.

17. Clean the housing and the impeller shaft, and lubricate the impeller shaft and the new mechanical seal with a soap-and-water solution.
18. Install the new mechanical seal bellows over the end of the impeller shaft with the spring oriented toward the impeller. Using a soft pusher tube and keeping your fingers away from the carbon seal, carefully push the mechanical seal assembly into the mechanical seal cavity. If binding occurs, apply more soap-and-water solution to the impeller shaft and the bellows.
19. Install the steel cup and seat it into the mechanical seal cover. Lubricate with a soap-and-water solution.
20. Remove and replace the seal rings in the mechanical seal cover. Apply the soap-and-water solution to the seal rings and then slide over the

Mechanical Seal Replacement



1. Impeller
2. Clearance Ring
3. Rear Bearing Housing Seal
4. Bearing/Seal Housing Gasket (impeller side)
5. Shaft Retaining Ring
6. Mechanical Seal Housing
7. Bearing/Seal Housing Gasket (mechanical seal side)
8. Shaft Seal Ring
9. Shaft Retaining Ring
10. Mechanical Seal And Steel Cup Assembly
11. Mechanical Seal Piston Ring
12. Shaft Seal Ring
13. Mechanical Seal Cover
14. Hexhead Screw, 7/16–14 x 1-1/4
15. Rear Bearing Housing
16. Hexhead Screw, 7/16–14 x 1-1/2
17. Hexhead Screw, 1/2–13 x 1-3/4
18. Rear Bearing Housing Gasket
19. Hexhead Screw, 5/8–11 x 1-1/4
20. Rear Bearing Washer
21. Bearing (aft)
22. Pump Shaft Slinger
23. Pump Shaft Gear
24. Bearing (forward)
25. Pump Shaft Gear Key
26. Pump Shaft
27. Impeller Key
28. Drive Unit Oil Seal

Fig. 1, Impeller Shaft Assembly (exploded view)

end of the impeller shaft. Make sure the mechanical seal remains seated in the bore of the cover.

21. Insert the mechanical seal cover into the mechanical seal cavity aligning it with the bolt holes and the orientation marks.
22. Insert the bolts in the mechanical seal housing to prevent the housing from rotating.
23. Install the four 7/16–14 x 1-1/4 capscrews. Tighten 53 lbf·ft (72 N·m).
24. Install the new slinger onto the impeller shaft. Then remove the retaining bolts.
25. Install the new gasket and oil seal in the rear bearing housing. Slide the housing and front bearing onto the rear impeller shaft. The bearing is a press-fit onto the impeller shaft and slip-fit in the housing.

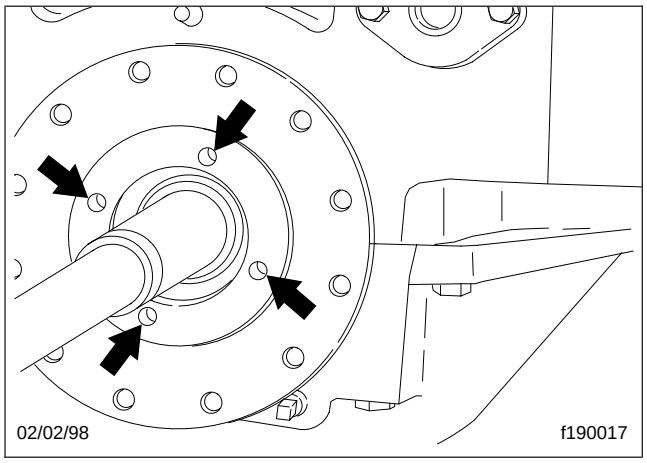
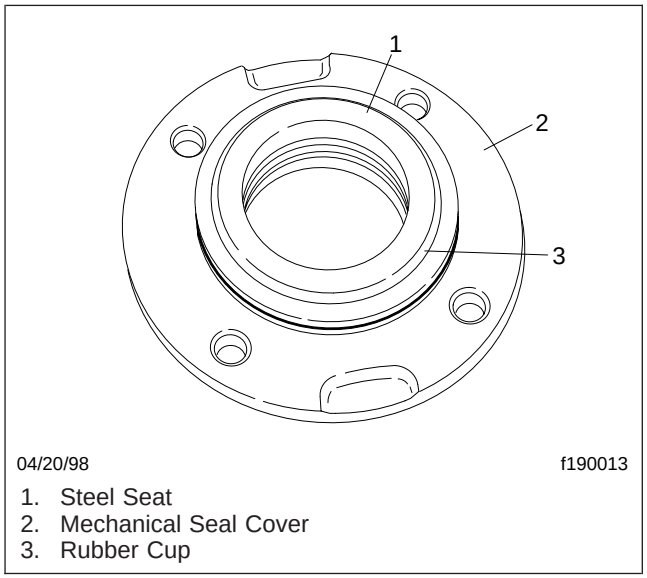


Fig. 2, Remove Four Capscrews



1. Steel Seat
2. Mechanical Seal Cover
3. Rubber Cup

Fig. 3, Mechanical Seal Assembly

IMPORTANT: Do not allow the weight of the rear bearing housing to rest on the oil seal.

26. Insert the gear through the opening in the housing and align it with the impeller shaft. Slide the housing, front bearing and gear onto the shaft. The front bearing will stop when the inner race contacts the seat on the impeller shaft.
27. Line up the keyway in the gear and install the key into the keyway.
28. Slide one of the two rear bearings onto the impeller shaft and into the housing. The rear bearings are a press-fit onto the shaft and a slip-fit in the housing.
29. Using a series of different length capscrews, install the rear bearing housing to the pump body. When it is possible, install the four capscrews (approximately 90 degrees apart). These bolts, in combination with the rear bearing, will center the housing. Double check to be sure the housing is centered and will clear the mechanical seal assembly.
30. Install the pusher bolt in the rear of the impeller shaft. Tighten the nut on the pusher bolt while holding the pusher bolt, pushing the rear bearing into the housing. Remove the pusher bolt and install the second of the two rear bearings. Then install the pusher bolt and tighten the nut while holding the pusher bolt to install the bearing.
31. Continue to tighten the nut on the pusher bolt while making sure the housing is aligned and centered. Once the pusher bolt is snug, the rear housing assembly, the gear, and the bearings should be in place. Remove the pusher bolt and rotate the impeller assembly by placing a large screwdriver between the housing and the gear. The impeller assembly should rotate.

NOTE: A new impeller will have some resistance when the impeller shaft is rotated.

32. Apply Loctite® 242 to the 5/8–11 x 1-1/4 bearing retainer capscrew. Install and tighten 80 lbf·ft (108 N·m).
33. Apply Loctite® 242 to the twelve 1/2–13 x 1-3/4 capscrews, install and tighten 80 lbf·ft (108 N·m).
34. Install the gearbox. See **Subject 110** for information.
35. Perform the annual service test on the pump. Check for leaks. Verify the oil pressure at 25 to 35 psi (172 to 241 kPa) at the oil injection point.
36. Remove the chocks from the front and rear tires.

Removal

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Drain the water from the pump.

⚠ WARNING

The gearbox assembly is heavy. Support the lower gearbox assembly with a lifting device. Failure to do so could result in the assembly falling, which could result in personal injury or property damage.

3. Remove the gearbox. See **Subject 110** for information.

⚠ WARNING

The lower pump body is heavy. Support the lower pump body and impeller assembly with a lifting device. Failure to do so could result in the lower pump body and impeller assembly falling, which could result in personal injury or property damage.

4. Remove the drain lines from the lower pump body. See **Fig. 1**.
5. Drain the oil from the AutoLube and remove the 1/2–13 x 2 capscrews from the upper half of the AutoLube and pump body.
6. Remove the 7/16–14 x 1-1/2 capscrews from the upper half of the rear bearing housing and pump body.
7. Remove the 1/2–13 x 1-1/4 capscrews from the lower pump body.

⚠ WARNING

Do not remove the four capscrews, one in each corner of the lower pump body, until the lifting device is in position. Failure to do so could result in the lower pump body and impeller assembly falling, which could result in personal injury or property damage.

8. Position the lifting device into place with the lower pump body lifting adapter between the lifting device and the lower pump body.
9. Remove the 5/8–11 x 5 capscrews in each corner of the lower pump body.
10. Lower the lower pump body and impeller assembly. Be sure to balance the assembly so that it does not tip from the lifting device.
11. Remove the remaining capscrews from the lower half of the AutoLube, the rear bearing housing, and the lower pump body.

⚠ WARNING

The impeller assembly is heavy. Do not attempt to lift the assembly without the aid of another person or persons, or a lifting device. Failure to do so could result in the impeller assembly falling, which could result in personal injury or property damage.

12. Remove the remaining screws from the rear bearing housing and then from the lower pump body.
13. Lift the impeller assembly from the lower pump housing. See **Fig. 2**. Set the assembly aside.
14. Clean all gasket surfaces of the upper and lower pump bodies, as well as those on the AutoLube and the rear bearing housing face.
15. Clean the clearance ring and clearance ring seats in both the upper and lower pump body halves to remove all the buildup material so that the new clearance ring will seat properly.

NOTE: Pitting of the clearance rings may occur from the buildup material and the effects of corrosion. Once the seats are cleaned, any pitting on the clearance rings is considered normal.

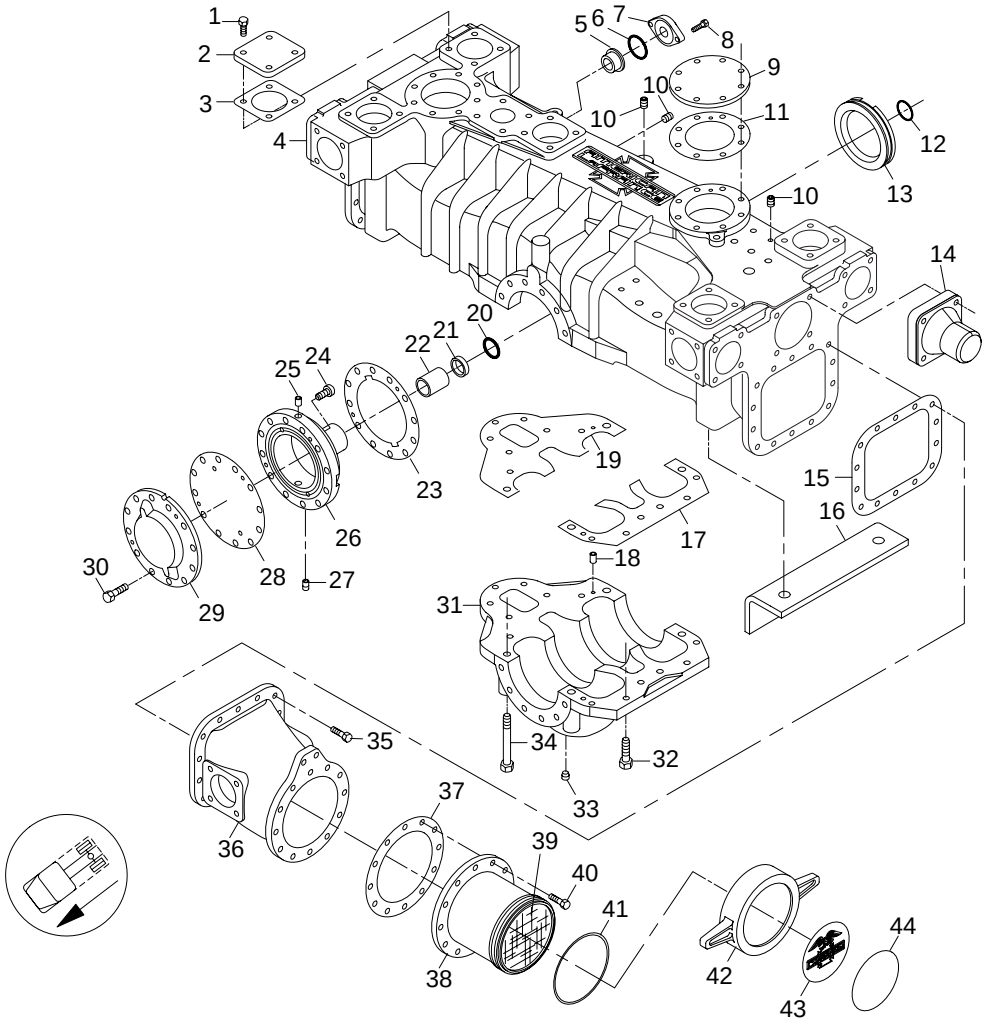
Installation

1. Install the pump body gaskets to the lower pump body, trimming as necessary to fit.

⚠ CAUTION

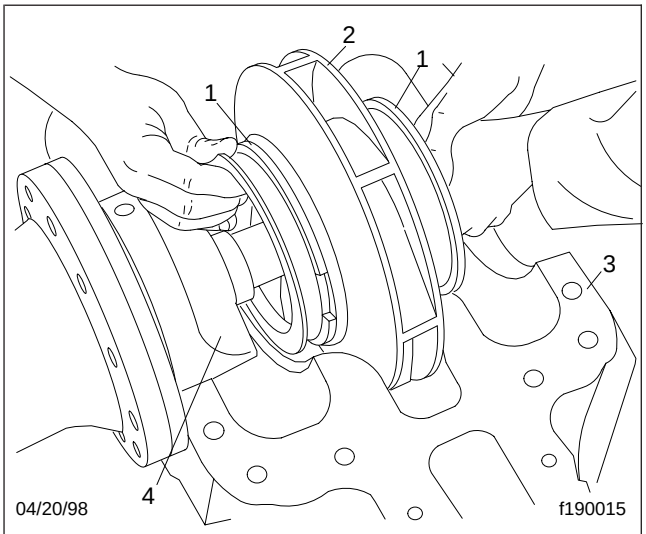
Failure to line up the clearance ring lock notches with the pump body tabs (as described in the next step) may result in pinched clearance rings, which could result in pump damage and pump failure.

Impeller Assembly Removal and Installation



1. Hexhead Screw, 7/16–14 x 1-1/4
2. Blank Flange
3. Flange Gasket
4. Upper Pump Body
5. Priming Valve Strainer
6. Priming Valve Plate Seal Ring
7. Priming Valve Plate
8. Hexhead Screw, 7/16–14 x 1-1/4
9. Tank Connection Flange
10. Plug, 1/4-inch
11. Tank Connection Gasket
12. Impeller Retaining Ring
13. Clearance Ring
14. QD Relief Valve Assembly
15. Suction Tube Extension Gasket
16. Pump Mounting Bracket
17. Pump Body Gasket (left side)
18. Dowel Pin
19. Pump Body Gasket (right side)
20. Oil Seal Retaining Ring
21. Front Bearing Housing Oil Seal
22. Front Bearing
23. Bearing/Seal Housing Gasket
24. Allen-head Screw, 3/8–16 x 3/4
25. Brass Socket Plug, 1/4-inch
26. Front Bearing Housing Assembly
27. Brass Socket Plug, 1/4-inch
28. Front Bearing Diaphragm
29. Front Bearing Cover
30. Hexhead Screw, 1/2–13 x 2
31. Lower Pump Body
32. Hexhead Screw, 1/2–13 x 1-3/4
33. Plug, 1/2-inch
34. Hexhead Screw, 5/8–11 x 5
35. Hexhead Screw, 1/2–13 x 1-1/4
36. Suction Tube Extension
37. Suction Tube Round Gasket
38. Suction Tube, 6-inch
39. Suction Strainer, 6-inch
40. Hexhead Screw, 7/16–14 x 1-1/4
41. Suction Cap Washer
42. Suction Cap
43. Medallion
44. Medallion O-Ring

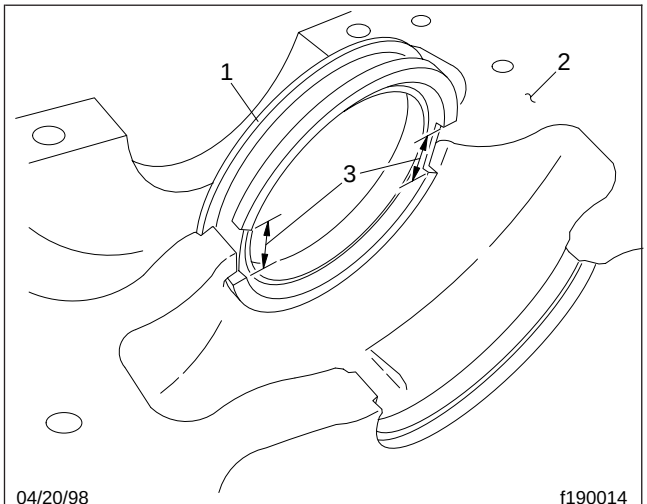
Fig. 1, Fire Pump Body Assembly (exploded view)



1. Clearance Ring
2. Impeller
3. Lower Pump Housing
4. Cut Water

Fig. 2, Lifting the Impeller Assembly from the Lower Pump Housing

2. Install the impeller assembly into the lower pump housing carefully aligning the clearance ring lock-notch with the clearance ring lock tabs in the lower pump body. Then rotate the clearance rings to one side to open up lock notches to line up with the lock tabs in the upper pump body. See **Fig. 3**.
3. Install the 1/2–13 x 1-3/4 capscrews through the rear bearing housing and the mechanical seal housing. Do not tighten.
4. Make sure the dowel pins are in the upper pump body to assist in aligning the lower pump body with the upper pump body.
5. Using a lifting device, slowly raise the lower pump body and the impeller assembly into place, making sure that the lower pump body aligns with the dowel pins and the clearance ring notches align with the clearance ring lock tabs in the upper pump body.
6. Rotate the impeller and check for freedom of movement when the lower pump body and the impeller assembly is in place.



1. Clearance Ring
2. Lower Pump Housing
3. Clearance Ring Notch

Fig. 3, Clearance Ring Mounted in Pump Housing

7. Apply Loctite® 242 and install the four 5/8–11 x 5 capscrews (one at each corner of the lower pump body). Tighten snug but do not fully torque.
8. Install the 1/2–13 x 1-3/4 screws in the rear bearing housing and mechanical seal housing. Tighten 53 lbf·ft (72 N·m).
9. Remove the lifting device.
10. Apply Loctite® 242 to the 1/2–13 x 1-3/4 lower pump body capscrews and install them. Tighten snug but do not torque.
11. Torque the 5/8–11 x 5 capscrews 150 lbf·ft (203 N·m) then, starting from the center and moving outward, tighten the lower pump body capscrews 65 lbf·ft (88 N·m).
12. Install the AutoLube. See **Subject 100** for instructions.
13. Install the gearbox. See **Subject 110** for instructions.
14. Operate the pump and check for leaks. Verify the oil pressure at 25 to 35 psi (172 to 241 kPa) at the oil injection point.
15. Remove the chocks.

Single-Stage Pump

Disassembly

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Remove the AutoLube. See **Subject 100** for instructions.
3. Remove the fire pump gear box. See **Subject 110** for instructions.
4. Remove the impeller assembly. See **Subject 130** for instructions and see **Fig. 1** for an exploded view of the assembly.
5. Place the impeller shaft on a work bench.
6. Note the orientation of the impeller vanes.
7. Remove the outer retaining ring.

WARNING

Wear protective, heat-resistant gloves while heating the impeller to remove it from the impeller shaft. Heated metal can cause injury to your hands.

CAUTION

Do not overheat the impeller. The impeller is constructed of bronze. If the impeller is overheated and turns red or blue during removal from the shaft, it has been weakened and must be replaced.

8. Using an acetylene torch, carefully heat the "eye" of the impeller for approximately two minutes.
9. When heated properly, the impeller will slide free of the shaft. If the impeller moves but does not slide free, do not immediately reheat. Allow the complete assembly to cool to room temperature then reheat and remove the impeller.
10. Allow the components to cool to room temperature.
11. Remove the inner clearance ring.
12. Remove the key.
13. Remove the inner retaining ring and slide the mechanical seal housing from the impeller shaft

Assembly

1. Clean the impeller shaft, the keyway, and the mechanical seal housing and face.
2. Check the waterway in the mechanical seal housing for restrictions.
3. Install the mechanical seal housing onto the impeller shaft.
4. Install the inner retaining ring.
5. Install the new gasket on the mechanical seal housing face.
6. Install the key into the keyway.

CAUTION

If the impeller or clearance rings are dropped, damaged, or deformed, they will need to be replaced.

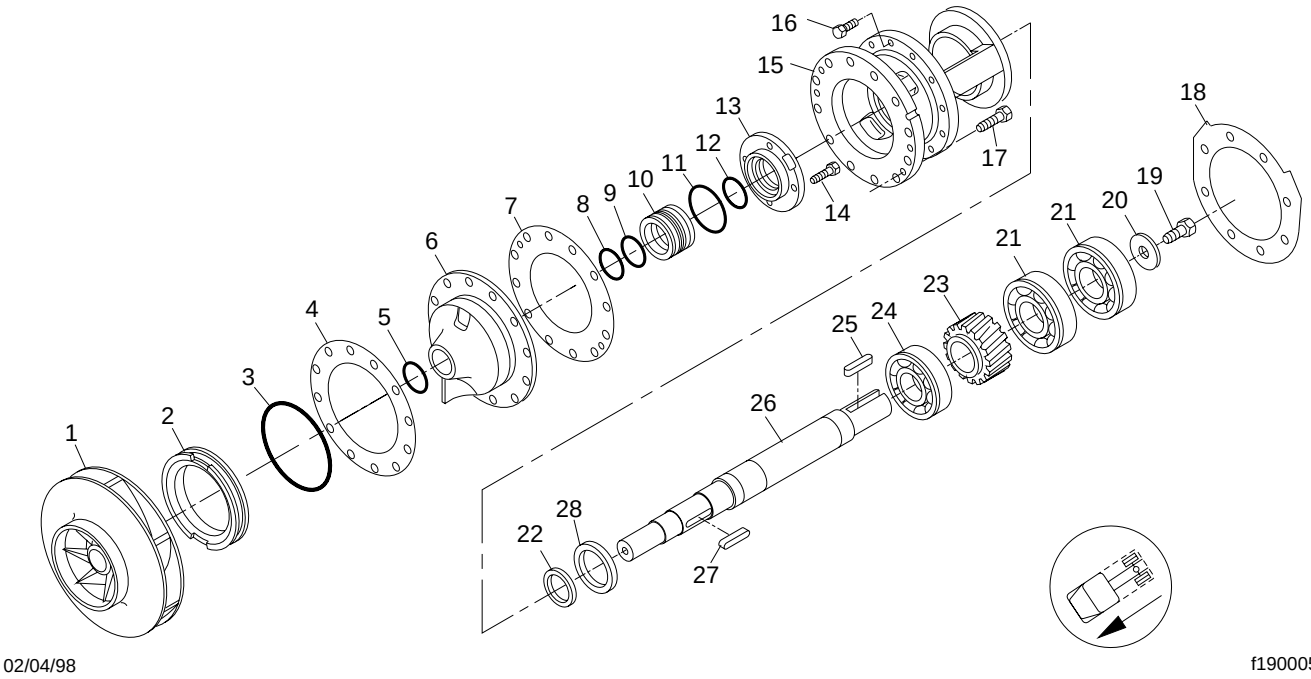
7. Install the inner clearance ring.

WARNING

Wear protective, heat-resistant gloves while heating the impeller to install it onto the impeller shaft. Heated metal can cause injury to your hands.

8. Using the torch, heat the "eye" of the new impeller for approximately two minutes. Then slide the impeller onto the shaft with vanes in proper orientation. If the impeller does not fully slide onto the shaft allow the assembly to cool to room temperature before reheating.
9. Install the outer retaining ring.
10. Install the impeller assembly. See **Subject 130** for instructions.
11. Install the outer clearance ring.
12. Install the impeller shaft assembly.
13. Install the fire pump gear box. See **Subject 110** for instructions.
14. Install the AutoLube. See **Subject 100** for instructions.
15. Remove the chocks from the front and rear tires.

Impeller Shaft Disassembly and Assembly



1. Impeller
2. Clearance Ring
3. Rear Bearing Housing Seal
4. Bearing/Seal Housing Gasket (impeller side)
5. Shaft Retaining Ring
6. Mechanical Seal Housing
7. Bearing/Seal Housing Gasket (mechanical seal side)
8. Shaft Seal Ring
9. Shaft Retaining Ring
10. Mechanical Seal And Steel Cup Assembly
11. Mechanical Seal Piston Ring
12. Shaft Seal Ring
13. Mechanical Seal Cover
14. Hexhead Screw, 7/16–14 x 1-1/4
15. Rear Bearing Housing
16. Hexhead Screw, 7/16–14 x 1-1/2
17. Hexhead Screw, 1/2–13 x 1-3/4
18. Rear Bearing Housing Gasket
19. Hexhead Screw, 5/8–11 x 1-1/4
20. Rear Bearing Washer
21. Bearing (aft)
22. Pump Shaft Slinger
23. Pump Shaft Gear
24. Bearing (forward)
25. Pump Shaft Gear Key
26. Pump Shaft
27. Impeller Key
28. Drive Unit Oil Seal

Fig. 1, Impeller Shaft Assembly (exploded view)

Two-Stage Pump

Disassembly

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.
2. Remove the AutoLube. See **Subject 100** for instructions.
3. Remove the fire pump gear box. See **Subject 110** for instructions.
4. Remove the impeller assembly. See **Subject 130** for instructions.
5. Place the impeller shaft assembly on a work bench.
6. Note the position of the impeller vanes.

7. Remove the inner and the outer retaining rings and then remove the mechanical seal housing.

WARNING

Wear protective, heat-resistant gloves while heating an impeller to remove it from the impeller shaft. Heated metal can cause injury to your hands.

CAUTION

Do not overheat the impeller. An impeller is constructed of bronze. If the impeller is overheated and turns red or blue during removal from the shaft, it has been weakened and must be replaced.

8. With an acetylene torch, carefully heat the "eye" of the impellers for approximately two minutes.

IMPORTANT: Mark the impellers as to whether they are the primary or secondary impeller in relation to the AutoLube. Improper or backward installation of the impellers affects pump performance.

9. When heated properly, an impeller will slide free of the shaft. If the impeller moves but fails to slide free, do not immediately reheat. Allow the complete assembly to cool to room temperature then reheat and remove the impellers. Heat the secondary impeller and remove. Then rotate the impeller shaft assembly end for end and heat and remove the primary impeller.
10. Remove the center support bearing.
11. Remove mechanical seal housing and then the inner clearance ring.
12. Remove the key.
13. Remove the inner retaining ring and slide the mechanical seal housing from the impeller shaft.

Assembly

1. Clean the impeller shaft, the keyway, and the mechanical seal housing and face.
2. Check the waterway in the mechanical seal housing for restrictions.
3. Install the new gasket on the mechanical seal housing face.
4. Install the key into the keyway.

CAUTION

If the impellers or the clearance rings are dropped, damaged, or deformed, they require replacement.

5. Install the inner clearance ring.

WARNING

Wear protective, heat-resistant gloves while heating the impeller to install it onto the impeller shaft. Heated metal can cause injury to your hands.

6. Using the torch, heat the "eye" of each impeller for approximately two minutes. Then slide the individual impellers onto the shaft. If an impeller does not fully slide onto the shaft allow the assembly to cool to room temperature before reheating.
7. Install the outer retaining ring.
8. Install the outer clearance ring.
9. Install the impeller assembly. See **Subject 130** for instructions.
10. Install the mechanical seal housing onto the impeller shaft.
11. Install the impeller shaft assembly.
12. Install the fire pump gear box. See **Subject 110** for instructions.
13. Install the AutoLube. See **Subject 100** for instructions.
14. Remove the chocks from the front and rear tires.

Valve Removal, Disassembly, Assembly and Installation

Pilot Valve

Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front and rear tires.

1. Drain the fire pump.
2. Rotate the adjustment handwheel counterclockwise to remove the spring tension.
3. Remove the capscrew and nut attaching the adjustment handwheel to the adjustment shaft. Then remove the handwheel.

CAUTION

Identify and mark the line connections on the control body before removing. Improper connection of lines may result in the failure of the pilot valve, which could cause damage to the fire pump.

4. Remove the pump discharge pressure line and the relief valve line from the control body of the pilot valve.
5. While holding the pilot valve, remove the four 1/4–20 x 5/8 machine screws attaching the valve and cover plate to the Pump Operator's Panel, and separate the valve, plate, and the relief valve setting indicator (if equipped with PMD) from the panel.
6. Disassemble the pilot valve.
   - 6.1 Remove the four 5/16–18 x 1 allen-head capscrews securing the control body to the rear of the spring housing. Then remove the control body.

CAUTION

Do not use pliers to unscrew the control valve from the diaphragm clamp. Damage to the control valve will render the pilot valve inoperative.

   - 6.2 Unscrew the control valve from the diaphragm clamp. Remove the diaphragm washer and the diaphragm.
   - 6.3 Remove the retaining ring, the seal, and the bearing.

WARNING

Use a spring compressor to remove the pilot valve spring. The spring is under compression and could become uncompressed, which could result in personal injury.

   - 6.4 Turn the adjustment handwheel clockwise to unscrew the adjustment shaft from the adjustment nut. From the handwheel end, remove the adjustment shaft from the spring housing.
   - 6.5 Remove both springs, the adjustment nut, and diaphragm clamp as an assembly from the spring housing and then separate.
7. Clean all the pilot valve components. Inspect and lubricate with grease the threads on the adjustment shaft.
8. Assemble the pilot valve.

WARNING

Use a spring compressor to install the pilot valve spring. The spring is under compression and could become uncompressed, which could result in personal injury.

CAUTION

Always remove the pilot valve discharge pressure inlet screen, which is located in the top of the discharge side of the pump. Clean or replace as necessary. Failure to do so could render the pilot valve inoperative.

   - 8.1 Combine both springs, the adjustment nut and the diaphragm clamp as an assembly and install into the spring housing. Align the guide pin-in adjustment nut with the slot in the spring housing and the indicator plate on the PMD.
   - 8.2 Slide the adjustment shaft into the spring housing from the handwheel end. Turn the adjustment handwheel counterclockwise in order to screw the adjustment shaft into the adjustment nut until it bottoms in the diaphragm clamp. Do not put the springs under tension.

Valve Removal, Disassembly, Assembly and Installation

8.3 Lubricate the new bearing and slide the new bearing and bearing washer over the adjustment shaft into the spring body housing. Install the retaining ring. Then install the new seal washer and rotate the adjustment shaft in both directions to check for freedom of movement.

8.4 Install the new diaphragm washer and diaphragm. Screw the control valve into the diaphragm clamp.

8.5 Install the control body. Apply Loctite® 242 to the four 5/16–18 x 1 allen-head capscrews attaching the control body to the rear of the spring housing.

9. Holding the pilot valve, align the cover plate and install the four 1/4–20 x 5/8 machine screws attaching the pilot valve and cover plate to the Pump Operator's Panel.
10. Install the pump discharge pressure line and relief valve line to the control body of the pilot valve.
11. Slide the adjustment handwheel onto the adjustment shaft and then install the retaining capscrew and nut.
12. Fill the pump and test the valve for proper operation and leaks.

Transfer Valve

See **Fig. 1** for an exploded view of the transfer valve.

1. Drain the fire pump.

IMPORTANT: The transfer valve is a timed device. It is therefore important during disassembly to note the location of the transfer bracket locating pin, the transfer drum stop pin, the transfer drum sleeve locating pin, and the transfer drum stem key. It is not necessary to remove the transfer bracket locating pin, the transfer drum sleeve locating pin, or the transfer drum stop pin during disassembly.

2. Turn the adjustment handwheel clockwise until it stops. The transfer indicator should be at the top of the slotted guide in the cover plate.
3. Remove the two allen-head set screws from the transfer indicator guide. Slide the transfer indicator guide (on an adjustment stem) towards the transfer valve.
4. Remove the stem drive gear lock pin. Slide the adjustment stem from the stem drive, the support, and the transfer indicator guide, being careful not to drop or damage the transfer indicator guide and transfer indicator.
5. Remove the four 7/16–14 x 1-1/4 capscrews retaining the transfer bracket assembly to the pump body. Carefully remove the transfer bracket and the transfer valve drum.
6. Disassemble the valve.

   6.1 Remove the locating pin that secures the countershaft in place.

   6.2 Remove the countershaft from the countershaft gear.

   6.3 Remove the countershaft gear and the countershaft gear spring from the transfer bracket assembly.

   6.4 Remove the allen-head set screw from the transfer drum gear. Slide the transfer drum gear from the drum stem. Remove the woodruff key from the transfer drum stem.

   6.5 Separate the transfer bracket from the transfer drum by sliding it from the transfer drum stem.

   6.6 Slide the transfer drum from the transfer sleeve.

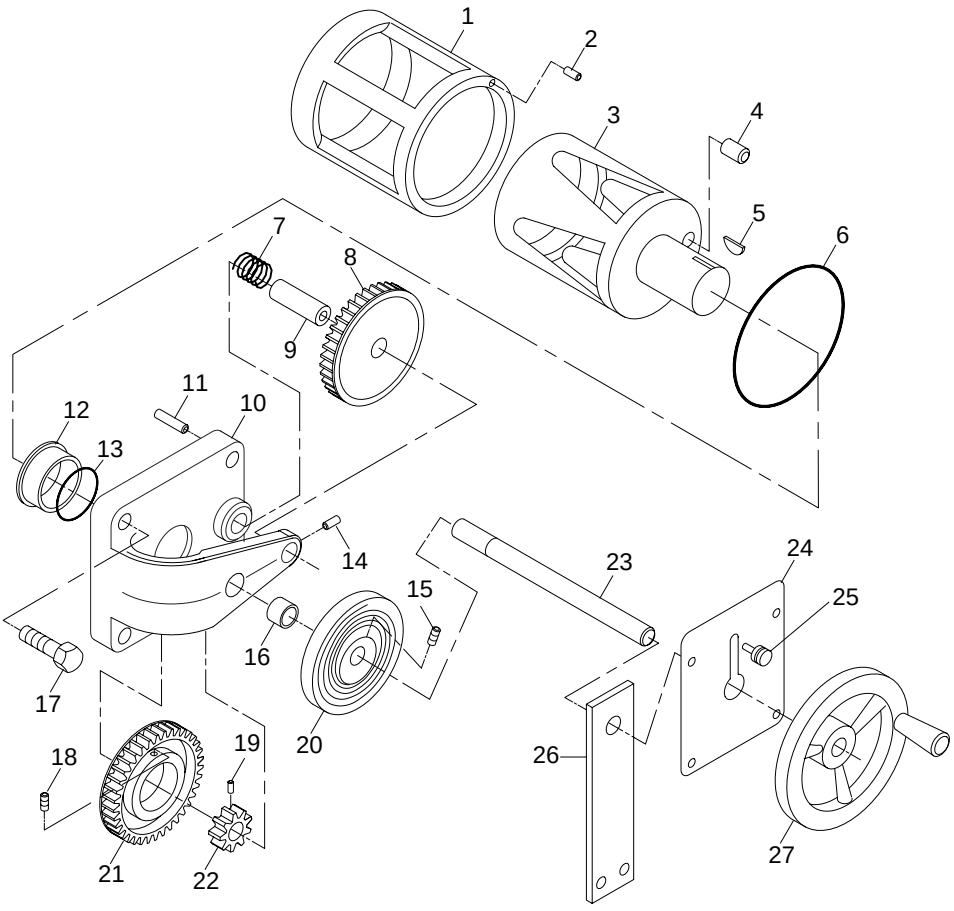
7. Assemble the valve.

   7.1 Clean and inspect all sealing surfaces, the mating surfaces of the transfer valve drum and sleeve. Clean and inspect the transfer bracket bushings and bushing surface on the transfer valve stem and the transfer valve adjustment stem.

   7.2 Install new O-ring seals on the transfer valve drum stem and the transfer valve bracket.

   7.3 Slide the transfer drum into the transfer bracket, being careful not to damage the bearing surfaces. Then rotate the transfer drum until the drum stop pin is in the correct position.

Valve Removal, Disassembly, Assembly and Installation



01/30/98 f190010

1. Transfer Drum Sleeve
2. Locating Pin
3. Transfer Drum
4. Transfer Drum Stop Pin
5. Gear Key
6. Transfer Bracket Seal Ring
7. Countershaft Gear Spring
8. Transfer Valve Countershaft Gear
9. Transfer Countershaft
10. Transfer Bracket (with bearings) Assembly
11. Bracket Locating Pin
12. Drum Bracket Bearing
13. Transfer Drum Seal Ring
14. Locating Pin
15. Sockethead Setscrew, 1/4–20 x 3/8
16. Transfer Valve Stem Drive Gear
17. Hexhead Screw, 7/16–14 x 1-1/4
18. Sockethead Setscrew, #10–32 x 1/2
19. Gear Lock Pin
20. Transfer Indicator Guide
21. Transfer Valve Transfer Drum Gear
22. Transfer Stem Drive Gear
23. Transfer Stem
24. Instruction Plate
25. Transfer Indicator
26. Support Stem
27. Adjusting Wheel Assembly

Fig. 1, Transfer Valve

7.4 Install the woodruff key into the transfer drum stem. Install the transfer drum gear onto the transfer drum stem. Apply Loctite® 242 to the allen-head set screw and install the transfer drum gear.

7.5 Assemble the countershaft gear spring in the countershaft gear and position the assembly into place in the transfer bracket. Then install the countershaft and

Valve Removal, Disassembly, Assembly and Installation

the countershaft locating pin to lock the countershaft in place.

8. Install the transfer valve.
   - 8.1 Align the transfer drum stop pin, the transfer bracket locating pin, and the transfer drum sleeve locating pin into proper position.
   - 8.2 Install the transfer valve drum and bracket assembly into the pump body.
   - 8.3 Apply Loctite® 242 to the four 7/16–14 x 1-1/4 transfer bracket capscrews and install and tighten 53 lbf·ft (72 N·m).
   - 8.4 Slide the adjustment stem through the cover plate, the transfer indicator guide, and the support and transfer bracket.
   - 8.5 Insert the stem drive gear into place in the transfer bracket and then slide the adjustment stem through the stem drive gear.
   - 8.6 Insert the stem drive gear lock pin into place, locking the stem drive gear onto the adjustment stem.
   - 8.7 Apply Loctite® 242 to the transfer indicator guide set screws and install. Do not tighten.
   - 8.8 Turn the adjustment handwheel counterclockwise until it stops. Make sure the transfer indicator is at the top of the slotted guide toward the transfer indicator, making certain that the transfer indicator engages the transfer indicator guide in the top groove. Then tighten the inside set screw in the transfer guide indicator.
   - 8.9 Rotate the adjustment handwheel from stop to stop. The transfer indicator should move freely from the top to the bottom of the slotted guide in the cover plate.
   - 8.10 Tighten the outside set screw in the transfer indicator guide, and recheck the movement of the transfer indicator.
9. Fill the pump and test the valve for proper operation and leaks.

Back Flow Valve

1. Drain the water tank and the pump.
2. Disconnect the control linkage at the Tank-to-Pump valve.
3. Disconnect both ends of the flexible hose connecting the water tank to the tank-to-pump valve. Then slide the flexible hose toward the water tank outlet or the tank-to-pump valve plumbing.

NOTE: If the tank-to-pump valve is air-operated, drain the vehicle's air system and disconnect the supply and the return line on the valve actuator, but do not remove the actuator from the valve. Also, the tank-to-pump valve may be connected to the pump body by capscrews or studs with nuts. If studs are used, it may be necessary to remove some or all of the studs to remove the valve. If so, remove only the studs necessary to remove the valve as any studs left will assist in realigning the valve during installation.

4. Remove the eight 7/16–14 x 1-1/2 capscrews retaining the tank-to-pump valve to the pump body.
5. Remove the tank-to-pump valve and associated plumbing.

NOTE: The back flow valve is a flat butterfly plate with two pivots attached at the top. These pivots fit into two open pivot sockets in the pump body. When the gasket is removed, the back flow valve may fall out.

6. Remove the old gasket from the pump body.
7. Remove the back flow valve.
8. To install the back flow valve, first clean all of the gasket surfaces on the pump body and the tank-to-pump flange.
9. Install the back flow valve. Using two fingers, hold the pivots in the pivot sockets and check the valve for freedom of movement.
10. Install a new gasket.
11. Apply Loctite® 242 to the eight 7/16–14 x 1-1/2 capscrews and attach the tank-to-pump valve to the pump body. Tighten 53 lbf·ft (72 N·m).

12. Slide the flexible connection hose so it is evenly spaced and secured on the water tank outlet and the tank-to-pump valve plumbing.
13. Attach the tank-to-pump valve controls and linkage.
14. Fill the pump and test the valve for proper operation and leaks.

Sensing Valve

1. Disconnect the following lines at the sensing valve:
    - pilot valve discharge line
    - QG relief valve line
    - PG relief valve line
    - sensing valve pump suction line
    - drain lines
2. Remove the 7/16–14 x 2 sensing valve mounting capscrew.
3. Remove the four 5/16–18 x 1 capscrews attaching the control body to the rear of the spring housing. Remove the control body, being careful not to lose the sensing valve spring.
4. Remove the control valve from the sensing valve body.
5. Unscrew the sensing valve from the diaphragm, being careful not to damage the control valve. Remove the diaphragm.
6. Before installing the sensing valve, clean all components.

⚠ CAUTION

Always remove the sensing valve suction inlet screen. Clean or replace as necessary. The screen is located in the suction side of the pump. Failure to do so may render components inoperative.

7. Install a new diaphragm on the diaphragm clamp. Apply Loctite® to the threads on the control valve and install the control valve into the sensing valve body.
8. Install the sensing valve spring into the valve body cover.
9. Apply Loctite® 242 to the four 5/16–18 x 1 capscrews and attach the control body to the rear of the spring housing. Make sure that the sensing valve spring properly aligns with the diaphragm clamp.
10. Make sure the up arrow is aligned properly.
11. Apply Loctite® 242 to the 7/16–14 x 2 sensing valve mounting capscrew. Tighten 40 lbf·ft (54 N·m).
12. Connect all lines.
13. Fill the pump and test the valve for proper operation and leaks.

TPM Relief Valve

1. Disconnect the line to the sensing valve and drain the fire pump. Make note of the wire connections.
2. Disconnect the indicator light switch.
3. Remove the four 7/16–14 x 1-1/4 capscrews attaching the relief valve assembly to the pump body.
4. Using a twisting motion, remove the relief valve assembly.
5. To disassemble the valve, remove the indicator light switch and remove the cover retaining ring and slide the cover out of the relief valve body.
6. Apply a small amount of pressure to the relief valve piston and remove the piston retaining ring. Carefully release the pressure held to the piston by the spring.
7. Remove the relief valve from the opposite end, sliding the relief valve stem out of the piston.
8. Reach through the center hole of the piston and pull the piston out of the indicator switch end of the relief valve body. Then remove the piston spring.
9. To assemble and install the valve, first clean and inspect all components.
10. Clean all sealing surfaces and install new O-rings seals.
11. Install the relief valve into the relief valve body.

Valve Removal, Disassembly, Assembly and Installation

12. Install the piston spring by sliding the piston into the relief valve body while at the same time sliding the piston onto the relief valve system.
13. Apply light pressure to the piston to compress the piston spring and install the piston retaining ring.
14. Slide the cover into the relief valve body. Then install the cover retaining ring.
15. Using a powered test light, screw the indicator light switch in until the light goes out. Then turn an additional 3/4 to 1-1/4 turn. Apply Loctite® to the jamnut and tighten.
16. Slide the relief valve assembly into the pump body with the side marked "top" up, being careful not to damage the O-rings.
17. Apply Loctite® 242 to the four 7/16–14 x 1-1/4 capscrews and install the assembly in the pump body. Tighten 53 lbf·ft (72 N·m).
18. Connect the indicator light switch.
19. Fill the pump and test the valve for proper operation and leaks.

QD Relief Valve

See **Fig. 2** for an exploded view of the QD relief valve.

1. Drain the pump.
2. Note the location of the wires and disconnect the indicator light switch.
3. Disconnect the relief valve supply line from the pilot valve and drain the line.
4. Remove the two 7/16–14 x 1-1/4 capscrews attaching the relief valve indicator light switch and the mounting bracket assembly to the relief valve cover. Remove the light switch and the bracket.
5. Compress the relief valve return spring by hand and remove the E-clip and washer. Then remove the return spring.
6. Remove the two remaining 7/16–14 x 1-1/4 capscrews retaining the relief valve cover to the pump body. Using a twisting motion, carefully remove the relief valve cover.

⚠ CAUTION

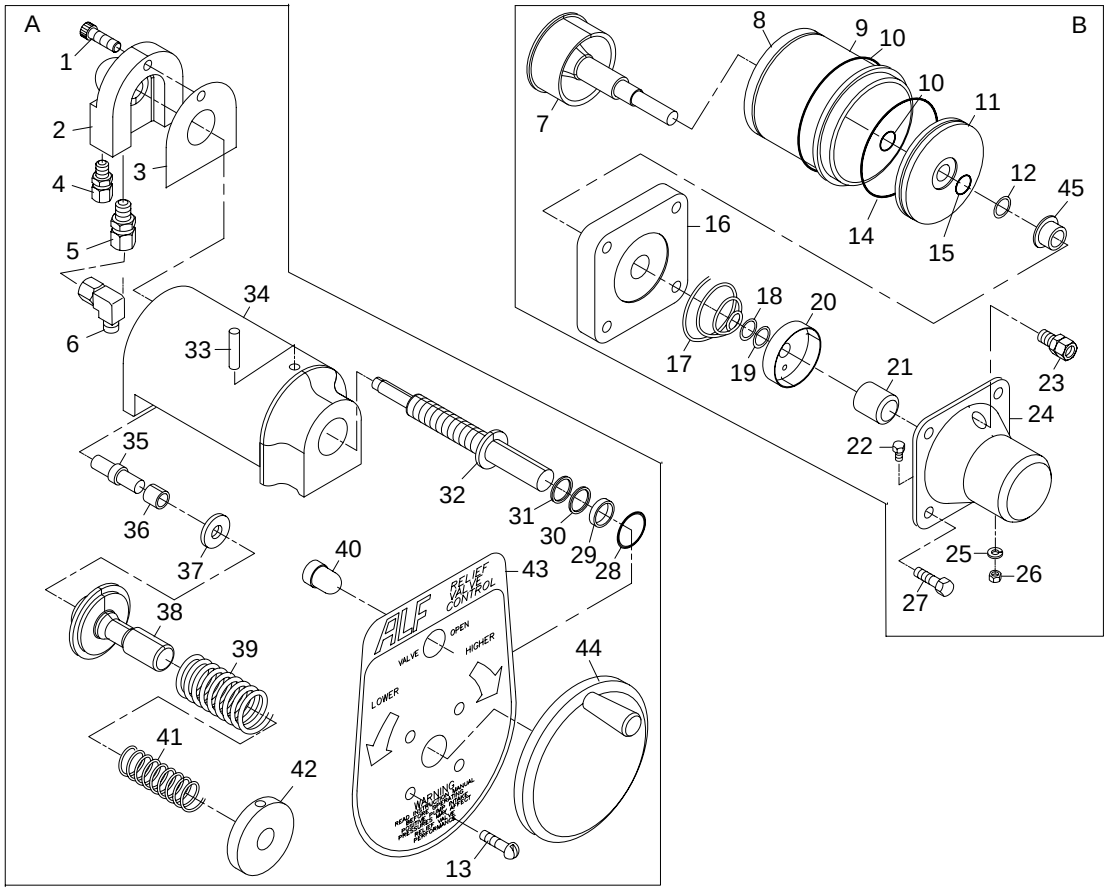
Do not push the relief valve too far into the pump body as it may fall into the pump body and become lodged or damaged. The relief valve is made of brass and is easily damaged by prying or hammering. Damaged valves must be replaced.

7. Remove the retaining ring securing the relief valve piston to the relief valve. Gently push the relief valve into the pump body approximately 1 inch (25 mm) and then pull it back out in a snap-motion. This should pop the relief valve piston out of the relief valve body. Repeat if necessary.

NOTE: It is not necessary to remove the relief valve unless it is damaged. To remove the relief valve, the relief valve body will have to be removed and the complete relief valve assembly will need to be replaced as it will be necessary to pry the relief valve body from the pump body, which will likely damage it.

8. Clean and inspect all of the relief valve assembly components.
9. Clean all sealing surfaces and install new O-rings and Quad-ring seals.
10. Install the relief valve piston in the stem of the relief valve. Do not push the relief valve into the pump body. As it is necessary to start the piston onto the relief valve stem, push the piston until you can grasp the relief valve stem. Then pull the relief valve stem outward while pushing on the relief valve piston. Once the relief valve piston is seated against the shoulder of the relief valve stem, install the retaining ring.
11. Operate the relief valve by hand to check for freedom of movement.
12. Slide the relief valve cover gasket and cover over the top of the relief valve stem to align the relief valve supply line from the pilot valve in the original position. Then apply Loctite® 242 to two 7/16–14 x 1-1/4 capscrews and install opposite of each other. Tighten, but do not torque.
13. Compress and install the return spring and secure it with a washer and E-clip.
14. Align the indicator light switch mounting bracket and switch with the two empty holes in the relief

Valve Removal, Disassembly, Assembly and Installation



07/22/98 f190007

A. PM Relief Valve Control Assembly
B. QD Relief Valve System Assembly

1. Sockethead Screw, 5/16–18 x 1
2. Control Body Assembly
3. PM Control Valve Diaphragm
4. Connector Tube, 1/8–3/4
5. Connector Tube, 1/4–3/8
6. Connector Strainer
7. Relief Valve
8. Valve Body Seal Ring
9. Relief Valve Body
10. Piston Seal Ring
11. Transfer/Relief Valve Piston
12. Piston Retaining Ring
13. Screw, 1/4–20 x 5/8
14. Cover and Piston Seal Ring
15. Cover Seal Ring
16. Relief Valve Cover
17. Valve Spring
18. Washer
19. Spring Retaining Ring
20. Switch Strap
21. Indicator Light Switch
22. Hexhead Screw, #10–32 x 1/2
23. Connector Tube, 1/4" x 3/8"
24. Switch Bracket
25. Lockwasher, #10
26. Hexnut, #10–32
27. Hexhead Screw, 7/16–14 x 2-1/4
28. Sealing Washer
29. Bearing Washer Retaining Ring
30. Bearing Washer
31. Thrust Bearing
32. Adjusting Stem
33. Indicator Pin
34. Spring Housing
35. Control Valve
36. Control Valve Bearing
37. Diaphragm Support Bearing
38. Diaphragm Clamp
39. Outside Spring
40. Light Bulb
41. Inside Spring
42. Adjusting Nut
43. Instruction Plate
44. Adjusting Wheel Assembly

Fig. 2, QD Relief Valve

Valve Removal, Disassembly, Assembly and Installation

valve cover. Install the two remaining capscrews. Tighten all capscrews 53 lbf·ft (72 N·m).

15. Connect the relief valve supply line from the pilot valve. Also connect the drain line.
16. Connect the indicator light switch.
17. Fill the pump and test the valve for proper operation and leaks.

TPM Dump Valve

1. Drain the pump.
2. Disconnect the indicator light switch.
3. Disconnect the line to the sensing valve.
4. Remove one 7/16–14 x 2 sensing valve mounting capscrew.
5. Remove the four 7/16–14 x 1-3/4 capscrews retaining the relief valve assembly to the atmosphere dump.
6. Remove the four 7/16–14 x 1-1/2 relief valve mounting capscrews to remove the relief valve from the pump body.
7. Remove the relief valve assembly
8. Remove the four 7/16–14 x 1-3/4 capscrews retaining the relief valve cover to the relief valve body.
9. Remove the indicator light switch assembly.
10. Apply a small amount of pressure to the relief valve spring and remove the spring retaining ring and washer. Carefully release the pressure held on the spring and then remove the spring.
11. Remove the relief valve cover.
12. Remove the piston retaining ring.
13. Remove the relief valve from the opposite end, sliding the relief valve stem out of the piston.
14. Reaching through the center hole of the piston, gently pull the piston from the indicator switch end of the relief valve body.
15. Before assembling and installing the valve, clean and inspect all components of the relief valve assembly.
16. Clean all sealing gasket surfaces and install new O-rings and gaskets.
17. Install the relief valve into the relief valve body.
18. Slide the piston into the relief valve body while at the same time sliding the piston onto the relief valve stem. Then install the piston retaining ring.
19. Install the new gasket and then install the cover onto the relief valve body.
20. Install two 7/16–14 x 1-3/4 capscrews finger-tight to keep the relief valve cover aligned with the valve body.
21. Install the valve spring over the relief valve stem. Then apply pressure to the valve spring to compress the spring.
22. Install the spring washer and the retaining ring.
23. Remove the two 7/16–14 x 1-3/4 capscrews installed to keep the relief valve cover aligned with the valve body. Place the indicator switch assembly into position on the relief valve cover. Apply Loctite® 242 to the four capscrews, install, and tighten 53 lbf·ft (72 N·m).
24. Apply Loctite® 242 to the four 7/16–14 x 1-1/2 capscrews to install the new gasket for the relief valve to the pump surface.
25. Apply Loctite® 242 to the four 7/16–14 x 1-1/2 capscrews and install the new gasket and relief valve assembly to the atmosphere dump. Tighten 53 lbf·ft (72 N·m).
26. Apply Loctite® 242 to the 7/16–14 x 2 capscrew, install the sensing valve and tighten 40 lbf·ft (54 N·m). Make sure the arrow points upward.
27. Connect the indicator light switch.
28. Connect the line to the sensing valve.
29. Fill the pump and test the valve for proper operation and leaks.

Check Valves (two-stage only)

1. Drain the pump.

NOTE: There are two check valves (one on each side) in the suction side on the front of the two-stage pump body. The following procedure is used for both check valves.

2. Remove the four 1/2–13 x 1-1/4 capscrews from the check valve cover on the front side of the pump body.

3. Remove the check valve.
4. Clean the gasket surfaces and inspect the check valve pivots and pivot sockets.
5. Install the check valve.
6. Install the new gasket in the pump body.
7. Apply Loctite® to the four capscrews and secure the check valve cover to the pump body with the capscrews, being careful to align the check valve pivot with the pivot socket in the check valve cover. Tighten 53 lbf·ft (75 N·m).
8. Fill the pump and test the valve for proper operation and leaks.

SPV Priming Valve

1. Drain the pump.
2. Disconnect the 3/4-inch (19 mm) vacuum hose connecting the priming valve to the primer.
3. Remove two 7/16–14 nuts attaching the priming valve to the studs in the pump body. If the studs are damaged, replace them with 7/16–14 x 1-3/4 zinc plated studs.

NOTE: If the valve strainer and O-ring seal remains on the pump body, remove it carefully for cleaning and installation. If the valve strainer is removed as part of the priming valve, remove it from the body and set it aside. Use care as the valve strainer is easily damaged.

4. Note the location of the drain hole on the diaphragm cover and then remove the eight 5/16–18 x 3/4 capscrews securing the diaphragm cover to the valve body. Remove the diaphragm cover and the diaphragm.
5. Hold pressure on the diaphragm washer to compress the valve spring then remove the diaphragm washer retaining screw. Remove the diaphragm washer and valve spring. From the opposite side of the valve body, remove the valve.
6. Clean all the components of the priming valve and mating surfaces. Inspect the valve seat and replace if worn or damaged.
7. Install the valve into the valve body from the pump side of the body.
8. Install the valve spring and diaphragm washer onto the valve. Apply Loctite® 242 to the diaphragm washer retaining screw, compress the valve spring with the diaphragm washer, and install the valve.
9. Align the diaphragm holes with the capscrew holes in the diaphragm cover. Apply Loctite® 242 to the eight 5/16–18 x 3/4 capscrews and install the diaphragm cover and diaphragm valve body. Tighten 17 lbf·ft (23 N·m).
10. Install the valve strainer and O-ring seal onto the pump side of the priming valve.
11. Apply Loctite® 242 on the two 7/16–14 priming valve mounting nuts and install the priming valve into the pump body. Tighten 40 lbf·ft (54 N·m).
12. Connect the vacuum hose to the primer.
13. Fill the pump and test the valve for proper operation and leaks.

Troubleshooting

Lack of use causes many problems for fire pumps and fire pump components.

IMPORTANT: The entire pumping system should be exercised on a regular basis, at least weekly. This routine procedure should include all discharge valves and suction valves.

Abuse of the fire pump is rarely a problem. If the pump and pump components have been abused, indications of problems may be fairly obvious. For example, bent controls are a common indicator.

Simultaneous oil and water leaks are uncommon. Normally, a water leak indicates that a line has come loose or is broken. Gaskets are used between mating surfaces *without* sealant. If a leak is present at a gasket-mating surface, whether oil or water, the components should be disassembled and repaired.

Be certain when a device indicates it is not working that it is not asimple electrical problem, such as a burned-out indicator bulb.

Troubleshooting Tables

Problem—Pump Will Not Engage

Problem—Pump Will Not Engage Possible Cause	Remedy
Parking brake not set.	Set the parking brake.
Transmission not in neutral.	Shift transmission to neutral.
Insufficient air supply.	Repeat the recommended shift procedure: Check the air pressure gauges. This procedure requires at least 100 psi (689 kPa), and shut the engine down and check for air leaks.
Pump shift or application of parking brake attempted before apparatus was stopped.	Release the braking system momentarily and repeat the recommended shift procedure. *

* This condition is known as "Butt Tooth," which occurs when the transmission shifts and the shift gear-teeth and the teeth on the drive gear do not line up and butt up against each other. The Twinflow fire pump transmission is designed with a sliding shift collar. Therefore, the occurrence of "Butt Tooth" will be rare.

Problem—Pump Will Not Shift

Problem—Pump Will Not Shift Possible Cause	Remedy
Battery voltage low.	Turn off accessories. Check the charging system of the apparatus. Inspect the batteries. If okay, recharge and try shift again.
Interface/Interlock module not receiving proper inputs.	Check the Officers Information Center output.
Transmission not receiving lock-up input.	Check output to transmission with Prolink.

Problem—Pump Will Not Prime

Problem—Pump Will Not Prime Possible Cause	Remedy
Low battery voltage.	Increase the engine speed 1000 to 1200 rpm for temporary support for electrical system requirements and primer operation. *
Worn or damaged priming system.	Perform the "Dry Vacuum Test" which follows the troubleshooting tables in this subject. If pump is tight but primer develops less than 22 inches of vacuum, the primer pump, motor, or Priming Valve may be worn or damaged.

Troubleshooting

Problem—Pump Will Not Prime	
Possible Cause	**Remedy**
Primer not operated long enough.	Operate for 30 seconds for pump up to 1250 gpm or for 45 seconds for 1500 and up gpm pump. Add 15 additional seconds if priming from front or rear suction. Do not run primer over 45 seconds. Stop and check for causes.
Suction lifts too high.	Do not attempt lifts exceeding 22 feet, except at low elevations.
Suction strainer blocked.	Check and clean.
Air pocket in suction hose or pump.	Place suction hose lower than suction intake. Slightly open a discharge valve momentarily to release trapped air.
Air leaks.	Perform the "Dry Vacuum Test" which follows the troubleshooting tables in this subject. Then shut engine off and listen for air leaks. Pressurize the discharge side of the pump with approximately 100 psi (689 kPa) from the hydrant and check for water leaks. Check connections and gaskets.

* Electric primer does not require engine speed to be increased for operation. A primer can and will draw in excess of 300 amps and primer operation can last 45 seconds.

Problem—Pump Loses Prime

Problem—Pump Loses Prime	
Possible Cause	**Remedy**
Suction lifts too high.	Do not attempt lifts exceeding 22 feet except at low elevations.
Suction strainer blocked.	Check and clean.
Air leaks.	Check all connections and gaskets. Perform the "Dry Vacuum Test" which follows the troubleshooting tables in this subject.
Pump pressure is too low when discharge appliance is opened.	Prime the pump again. Raise pump pressure higher and open the discharge appliance slowly.

Problem—Pump Primer Does Not Operate Properly

Problem—Pump Primer Does Not Operate Properly	
Possible Cause	**Remedy**
Does not operate electrically.	Check the battery, connections, primer, and primer control. Check the control switch and solenoid on the primer. If the primer has not been used recently, it could be frozen. It should, if contact is still being made internally, show heavy current draw.
Primer is slow or lower than normal.	Check batteries, wiring, and connections. A large quantity of suction hoses or suction pipes can exceed primer capabilities. Too small diameter or too long a length of piping between primer and pump can exceed primer capabilities. Lift not to exceed 20 feet (6 m) and 10 feet (3 m) for testing. The primer pump itself may be worn out.
Pulls some prime.	The primer pump could be in need of repairs or cleaning. Check for air leaks and verify that the Priming Valve is not sticking.
Pulls full prime.	Check for air leaks. Check for clogged inlet strainer and screens. Check that the suction hose is submerged in adequate water supply. Check for air pockets and air accumulation in piping. Check for turbulence in piping. The pump impeller may be damaged or severely worn.

Problem—Insufficient Capacity or Pressure

Problem—Insufficient Capacity or Pressure	
Possible Cause	**Remedy**
Insufficient engine power.	Check engine performance.
Improperly set relief valve.	Readjust the relief valve to a higher pressure setting. If the relief valve is set too low it will open to relieve pressure and reduce capacity.
Transmission in incorrect range.	Check the transmission selector for correct range recommended for pumping procedure. Check that the Fourth range lockup has occurred. If the transmission shifts while increasing engine speed, lock up has not occurred. Check engine speed or drive shaft speed for correct transmission range and inaccurate tachometer.
Air leaks.	Perform the "Dry Vacuum Test" which follows the troubleshooting tables in this subject.
Transfer valve in incorrect position.	Transfer valve must be in the "parallel or volume" setting for capacity in the "series or pressure" setting for pressure. The transfer valve indicator may be out of adjustment. At idle, shift the transfer valve back and forth. You should hear the check valves close and see a change in pressure on the Master Pressure gauge.
Tank fill valve leaking.	Repair the leak.

Problem—Engine Speed Too High for Capacity or Pressure

Problem—Engine Speed Too High for Capacity or Pressure	
Possible Cause	**Remedy**
Impeller blockage.	Check and clean. Backflushing through the discharge side of the pump may clear the obstruction. It may require disassembly of the pump.
Worn impeller or clearance rings.	Overhaul the pump. All other possibilities should be eliminated before overhauling the pump.
Suction strainer blocked.	Clean and check.
Lift too high.	Lifts over 10 feet will cause higher engine speeds and vacuum.
Transmission in incorrect range.	Check the transmission selector for correct range for recommended pumping procedure. Check that Fourth range lockup has occurred. If the transmission shifts while increasing engine speed, lockup has not occurred. Check engine speed or drive shaft speed for correct transmission range and inaccurate tachometer.
Check Valves damaged or missing.	At idle, shift the transfer valve back and forth. You should detect a change in the engine/pump sound, hear the check valves close, and see a change in the pressure on the Master Pressure gauge. If no apparent change occurs, remove the suction inlet cap and visually inspect the check valves. Insert a broom handle in the suction inlet and gently push each check valve open and let it close. Check valves should move freely.
Tank fill valve leaking.	Repair the leak.

Troubleshooting

Problem—Relief Valve Does Not Relieve When Valves are Closed

Problem—Relief Valve Does Not Relieve When Valves are Closed	
Possible Cause	**Remedy**
Incorrect pilot valve setting.	Repeat the proper procedure for setting the relief valve.
Pilot valve inoperative.	Disassemble, clean, and lubricate. Inspect the control valve diaphragm for wear or damage.
Relief valve inoperative.	Disassemble, clean, and lubricate.

Problem—Relief Valve Does Not Recover When Valves are Opened

Problem—Relief Valve Does Not Recover When Valves are Opened	
Possible Cause	**Remedy**
Dirt in system resulting in slow or sticky operation.	Disassemble, clean and lubricate.

Problem—Unable to Attain Proper Setting

Problem—Unable to Attain Proper Setting	
Possible Cause	**Remedy**
Incorrect procedure.	Check procedure and reset.
Blocked strainer.	Disconnect the pilot valve supply line from the discharge side of pump. Remove the 90-degree fitting where the supply line connects to the pump. The strainer is attached to this fitting. Clean or replace the strainer and fitting assembly.
Dirt in pilot valve.	Disassemble, clean, and lubricate.
Hunting condition.	Insufficient water supply to the pilot valve. Check strainer and supply lines. If there is dirt in the pilot valve, disassemble, clean, and lubricate.

Problem—TPM Valve Does Not Relieve

Problem—TPM Valve Does Not Relieve	
Possible Cause	**Remedy**
Sensing valve inoperative.	Disassemble, clean, and lubricate. Inspect the control valve diaphragm for wear or damage.
PG relief valve inoperative.	Disassemble, clean, and lubricate.
PG relief valve sluggish.	Check and clean the discharge and suction strainers in the pump body.

Problem—TPM Valve Does Not Recover

Problem—TPM Valve Does Not Recover	
Possible Cause	**Remedy**
Dirt in system resulting in slow or sticky operation.	Disassemble, clean, and lubricate. Check and clean the discharge and suction strainers in the pump body.

Problem—AutoLube

Problem—AutoLube	
Possible Cause	**Remedy**
External leaks.	External leaks are the result of gasket failures. Disassemble and repair.
Internal leaks.	If water is leaking, replace the diaphragm. If oil is leaking, replace the AutoLube seal and the impeller bushing. Heavy oil usage by the AutoLube or oil present in the water when the pump master drain is opened indicates that the AutoLube seal and possibly the impeller bushing is damaged.

Problem—Mechanical Seal Leaks

Problem—Mechanical Seal Leaks	
Possible Cause	**Remedy**
Leak at mechanical seal.	If the mechanical seal is leaking it will have to be replaced. If properly cared for, the mechanical seal should be almost maintenance free. Water quality will greatly affect seal life. The most common failure of the mechanical seal is from thermal-shock. That is running the pump dry, heating up the seal and then opening to a cool or cold water supply. The seal may shatter. Check the AutoLube. If the bushing is worn or missing, the impeller shaft will wobble and fracture the mechanical seal.

Problem—Pump Gear Box Does Not Function Properly

Problem—Pump Gear Box Does Not Function Properly	
Possible Cause	**Remedy**
Water in gear box.	Locate and repair the leak. Remove and clean the gear box filter. Replace the transmission oil. Water leaking onto the input drive shaft of the pump gear box will actually be screwed into the pump transmission past the oil seals. This is not a seal problem. Be certain the slinger(s) are in place. Check the pump gear box cooling line for internal fractures. Pump gear box will fill with water and overflow through breather.
Whine in gear box.	Check the oil level. If oil is low, helical gears and/or tapered bearings will whine. Check oil pressure. If the filter is clogged, oil pressure will be low. Drain oil and check for metal. Remove filter and check for metal. If metal is detected, pump gear box will have to be disassembled for complete inspection and repairs.
Knock or rattle in gear box.	Check for gears missing teeth. Check for damaged bearings. Disassemble and repair. *

* The cause may include foreign objects, low or contaminated oil, or low oil pressure. Low oil level or pressure will result in the transmission being damaged due to overheating.

Troubleshooting

Dry Vacuum Test

1. Open all the intake valves.
2. Cap all intakes, and close and uncap all discharge valves.
3. Using the pump's priming devices, develop a vacuum of at least 22 inHg (74.5 kPa) for 30 seconds for pumps up to 1250 gpm or 45 seconds for pumps 1500 gpm or greater.
4. Reduce the maximum vacuum attained by 1 inHg (3.4 kPa) for each 1,000 ft. (305 m) of elevation of the test site above 2,000 ft. (610 m).

NOTE: The vacuum should not drop more than 10 inHg (33.9 kPa) in five minutes. Do not operate the pump priming device once the five-minute test has begun.

See **Fig. 1** for the fire pump wiring diagram.

See **Fig. 2** for the fire pump controls wiring diagram. See **Fig. 3** for a detailed view of the RH switch panel for the fire pump controls and **Fig. 4** for a detailed view of the electrical center.

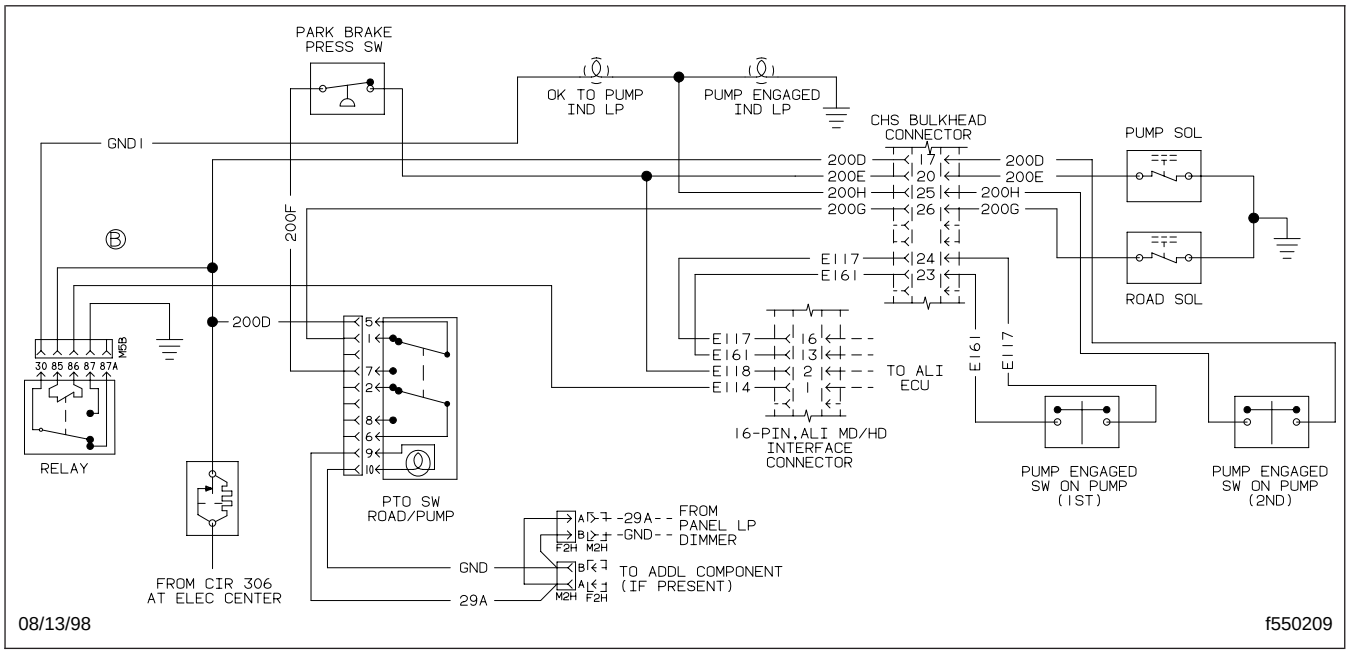


Fig. 1, Fire Pump Wiring Diagram

Specifications

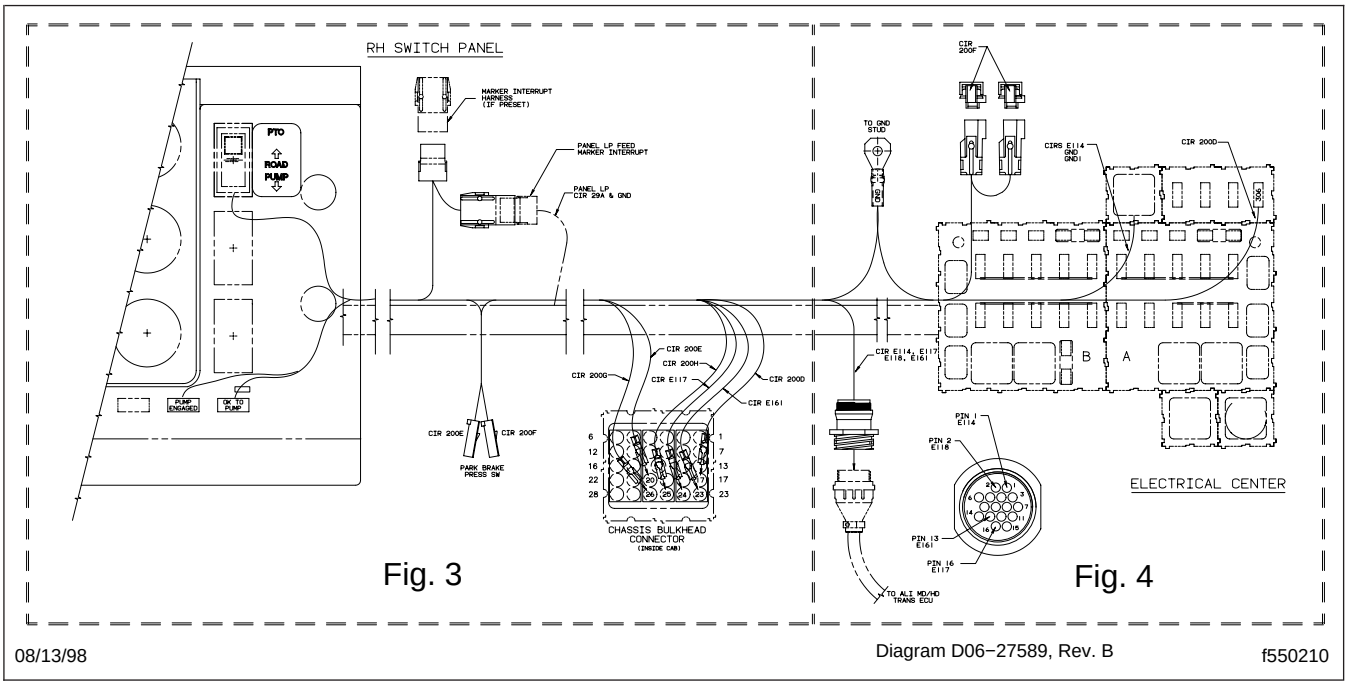


Fig. 2, Fire Pump Controls Wiring Diagram

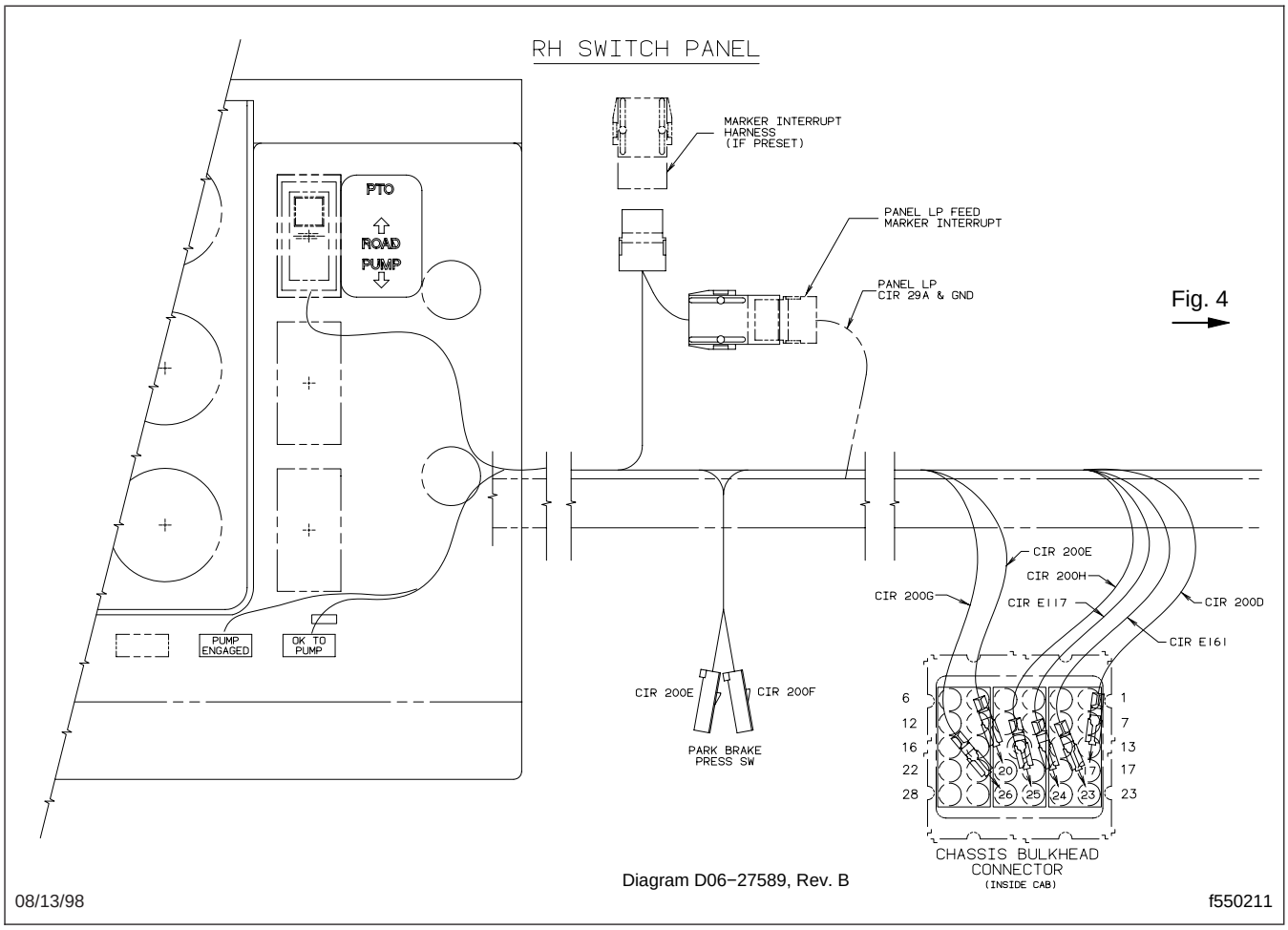


Fig. 3, Fire Pump Controls, RH Switch Panel

Specifications

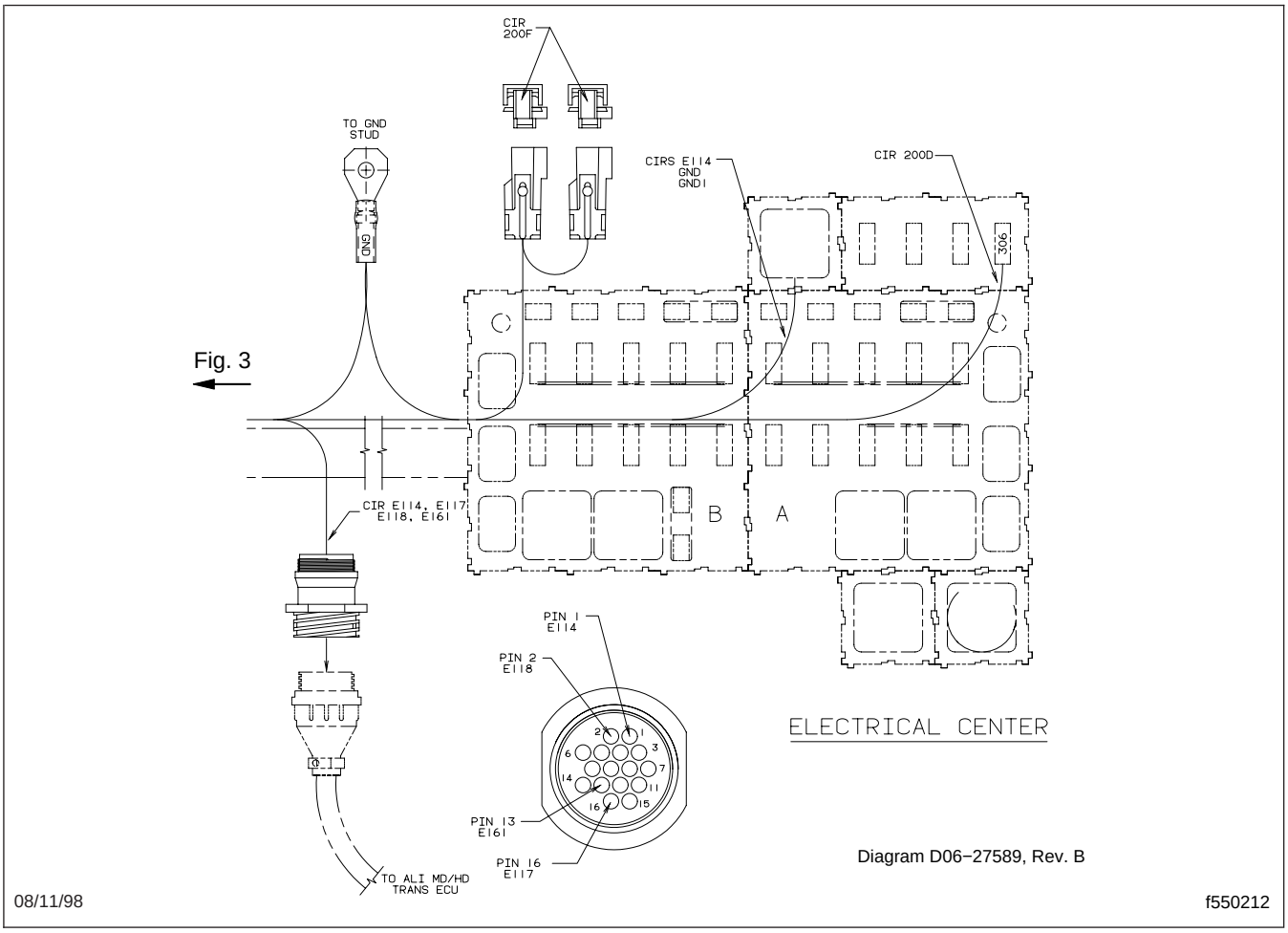


Fig. 4, Fire Pump Controls, Electrical Center

General Information

The Findlay bench seat is a full-width three-person seat. **See Fig. 1 .** A lever under the driver's side allows the seat to be adjusted forward and backward. Three-point seat-belt/shoulder-harnesses are provided for the driver and the right-side passenger; a lap belt is provided for the center-seat passenger.

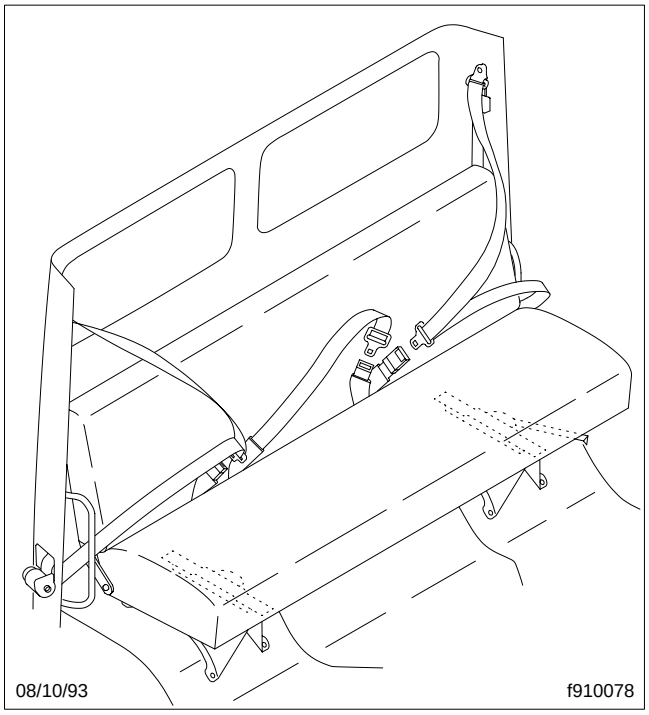


Fig. 1, Findlay 3-Person Bench Seat

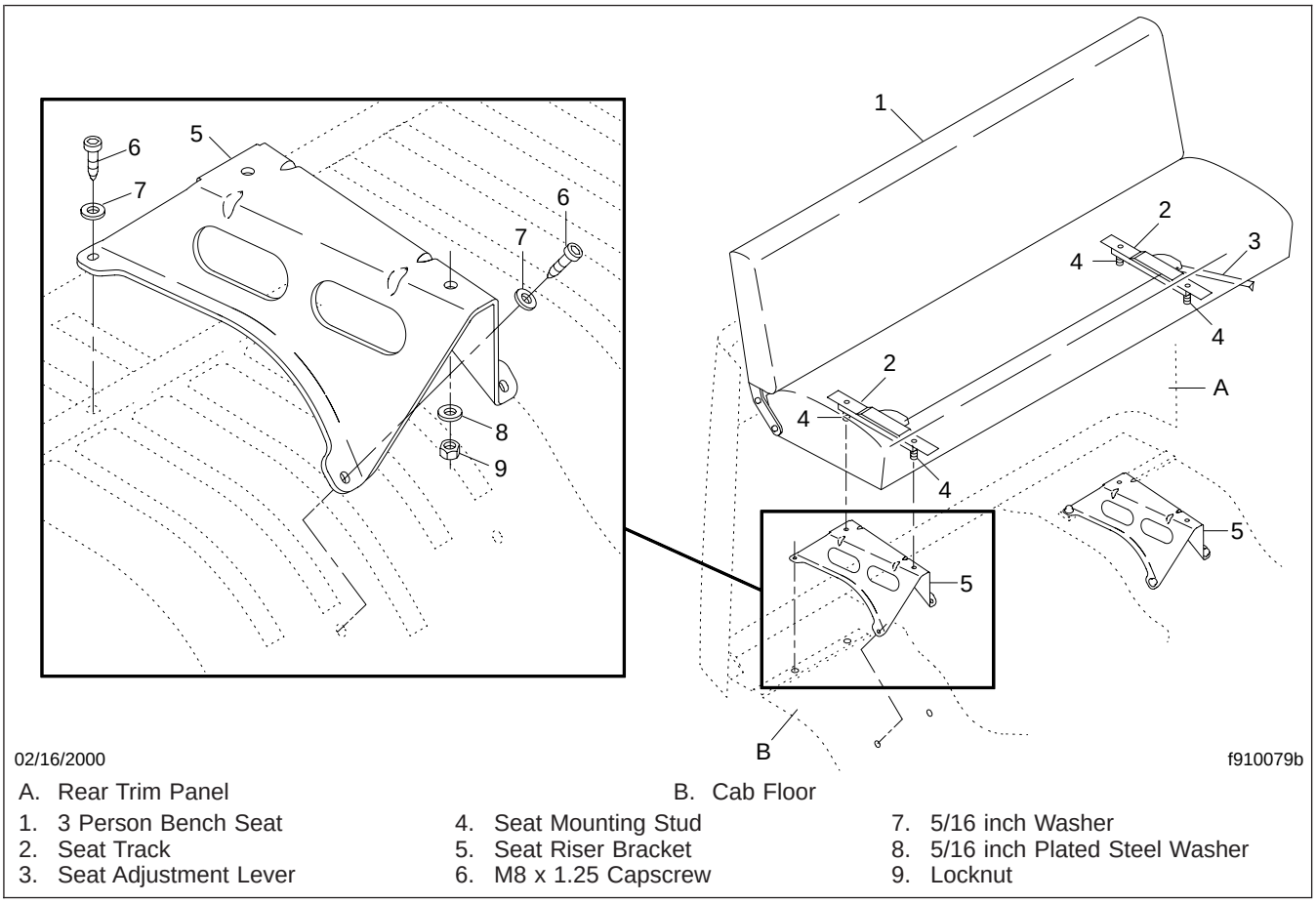
Removal

1. Slide the seat to its forward most position.
2. Push the ends of the four floor-mounted seat belt halves down through the opening between the seat back cushion and bottom cushion.
3. Remove the washers and locknuts that attach the rear of the seat tracks to the seat riser brackets. See **Fig. 1**.
4. Slide the seat to its rearmost position.
5. Remove the locknuts and washers that attach the front of the seat tracks to the riser brackets.
6. With the assistance of another person, lift the seat until the seat mounting studs clear the riser brackets; then remove the seat from the cab.

Installation

1. With the assistance of another person, position the seat in the cab, so that all four seat mounting studs are in the holes in the tops of the seat riser brackets. See **Fig. 1**.
2. Slide the seat to its rearmost position.
3. Install the washers and locknuts that attach the front of the seat tracks to the riser brackets. Tighten the locknuts 14 lbf·ft (19 N·m).
4. Slide the seat to its forwardmost position.
5. Install the washers and locknuts that attach the rear of the seat tracks to the riser brackets. Tighten the locknuts 14 lbf·ft (19 N·m).
6. Reaching through the opening between the seat back cushion and bottom cushion, pull the ends of the four floor-mounted seat belt halves onto the seat.
7. Adjust the position of the seat for driver comfort.

Seat Removal and Installation



A. Rear Trim Panel
B. Cab Floor

1. 3 Person Bench Seat
2. Seat Track
3. Seat Adjustment Lever
4. Seat Mounting Stud
5. Seat Riser Bracket
6. M8 x 1.25 Capscrew
7. 5/16 inch Washer
8. 5/16 inch Plated Steel Washer
9. Locknut

Fig. 1, Bench Seat Installation

Specifications

This subject contains the following table: •Fastener Torques

Description	Size	Grade	Torque N·m (lbf·ft)
Seat Track Mounting Stud Locknut	5/16–24	B	19 (14)

Table 1, Fastener Torques

General Information

The National model 96 Cush-N-Aire **(Fig. 1)** and Easy-Aire **(Fig. 2)** mid-back air suspension seats offer adjustment features for height, fore and aft positioning, back cushion tilt, lumbar support, and seat cushion tilt. The air suspension and height-adjustment features are provided by an inflatable air spring (air bag).

For Cush-N-Aire seats (installed only in vehicles with air brakes), air pressure for the air spring is provided by the vehicle air system and is controlled by an air valve attached to the seat frame. **See Fig. 1 .**

For Easy-Aire seats, the air pressure is provided by and controlled by a hand pump that attaches to the side of the seat frame. **See Fig. 2 .**

Both seat styles are equipped with a shock absorber to dampen unwanted up and down motion of the seat.

For complete operating instructions, refer to the vehicle driver's manual.

General Information

1. Seat Cushion
2. Cushion Handle
3. Seat Cushion Adjustment Rod
4. Lumber Adjustment Knob
5. Back Cushion and Upper Frame
6. Lower Frame
7. Backrest Adjustment Knob
8. Seat Cushion Adjustment Rod Cap
9. Hose Barbed Fitting
10. Air Spring Supply Hose
11. Air Valve Supply Hose
12. Air Valve
13. Tie Strap
14. 5/16−18 Locknut
15. Track Assembly
16. Fore−and−Aft Adjustment Lever
17. Seat Track Stop
18. Belt Bar
19. M8 Socket−Head Capscrew and Washer
20. Base Assembly
21. Belt−Bar Spacer
22. Shock Absorber Assembly
23. Air Spring

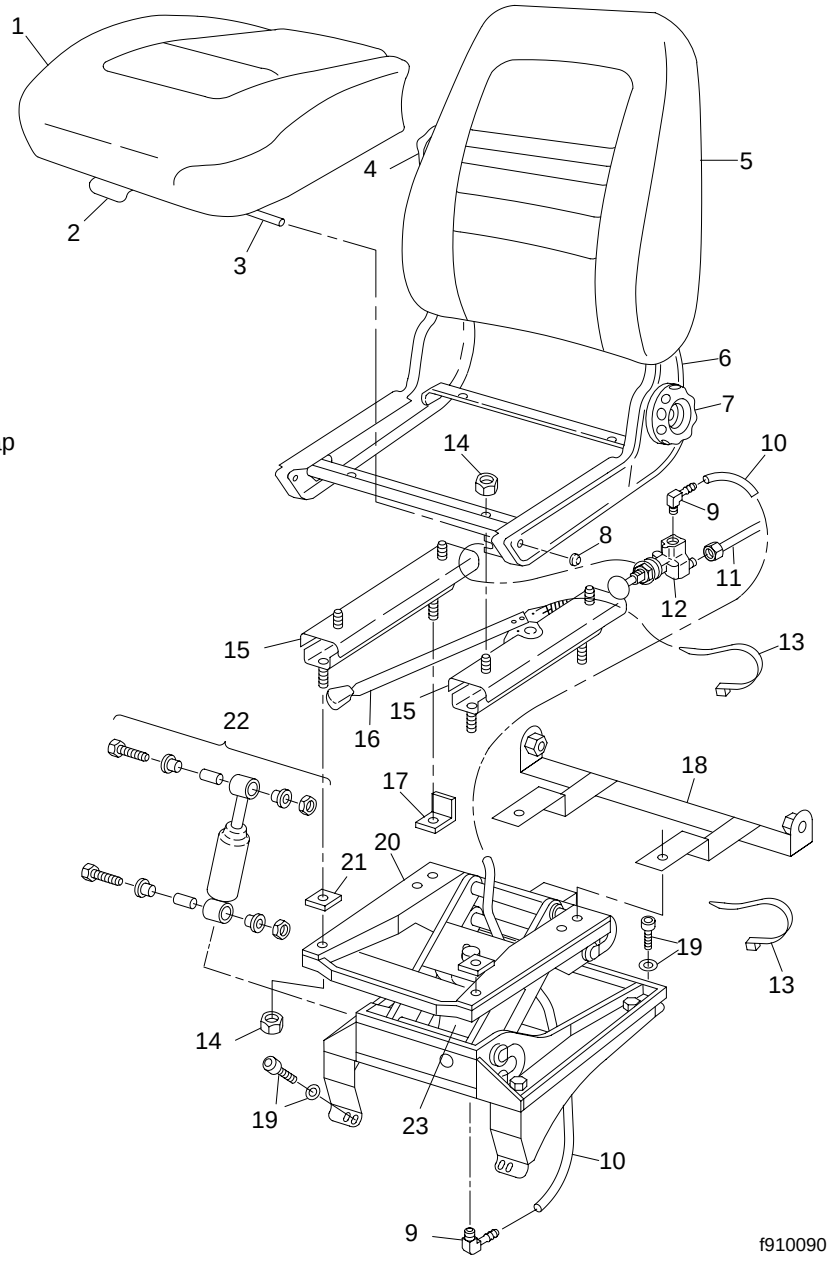
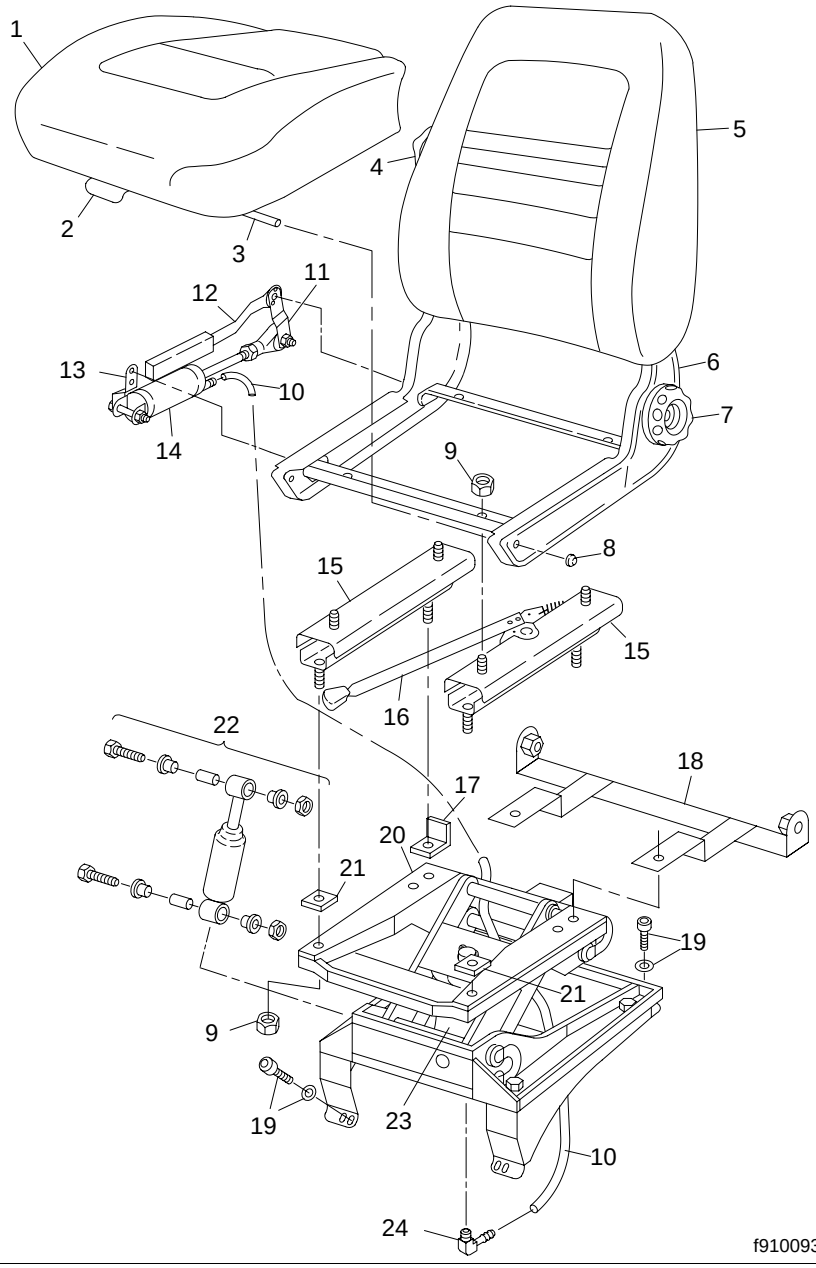


Fig. 1, National Cush-N-Aire (Mid-Back) Seat, Model 96

1. Seat Cushion
2. Cushion Handle
3. Seat Cushion Adjustment Rod
4. Lumbar Adjustment Knob
5. Back Cushion and Upper Frame
6. Lower Frame
7. Backrest Adjustment Knob
8. Seat Cushion Adjustment Rod Cap
9. 5/16−18 Locknut
10. Air Spring Supply Hose
11. Hand Pump Lever
12. Hand Pump Handle
13. Pump Bracket
14. Hand Pump
15. Track Assembly
16. Fore−and−Aft Adjustment Lever
17. Seat Track Stop
18. Belt Bar
19. M8 Socket−Head Capscrew and Washer
20. Base Assembly
21. Belt−Bar Spacer
22. Shock Absorber Assembly
23. Air Spring
24. Hose Barbed Fitting



08/10/93 f910093

Fig. 2, National Easy-Aire (Mid-Back) Seat, Model 96

Removal (Refer to Fig. 1 and Fig. 2)

1. For an Easy-Aire seat, hold down the pump handle (**Fig. 1** , Ref. 10) until all air is exhausted from the air spring (Ref. 21). Go to the step for removing the bolts, washers, and spacers.

   For a Cush-N-Aire seat, remove the air valve and air hoses (**Fig. 1** , Refs. 3, 1, and 8) from the seat.

   1.1 Pull the air valve knob (Ref. 6) until all air is exhausted from the air spring (Ref. 21).

   1.2 Pull up and support the rear edge of the seat cushion (Ref. 14) as needed to gain access to the air valve from the top.

   1.3 Cut off the air spring supply hose (Ref. 1) close to the air valve barbed fitting (Ref. 2); minimize hose length loss. Remove the scrap hose from the barbed fitting. Tape the hose and fitting ends to prevent dirt or other matter from entering.

   1.4 Cut the tie strap that attaches the air valve supply hose to the belt bar (Refs. 15, 8, and 16).

   1.5 Loosen the nut (Ref. 5) that attaches the air valve to the lower frame. If needed, move the fore-and-aft adjustment lever (Ref. 22) to the right, and

   slide the upper seat assembly far enough forward to allow removal of the air valve. Remove the valve (and air valve supply hose) from the lower frame, and lay it on the cab deck, behind the seat.

2. Remove the bolts, washers, and spacers that attach the seat belts and tether belts to the belt bar. **See Fig. 2** , Details *B* and *C* .

3. Remove the capscrews and washers (**Fig. 1** , Refs. 18 and 19) that attach the seat risers to the cab deck. Remove the seat from the cab.

Installation (Refer to Fig. 1 and Fig. 2)

1. Place the seat on the cab deck. Insert the socket-head capscrews through the washers (**Fig. 1** , Refs. 18 and 19) and the seat risers. Insert the forward fasteners through the left-hand hole in each seat riser (typical for driver's and passenger's seats); **refer to Fig. 2** , Detail *A*. Tighten the bolts 18 N·m (13 lbf·ft).

2. Attach the seat belts and tether belts to the belt bar, **as shown in Fig. 2** , Details *B* and *C*. Tighten the bolts 54 N·m (40 lbf·ft).

3. For a Cush-N-Aire seat, install the air valve and air hoses (**Fig. 1** , Refs. 3, 1, and 8) on the seat. **See Fig. 1** , Detail *A* .

   3.1 Attach the air valve to the lower frame (Ref. 9), with the lockwasher (Ref. 4) between the nut (Ref. 5) and the front of the valve bracket (Ref. 7); then turn the air valve so the barbed fitting (Ref. 2) is on top. Tighten the nut finger-tight. Using a wrench, tighten the nut one-half turn more.

   3.2 Install a new tie strap to attach the air valve supply hose to the belt bar (Refs. 15, 8, and 16).

   3.3 Pull up and support the rear edge of the seat cushion as needed to gain access to the air valve from the top. Unplug the air spring supply hose and air valve barbed fitting (Refs. 1 and 2), then route the hose through the tie strap (Ref. 15) attached to the track assembly latch mechanism. Push the hose onto the barbed fitting on the valve.

   3.4 Move the fore-and-aft adjustment lever (Ref. 22) to the right, and slide the upper seat assembly forward and rearward while making sure that both air hoses move without restriction. Return the seat cushion to its original position.

Seat Removal and Installation

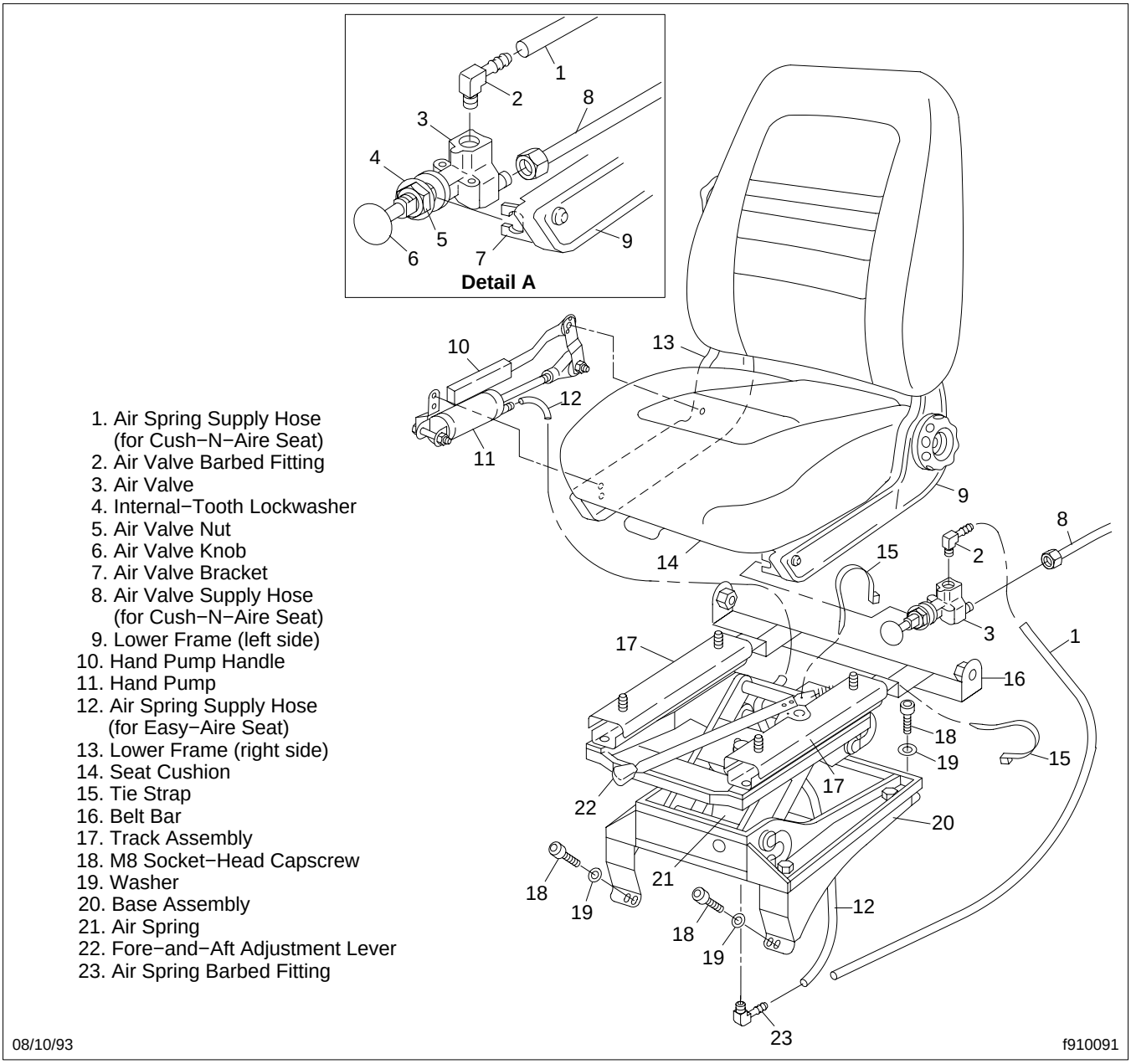


Fig. 1

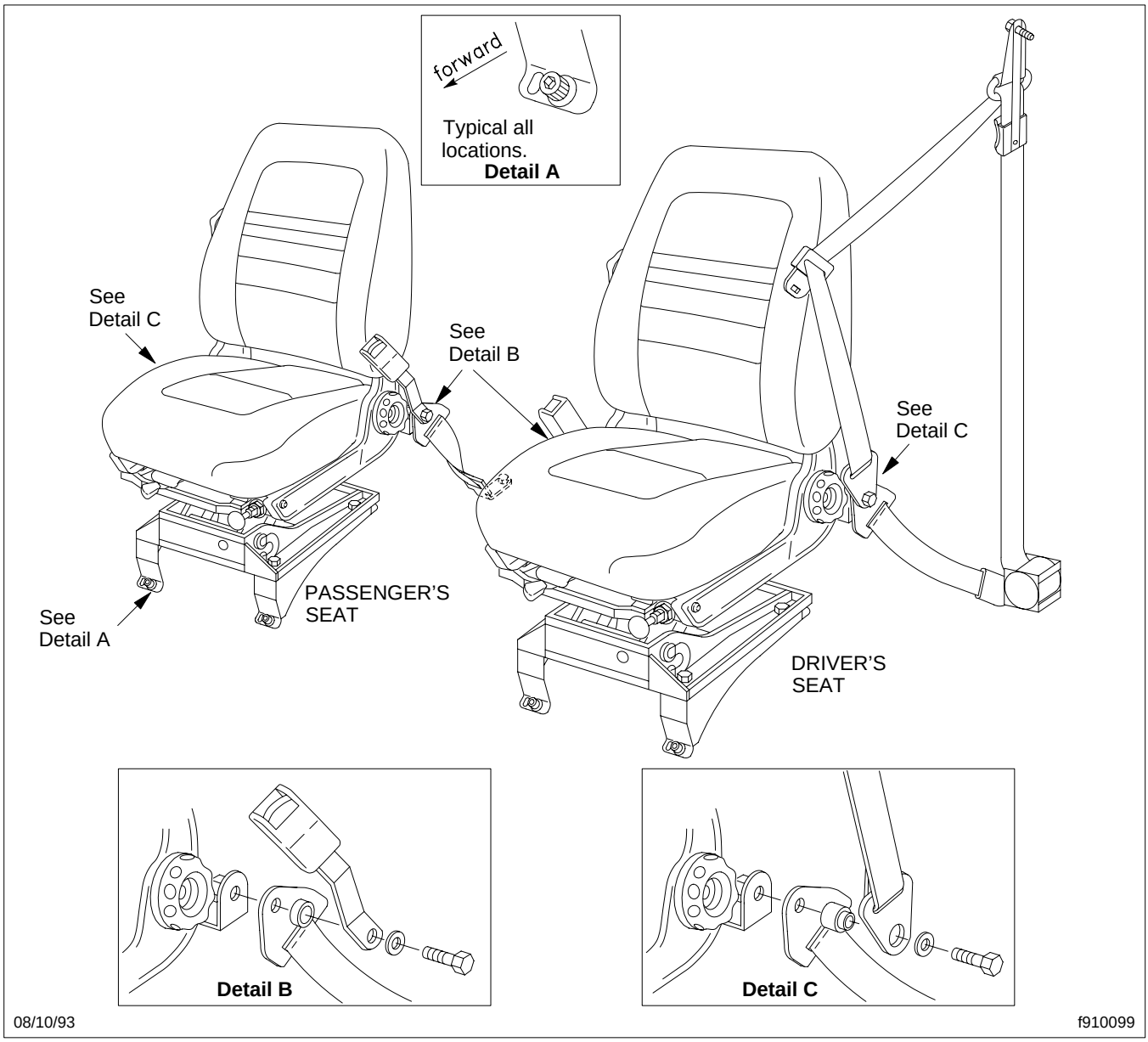

forward
Typical all locations.
Detail A
See Detail C
See Detail B
See Detail C
See Detail A
PASSENGER'S SEAT
DRIVER'S SEAT
Detail B
Detail C
08/10/93
f910099

Fig. 2

Air Valve Replacement

(Refer to Fig. 1)

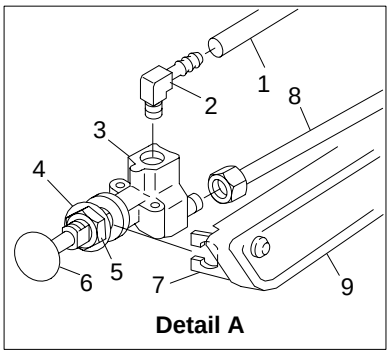
1. Apply the parking brakes and chock the vehicle tires. Drain all air from the vehicle air system.
2. Pull the air valve knob (Ref. 6) until all air is exhausted from the air spring.
3. Disconnect the air hoses and remove the air valve (Refs. 1, 8, and 3) from the seat.
   - 3.1 Pull up and support the rear edge of the seat cushion (Ref. 10) as needed to gain access to the air valve from the top.
   - 3.2 Cut off the air spring supply hose close to the air valve barbed fitting (Refs. 1 and 2); minimize hose length loss. Remove the scrap hose from the barbed fitting. Tape the hose end to prevent dirt or other matter from entering.
   - 3.3 Remove the air valve supply hose (Ref. 8) from the rear of the air valve; plug the hose.
   - 3.4 Loosen the nut (Ref. 5) that attaches the air valve to the lower frame. If needed, move the fore-and-aft adjustment lever (Ref. 13) to the right, and slide the upper seat assembly far enough forward to allow removal of the air valve. Remove the valve.
   - 3.5 Remove and save the air valve barbed fitting (Ref. 2).
4. Install the new air valve, and attach the air hoses.
   - 4.1 Install the air valve barbed fitting (Ref. 2) in the new air valve; position the fitting so it will point to the rear when the air valve is installed.
   - 4.2 Attach the air valve to the lower frame, with the lockwasher (Ref. 4) between the nut (Ref. 5) and the air valve bracket (Ref. 7); then turn the air valve so the barbed fitting is on top. Tighten the nut finger-tight. Using a wrench, tighten the nut one-half turn more.
   - 4.3 Unplug the air valve supply hose (Ref. 8). Route it through the tie strap attached to the belt bar (Refs. 11 and 12). Install the hose on the valve.
   - 4.4 Unplug the air spring supply hose (Ref. 1). Route it through the tie strap (Ref. 11) attached to the track assembly latch mechanism. Push the hose onto the barbed fitting on the valve.
   - 4.5 Move the fore-and-aft adjustment lever (Ref. 13) to the right, and slide the upper seat assembly forward and rearward while making sure that both air hoses move without restriction. Return the seat cushion to its original position.
5. Start the engine and allow the vehicle air system to fill. Push the air valve knob to raise the seat. Then pull the air valve knob to lower the seat. Repair any air leaks.
6. Remove the chocks.

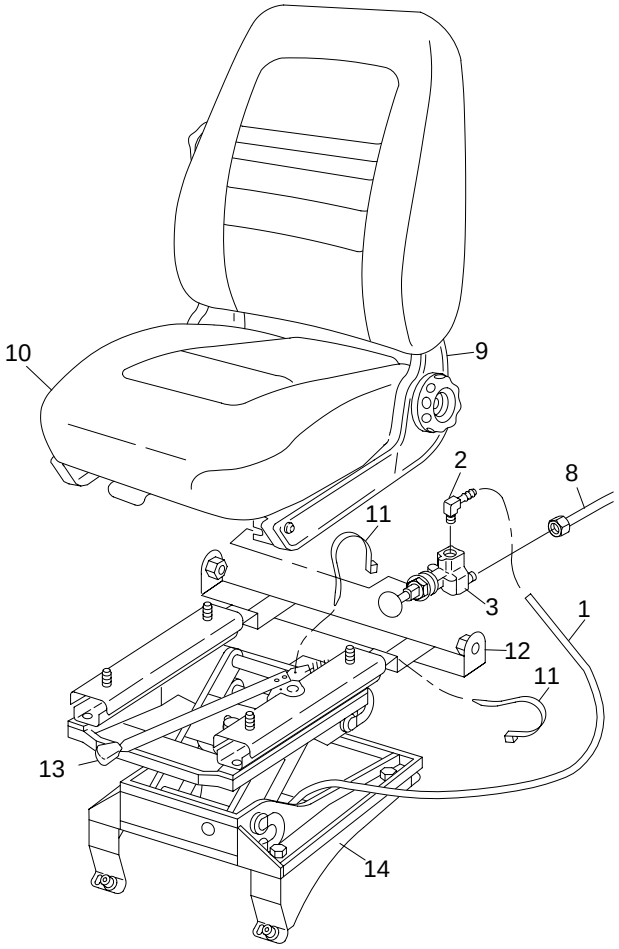
Hand Pump Replacement

(Refer to Fig. 2)

1. Hold down the hand pump handle (Ref. 8) until all air is exhausted from the air spring.
2. Disconnect the air hose (Ref. 11), and remove the hand pump from the seat.
   - 2.1 Remove the end of the air spring supply hose from the connection on the hand pump (Refs. 11 and 12).
   - 2.2 Back off the jam nut that secures the hand pump push rod from turning in the pump clevis (Refs. 13, 14, and 6).
   - 2.3 Remove the locknut and bolt that attach the hand pump mounting ears to the pump mounting bracket (Refs. 21, 17, and 19).
   - 2.4 Unscrew the hand pump push rod from the pump clevis, and remove the pump.
3. Check the pump pivot bolt, lever, clevis, handle, and bracket (Refs. 4, 5, 6, 8, and 19) for wear or damage, and replace the parts as needed.
4. Install the new hand pump, and connect the air hose.
   - 4.1 With the jam nut (Ref. 13) turned onto the hand pump push rod (Ref. 14) as far as it

Component Replacement





1. Air Spring Supply Hose
2. Air Valve Barbed Fitting
3. Air Valve
4. Internal−Tooth Lockwasher
5. Air Valve Nut
6. Air Valve Knob
7. Air Valve Bracket
8. Air Valve Supply Hose
9. Lower Frame
10. Seat Cushion
11. Tie Strap
12. Belt Bar
13. Fore−and−Aft Adjustment Lever
14. Base and Track Assemblies

08/10/93 f910092

Fig. 1

will go, screw the push rod into the pump clevis (Ref. 6) as far as it will go. Then, back it out until the air spring supply hose connection (Ref. 12) is at the bottom of the pump cylinder, and the bolt holes through the mounting ears (Ref. 17) are aligned horizontally.

4.2 Install the bolt and locknut (Refs. 21 and 16) that attach the hand pump to the pump mounting bracket. Turn the prevailing torque locknut until three threads of the bolt are showing past the nut; don't tighten it further.

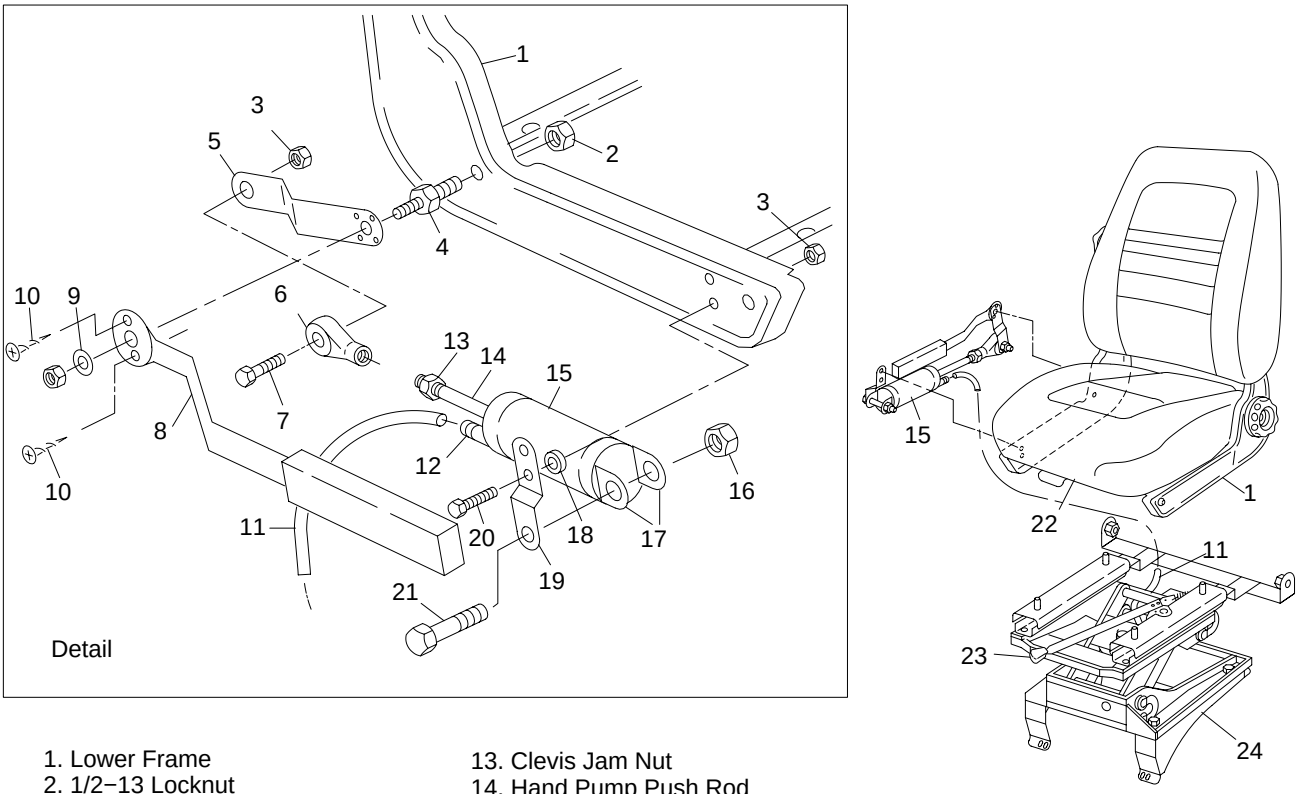
4.3 Securely tighten the jam nut against the pump clevis.

4.4 Connect the air spring supply hose to the connection on the hand pump.

5. Operate the hand pump; check for and correct any air leaks.

Shock Absorber Removal and Installation (Refer to Fig. 3)

1. Move the fore-and-aft adjustment lever (Ref. 16) to the right, and slide the upper seat assembly back as far as possible.



1. Lower Frame
2. 1/2−13 Locknut
3. 1/4−28 Locknut
4. Pump Pivot Bolt
5. Pump Lever
6. Pump Clevis
7. 1/4−28 Bolt
8. Hand Pump Handle
9. Washer
10. 10−32 Thread−Forming Screw
11. Air Spring Supply Hose
12. Hose Connection
13. Clevis Jam Nut
14. Hand Pump Push Rod
15. Hand Pump
16. 3/8−16 Locknut
17. Mounting Ears
18. Pump Spacer
19. Pump Bracket
20. 1/4−28 Bolt
21. 3/8−16 Bolt
22. Seat Cushion
23. Fore−and−Aft Adjustment Lever
24. Base and Track Assemblies

08/10/93 f910094

Fig. 2

2. For an Easy-Aire seat, work the hand pump (Ref. 15) until the upper seat assembly is raised to maximum height. Support the seat in this position by placing a wooden block between the lower arm and lower base. Refer to Detail *A* **in Fig. 3 ,** Refs. 9, 8, and 5. Hold down the pump handle (Ref. 14) until all air is exhausted from the air spring.

   For a Cush-N-Aire seat, push the air valve knob (Ref. 17) to raise the upper seat assembly to maximum height. Support the seat in this position by placing a wooden block between the lower arm and lower base. Refer to Detail *A* **in Fig. 3 ,** Refs. 9, 8, and 5. Pull the air valve knob until all air is exhausted from the air spring.

3. Remove the shock absorber, bushings, and spacers. See Detail *B* **in Fig. 3 .**

   3.1 Remove the nuts and bolts (Detail *B* **in Fig. 3 ,** Refs. 13 and 10) that attach the shock absorber to the upper and lower bases (Detail *A* **in Fig. 3 ,** Refs. 1 and 5). Remove the shock absorber.

Component Replacement

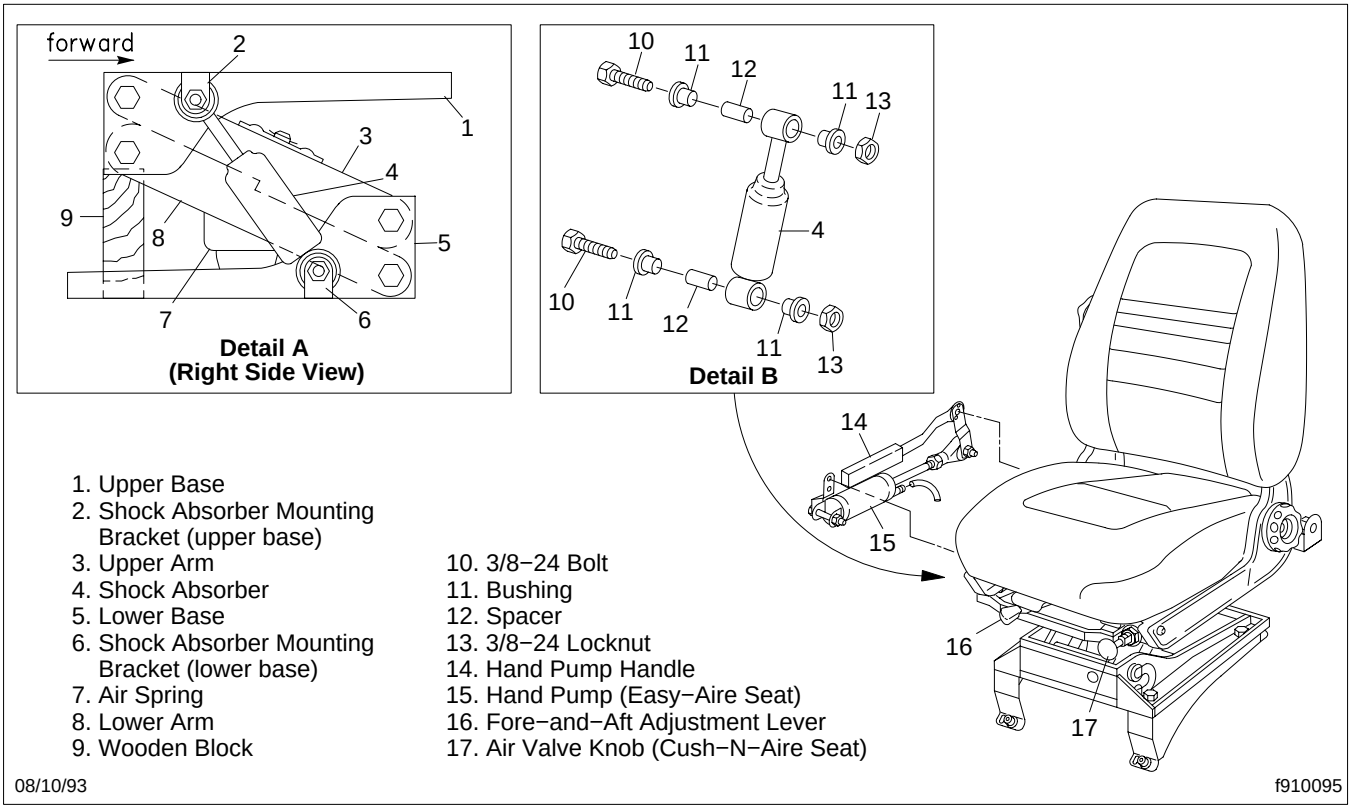


Fig. 3

3.2 Remove the bushings and spacers (Refs. 11 and 12) from the shock absorber.

4. Check the operation of the shock absorber, and replace it if needed.

5. Install the shock absorber and new spacers and bushings.

5.1 Install new spacers and bushings in the shock absorber eyes.

5.2 Position the shock absorber so its piston-rod end is in the mounting bracket of the upper base (Detail *A* **in Fig. 3 ,** Ref. 2). Install the bolt and locknut to attach the shock absorber to the bracket. Tighten the locknut 34 N·m (25 lbf·ft).

5.3 Position the cylinder end of the shock absorber in the mounting bracket of the lower base (Detail *A* **in Fig. 3 ,** Ref. 6). Install the bolt and locknut to attach the shock absorber to the lower bracket. Tighten the locknut 34 N·m (25 lbf·ft).

6. Work the hand pump (Easy-Aire seat), or push the air valve knob (Cush-N-Aire seat), to raise the seat. Remove the wooden block.

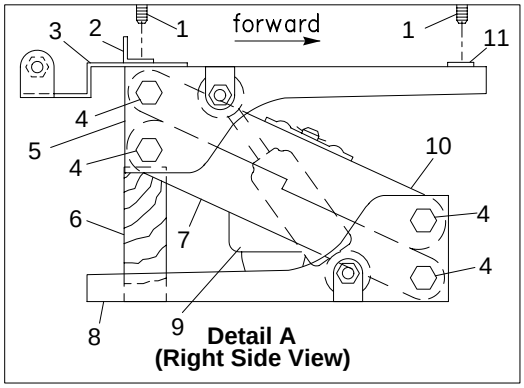
Air Spring Replacement

(Refer to Fig.4)

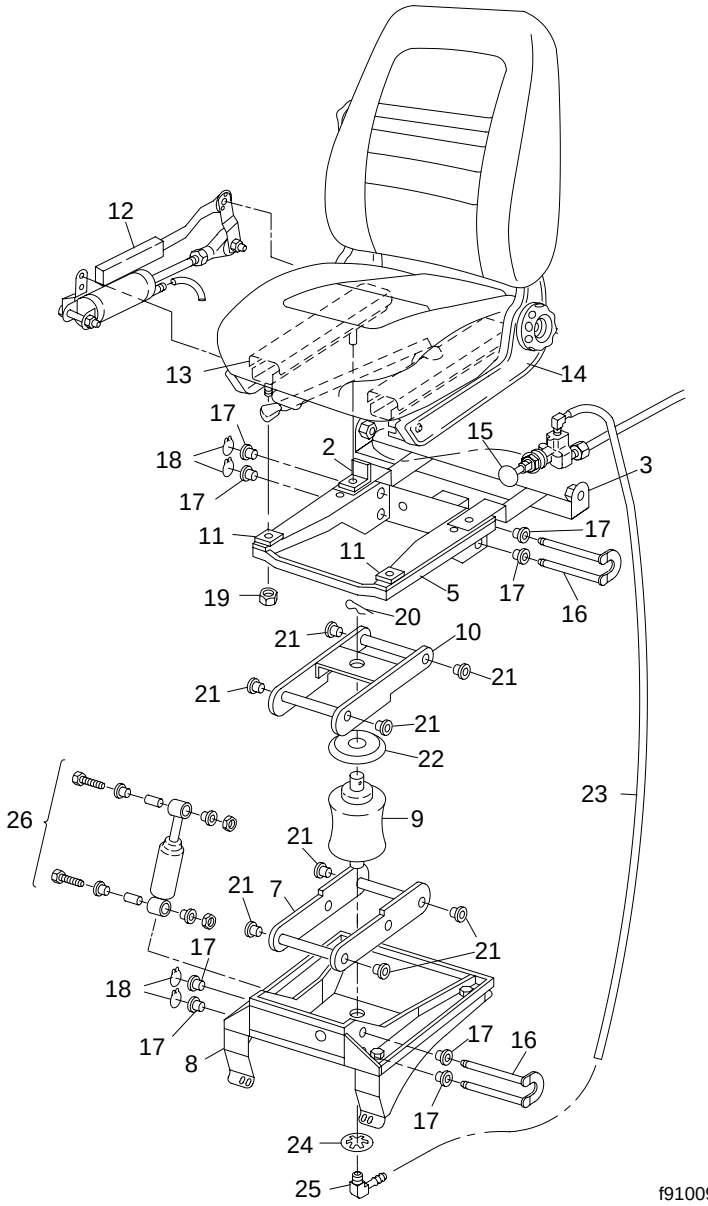
1. For an Easy-Aire seat, work the hand pump handle (Ref. 12) until the upper seat assembly is raised to maximum height. Support the seat in this position by placing a wooden block between the lower arm and lower base. Refer to Detail *A* **in Fig.4,** Refs. 6, 7, and 8. Hold down the pump handle until all air is exhausted from the air spring.

   For a Cush-N-Aire seat, push the air valve knob (Ref. 15) to raise the upper seat assembly to maximum height. Support the seat in this position by placing a wooden block between the lower arm and lower base. Refer to Detail *A*

in Fig.4, Refs. 6, 7, and 8. Pull the air valve knob until all air is exhausted from the air spring.



1. Track Assembly Lower Stud
2. Seat Track Stop
3. Belt Bar
4. Hexhead Pivot Bolt
5. Upper Base
6. Wooden Block
7. Lower Arm
8. Lower Base
9. Air Spring
10. Upper Arm
11. Belt Bar Spacer
12. Hand Pump Handle (Easy−Aire Seat)
13. Track Assembly
14. Upper Seat Assembly
15. Air Valve Knob (Cush−N−Aire Seat)
16. Connected Shaft Assembly
17. Sleeve (Bearing)
18. Snap Rings
19. 5/16−18 Locknut
20. Pin Clip
21. Bearing (Sleeve)
22. Air Spring Washer
23. Air Spring Supply Hose
24. Air Spring Retaining Ring
25. Air Spring Barbed Fitting
26. Shock Absorber Assembly



08/10/93 f910097

Fig. 4

2. Remove the seat from the vehicle as instructed **in Subject 100.**
3. Lay the seat on its side, with the wooden block still in place.
4. For an Easy-Aire seat, cut off the air spring supply hose close to the barbed 90-degree fitting at the bottom of the air spring (Refs. 23 and 25); minimize hose length loss. Remove the scrap hose from the barbed fitting, then remove the fitting from the air spring. Tape the ends of the

hose and fitting to prevent dirt or other matter from entering.

For a Cush-N-Aire seat, remove, as an assembly, the fitting and the air hose (Refs. 25 and 23) from the air spring. Tape the end of the fitting to prevent dirt or other matter from entering.

5. Pry the retaining ring (Ref. 24) from the bottom of the air spring.
6. Remove the pin clip (Ref. 20) that secures the air spring to the upper arm (Ref. 10). Remove the washer (Ref. 22) and air spring.
7. Position the new air spring in the lower base (Ref. 8), and secure it with a new retaining ring (Ref. 24).
8. Place the washer (Ref. 22) on top of the air spring, and insert the top of the air spring in the opening of the upper arm (Ref. 10). Install the pin clip (Ref. 20) on the air spring.
9. Install the air spring fitting (Ref. 25) and air hose in the bottom of the air spring.
10. Install the seat as instructed in Subject 100.
11. Work the hand pump (Easy-Aire seat), or push the air valve knob (Cush-N-Aire seat), to raise the seat. Remove the wooden block.

Base Assembly Bearing/Sleeve Replacement (Refer to Fig. 4)

1. Remove the shock absorber as instructed earlier.
2. Remove the seat as instructed **in Subject 100.**
3. For an Easy-Aire seat, cut off the air spring supply hose (Ref. 23) close to the barbed 90-degree fitting at the bottom of the air spring (Ref. 25); minimize hose length loss. Remove the scrap hose from the barbed fitting. Tape the hose and fitting ends to prevent dirt or other matter from entering.

   For either seat version, remove the four locknuts (Ref. 19) that attach the track assemblies, seat track stop, belt bar and spacers, and upper seat assembly (Refs. 13, 2, 3, 11, and 14) to the upper base (Ref. 5). Remove the upper seat assembly, track assemblies, seat track stop, and belt bar and spacers.
4. Remove the pin clip (Ref. 20) that secures the air spring to the upper arm (Ref. 10).
5. Remove the bearings and/or sleeves (Refs. 17 and 21) from the upper and lower bases and the upper and lower arms.

   5.1 If the arms are attached to the bases with pivot bolts (Ref. 4), remove all eight bolts. If the arms are attached to the bases with connected shafts held in place by snap rings (Refs. 16 and 18), use snap ring pliers to remove the four snap rings from the shaft assemblies. Then, using a drift punch, drive out the shaft assemblies from the bases.

   NOTE: Place the punch against the snap ring end of the shafts. Drive each shaft end a little at a time, as the two shafts are connected to each other on the opposite side.

   5.2 Remove the upper base, and the upper and lower arms from the air spring and lower base.

   5.3 Remove the bearings/sleeves (Ref. 21) from the upper and lower arms. Discard the bearings/sleeves.

   5.4 If so equipped, remove the sleeves/ bearings (Ref. 17) from the upper and lower bases. Discard the sleeves/ bearings.
6. Install new bearings/sleeves, as equipped.

   6.1 Install new bearings/sleeves in the upper and lower arm tubes.

   6.2 If so equipped, install new sleeves/ bearings in the upper and lower bases.

   6.3 Align the tubes of the lower and upper arms with the holes in the lower base. Be sure the notch in the lower arm is forward and up, and the notch in the upper arm is to the rear and down. See Detail *A* **in Fig.4,**

   6.4 As equipped, install and tighten the pivot bolts (Ref. 4), or install the connected shaft assembly (Ref. 16) through the lower base and the upper and lower arm forward tubes.

   6.5 Align the holes of the upper base with the rear tubes of the lower and upper arms.

6.6 As equipped, install and tighten the pivot bolts, or install the connected shaft assembly through the upper base and the upper and lower arm tubes.

6.7 For connected shaft assemblies, use snap ring pliers to install the snap rings that secure the shafts and the arms to the lower and upper bases.

7. Place the washer (Ref. 22) on the top of the air spring, and insert the top of the air spring through the upper arm. Install the pin clip (Ref. 20).

8. For an Easy-Aire seat, push the air spring supply hose (Ref. 23) onto the barbed 90-degree fitting at the bottom of the air spring (Ref. 25).

   For either seat version, set the seat base assembly upright.

9. Install the shock absorber as instructed earlier.

10. Place the belt bar and spacers, seat track stop, track assemblies, and upper seat assembly (Refs. 3, 11, 2, 13, and 14) on the upper base (Ref. 5). Install the locknuts (Ref. 19). Tighten the locknuts 20 N·m (15 lbf·ft). Remove the wooden block.

11. Install the seat as instructed **in Subject 100**.

Track Assembly Replacement

(Refer to Fig. 5)

1. For an Easy-Aire seat, work the hand pump (Ref. 21) until the upper seat assembly is raised to maximum height. Support the seat in this position by placing a wooden block between the lower base and lower arm. Refer to Detail *A* **in Fig.5,** Refs. 5, 6, and 7. Hold down the pump handle (Ref. 20) until all air is exhausted from the air spring.

   For a Cush-N-Aire seat, push the air valve knob (Detail *B* **in Fig.5,** Ref. 15) to raise the upper seat assembly to maximum height. Support the seat in this position by placing a wooden block between the lower base and lower arm. Refer to Detail *A* **in Fig.5,** Refs. 5, 6, and 7. Pull the air valve knob until all air is exhausted from the air spring.

2. Pull up and support the rear edge of the seat cushion (Ref. 19) as needed to gain access to the track assembly upper locknuts (Ref. 24).

3. For an Easy-Aire seat, remove the end of the air spring supply hose from the connection (Refs. 10 and 22) on the hand pump. Then go to step 4.

   For a Cush-N-Aire seat, remove the air valve and air hoses (Refs. 12, 10, and 18) from the seat. Refer to Detail *B* **in Fig.5.**

   3.1 Cut and remove the tie strap (Ref. 27) that attaches the air spring supply hose (Ref. 10) to the track assembly latch mechanism.

   3.2 Cut and remove the tie strap that attaches the air valve supply hose (Ref. 18) to the belt bar (Ref. 3).

   3.3 Loosen the nut (Ref. 14) that attaches the air valve to the lower frame. If needed, move the fore-and-aft adjustment lever (Ref. 26) to the right, and slide the upper seat assembly far enough forward to allow removal of the air valve.

   3.4 Remove the air valve and hoses (as an assembly), and lay them on the cab deck, behind the seat.

4. Remove the four locknuts (Ref. 24) that attach the lower frame to the top of the track assemblies. Remove the upper seat assembly (Ref. 23).

5. Remove the four locknuts (Ref. 28) that attach the track assemblies to the top of the upper base. Remove the track assemblies.

6. With the holes in the belt bar, the belt bar spacers, and the seat track stop (Refs. 3, 9, and 2) aligned with the holes in the upper base, install the new track assemblies on

   the upper base. Install and tighten the locknuts (Ref. 28) 20 N·m (15 lbf·ft).

7. Move the upper half of the track assemblies as needed to align their studs with the holes in the lower frame. Place the upper seat assembly (Ref. 23) on the track assemblies. Install and tighten the locknuts (Ref. 24) 20 N·m (15 lbf·ft).

8. For an Easy-Aire seat, connect the air spring supply hose to the connection on the hand pump (Refs. 10 and 22). Skip the following sub-steps

Component Replacement

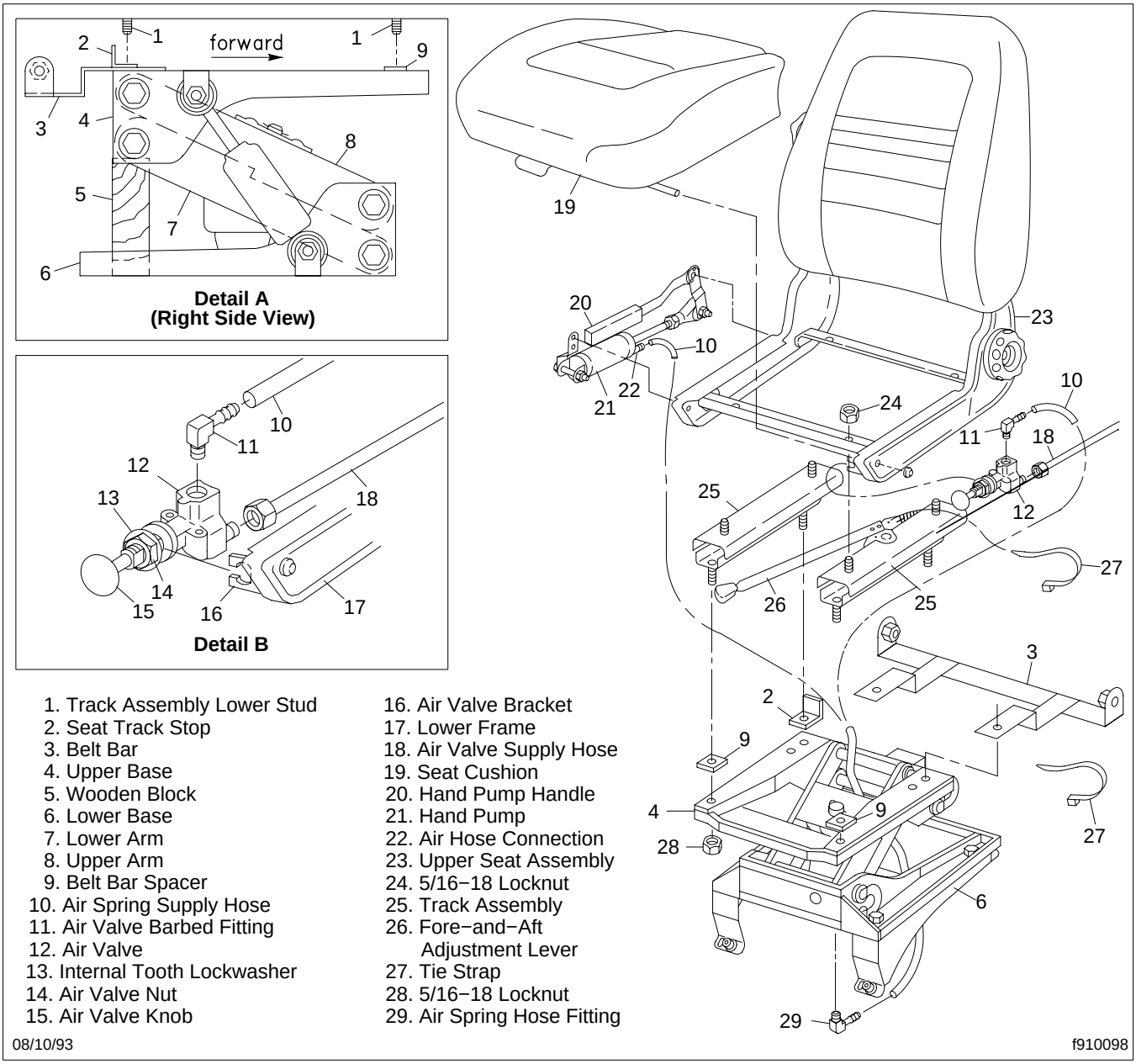


Fig. 5

for attaching the air valve and hoses on the seat, and go on.

For a Cush-N-Aire seat, install the air valve and hoses on the seat (Refs. 12, 10, and 18). Refer to Detail *B* **in Fig.5.**

8.1 Attach the air valve to the lower frame, with the lockwasher (Ref. 13) between the nut (Ref. 14) and the front of the air valve bracket (Ref. 16). Turn the air valve so its barbed fitting (Ref. 11) is on top.

8.2 Tighten the air valve nut finger-tight. Using a wrench, tighten the nut one-half turn more.

8.3 Install a new tie strap (Ref. 27) to attach the air spring supply hose (Ref. 10) to the track assembly latch mechanism.

8.4 Install a new tie strap to attach the air valve supply hose to the belt bar (Ref. 3).

9. Move the fore-and-aft adjustment lever to the right, and slide the upper seat assembly forward and rearward while making sure that the air hoses move without restriction. Return the seat cushion to its original position.

10. Work the hand pump (Easy-Aire seat), or push the air valve knob (Cush-N-Aire seat) to raise the seat. Remove the wooden block.

Specifications

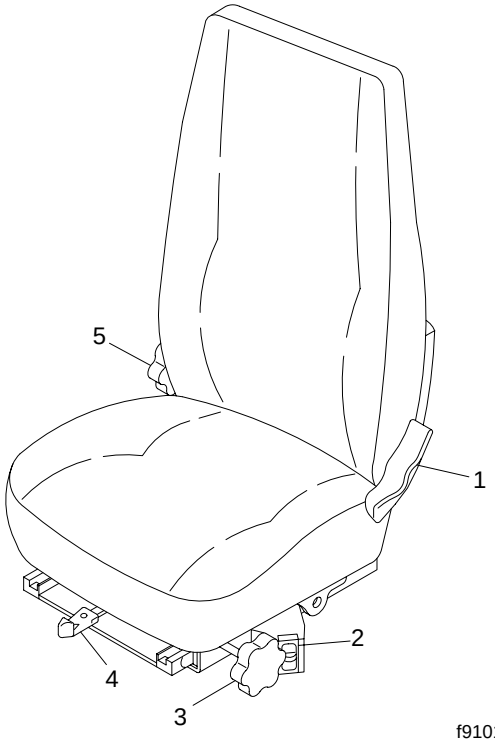
This subject contains the following table: •Fastener Torques

Description	Torque N·m (lbf·ft)
Seat Riser to Cab Deck Socket-Head Bolts	18 (13)
Seat Belt/Tether Belt to Belt Bar Bolts	54 (40)
Shock Absorber to Bracket Locknuts	34 (25)
Track Assembly to Upper Base Locknuts	20 (15)
Track Assembly to Lower Frame Locknuts	20 (15)

Table 1, Fastener Torques

General Information

The Bostrom Talladega 910 air suspension seats offer weight-height adjustment, lumbar support and a fore and aft roller track isolator system. See **Fig. 1**.

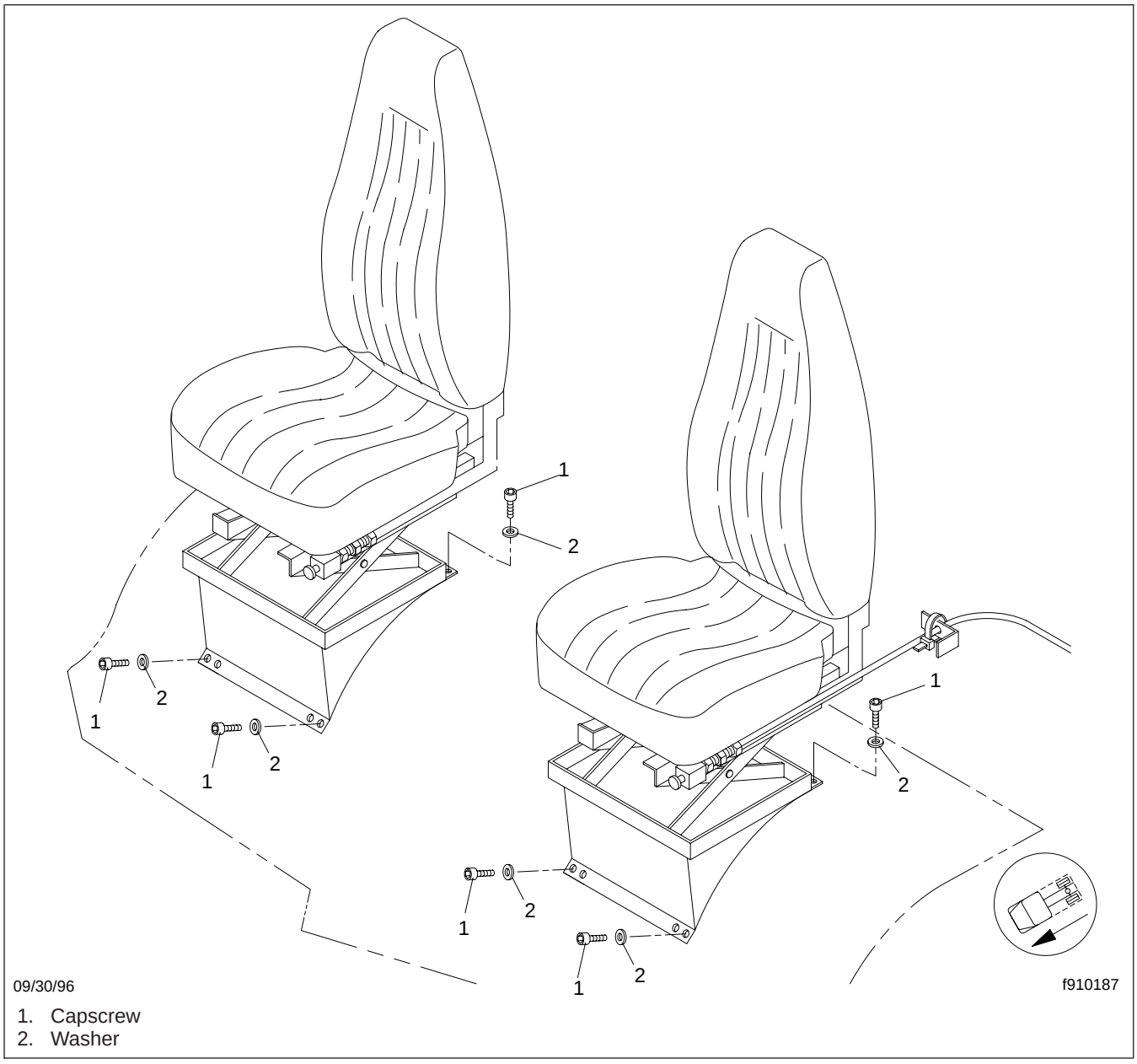


1. Back Angle Adjustment
2. Weight and Height Adjustment
3. Seat Cushion Tilt Adjustment
4. Fore and Aft Isolation and Seat Position Adjustment
5. Lumbar Adjustment

Fig. 1, Bostrom Talladega 910 Seat

For complete operating instructions, refer to the vehicle driver's manual.

Removal (See Fig. 1)



1. Capscrew
2. Washer

Fig. 1, Seat Installation

1. Apply the parking brakes, and chock the tires.
2. Push in on the top of the seat ride height switch until the seat is adjusted to its maximum height.
3. Cut a wooden block to the length required to support the seat at its maximum height, and

Seat Removal and Installation

place the block between the rear crossbars of the air suspension's inner and outer lever assemblies.

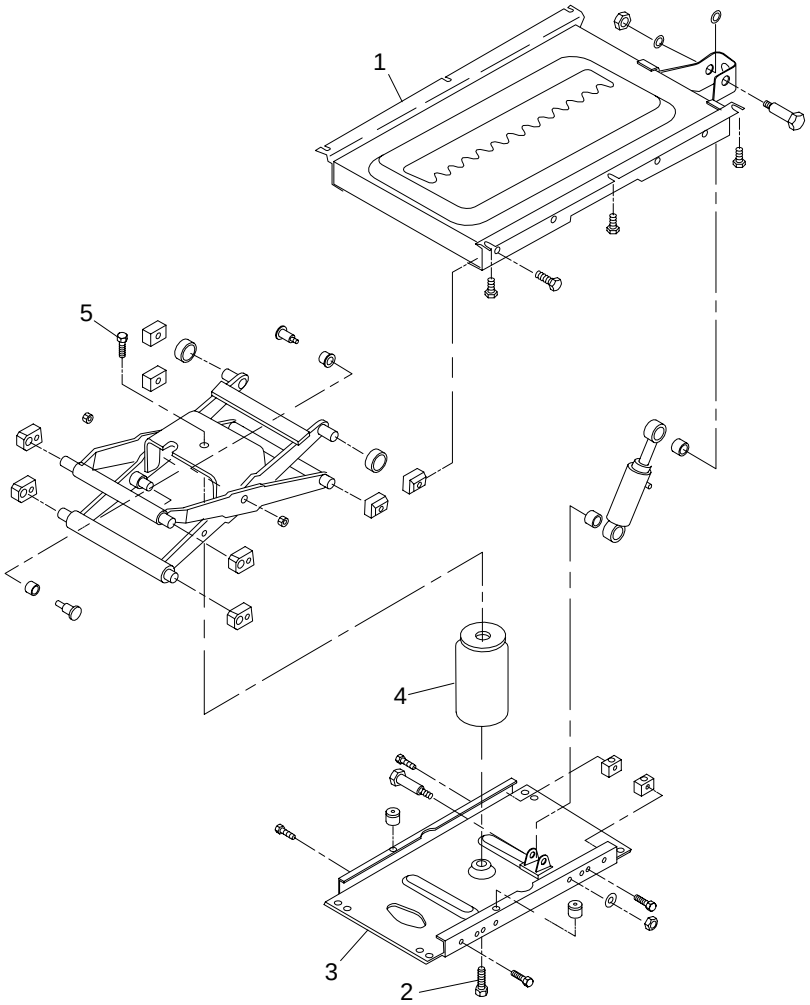
4. Drain the vehicle air reservoirs. Then push in on the bottom of the seat ride height rocker switch until all air is exhausted from the air spring.
5. Disconnect the air valve air supply hose at the quick-connect union.
6. Remove the seat belt straps and tether straps.
7. Remove the capscrews and washers that attach the seat to the cab deck. Remove the seat from the cab.

Installation (See Fig. 1)

1. Place the seat on the cab deck. Insert the capscrews through the washers and the seat base. Tighten the capscrews 27 lbf·ft (37 N·m).
2. Attach the seat belt straps and tether straps. Tighten the capscrews 40 lbf·ft (54 N·m).
3. Connect the air valve air supply hose by pressing the pneumatic tubing into the quick-connect union.
4. Start the engine and allow the air reservoirs to fill. Push in on the top of the seat ride height rocker switch until the seat is adjusted to its maximum height, then remove the wooden block that supports the seat suspension.
5. Remove the chocks from the tires.

Air Spring Removal and Installation

Removal (See Fig. 1)



10/04/96 f910196

1. Upper Frame
2. Bottom Screw
3. Base
4. Air Spring
5. Top Screw

Fig. 1, Bostrom Talladega 910 Seat

1. Fill the air spring so that the seat is at maximum height.
2. Block the suspension up with a spacer placed between the base and the upper frame.
3. Release the air pressure from the air spring so that the seat is supported by the spacer.
4. Remove the complete seat assembly from the vehicle using the instructions in **Subject 100**.
5. Disconnect the air line from the air spring by loosening the fitting and pullling the air line out of the fitting.
6. Remove the top and bottom screws from the air spring.
7. Remove the air spring from the suspension.

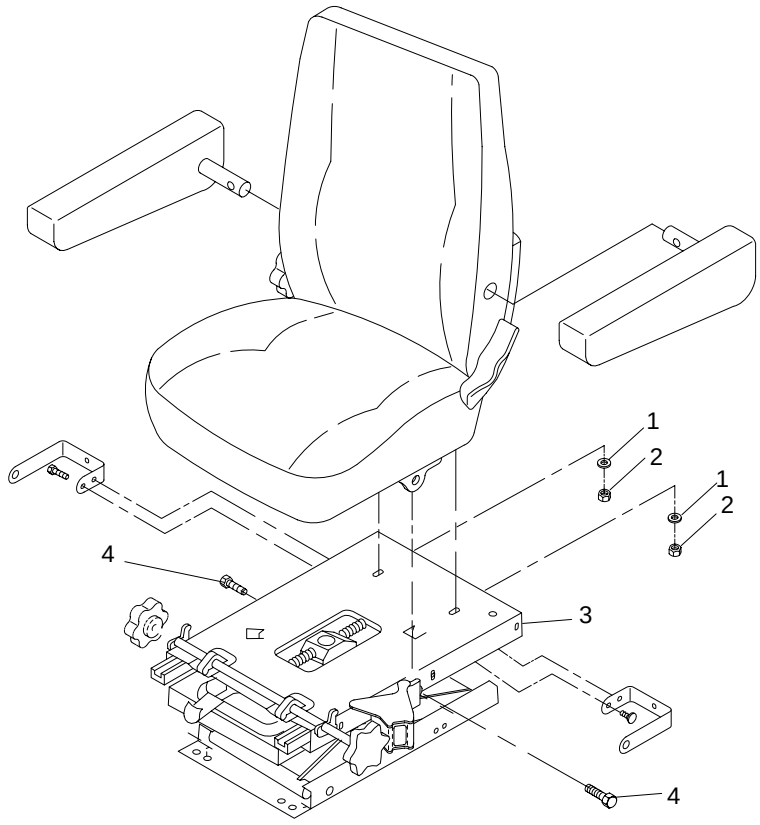
Air Spring Removal and Installation

Installation (See Fig. 1)

1. Position the air spring so the fitting at the bottom of the air spring is toward the front of the seat. Install the bottom screw into the air spring.
2. Tighten the bottom screw 9 to 11 lbf·ft (12 to 15 N·m).
3. Install the top screw and tighten it 15 to 19 lbf·ft (20 to 26 N·m).
4. Connect the air line to the fitting in the air spring by pushing the tube into the fitting.
5. Install the seat assembly in the vehicle, using the instructions in **Subject 100**.
6. Fill the air spring and remove the spacer block.

Seat/Back Assembly Removal and Installation

Removal (See Fig. 1)



1. Flatwasher
2. Nut
3. Channel Assembly
4. Shoulder Bolt

Fig. 1, Bostrom Talladega 910 Seat

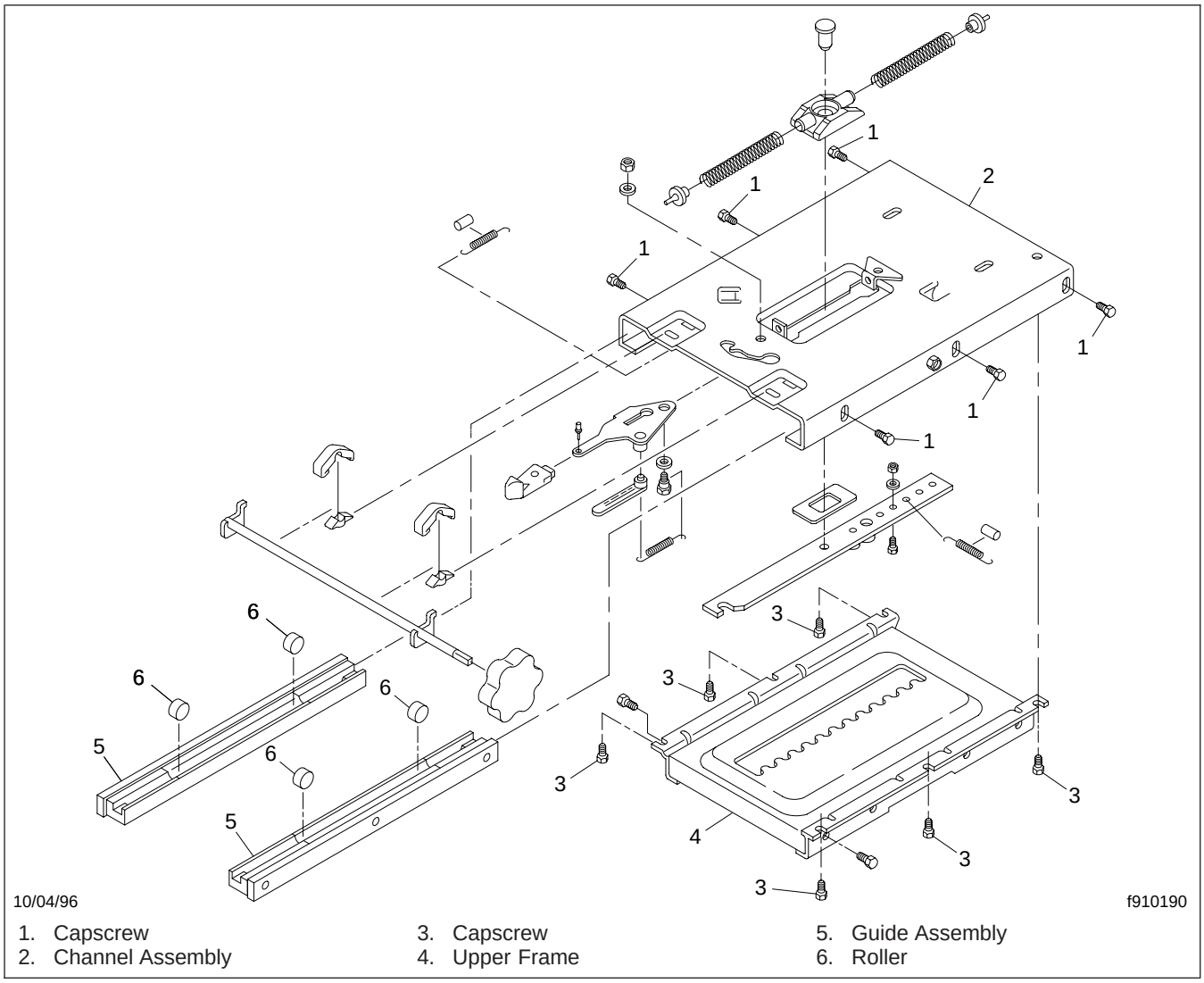
1. Adjust the seat/back assembly to the most rearward position and remove the two nuts and flatwashers from the underside of the channel assembly.
2. Remove the two shoulder bolts from the channel assembly.
3. Disconnect the air line from the air lumbar, if equipped.
4. Remove the seat/back assembly.

Installation (See Fig. 1)

1. Place the seat/back assembly onto the channel assembly.
2. Connect the air line to the air lumbar, if equipped.
3. Install the two shoulder bolts to the channel assembly.
4. Install the two nuts and flatwashers to the underside of the channel assembly.

Roller Guide Removal and Installation

Removal (See Fig. 1)



1. Capscrew
2. Channel Assembly
3. Capscrew
4. Upper Frame
5. Guide Assembly
6. Roller

Fig. 1, Channel Assembly (exploded)

1. Adjust the channel assembly until the cutouts in the underside of the channel line up with the capscrews. Remove the capscrews.
2. Remove the three capscrews on each side of the channel assembly.
3. Remove both guide assemblies and the four rollers.

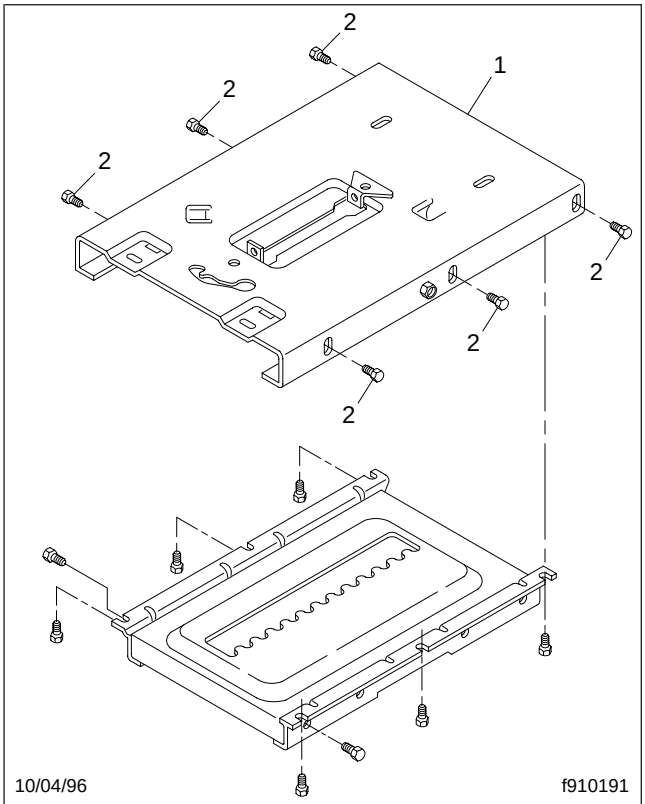
Installation (See Fig. 1)

1. Install both guide assemblies and the four rollers.
2. Install the three capscrews on each side of the channel assembly. Do not fully tighten the capscrews.

Roller Guide Removal and Installation

3. Install the center capscrews on the underside of the channel assembly. Tighten the capscrews 5 to 7 lbf·ft (7 to 9 N·m).
4. Carefully move the assembly rearward and install the front capscrew. Move the assembly forward and install the rear capscrew. Tighten the capscrews 5 to 7 lbf·ft (7 to 9 N·m).
5. Tighten the capscrews on the side of the channel assembly 5 to 7 lbf·ft (7 to 9 N·m).
6. Adjust the channel assembly using the instructions in **Subject 140**.

Adjustment (See Fig. 1)

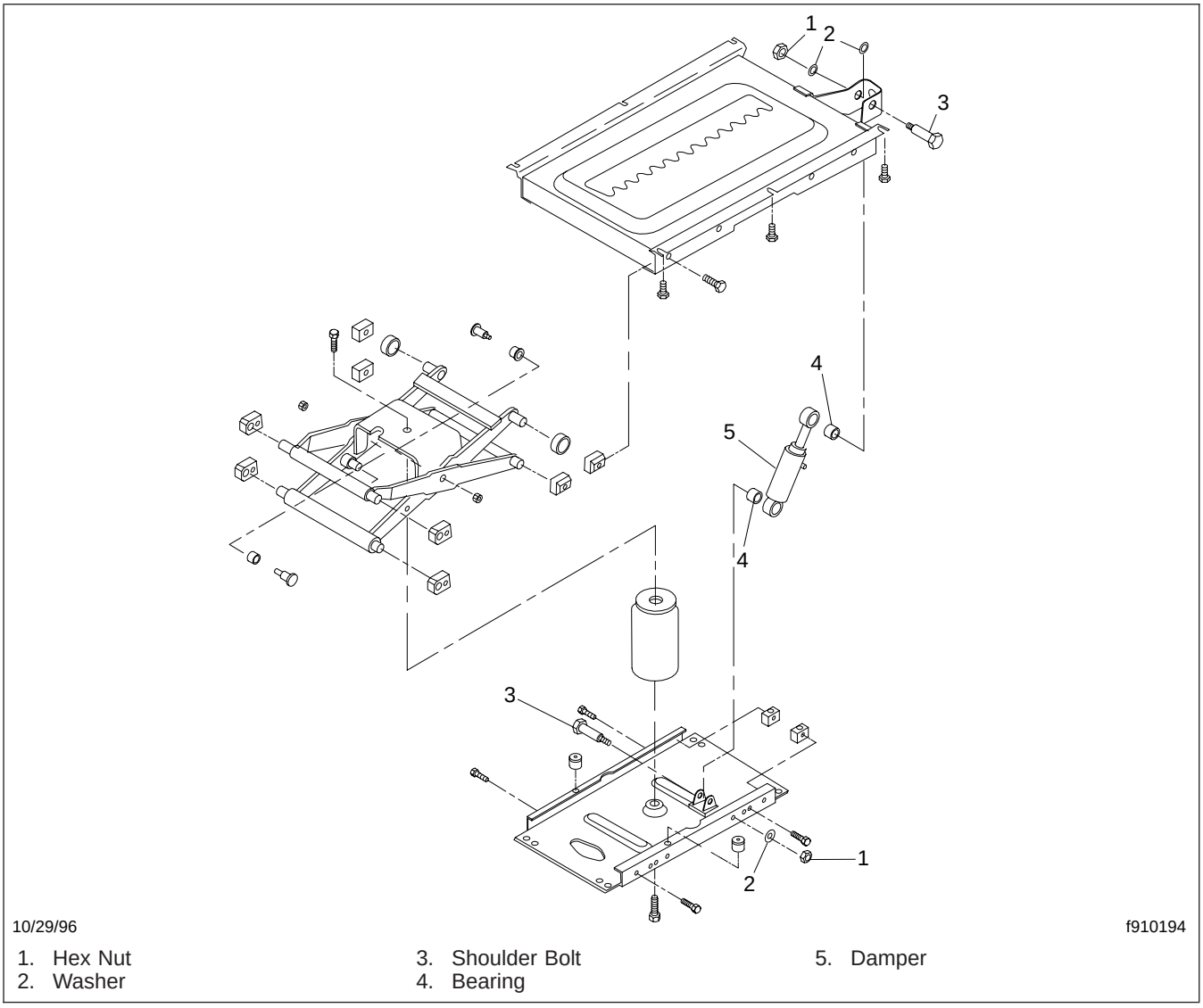


1. Channel Assembly
2. Capscrew

Fig. 1, Bostrom Talladega 910 Seat

1. Loosen the six capscrews along the side of the channel assembly.
2. Push down on the channel assembly to adjust vertical play.
3. Retighten the six capscrews. Tighten the capscrews 5 to 7 lbf·ft (7 to 9 N·m).

Removal (See Fig. 1)



1. Hex Nut
2. Washer
3. Shoulder Bolt
4. Bearing
5. Damper

Fig. 1, Bostrom Talladega 910 Seat

NOTE: The seat/back assembly does not need to be removed.

1. Move the channel assembly to the rearmost position to provide access to the damper assembly.
2. Fill the air spring so that the seat is at maximum height.
3. Remove the shoulder bolts and hex nuts.
4. Remove the damper.

Installation (See Fig. 1)

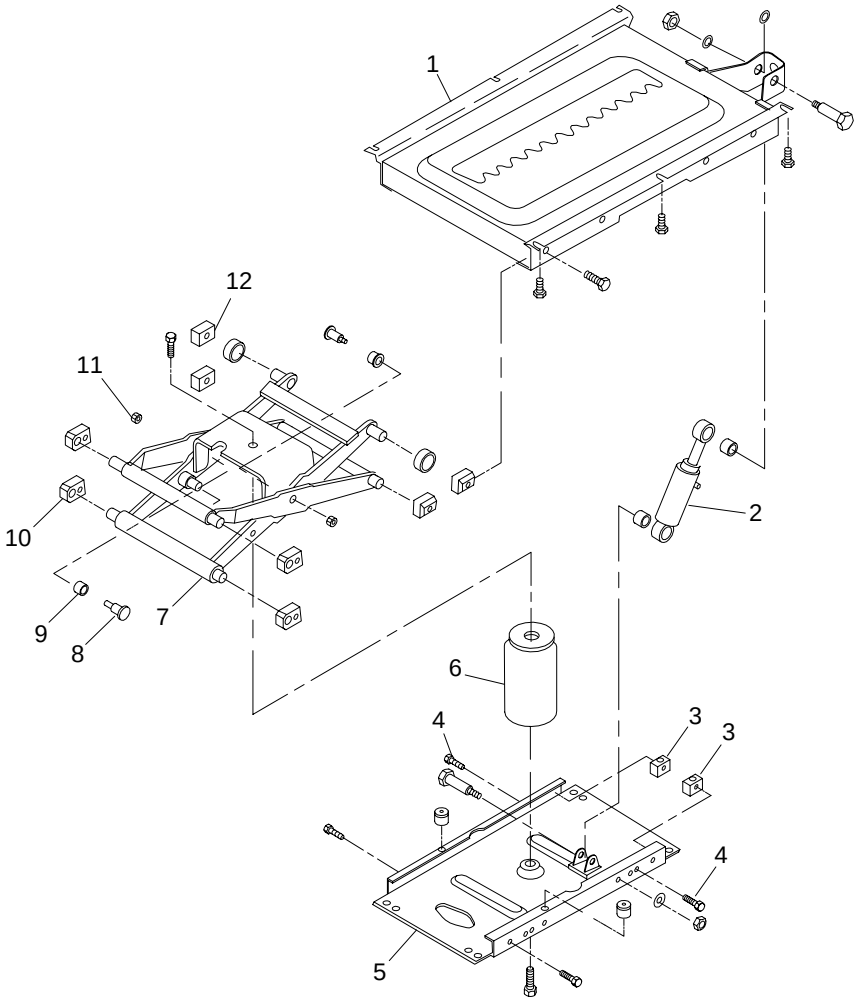
1. Install the new damper with the flanges of the bearings to the outside of the suspension.
2. Install the thrust washers.

Damper Removal and Installation

3. Install the shoulder bolts and hex nuts.

Suspension Rebuild Bearing/Slide Block Removal and Installation

Removal (See Fig. 1)



10/04/96 f910195

1. Upper Frame
2. Damper
3. Stop Block
4. Capscrew
5. Base
6. Air Spring
7. Slide Lever Assembly
8. Shoulder Bolt
9. Bearing
10. Bearing Block
11. Nut
12. Slide Block

Fig. 1, Bostrom Talladega 910 Seat Suspension (exploded)

1. Bleed all the air from the supply line. Disconnect the air supply line to the seat. Using the air valve, exhaust all air from the air spring. Remove the complete seat assembly from the vehicle using the instructions in **Subject 100**.
2. Remove the seat/back assembly, using the instructions in **Subject 120**.
3. Remove the capscrews and the ICP bracket.
4. Block the suspension up with a spacer placed between the base and the upper frame.
5. Remove the air spring using the instructions in **Subject 110**. Mark the air line for reassembly.

Suspension Rebuild Bearing/Slide Block Removal and Installation

6. Remove the damper using the instructions in **Subject 150**.
7. Remove the capscrews from the upper front bearing blocks and the lower rear stop block assemblies.
8. Remove the upper frame assembly by lifting and sliding it forward off the bearing blocks and the slide blocks.
9. Remove the capscrews from the lower front bearing blocks and slide the lever assemblies forward until the bearing blocks are removed from the channel on the base. Slide the lever assemblies rearward to remove the slide blocks from the channel.
10. Remove the shoulder bolts and nuts from the pivots of the lever assemblies and inspect the bolts. If the bolts are worn, replace them.

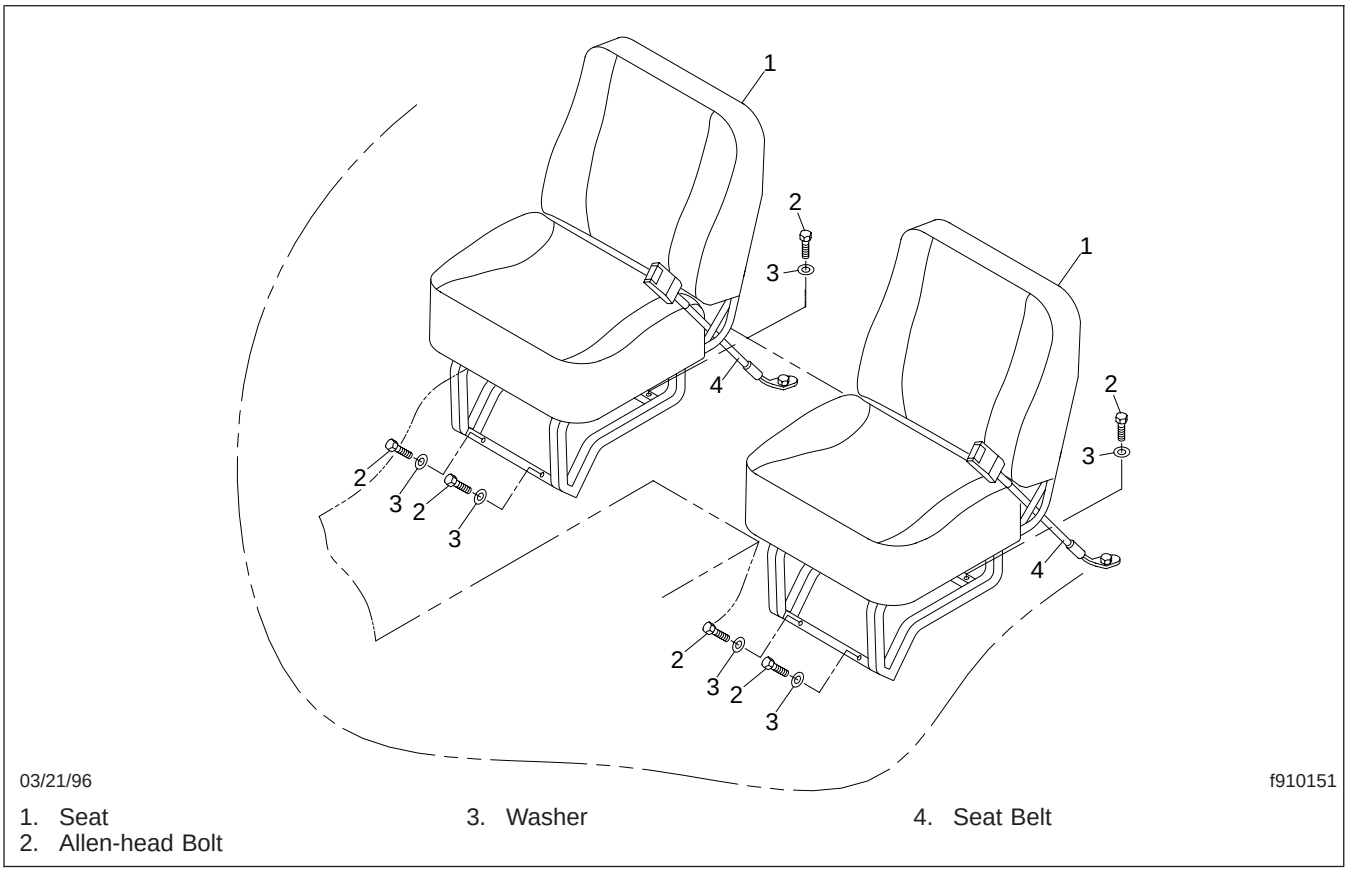
Installation (See Fig. 1)

1. Replace the bearings at the pivots on the lever assembly by pushing out the old bearings and pressing in the new bearings. The flange of the bearings should be on the outside of the lever assembly.
2. Install the shoulder bolts and nuts into the pivots of the lever assemblies. Tighten the bolts 18 to 22 lbf·ft (24 to 30 N·m).
3. Install the new bearing blocks, spacers, and slide blocks on the levers with the beveled surfaces outward and slide the levers with blocks into the channel on the base. Tighten the screws 27 to 33 lbf·ft (37 to 45 N·m).
4. Slide the upper frame assembly over the blocks. Line up the capscrews with the bearing blocks and tighten the screws 27 to 33 lbf·ft (37 to 45 N·m).
5. Manually move the suspension up and down to make sure there are no clearance problems.
6. Block the suspension up with a spacer placed between the base and the upper frame. Install the air spring using the instructions in **Subject 110**.
7. Install the damper using the instructions in **Subject 150**.
8. Install the ICP bracket and capscrews.
9. Install the seat/back assembly using the instructions in **Subject 120**.
10. Install the seat assembly in the vehicle, using the instructions in **Subject 100**. Connect the air supply line to the seat.

Bostrom Tube Frame Seat Removal and Installation

Removal

1. Remove the four allen-head bolts attaching the seat frame to the deck of the cab.
2. Pull the seat belt from the rear of the seat frame assembly. See **Fig. 1.**



1. Seat
2. Allen-head Bolt
3. Washer
4. Seat Belt

Fig. 1, Bostrom Tube Frame Seat Assembly

3. Lift the seat from the cab deck.

Installation

1. Place the seat on the cab deck.
2. Secure the seat to the deck with the bolts and the washers. See **Fig. 1**.
3. Tighten the bolts.
4. Insert the seat belt through the rear of the seat frame assembly.

General Information

Although the three-point seat belts installed in Freightliner vehicles (See **Fig. 1**) appear similar to the seat belts used in passenger cars, there are some important differences that can affect service life.

- A heavy truck can travel more miles in a year than a car might go in its lifetime.
- There is more movement in truck seat and belt systems, especially with air ride seats.
- Trucks often operate in more severe environments than cars, such as gravel pits, cement plants, and grain elevators, where the belts are exposed to abrasive dirt and dust.

Because of these factors, truck seat belt systems need to be inspected regularly to ensure that they are in proper condition.

⚠ WARNING

WARNING: Inspect and maintain seat belts. Worn or damaged seat belts could fail during a sudden stop or crash, possibly resulting in serious personal injury or death.

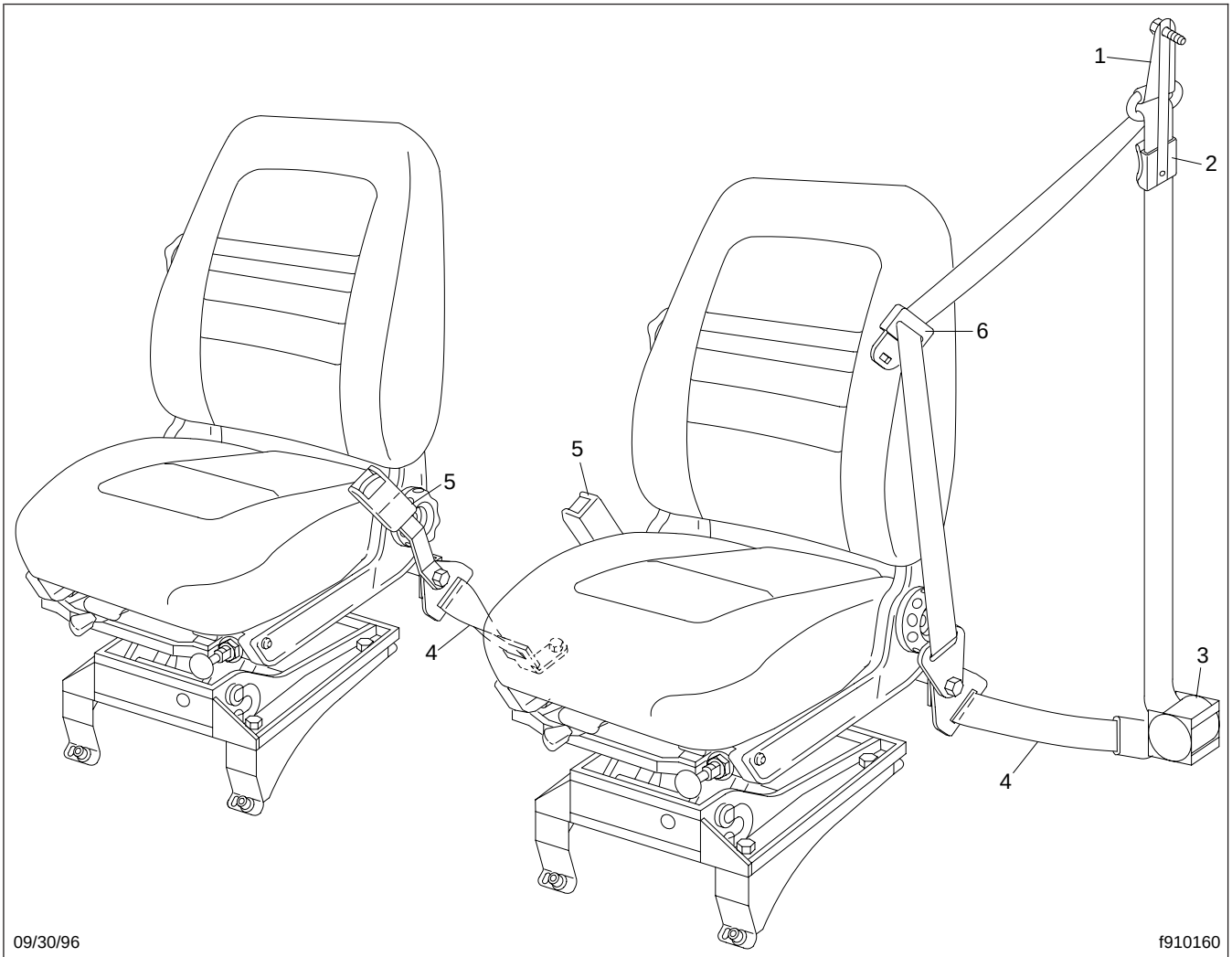
⚠ CAUTION

CAUTION: Any time a vehicle is involved in an accident, the entire vehicle seat belt system must be replaced before again operating the vehicle.

IMPORTANT: When any part of a seat belt system needs replacement, the entire seat belt must be replaced, both retractor and buckle side.

IMPORTANT: Seat belts have a finite life which may be much shorter than the life of the vehicle. Regular inspections and replacement as needed are the only assurance of adequate seat belt security over the life of the vehicle.

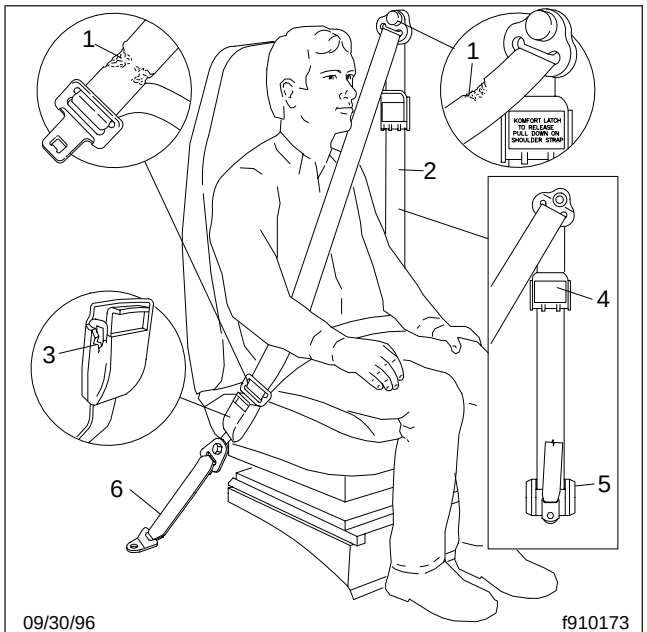
General Information



1. Pillar Loop Web Guide
2. Komfort Latch™
3. Retractor
4. Tether
5. Buckle
6. Latch

Fig. 1, Three-Point Seat Belt System

Inspection (See Fig. 1)



1. Worn Web
2. Web
3. Buckle
4. Komfort Latch
5. Retractor
6. Tether Belt

Fig. 1, Seat Belt Inspecting

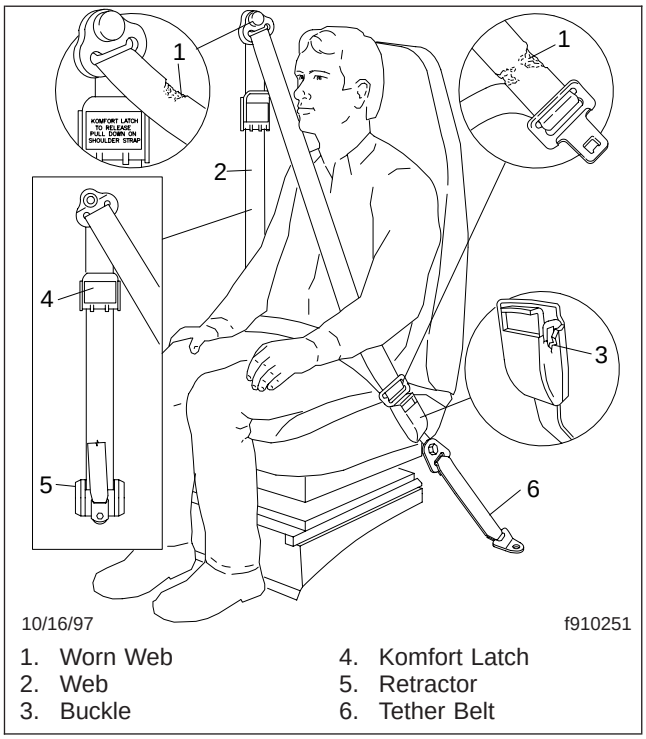
IMPORTANT: Seat belts have a finite life which may be much shorter than the life of the vehicle. Regular inspections and replacement as needed are the only assurance of adequate seat belt security over the life of the vehicle.

Inspect the seat belts and tether belts (if so equipped). For right-hand-drive vehicles, see **Fig. 2**.

⚠ WARNING

Inspect and maintain seat belts as instructed below. Worn or damaged seat belts could fail during a sudden stop or crash, possibly resulting in serious personal injury or death.

1. Check the web for fraying, cuts, or extreme wear, especially near the buckle latch plate and in the D-loop guide area.
2. Check the web for extreme dirt or dust, and for severe fading from exposure to sunlight.



1. Worn Web
2. Web
3. Buckle
4. Komfort Latch
5. Retractor
6. Tether Belt

Fig. 2, Seat Belt Inspecting (right-hand-drive vehicle)

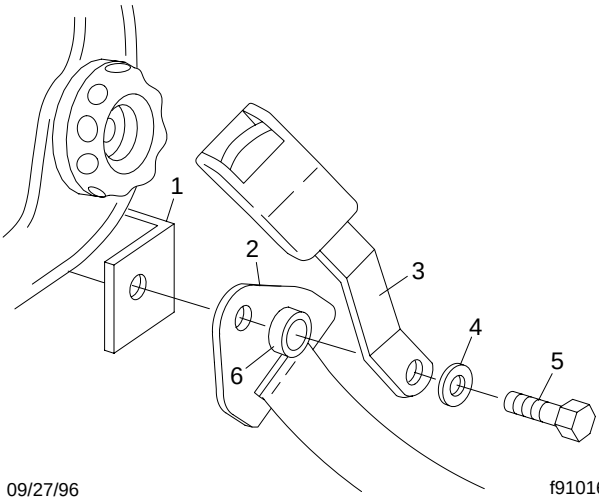
3. Check the buckle and latch for operation and for wear or damage.
4. Check the Komfort Latch™ for function and cracks or other damage.
5. Check the web retractor for function and damage.
6. Check the mounting bolts for tightness, and tighten any that are loose.

IMPORTANT: When any part of a seat belt system needs replacement, the entire seat belt must be replaced, both retractor and buckle side.

Seat Belts and Tethers Removal and Installation

Suspension Seat Removal

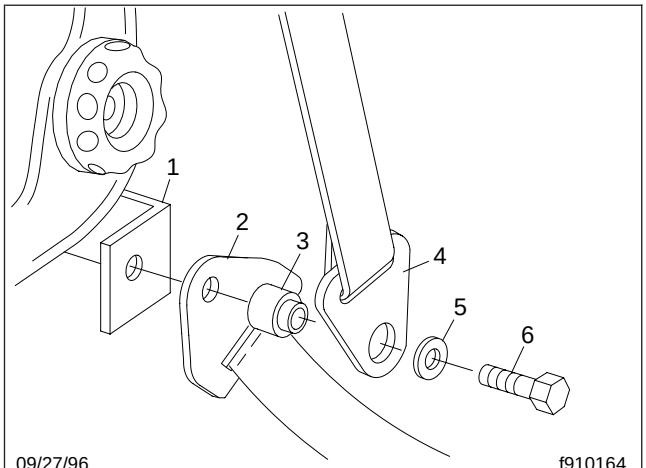
1. Apply the parking brakes, and chock the tires.
2. Remove the bolt and washer holding the buckle, the spacer, and the tether to the seat. Also remove the bolt holding the tether to the floor. Remove the buckle and the tether. See **Fig. 1**.



1. Mounting Bracket
2. Tether
3. Buckle
4. Washer
5. Bolt
6. Spacer

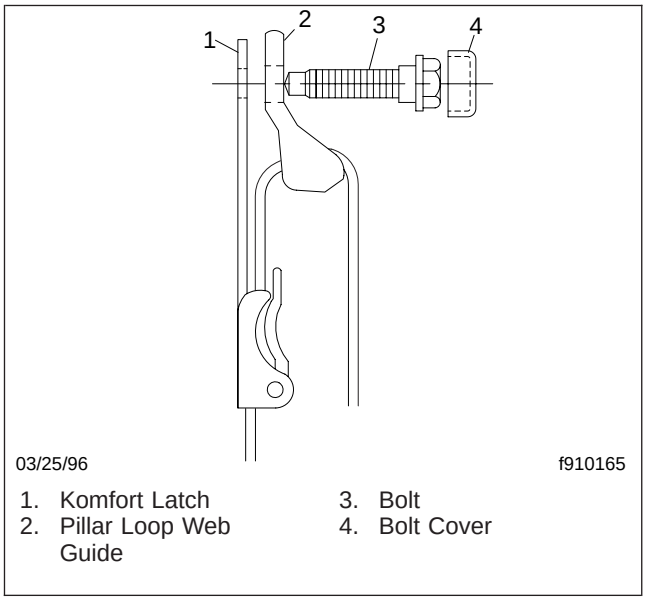
Fig. 1, Buckle Mounting

3. Remove the bolt and washer holding the seat belt, the spacer, and the inboard tether to the seat. Remove the seat belt and the tether. See **Fig. 2**.
4. Remove the bolt cover and the bolt holding the pillar loop web guide and the Komfort Latch. Remove the pillar loop web guide and the Komfort Latch™. See **Fig. 3**.
5. Remove the bolt and washer holding the outboard tether, the spacer, and the grab handle. See **Fig. 4**.
6. Remove the trim panel. Remove the bolt and washer holding the retractor. Remove the retractor.



1. Mounting Bracket
2. Tether
3. Spacer
4. Seat Belt
5. Washer
6. Bolt

Fig. 2, Seat Belt Mounting



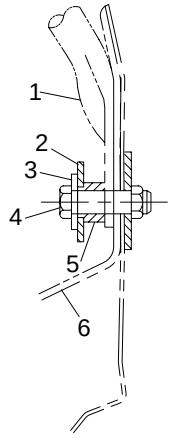
1. Komfort Latch
2. Pillar Loop Web Guide
3. Bolt
4. Bolt Cover

Fig. 3, Pillar Loop Web Guide and Komfort Latch Mounting

Suspension Seat Installation

1. Attach the retractor by inserting the bolt and washer through the retractor. Tighten 40 lbf·ft (54 N·m). Install the trim panel.

Seat Belts and Tethers Removal and Installation



03/25/96 f910166

1. Grab Handle
2. Tether
3. Washer
4. Bolt
5. Spacer
6. Trim Panel

Fig. 4, Outboard Tether Mounting

IMPORTANT: The retractor must be mounted correctly before the web will reel out of the retractor and function properly.

2. Insert the bolt and washer through the outboard tether, the spacer, and the grab handle. Tighten 40 lbf·ft (54 N·m). See **Fig. 4**.

NOTE: Install the tether belt marked "IN" on the inboard side of the seat and the tether belt marked "OUT" on the outboard side of the seat.

3. Attach the pillar loop web guide. See **Fig. 3**.

   3.1 Insert a bolt through the pillar loop web guide, the Komfort Latch™, and an optional metal spacer.

   NOTE: Some applications require a metal spacer to move the Komfort Latch/pillar loop web guide away from the vehicle cab trim (and some applications do not utilize the Komfort Latch).

   3.2 Thread the bolt into the anchor nut provided in the pillar.

   3.3 Tighten the bolt 40 lbf·ft (54 N·m). The Komfort Latch must be mounted vertically in line with the belt and remain rigid after tightening.

   IMPORTANT: The pillar loop web guide must rotate freely after assembly of the system.

   3.4 Snap the bolt cover in place over the bolt head.

4. Attach the seat belt by inserting a bolt through the seat belt, a metal spacer, the tether, and the mounting bracket. Secure with a nut. Tighten 40 lbf·ft (54 N·m). See **Fig. 2**.

5. Attach the buckle by inserting the bolt and washer through the buckle, the tether, and the mounting bracket. Secure with a nut. Tighten 40 lbf·ft (54 N·m). See **Fig. 1**.

6. Attach the inboard tether by inserting the bolt through the tether and into the weldnut provided in the cab floor. Tighten 40 lbf·ft (54 N·m).

7. Remove the chocks from the tires.

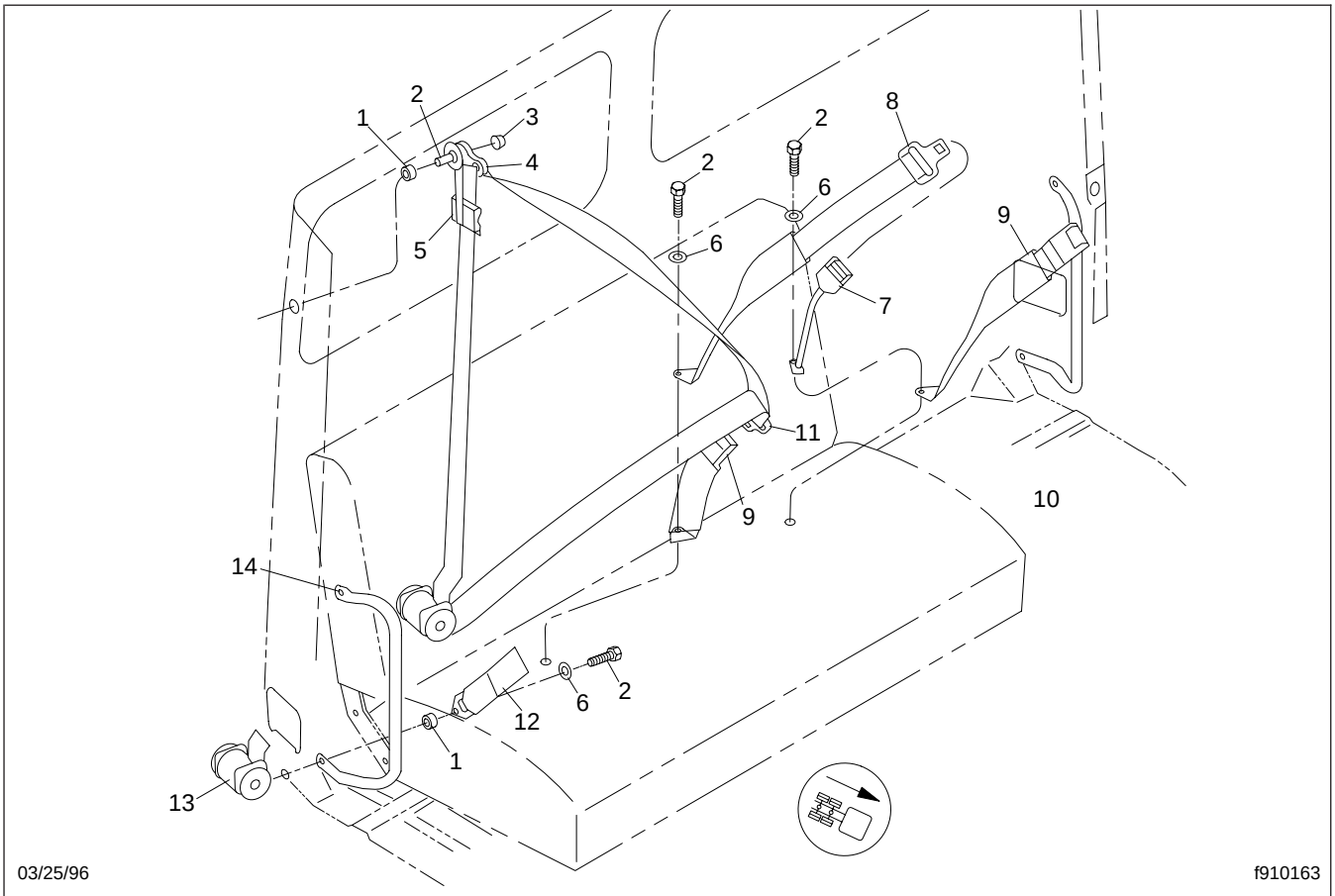
Bench Seat and Static Seat Removal (See Fig. 5)

1. Apply the parking brakes and chock the tires.
2. Remove the bolt and washer holding the buckle (Ref. 9) and the center belt latch (passenger side with bench seat only) or the center belt buckle (driver side with bench seat only). Remove the buckle.
3. Remove the bolt and washer holding the seat belt (Ref. 12) and the grab handle (Ref. 14).
4. Remove the bolt cover. Remove the bolt and washer holding the pillar loop web guide and the Komfort Latch™. Remove the pillar loop web guide and the Komfort Latch.
5. Remove the trim panel. Remove the bolt and washer holding the retractor. Remove the retractor.

Bench Seat and Static Seat Installation (See Fig. 5)

1. Attach the retractor by inserting the bolt and washer through the retractor. Tighten 40 lbf·ft (54 N·m). Install the trim panel.

Seat Belts and Tethers Removal and Installation



NOTE: Driver side retractor and belt not shown.

1. Spacer
2. Bolt
3. Bolt Cover
4. Pillar Loop Web Guide
5. Komfort Latch™
6. Washer
7. Center Belt Buckle
8. Center Belt Latch
9. Buckle
10. Bench Seat
11. Passenger Side Latch
12. Seat Belt
13. Retractor
14. Grab Handle

Fig. 5, Bench Seat Seat Belt Mounting

IMPORTANT: The retractor must be mounted correctly before the web will reel out of the retractor and function properly.

2. Attach the seat belt by inserting the bolt and washer through the belt, the spacer, and the grab handle. Tighten 40 lbf·ft (54 N·m).
3. Attach the pillar loop web guide. See **Fig. 3**.
   - 3.1 Insert a bolt through the pillar loop web guide, the Komfort Latch™, and an optional metal spacer.

NOTE: Some applications require a metal spacer to move the Komfort Latch/pillar loop web guide away from the vehicle cab trim (and some applications do not utilize the Komfort Latch).

- 3.2 Thread the bolt into the anchor nut provided in the pillar.
- 3.3 Tighten the bolt 40 lbf·ft (54 N·m). The Komfort Latch must be mounted vertically in line with the belt and remain rigid after tightening.

Seat Belts and Tethers Removal and Installation

IMPORTANT: The pillar loop web guide must rotate freely after assembly of the system.

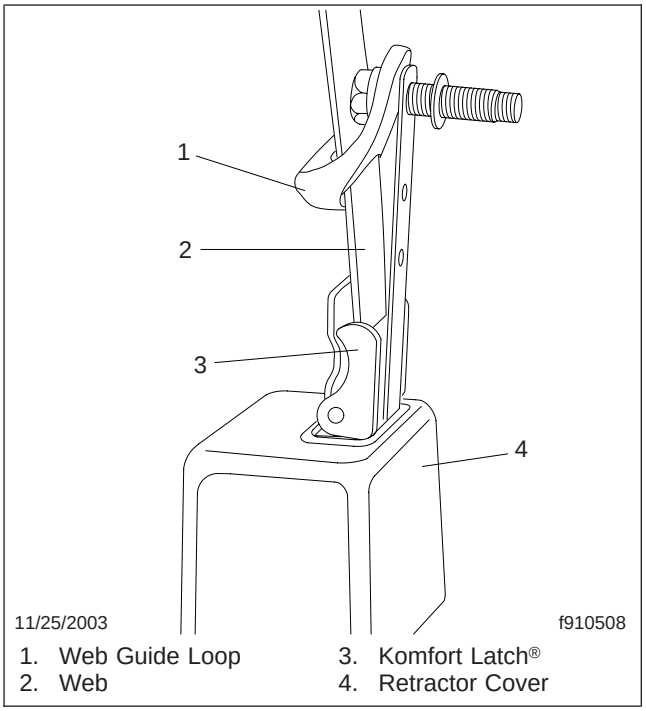
3.4 Snap the bolt cover in place over the bolt head.

4. Attach the buckle by inserting the bolt and washer through the center belt latch (passenger side) or center belt buckle (driver side) and the buckle. Tighten 40 lbf·ft (54 N·m).
5. Remove the chocks from the tires.

Unlocking an Installed Retractor

Seat belt retractors are locking up and preventing the webbing from being extracted. This condition is known as reverse lock-up and is caused by excessive webbing spooling into the retractor before installation in the vehicle.

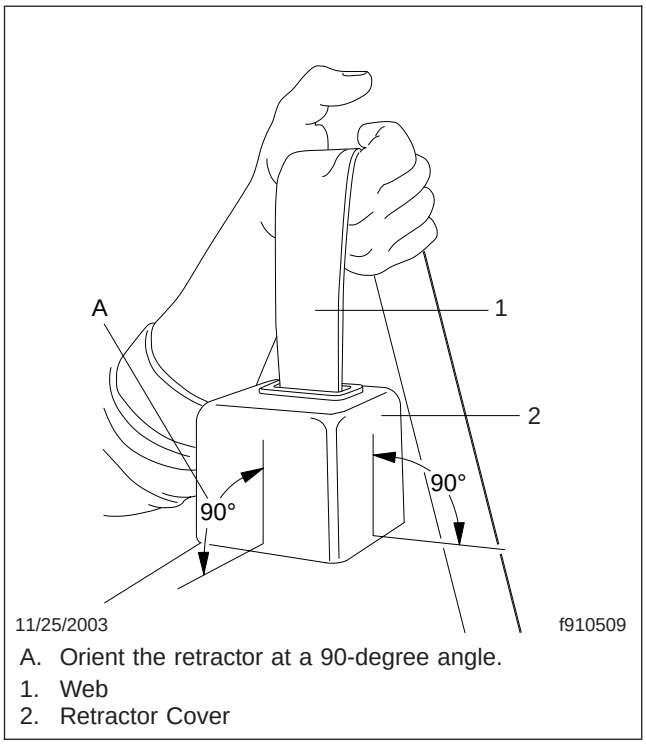
1. Park the vehicle, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Verify that the retractor is mounted in the 90-degree position. See **Fig. 1**.
3. Firmly grasp the web close to the retractor. See **Fig. 2**.



1. Web Guide Loop
2. Web
3. Komfort Latch®
4. Retractor Cover

Fig. 1, Retractor in the 90-Degree Position

4. Pull on the web with enough force to tighten the web onto the spool until the webbing locks back onto the retractor. The retractor should unlock when tension is released.
5. Remove the chocks from the tires.



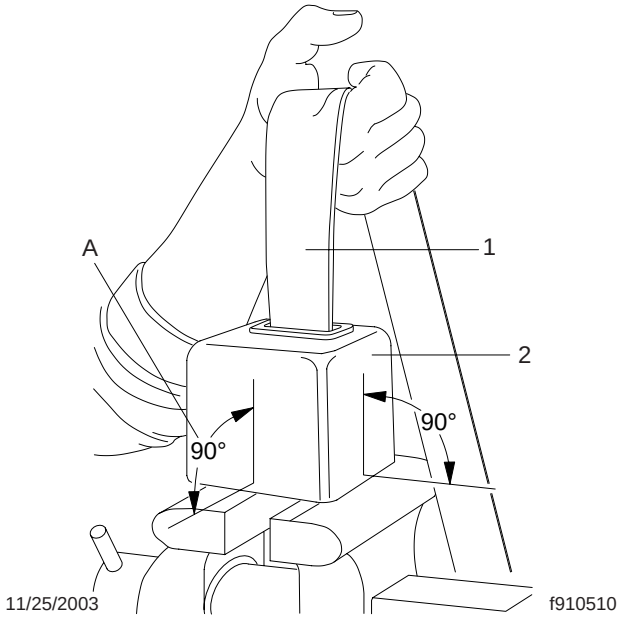
A. Orient the retractor at a 90-degree angle.
1. Web
2. Retractor Cover

Fig. 2, Firmly Grasp the Webbing

Unlocking an Uninstalled Retractor

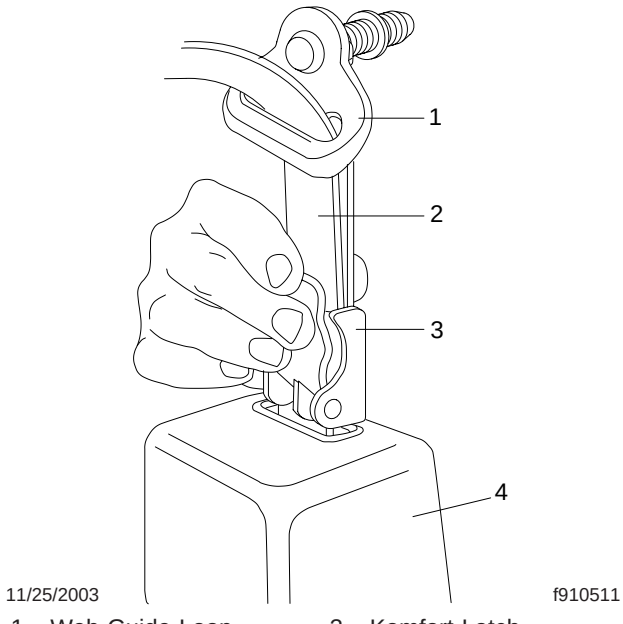
1. Clamp the retractor in a vice at a 90-degree angle. See **Fig. 3**.
2. Pull on the web with enough force to tighten the web onto the spool.
3. Release the web. This allows 1/2-inch (12.7-mm) of the webbing to feed back into the retractor storage housing and unlock the retractor.
4. Pull all the webbing out of the retractor, and allow only 12 to 15 inches (304 to 381 mm) to retract. Lock the Komfort Latch on the web. See **Fig. 4**.

Seat Belt Retractor Unlocking



A. Retractor oriented at a 90-degree angle.
1. Web
2. Retractor Cover

Fig. 3, Place the Retractor in a Vice



1. Web Guide Loop
2. Web
3. Komfort Latch
4. Retractor Cover

Fig. 4, Lock the Komfort Latch

Troubleshooting

Replace the entire seat belt system if any of the following problems exist. See the instructions in **Section 110**.

- cuts, fraying, or extreme wear of any area of the web (shoulder or lap belt)
- buckle and latch do not engage with a solid sounding "click" or do not release freely when the button is pushed
- Komfort Latch™ is broken or does not lock in place easily and does not release by tugging downward on the webbing
- retractor locks up at improper times or web does not flow freely to and from the retractor while vehicle is not moving
- seat belt web has been exposed to extreme sun light, dust, or dirt, causing the web color to fade and deterioration of web physical strength
- molded plastic around the buckle is deformed, cracked, or broken, exposing the internal mechanism
- molded plastic cover around the retractor is cracked or broken, exposing the internal mechanism or stored web
- metal or molded plastic area of latch is deformed, cracked, corroded, or broken
- molded plastic D-loop is deformed, cracked, or broken

If any of the following problems exist, see the instructions in **Section 110** for replacement, adjustment, tightening and torque requirement. Replace hardware with authorized parts.

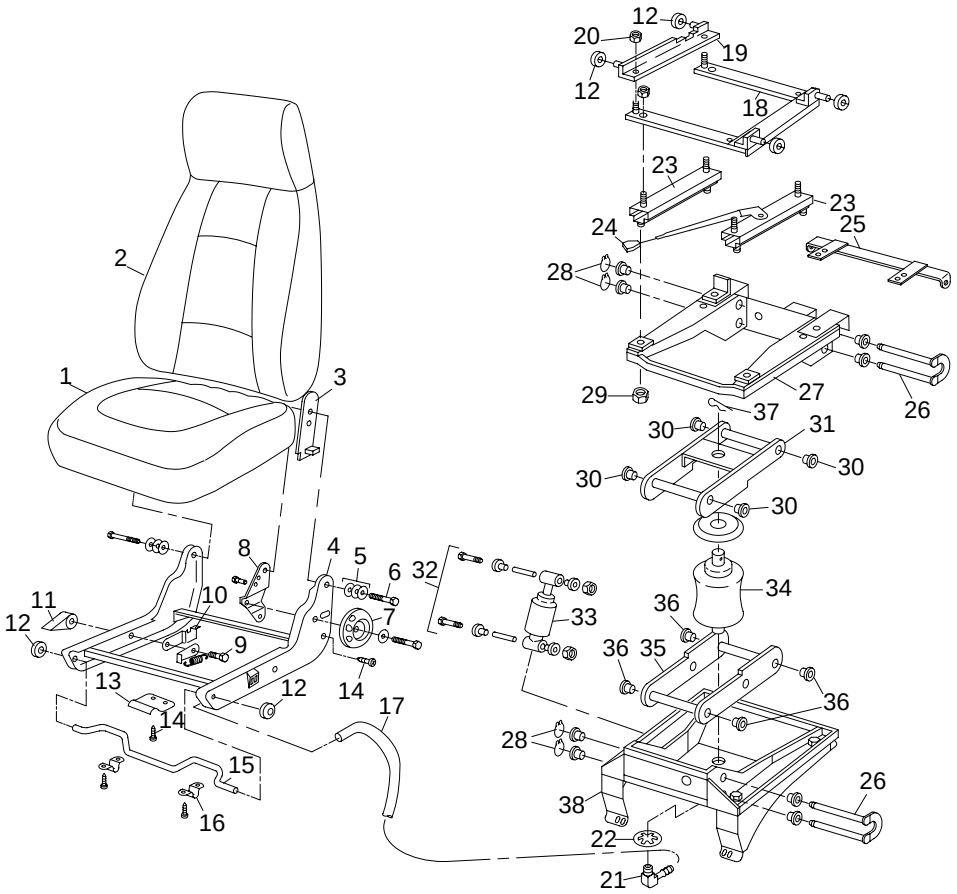
- tethers are missing, not attached to seat, or hang extremely loose
- D-loop web guide does not rotate freely
- hardware is missing, rusted, corroded, or damaged
- hardware does not appear to be tight

General Information

National Cush-N-Aire II air suspension seats (see **Fig. 1**) offer adjustment features for height, fore and aft positioning, back cushion tilt, lumbar support, and seat cushion tilt. The air suspension and height-adjustment features are provided by an inflatable air spring (air bag) that receives air pressure from the vehicle air system; pressure in the air spring is controlled by a set of switches attached to the seat frame. Each seat is equipped with a shock absorber to dampen unwanted up and down motion of the seat. An isolator (Chugger-Snubber®) isolates the seat from the cab's fore and aft motion; at the side of the seat's lower frame is an isolator lockout handle that can be used whenever the isolator feature is not desired.

For a complete description of, and operating instructions for, all seat adjustment features, refer to the vehicle driver's manual.

General Information

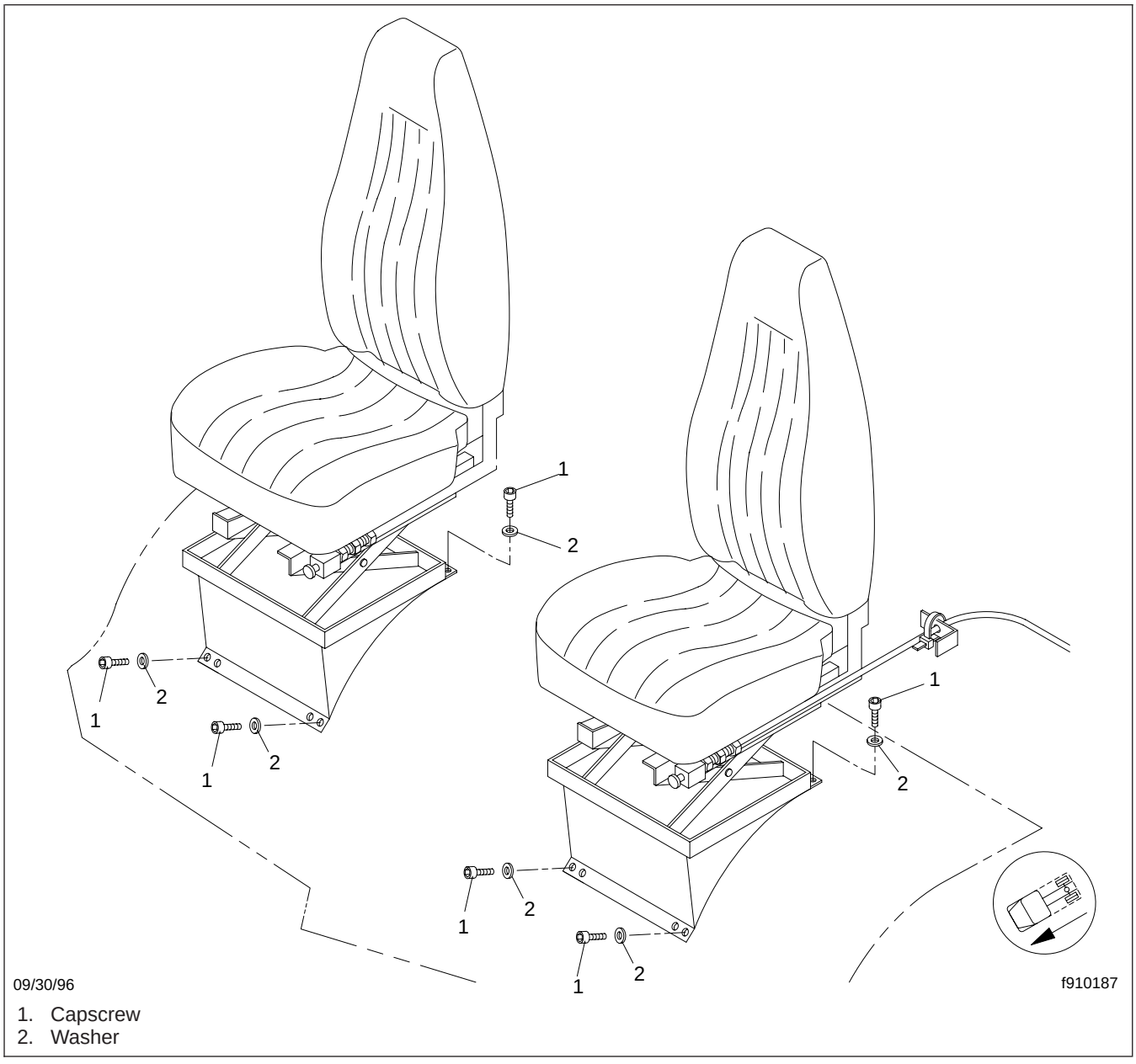


04/22/97 f910200

1. Seat Cushion
2. Seat Back
3. Back Frame Bracket
4. Upper Seat Frame
5. Flatwashers
6. Back Frame Bolt
7. Back Recline Adjustment Knob
8. Back Limit Bolt Bracket
9. Cushion Adjustment Bolt
10. Cushion Adjustment Bracket
11. Cushion Adjustment Lever
12. Bearing
13. Adjustment Rod Bracket
14. Fastener
15. Adjustment Rod
16. Adjustment Rod Bracket
17. Air Hose
18. Isolator
19. Isolator Bar
20. Locknut
21. Hose Barbed Fitting
22. Retaining Ring
23. Track
24. Fore-and-Aft Adjustment Lever
25. Belt Bar
26. Connected Shaft
27. Seat Support
28. Snap Ring
29. Locknut
30. Bearing
31. Upper Arm
32. Shock Absorber Assembly
33. Shock Absorber
34. Air Spring
35. Lower Arm
36. Bearing
37. Pin Clip
38. Seat Base

Fig. 1, National Cush-N-Aire II Seat (exploded view)

Removal (See Fig. 1)



1. Capscrew
2. Washer

Fig. 1, Seat Installation

1. Apply the parking brakes, and chock the tires.
2. Push in on the top of the seat ride height rocker switch until the seat is adjusted to its maximum height.
3. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the air suspension seat base and the rear crosstube of the lower arm.

Seat Removal and Installation

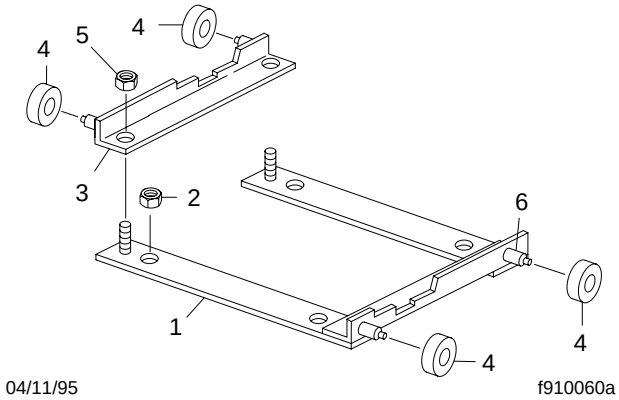
4. Drain the vehicle air reservoirs. Then push in on the bottom of the seat ride height rocker switch until all air is exhausted from the air spring.
5. Disconnect the air valve air supply hose.
6. Unscrew the capscrews that attach the seat belt straps and tether straps.
7. Remove the capscrews and washers that attach the seat to the cab deck. Remove the seat from the cab.

Installation

1. Place the seat on the cab deck. Insert the capscrews through the washers and the seat base. Tighten the capscrews 27 lbf·ft (37 N·m).
2. Attach the brackets of the seat belt straps and tether straps. Tighten the capscrews 40 lbf·ft (54 N·m).
3. Attach the air valve air supply hose.
4. Start the engine and allow the air reservoirs to fill. Push in on the top of the seat ride height rocker switch until the seat is adjusted to its maximum height, then remove the wooden block that supports the seat suspension.
5. Remove the chocks from the tires.

Isolator Assembly (Chugger-Snubber®) Replacement

Replacement (See Fig. 1)



1. Welded Bearing Support Frame
2. Locknut
3. Bearing Support Rail
4. Bearing
5. Hexnut
6. Bearing Stud

Fig. 1, Isolator Assembly

1. Remove the air spring supply hose from the seat.
2. Cut off the air spring supply hose close to the barbed fitting; minimize hose length loss. Remove the scrap hose from the barbed fitting. Tape the hose and fitting ends to prevent dirt or other matter from entering.
3. Remove the hexnuts that attach the isolator bearing support rail to the studs on the isolator bearing support frame.
4. Lift up on the side of the seat's lower frame, to slide the bearing support rail up and off the bearing support frame.

NOTE: Two of the isolator bearings will fall off when the bearing support rail is removed.

5. Push the upper seat frame toward the opposite side, to remove the other two bearings. Remove the bearings and the unattached upper seat components.
6. Remove the four 5/16–18 locknuts from the bearing support frame. Remove the bearing support frame.
7. Using a multi-purpose chassis grease, lubricate the bearing cups and new isolator bearings.
8. Install the welded bearing support frame on the track assembly. Tighten the four 5/16–18 locknuts 15 lbf·ft (20 N·m).
9. Install two of the isolator bearings on the bearing studs of the bearing support frame, then align the bearing cups on the upper seat frame over the bearings.
10. Assemble the isolator bearing support rail and the two remaining isolator bearings. With the seat cushion tilted forward, install the support rail's bearings in the upper seat frame, and lower the seat frame and support rail assembly onto the isolator bearing support frame. Install the 5/16–18 hexnuts, and tighten them finger-tight.

    Push the isolator assembly fore and aft, and check the position of the isolator bearing support rail before tightening the hexnuts. The isolator should be tight enough to eliminate side play without interfering with the fore-and-aft movement of the seat. Tighten the 5/16–18 hexnuts 15 lbf·ft (20 N·m).
11. Install the air spring supply hose.

Shock Absorber Removal and Installation

Removal

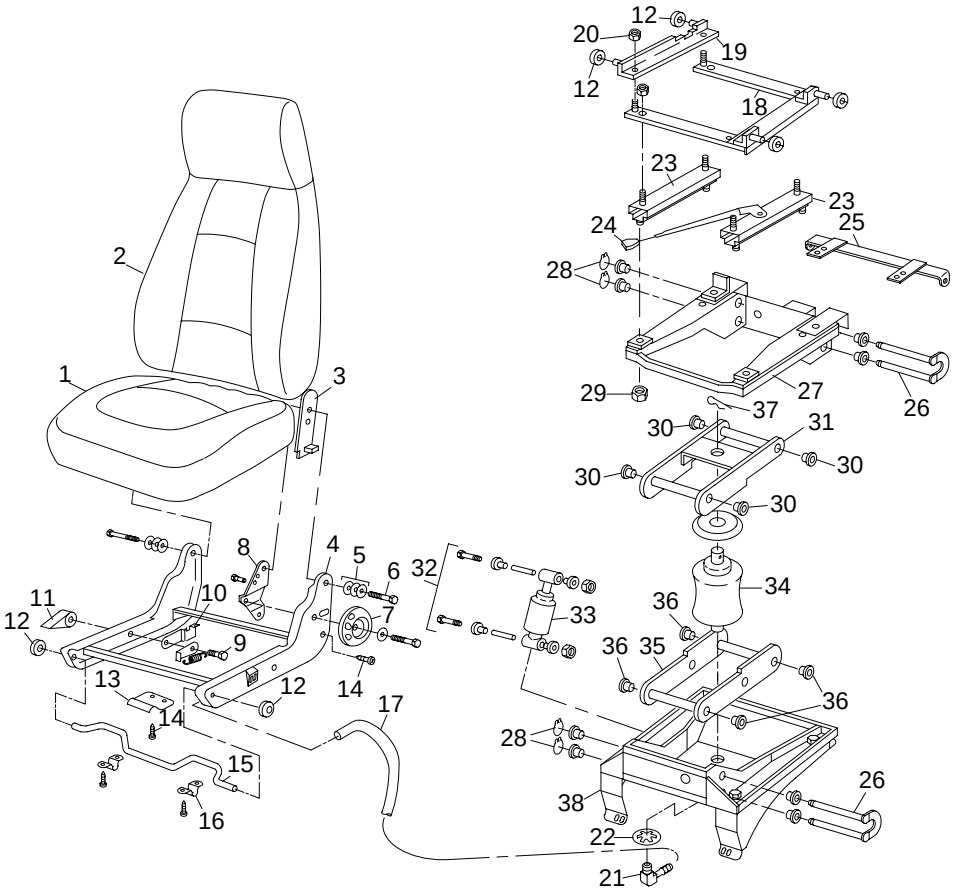
1. Move the fore-and-aft adjustment lever to the right, and slide the upper seat assembly back as far as possible.
2. Raise the upper seat assembly to maximum height. Support the seat in this position by placing a wooden block between the lower arm and the seat base.
3. Remove the shock absorber, bushings, and bearings.
   - 3.1 Remove the nuts and bolts that attach the shock absorber to the upper arm and the seat base. Remove the shock absorber.
   - 3.2 Remove the bushings and bearings from the shock absorber.

Installation

1. Check the operation of the shock absorber, and replace it if needed.
2. Install the shock absorber and new bearings and bushings.
   - 2.1 Install new bearings and bushings in the shock absorber eyes.
   - 2.2 With the upper arm blocked up, position the shock absorber so its piston-rod end is in the mounting bracket of the upper arm. Install the bolt and locknut to attach the shock absorber to the bracket. Tighten the locknut 25 lbf·ft (34 N·m).
   - 2.3 Position the cylinder end of the shock absorber in the mounting bracket of the seat base. Attach the shock absorber to the seat base. Tighten the locknut 25 lbf·ft (34 N·m).
3. Raise the seat. Remove the wooden block.

Replacement (See Fig. 1)

1. Raise the upper seat assembly to maximum height. Support the seat in this position by placing a wooden block between the lower arm and the seat base.
2. Remove the seat from the vehicle as instructed in **Subject 100**.
3. Lay the seat on its side, with the wooden block still in place.



04/22/97 f910200

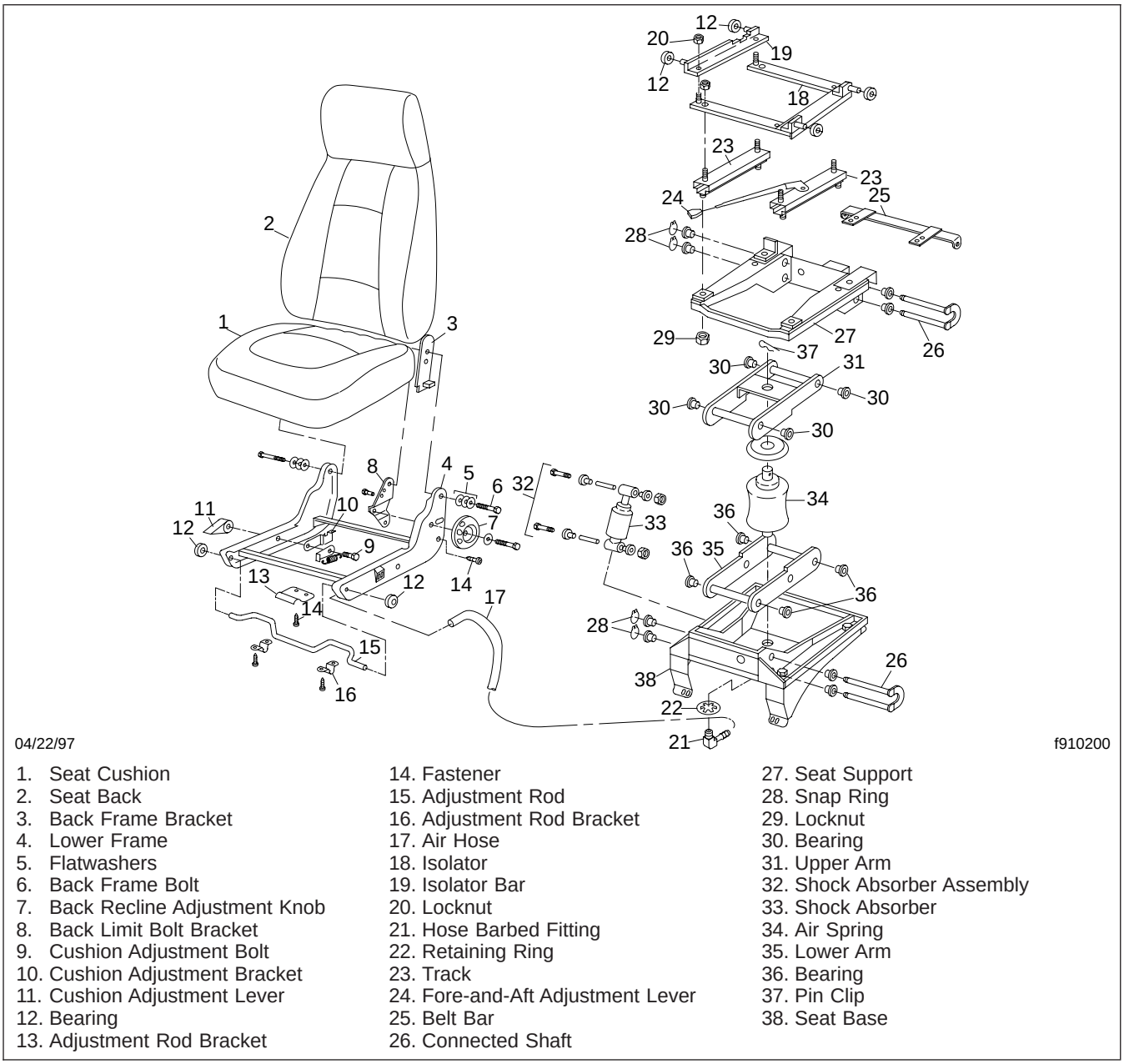
1. Seat Cushion
2. Seat Back
3. Back Frame Bracket
4. Upper Seat Frame
5. Flatwashers
6. Back Frame Bolt
7. Back Recline Adjustment Knob
8. Back Limit Bolt Bracket
9. Cushion Adjuster Bolt
10. Cushion Adjustment Bracket
11. Cushion Adjustment Lever
12. Bearing
13. Adjustment Rod Bracket
14. Fastener
15. Adjustment Rod
16. Adjustment Rod Bracket
17. Air Hose
18. Isolator
19. Isolator Bar
20. Locknut
21. Hose Barbed Fitting
22. Retaining Ring
23. Track
24. Fore-and-Aft Adjustment Lever
25. Belt Bar
26. Connected Shaft
27. Seat Support
28. Snap Ring
29. Locknut
30. Bearing
31. Upper Arm
32. Shock Absorber Assembly
33. Shock Absorber
34. Air Spring
35. Lower Arm
36. Bearing
37. Pin Clip
38. Seat Base

Fig. 1, National Cush-N-Aire II Seat (exploded view)

Air Spring Replacement

4. Remove, as an assembly, the fitting and the air hose from the air spring. Tape the end of the fitting to prevent dirt or other matter from entering.
5. Pry the pin clip from the bottom of the air spring.
6. Remove the retaining ring that secures the air spring to the upper arm. Remove the air spring.
7. Position the new air spring in the seat base, and secure it with a new pin clip.
8. Insert the top of the air spring in the opening of the upper arm. Install the retaining ring on the air spring.
9. Install the air spring fitting and air hose in the top of the air spring.
10. Install the seat as instructed in **Subject 100**.
11. Raise the seat. Remove the wooden block.

Replacement (See Fig. 1)



1. Seat Cushion
2. Seat Back
3. Back Frame Bracket
4. Lower Frame
5. Flatwashers
6. Back Frame Bolt
7. Back Recline Adjustment Knob
8. Back Limit Bolt Bracket
9. Cushion Adjustment Bolt
10. Cushion Adjustment Bracket
11. Cushion Adjustment Lever
12. Bearing
13. Adjustment Rod Bracket
14. Fastener
15. Adjustment Rod
16. Adjustment Rod Bracket
17. Air Hose
18. Isolator
19. Isolator Bar
20. Locknut
21. Hose Barbed Fitting
22. Retaining Ring
23. Track
24. Fore-and-Aft Adjustment Lever
25. Belt Bar
26. Connected Shaft
27. Seat Support
28. Snap Ring
29. Locknut
30. Bearing
31. Upper Arm
32. Shock Absorber Assembly
33. Shock Absorber
34. Air Spring
35. Lower Arm
36. Bearing
37. Pin Clip
38. Seat Base

Fig. 1, National Cush-N-Aire II Seat (exploded view)

1. Remove the shock absorber as instructed in **Subject 120**.
2. Remove the seat as instructed in **Subject 100**.
3. Remove the four locknuts that attach the track assemblies, seat track stop, belt bar and bearings, and upper seat assembly to the seat sup-

Base Assembly Bearing/Sleeve Replacement

port. Remove the upper seat assembly, track assemblies, seat track stop, and belt bar and spacers.

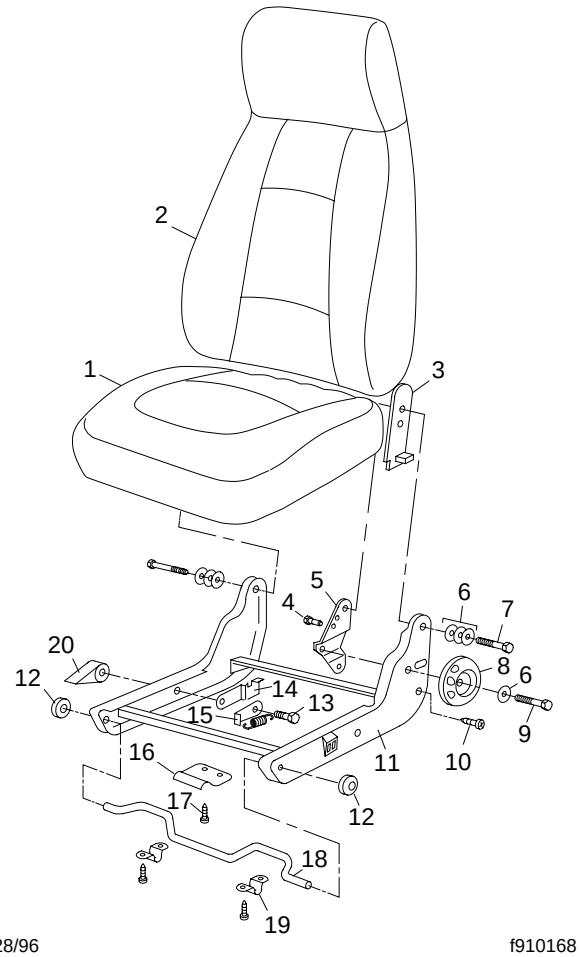
4. Remove the retaining ring that secures the air spring to the upper arm.
5. Remove the bearings and/or sleeves from the seat support and the seat base and the upper and lower arms.
   - 5.1 Use snap ring pliers to remove the four snap rings from the connected shaft assemblies. Then, using a drift punch, drive out the shaft assemblies from the seat support and the seat base.

   NOTE: Place the punch against the snap ring end of the shafts. Drive each shaft end a little at a time; the two shafts are connected to each other on the opposite side.

   - 5.2 Remove the seat support, and the upper and lower arms from the air spring and seat base.
   - 5.3 Remove the bearings/sleeves from the upper and lower arms. Discard the bearings/sleeves.
   - 5.4 If so equipped, remove the sleeves/bearings from the seat support and the seat base. Discard the sleeves/bearings.
6. Install new bearings/sleeves, as equipped.
   - 6.1 Install new bearings/sleeves in the upper and lower arm tubes.
   - 6.2 If so equipped, install new sleeves/bearings in the seat support and the seat base.
   - 6.3 Align the tubes of the lower and upper arms with the holes in the seat base. Be sure the notch in the lower arm is forward and up, and the notch in the upper arm is to the rear and down.
   - 6.4 Install the connected shaft assembly through the seat base and the upper and lower arm forward tubes.
   - 6.5 Align the holes of the seat support with the rear tubes of the lower and upper arms.
   - 6.6 As equipped, install and tighten the pivot bolts, or install the connected shaft assembly through the seat support and the upper and lower arm tubes.
   - 6.7 For connected shaft assemblies, use snap ring pliers to install the snap rings that secure the shafts and the arms to the seat base and the seat support.
7. Insert the top of the air spring through the upper arm. Install the retaining ring.
8. Set the seat base assembly upright.
9. Install the shock absorber as instructed in **Subject 120**.
10. Place the belt bar and bearings, seat track stop, track assemblies, and upper seat assembly on the seat base. Install the locknuts, and tighten 15 lbf·ft (20 N·m).
11. Install the seat as instructed in **Subject 100**.

Upper Seat Frame Removal and Installation

Removal (See Fig. 1)



03/28/96 f910168

1. Seat Cushion
2. Seat Back
3. Back Frame Bracket
4. Back Limit Bolt
5. Back Limit Bolt Bracket
6. Flatwashers
7. Back Frame Bolt
8. Back Recline Adjustment Knob
9. Hexbolt
10. Screw
11. Lower Frame
12. Bearing
13. Cushion Adjustment Bolt
14. Cushion Adjustment Bracket
15. Cushion Adjustment Spring Bracket
16. Adjustment Rod Bracket
17. Fastener
18. Adjustment Rod
19. Adjustment Rod Bracket
20. Cushion Adjustment Lever

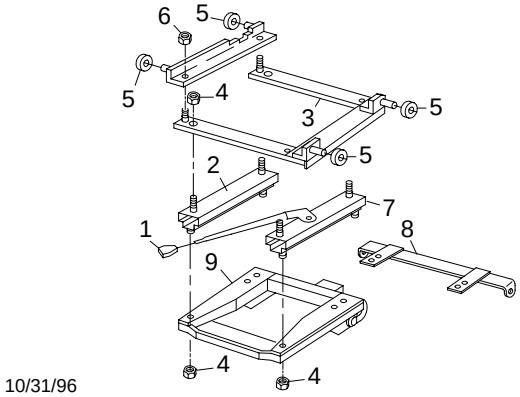
Fig. 1, Upper Seat Frame Assembly (exploded view)

1. Remove the suspension shroud (if equipped) from the seat base.
2. Remove the plastic tie strap that attaches the seat cushion to the upper seat frame assembly.
3. Remove the fasteners that attach the seat cushion to the front cushion adjustment rod. Remove the seat cushion.
4. Disconnect the air spring supply hose from the air spring.
5. Remove the four locknuts from under the top flange of the seat support assembly.
6. Remove the lower frame from the seat base.

Installation

1. Place the lower frame on the seat support assembly. Install the locknuts under the top flange of the seat support assembly. Tighten the locknuts 10 lbf·ft (15 N·m).
2. Attach the air spring supply hose to the air spring. Make sure that the air hose moves without any restrictions when the seat is moved forward or rearward.
3. Position the seat cushion, then install the fasteners that attach the seat cushion to the front cushion adjustment rod.
4. Install a new plastic tie strap to secure the seat cushion to the lower frame assembly.
5. Install the suspension shroud (if equipped) on the seat base.

Replacement (See Fig. 1)



1. Fore-and-Aft Adjustment Lever
2. Right-Side Track
3. Welded Bearing Support Frame
4. Locknut
5. Bearing
6. Hexnut
7. Left-Side Track
8. Belt Bar
9. Seat Support

Fig. 1, Track Assembly (exploded view)

1. Raise the upper seat assembly to maximum height. Support the seat in this position by placing a wooden block between the lower base and lower arm.
2. Pull up and support the rear edge of the seat cushion as needed to gain access to the isolator-assembly-to-track-assembly 5/16–18 locknuts.
3. Remove the air spring supply hose from the seat.
   - 3.1 Cut and remove the tie strap that attaches the air spring supply hose to the track assembly latch mechanism.
   - 3.2 Remove the air spring supply hose (as an assembly), and lay it on the cab deck, behind the seat.
4. Remove the four 5/16–18 locknuts that attach the isolator assembly to the top of the track assemblies. Remove the upper seat assembly.
5. Remove the four 5/16–18 locknuts that attach the track assemblies to the top of the seat support. Remove the track assemblies.
6. With the holes in the belt bar, belt bar spacers, and seat track stop aligned with the holes in the seat support, install the new track assemblies on the seat support. Install and tighten the four 5/16–18 locknuts 15 lbf·ft (20 N·m).
7. Move the upper half of the track assemblies as needed to align their studs with the holes in the isolator assembly. Place the upper seat assembly on the track assemblies. Install and tighten the four 5/16–18 locknuts 15 lbf·ft (20 N·m).
8. Install the air spring supply hose.
   - 8.1 Install a new tie strap to attach the air spring supply hose to the track assembly latch mechanism.
   - 8.2 Install a new tie strap to attach the air valve supply hose to the belt bar.
9. Move the fore-and-aft adjustment lever to the right, and slide the upper seat assembly forward and rearward while making sure that the air hose moves without restriction. Return the seat cushion to its original position.
10. Raise the seat. Remove the wooden block.

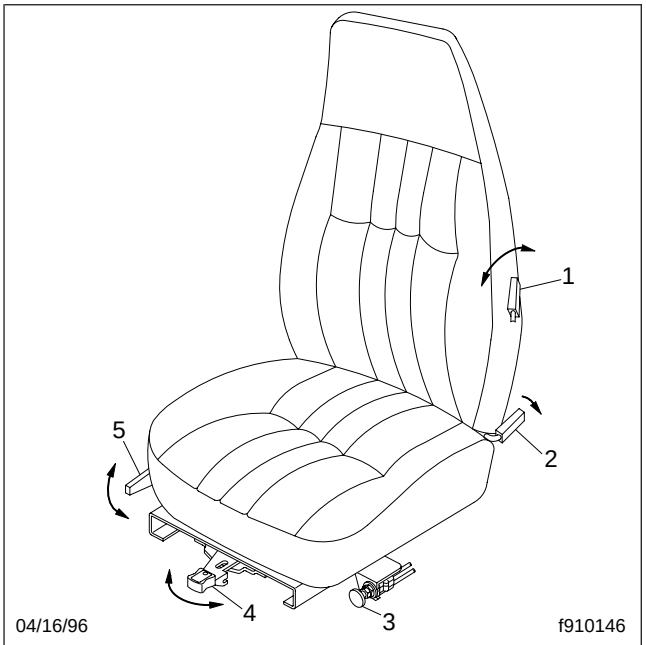
Specifications

Description	Torque: lbf·ft (N·m)
Seat Base to Cab Deck Socket-Head Bolts	13 (18)
Seat Belt/Tether Belt to Belt Bar Capscrews	40 (54)
Shock Absorber to Bracket Locknuts	25 (34)
Track Assembly to Isolator Assembly Locknuts	15 (20)
Track Assembly to Upper Seat Frame Locknuts	15 (20)

Table 1, Fastener Torques

General Information

The Bostrom 910 air suspension seats offer lumbar support, back angle adjustment, weight and height adjustment, a fore and aft roller track isolator system, and seat cushion tilt adjustment. See **Fig. 1**.

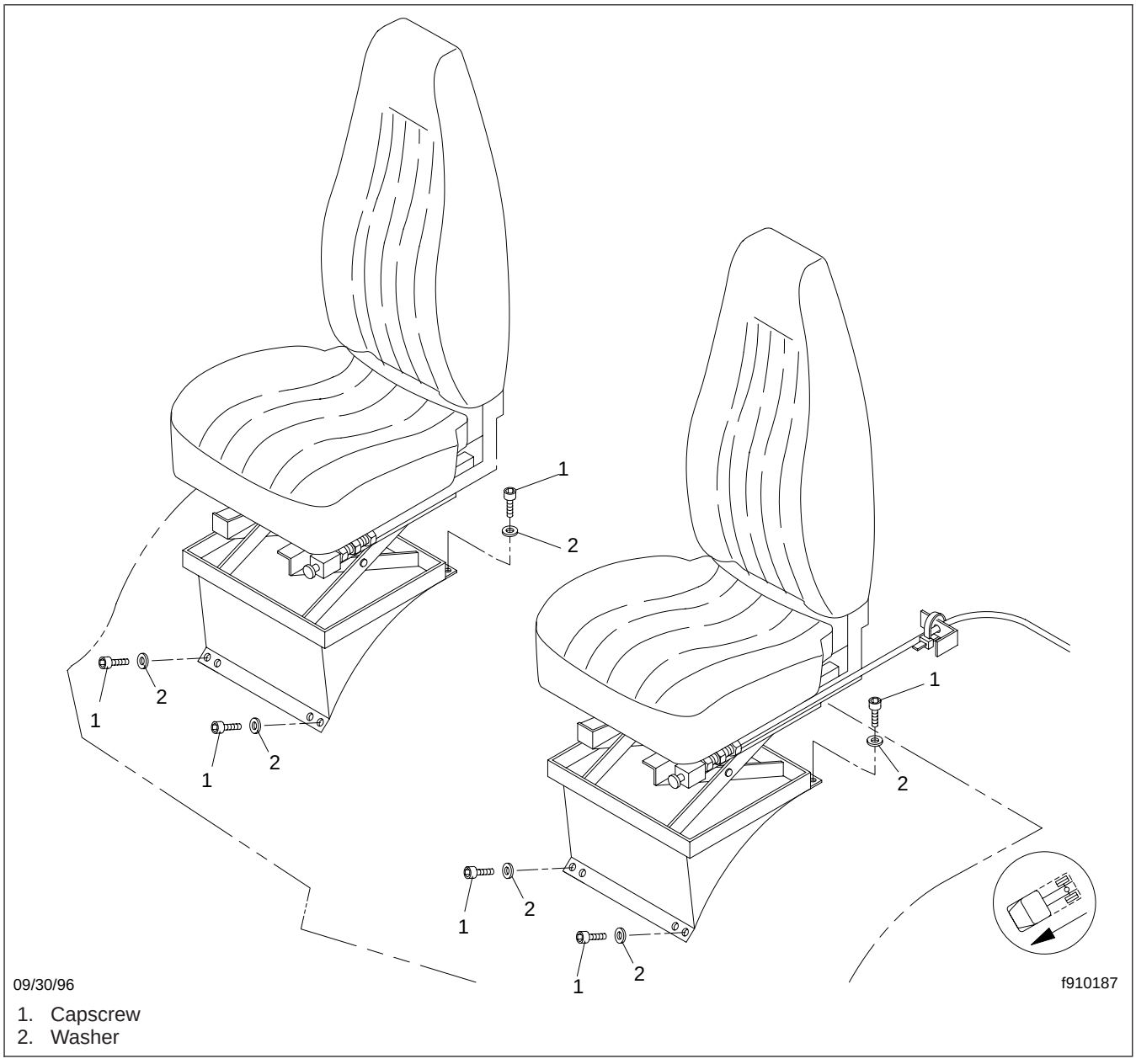


1. Lumbar Adjustment
2. Back Angle Adjustment
3. Weight and Height Adjustment
4. Fore and Aft Isolation and Seat Position Adjustment
5. Seat Cushion Tilt Adjustment

Fig. 1, Bostrom 910 Seat

For complete operating instructions, refer to the vehicle driver's manual.

Removal (See Fig. 1)



1. Capscrew
2. Washer

Fig. 1, Seat Installation

1. Apply the parking brakes, and chock the tires.
2. Push in on the seat height adjustment valve knob until the seat is adjusted to its maximum height.
3. Cut a wooden block to the length required to support the seat at its maximum height, and

Seat Removal and Installation

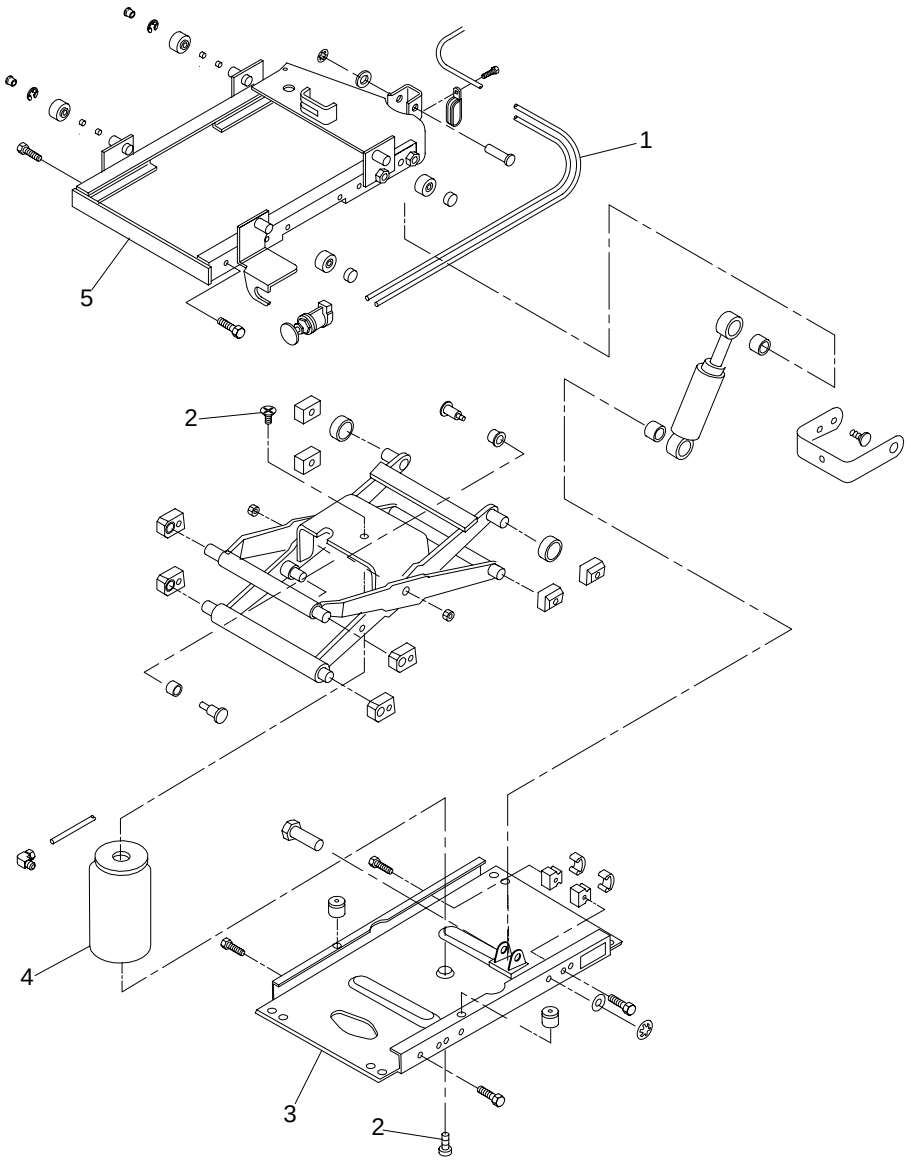
place the block between the rear crossbars of the air suspension's inner and outer lever assemblies.

4. Drain the vehicle air reservoirs. Then pull out on the seat height adjustment valve knob until all air is exhausted from the air spring.
5. Disconnect the air line from the air spring assembly by pushing in the collar of the fitting while pulling the air line out of the fitting.
6. Remove the seat belt straps and tether straps.
7. Remove the capscrews and washers that attach the seat to the cab deck. Remove the seat from the cab.

Installation

1. Place the seat on the cab deck. Insert the capscrews through the washers and the seat base. Tighten the capscrews 27 lbf·ft (37 N·m).
2. Attach the brackets of the seat-belt straps and tether straps. Tighten the capscrews 40 lbf·ft (54 N·m).
3. Connect the air line to the fitting in the air spring assembly by pushing the tube into the fitting.
4. Start the engine and allow the air reservoirs to fill. Push in on the seat height adjustment valve knob until the seat is adjusted to its maximum height, then remove the wooden block that supports the seat suspension.
5. Remove the chocks from the tires.

Removal (See Fig. 1)



1. Air Line
2. Screw
3. Base Riser
4. Air Spring
5. Upper Frame

Fig. 1, Bostrom 910 Seat

1. Remove the complete seat assembly from the vehicle using the instructions in **Subject 100**.
2. Remove the seat/back assembly using the instructions in **Subject 120**.
3. Remove the channel assembly using the instructions in **Subject 130**. Be careful not to lose the roller parts; they will be needed for reassembly.
4. Remove the ICP bracket.

Air Spring Removal and Installation

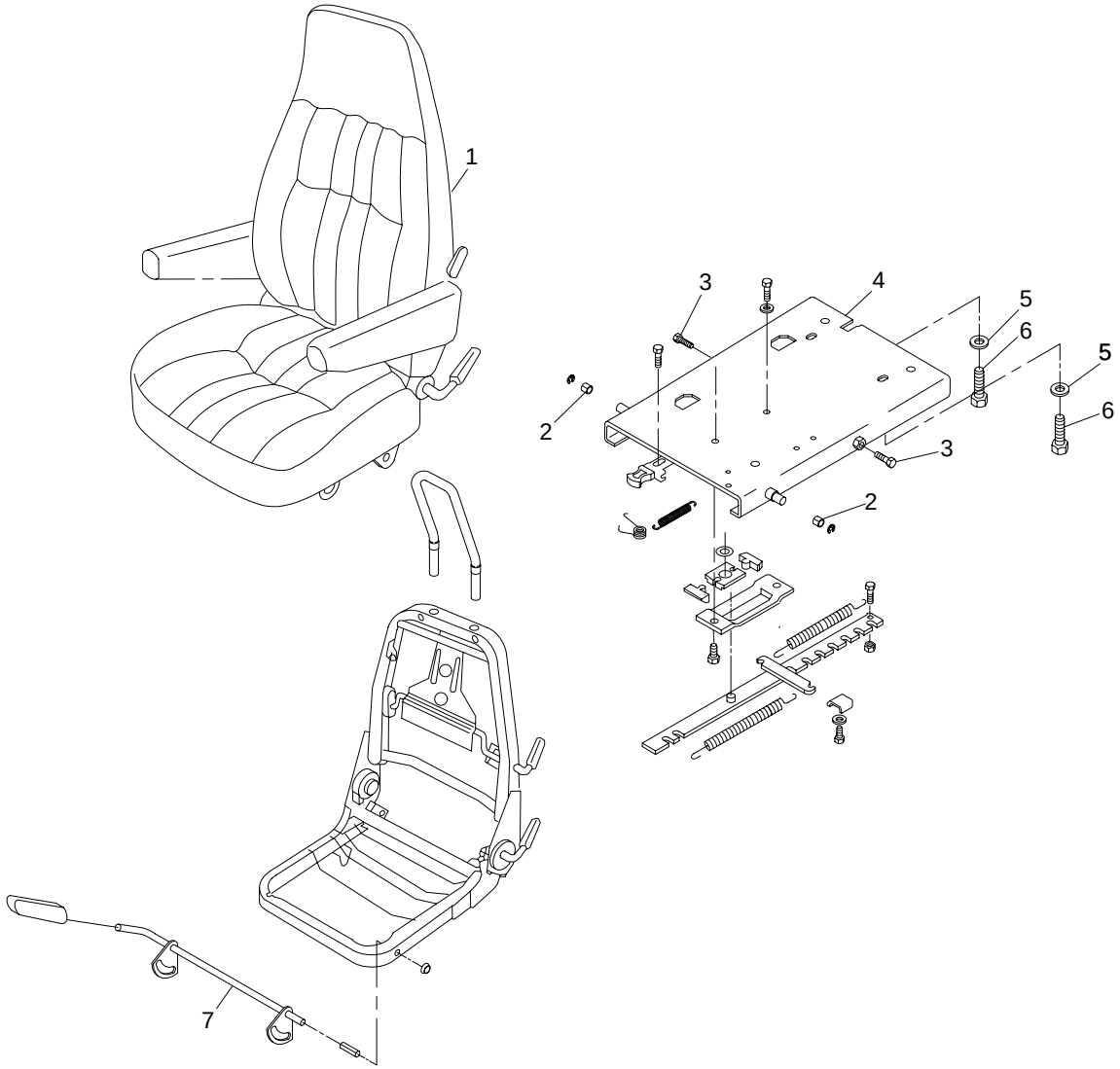
5. Disconnect the air line from the air spring fitting.
6. Remove the air spring screws from the air spring. Remove the air spring from the suspension.

Installation (See Fig. 1)

1. Position the air spring so the fitting at the bottom of the air spring is on the right hand side facing rearward. Install the screws into the air spring.
2. Tighten the screws 15 to 19 lbf·ft (20 to 26 N·m).
3. Connect the air line to the fitting on the air spring.
4. Attach the ICP bracket.
5. Install the channel assembly using the instructions in **Subject 130**.
6. Install the seat/back assembly using the instructions in **Subject 120**.
7. Install the seat assembly in the vehicle using the instructions in **Subject 100**.

Seat/Back Assembly Removal and Installation

Removal (See Fig. 1)



1. Seat/Back Assembly
2. Sleeve Bearing
3. Shoulder Bolt
4. Channel Assembly
5. Flatwasher
6. Capscrew
7. Seat Tilt Cam Assembly

Fig. 1, Bostrom 910 Seat

1. Adjust the seat/back assembly to the most rearward position, then remove the two capscrews and flatwashers from the underside of the channel assembly.
2. Remove the two shoulder bolts from the channel assembly.

Seat/Back Assembly Removal and Installation

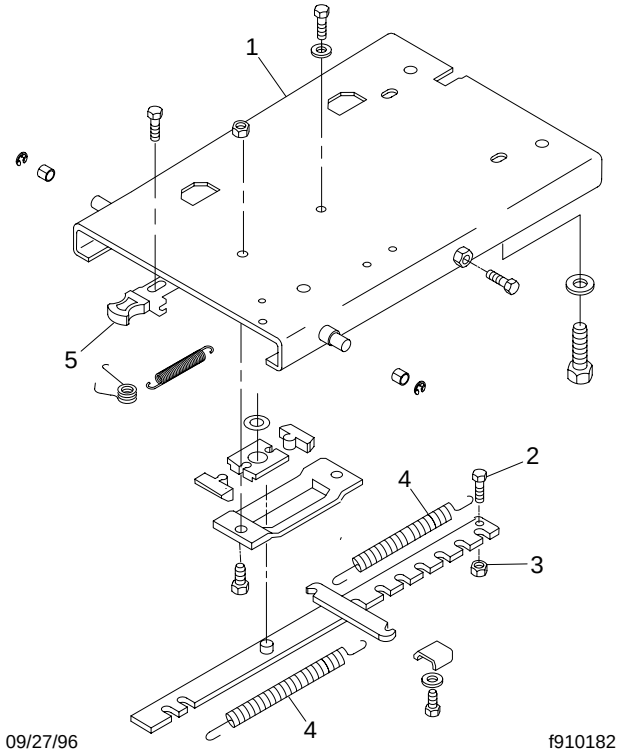
3. Move the seat/back assembly forward to disengage the seat tilt cam assembly from the sleeve bearings on the channel assembly.
4. Remove the seat/back assembly.

Installation (See Fig. 1)

1. Place the seat/back assembly onto the channel assembly.
2. Move the seat/back assembly rearward to engage the seat tilt cam assembly to the sleeve bearings on the channel assembly.
3. Install the two shoulder bolts to the channel assembly. Tighten them 18 to 22 lbf·ft (24 to 30 N·m).
4. Install the two capscrews and flatwashers to the underside of the channel assembly. Tighten them 10 to 13 lbf·ft (14 to 18 N·m).

Fore and Aft Isolation Channel Removal and Installation

Removal (See Fig. 1)

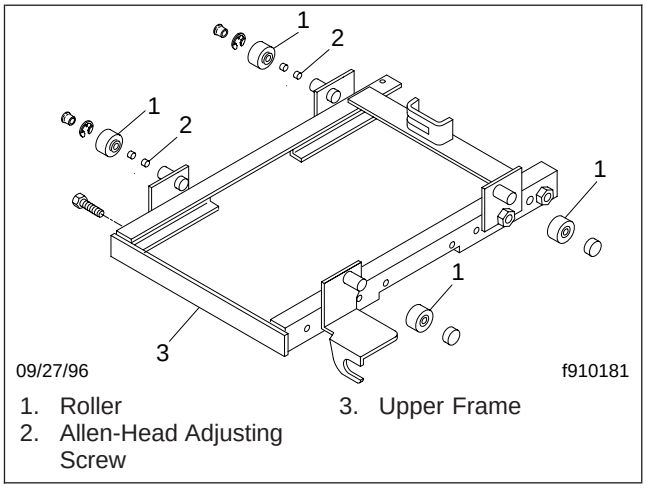


1. Channel Assembly
2. Screw
3. Nut
4. Isolator Spring
5. Isolator Handle

Fig. 1, Channel Assembly (exploded)

1. Remove the seat/back assembly using the instructions in **Subject 120**.
2. Adjust the channel assembly to the rearmost position.
3. With the isolator handle on the channel assembly in the isolation position (center position), push the channel assembly forward to expose the screw and the nut. Remove the screw and the nut and save for reassembly.
4. Move the isolator handle on the channel assembly to the fore and aft release position (outboard position). Slide the channel assembly forward past both sets of rollers. See **Fig. 2**.

NOTE: Be careful not to lose the roller parts. Either remove and save for reassembly or replace with new parts from a roller assembly kit.



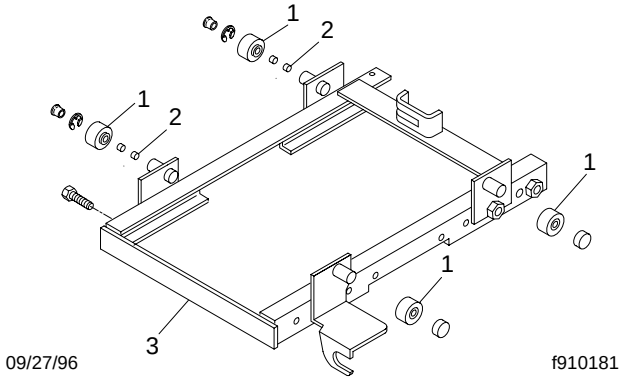
1. Roller
2. Allen-Head Adjusting Screw
3. Upper Frame

Fig. 2, Upper Frame Assembly (exploded)

Installation (See Fig. 1)

1. Slide the channel assembly rearward over both sets of rollers. The isolator handle should be in the fore and aft release position (outboard position).
2. With the isolator handle in the isolation position (center position), push the channel assembly forward to install the screw and nut.
3. Adjust lateral side play using the instructions in **Subject 140**.
4. Install the seat/back assembly using the instructions in **Subject 120**.

Adjustment (See Fig. 1)



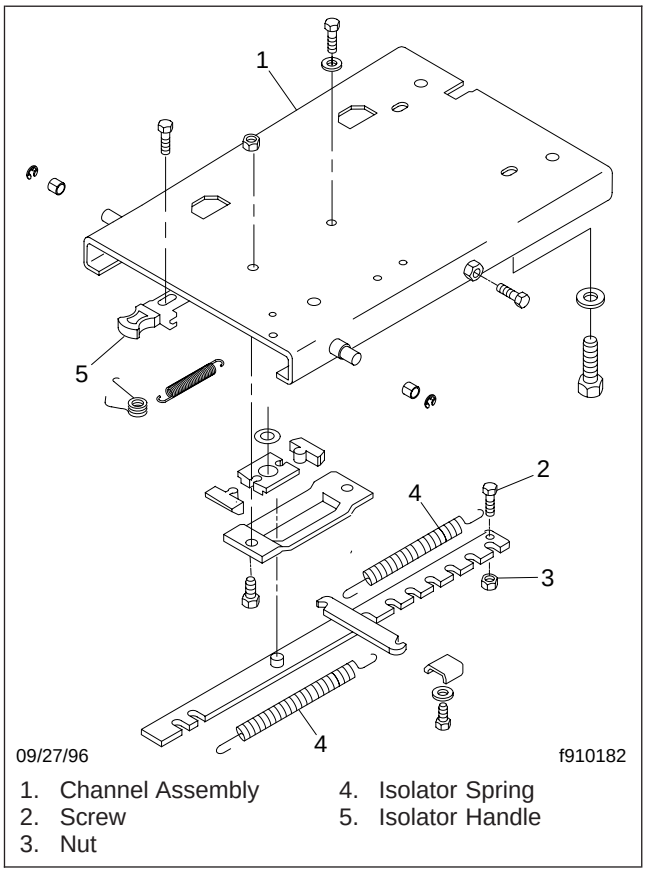
1. Roller
2. Allen-Head Adjusting Screw
3. Upper Frame

Fig. 1, Upper Frame Assembly (exploded)

1. Remove the seat/back assembly from the channel assembly, using the instructions in **Subject 120**.
2. Adjust the channel assembly until the allen-head adjusting screws in the right isolator roller shafts on the upper frame are visible in the cutouts on the inboard side of the channel assembly.
3. Use a 3 mm allen wrench (do not use a 1/8-inch allen wrench) to adjust the two allen-head screws. Turn the screws in until resistance is felt, then turn the screws 1-1/2 turns more.
4. Move the channel assembly through the entire fore and aft adjustment range to check the lateral clearance for binding. The isolator springs (see **Fig. 2**) should return the channel to the neutral position for the best ride. Friction must not exceed 10.1 lbs. (45 N) to move the channel assembly.

NOTE: To ensure the best performance, make certain the roller parts are assembled correctly.

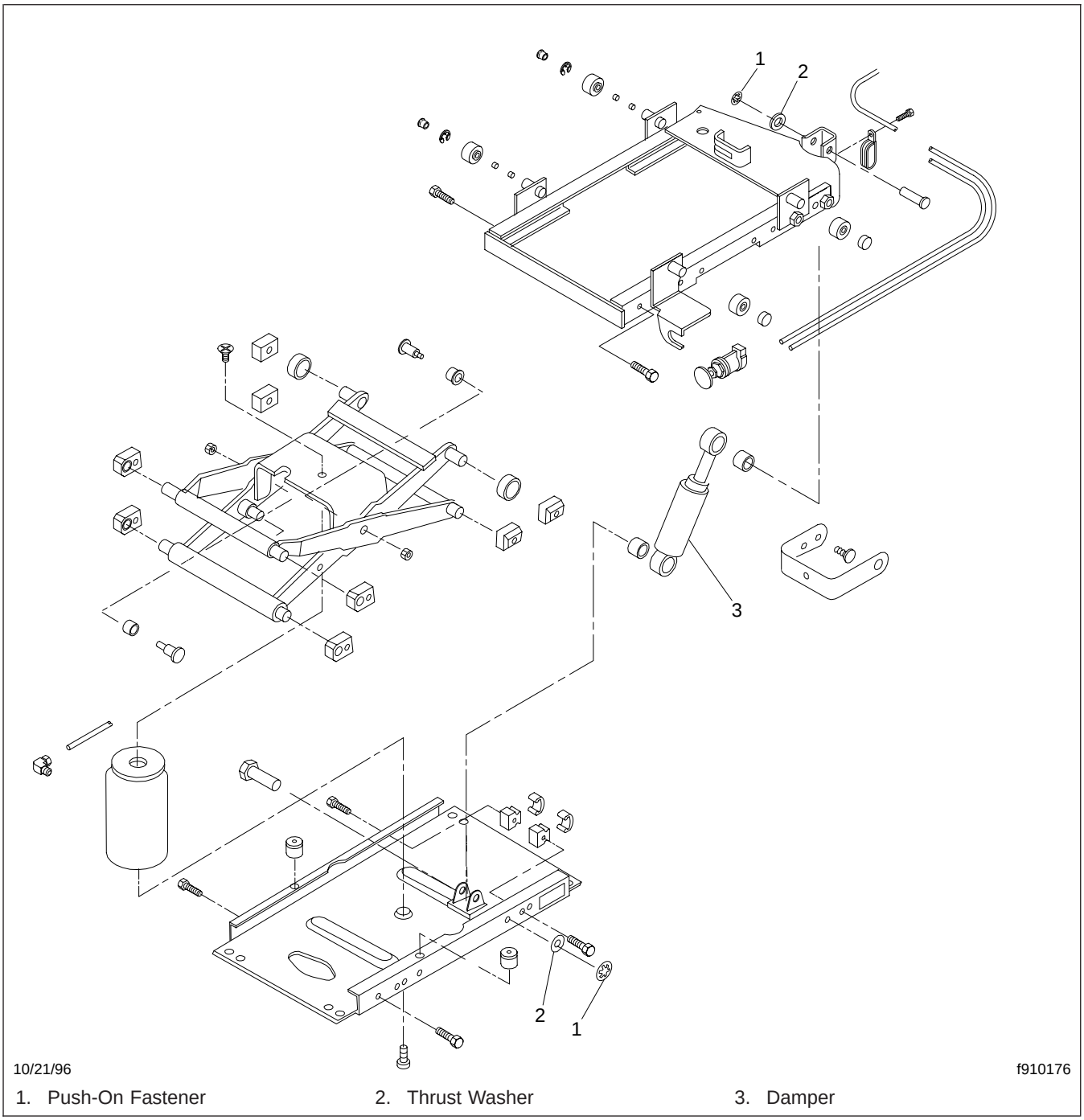
5. Replace the seat/back assembly on the channel assembly using the instructions in **Subject 120**.



1. Channel Assembly
2. Screw
3. Nut
4. Isolator Spring
5. Isolator Handle

Fig. 2, Channel Assembly (exploded)

Removal (See Fig. 1)



1. Push-On Fastener
2. Thrust Washer
3. Damper

Fig. 1, Bostrom 910 Seat

Damper Removal and Installation

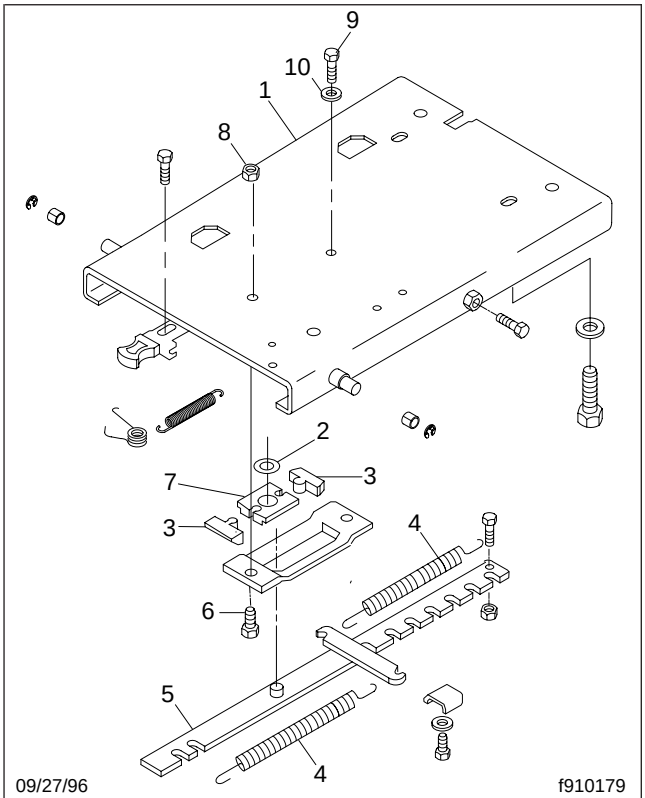
1. Remove the complete seat assembly from the vehicle using the instructions in **Subject 100**.
2. Remove the seat/back assembly using the instructions in **Subject 120**.
3. Remove the channel assembly using the instructions in **Subject 130**. Be careful not to lose the roller parts; they will be needed for reassembly.
4. Remove the ICP bracket.
5. Use pliers or a screwdriver to twist off the push-on fasteners. The push-on fasteners are not reusable.
6. Remove the damper assembly.

Installation **(See Fig. 1)**

1. Install the new damper.
2. Install the thrust washers and the push-on fasteners until they seat. A 1/2-inch box end wrench works well to push the fasteners on.
3. Attach the ICP bracket.
4. Install the channel assembly using the instructions in **Subject 130**.
5. Install the seat/back assembly using the instructions in **Subject 120**.
6. Install the seat assembly in the vehicle using the instructions in **Subject 100**.

Isolation Bumper Removal and Installation

Removal (See Fig. 1)



1. Channel Assembly
2. Retaining Ring
3. Isolation Bumper
4. Isolator Spring
5. Latch Bar
6. Screw
7. Pivot Block
8. Locknut
9. Screw
10. Lockwasher

Fig. 1, Channel and Isolation Bumper Assembly

1. Remove the seat/back assembly using the instructions in **Subject 120**.
2. Remove the channel assembly using the instructions in **Subject 130**.

   Be careful not to loose the roller parts; they will be needed for reassembly.
3. Remove the two isolator springs by carefully extending the springs and disconnecting them from the mounting points.
4. Slide the latch bar until the retaining ring can be seen through the hole in the channel assembly. Remove the retaining ring and keep it for reassembly.
5. Pull the latch bar free of the pivot block.
6. The rubber isolation bumpers are now accessible and can be replaced if necessary.

NOTE: The pivot block can be removed by first removing the screw and lockwasher, then remove the screw and locknut.

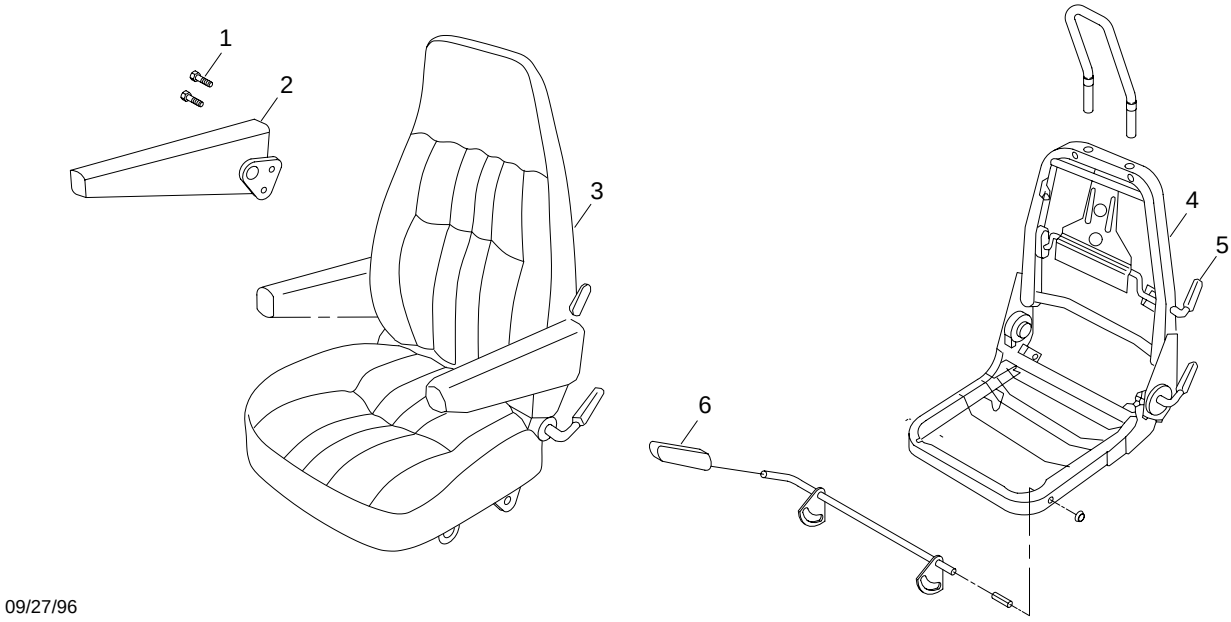
Installation (See Fig. 1)

1. If the pivot block was removed, install the pivot block. Tighten the bolt 14 to 18 lbf·ft (20 to 24 N·m).
2. Install the isolation bumpers.
3. Replace the latch bar on the pivot block.
4. Replace the retaining ring.
5. Replace the two isolator springs by carefully extending the springs and connecting them to the mounting points.
6. Install the channel assembly using the instructions in **Subject 130**.

   Be sure the roller parts are installed correctly on the roller pins.
7. Install the seat/back assembly using the instructions in **Subject 120**.

Back Cover/Pad Assembly Removal and Installation

Removal (See Fig. 1)



1. Armrest Fastener
2. Armrest
3. Upper Seat Assembly
4. Seat Frame Assembly
5. Lumbar Adjustment Handle
6. Seat Tilt Adjustment Handle

Fig. 1, Upper Seat Assembly

1. Remove the upper seat assembly from the suspension, using the instructions in **Subject 120**. Remove the armrests if the seat assembly has armrests.
2. Remove the back cover and pad from the seat frame assembly. Note the location of the fasteners on the existing back cover.

Installation (See Fig. 1)

1. Place a new pad over the back frame. If the seat has lumbar adjustment, make a cut in the outboard edge of the pad to fit around the handle.
2. Place the cover (inside out) over the top of the back pad. Pull down the cover until the three tie-down tabs are even with the three slots in the pad. Pull the tie-down tabs through the slots in the pad and run a short wire through all three tabs. Continue to pull the cover down completely over the pad. Tuck the front flap of the back cover between the seat cushion and the bottom of the back pad. Insert two long wires into the looped material sewn to the bottom of the cover. (One in the rear flap and one in the front flap.) Starting at the top, pull the cover down tight and hog ring the two wires at the bottom of the cover together behind the seat pad with the three tie-down tabs.

NOTE: If the seat has a high back, there will be two sets of tie-down tabs (six total with two wires) to be pulled through the back pad and wired.

3. Attach the upper seat assembly to the suspension using the instructions in **Subject 120**. Attach the armrests if the seat has armrests.

Suspension Rebuild Bearing/Slide Block Removal and Installation

Removal (See Fig. 1)

1. Remove the complete seat assembly from the vehicle using the instructions in **Subject 100**.
2. Remove the seat/back assembly using the instructions in **Subject 120**.
3. Remove the channel assembly using the instructions in **Subject 130**.

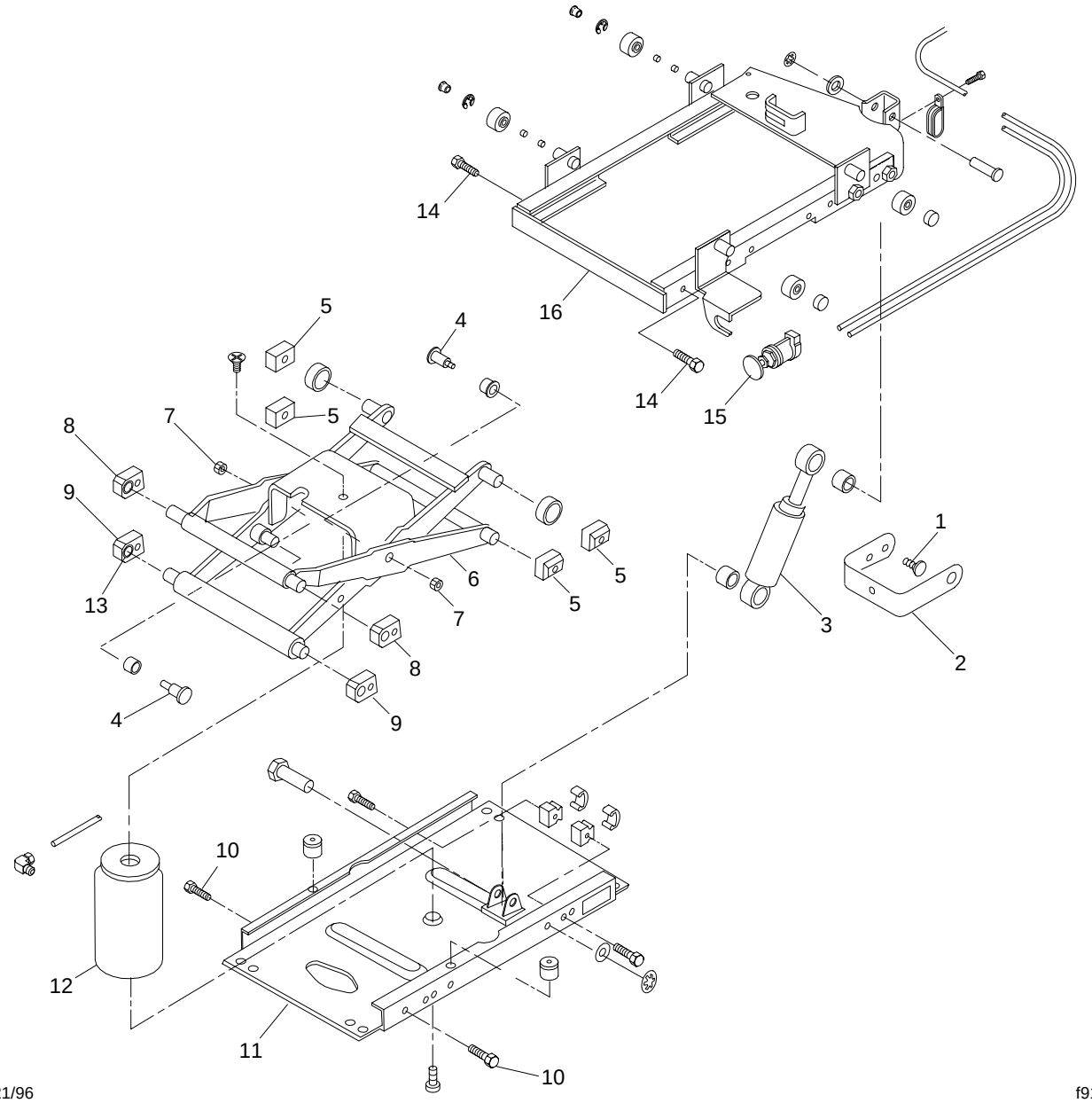
   Be careful not to loose the roller parts; they will be needed for reassembly.
4. Remove the capscrews and the ICP bracket.
5. Remove the air valve by loosening the nut on the valve and removing it from the bracket on the upper frame assembly.
6. Remove the capscrews from the upper front bearing blocks.
7. Remove the upper frame assembly by sliding it forward off of the bearing blocks and the slide blocks.
8. Remove the air spring using the instructions in **Subject 110**. Mark the air line for reassembly.
9. Remove the damper using the instructions in **Subject 150**.
10. Remove the capscrews from the lower front bearing blocks and slide the lever assemblies forward until the bearing blocks are removed from the channel on the base riser. Slide the lever assemblies rearward to remove the slide blocks from the channel.
11. Remove the shoulder bolts and nuts from the pivots of the lever assemblies and inspect the bolts. If the bolts are worn, replace them.

Installation (See Fig. 1)

1. Replace the bearings at the pivots on the lever assembly by pushing out the old bearings and pressing in the new bearings. The flange of the bearings should be on the outside of the lever assembly.
2. Install the shoulder bolts and nuts into the pivots of the lever assemblies. Tighten the bolts 18 to 22 lbf·ft (24 to 30 N·m).
3. Install new bearing blocks, spacers, and slide blocks on the levers with the beveled surfaces outward. Slide the levers with the blocks into the channel on the base riser. Tighten the screws 27 to 33 lbf·ft (37 to 45 N·m).
4. Slide the upper frame assembly over the blocks. Line up the capscrews with the bearing blocks and tighten the screws 27 to 33 lbf·ft (37 to 45 N·m).
5. Manually move the suspension up and down to make sure there are no clearance problems.
6. Block the suspension up with a spacer placed between the base riser and the upper frame. Install the air spring using the instructions in **Subject 110**.
7. Install the damper using the instructions in **Subject 150**.
8. Install the air valve onto the bracket on the upper frame.
9. Install the ICP bracket and capscrews.
10. Install the channel assembly using the instructions in **Subject 130**.

    Be sure the roller parts are installed correctly on the roller pins.
11. Install the seat/back assembly using the instructions in **Subject 120**.
12. Adjust lateral side play using the instructions in **Subject 140**.
13. Install the seat assembly in the vehicle, using the instructions in **Subject 100**.

Suspension Rebuild Bearing/Slide Block Removal and Installation

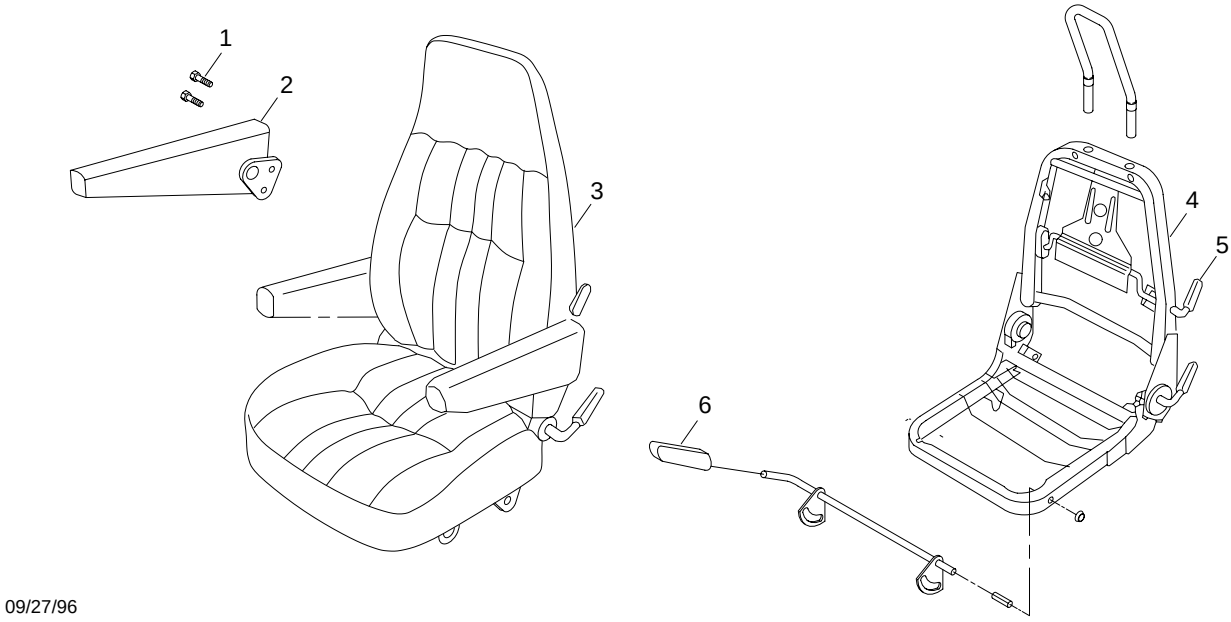


1. ICP Capscrew
2. ICP Bracket
3. Damper
4. Shoulder Bolt
5. Slide Block
6. Lever Assembly
7. Nut
8. Upper Bearing Block
9. Lower Bearing Block
10. Capscrew
11. Base Riser
12. Air Spring
13. Bearings
14. Screw
15. Air Valve
16. Upper Frame

Fig. 1, Bostrom 910 Seat (exploded)

Seat Cover/Pad Assembly Removal and Installation

Removal (See Fig. 1)



1. Armrest Fastener
2. Armrest
3. Upper Seat Assembly
4. Seat Frame Assembly
5. Lumbar Adjustment Handle
6. Seat Tilt Adjustment Handle

Fig. 1, Upper Seat Assembly

1. Remove the upper seat assembly from the suspension using the instructions in **Subject 120**.
2. Remove the seat cover and pad from the seat frame assembly. Note the location of the fasteners on the existing seat cover. Do not remove the small vinyl patch from the seat tilt handle, unless it needs replacement.

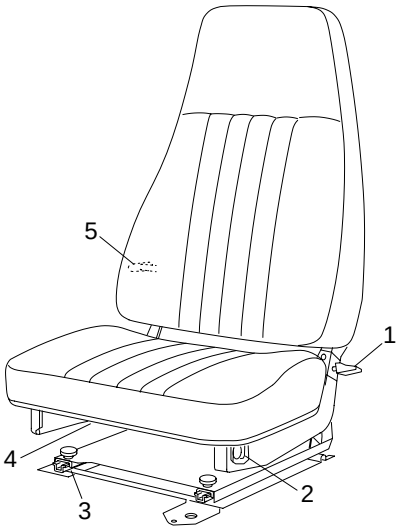
Installation (See Fig. 1)

1. Place a new pad over the seat frame making sure the back edge of the pad is hooked over the rear support tube. If the seat is equipped with a seat tilt adjustment handle, make a cut in the bottom edge of the pad (right side) to fit around the handle.
2. Place the cover over the seat tilt handle and the top of the seat pad. Fold the rear half of the cover forward to expose the three tie-down tabs. Push the tie-down tabs through the holes in the foam. Reposition the cover and turn the seat over.
3. Pull the tie-down tabs tight and attach them to the center support wire (third wire from the rear). Use one hog ring per tab.
4. Insert the longest wire into the looped material sewn to the bottom of the cover. Place the shorter wire into the rear flap of the cover.
5. Pull the rear corners of the side panels rearward around the back corners of the frame. Attach the material with one hog ring per side.
6. Starting at the front of the seat cover and working rearward, hog ring the wire through the holes in the seat frame. Ten hog wires are required for the frame. Fold the rear flap down and toward the front of the seat. Pull the flap tightly and fasten it with three hog rings to the most rearward foam support wire.
7. Install the upper seat assembly onto the suspension, using the instructions in **Subject 120**.

General Information

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

The Dura-Form air suspension seats offer lumbar support, back cushion tilt adjustment, height adjustment, a fore and aft isolator system, and seat cushion adjustment. See **Fig. 1**.



1. Back Cushion Tilt Adjustment
2. Height Adjustment
3. Isolator and Fore-Aft Adjustment
4. Seat Cushion Adjustment
5. Lumbar Support

Fig. 1, Dura-Form Seat

For complete operating instructions, see Chapter 2 of the *Business Class Trucks Driver's Manual*.

Removal

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

1. Apply the parking brakes, and chock the tires.
2. Press the seat height adjustment rocker switch until the seat is adjusted to its maximum height.
3. If the seat is equipped with a seat suspension shroud, remove the shroud. It is held in place with Velcro and upholstery-panel fasteners.

   If the seat is equipped with a rubber bellows seat suspension cover, raise the rubber bellows.
4. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the air suspension lower base and the rear crosstube of the lower arm.
5. Drain the vehicle air reservoirs. Then, press the seat height adjustment rocker switch until all air is exhausted from the air spring.
6. Disconnect the air valve air-supply hose at the quick-connect union behind the seat.
7. Using an 11/16-inch wrench or a T50 Torx® wrench, unscrew the capscrews that attach the seat-belt straps and tether straps to the intermediate-connecting-point threaded rod.
8. Remove the capscrews and washers that attach the seat to the cab deck. Remove the seat and both mounting support channels from the cab.

Installation

1. Place the seat on the cab deck. Position a mounting support channel at the front edge, and another at the rear edge of the seat base. Insert the capscrews through the washers, the support channels, and the seat base. Tighten the capscrews 27 lbf·ft (37 N·m).
2. Attach the brackets of the seat-belt straps and tether straps to the intermediate-connecting-point threaded rod. Tighten the capscrews 40 lbf·ft (54 N·m).
3. Connect the air valve air-supply hose by pressing the pneumatic tubing into the quick-connect union behind the seat.
4. Start the engine and allow the air reservoirs to fill. Press the seat height adjustment rocker switch until the seat is adjusted to its maximum height. If the seat is equipped with a rubber bellows seat suspension cover, raise the rubber bellows. Remove the wooden block that supports the seat suspension.
5. If the seat is equipped with a seat suspension shroud, install the shroud.
6. Remove the chocks from the tires.

Air Spring Removal and Installation

Removal

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

1. Apply the parking brakes, and chock the tires.
2. Press the seat height adjustment switch until the seat is adjusted to its maximum height.
3. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the lower housing and the upper housing.
4. Drain the vehicle air reservoirs. Then press the seat height adjustment switch until all the air is exhausted from the air spring.
5. Disconnect the 7/16-inch air fitting at the bottom of the air spring. Remove the 3/4-inch jam nut.
6. Remove the 1/2-inch hexhead bolt and lockwasher at the top of the air spring.
7. Compress the air spring and rotate it forward to lift it out.

Installation

1. Compress the air spring and install it by rotating it rearward.
2. Install the 1/2-inch hexhead bolt and lockwasher at the top of the air spring. Tighten 15 to 20 lbf·ft (20 to 27 N·m).
3. Apply pipe sealant to the threads of the elbow. Insert the tube into the fitting until the tube bottoms in the fitting, then tighten one wrench turn past finger tight. Tighten the pipe threads on the fitting 12 to 18 lbf·ft (16 to 24 N·m).
4. Connect the air fitting to the air spring with the 3/4-inch jam nut. Tighten 72 to 96 lbf·in (800 to 1100 N·cm).
5. Start the engine and allow the air reservoirs to fill. Press the seat height adjustment switch until the seat is adjusted to its maxium height, then remove the wooden block.
6. Remove the chocks from the tires.

Shock Absorber Removal and Installation

Removal

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

1. Apply the parking brakes, and chock the tires.
2. Press the seat height adjustment switch until the seat is adjusted to its maximum height.
3. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the lower housing and the upper housing.
4. Remove the 5/16-inch nut at the top of the shock absorber.
5. Remove the retaining ring and the shock pin at the bottom of the shock absorber.
6. Remove the shock absorber.

Installation

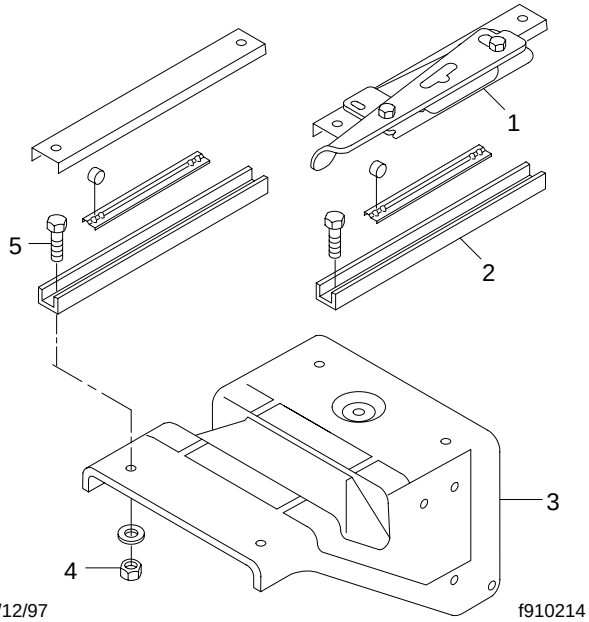
1. Install the shock absorber.
2. Install the 5/16-inch nut at the top of the shock absorber. Tighten 10 to 15 lbf·ft (14 to 20 N·m).

NOTE: The pin hole closest to the air spring is the firmer ride.

3. Install the shock pin and the retaining ring at the bottom of the shock absorber.
4. Remove the wooden block from the seat, and the chocks from the tires.

Isolator and Slides Removal and Installation

Removal (See Fig. 1)



1. Isolator Plate and Handle
2. Slide
3. Upper Housing
4. Nut
5. Screw

Fig. 1, Isolator and Slides Assembly

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

1. Apply the parking brakes, and chock the tires.
2. Press the seat height adjustment switch until the seat is adjusted to its maximum height.
3. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the lower housing and the upper housing.
4. Remove the seat/back assembly using the instructions in **Subject 140**.
5. Using a 1/2-inch socket and a 1/2-inch wrench, remove the isolator assembly.

Installation (See Fig. 1)

1. Using a 1/2-inch socket or wrench and a screwdriver, install the isolator assembly.
2. Install the seat/back assembly using the instructions in **Subject 140**.
3. Remove the wooden block from the seat, and the chocks from the tires.

Seat/Back Assembly Removal and Installation

Removal

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

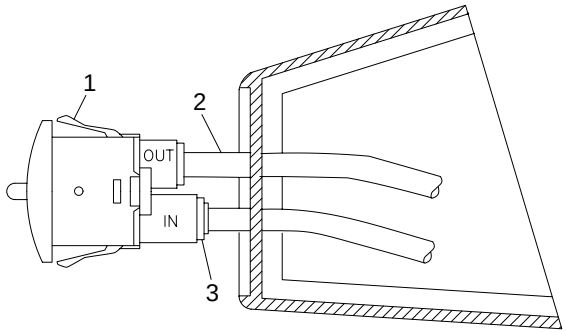
1. Apply the parking brakes, and chock the tires.
2. Using a 1/2-inch socket and a 1/2-inch wrench, remove the four mounting bolts.
3. Remove the seat/back assembly.

Installation

1. Place the seat/back assembly onto the isolator assembly.
2. Using a 1/2-inch socket and a 1/2-inch wrench, install the four mounting bolts.
3. Remove the chocks from the tires.

Air Valve Removal and Installation

Removal (See Fig. 1)



1. Retaining Fingers
2. Air Hose
3. Retaining Ring

Fig. 1, Air Valve Assembly

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

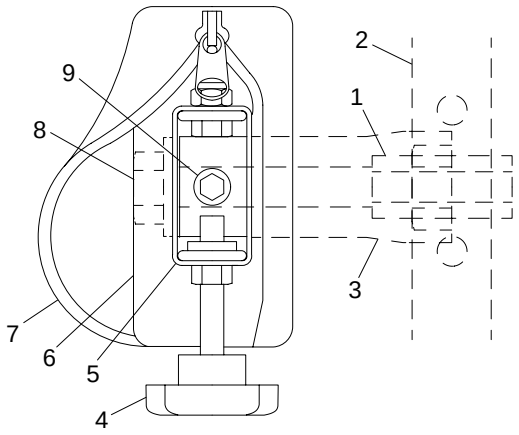
1. Apply the parking brakes, and chock the tires.
2. Drain the vehicle air reservoirs. Then press the seat height adjustment rocker switch until all air is exhausted from the air spring.
3. Reach behind and inside the air control panel and compress the two retaining fingers together on the air valve.
4. Remove the air valve by pushing it outward through the slot in the control panel.
5. Compress the gray retaining ring on the valve body inlet port toward the valve, and pull on the air hose to remove it from the valve.
6. Repeat the previous step for the outlet port.

Installation (See Fig. 1)

IMPORTANT: When installing the air lines, make sure they are connected to the same valve port they were removed from, and are firmly pressed into place. The new air line will insert approximately 1/2-inch when installed properly.

1. Install the air lines in the valve. Pull outward slightly on the new air lines to ensure a solid installation. Do not compress the air line retaining rings when verifying the installation.
2. Make sure the valve is properly oriented, and firmly press the complete valve back into the slot in the air control panel until you hear a "click." The "click" assures the valve retaining fingers are properly secured to the air control panel.
3. Start the engine and allow the air reservoirs to fill.
4. Remove the chocks from the tires.

Removal (See Fig. 1)



03/13/97 f910216

1. Coupling Nut (welded to seat frame assembly)
2. Seat Frame Assembly
3. Pivot Bar
4. Adjustment Knob
5. Armrest Tube
6. Armrest Foam
7. Armrest Cover
8. Armrest Bolt
9. Socket Head Screw

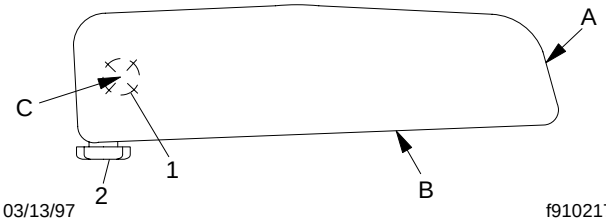
Fig. 1, Armrest, Rear View

NOTE: Call Dura-Form Customer Service at 800–553–3013 to answer any questions concerning any Dura-Form seat style not covered by the information provided.

1. Apply the parking brakes, and chock the tires.
2. Unzip the armrest cover.
3. Remove the socket head screw from the pivot bar in the armrest.
4. Loosen the armrest bolt.
5. Remove the armrest.
6. Remove the pivot arm from the seat back.

Installation

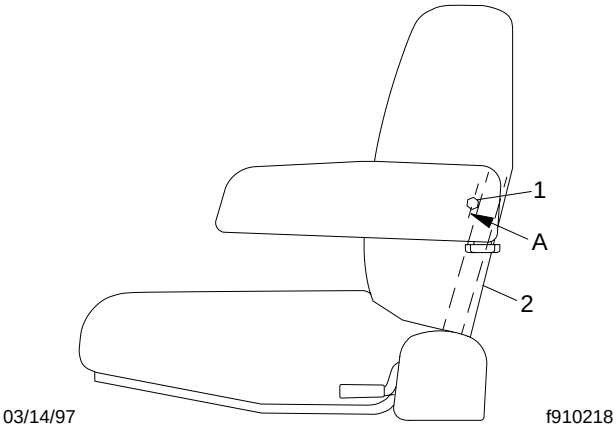
1. Locate the hole in the side of the armrest foam and make an incision. See **Fig. 2**.
2. Locate the coupling nut (welded to the seat frame assembly). Make an incision in the seat back cover. See **Fig. 3**.



03/13/97 f910217

A. Front
B. Bottom
C. Place incision on this side for the left-hand armrest. Place on the opposite side for the right-hand armrest.
1. Hole
2. Adjustment Knob

Fig. 2, Armrest



03/14/97 f910218

A. Place incision on this side for the left-hand armrest. Place on the opposite side for the right-hand armrest.
1. Coupling Nut (welded to seat frame assembly)
2. Seat Back

Fig. 3, Coupling Nut Location

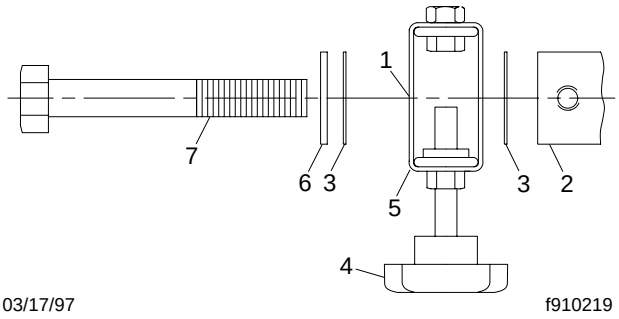
3. Insert the pivot bar through the incision in the seat back cover. Slide the pivot bar over the coupling nut with the hole for the socket head screw facing rearward. See **Fig. 1**.

NOTE: The seat back cover and foam will hold the pivot bar in place while the remainder of the armrest is prepared for assembly.

4. Unzip the armrest cover and assemble the armrest bolt, the metal washer, and the plastic washers through the hole in the side of the armrest tube. See **Fig. 4**. The armrest tube must be

Armrest Removal and Installation

clamped between the two plastic washers when assembly is complete.



1. Small Hole
2. Pivot Bar
3. Plastic Washer
4. Adjustment Knob
5. Armrest Tube
6. Metal Washer
7. Armrest Bolt

Fig. 4, Armrest Assembly

5. Slide the assembled armrest over the pivot bar. Tighten the armrest bolt 22 to 23 lbf·ft (29 to 31 N·m). See **Fig. 1**.

IMPORTANT: The pivot bar must be seated against the seat frame while the armrest bolt is tightened.

6. Install the socket head screw into the pivot bar. See **Fig. 1**. Tighten 10 to 16 lbf·ft (13 to 21 N·m).
7. Zip up the armrest cover.
8. Remove the chocks from the tires.

Specifications

Fastener Torques		
Description	**Size**	**Torque**
Seat Base Hexhead Capscrews	3/8–16	27 lbf·ft (37 N·m)
Intermediate-Connecting-Point Rod Capscrews	11/16	40 lbf·ft (54 N·m)
Air Spring Hexhead Bolt	1/2	15–20 lbf·ft (20–27 N·m)
Air Spring Fitting Pipe Threads	—	12–18 lbf·ft (16–24 N·m)
Air Fitting to Air Spring Jam Nut	3/4	72–96 lbf·in (800–1100 N·cm)
Shock Absorber Nut	5/16	10–15 lbf·ft (14–20 N·m)
Armrest Bolt	—	22–23 lbf·ft (29–31 N·m)
Socket Head Screw	—	10–16 lbf·ft (13–21 N·m)

Table 1, Fastener Torques

General Information

Freightliner Corporation currently applies DuPont® single-stage Imron® 5000 or two-stage (base coat and clear coat) Imron 6000 high-solids polyurethane enamel on the vehicle cab at the factory.

Black Standard Urethane or Imron 5000 is used on the vehicle chassis. The chassis includes the frame, spoke spider, running gear, and any components attached to the frame. Aluminum fuel tanks are not painted.

To meet the federal air quality regulations imposed by the EPA and local jurisdictions, these products contain lower levels of volatile organic compounds (VOCs) than earlier types (916Y, Centari®, and Imron), and are formulated free of lead and chrome.

The procedures in this section are for use with DuPont products. Unless otherwise noted, all products are manufactured by E. I. du Pont de Nemours and Company, Inc. Obtain approval from a Freightliner Regional Office for use of topcoats produced by other manufacturers.

Color-Matching

The recommended aftermarket paints for color-matching factory-applied paint are as follows:

- Cab—use Imron 5000 or Imron 6000
- Chassis—use only Imron 5000

To ensure proper gloss, durability, and color-matching of the enamel, use only Imron 5000 on panels that were previously painted with Imron 5000, and use only Imron 6000 on panels painted with Imron 6000.

To determine the correct paint number for color-matching any original finish on a vehicle, refer to the paint specification on the vehicle specification decal. Refer to the vehicle driver's manual for the location of this decal.

NOTE: The high-solids Standard Urethane applied to the chassis at the factory is sold to original equipment manufacturers (OEMs) only, and is not available for aftermarket sale. Use Imron 5000, N0001 Black, for repainting.

General Guidelines

This section provides instructions for preparing large panels or the entire cab for topcoating with DuPont® products. For spot repairs or touch-ups, see **Subject 120**.

Before topcoating, the surface must be thoroughly cleaned and sanded. Any bare areas must also be conditioned and primed.

1. Preparation materials specified for one type of surface should not be used for any other type of surface.
2. Limit intermediate coatings, such as primers, to the brand and type specified by the finish-coat manufacturer.

⚠ CAUTION

Only experienced, qualified persons using proper equipment should attempt repainting or touch-up painting. Incorrect application of chemicals or paint could damage the surface or impair the finish.

Preparation for Prime Coat

Use the cleaners and conditioners specified in each step to prepare the surface for priming. See **Specifications, 400** for a summary of the products used in this procedure.

⚠ WARNING

Do not use solvent-based cleaners on large areas of plastic or fiberglass, such as the hood. Wiping down these large areas may cause a buildup of static electricity. The resulting spark could cause a flash fire, which could result in personal injury or property damage.

1. Wash and dry the entire vehicle with a mild detergent.

⚠ WARNING

Solvents are flammable. Keep them away from heat, sparks, and open flame. Keep the container closed. Use only with adequate ventilation. Avoid breathing the vapor, or headache, nausea, and impaired reaction time and coordination may result.

2. Wipe all surfaces to be painted with a clean cloth soaked with solvent or cleaner. Remove all traces of wax, polish, grease, and silicones.
   - Metal—use DuPont Prep-Sol 3919 S.
   - Plastic—use DuPont Plastic Prep 2319 S.
   - Fiberglass—use DuPont Prep-N-Solv.

   2.1 Work on small areas at a time, wetting the surface liberally.

   2.2 Quickly wipe the surface with a clean cloth before the solvent or cleaner has a chance to dry. Change cloths frequently.
3. Feather the edge of all repaired areas, chipped surfaces, and scratches.

   3.1 Cut down the edges of broken spots with no. 220 sandpaper.

   3.2 Feather the edges by hand, using a sanding block with no. 400 sandpaper.
4. Sand the entire area to be painted. Using a sanding block and no. 400 sandpaper, remove the gloss to improve adhesion of the primer.
5. Using a clean cloth soaked with cleaner, remove any sanding dust.
   - Metal or plastic—use DuPont 3939 S lacquer and enamel cleaner.
   - Fiberglass—use a solution of one part water and one part isopropyl alcohol (IPA).
6. Treat bare metal and rusted areas.
   - Steel—use DuPont 5717 S metal conditioner.
   - Aluminum—use DuPont 225 S aluminum cleaner.

   6.1 Mix one part of the cleaner with two parts of water in a plastic bucket.

   6.2 Apply the cleaner with a cloth or sponge. If corrosion is present, work the surface with a stiff plastic brush or 3M Scotch-Brite® pad. Do not use any pads containing iron.

   6.3 While the metal is still wet, wipe thoroughly with a clean, dry cloth. Allow the

Preparing for Topcoating

surface to dry before applying a conversion coating.

7. Apply a conversion coating to all bare metal.
   - Steel—use DuPont 5718 S metal conversion coating.
   - Zinc casings or galvanized surfaces (iron or steel)—use DuPont 5718 S metal conversion coating.
   - Aluminum—use DuPont 226 S aluminum conversion coating.

   7.1 Pour the conversion coating into a plastic container (do not dilute). Using a 3M Scotch-Brite or similar non-iron abrasive pad, apply the conversion coating to the metal surface. Work only as much area as can be coated and rinsed before the solution dries.

   7.2 Leave the coating on the surface for 2 to 5 minutes. Then, rinse off the solution with cold water, or mop with a sponge or cloth rinsed frequently in clean water.

   If the metal surface dries before rinsing, reapply the conversion coating, then repeat the previous substep.

   7.3 Wipe the surface dry with a clean cloth, or air dry.

8. With paper and tape, mask all areas that are not to be painted.

Prime Coat

Prime all bare and feathered areas before topcoating. The specified primers can be used on any surface.

1. Clean all cracks and surfaces with dry compressed air.
2. Using a tack cloth, wipe all surfaces to be painted.

⚠ WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying primer, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.

3. Prime all bare metal and feathered areas with DuPont primer.
   - Steel and aluminum—use Corlar 824 S epoxy primer.
   - Fiberglass—use Corlar 825 S epoxy primer.

   3.1 Stir the primer thoroughly.

   3.2 Mix two parts Corlar epoxy primer with one part DuPont 826 S activator.

   3.3 Reduce three parts of this mixture with one part DuPont 3602 S lacquer thinner (viscosity reading is 18 to 22 seconds in a no. 2 Zahn cup). Stir thoroughly.

   3.4 Wait 1 to 2 hours from time of mixing before using. This provides time for complete chemical induction.

   3.5 Set the air pressure at the spray gun at 45 psi (310 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.

   3.6 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.

   3.7 Spray one full wet coat to give a dry film thickness of 0.7 to 1.0 mil (18 to 25 µm).

   3.8 Clean the equipment immediately after use with DuPont 3602 S lacquer thinner.

   3.9 Air dry 2 hours or force dry 20 minutes.

4. Wet sand the primer with no. 400 grit or finer sandpaper. Feather the edge into the surrounding area.
5. Dry the surface. Using a clean cloth soaked with cleaner, remove any sanding dust.
   - Metal or plastic—use DuPont 3939 S lacquer and enamel cleaner.
   - Fiberglass—use solution of 1 part water and 1 part isopropyl alcohol (IPA).

NOTE: See **Subject 110** for topcoating instructions.

General Guidelines

This section provides instructions for applying a topcoat of DuPont® enamel to full panels or the entire cab. For spot repairs or touch-ups, see **Subject 120**.

⚠ CAUTION

Only experienced, qualified persons using proper equipment should attempt repainting or touch-up painting. Incorrect application of chemicals or paint could damage the surface or impair the finish.

Do not mix additives with the finish coats unless they are specified by the finish-coat manufacturer. See **Specifications, 400** for a summary of the products used in this procedure.

Before applying any topcoat:

1. Prepare the surface for topcoating. See **Subject 100** for instructions.
2. Clean all cracks and surfaces with dry compressed air.
3. Using a tack cloth, wipe all surfaces to be painted.

After topcoating, remove the masking as follows:

- After normal air drying—remove all masking when the surface is reasonably dry.
- After forced drying—remove the masking immediately after the finish has been baked.
- After two-toning—remove the masking used for the first coat as soon as it has set up, usually in about 35 to 40 minutes. Follow the same procedure for the second color.

Imron 5000 Topcoating

Imron 5000 is a single-stage, low VOC, high-solids polyurethane enamel. It provides a durable, high-gloss surface with good chemical resistance. It requires the addition of an activator.

⚠ WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator approved by NIOSH or MSHA (TC-19C), while spraying Imron 5000, and until the work area has been exhausted of all vapor and spray mist. Breathing paint vapor or spray mist can cause personal injury.

MIXING

1. Stir the Imron 5000 enamel thoroughly.
2. Mix three parts Imron 5000 enamel with one part of DuPont 193 S or 194 S activator. No further reduction is necessary for application.

NOTE: The pot life of the mixture is about 2 to 4 hours at 70°F (21°C), unless an accelerator is added.

3. If faster curing time is desired, add DuPont 389 S fast-dry accelerator. Add up to 2 ounces (60 mL) to 1 gallon (3.8 L) of mixed material.
4. Mix thoroughly and strain.

NOTE: The viscosity of the mixture is about 9 to 20 seconds in a no. 3 Zahn cup, depending on the color. Adding reducer could affect the color match on some metallics.

APPLICATION

1. Set the air pressure at the spray gun to 60 to 65 psi (410 to 450 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.
2. Apply the topcoating.
   - 2.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.
   - 2.2 Using a cross-coat technique, spray one medium-wet coat in a north-to-south direction
   - 2.3 Allow 5 to 10 minutes drying time between each application. Do not sand.
   - 2.4 Apply a second medium-wet coat in an east-to-west direction.
   - 2.5 A third medium-wet coat may be needed for good coverage of some colors.
3. To air dry, allow 2 to 4 hours with accelerator 389 S, and 6 to 8 hours without the accelerator.

   To force dry, wait 15 minutes following the application of the final coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).

4. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.
5. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

RECOATING OR DECORATING

Two-toning, striping, or lettering may be applied in 4 to 6 hours if DuPont 389 S accelerator is used. Wait 10 to 12 hours if no accelerator is used.

Decals may be applied in 12 to 16 hours if 389 S accelerator is used. Wait 24 hours if no accelerator is used.

For topcoats cured over 72 hours, scuff-sand with no. 400 grit sandpaper and wipe with a clean tack cloth before recoating, striping, lettering, or applying decals.

Imron 6000 Topcoating

Imron 6000 is a two-stage, high-solids polyurethane enamel. It provides good cover with one cross-coat of the base color followed by one coat of Imron 6000 clear coat. Both the base color and clear coat require the addition of an activator.

⚠ WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator approved by NIOSH or MSHA (TC-19C), while spraying Imron 6000, and until the work area has been exhausted of all vapor and spray mist. Breathing paint vapor or spray mist can cause personal injury.

MIXING

1. Stir the Imron 6000 base color thoroughly.
2. Mix three parts Imron 6000 base color with one part DuPont 193 S or 194 S activator. No further reduction is necessary for application.

NOTE: The pot life of the mixture is about 2 to 4 hours at 70°F (21°C), unless an accelerator is added.

3. If faster curing time is desired, add DuPont 389 S fast-dry accelerator. Add up to 2 ounces (60 mL) to 1 gallon (3.8 L) of mixed material.
4. Mix thoroughly and strain.

NOTE: For solids, the viscosity of the mixture is about 20 seconds in a DuPont M-222 (M-50) cup; for metallics, it is about 18 seconds.

APPLICATION

1. Set the air pressure at the spray gun to 60 to 65 psi (410 to 450 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.
2. Apply the topcoating.
   - 2.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.
   - 2.2 Apply one cross-coat of the Imron 6000 base color.
   - 2.3 Flash 10 minutes minimum. Do not sand.
   - 2.4 Mix three parts DuPont 3440 S or 3480 S clear with one part DuPont 193 S or 194 S activator.
   - 2.5 Apply one coat of the activated DuPont 3440 S or 3480 S clear.
3. To air dry, allow 2 to 4 hours if DuPont 389 S accelerator is used, and 6 to 8 hours if no accelerator is used.

   To force dry, wait 15 minutes following the application of the clear coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).
4. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.
5. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

RECOATING OR DECORATING

Two-toning, striping, and lettering may be applied in 4 to 6 hours if DuPont 389 S accelerator is used. Wait 10 to 12 hours if no accelerator is used.

Decals may be applied in 12 to 16 hours if 389 S accelerator is used. Wait 24 hours if no accelerator is used.

For topcoats cured over 72 hours, scuff-sand with no. 400 grit sandpaper and wipe with a clean tack cloth before recoating, striping, lettering, or applying decals.

General Guidelines

This section provides instructions for making spot repairs or touch-ups with DuPont® enamels. Buffing may correct minor imperfections; more serious repairs require surface preparation before a topcoating can be applied. For striping, lettering, or decal application after the repair is complete, see **Subject 110**.

1. Preparation materials specified for one type of surface should not be used for any other type of surface. See **Specifications, 400** for a summary of the materials used in this section.
2. Limit intermediate coatings, such as primers, to the brand and type specified by the finish-coat manufacturer.
3. Do not mix additives with the finish coats unless they are specified by the finish-coat manufacturer.

⚠ CAUTION

Only experienced, qualified persons using proper equipment should attempt repainting or touch-up painting. Incorrect application of chemicals or paint could damage the surface or impair the finish.

Buffing Minor Imperfections

1. Clean the area carefully with a mild detergent and rinse.
2. Remove imperfections using ultra-fine or micro-fine sandpaper (1500 or 2000 grit) and water. Rinse the area with clean water, then dry.
3. Buff the area.
   - 3.1 Use a clean foam pad at low speed (about 1600 rpm) with one of the following products:
     - DuPont 1500 S
     - Meguiar's No. 2
     - 3M Finesset Two 5928
   - 3.2 Using medium pressure, buff slowly in an overlapping pattern until the imperfection has been eliminated. Repeat as necessary.
   - 3.3 Rinse the area with clean water, then dry.
4. Polish the area.
   - 4.1 Apply one of the following products with a clean pad (3M Waffle Pad):
     - DuPont 3000 S
     - Meguiar's No. 9
     - 3M 5996
   - 4.2 Using medium pressure, work small areas using an even, overlapping pattern until the gloss is restored. As the polish dries and the gloss appears, ease the pressure on the polishing pad. Repeat as necessary.

Preparing for Topcoating

1. Wash the entire panel with mild detergent. Dry with a clean, lint-free cloth.

⚠ WARNING

Solvents are flammable. Keep them away from heat, sparks, and open flame. Keep the container closed. Use only with adequate ventilation. Avoid breathing the vapor, or headache, nausea, and impaired reaction time and coordination may result.

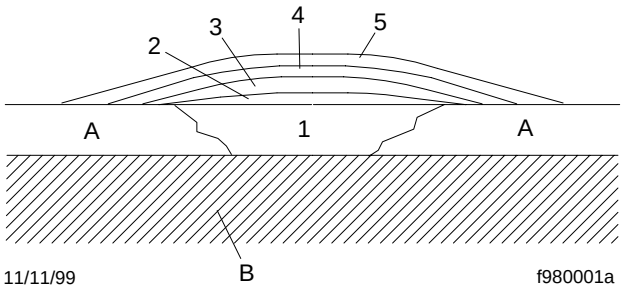
2. Clean the area to be repaired with DuPont 3939 S solvent and quickly wipe the surface with a clean, lint-free cloth before the solvent dries. Remove all traces of wax, polish, grease, and silicones.
3. Sand or grind all dents and scratches.
4. Wet sand and the area being repaired with no. 320 grit or finer sandpaper, or a 3M Scotch-Brite® or similar non-iron abrasive pad. Feather the edge.
5. Remove the sanding dust. Use the same solvent and wipe-on, wipe-off method used earlier to clean the area.
6. Mask all areas that will not be painted.
7. Clean all cracks and surfaces with dry compressed air.
8. Using a tack cloth, wipe all surfaces to be painted.

Spot Repair

WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying primer, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.

9. Prime all bare metal and feathered areas with DuPont primer. See **Fig. 1**.
   - Steel and aluminum—use Corlar 824 S epoxy primer.
   - Fiberglass—use Corlar 825 S epoxy primer.



NOTE: Scale exaggerated for clarity. The number of layers depends on the specific application.

A. Existing Paint
B. Panel Material (substrate)
1. Primer
2. First Color Topcoat
3. Second Color Topcoat
4. Third Color Topcoat
5. Clear Coat

Fig. 1, Spot Repair Cross-Section

9.1 Stir primer thoroughly.

9.2 Mix two parts Corlar epoxy primer with one part DuPont 826 S activator.

9.3 Reduce three parts of this mixture with one part DuPont 3602 S lacquer thinner (viscosity reading is 18 to 22 seconds in a no. 2 Zahn cup). Stir thoroughly.

9.4 Wait 1 to 2 hours from time of mixing before using. This provides time for complete chemical induction.

9.5 Set the air pressure at the spray gun to 45 psi (310 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.

9.6 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.

9.7 Spray one wet coat to give a dry film thickness of 0.7 to 1.0 mil (18 to 25 µm).

9.8 Clean the equipment immediately after use with DuPont 3602 S lacquer thinner.

9.9 Air dry 2 to 4 hours or force dry 20 minutes.

10. Wet sand the primer with no. 400 grit or finer sandpaper. Feather the edge into the surrounding area.
11. If the original paint was Imron 6000, hand-rub the area around the spot repair with a medium grade compound to ensure a seamless finish.
12. Remove the sanding dust. Use the same solvent and wipe-on, wipe-off method used earlier to clean the area.
13. Wipe the repair area with a tack cloth.
14. If the finish is old, apply one coat of DuPont 222 S adhesion promoter over the entire repair area.

    14.1 Set the air pressure to 35 psi (240 kPa) at the spray gun.

    14.2 Flash for 5 to 10 minutes at 70°F (21°C) before topcoating.

Topcoating a Spot Repair

WARNING

Wear a positive-pressure, supplied-air, vapor and particulate respirator approved by NIOSH or MSHA (TC-19C), while spraying topcoating, and until the work area has been exhausted of all vapor and spray mist. Breathing topcoating vapor or spray mist can cause personal injury.

Imron 5000 Topcoating

1. Mix the Imron 5000 polyurethane enamel.

   1.1 Stir the Imron 5000 enamel thoroughly.

1.2 Mix three parts Imron 5000 base color with one part DuPont 193 S or 194 S activator. No further reduction is necessary for application.

1.3 Mix thoroughly and strain.

2. Set the air pressure at the spray gun at 60 to 65 psi (410 to 450 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.

3. For metallic topcoats only, apply one coat of DuPont 500 S urethane clear.

3.1 Mix eight parts of 500 S urethane with one part 193 activator.

3.2 Reduce the activated 500 S urethane mixture 50 percent with 8685 S reducer.

3.3 Apply a medium-wet coat of the reduced 500 S urethane over the entire repair area, and well beyond where the color will be applied.

3.4 Flash 3 minutes before applying the Imron 5000 topcoat.

4. Apply the solid color or metallic topcoating.

4.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.

4.2 Spray one medium-wet coat over the primed area.

4.3 Flash 5 to 10 minutes.

4.4 Apply a second medium-wet coat. Extend the spray area slightly to taper the edge and avoid a visible ring.

4.5 A third medium-wet coat may be needed for good coverage of some colors. Allow each coat to flash before applying the next coat.

NOTE: A mist coat of five parts of color to three parts of 8022 S is recommended when applying metallics. Hold the gun about 18 inches (45 cm) from the surface.

5. Blend the repair area into the OEM finish.

5.1 Lower the air pressure to 15 to 20 psi (100 to 140 kPa) at the spray gun.

5.2 Empty the spray cup and refill it with DuPont 8022 S reducer or a blend of 8022 S and 8093 S.

5.3 Carefully blend the edge of the repair with even coats to melt in the overspray.

5.4 Spray one or two medium coats of the reducer over the entire area.

5.5 If a haze appears around the edge after the reducer has dried, lightly rub the edge with DuPont 1500 S one-step polish.

6. To air dry, allow 2 to 4 hours if DuPont 389 S accelerator is used, and 6 to 8 hours if no accelerator is used.

To force dry, wait 15 minutes following the application of the final coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).

7. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.

8. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

Imron 6000 Topcoating

1. Mix the Imron 6000 polyurethane enamel.

1.1 Stir the Imron 6000 base color thoroughly.

1.2 Mix three parts Imron 6000 base color with one part DuPont 193 S or 194 S activator. No further reduction is necessary for application.

1.3 Mix thoroughly and strain.

2. Set the air pressure at the spray gun at 60 to 65 psi (410 to 450 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 mL) per minute.

3. Apply the topcoating.

3.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.

3.2 Apply one cross-coat of the Imron 6000 base color over the primed area. No flash time is required before applying a clear coat.

3.3 Flash 10 minutes minimum. Do not sand.

Spot Repair

3.4 Mix three parts DuPont 3440 S or 3480 S clear with one part DuPont 193 S or 194 S activator.

NOTE: For best results, apply the clear coat over the entire panel. If a blend of the repair area is attempted, apply the clear coat only over the repair area, overspraying the edge slightly.

3.5 Apply one coat of the activated DuPont 3440 S or 3480 S clear.

4. Blend the 3440 S or 3480 S clear into the surrounding topcoat.

   4.1 Set the air pressure to 25 psi (170 kPa) at the spray gun.

   4.2 Apply one coat of 3401 S blending clear over the repair area only to the overspray edge.

   4.3 Flash 2 minutes. Repeat if necessary.

5. To air dry, allow 2 to 4 hours if DuPont 389 S accelerator is used, and 6 to 8 hours if no accelerator is used.

   To force dry, wait 15 minutes following the application of the final coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).

6. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.

7. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

Equipment Application Parameters

Equipment Application Parameters		
Parameter	**English Units**	**Metric Units**
Atomizing Air		
Primer	45 psi	310 kPa
Enamel	60–65 psi	410–450 kPa
Fluid Delivery	12–16 oz/min	350–470 mL/min
Booth Temperature	75°F	23°C
Spray Gun Distance	10–12 in	25–30 cm

DuPont Surface Preparation Materials

Step	**Surface Preparation Materials**			
	Steel	**Aluminum**	**Plastic**	**Fiberglass**
Wash and dry	Mild detergent (such as diswashing detergent)			
Wipe with cleaner	Prep-Sol 3919 S	Prep-Sol 3919 S	Plastic Prep 2319 S	Prep-N-Solv
Sand and feather	220 grit, then 400 grit			320 grit
Remove sanding dust	3939 S lacquer and enamel cleaner			Mix: - 1 part water - 1 part isopropyl alcohol
Treat bare metal	5717 S metal conditioner	225 S aluminum cleaner	—	—
Apply conversion coating to bare metal	5718 S metal conversion coating	226 S aluminum conversion coating	—	—
Apply sealer primer	Mix: - 2 parts Corlar 824 S primer with 1 part DuPont 826 S activator - reduce 3 parts of mixture with 1 part DuPont 3602 S lacquer thinner		Mix: - 2 parts Corlar 825 S primer with 1 part DuPont 826 S activator - reduce 3 parts of mixture with 1 part DuPont 3602 S lacquer thinner	

DuPont Topcoating Materials

Step	**Topcoating Materials**	
	Imron 6000	**Imron 5000**
Mix enamel	Mix: - 3 parts Imron 6000 - 1 part 193 S or 194 S activator	Mix: - 3 parts Imron 5000 - 1 part 193 S or 194 S activator
Add accelerator (optional)	389 S accelerator (up to 2 oz/gal of activated enamel)	
Mix clear coat	Mix: - 3 parts 3440 S or 3480 S clear - 1 part 193 S or 194 S activator	—

Specifications

Step	Topcoating Materials	
	Imron 6000	Imron 5000
Pressure at gun	60–65 psi (414–448 kPa)	60 psi (414 kPa)
Equipment cleanup	3939 S lacquer and enamel cleaner or 8685 S reducer	

DuPont Spot Repair Materials

Step	Spot Repair Materials	
	Imron 6000	Imron 5000
Cleaning	3939 S lacquer and enamel cleaner	
Sanding	320 grit or finer	
Sealer primer	Mix: - 2 parts Corlar 824 S primer with 1 part DuPont 826 S activator - reduce 3 parts of mixture with 1 part DuPont 3602 S lacquer thinner	
Compound	Medium grade compound	—
Adhesion promoter	222 S adhesion promoter	
Topcoat	1 coat Imron 6000: - 3 parts base color - 1 part 193 S or 194 S activator	2 coats Imron 5000: - 3 parts enamel - 1 part 193 S or 194 S activator
Topcoat viscosity	Solids: 20 sec; Metallics: 18 sec (#2 Zahn cup)	9–20 sec (#3 Zahn cup)
Clear coat	Mix: - 3 parts 3440 S or 3480 S clear - 1 part 193 S or 194 S activator	—
Accelerator (optional)	389 S accelerator	
Blending clear	1 coat 3401 S blending clear	
Equipment cleanup	3939 S lacquer and enamel cleaner or 8685 S reducer	