STERLING
TRUCKS

CARGO WORKSHOP MANUAL

STI-448, S11 (9/08P)

Published by
Daimler Trucks North America LLC
4747 N. Channel Ave.
Portland, OR 97217
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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 vehicle manufacturer or the component manufacturer.

Maintenance schedules and additional service information are included in the *Cargo Maintenance Manual*.

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

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

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.

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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 in paper and electronic (via ServicePro®) formats.

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, and specifications.

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, and 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 and post-trip inspections, and daily, weekly, and monthly maintenance of vehicle components. Driver's/operator's manuals do not contain detailed repair or service information.

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.

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

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ServicePro

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

PartsPro

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

EZWiring

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

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

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Page Description

For an example of a *Cargo Workshop Manual* page, see **Fig. 1**.



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

Fig. 1, Example of a Cargo Workshop Manual Page

Workshop 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
91	Seats and Restraint Systems
98	Paint

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54	Electrical, Instruments, and Controls
60	Cab
72	Doors
82	Windshield Wipers and Washer
83	Heater and Air Conditioner
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.

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)

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: For vehicles built May 1, 2000, or later, see **Subject 060** for the Sterling vehicle identification numbering system or **Subject 070** for the Freightliner system.

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 Sterling VIN, 480ALEBDXWA345678.

On Sterling vehicles, the VIN can be found on the Vehicle Specification Decal (see the driver's manual for decal location) and stamped on the outside of the left-hand frame rail about 24 to 40 inches (60 to 100 cm) aft of the front axle centerline. On Sterling vehicles built before July 1998, the VIN is stamped on the frame rail near the front axle position.

On Freightliner vehicles, the VIN can be found on the Vehicle Specification Decal (see the driver's manual for decal location) and stamped into 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	**4 8 0**	**A**	**L**	**E B**	**D**	**X**	**W**	**A**	**345678**
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**	**Table 9**	**—**
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 for Vehicles Built through April 30, 2000

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
1FV	Freightliner, U.S.A.	Freightliner	Incomplete Vehicle
2FU	Freightliner, Canada	Freightliner	Truck-Tractor
2FV	Freightliner, Canada	Freightliner	Incomplete Vehicle
2FW	Sterling, Canada-built	Sterling	Truck-Tractor
2FZ	Sterling, Canada-built	Sterling	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
480	Sterling, U.S.-built	Sterling	Truck-Tractor
49H	Sterling, U.S.-built	Sterling	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

VIN Position 4 (Chassis, Front Axle Position, Brakes)			
Code	**Chassis**	**Front Axle Position**	**Brakes**
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
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
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

VIN for Vehicles Built through April 30, 2000

VIN Position 4 (Chassis, Front Axle Position, Brakes)			
Code	**Chassis**	**Front Axle Position**	**Brakes**
8	Glider	Forward	Air
9	4 x 2 Truck	Setback	Air/Hydraulic
0	Glider	Setback	Air

Table 3, VIN Position 4 (Chassis, Front Axle Position, Brakes)

Sterling VIN Position 5 (Vehicle Model Series, Cab)	
Code	**Sterling Models**
A	L7500 series
B	L8500 series
C	L9501
D	L8511
E	L9500 series
F	L9522
G	A9522
H	A9500 series
J	A9513
K	L9513

Sterling VIN Position 5 (Vehicle Model Series, Cab)	
Code	**Sterling Models**
L	L8501
M	L8513
N	L9511
R	L7501
S	ST9500
W	SC8000
2	SC6000
7	SC7000

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

Freightliner VIN Position 5 (Model Series, Cab)	
Code	**Freightliner Models**
W	FC80 Freightliner Cargo COE
2	FC60 Freightliner Cargo COE
7	FC70 Freightliner Cargo COE

Table 5, Freightliner 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
F4	Cummins	B5.9 (propane)	185–224
FA	Cummins	6BT 5.9 (diesel) / ISB	185–224

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VIN Positions 6 and 7 (Engine Manufacturer, Model, Horsepower Range)			
Code	**Engine Manufacturer**	**Engine Model**	**HP Range**
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
TD	Detroit Diesel	S-55	336–407
TE	Detroit Diesel	S-55	408–495

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Code	**Engine Manufacturer**	**Engine Model**	**HP Range**
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	CFE/3126	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 6, VIN Positions 6 and 7 (Engine Manufacturer, Model, Horsepower Range)

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

VIN for Vehicles Built through April 30, 2000

VIN Position 8 (Gross Vehicle Weight Rating)		
Code	**lb**	**kg**
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 7, VIN Position 8 (Gross Vehicle Weight Rating)

VIN Position 10 (Vehicle Model Year)	
Code	**Model Year**
N	1992
P	1993
R	1994
S	1995
T	1996
V	1997
W	1998
X	1999
Y	2000
1	2001
3	2002

Table 8, VIN Position 10 (Vehicle Model Year)

VIN Position 11 (Plant of Manufacture)	
Code	**Plant of Manufacture**
A	St. Thomas, Ontario
H	Mt. Holly, North Carolina

Table 9, VIN Position 11 (Plant of Manufacture)

Sterling 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 Sterling VIN, 2FZPABAV11AA12345.

The VIN can be found on the Vehicle Specification Decal (see the driver's manual for decal location) and stamped on the outside of the frame rails about 24 to 40 inches (60 to 100 cm) aft of the front axle centerline.

IMPORTANT: A revised 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 different for each business unit. For example, the code AB in positions 5 and 6 for a Sterling vehicle indicates an SC7000 Cargo. Code AB in the same position for a Freightliner vehicle represents an FLD112.

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	**2 F Z**	**P**	**A B**	**A V**	**1**	**1**	**A**	**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**
2FW	Sterling, Canada-built	Sterling	Truck-Tractor
2FZ	Sterling, Canada-built	Sterling	Incomplete Vehicle
480	Sterling, U.S.-built	Sterling	Truck-Tractor
49H	Sterling, U.S.-built	Sterling	Incomplete Vehicle

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

VIN Position 4 (Chassis Configuration)	
Code	**Chassis**
D	4 x 4 Truck
E	4 x 4 Truck-Tractor

Sterling VIN for Vehicles Built from May 1, 2000

VIN Position 4 (Chassis Configuration)	
Code	**Chassis**
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, Front Axle Position, Brakes)

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**Class (GVWR)**
AA	SC7000 Cargo	COE	Class 6 *
AB	SC7000 Cargo	COE	Class 7 †
AC	SC7000 Cargo	COE	Class 8 ‡
AD	SC8000 Cargo	COE	Class 7
AE	SC8000 Cargo	COE	Class 8
AF	M5500 Acterra	Conventional	Class 5 §
AG	M6500 Acterra	Conventional	Class 5
AH	M6500 Acterra	Conventional	Class 6
AJ	M7500 Acterra	Conventional	Class 6
AK	M7500 Acterra	Conventional	Class 7
AL	M8500 Acterra	Conventional	Class 6
AM	M8500 Acterra	Conventional	Class 7
AN	M8500 Acterra	Conventional	Class 8

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**Class (GVWR)**
AP	L7500 Series	Conventional	Class 5
AR	L7500 Series	Conventional	Class 6
AS	L7500 Series	Conventional	Class 7
AT	L7500 Series	Conventional	Class 8
AU	L7500 Series Glider	Conventional	Glider
AV	L8500 Series	COE	Class 7
AW	L8500 Series	COE	Class 8
AX	L8500 Series Glider	COE	Glider
AY	L9500 Series	Conventional	Class 7
AZ	L9500 Series	Conventional	Class 8
A1	L9500 Series Glider	Conventional	Glider
A2	A9500 Series	Conventional	Class 7
A3	A9500 Series	Conventional	Class 8
A4	A9500 Series Glider	Conventional	Glider
A5	ST9500 Series	Conventional	Class 7
A6	ST9500 Series	Conventional	Class 8
A7	ST9500 Series Glider	Conventional	Glider
A8	L7501	Conventional	Class 6
A9	L7501	Conventional	Class 7
A0	L7501	Conventional	Class 8
BA	L8501	Conventional	Class 6
BB	L8501	Conventional	Class 7
BC	L8501	Conventional	Class 8
BD	L8511	Conventional	Class 7
BE	L8511	Conventional	Class 8
BF	L8513	Conventional	Class 7
BG	L8513	Conventional	Class 8
BH	L9501	Conventional	Class 7
BJ	L9501	Conventional	
BK	L9511	Conventional	Class 7
BL	L9511	Conventional	Class 8
BM	L9513	Conventional	Class 7
BN	L9513	Conventional	Class 8

Sterling VIN for Vehicles Built from May 1, 2000

VIN Positions 5 and 6 (Model, Cab, Class/GVWR)			
Code	**Model**	**Cab**	**Class (GVWR)**
BP	A9522	Conventional	Class 7
BR	A9522	Conventional	Class 8
BS	L9522	Conventional	Class 7
BT	L9522	Conventional	Class 8
BU	T-2	COE	Class 7
BV	T-2	COE	Class 8
BW	L9513	Conventional	Class 7
BX	L9513	Conventional	Class 8

* Class 6 GVWR is 19,501–26,000 lb.

† Class 7 GVWR is 26,001–33,000 lb.

‡ Class 8 GVWR is 33,001 lb and over.

§ Class 5 GVWR is 16,001–19,500 lb.

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

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displace-ment (L)**	**Config-uration**	**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
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

Sterling VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displace-ment (L)**	**Config-uration**	**Brakes**
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
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

Sterling VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displace-ment (L)**	**Config-uration**	**Brakes**
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
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

Sterling VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displace-ment (L)**	**Config-uration**	**Brakes**
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
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, 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 (Vehicle Model Year)

VIN Position 11 (Build Location)	
Code	**Build Location**
A	St. Thomas, Ontario
H	Mt. Holly, North Carolina

Table 7, VIN Position 11 (Build Location)

Freightliner 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 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 different for each business unit. 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

Freightliner 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

VIN Position 4 (Chassis Configuration)	
Code	**Chassis**
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)**
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

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

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displace-ment (L)**	**Config-uration**	**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
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

Freightliner VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displace-ment (L)**	**Config-uration**	**Brakes**
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
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

Freightliner VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displace-ment (L)**	**Config-uration**	**Brakes**
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
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

Freightliner VIN for Vehicles Built from May 1, 2000

VIN Positions 7 and 8 (Engine, Brakes)					
Code	**Engine**	**Fuel**	**Displace-ment (L)**	**Config-uration**	**Brakes**
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
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

VIN Position 10 (Model Year)	
Code	**Model Year**
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

Freightliner VIN for Vehicles Built from May 1, 2000

VIN Position 11 (Build Location)	
Code	**Build Location**
P	Portland, Oregon

Table 7, VIN Position 11 (Build Location)

Threaded Fastener Types

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 threaded 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.

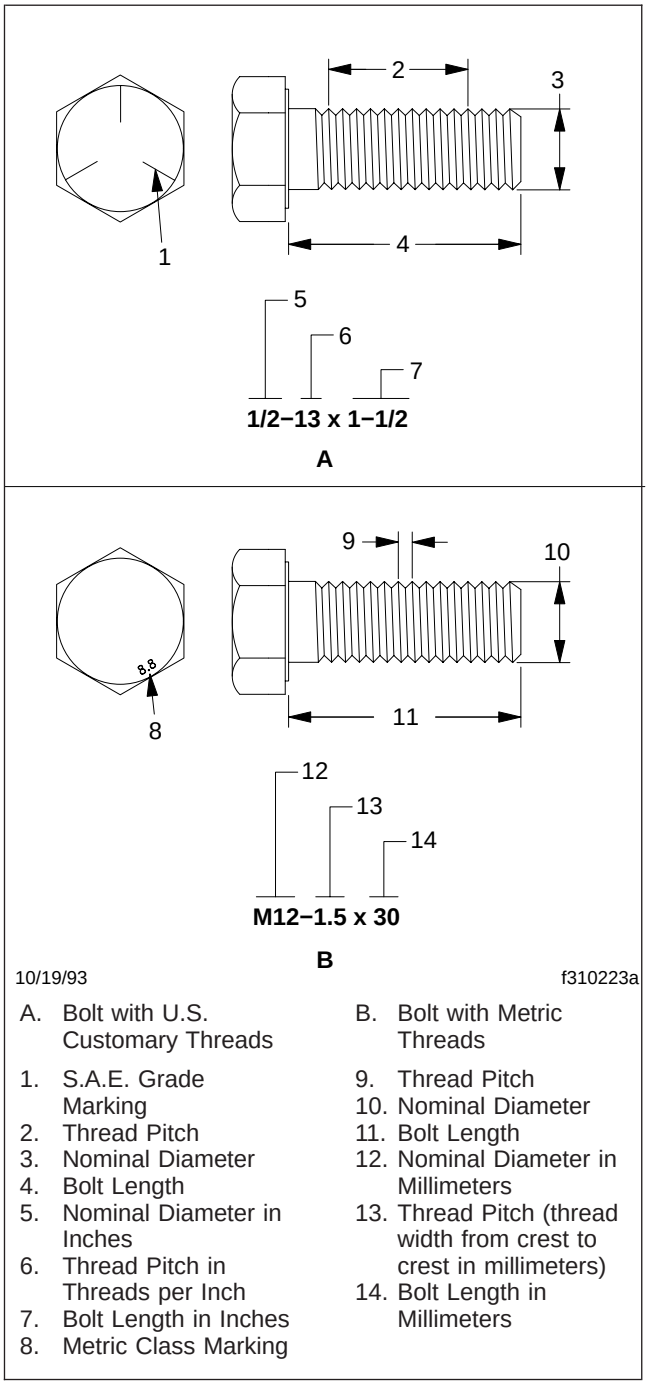
Some fasteners smaller than 1/2-inch diameter are flanged fasteners, which have integral flanges that fit against the parts being fastened. The flanges eliminate the need for washers.

NOTE: The standard fasteners used to assemble the vehicle frame and to attach components to the vehicle frame are threaded lockbolts (Spin Hucks). These fasteners are covered in **Section 31.00**.

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. See **Fig. 2**. Hexnut (and locknut) grades can be identified by the number and pattern of lines and dots on various surfaces of the nut. See **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.

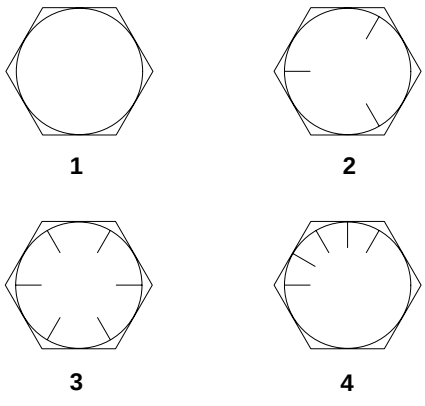
Fasteners with metric threads are divided into classes adopted by the American National Standards Institute (ANSI). The higher the class number, the stronger the fastener. Bolt classes can be identified by the numbers forged on the head of the bolt. See **Fig. 4**. Hexnut (and locknut) classes can be identified by the marks or numbers on various surfaces of the



A. Bolt with U.S. Customary Threads
B. Bolt with Metric Threads
1. S.A.E. Grade Marking
2. Thread Pitch
3. Nominal Diameter
4. Bolt Length
5. Nominal Diameter in Inches
6. Thread Pitch in Threads per Inch
7. Bolt Length in Inches
8. Metric Class Marking
9. Thread Pitch
10. Nominal Diameter
11. Bolt Length
12. Nominal Diameter in Millimeters
13. Thread Pitch (thread width from crest to crest in millimeters)
14. Bolt Length in Millimeters

Fig. 1, Fastener Size and Thread Identification

nut. See **Fig. 5**. Class 8 hexnuts are always used with class 8.8 bolts; class 10 hexnuts with class 10.9 bolts.



NOTE: Grade 2 bolts have no grade marking; grade 2 bolts are rarely used by Freightliner.These grade markings are used on plain hex-type and flanged bolts (capscrews). In addition to the grade markings, the bolt head must also carry the manufacturer's trademark or identification.

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

Fig. 2, Bolt Grades

Frame Fasteners

The standard fasteners used to assemble the vehicle frame and to attach most components to the vehicle frame are threaded lockbolts (Spin Hucks). These fasteners are covered in **Section 31.00**.

For some other 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**.

Tightening Fasteners

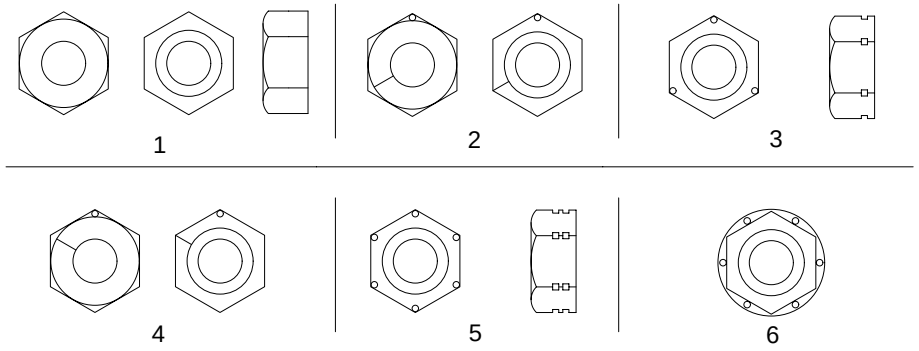
When a capscrew is tightened to its torque value in a threaded hole, or a nut is tightened to its torque value on a bolt, the shank of the capscrew or bolt is stretched slightly. This stretching (tensioning) results in a preload that reduces fatigue of the fasteners. The torque values given in the tables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

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. 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, Cargo 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.

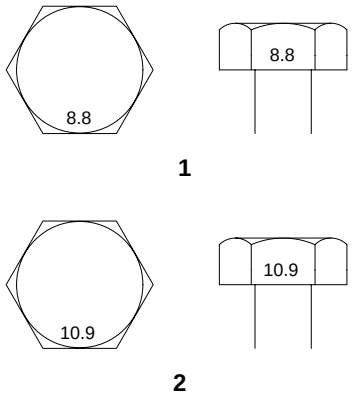


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NOTE: Grade 2 (S.A.E.) and grade A (I.F.I.) nuts have no identification marks or notches; they are rarely used by Freightliner. Grade B (I.F.I.) nuts have three identification marks at 120 degrees, or 6 notches. Grade C (I.F.I.) nuts have three identification marks at 60 degrees, or 12 notches. Grade G (I.F.I.) flanged nuts have six identification marks as shown; each identification mark may be a dot, line, pair of dots or lines, or any other symbol at the manufacturer's option.

1. S.A.E. Grade 2 or I.F.I. Grade A Nut (strength compatible with grade 2 bolt.)
2. S.A.E. Grade 5 Nut (strength compatible with grade 5 bolt.)
3. I.F.I. Grade B Nut (strength compatible with grade 5 bolt.)
4. S.A.E. Grade 8 Nut (strength compatible with grade 8 or grade 8.2 bolt.)
5. I.F.I. Grade C Nut (strength compatible with grade 8 or grade 8.2 bolt.)
6. I.F.I. Grade G Nut (flanged locknut; strength compatible with grade 8 or grade 8.2 bolt.)

Fig. 3, Nut Grades

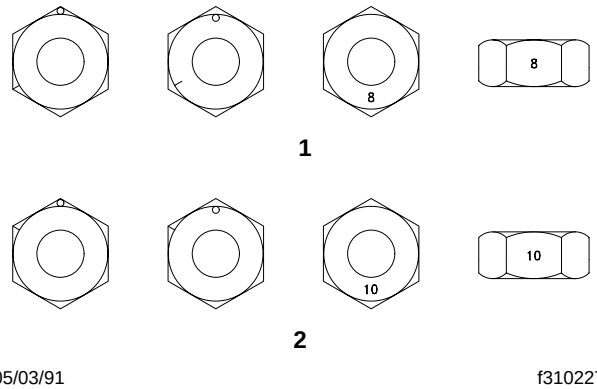


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NOTE: In addition to the class markings, the bolt head must also carry the manufacturer's trademark or identification.

1. Class 8.8 2. Class 10.9

Fig. 4, Bolt Classes

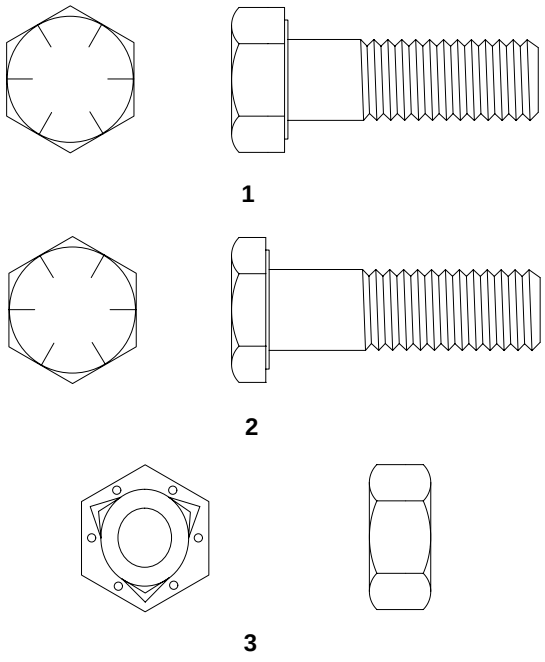


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1. Class 8 Nut 2. Class 10 Nut

Fig. 5, Nut Classes

General Information



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

Fig. 6, Frame Fastener Identification

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 vehicle 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 4 inches (100 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 extends through the nut after it has been tightened. For bolts longer than 4 inches (100 mm), allow a minimum of 1-1/2 threads and a maximum of 3/4-inch (19-mm) 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, Cargo 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 **Specifications 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

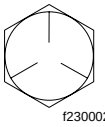
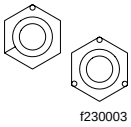
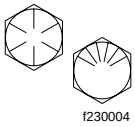
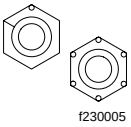
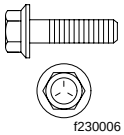
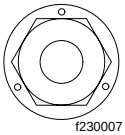
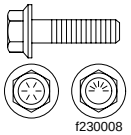
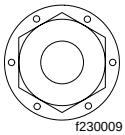
with a thread diameter of 1 inch (25 mm) or less, use Loctite® 271 or Perma-Lok® HM-128.

For thread diameters over 1 inch (25 mm), 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 400°F (200°C) before removing the nut. Every time the fasteners are disassembled, replace them. If any parts are damaged by overheating, replace the parts.

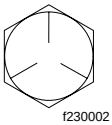
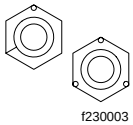
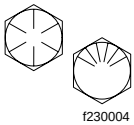
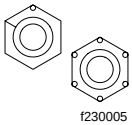
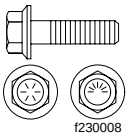
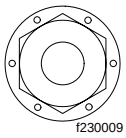
TORQUE VALUES FOR U.S. CUSTOMARY THREAD FASTENERS WITH LUBRICATED * OR PLATED THREADS †								
Thread Diameter–Pitch	Regular Hex				Flanged			
	 f230002	 f230003	 f230004	 f230005	 f230006	 f230007	 f230008	 f230009
	Grade 5 Bolt	Grade 5 or B Nut	Grade 8 or 8.2 Bolt	Grade 8 or C Nut	Grade 5 Bolt	Grade 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)	
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

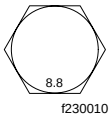
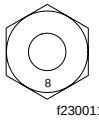
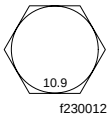
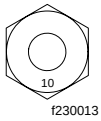
Specifications

TORQUE VALUES FOR U.S. CUSTOMARY THREAD FASTENERS WITH DRY (UNLUBRICATED) * PLAIN (UNPLATED) THREADS †						
Thread Diameter–Pitch	Regular Hex				Flanged	
	 f230002	 f230003	 f230004	 f230005	 f230008	 f230009
	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)	
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)**	
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	231 (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 Cargo 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 $_2$O ..... 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

General Information

The Cummins ISB engine 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, see the *Cummins ISB Operation and Maintenance Manual*, *Cummins Troubleshooting and Repair Manual ISB Series*, and *Cummins Workshop Manual ISB Series*.

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.

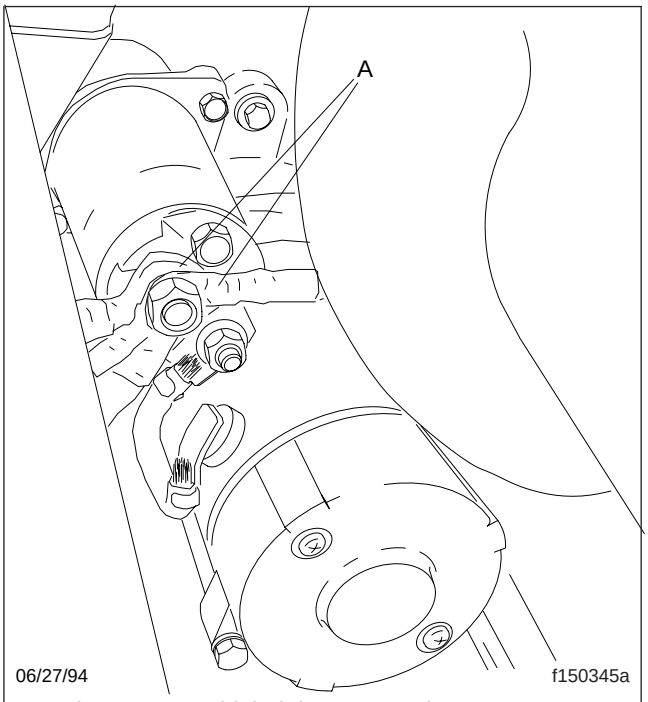
1. Apply the parking brakes, chock the tires, and (if applicable) drain the air system.
2. Disconnect the batteries or, if the vehicle is equipped with a battery shutoff switch, turn off the switch.
   - 2.1 Disconnect the battery ground cable at the vehicle frame.
   - 2.2 Disconnect the positive battery cable from the batteries.
3. Tilt the cab
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. Disconnect or remove the air intake, exhaust pipe, and hoses.
   - 5.1 If the vehicle is equipped with air brakes, disconnect the air compressor outlet line.
   - 5.2 If the vehicle is equipped with air brakes, disconnect the two air signal lines from the air governor at the top of the compressor.
   - 5.3 Disconnect the air inlet and outlet hoses from the aftercooler.
   - 5.4 Disconnect the air intake pipe from the turbocharger.
   - 5.5 Disconnect the V-clamp connecting the exhaust pipe to the rear of the turbocharger. Remove the pipe from the turbocharger.
6. Disconnect the coolant hoses.
   - 6.1 If equipped, remove the automatic transmission cooler.
   - 6.2 Disconnect the coolant inlet and outlet hoses from the radiator.
   - 6.3 Disconnect the vent hose from the upper radiator pipe, and remove the hose bracket from the condenser mounting bolt.
   - 6.4 Disconnect the fill hose from the bottom of the surge tank.
   - 6.5 Disconnect the heater inlet hose below air conditioning compressor.
   - 6.6 Disconnect the heater outlet hose in front of the turbocharger.
7. Remove the refrigerant compressor.
   - 7.1 Disconnect the compressor electrical connectors.
   - 7.2 Remove the four bolts securing the compressor to its mount.
   - 7.3 To keep the refrigerant system intact, with no leaks and no need for purging and recharging, move the refrigerant compressor to the side.
   - 7.4 Secure the compressor out of the way with wire.
8. Remove the two power steering pump mounting bolts, and move the pump aside while keeping the steering fluid system intact.
9. Disconnect the engine fuel and oil system components.
   - 9.1 Disconnect the fuel delivery line at the rear of the engine.
   - 9.2 Disconnect the fuel return line from the rear of the engine.
   - 9.3 Disconnect the oil pressure gauge line under the fuel injection pump.
10. Disconnect the engine electrical connections.
    - 10.1 Disconnect the ground strap from the engine.
    - 10.2 Disconnect the wires from the starter and label them for reassembly. See **Fig. 1**.

Removal and Installation



A. Disconnect and label the starter wires.

Fig. 1, Disconnect and Label Starter Wires

10.3 Disconnect and label 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.

10.4 Remove the engine wiring harness from the engine and secure aside.

11. Disconnect the transmission-mounted components.

11.1 Remove the transmission dipstick, bracket and tube.

11.2 Disconnect the tachometer sensor at the engine flywheel.

11.3 Disconnect the speedometer sensor at the transmission output.

11.4 If the vehicle is equipped with hydraulic brakes, release the parking brake, and disconnect the parking brake cable from the parking brake.

11.5 Remove the shift tower from the transmission. 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.

11.6 Remove the clevis pin from the clutch release lever, then remove the clutch slave cylinder from its mounting bracket on the right side of the transmission. See **Fig. 2**.

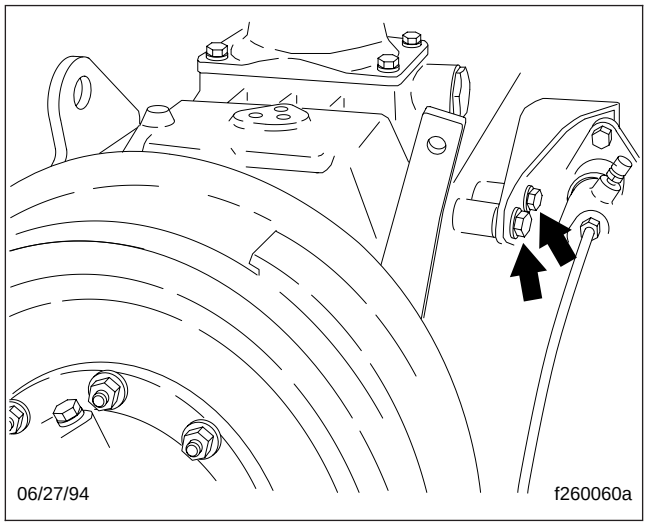


Fig. 2, Remove the Clutch Slave Cylinder from Its Mounting Bracket (right side)

11.7 At the transmission bell housing, remove the bracket that supports the exhaust pipe.

11.8 Remove the driveshaft from the transmission output end yoke. For instructions, see **Group 41** in this manual.

12. Remove the engine from the vehicle.

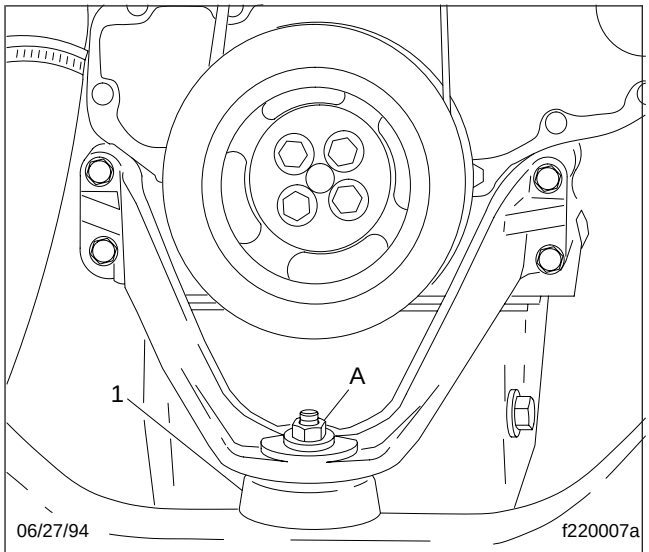
⚠ WARNING

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.

12.1 Attach a chain to the two engine lifting eyes, and position a crane to lift the en-

gine. Attach the chain to the crane, and raise the chain to remove any slack.

12.2 Remove the bolt from the front engine mount. See **Fig. 3**.



A. Remove this nut.
1. Front Engine Mount

Fig. 3, Remove the Front Engine Mount Bolt

12.3 Remove the bolts from the two rear engine mounts. See **Fig. 4** and **Fig. 5**.

12.4 Carefully lift the engine and pull it rearward to remove it from the engine compartment.

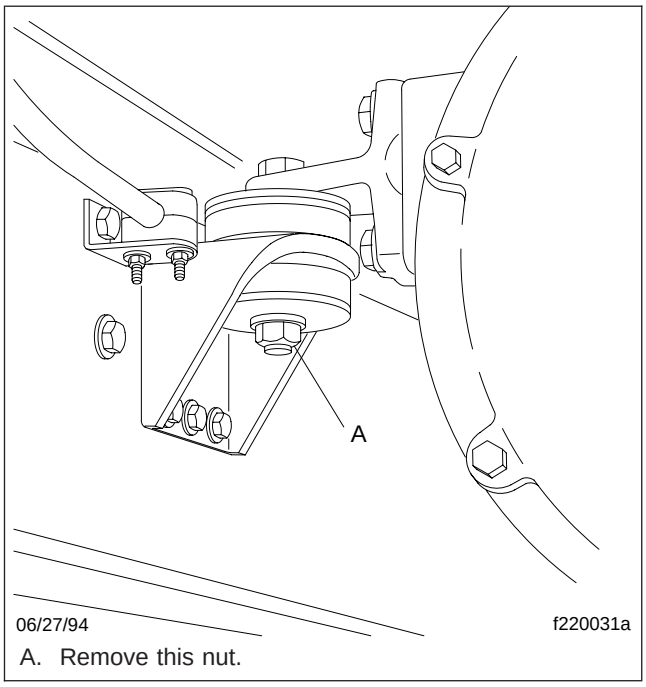
12.5 Disconnect air line from valve to dryer.

Installation

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

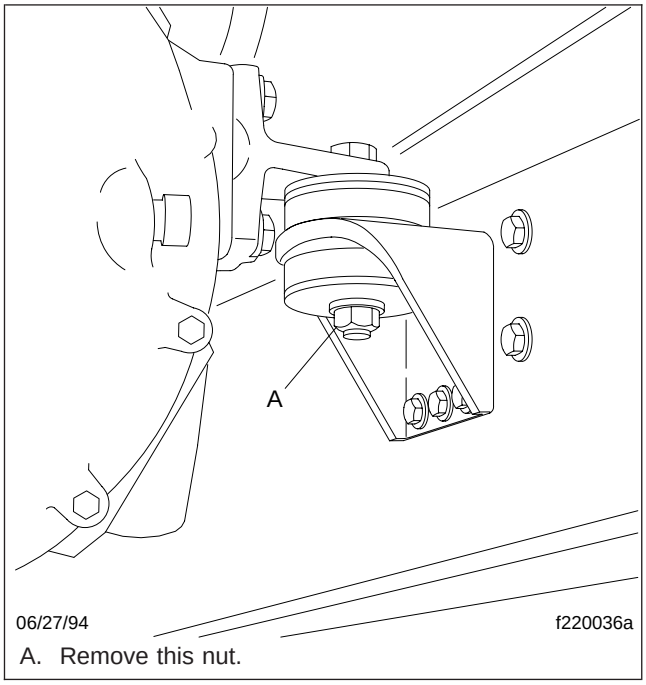
⚠ WARNING

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 en-



A. Remove this nut.

Fig. 4, Left Rear Engine Mount



A. Remove this nut.

Fig. 5, Right Rear Engine Mount

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

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.

2.3 Install power steering pump and air line to cab.

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

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

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

3. Connect the transmission-mounted components.

3.1 Connect the driveline to the transmission output end yoke. See **Group 41** in this manual for instructions.

3.2 Install the exhaust pipe bracket on the transmission bell housing.

3.3 Connect the clutch release lever with a new clevis pin, and install the clutch slave cylinder on the bracket at the right side of the transmission. See **Fig. 2**.

3.4 Install the transmission shift tower.

3.5 Connect the parking brake cable to the parking brake.

3.6 Connect the speedometer sensor at the transmission output.

3.7 Connect the tachometer sensor at the engine flywheel.

3.8 Install the transmission dipstick tube and bracket.

4. Connect the engine electrical connections.

4.1 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.

4.2 Connect the wiring harness brackets to the firewall.

4.3 Connect the starter wires. See **Fig. 1**.

4.4 Connect the engine ground strap to the frame rail.

5. Connect the fuel and oil components.

5.1 Connect the oil pressure gauge line at the fuel injection pump.

5.2 Connect the fuel return line at the rear of the engine.

5.3 Connect the fuel delivery line at the rear of the engine.

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

7. Install the air conditioning components on the engine.

7.1 Carefully move the refrigerant compressor back into place.

7.2 Position the compressor on its mount, and insert the four mounting bolts.

7.3 Tighten the compressor mounting bolt nuts 59 lbf·ft (80 N·m).

7.4 Connect the compressor electrical connectors to the wiring harness.

8. Connect the coolant hoses.

8.1 Connect the heater outlet hose below the air conditioning compressor.

8.2 Connect the heater inlet hose in front of the turbocharger.

8.3 Connect the vent hose to the upper radiator pipe. Connect the hose bracket at the condenser.

8.4 Connect the coolant inlet and outlet hoses to the radiator.

8.5 Connect the fill hose to the bottom of the surge tank.

8.6 If equipped, install the automatic transmission cooler.

9. Connect or install the air intake, exhaust pipe, and hoses.

9.1 Connect the air inlet and outlet hoses to the aftercooler. Tighten the hose clamps 60 lbf·in (680 N·cm).

9.2 Connect the exhaust pipe to the rear of the turbocharger, and install the V-clamp that secures the pipe.

9.3 Install the air intake pipe on the turbocharger.

9.4 If the vehicle is equipped with air brakes, connect the air outlet line to the air compressor.

9.5 If the vehicle is equipped with air brakes, connect the two air signal lines to the air governor on top of the compressor.

10. Connect the batteries or, if the vehicle is equipped with a battery shutoff switch, turn on the switch.

10.1 Connect the positive battery cable to the batteries.

10.2 Connect the battery ground cable to the vehicle frame.

11. Fill the engine coolant system.

11.1 Close the petcock on the bottom of the radiator.

11.2 Fill the system with coolant at the surge tank. For coolant specifications, see Group 20 of the vehicle maintenance manual.

11.3 Tighten the surge tank cap.

12. Start the engine and check for leaks. Eliminate any leaks.

13. After the engine has run for about 20 minutes, check the coolant level and add coolant if needed.

14. Fill and bleed the power steering system as needed. For instructions, see **Group 46** in this manual.

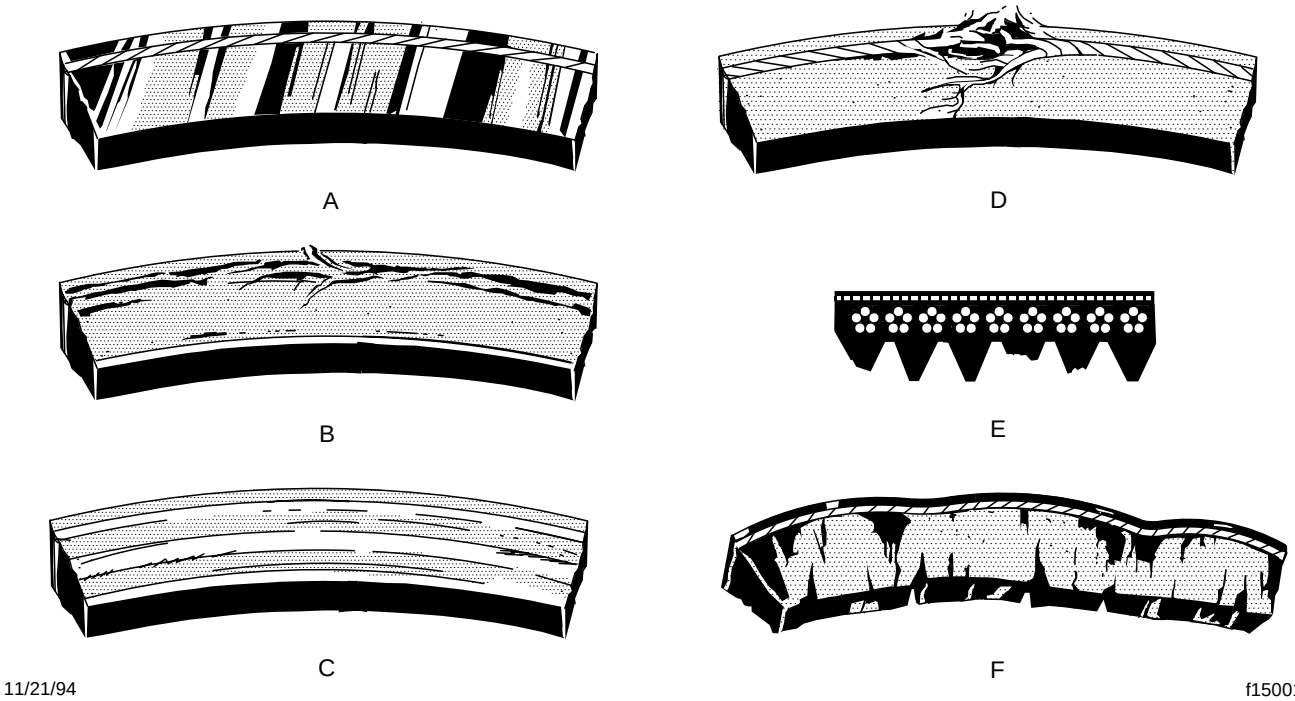
15. Return the cab to the operating position, and remove the chocks from the tires.

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

Table 1, Fastener Torques

Pulley and Drive Belt Inspection

Inspection (See Fig. 1)



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

Fig. 1, Inspect All Used Drive Belts

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

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

   1.1 Inspect for glazing (shiny sidewalls). 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.

   1.2 Inspect for separating layers. 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.

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

   1.4 Check for tensile breaks (breaks in the cord body). 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.

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

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

   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.

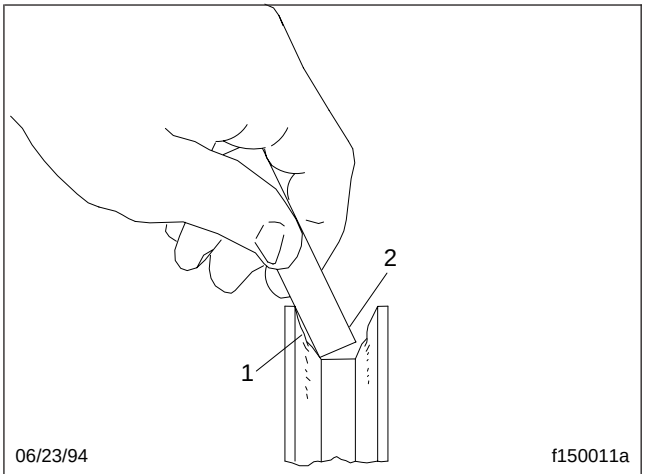
2. Check all pulley bearings for roughness. Replace the bearings if they're rough.

3. Inspect all pulleys for foreign objects, oil, or grease in the grooves. Use a non-flammable

Pulley and Drive Belt Inspection

cleaning solvent to remove oils. Use a wire brush to remove rust, and a file to remove burrs.

4. Inspect the pulleys for wear on the inner walls. Hold a small straightedge against the inside of the pulley walls (**Fig. 2**), 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

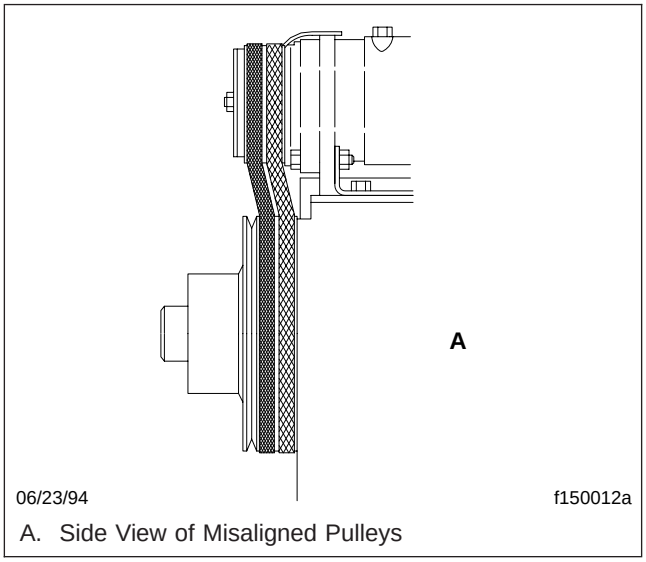
Fig. 2, Inspect the Pulleys for Wear on the Inner Walls

5. Check the alignment of pulleys. See **Fig. 3**. 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 1/16 inch for each foot (1.5 mm for each 30.5 cm) 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.

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



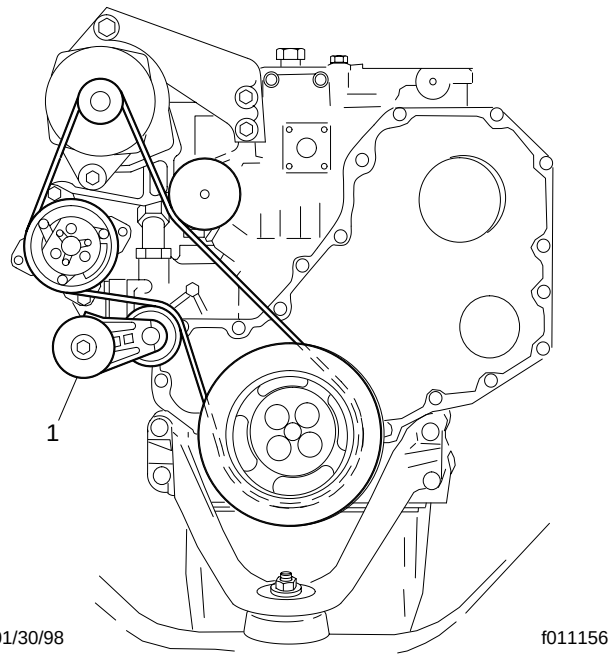
A. Side View of Misaligned Pulleys

Fig. 3, Check the Alignment of the Pulleys

Accessory Drive Belt Replacement

Replacement

1. Shut down the vehicle, apply the parking brakes, and tilt the cab.
2. Insert a 1/2-inch rachet drive into the square hole in the belt tensioner, and turn the tensioner clockwise. See **Fig. 1**.



1. Belt Tensioner

Fig. 1, Accessory Drive Belt

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

CAUTION

When installing a 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.

5. Position the drive belt over all the pulleys *except the drive belt tensioner.* For the correct belt routing, see **Fig. 1**.
6. Insert a 1/2-inch rachet drive into the square hole in the belt tensioner, and turn the tensioner clockwise. See **Fig. 1**.
7. Position the tensioner against the belt, and remove the rachet drive from the tensioner.
8. Return the cab to the operating position and remove the chocks from the tires.

Specifications

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

Table 1, Fastener Torques

Drive Belt Tensions	
Description	**Tension lb (kg)**
Refrigerant Compressor Belt	100 (45)

Table 2, Drive Belt Tensions

General Information

The Phillips Temro engine block heater keeps the engine coolant about 80°F (27°C) 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 725°F (385°C). 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. A cord plugs into the outside end of the element, and the cord runs to a receptacle mounted below the driver's door.

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.

Engine Block Heater Element Replacement

Removal

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

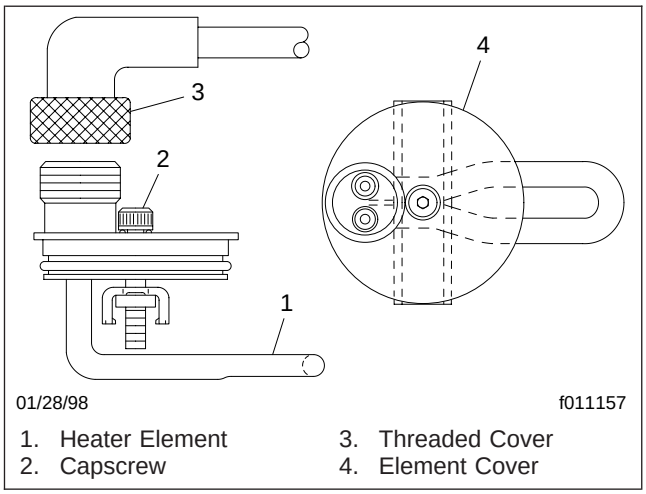
WARNING

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 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. Loosen the capscrew in the center of the element cover, and pull out the element.

Installation

1. Install the element in the block and tighten the capscrew 10 lbf·ft (13 N·m).
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, see Group 20 of 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.
6. Return the cab to the operating position, and remove the chocks from the tires.



1. Heater Element
2. Capscrew
3. Threaded Cover
4. Element Cover

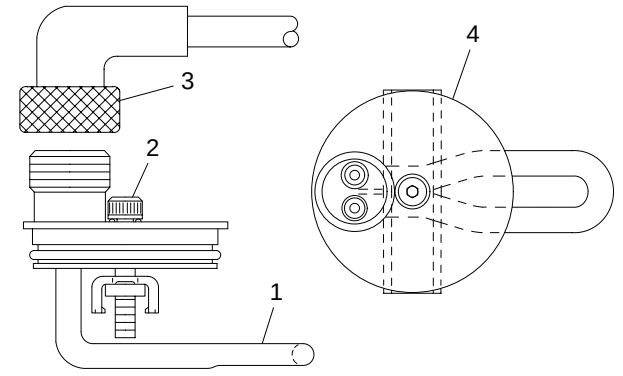
Fig. 1, Heater Element Replacement

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 cab.
3. Unscrew the threaded cover that secures the cord to the element. See **Fig. 1**. Pull the cord off the element.



1. Heater Element
2. Capscrew
3. Threaded Cover
4. Element Cover

Fig. 1, Pull the Cord Off of 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.
9. Return the cab to the operating position, and remove the chocks from the tires.

FOULED ELEMENT

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

⚠ 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 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. 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, 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 see Group 20 of the *Cargo Maintenance Manual* for the recommended coolant additives.

   Blue or black discoloration on the element indicates the coolant system needs more coolant.

Troubleshooting

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 see Group 20 of the *Cargo Maintenance Manual* for the recommended antifreeze to water concentrations.

7. Return the cab to the operating position, and remove the chocks from the tires.

Specifications

Fastener Torques			
Description	**Grade**	**Size**	**Torque lbf·ft (N·m)**
Element Capscrew	8	1/4–20	10 (13)

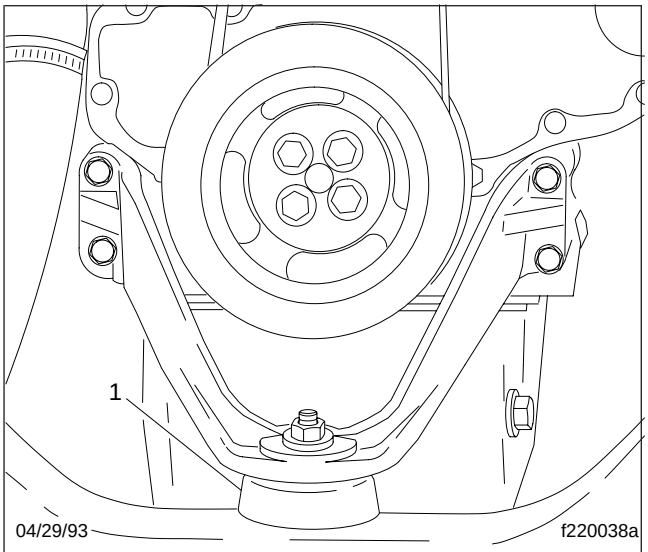
Table 1, Fastener Torques

General Information

Three mounts support the engine and transmission, holding a total of almost 1800 lb (816 kg). Two of the engine mounts support the rear of the engine and transmission assembly. The third supports the front of the assembly.

The rear engine mount is bolted to the inside of the frame rail near the flywheel housing. These mounts support legs which are bolted to the flywheel housing. The engines use a rear engine leg which rests flat on the mount.

The front engine mount is an underslung crossmember under the front of the engine. It supports a bracket (**Fig. 1** and **Fig. 2**) which is bolted to the engine at each side of the vibration damper pulley.



1. Front Engine Mount

Fig. 1, Front Engine Mount

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.

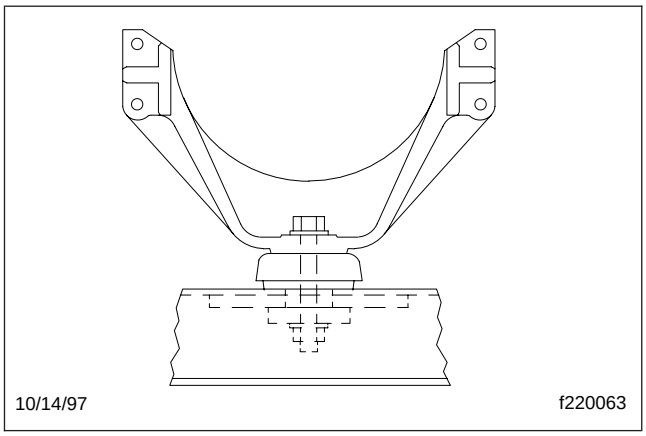
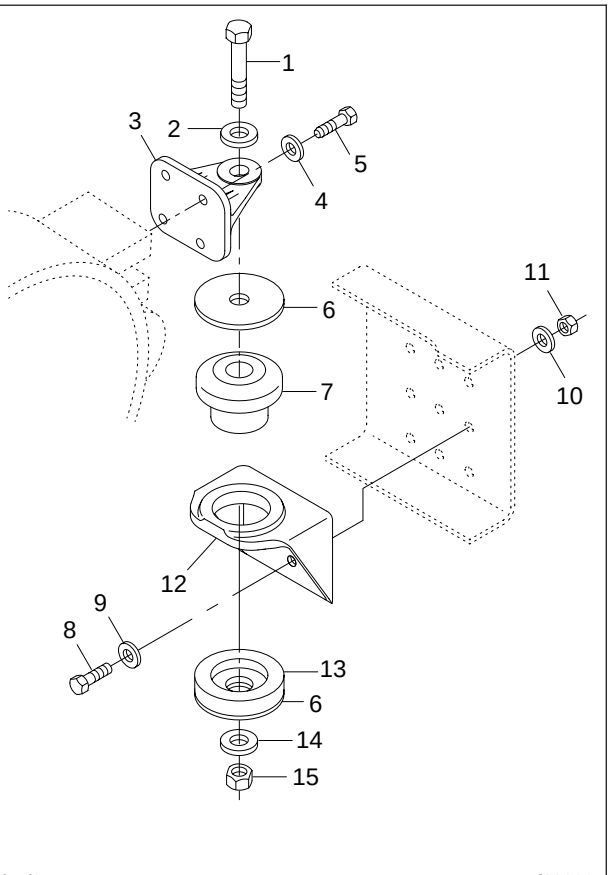


Fig. 2, Front Engine Support Bracket

Replacement (See Fig. 1)

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



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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

⚠ 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. 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 80 lbf·ft (108 N·m).

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 the bolts 55 to 65 lbf·ft (75 to 88 N·m).

   Engines used with Allison automatic transmissions have an iron flywheel housing instead of the standard aluminum housing. On these vehicles, tighten the support bracket bolts 60 to 76 lbf·ft (81 to 103 N·m).

6. 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.

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

Rear Engine Mount Replacement

⚠ 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 241 lbf·ft (327 N·m).

⚠ 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 80 lbf·ft (108 N·m).
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 the bolts 55 to 65 lbf·ft (75 to 88 N·m).

    Engines used with Allison automatic transmissions have an iron flywheel housing instead of the standard aluminum housing. On these engines, tighten the support bracket bolts 60 to 76 lbf·ft (81 to 103 N·m).
13. 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.

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

⚠ 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.

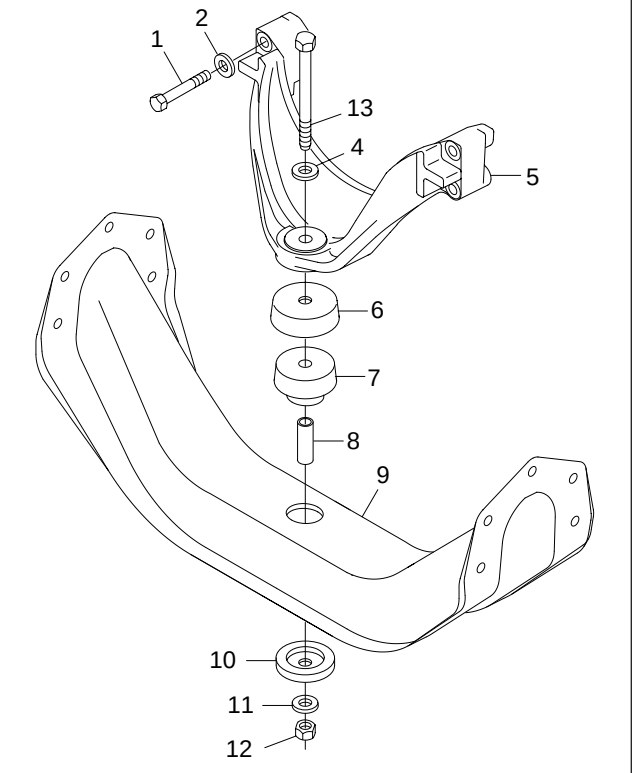
15. Secure the engine to the engine mounts.
    - 15.1 If not in place, set a jack under the rear of the engine and raise the jack until it is braced against the engine.

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 241 lbf·ft (327 N·m).

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

Replacement (See Fig. 1)



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

1. Apply the parking brakes, chock the tires, and (if applicable) drain the air brake system.
2. Remove four oil cooler mounting bolts.

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.

3. Disconnect the engine from the front engine mount.

   3.1 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.

   3.2 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.

   3.3 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.

4. If necessary, remove the bolts which secure the engine support bracket to the front of the engine. Remove the bracket from the engine.
5. 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 55 to 65 lbf·ft (75 to 88 N·m).
6. 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.

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

Front Engine Mount Replacement

⚠ 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.

8. Secure the engine to the front engine mount.
   - 8.1 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.
   - 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(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) 150 lbf·ft (203 N·m).

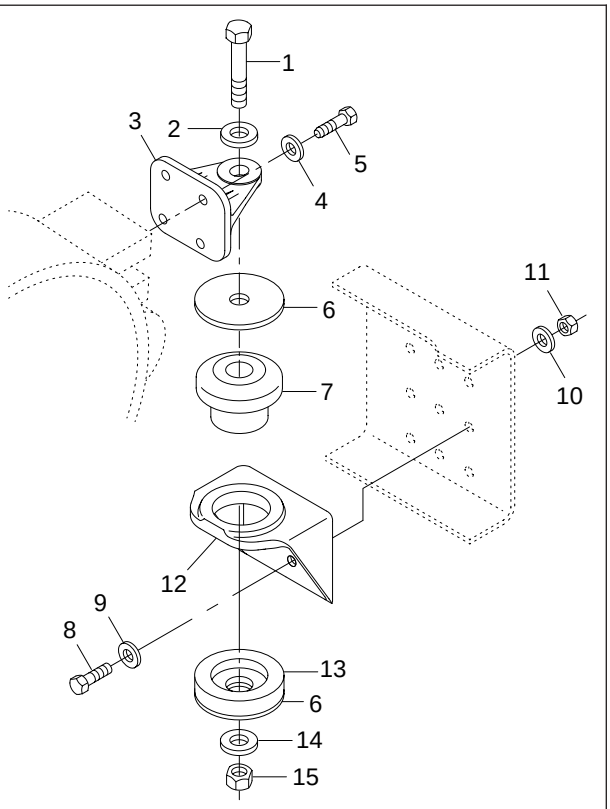
   NOTE: If you loosened the bolts that run through the rear engine mounts, tighten those bolts 241 lbf·ft (327 N·m).

   - 8.4 Remove the lifting chain from the engine lifting hooks.
9. Install four oil cooler mounting bolts.
10. Remove the chocks from the tires.

Rear Engine Mount Isolator Replacement

Replacement (See Fig. 1)

1. Apply the parking brakes, chock the tires, and drain the air brake system.



10/14/97 f220065

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

⚠ 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. 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.
   - 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

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.

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

Rear Engine Mount Isolator Replacement

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 241 lbf·ft (327 N·m).

⚠ 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.
   - 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

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.

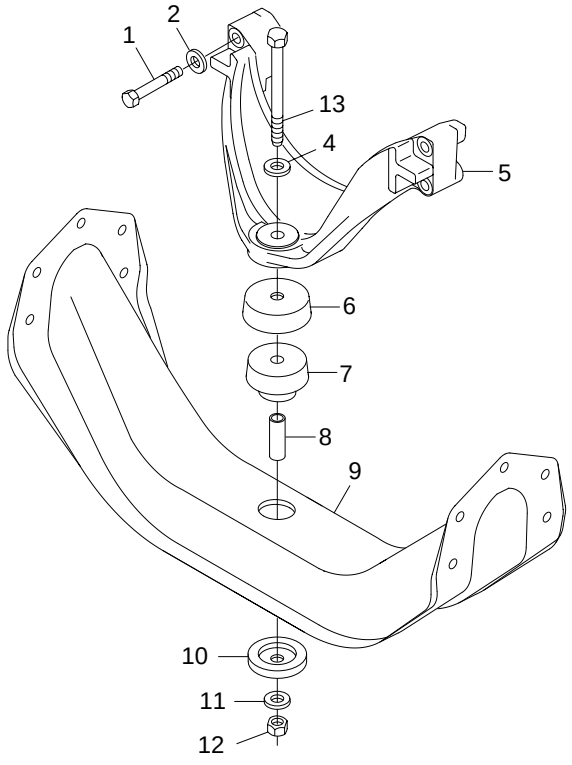
⚠ WARNING

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 241 lbf·ft (327 N·m).
10. Remove the jack from under the engine, and remove the chocks from the tires.

Front Engine Mount Isolator Replacement

Replacement (See Fig. 1)



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

1. Apply the parking brakes, chock the tires, and drain the air brake system.
2. Remove four oil cooler mounting bolts.

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.

3. Disconnect the engine from the front engine mount.

   3.1 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.

   3.2 Remove the bolt(s) from the front engine mount. Save the fasteners, tube(s), and 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.

   3.3 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.

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

CAUTION

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

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

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 en-

Front Engine Mount Isolator Replacement

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

6. Secure the engine to the front engine mount.
   - 6.1 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.
   - 6.2 Lift the engine slightly to remove the engine stands. Remove the stands, and carefully lower the engine onto the engine mount.
   - 6.3 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) 150 lbf·ft (203 N·m).

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

   - 6.4 Remove the lifting chain from the engine lifting hook(s).
7. Install four oil cooler mounting bolts.
8. Remove the chocks from the tires.

Specifications

Engine Mount Torques			
Description	**Grade**	**Size**	**Torque lbf·ft (N·m)**
Rear Engine Mount Bolt	8	3/4 inch	241 (327)
Rear Engine Mount to Frame Rail Bolts	8	1/2 inch	80 (108)
Rear Support Bracket to Engine Bolts	10.9	12 mm	55–65 (75–88)
Front Support Bracket to Engine Bolts	10.9	12 mm	55–65 (75–88)
Front Engine Mount Bolt	8	5/8 inch	150 (203)

Table 1, Engine Mount Torques

General Information

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 725°F (385°C). 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 360°F (182°C). Therefore, ether vapor injected with the engine intake air ignites at the lower cylinder temperature, and the burning ether ignites the diesel.

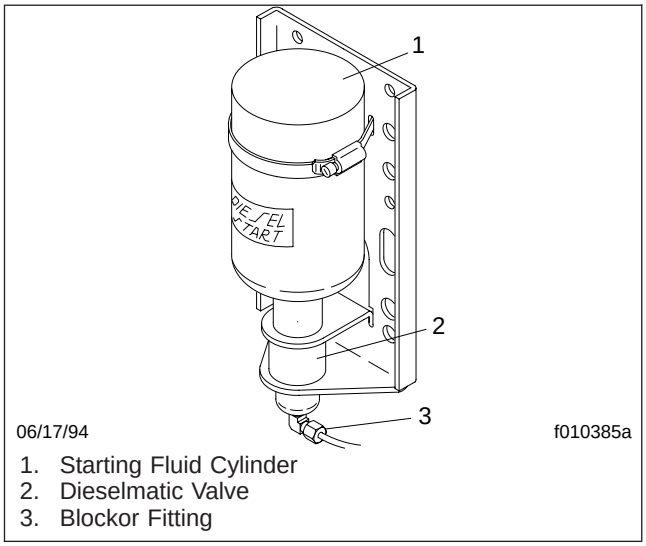
Using the starting fluid system reduces the necessary cranking time in cold weather, and it prevents excessive wear on the battery and starter.

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.

The starting fluid cylinder (**Fig. 1**) 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 40°F (4°C).



1. Starting Fluid Cylinder
2. Dieselmatic Valve
3. Blockor Fitting

Fig. 1, Starting Fluid Cylinder

Replacement (See Fig. 1)

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

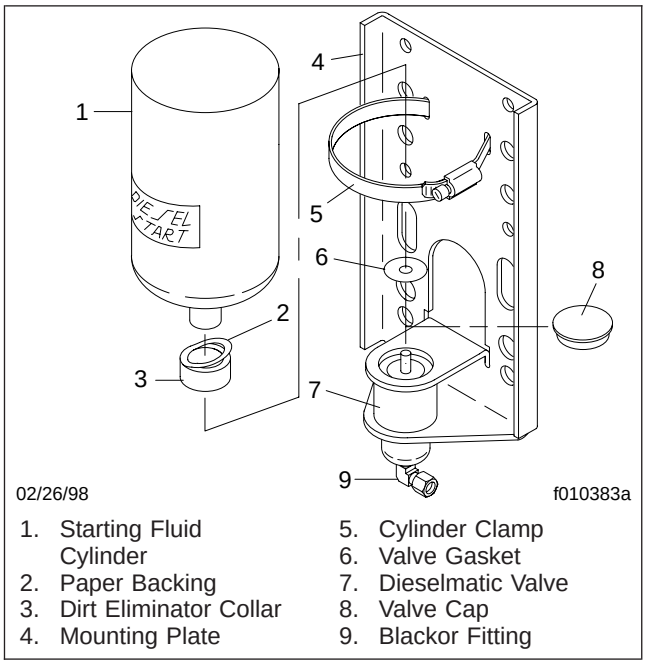
⚠ WARNING

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.
   - 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 (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. 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 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 60 lbf·in (680 N·cm).
8. If the ambient temperature is below 40°F (4°C), test the starting fuel system.
9. Return the cab to the operating position, and remove the chocks from the tires.



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. Blackor Fitting

Fig. 1, Starting Fluid Cylinder Assembly

Removal

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

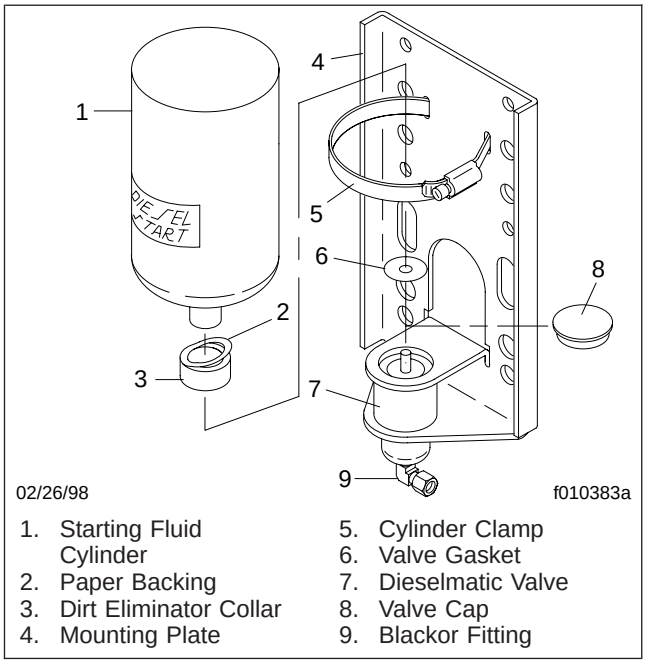
⚠ WARNING

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3. Remove the starting fluid cylinder. See **Fig. 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 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.
   - 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.
   - 6.1 Disconnect the sensor ground wire at the alternator ground terminal.



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. Blackor Fitting

Fig. 1, Starting Fluid Cylinder Assembly

   - 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

1. Remove the plug in the engine intake manifold and screw the ether nozzle in place.
2. Install the engine temperature sensor.
   - 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.
   - 3.1 Place the mounting plate against the mounting bracket, and secure it with four bolts. Tighten the bolts 22 lbf·ft (30 N·m).
   - 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 60 lbf·in (680 N·cm).
5. If the ambient temperature is below 40°F (4°C), test the starting fuel system.

Troubleshooting

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

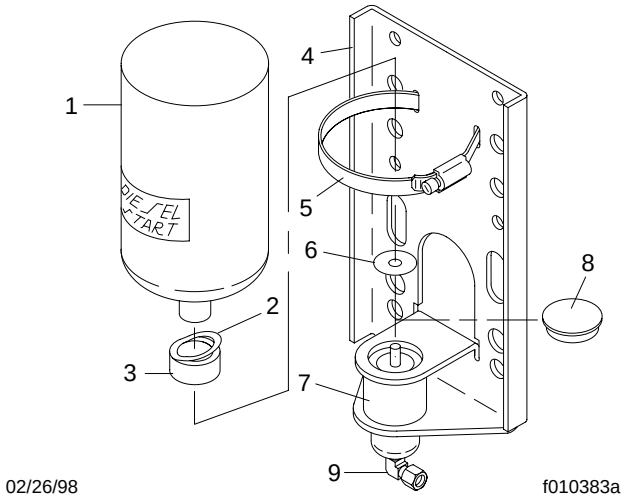
⚠ WARNING

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. 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.



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. Blackor Fitting

Fig. 1, Starting Fluid Cylinder Assembly

Cylinder Weight by Size		
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 1, Cylinder Weight by Size

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 60 lbf·in (680 N·cm).

CLOGGED ETHER NOZZLE

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

Troubleshooting

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.

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.

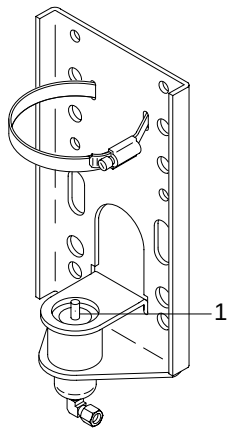
ELECTRICAL PROBLEMS

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 40°F (4°C), remove the black ground wire from the engine temperature sensor, and ground it.
   - 4.3 Crank the starter, and look for the valve plunger (**Fig. 2**) to move up and stay up while the starter is cranked.



1. Valve Plunger

Fig. 2, Crank the Starter and Look for the Valve Plunger to Move Up

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

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

Table 1, Fastener Torques

Starting Fluid Cylinder Weights		
Cylinder Size oz (g)	Weight	
	oz (g)	oz (g)
21 (595)	16 (455)	37 (1050)
18 (510)	15 (425)	38 (935)
8 (225)	10 (285)	18 (510)

Table 2, Starting Fluid Cylinder Weights

General Information

The Phillips Temro oil pan heater keeps the crankcase oil about 90°F (32°C) 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. A cord plugs onto the outside end of the element, and the cord runs to a receptacle mounted below the driver's door.

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.

Oil Pan Heater Element Removal and Installation

Removal

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Tilt the cab.
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.
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.
3. Install the oil drain plug in the crankcase, and fill the engine with oil. For recommended oil types and engine oil capacities, see Group 00 in 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.
6. Return the cab to the operating position, and remove the chocks from the tires.

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 cab.
3. Unscrew the threaded cover that secures the cord to the element. Pull the cord off the element.
4. Using an ohmmeter, check the continuity between the two poles of the element. The resistance should be about 96 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.
6. Using an ohmmeter at the receptacle, check the continuity between the two power terminals. The resistance should be about 96 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.
9. Return the cab to the operating position, and remove the chocks from the tires.

FOULED ELEMENT

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

⚠ 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. 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.
7. Return the cab to the operating position, and remove the chocks from the tires.

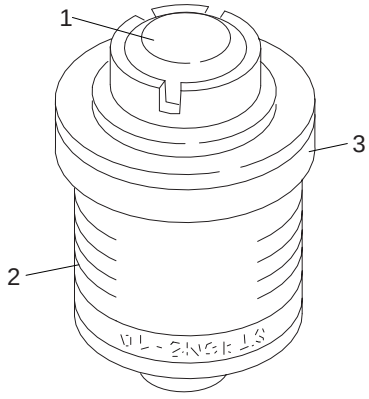
General Description

Air Cleaner Element

A dry-type ail cleaner is standard equipment. Air is filtered through a pleated, chemically-treated paper element to remove contaminants before entering the engine induction system.

Air Restriction Gauge

The air restriction gauge (**Fig. 1**) is connected to the air outlet tube of the air cleaner housing. A yellow indicator moves toward the red line on the gauge meter as the filter performs and nears the end of its service life.



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1. Reset Button
2. Graduated Markings
3. Air Cleaner Restriction Indicator Assembly

Fig. 1, Air Restriction Gauge

The yellow indicator keeps its position, even when the vehicle is not running. The filter must be replaced when the yellow indicator reads 25 inches (6.2 kPa) of water. When the filter is replaced, the button on the air restriction gauge must be pressed in order to reset the gauge indicator.

The air cleaner restriction indicator should be checked as part of the pretrip inspection.

Air Cleaner Stack Pipe Removal and Installation

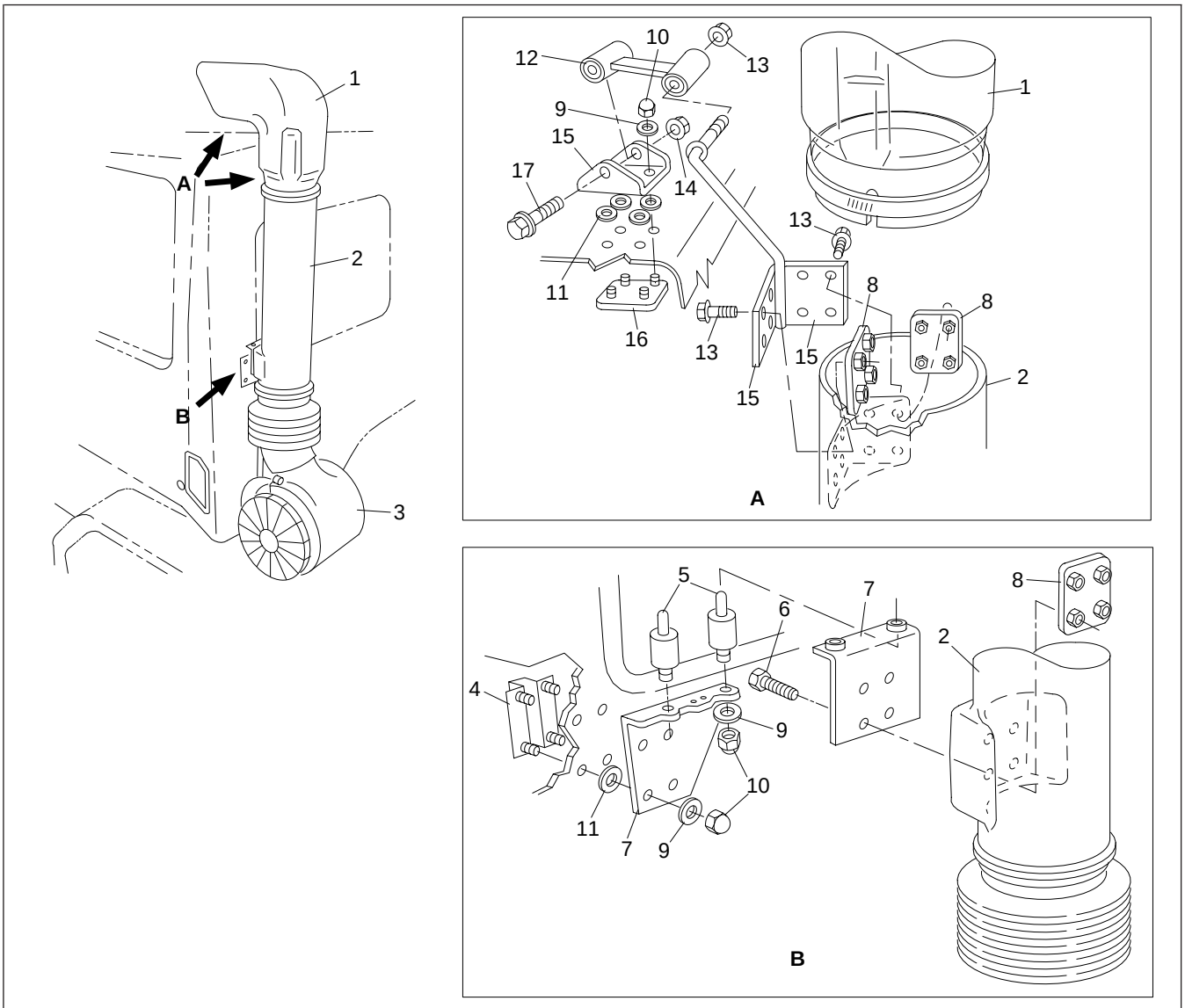
Removal (See Fig. 1)

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires.
2. Remove the fasteners attaching the stay assembly to the air cleaner stack pipe bracket. Remove the stay assembly from the bracket.
3. Remove the clamps and remove the upper scoop assembly and the lower flexible seal from the air cleaner stack pipe.
4. Lift the air cleaner stack pipe assembly off of the air cleaner duct insulators and remove the stack from the vehicle.

Installation (See Fig. 1)

1. Insert the stack upward into the upper scoop as far as it will go.
2. Place the air cleaner stack pipe assembly onto the air cleaner duct insulators.
3. Attach the stay assembly to the air cleaner stack pipe bracket. Position the stay assembly and install the fasteners. Tighten the fasteners 7 to 10 lbf·ft (9 to 14 N·m).
4. Install the clamps on the upper scoop assembly and the lower flexible seal and tighten them securely.
5. Remove the chocks from the tires.

Air Cleaner Stack Pipe Removal and Installation



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A. View A
B. View B

1. Scoop Assembly
2. Stack Pipe Assembly
3. Air Cleaner Assembly
4. Stack Pipe Lower Reinforcement
5. Duct Insulator
6. Bolt
7. Bracket Assembly
8. Stack Pipe Nut Plate
9. Washer
10. Nut
11. Washer
12. Stack Pipe Stay
13. Nut
14. Nut
15. Stack Pipe Bracket
16. Body Reinforcement
17. Bolt

Fig. 1, Stack Pipe Assembly

Air Cleaner Element Replacement

Removal

1. Shut down the engine, apply the brakes, and chock the tires.
2. Remove the two thumb nuts that retain the cover assembly, and remove the cover.
3. Release the seal gently. The filter element fits tightly over the outlet tube, creating the critical seal on the inside diameter of the element end cap. Remove the element gently to reduce the amount of dust dislodged. There will be some initial resistance. Gently move the end of the element up and down and side to side or twist to break the seal. See **Fig. 1**.

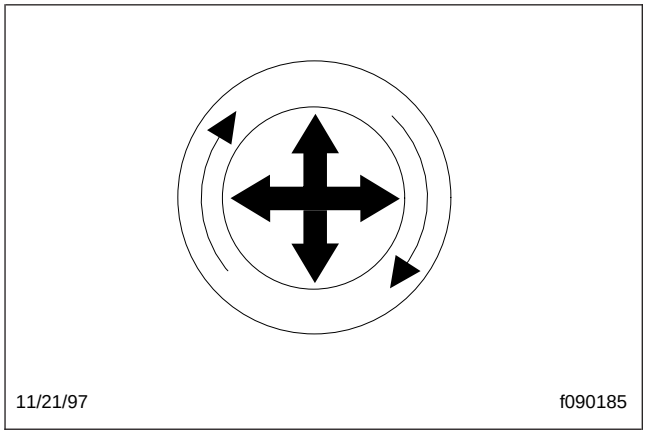


Fig. 1, Release the Seal

4. Avoid dislodging dust from the filter element. Gently pull the filter element off the outlet tube and out of the housing. Avoid knocking the element against the housing. See **Fig. 2**.

⚠ CAUTION

Use care when handling the outlet tube. If damaged, air leaks could result.

5. With a clean shop cloth, carefully clean the outlet tube where it extends into the housing. Inspect for possible air leaks in the housing, inlet or outlet pipes.
6. Clean the inside of the outlet tube carefully. See **Fig. 3**. Dirt accidentally transferred to the inside of the outlet tube will reach the engine and cause wear. Use care not to damage the air cleaner element sealing area on the tube.

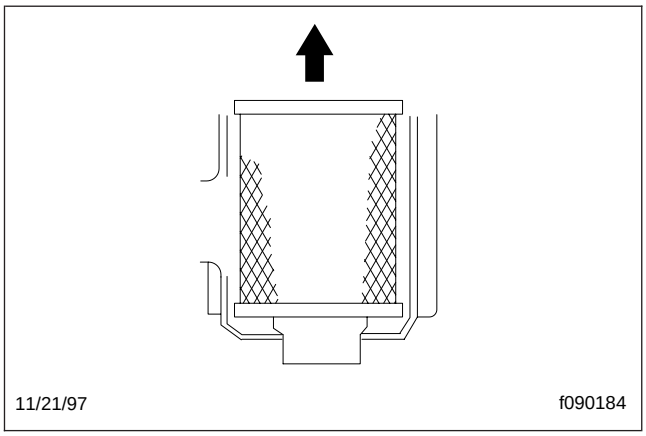


Fig. 2, Remove the Filter Element

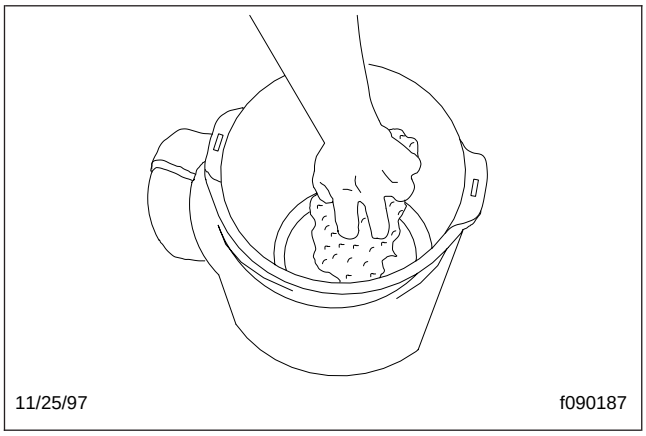


Fig. 3, Clean the Inside of the Outlet Tube

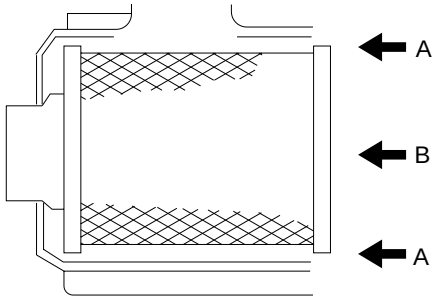
7. Check the old air cleaner element. Inspect for foreign material on the sealing surface that is causing leakage. A streak of dust on the clean air side of the air cleaner element seal is the telltale sign. If dust exists, make sure the cause is removed before installing a new air cleaner element.

Installation

1. Inspect the new element for damage. Always look for possible shipping or handing damage. Pay particular attention to the inside of the open end (the sealing area). Check for cuts, or other damage. Do not use a damaged element.
2. Insert the new element properly. The radial seal area is on the inside of the open end of the element. This critical sealing area will stretch

Air Cleaner Element Replacement

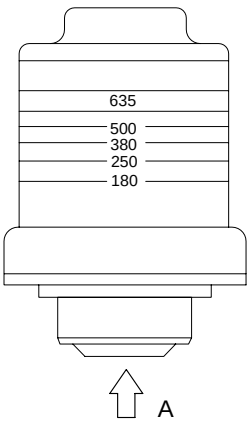
slightly, adjust itself and distribute the sealing pressure evenly as the element is forced onto the outlet tube. Apply firm pressure to complete a tight seal. Apply pressure at the outer rim of the element, not the flexible center. Cover pressure is not necessary to compress the element seal. See **Fig. 4**.



A. Apply pressure here.
B. Don't apply pressure here.

Fig. 4, Insert the New Element

3. Position the cover assembly to the housing and install the two thumb nuts that retain the cover assembly. Cover pressure is not necessary to compress the element seal.
4. Press the air restriction reset button located on the restriction gauge (if so equipped). See **Fig. 5**.



A. Press to reset the indicator.

Fig. 5, Air Restriction Gauge

5. Check the connections and ducts for an airtight fit. Make sure all the clamps, flange connections and cleaner mounting bolts are tight. Seal any leaks in the clean air ducting immediately to prevent dirt from entering the engine. All ducts, from the air cleaner to the engine, must be tight.
6. Remove the chocks.

Air Cleaner Removal and Installation

Removal

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires.

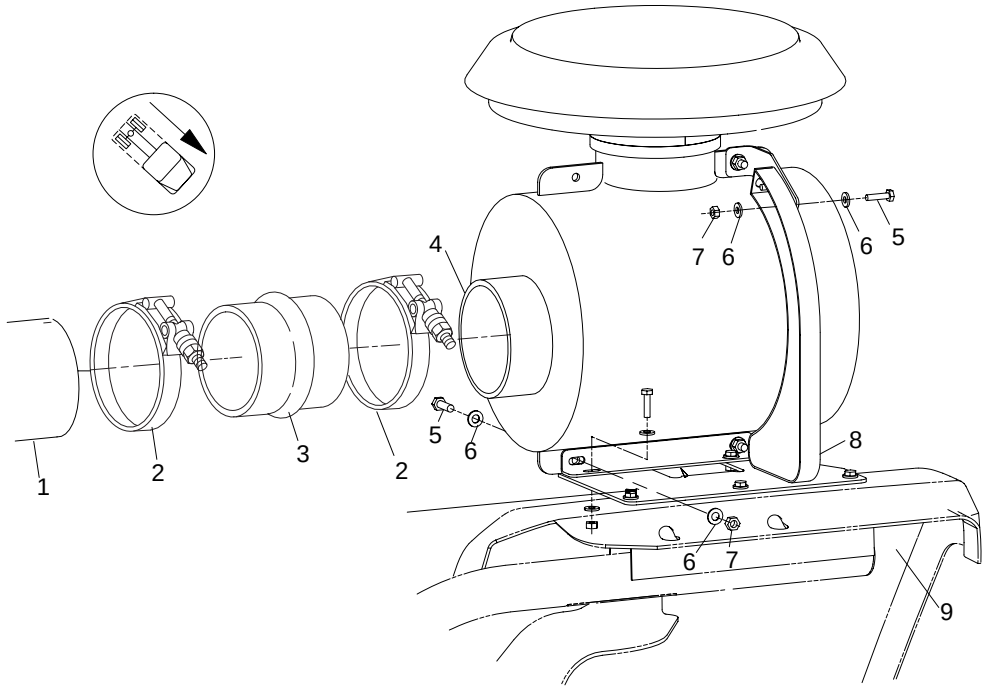
NOTE: If the vehicle is equipped with an air cleaner stack pipe, remove it. See **Subject 100** in this section.

2. Loosen the hose clamps on the air cleaner outlet hose (attached to the air cleaner outlet tube). See **Fig. 1**.
3. Detach the outlet hose and the outlet tube from the air cleaner assembly.
4. Remove the three capscrews, locknuts, and washers attaching the air cleaner assembly to the air cleaner bracket. See **Fig. 2**.
5. Remove the air cleaner assembly.

Installation

1. Place the air cleaner assembly in position against the air cleaner bracket.
2. Install the three mounting capscrews, washers, and locknuts and tighten 15 to 20 lbf·ft (20 to 27 N·m).
3. Attach the outlet tube to the outlet hose. Attach the outlet hose to the air cleaner assembly. Tighten the two hose clamps securely.
4. Install the air cleaner stack pipe, if so equipped. See **Subject 100** in this section.
5. Remove the chocks from the tires.

Air Cleaner Removal and Installation

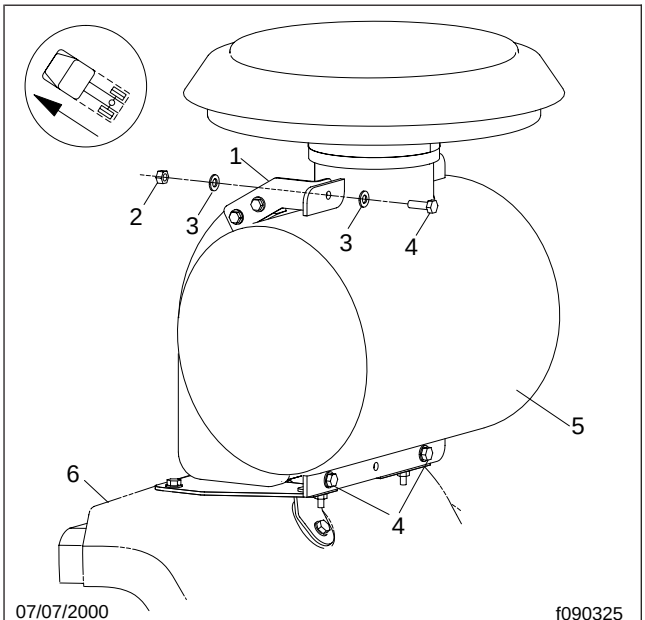


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1. Outlet Tube
2. Hose Clamp
3. Outlet Hose
4. Air Cleaner Assembly
5. Capscrew (air cleaner-to-bracket)
6. Washer
7. Locknut
8. Air Cleaner Mounting Bracket
9. Fender

Fig. 1, Air Cleaner Assembly (front view)

Air Cleaner Removal and Installation



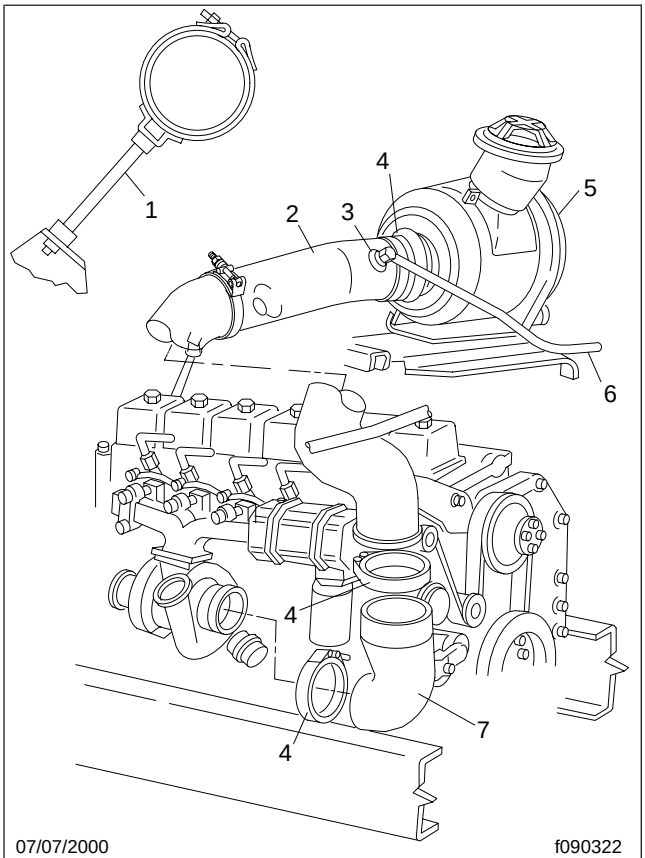
1. Air Cleaner Mounting Bracket
2. Locknut
3. Washer
4. Capscrew (air cleaner-to-bracket)
5. Air Cleaner Assembly
6. Fender

Fig. 2, Air Cleaner Assembly (rear view)

Air Cleaner Outlet Tube Removal and Installation

Removal

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires.
2. Disconnect the air restriction indicator hose from the fitting on the air cleaner outlet tube. See **Fig. 1**.



1. Prop Rod
2. Outlet Tube
3. Air Restriction Indicator Hose Fitting
4. Hose Clamp
5. Air Cleaner Assembly
6. Air Restriction Indicator Hose
7. Turbocharger Inlet Tube

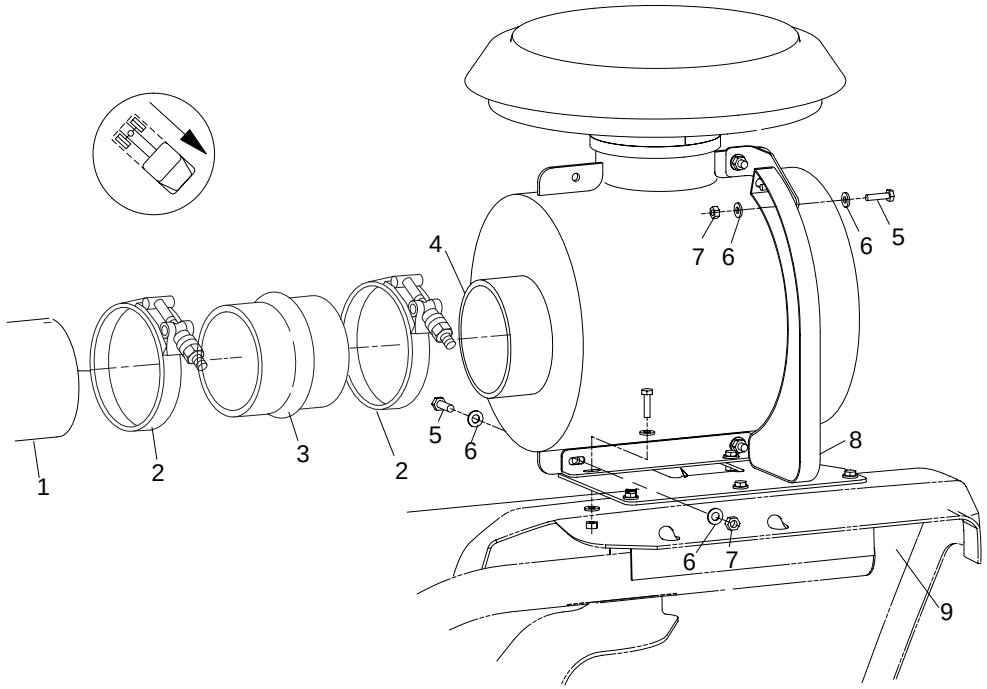
Fig. 1, Air Cleaner Outlet Tube Assembly

3. Disconnect the clamp securing the air cleaner outlet hose to the outlet tube. See **Fig. 2**.
4. Disconnect the clamp securing the turbocharger inlet tube to the air cleaner outlet tube.
5. Disconnect the outlet tube from the prop rod.
6. Remove the outlet tube.

Installation

1. Place the outlet tube in position.
2. Attach the outlet tube to the prop rod, but do not tighten the clamp.
3. Connect the outlet tube to the turbocharger inlet tube.
4. Connect the outlet tube to the air cleaner outlet hose.
5. Install the hose clamps at each side of the outlet tube and tighten them securely.
6. Tighten the prop rod clamp securely.
7. Connect the air restriction indicator hose to the fitting on the air cleaner outlet tube.
8. Remove the chocks from the tires.

Air Cleaner Outlet Tube Removal and Installation



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1. Outlet Tube
2. Hose Clamp
3. Outlet Hose
4. Air Cleaner Assembly
5. Capscrew (air cleaner-to-bracket)
6. Washer
7. Locknut
8. Air Cleaner Mounting Bracket
9. Fender

Fig. 2, Air Cleaner Assembly

Air Inlet Restriction Check

The best method for determining the dry-type air cleaner maintenance periods is through a periodic visual check of the air restriction indicator. It is recommended that the air restriction indicator be used to determine service intervals. A visual inspection of the air cleaner element will not ascertain the need for service. Overservicing is not recommended.

Air Cleaner Element

Inspect air cleaner element for foreign material, oil accumulation, distortion or damage.

Engine Air Cleaner

Using a mild detergent or compressed air, clean the air cleaner body and the cover. Wipe the air cleaner body and cover dry. Inspect the air cleaner body and cover for distortion or damage at the gasket mating surfaces. Replace the cover or body if they are damaged beyond service.

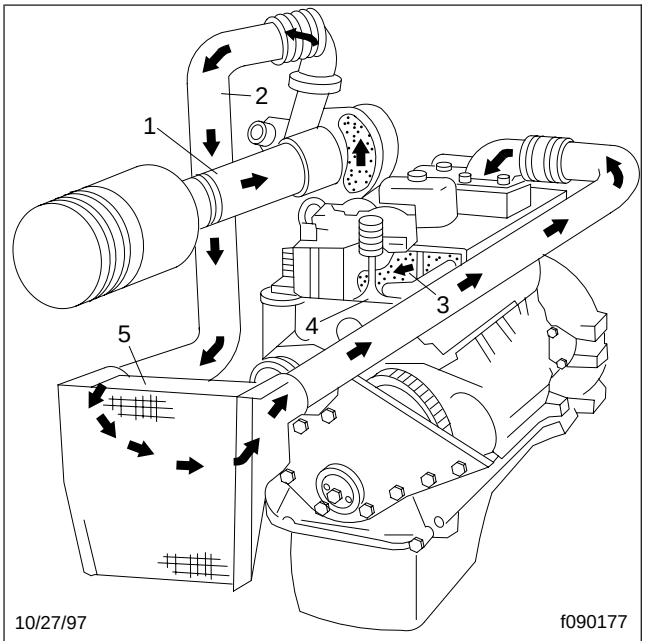
Specifications

Torque Values		
Description	**lbf·ft**	**N·m**
Air Cleaner Bracket Capscrews	15 to 20	20 to 27
Stack Pipe Stay Assembly Fasteners	7 to 10	9 to 14

Table 1, Torque Values

General Information (See Fig. 1)

Air enters the air cleaner through the air cleaner stack pipe. On turbocharged and aftercooled engines, the intake air flow is from the air cleaner to the turbocharger. It is then routed to the charge air cooler (CAC) located in front of the radiator. Air leaves the charge air cooler and is routed to the intake manifold where it is forced into the cylinders and used for combustion. The CAC reduces the temperature of the air, which lowers combustion chamber temperatures, which in turn reduces nitrogen oxide emissions. Also, cooling the air makes it more dense, allowing more fuel to be injected into the engine to increase the power-to-weight ratio.



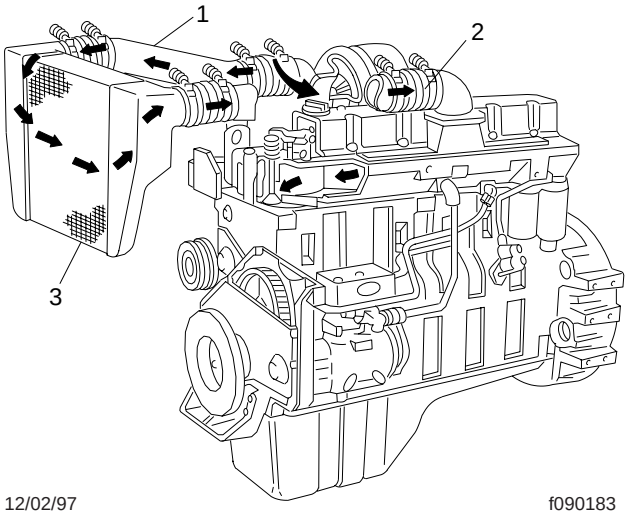
1. Intake Air Inlet
2. Turbocharger Air to Charge Air Cooler
3. Intake Manifold
4. Intake Valve
5. Charge Air Cooler

Fig. 1, Air Induction System

General Description (See Fig. 1)

As air in the turbocharger is compressed, it is also heated. To remove the heat, the air is routed through the charge air cooler. The charge air cooler is an air-to-air heat exchanger similar in construction and function to a radiator. By lowering the temperature of the air, it is made denser. The increased density of the air delivered to the engine cylinders permits a corresponding increase in the weight of fuel that can be injected into the cylinders, while maintaining the air/fuel ratio required for proper combustion. Since engine power output is a function of the weight of fuel burned, the increase in the weight of fuel introduced as a result of turbo charger operation results in an increase in engine power output.

In addition to power increases, cooler air tends to lower stress on the engine. It also reduces nitrogen oxide emission by lowering combustion chamber temperature.



1. Inlet Duct
2. Outlet Duct
3. Charge Air Cooler

Fig. 1, Charge Air Cooler

Charge Air Cooler, Removal and Installation

Removal

1. Shut down the vehicle, apply the parking brake, and chock the front and rear tires. Tilt the cab.
2. Remove the condenser line retainers at the right-hand side of the radiator.
3. Place the air conditioning condenser on the front of the chassis.
4. Remove the oil cooler hose retainer and fasteners, and place the oil cooler on the front chassis.
5. Disconnect the charge air cooler inlet and outlet tubes.
6. Tilt the charge air cooler toward the front of the vehicle and remove it.

Installation

1. Connect the charge air cooler to the radiator fasteners.
2. Connect the charge air cooler inlet and outlet tubes. Tighten the fasteners.
3. Install the oil cooler hose retainer and fasteners.
4. Connect the condenser line retainers at the right-hand side of the radiator.
5. Return the cab to the operating position and remove the chocks from the tires.

Charge Air Cooler Inspection and Leakage Test

Inspection

1. Apply the parking brakes, chock the tires, and tilt the cab.
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. 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)**
Cummins	7 (48)	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 cab.
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 adaptor 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 adaptor 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.

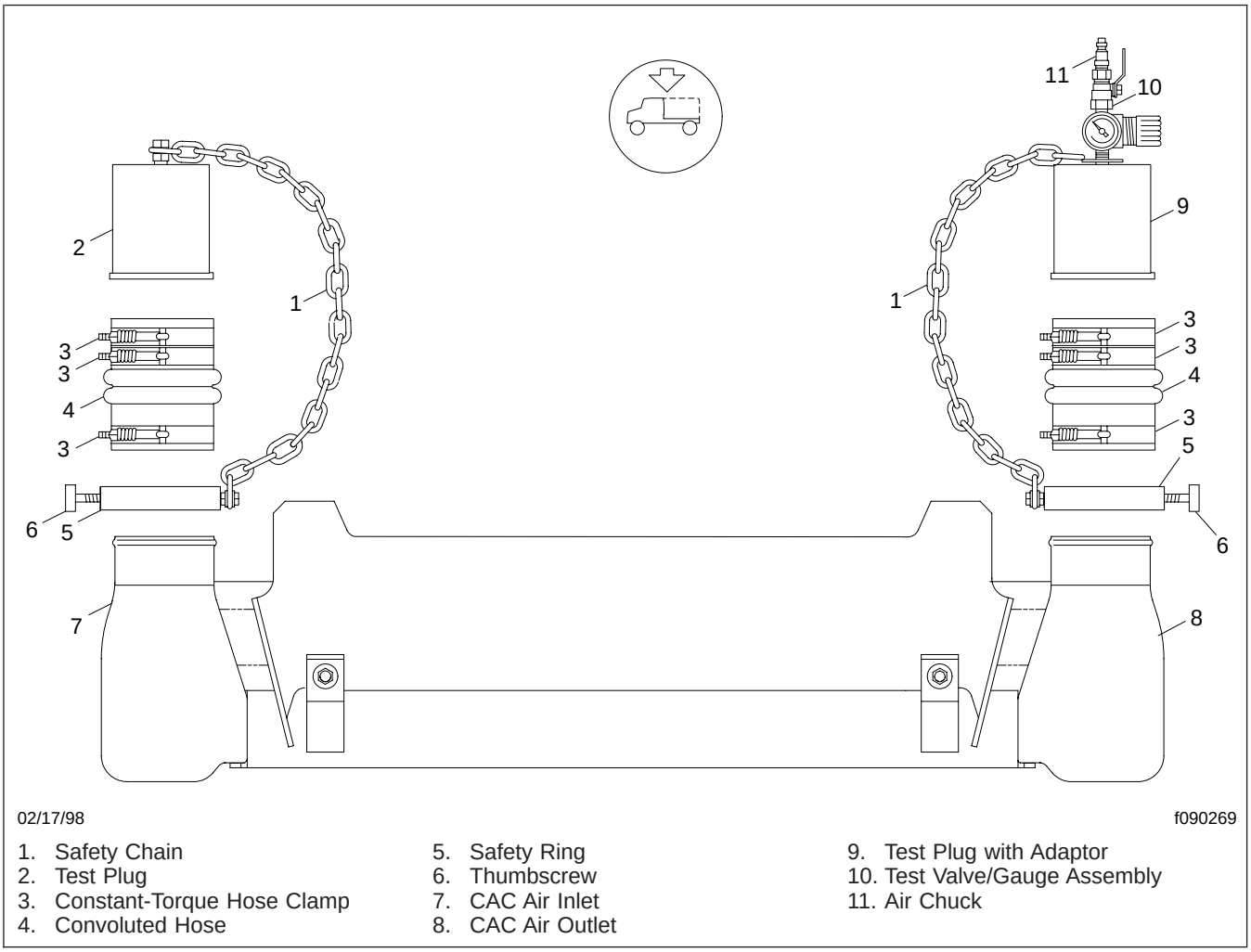
   - 2.6 If not already installed, install a test valve/gauge assembly and air chuck in the test plug with adaptor.
   - 2.7 Attach a pressurized air line to the air chuck on the pressure regulator valve.
3. Test the CAC core.

⚠ 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 suddenly release debris at high speed, possibly resulting in eye injury or other serious personal injury.

   - 3.1 Open the shutoff valve, then slowly open the pressure regulator valve and allow the

Charge Air Cooler Inspection and Leakage Test



1. Safety Chain
2. Test Plug
3. Constant-Torque Hose Clamp
4. Convoluted Hose
5. Safety Ring
6. Thumbscrew
7. CAC Air Inlet
8. CAC Air Outlet
9. Test Plug with Adaptor
10. Test Valve/Gauge Assembly
11. Air Chuck

Fig. 1, CAC Core Testing

charge air cooler system to gradually fill with air to the start pressure specified in **Table 1**.

3.2 Close the shutoff 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 (**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 cab and remove the chocks from the tires.

Fin and Sidemember Straightening

Fins

Using a pointed object no more than 0.02 inches (0.5 mm) in diameter at the tip, straighten the fins. Take care not to damage the louvers or distort the louver angle.

Sidemembers

Using pliers, vise-grips, or a similar tool, straighten the sidemember from the sides only. Never pry against the tubes or header. Be sure not to damage the fins, tubes, or headers when straightening the sidemembers.

Surface Preparation

All surfaces to be welded must be free of paint, oil, grease, water and other foreign matter. This will ensure that the weld repair will adhere to the bare aluminum and will not be contaminated.

Welding Tanks

Prepare the tank surfaces. Heat the crack to chase the ends until they stop. MIG weld to fill the crack and continue the bead past the ends of the crack approximately 1 inch (25 mm). Using a wire brush, grind excess weld material to blend with the tank surface.

Welding Mounting Brackets

IMPORTANT: Do not melt the fins of the tube-to-header braze joint. If welding near the core, shield the core with a large steel plate. This will protect it from sparks and weld splatter and will act as a heat sink.

1. Tack the brackets in place so the bracket will retain its correct orientation.
2. MIG weld the bracket in place.
3. Allow the weld to air cool.
4. Check the alignment.

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.

Troubleshooting

This troubleshooting table lists components of the air cooler system and the types of damage that occur.

Some types of damage can be repaired while other types cannot. The corrective action is shown for each type of damage. In some cases, the cooler should be replaced not repaired.

Aluminum Charge Air Cooler Troubleshooting	
Condition	**Action to Take**
Tubes are torn or cracked.	Replace the cooler. For instructions, see **Subject 100**.
Tubes are dented, kinked or bent, resulting in a round edge with a radius less than 1/32 inch (1 mm).	Weld or epoxy. For instructions, see **Subject 130**.
Tubes are dented, kinked or bent, resulting in a round edge with a radius more than 1/32 inch (1 mm).	No repair required.
Holes in the tubes are less than 1/32 inch (1 mm) in all directions on the tube surface.	Weld or epoxy to fill. For instructions, see **Subject 130**.
External fins are crushed or bent, resulting in a height reduction of no more than 1/32 inch (1 mm) per fin row, and the sidemember-to-sidemember dimension is within specification (26-3/4 inch [687 mm]).	No repair required.
External fins are pushed in with no tearing.	Straighten the fins. For instructions, see **Subject 120**.
External fins are pushed in with tearing less than 3/8 inch (10 mm) deep from the core face. Also tearing is less than 20 percent of a given fin row and less than 5 percent of the total fin rows.	Remove the loose fin material and straighten. For instructions, see **Subject 120**.
External fins are pushed in with tearing of more than 3/8 inch (10 mm) from the face core or more than 20 percent of a given row or more than 5 percent of the total fin row.	Replace the cooler. For instructions, see **Subject 100**.
Sidemembers are bent or dented.	Straighten the sidemember to the original form. If the tubes are dented or the fins are crushed, see **Subject 120** for straightening procedures.
The sidemember surface is cracked or broken through.	Weld the sidemember. For instructions, see **Subject 130**.
The headers are bent or dented, resulting in three or fewer tube or tube-to-header leaks, and the cracks are less than 1/16 inch (2 mm).	Weld the header. For instructions, see **Subject 130**. NOTE: If crack is less than 1/32 inch (1 mm), repair can be made with epoxy
The headers are bent or dented with more than three tube or tube-to-header leaks, or a crack width greater than 1/16 inch (2 mm).	Replace the cooler. For instructions, see **Subject 100**.
The headers are cracked.	Replace the cooler. For instructions, see **Subject 100**.
The tank walls are dented but not cracked or broken through. Also, the fit and function of the cooler is not affected.	No repair required.
A tank is cracked. The crack is no more than 1/16 inch (2 mm) wide and 3/4 inch (20 mm) long.	Weld the tank. For instructions, see **Subject 130**.
A tank is cracked. The crack is more than 1/16 inch (2 mm) wide and 3/4 inch (20 mm) long.	Replace the cooler. For instructions, see **Subject 100**.
A tank is punctured and the hole is no more than 3/16 inch (5 mm) in all directions on the tank surface.	Weld the tank. For instructions, see **Subject 130**.

Troubleshooting

Aluminum Charge Air Cooler Troubleshooting	
Condition	**Action to Take**
A tank is punctured and the hole is more than 3/16 inch (5 mm) in all directions on the tank surface.	Replace the cooler. For instructions, see **Subject 100**.
The tank-to-header welds are cracked or porous.	Weld. For instructions, see **Subject 130**. IMPORTANT: Repair welds must not start or stop were a production weld ends.
The threads are stripped in the tapped holes.	Drill out the stripped threads and tap to accept the proper heilcoil insert of the same diameter and thread the pitch of the original hole.
The bosses and mounting brackets are cracked or broken off, but the cracked or fractured surface does not go into the tank wall.	Weld. For instructions, see **Subject 130**.
The bosses and mounting brackets are cracked or broken off, and the crack goes into the tank wall.	Replace the cooler. For instructions, see **Subject 100**.
The mounting pins or other hardware are cracked, broken or otherwise damaged, and the repair will not affect the fit, function, or durability.	Repair to original condition.
The mounting pins or other hardware are cracked, broken or otherwise damaged, and the repair will affect the fit, function, or durability.	Replace the cooler. For instructions, see **Subject 100**.

Table 1, Aluminun Charge Air Cooler Troubleshooting

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 120 psi (825 kPa), 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 90 psi (620 kPa), 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 120 psi (825 kPa), 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.*

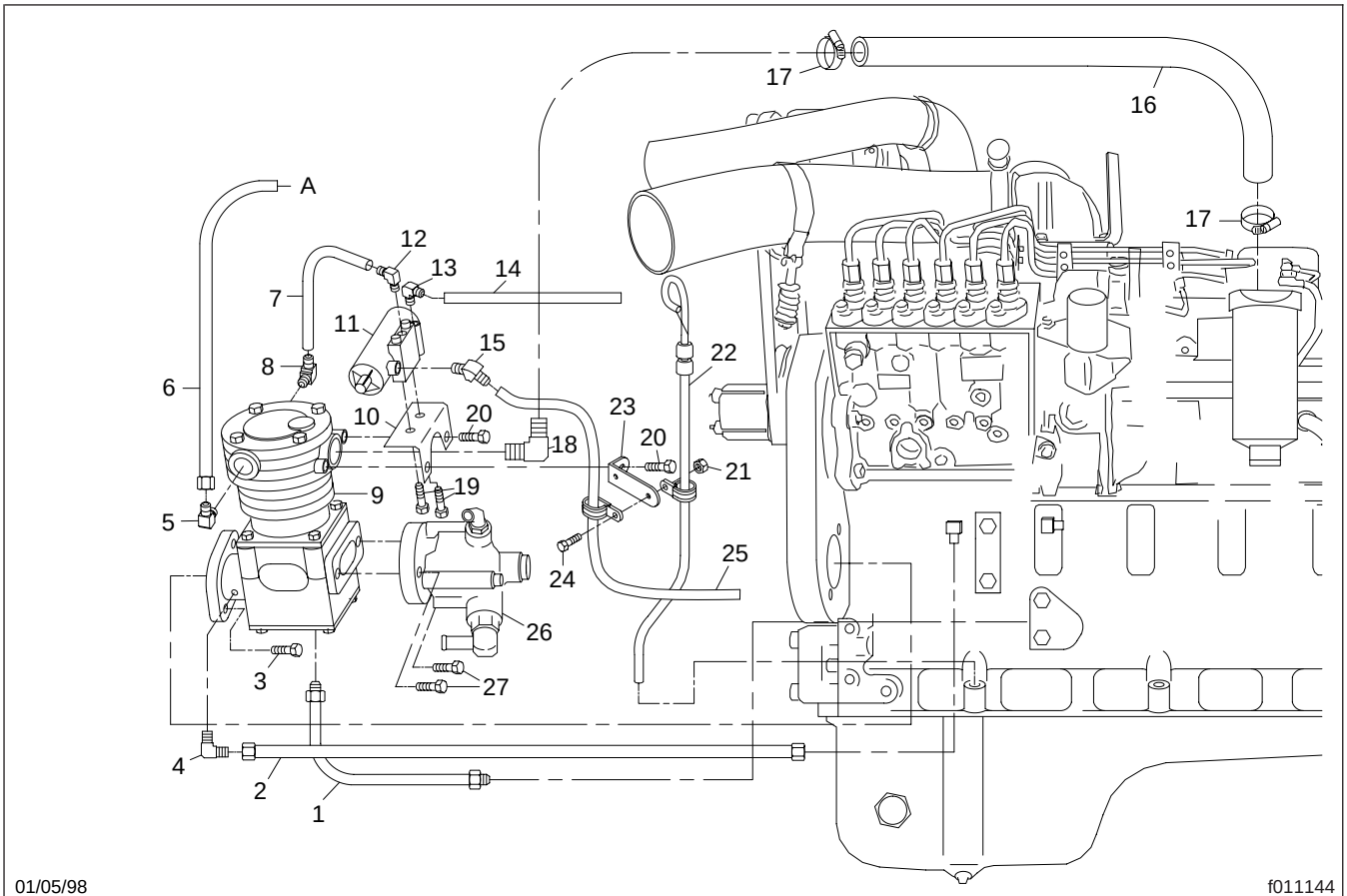
Removal (See Fig. 1)

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Drain the air reservoirs.
3. Tilt the cab.
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.

4.3 Disconnect the air signal line (Ref. 7) between the compressor and the air governor.



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A. Supply Tank
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

Fig. 1, Holset SS191B Air Compressor

Air Compressor Removal and Installation

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 (See Fig. 1)

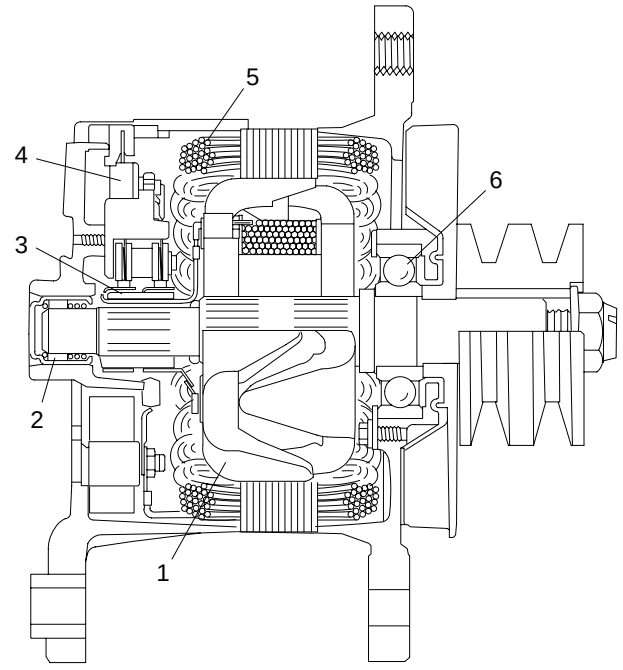
1. Install the air compressor.
   - 1.1 Position the compressor on the engine, and secure it with the air compressor mounting bolts (Ref. 3). Tighten the bolts 54 lbf·ft (73 N·m).
   - 1.2 If removed, install the air governor on the compressor. Install the stand-off bracket (Ref. 23) with the left bracket bolt, and tighten both bolts 15 lbf·ft (20 N·m).
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 28 lbf·ft (38 N·m).
   - 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. Return the cab to the operating position, and remove the chocks from the tires.

Fastener Torques			
Description	Grade	Size	Torque lbf·ft (N·m)
Air Governor Bracket Bolts	5	5/16–18	15 (20)
Air Compressor Mounting Bolts	8.8	M12 x 1.75	54 (73)
Power Steering Pump Mounting Bolts	5	3/8–16	28 (38)

Table 1, Fastener Torques

General Description

The Delco Remy 21–SI series alternator (**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**.



1. Rotor
2. Roller Bushings
3. Brushes
4. Regulator
5. Field Windings
6. Ball Bearings

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 Information

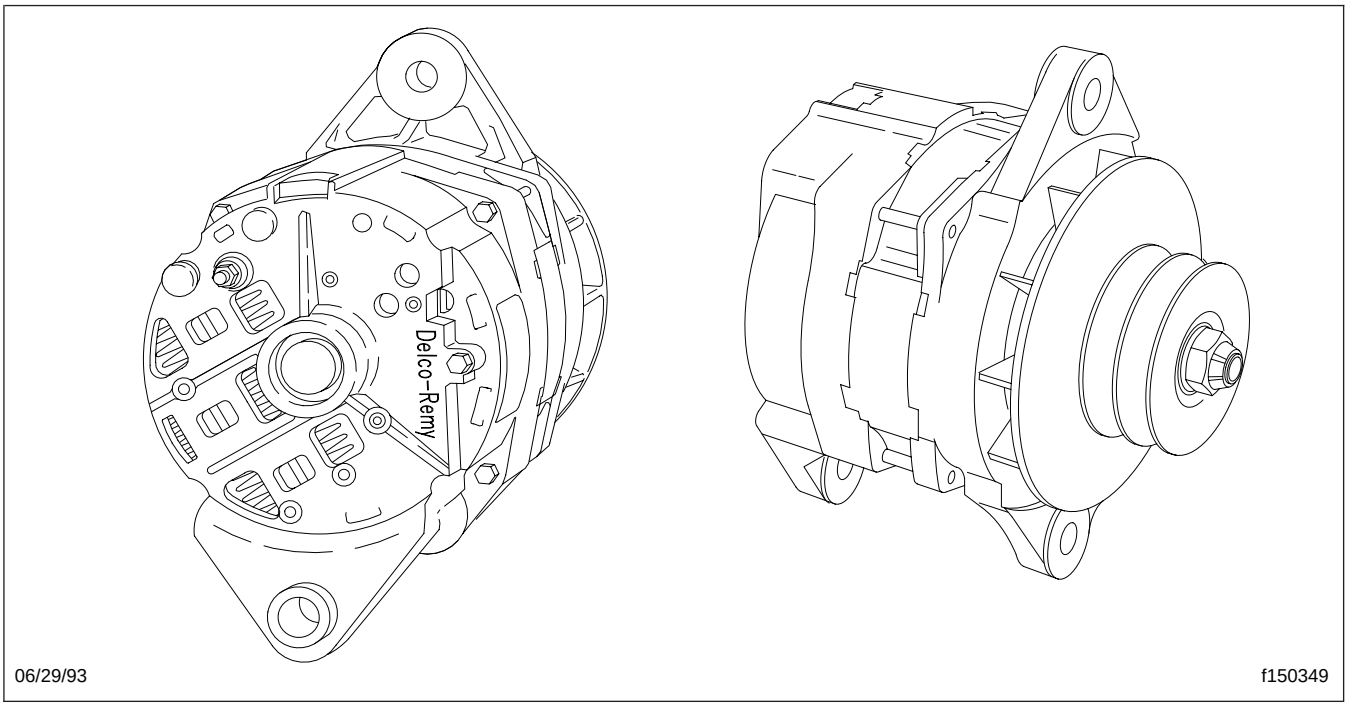


Fig. 2, Delco Remy 21-SI Alternator

Alternator Removal and Installation

Removal

1. Apply the parking brakes, chock the tires, and tilt the cab.
2. Disconnect the battery ground cable.
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 (**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. See **Fig. 2**.

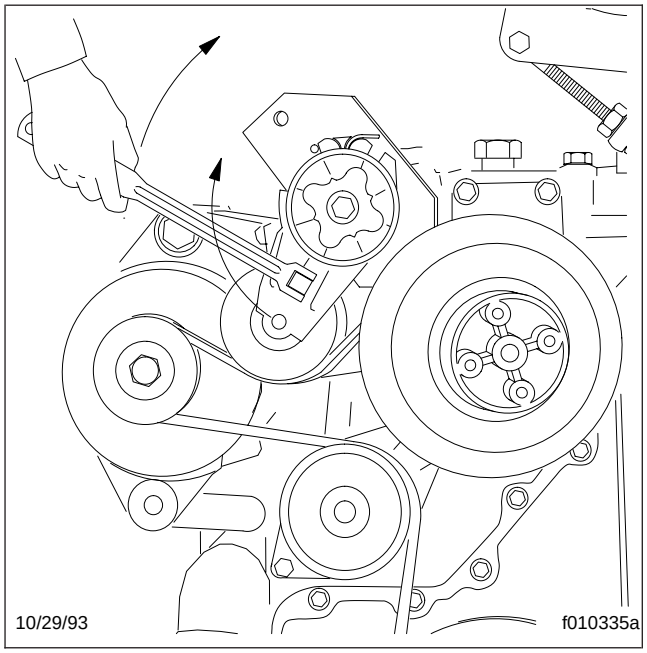


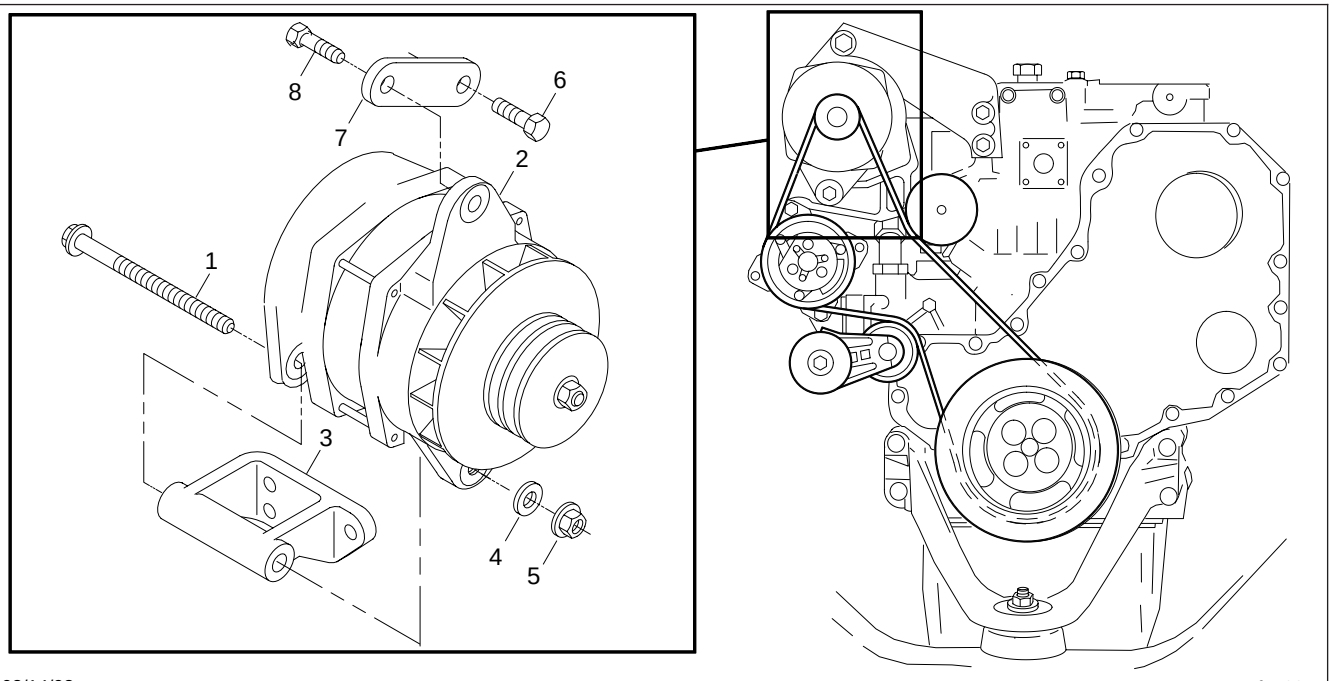
Fig. 1, Belt Tensioner

   - 5.1 Remove the top mounting bolt from the alternator.
   - 5.2 Securely hold the alternator to prevent it from falling, and remove the pivot bolt.
   - 5.3 Remove the alternator from the vehicle.

Installation

1. Install the alternator on the alternator mount. See **Fig. 2**.
   - 1.1 Position the alternator on the mount.
   - 1.2 Install the lower bolt between the two ears. Do not tighten.
   - 1.3 Install the upper bracket bolt.
   - 1.4 Tighten the lower bolt 68 lbf·ft (92 N·m).
2. Install the capscrew (Ref. 8) to secure the lower alternator mount to the alternator link (Ref. 7), and tighten it 16 lbf·ft (21 N·m). Tighten the nut on the end of the pivot bolt 40 lbf·ft (54 N·m).
3. Install the belt on the alternator.
   - 3.1 Insert a 3/8-inch breaker bar in the belt tensioner (**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 battery ground cable.
6. Lower the cab, and remove the chocks from the tires.

Alternator Removal and Installation



1. Pivot Bolt
2. Alternator
3. Alternator Mount
4. Pivot Bolt Washer
5. Pivot Bolt Nut
6. Link Capscrew
7. Link
8. Link Capscrew

Fig. 2, Alternator Installation

Troubleshooting

The following symptoms indicate that the batteries may be undercharged:

- The engine does not crank or only cranks slowly
- The vehicle lights are dim
- The turn signals flash more slowly than normal
- The voltmeter reads low

The following symptoms indicate that the batteries may be overcharged:

- The battery smells bad
- The battery is swollen or spews electrolyte
- The lights are brighter than normal
- The lights are burned out, or burn out when the engine starts
- The voltmeter reads high

To troubleshoot the SmartChek™ diagnostic alternator, do the following steps:

1. With the engine off, clean the top of the regulator using a shop cloth until you can see the SmartChek indicator.
2. Start the engine. If the SmartChek indicator glows red, replace the alternator.

   If the indicator glows green, go to the next step.
3. Turn on a number of vehicle accessories, such as lights and heater fans. If the green indicator changes to red, replace the alternator.

   If the indicator continues to glow green, the alternator is OK. Check the other components of the electrical system.

Troubleshooting Tables

Problem—The Batteries Seem Undercharged

Problem—The Batteries Seem Undercharged	
Possible Cause	**Remedy**
The drive belt is loose.	Check the drive belt. See 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 do the "Alternator Voltage Test."
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 crank the engine. If the engine cranks OK, do the "Alternator Voltage Test." If the engine still cranks slowly, check the cranking circuit.
The batteries cannot hold a charge.	Do a load test on the batteries. Refer to the applicable section in **Group 54** for instructions. Charge or replace batteries as needed. If the batteries were discharged, but are able to hold a charge, do the "Alternator Voltage Test."
The wiring is broken.	Check the wiring and repair or replace any broken wires.
The wiring is undersized.	Check the wire list in **Group 54** for the correct wire sizes. Replace any undersized wires.
Terminals are corroded, broken, loose, or dirty.	Clean, tighten, repair, and replace terminals as needed.
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.

Troubleshooting

Problem—The Batteries Seem Undercharged	
Possible Cause	**Remedy**
The battery cables do not deliver sufficient voltage to the starter.	Check the available cranking voltage.
The alternator is malfunctioning.	Replace the alternator.

Problem—The Batteries Seem Overcharged

Problem—The Batteries Seem Overcharged	
Possible Cause	**Remedy**
The batteries are overheated.	If 119°F (48°C) or below, load test the batteries. Refer to the applicable section in **Group 54** for instructions.
The batteries need replacing.	Check battery temperatures. If 119°F (48°C) or below, load test the batteries. Refer to the applicable section in **Group 54** for instructions.
The voltage regulator is poorly adjusted or damaged.	Do the "Alternator Voltage Test." If the voltmeter reads 15.5V or above, adjust the voltage regulator. Do the "Alternator Voltage Test" again. If adjusting the voltage regulator did not bring the voltmeter reading down below 15.5V, replace the alternator.
The dash voltmeter is broken.	If the test voltmeter reads below 15.5V, check and, if necessary, replace the dash voltmeter.

Alternator Voltage Test

IMPORTANT: Before starting this test, make sure that all belts are correctly tightened, and that the wiring and terminals are in good condition and properly protected. Check that the batteries are 95% to 100% charged, and are functioning according to the manufacturer's specifications.

1. Shut off all electrical accessories and run the engine at approximately 1500 RPM.
2. Connect a DC voltmeter to the battery terminals and measure the voltage.

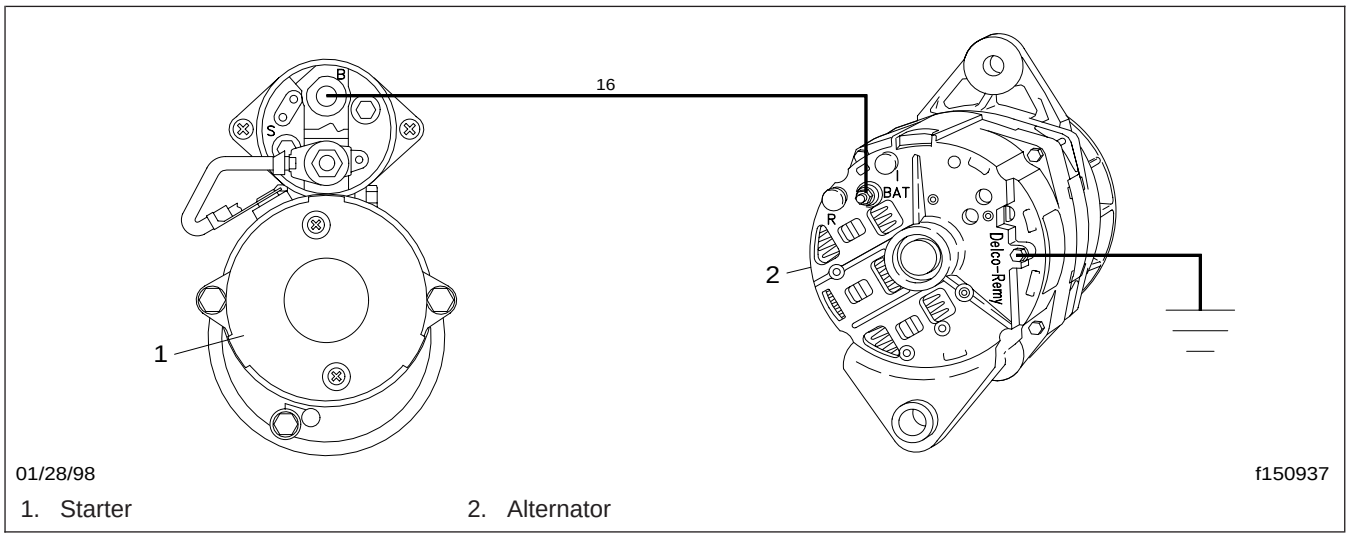
   If the voltage is above 14.8 volts, the batteries are overcharged. For troubleshooting information, go to "Problem—The Batteries Seem Overcharged."

   If the voltage is below 12.8 volts, the batteries are undercharged. For troubleshooting information, go to "Problem—The Batteries Seem Undercharged."

See **Fig. 1** for the alternator wiring diagram.

Fastener Torque			
Description	**Grade**	**Size**	**Torque lbf·ft (N·m)**
Alternator Adjusting Rod Guide Capscrew	8	3/8–16	40 (54)
Alternator Link Capscrew	8.8	M8	16 (21)

Table 1, Fastener Torque



1. Starter
2. Alternator

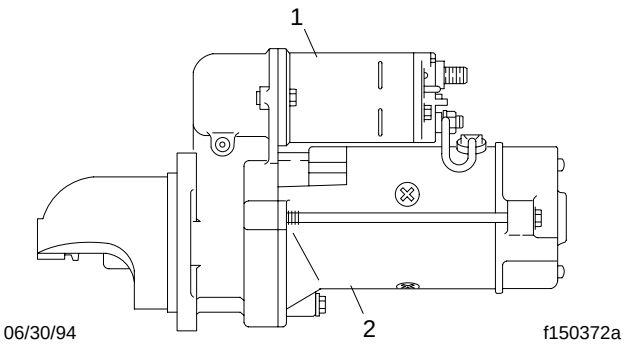
Fig. 1, Delco Remy Alternator 21-SI Wiring Diagram

General Description

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.

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.



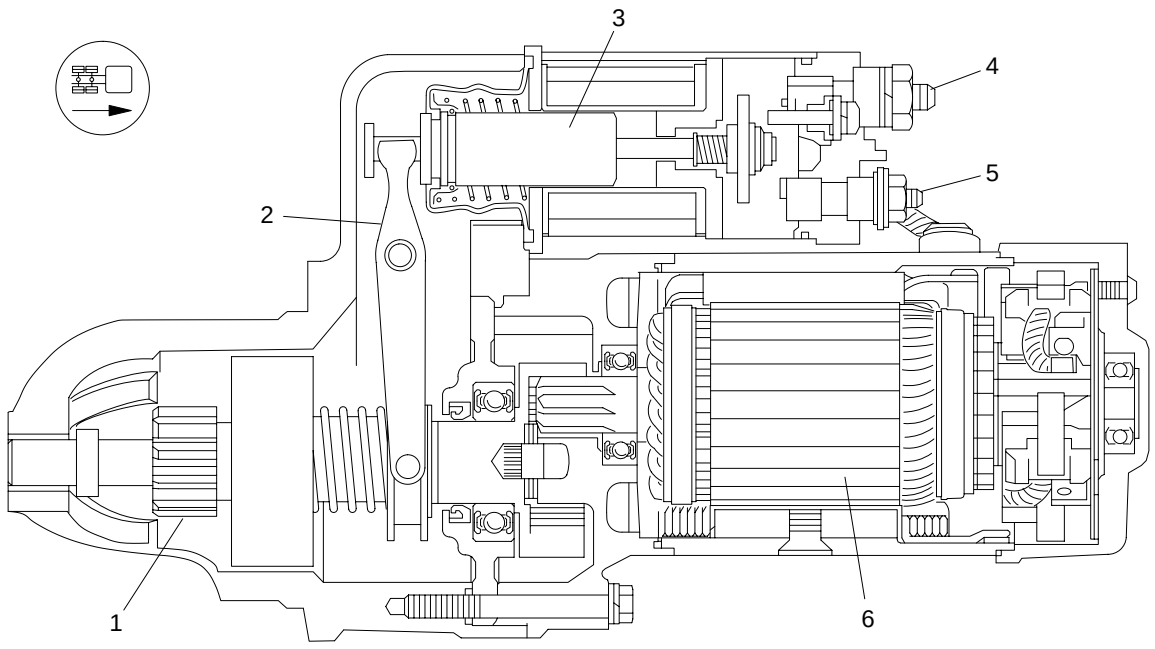
1. Starter Solenoid
2. Starter Motor

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



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1. Starter Drive Gear
2. Shift Lever
3. Solenoid Plunger
4. Battery Terminal
5. Motor Terminal
6. Starter Motor

Fig. 2, Starter Components

Starter Removal and Installation

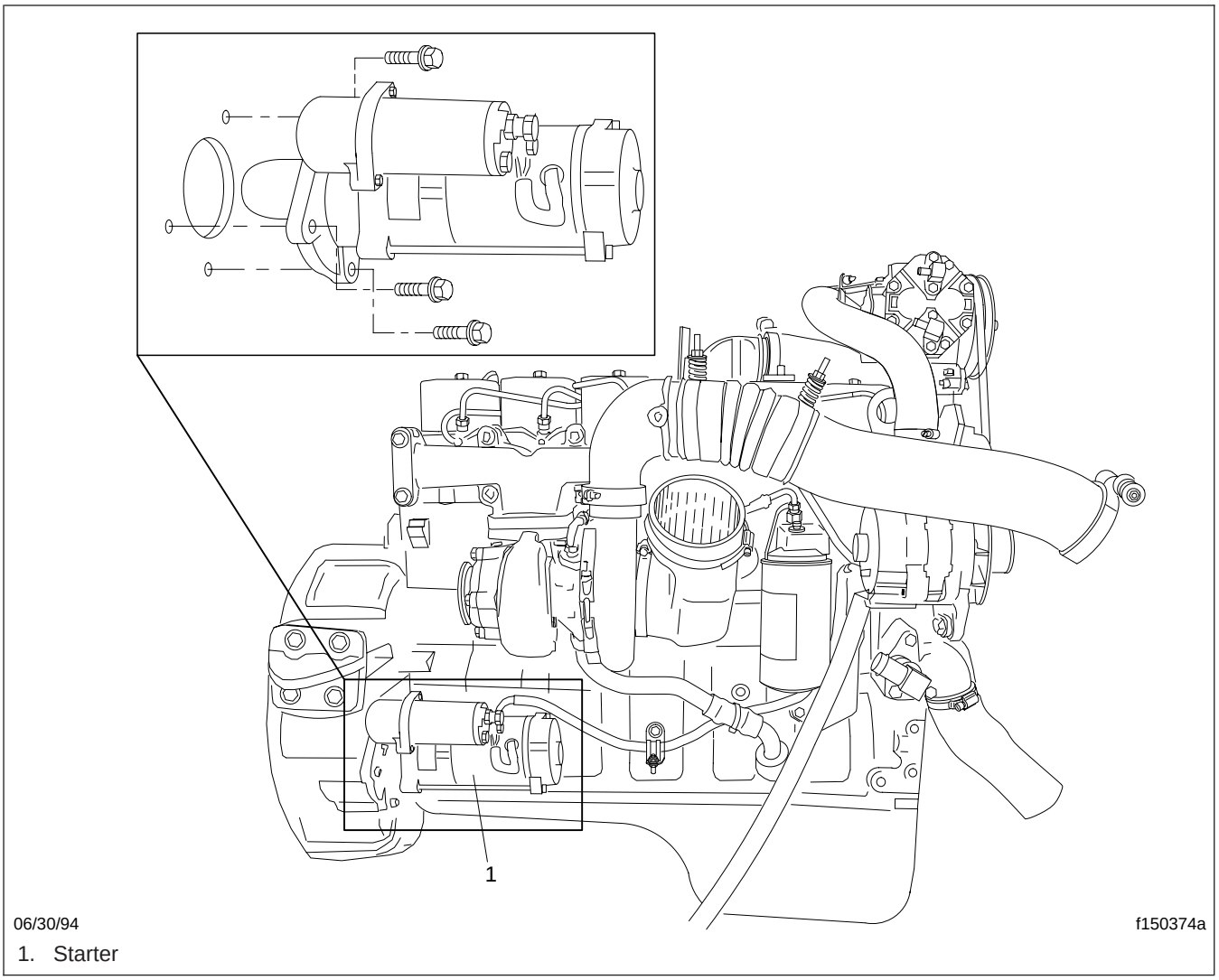
Removal

1. Apply the parking brakes, chock the tires, and tilt the cab.
2. Disconnect the battery ground cable at the vehicle frame.
3. Disconnect the wires from the starter solenoid terminals, and label them for reassembly.
4. Remove the starter from the engine.

   Remove the three capscrews that secure the starter to the engine. See **Fig. 1** .

Installation

1. Position the starter on the engine and secure it with the three capscrews. See **Fig. 1**. Tighten the capscrews 32 lbf·ft (43 N·m).
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 battery ground cable to the vehicle frame.



1. Starter

Fig. 1, Cummins B Series Engine

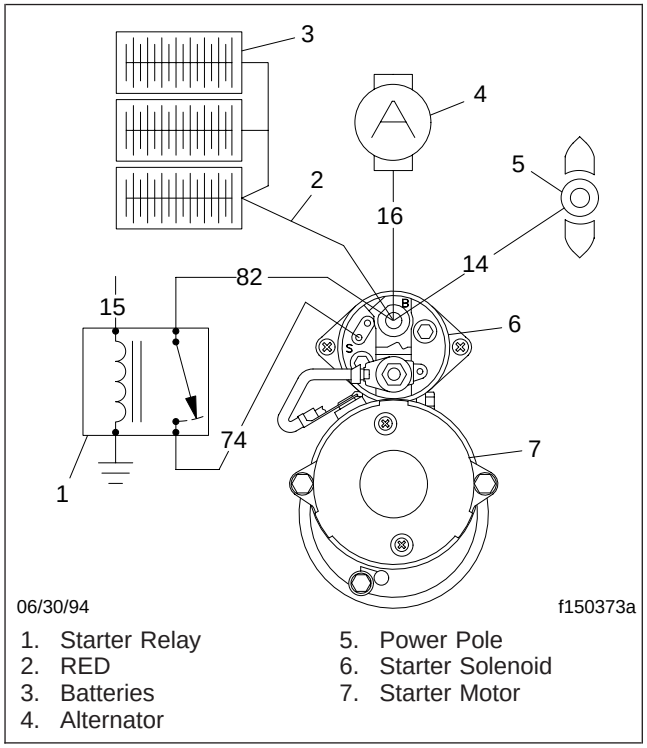
Starter Removal and Installation

4. Lower the cab, and remove the chocks from the tires.
5. Start the engine to test the starter.

See **Fig. 1** for the starter wiring diagram.

Fastener Torques			
Description	**Grade**	**Size**	**Torque lbf·ft (N·m)**
Starter Mounting Capscrews	8.8	M10 x 1.5	32 (43)

Table 1, Fastener Torques



1. Starter Relay
2. RED
3. Batteries
4. Alternator
5. Power Pole
6. Starter Solenoid
7. Starter Motor

Fig. 1, Starter Wiring Diagram

General Description

The Leece-Neville JB series alternator is a 14-volt self-load-limiting alternator equipped with a three-step adjustable voltage regulator. See **Fig. 1**.

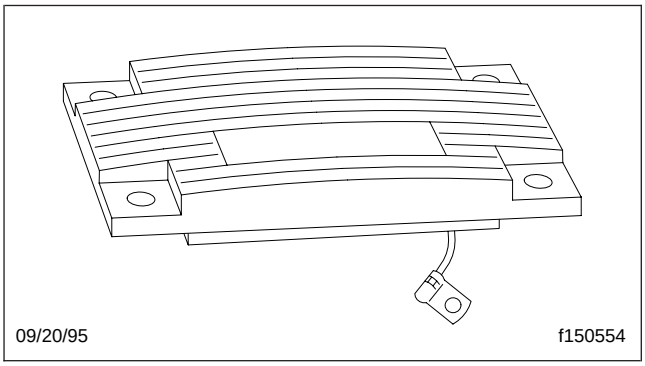


Fig. 1, Three-Step Adjustable Voltage Regulator

Six silicon diodes mounted in heat sinks convert alternating current from the delta-wound stator into direct current. A capacitor connected between the heat sinks helps suppress transient voltage spikes, which could possibly damage the diodes.

The brushes and voltage regulator are located in a waterproof housing that may be removed for replacement or inspection. An external relay terminal is also provided.

The voltage regulator is also equipped with transient voltage protection and will withstand instantaneous opening of the charging circuit under full load conditions.

Principles of Operation

Current is produced by rotating a magnet inside a stationary winding. The rotating magnet is called a rotor and the stationary winding is called a stator. See **Fig. 2**.

The rotor is electrically magnetized by a small current flowing through the brushes, riding on smooth slip rings. See **Fig. 3**. Alternating current is then produced as the magnetic poles of the rotor pass the coil windings of the stator.

These alternators have 12 magnetic poles in the rotor (**Fig. 4**) and three separate windings in the stator (**Fig. 5**). Since the rotor produces alternating current as it passes the coil windings of the stator, increased engine speed produces more current.

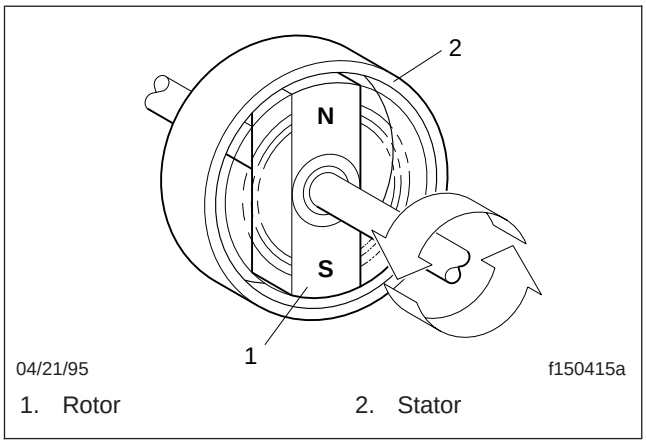


Fig. 2, Producing the Current

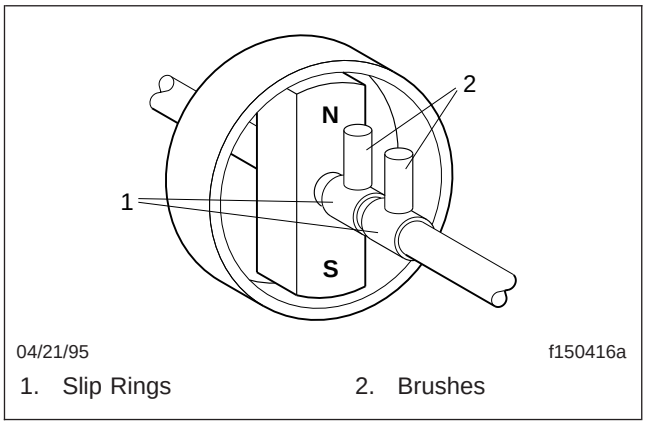


Fig. 3, Magnetizing the Rotor

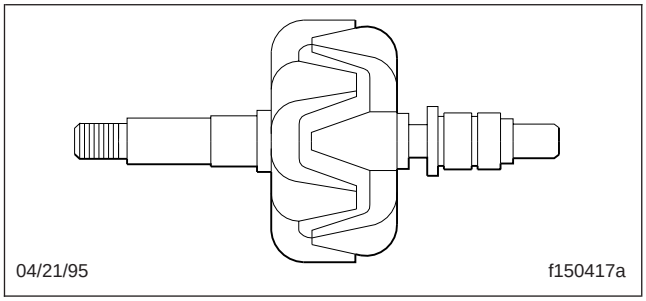


Fig. 4, Rotor

Rectifier assemblies convert alternating current to direct current for storage in the batteries. Rectifiers consist of silicon diodes that work as electrical switches and permit current flow in only one direc-

General Information

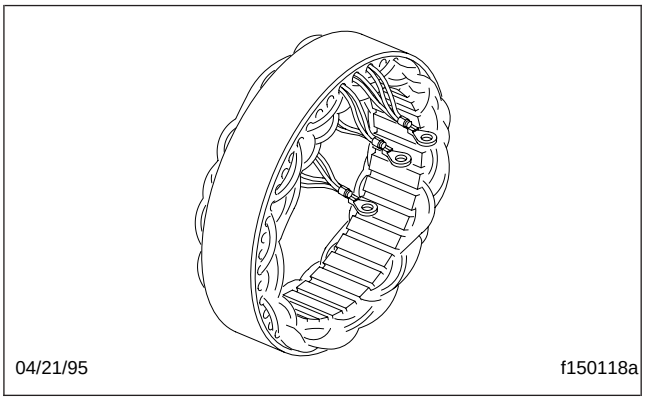


Fig. 5, Stator

tion. They are mounted in an aluminum casting, which is finned to dissipate heat. This is called a heat sink. See **Fig. 6**.

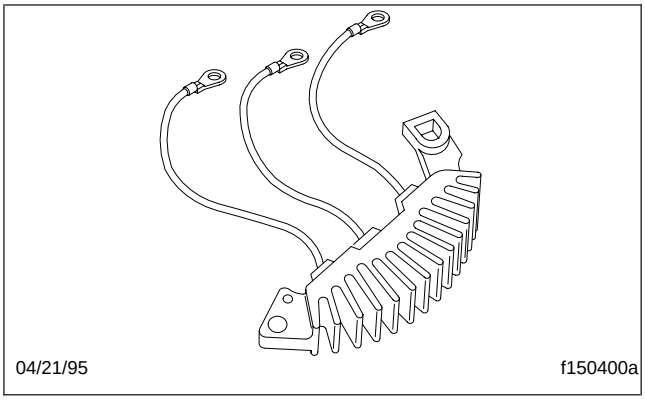


Fig. 6, Heat Sink

The voltage regulator (**Fig. 1**) controls the alternator output and the state of charge of the batteries. It is used in the charging system to regulate the battery voltage to the vehicle.

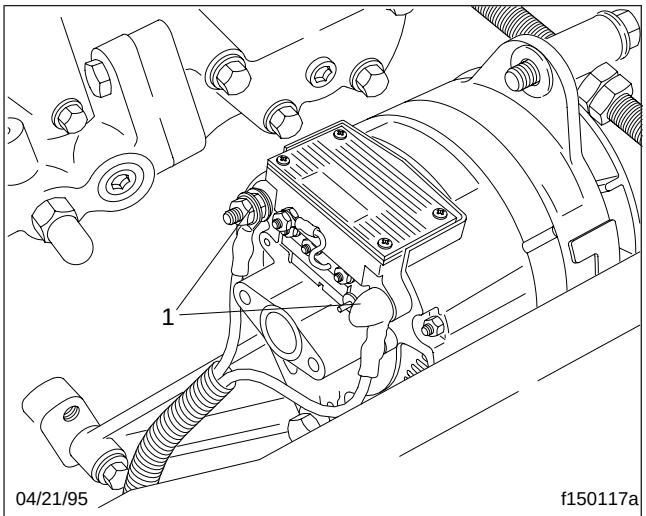
The diode trio converts a small amount of alternating current from the stator into direct current which is used as a signal to turn on the regulator.

When the battery is charged, the regulator reduces the field current flow to the rotor. Reducing the field current flow, in turn, reduces the alternator output. When the headlights or accessories place a load on the battery, the regulator increases the current flow to the rotor, and alternator output increases, to maintain voltage.

Leece-Neville Alternator Removal and Installation

Removal

1. Apply the parking brake, chock the tires, and tilt the cab.
2. Disconnect the battery ground cable.
3. Mark all electrical leads and disconnect them from the alternator. See **Fig. 1**.



1. Lead Connections

Fig. 1, Electrical Connectors

4. Remove the alternator belt from the alternator pulley.
   - 4.1 Insert a breaker bar in the belt tensioner and rotate the tensioner up and off the belt.
   - 4.2 Holding the tensioner up, take the belt off the alternator pulley.
   - 4.3 Slowly release the belt tensioner, and remove the breaker bar. It is not necessary to remove the belt from the vehicle.
5. Remove the alternator. See **Fig. 2**.
   - 5.1 Remove the top mounting bolt from the alternator.
   - 5.2 Securely hold the alternator to prevent it from falling, and remove the long bolt that secures the alternator to the condensor bracket.
   - 5.3 Remove the alternator from the vehicle.
6. Inspect the drive belt. For instructions, see **Section 01.01, Subject 100**.

Installation

1. Install the alternator on the pivot bracket. See **Fig. 2**.
   - 1.1 Position the alternator on the bracket.
   - 1.2 Insert the pivot capscrew (Ref. 3) through the alternator, the bracket, and the brace.
   - 1.3 Install the washer and nut on the end of the pivot capscrew.
2. Install the alternator mounting capscrew, and tighten it 16 lbf·ft (21 N·m). Tighten the pivot capscrew 40 lbf·ft (54 N·m).
3. Install the drive belt on the pulley as removed. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m).

NOTE: The Cummins 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.

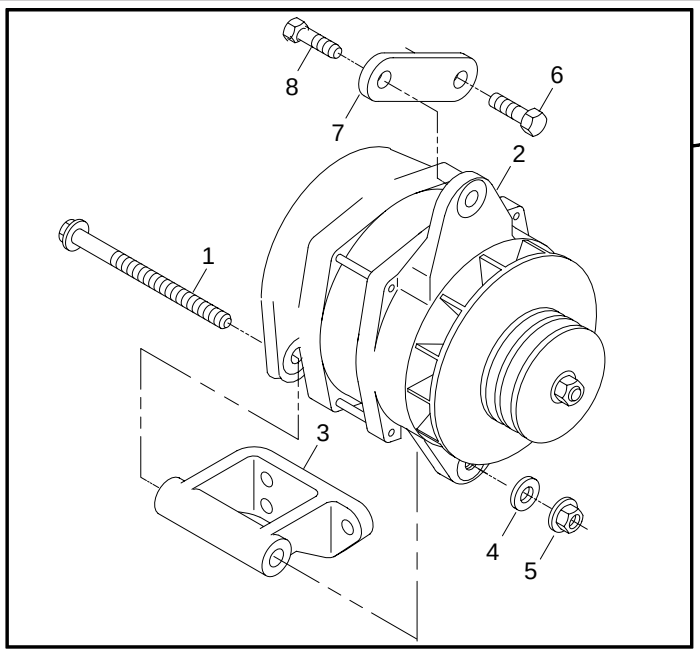
4. Connect all leads to the back of the alternator as removed. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm).
5. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

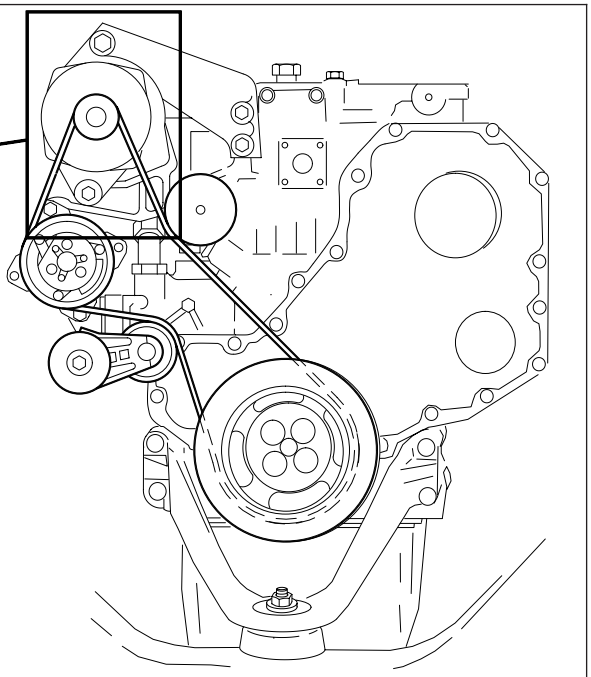
Approved Dielectric Red Enamel	
Protectant Material	**Approved Brands**
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 1, Approved Dielectric Red Enamel

6. Connect the batteries.
7. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Test" in **Troubleshooting 300**.

Leece-Neville Alternator Removal and Installation





02/14/98 f150944

1. Pivot Bolt
2. Alternator
3. Alternator Mount
4. Pivot Bolt Washer
5. Pivot Bolt Nut
6. Link Capscrew
7. Link
8. Link Capscrew

Fig. 2, Alternator Installation

Adjustment

NOTE: Before checking or adjusting the alternator voltage, check the wiring, connections, and belt tension.

1. Turn off all accessories. Run the engine at fast idle (approximately 1200 RPM) and charge the batteries.
2. Connect an accurate voltmeter across the batteries to determine the charging voltage. If the voltage is below 13.8V, or above 14.1V, adjust the voltage regulator.
3. Shut down the engine.
4. If needed, adjust the charging voltage.
   - 4.1 Remove the small black cap on the regulator cover to expose the adjustment screw.
   - 4.2 Using a small screwdriver, turn the adjusting screw until the voltage is between 13.8V and 14.1V.
     - To increase the voltage, turn the adjusting screw clockwise.
     - To decrease the voltage, turn the adjusting screw counterclockwise.
5. Run the engine at fast idle (approximately 1200 RPM) and check the voltage again to make sure it has been properly adjusted. Readjust as necessary.

NOTE: If adjustment does not bring the voltage into the proper range, replace the voltage regulator.

6. Shut down the engine.
7. Replace the plastic cap on the access hole over the adjusting screw.

Troubleshooting

The following symptoms indicate that the batteries may be undercharged:

- The engine does not crank or only cranks slowly
- The vehicle lights are dim
- The turn signals flash more slowly than normal
- The voltmeter reads low

The following symptoms indicate that the batteries may be overcharged:

- The battery smells bad
- The battery is swollen or spews electrolyte
- The lights are brighter than normal
- The lights are burned out, or burn out when the engine starts
- The voltmeter reads high

Troubleshooting Tables

Problem—The Batteries Seem Undercharged

Problem—The Batteries Seem Undercharged	
Possible Cause	**Remedy**
The drive belt is loose.	Check the drive belt. See 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 do the "Alternator Voltage Test."
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 crank the engine. If the engine cranks OK, do the "Alternator Voltage Test." If the engine still cranks slowly, check the cranking circuit.
The batteries cannot hold a charge.	Do a load test on the batteries. See **Group 54** for instructions. Charge or replace batteries as needed. If the batteries were discharged, but are able to hold a charge, do the "Alternator Voltage Test."
The wiring is broken.	Check the wiring and repair or replace any broken wires.
The wiring is undersized.	Refer to the applicable section in **Group 54** for the correct wire sizes. Replace any undersized wires.
Terminals are corroded, broken, loose, or dirty.	Clean, tighten, repair, and replace terminals as needed.
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 battery cables do not deliver sufficient voltage to the starter.	Check the available cranking voltage.
The alternator is malfunctioning.	Replace the alternator.

Troubleshooting

Problem—The Batteries Seem Overcharged

Problem—The Batteries Seem Overcharged	
Possible Cause	**Remedy**
The batteries are overheated.	If 119°F (48°C) or below, load test the batteries. See **Group 54** for instructions.
The batteries need replacing.	Check battery temperatures. If 119°F (48°C) or below, load test the batteries. See **Group 54** for instructions.
The voltage regulator is poorly adjusted or damaged.	Do the "Alternator Voltage Test." If the voltmeter reads 15.5V or above, adjust the voltage regulator. Do the "Alternator Voltage Test" again. If adjusting the voltage regulator did not bring the voltmeter reading down below 15.5V, replace the alternator.
The dash voltmeter is broken.	If the test voltmeter reads below 15.5V, check and, if necessary, replace the dash voltmeter.

Alternator Voltage Test

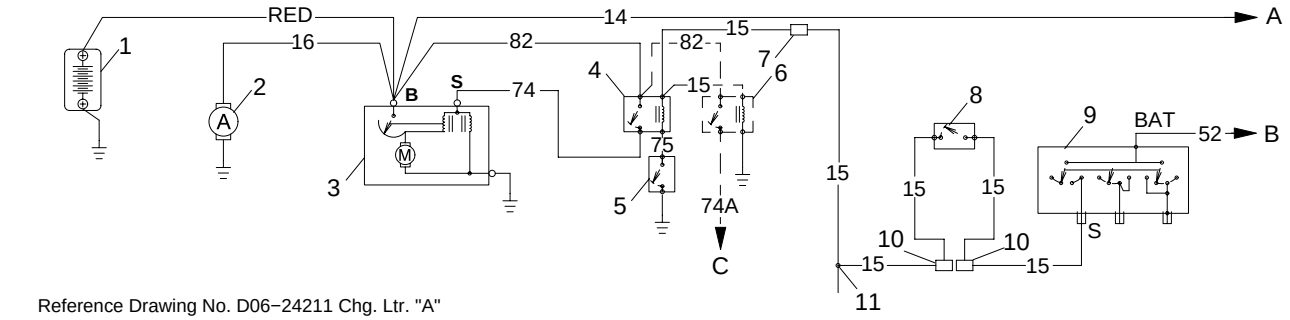
IMPORTANT: Before starting this test, make sure that all belts are correctly tightened, and that the wiring and terminals are in good condition and properly protected. Check that the batteries are 95% to 100% charged, and are functioning according to the manufacturer's specifications.

1. Shut off all electrical accessories and run the engine at approximately 1000 to 2000 RPM.
2. Connect a DC voltmeter to the battery terminals and measure the voltage.

   If the voltage is above 14.8 volts, the batteries are overcharged. For troubleshooting information, go to "Problem—The Batteries Seem Overcharged."

   If the voltage is below 12.8 volts, the batteries are undercharged. For troubleshooting information, go to "Problem—The Batteries Seem Undercharged."

See **Fig. 1** for a charging circuit wiring diagram.



A. To Power Stud
B. To 15-Amp Circuit Breaker
C. To Fuel Pump Solenoid

1. Battery
2. Alternator
3. Starter
4. Magnetic Switch
5. Neutral Start Switch (automatic transmission only)
6. Fuel Solenoid Relay
7. Bulkhead Connector
8. Starter Interrupt Switch
9. Ignition Keyswitch
10. Main Cab Harness Connector
11. Wire 15 Splice

Fig. 1, Charging Circuit Wiring Diagram

Mounting Fastener Torques			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Alternator Mounting Capscrew	10.9PO	M8 x 1.25	16 (21)
Pivot Capscrew	10.9PO	M10 x 1.5	40 (54)

Table 1, Mounting Fastener Torques

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)

Table 2, Terminal Fastener Torques

Pulley Nut Torque, All Engines			
Description	**Grade**	**Size**	**Torque: lbf·ft (N·m)**
Pulley Nut	8PO	1/2–20	75 (102)

Table 3, Pulley Nut Torque, All Engines

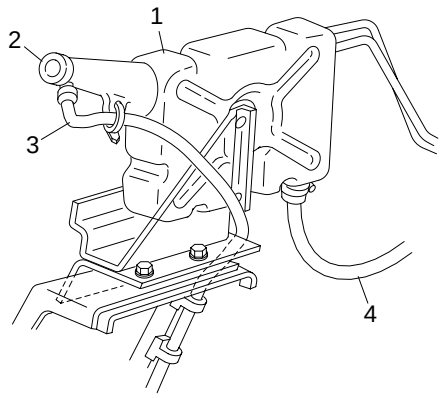
General Description

All radiators are of the tube and serpentine type with the tubes arranged for vertical flow of the coolant. Two header tanks, one on the top and one on the bottom of the radiator, provide uniform distribution of the coolant to the tubes. The radiator outlet port(s) (lower header tank) is connected to the water pump inlet port. The radiator inlet port(s) (upper header tank) is connected to the coolant outlet fitting of the engine, thereby permitting coolant circulation through the radiator when the thermostat is open.

The radiator tanks are molded glass-filled nylon and are secured to the core header by crimp strips. If damaged, replace the tank. Do not attempt to repair or reseal it.

Valeo radiators are a modular design, featuring copper-brass core and header assemblies combined with plastic tanks. The plastic tank is sealed to the header with an oval gasket seal and is held in place with removable crimp strips. Radiator core replacements and tank replacements can be performed in the dealership.

Vehicles have a separate coolant recovery reservoir (coolant supply tank), with the radiator cap on the tank. See **Fig. 1**.



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1. Supply Tank
2. Cap
3. Drain Tube
4. Supply Hose or Tubing

Fig. 1, Coolant Recovery System

Radiator Removal and Installation

Removal

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

⚠ 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 radiator surge tank cap.
   - 3.2 Open the petcock on the radiator to drain the engine coolant.
4. Remove charge air cooler lines.
5. Remove the upper radiator hose, from the engine and radiator.
6. Disconnect the coolant recovery reservoir hose from the radiator.
7. Remove the A/C condenser to radiator attaching bolts (if equipped) and position condenser out of the way.
8. Remove the lower radiator hose.
9. Remove the fan and clutch assembly.
10. Remove the radiator and charge air coooler support bolts.
11. Remove the radiator.
12. Lift the shroud off the fan.

Installation

1. Install the shroud on the fan.
2. Install the radiator.
3. Install the radiator and charge air coooler support bolts.
4. Install the fan and clutch assembly.
5. Install the lower radiator hose.

NOTE: Your hose clamps can be either T-bolt clamps (see **Fig. 1**), Breeze Constant-Torque clamps (see **Fig. 2**), or ABA Radial worm-drive clamps (see **Fig. 3**).

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**. Over-tightening an ABA Radial worm-drive hose clamp can result in coolant leaks.

6. Position the condenser to the radiator, and install the A/C condenser to radiator attaching bolts (if equipped).
7. Connect the coolant recovery reservoir hose to the radiator.
8. Install the upper radiator hose, from the engine to the radiator.
9. Install the charge air cooler lines.
10. Fill the cooling system.
11. Lower the cab.
12. Remove the chocks from the tires.

Radiator Removal and Installation

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

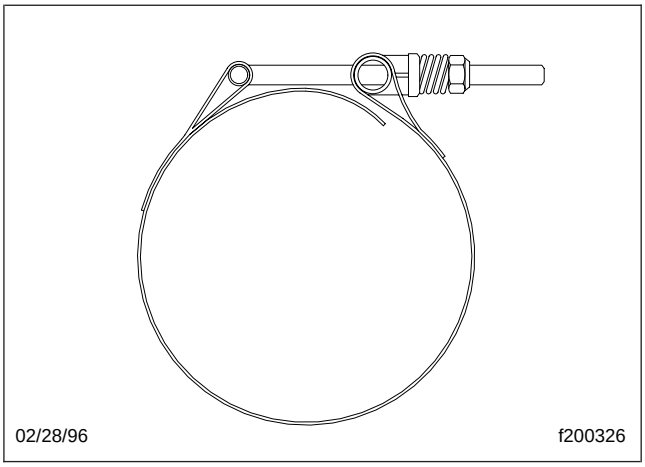


Fig. 1, T-Bolt Type Hose Clamp

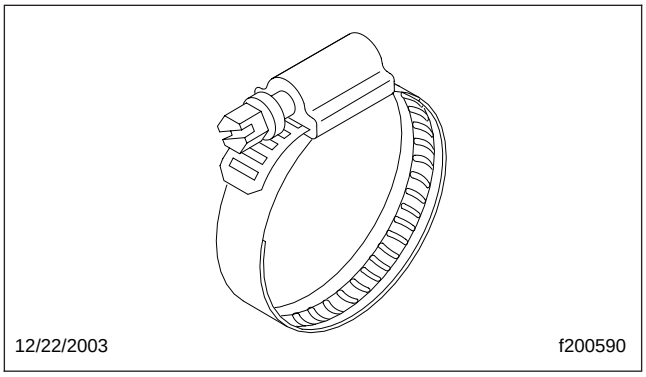


Fig. 3, ABA Radial Worm-Drive Hose Clamp (typical)

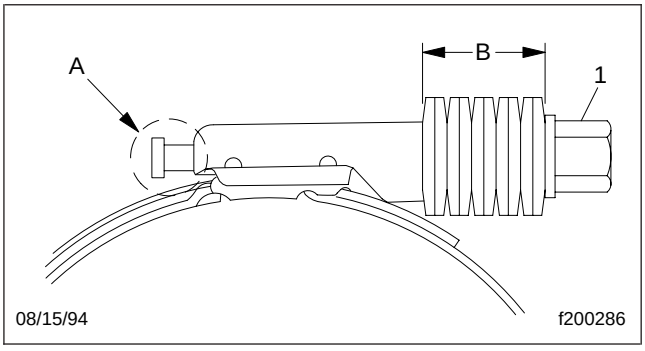


Fig. 2, Breeze Constant-Torque Hose Clamp Installation

Disassembly

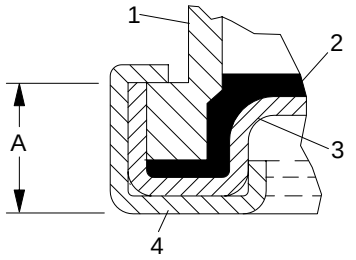
1. Remove the nuts and bolts that hold the charge air cooler to the radiator assembly.
2. Remove the charge air cooler from the radiator assembly.
3. Remove the drain cock and de-aeration fitting as required.

NOTE: Always use new crimp strips and gaskets when servicing these assemblies.

4. Service the heat exchangers as required. Mount the radiator in a crimp machine (Plastech by Rad-Pal or similar machine), compress the gasket and uncrimp the retaining tabs by approximately 90 degrees (facing straight up) starting near the center of the tank and working toward the ends. Remove the crimp strips, tank and gasket.
5. Final crimp the tabs beginning at the center of the tank and work outward. Finish with the end tabs.
6. Invert the radiator and repeat procedure for remaining tank.
7. Surface preparation for service and refinishing can be accomplished through a boil-out procedure. This will remove any detrimental contaminants and allow proper soldering.
8. Number of blocked tubes allowed: two tubes can be soldered shut if required for service, providing they are not in line from front to back.

Assembly

1. Mount the radiator core in the crimp and compress machine, install a lubricated (glycol) gasket in the header and compress the gasket with the tank.
2. Precrimp the four end tabs at each end of tank. Also precrimp three tabs located near the center of the tank on both sides. Precrimp remaining tabs beginning near the center of tank and work outward to the ends of the tanks.
3. Final crimp the tabs beginning at the center of the tank and work outward. Finish with the end tabs.
4. Invert the radiator and repeat procedure for remaining tank.
5. Proper gasket compression is vital to proper tank-to-head seal. Compression is controlled by proper crimp height of crimp strip tabs. See **Fig. 1**.



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A. Crimp Height
1. Tank
2. Gasket
3. Header
4. Crimp Strip

Fig. 1, Gasket Compression

6. Remove clamping device before taking crimp height measurement.
7. Use vernier calipers or similar accurate measuring device to check for ideal crimp dimension of 0.470 to 0.475 inch (11.7 to 12.1 mm) measured between tabs from top of tank foot to the bottom of crimp strip. Tabs bent 90 degrees indicates proper crimp.
8. Pressure leak test to 18 psi (124 kPa).
9. If removed, install the drain cock and the de-aeration fitting.

NOTE: Loctite® 242 or equivalent is recommended on all threads.

10. Install the charge air cooler on the radiator assembly.

Pressure Test

Install a pressure tester to assist in testing the cooling system. Follow the manufacturer's recommended corrections and testing procedures.

⚠ WARNING

Never remove the radiator cap under any conditions while the engine is operating. Failure to follow these instructions can result in personal injury and damage to the cooling system and engine.

To avoid having scalding hot coolant or steam blow out of the radiator, use extreme care when removing the cap from a hot radiator. If possible, wait until the engine has cooled, then wrap a thick cloth around the radiator cap and turn it slowly to the first stop. Step back while the pressure releases from the cooling system. When you are sure all the pressure has been released, press down on the cap (still using a cloth), turn and remove it.

1. Make sure the coolant level in the supply tank is within specified limits. Replenish as necessary.
2. Connect the flexible tubing supplied with the pressure regulator pump to the body of the pump. Connect the remaining end of the tubing to the supply tank pressure cap outlet. See **Fig. 1**.

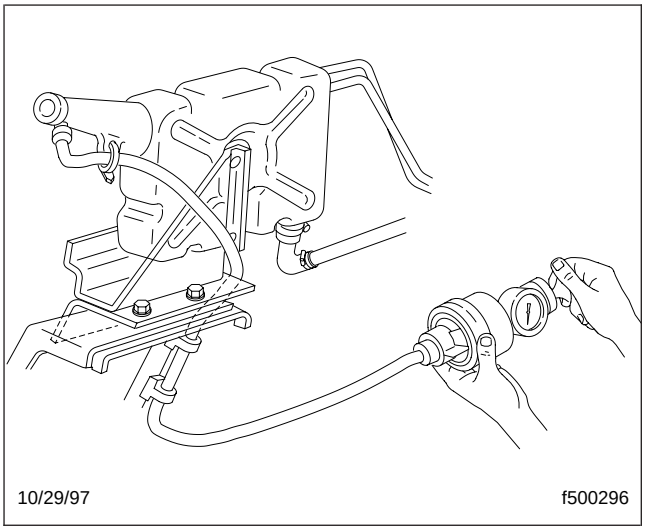


Fig. 1, Connect Pressure Pump and Gauge

3. Operate the pump handle until the pressure gauge indicates the specified cooling system pressure. Allow the cooling system to remain under pressure for approximately one minute.

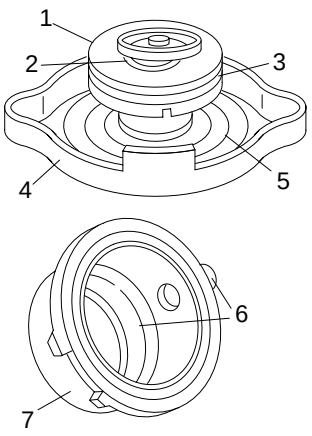
NOTE: Cylinder head gasket leakage can be positively identified by running the engine at approximately 1000 rpm for 15 minutes with the pressure test equipment installed. Gasket leakage will be indicated by pressure readings in excess of the normal system pressure.

4. If system pressure has reduced after this time, a cooling system leak is indicated. Visually inspect the entire cooling system, including the oil cooler and water-cooled compressor to establish the source of the leak. If an external coolant leak cannot be identified, an internal leak is indicated. Coolant leakage could be from the following:
   - cylinder head gasket
   - oil cooler tubes
   - cylinder block or cylinder head porosity
5. Service any coolant leakage as necessary, and check cooling system pressure. If satisfactory, remove the test equipment. Check and, if necessary, top off the coolant level. Install the pressure cap.

Radiator Cap Pressure Test

1. Remove the radiator cap from the supply tank filler neck.
2. Use water to clean the cap in the area of the rubber seal and the vacuum relief valve. Immerse the radiator cap in water and install it on the shallow filler neck of the adaptor from the radiator/heater pressure tester.
3. The filler neck seal is reversible so that it can be used on either a deep or shallow radiator filler neck. See **Fig. 2**. It will also fit either end of the radiator cap pressure test adaptor.
4. Immerse the filler neck seal in water and install it in the filler neck adaptor.
5. Apply seal to the deep end of the filler neck adaptor. Install the filler neck adaptor to the radiator cap pressure test adaptor.

Component Testing



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A. Radiator Cap
B. Radiator Filler Neck
1. Seal Surface
2. Under Rubber Seal
3. Overflow System Seal
4. Under Vacuum Valve
5. Sealing Surface

Fig. 2, Radiator Cap and Filler Neck Opening

6. Connect the female quick disconnect fitting of the pressure test pump to the male quick disconnect fitting of the filler neck adaptor.
7. Slowly press the plunger of the pressure test pump slowly until the pressure gauge reading stops increasing. Note the highest pressure reading.

NOTE: If the plunger is pressed too quickly, an incorrect pressure reading will result.

8. Release the pressure by turning the pressure relief screw counterclockwise. Then, tighten the pressure relief screw and repeat the previous step at least twice to make sure the pressure reading is repeatable within the acceptable gauge reading limits of the radiator cap. See **Specifications, 400**.
9. If the pressure test results are not within the acceptable gauge reading limits, replace the radiator cap. If the pressure test results are within the acceptable gauge reading limits, perform the pressure test at the beginning of this subject.

Cooling System Draining, Filling, and Bleeding

1. To prevent loss of antifreeze when draining the radiator, attach a hose to the radiator drain cock and drain the coolant from the radiator into a clean container.
2. Open the drain cock and remove the radiator or supply tank cap.
3. Close the drain cock.
4. Place the heater temperature control in maximum HEAT position.
5. Fill the supply tank or the radiator to the bottom of the filler neck with the recommended permanent antifreeze mixture. Leave the radiator cap off.

CAUTION

Never operate an engine with the cooling system filled solely with water as severe engine corrosion can result. See Group 20 of the maintenance manual for proper cooling system additives. Do not operate the engine without an additive.

NOTE: Always use a mixture of water, heavy-duty diesel engine cooling system fluid, and additive specified in Group 20 of the vehicle maintenance manual. In areas where protection against freezing is not required (hot climates), it is advisable to use a concentration of antifreeze to make sure of protection against corrosion. The approved antifreeze agents contain corrosion-inhibiting properties. See **Specifications, 400** to establish correct proportions of water and antifreeze to be used in cooling system.

WARNING

Do not stand in line with or near the cooling fan when revving the engine as personal injury or property damage may result.

NOTE Do not run engines over 2500 rpm during the following step.

6. Fill the supply tank or the radiator to bottom of filler neck with the recommended permanent antifreeze mixture. Leave the radiator cap off.
   - 6.1 Increase the rpm to maximum (governed) and run the engine until the thermostat opens (upper radiator hose becomes hot) and an additional ten minutes to allow air to escape from the cooling system.
   - 6.2 Throttle back to idle and fill the system with coolant to the bottom of the filler neck. Install the radiator cap. During the subsequent operation of the engine, some coolant may be disposed of through the overflow nipple. This is normal. After extended operation of the vehicle, when the engine has cooled off to an ambient temperature, the coolant level should be stabilized at a level approximately in line with the mounting tabs of the tank.
   - 6.3 If the vehicle is equipped with a coolant recovery reservoir, fill to it the HOT mark.

Cooling System Flushing

1. Slowly fill the cooling system with a mixture of clean water and a suitable flushing agent (mixed according to manufacturer's recommendations). If the cooling system is still hot, either fill it with hot water or allow the system to cool, then fill with cold water.
2. Start the engine and allow it to idle until normal operating temperature is reached. Run the engine for ten minutes, and then switch it off.
3. Drain the cooling system, fill, and run the engine. Repeat the procedure until the water draining from the radiator is clean.
4. Reverse-flush the radiator.
   - 4.1 Disconnect the radiator top and bottom hoses.
   - 4.2 Insert a hose in the radiator lower tank, and pack around the hose with cloth.
   - 4.3 Back-flush the radiator until clean water flows freely from the top connection. If difficulty is experienced in back-flushing, remove the radiator from the vehicle. Turn the radiator upside down, and then back-flush.
5. Back-flush the cylinder block and the cylinder head.
   - 5.1 Remove the thermostat housing cover and the thermostat(s).
   - 5.2 Insert a hose into the thermostat housing, and back-flush the engine until clean water flows freely from the radiator bottom hose.
6. Install the thermostat(s) and housing cover. Connect the radiator top and bottom hoses. Tighten securely.
7. After flushing the system, replace the coolant filter.

Heater Core Back-Flushing

All engine cooling system flushing and back-flushing procedures must include a separate back-flushing of the heater or air conditioning system heater core after the back-flushing of the engine cooling system. This will prevent engine cooling system particles from clogging the heater core tubes and reducing (or eliminating) coolant flow through the heater core. The heater core must be back-flushed separately from the engine cooling system for proper back-flush water flow direction through the heater core.

1. Disconnect the heater core outlet heater hose from the water pump fitting. Install a female garden hose-end fitting adapter in the end of the outlet heater hose. Secure with a hose clamp.
2. Connect the female garden hose-end of the outlet heater hose to the male end of a water supply garden hose.
3. Disconnect the heater core inlet heater hose from the engine block fitting and allow it to drain onto the ground or into a floor drain.
4. Check to be certain the water valve is open (no vacuum) if a water valve is installed in the heater core inlet heater hose.
5. Turn the water supply valve on and off several times so the surge action will help to dislodge larger stubborn particles from the heater core tubes. Allow full water pressure to flow for approximately five minutes.
6. If a water valve is installed in the heater core inlet heater hose, apply vacuum to the water valve vacuum motor to ensure proper operation of the water valve and proper closure with no water leakage. Replace the water valve if required.
7. Remove the hose clamp and female garden hose-end adapter from the end of the outlet heater hose and connect the outlet heater hose onto the water pump fitting.
8. Connect the inlet heater hose onto the engine block fitting.
9. Test the system for proper heater performance with the specified engine cooling system conditions.

Cooling System Cleaning

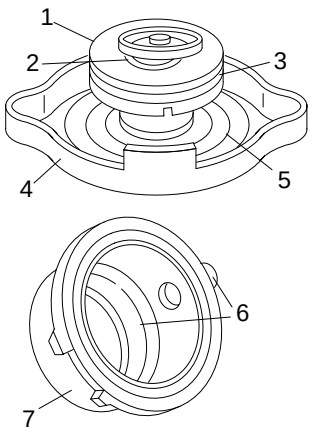
Radiator Cap

⚠ WARNING

Never remove the radiator cap under any conditions while the engine is operating. Failure to follow these instructions can result in personal injury, and damage to the cooling system and engine.

To avoid having scalding hot coolant or steam blow out of the radiator, use extreme care when removing the cap from a hot radiator. If possible, wait until the engine has cooled, then wrap a thick cloth around the radiator cap and turn it slowly to the first stop. Step back while the pressure is released from the cooling system. When you are sure all the pressure has been released, press down on the cap (still using a cloth), turn and remove it.

1. Inspect the areas under the vacuum valve and rubber seal for rust or dirt particles. See **Fig. 1**.



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1. Radiator Cap
2. Radiator Filler Neck
3. Seal Surface
4. Under Rubber Seal
5. Overflow System Seal
6. Under Vacuum Valve
7. Sealing Surface

Fig. 1, Radiator Cap and Filler Neck Opening

2. Raise the vacuum valve and rubber seal. Using warm tap water, flush away loose rust or dirt particles trapped under the vacuum valve, rubber seal and on the seal surface.
3. Inspect and remove any embedded rust or dirt particles on the sealing surfaces of the rubber seal.

If paint is observed on the filler neck sealing surface, remove it using paint thinner.

4. Inspect the supply tank filler neck opening for rust or dirt particles on the sealing surface at the bottom of the filler neck opening. Use a clean cloth and wipe the sealing surface to remove any rust or dirt particles.
5. If rubber seals are torn, badly worn or have unusual wear pattern, replace with a new cap.
6. If the seal surface on the fill neck is damaged or distorted, replace it.

Radiator

EXTERNAL

The radiator core can be cleaned externally with a soft bristle brush, warm water and a mild household liquid detergent. Rinse with clear water.

INTERNAL

IMPORTANT: Do not use caustic cleaning solutions.

Internal cleaning of the radiator core can be accomplished by removing one radiator tank to gain access to the tubes. Clean the tubes with a mild household liquid detergent. Rinse the core with clean water when completed. Do not use a metal brush to clean the core. Use only horsehair, bristle or nylon brushes. Use of a radiator boil-out tank is permissible only after the plastic tanks and rubber sealing gaskets are removed from the radiator core.

Specifications

Coolant Mixture					
Percentage of Specified Antifreeze (by volume)	**Remains Fluid Down To:**	**Solidifies at:**	**Parts of Antifreeze**	**Parts of Water**	**Specific Gravity Reading ***
25%	9°F (–13°C)	–20°F (–29°C)	2–1/2	7–1/2	1.046
30%	3°F (–16°C)	–38°F (–39°C)	3	7	1.054
40%	–13°F (–25°C)	–54°F (–48°C)	4	6	1.069
50%	–34°F (–37°C)	–72°F (–58°C)	5	5	1.084

* Specific gravity readings at constant temperature of 60°F (15°C)

Table 1, Coolant Mixture

Cooling System Pressures		
Engine	**Operating Pressure**	**Minimum Test Pressure**
All Diesel Engines	7 psi (48 kPa)	6 psi (41 kPa)

Table 2, Cooling System Pressures

Tank-to-Header Crimp Assembled Height	
Radiator	**Height**
Copper/Brass Core	.462 ± .010 inch (11.7 ± .25 mm)

Table 3, Tank-to-Header Crimp Assembled Height

Torque Values		
Description	**lbf·ft**	**N·m**
Water Temperature Indicator Sender	12–18	16–24
Charge Air Cooler to Radiator Support Frame:		
3/8" Bolts	35	47
3/8" Nuts	15	20

Table 4, Torque Values

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.

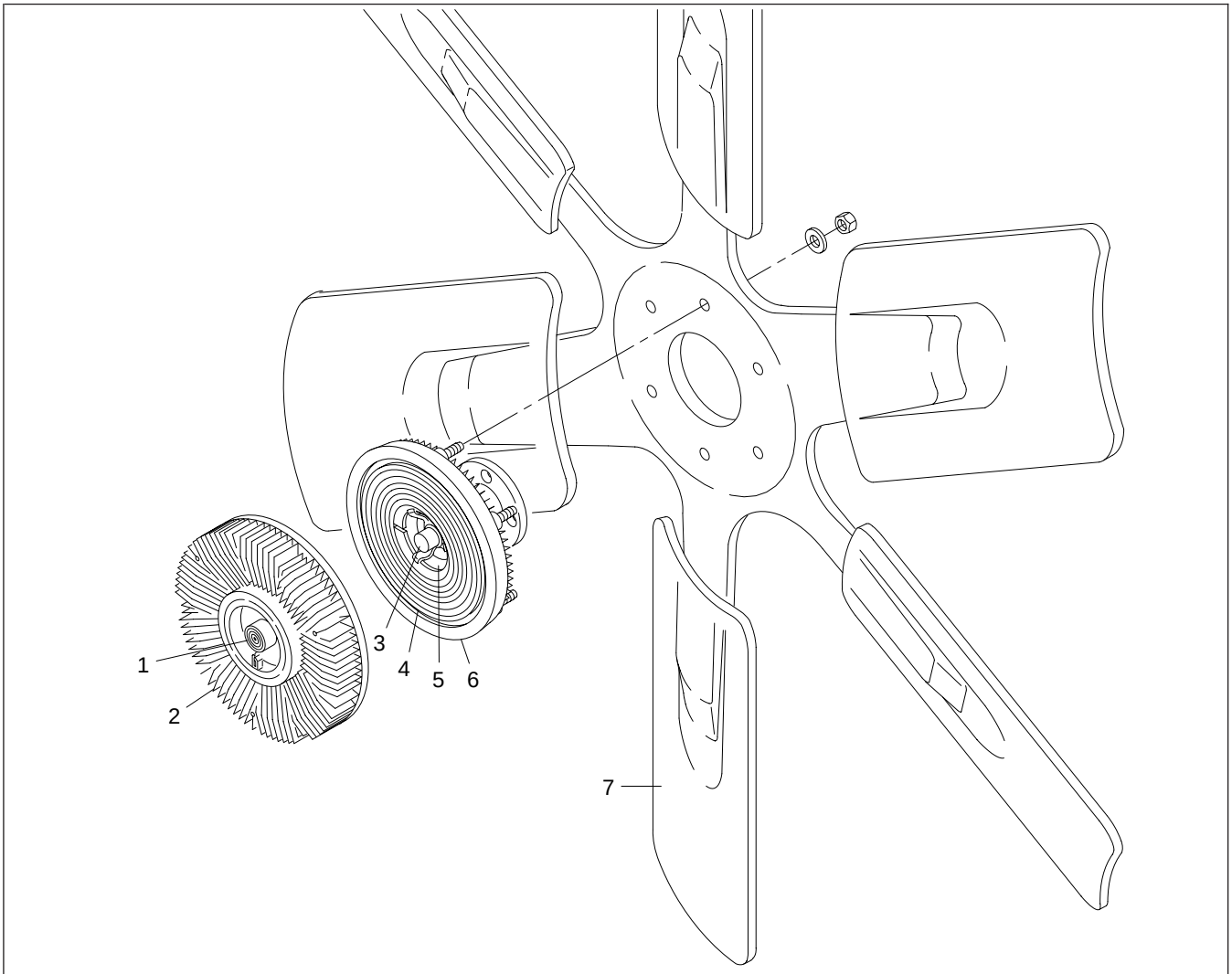
When the fan is disengaged, a single bearing allows the output plate and fan to free-wheel in relation to the input shaft and plate. Both the output and input plates are lined with concentric grooves (Ref. 4) which intermesh with very close tolerance.

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 Information



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NOTE: The Eaton 660 fan clutch is shown here. The 610 fan clutch has four studs for mounting the fan. The Eaton Tempatrol 575 fan clutch 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, Eaton Viscous Clutch Fan Drive

Fan Clutch Inspection and Operation Checking

Inspection

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 adaptor. They should be tightened as follows:
     - Fan clutch input shaft to fan hub, Cummins B Series engine: 45 lbf·ft (61 N·m);
   - 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 140°F (60°C) before the start of the test; the outside temperature should be above 50°F (10°C). Ideally, a temperature probe placed about 1/2 inch (13 mm) 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 7-inch (18-cm) 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. Don't try to restrict the fan blade rotation when the engine is on. Contact with the fan blades during operation could result in bodily injury.

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.
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 155°to 165°F (68°C).

Fan Clutch Inspection and Operation Checking

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 120°to 130°F (49°C).

    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.

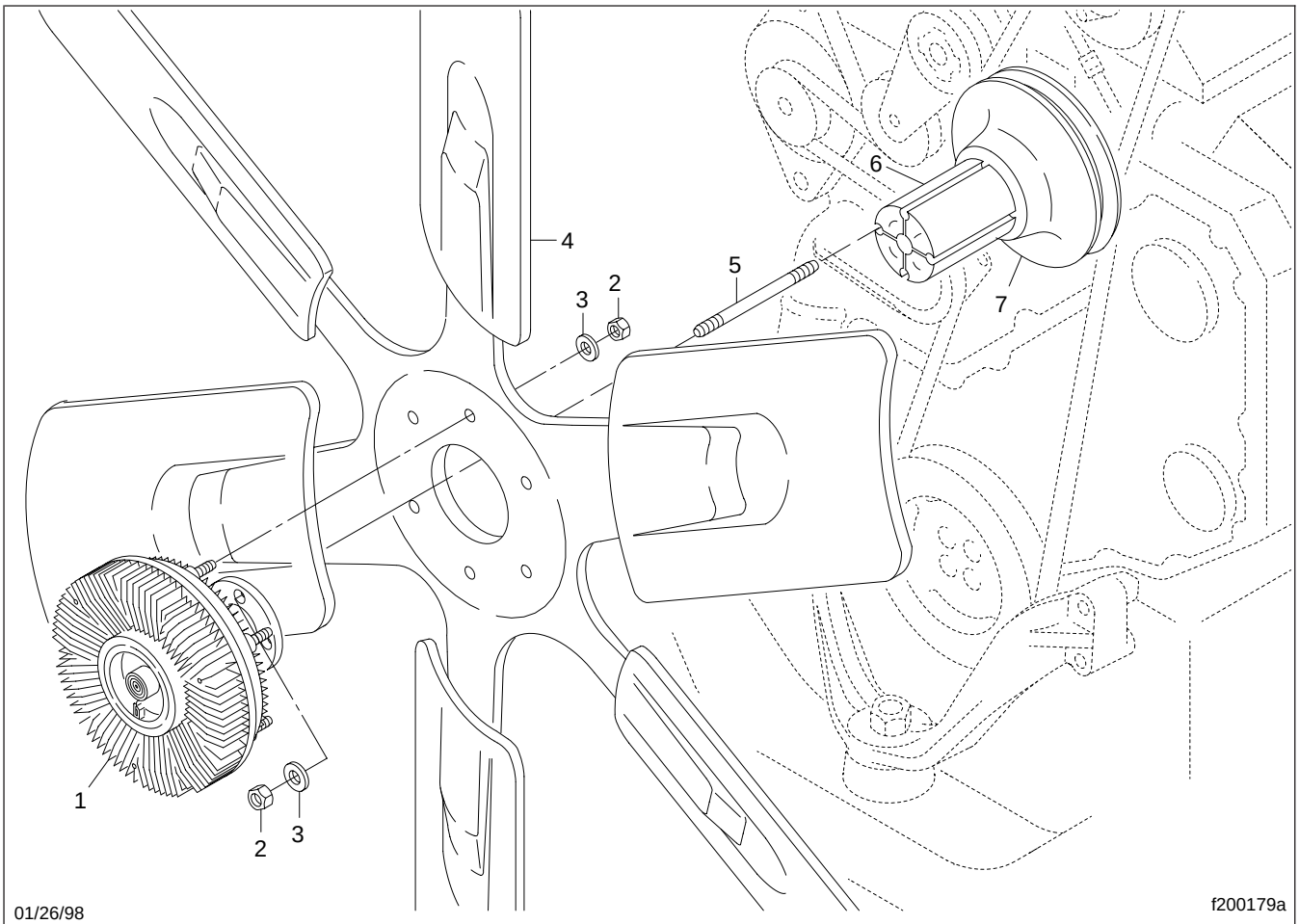
Fan Clutch Removal and Installation

Removal (See Fig. 1)

1. Shut down the vehicle, apply the parking brakes, and chock the tires.
2. Disconnect the battery ground cable at the vehicle frame.
3. Tilt open the cab.
4. Drain the coolant, and remove the upper radiator hose.
5. Remove the coolant recovery line.
6. Remove the locknuts and lockwashers (see **Fig. 1**, Refs. 2 and 3) that hold the clutch to the fan hub. Remove the clutch from the engine.
7. Remove the four mounting bolts that hold the fan blade to the clutch. Remove the blade.

Installation (See Fig. 1)

1. Install the fan blade on the fan clutch. Tighten the fan mounting locknuts as follows:



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. 1, Fan Clutch Mounting for Cummins B Series Engine

Fan Clutch Removal and Installation

- Model 610: 40 lbf·ft (54 N·m);
- Model 660: 22 lbf·ft (30 N·m);
- Model 575: 15 to 20 lbf·ft (20 to 27 N·m).

NOTE: 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. Install the fan clutch assembly. Tighten the fasteners to 45 lbf·ft (61 N·m).
3. Install the upper radiator hose.
4. Install the coolant recovery hose.
5. Refill the coolant.
6. Return the cab to the operating position, connect the batteries, and remove the chocks from the tires.

Specifications

Fastener Torques			
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	10.9	M10	45 (61)

Table 1, Fastener Torques

General Description and Principles of Operation

The Horton on/off fan clutch (**Fig. 1**) is an air-operated, temperature-controlled clutch for the engine cooling fan. It is specifically designed for Cargo vehicles equipped with Cummins ISB engines, and is mounted on the crankshaft vibration damper rather than the water pump pulley. For this reason, no other type of fan clutch can be used on these vehicles. This fan clutch is not serviceable.

The purpose of the fan clutch is to maintain engine temperature by engaging or disengaging the fan. The fan clutch is engaged by air pressure when the coolant temperature rises above the specified temperature range. When the coolant temperature is below the range, the clutch is disengaged by spring pressure.

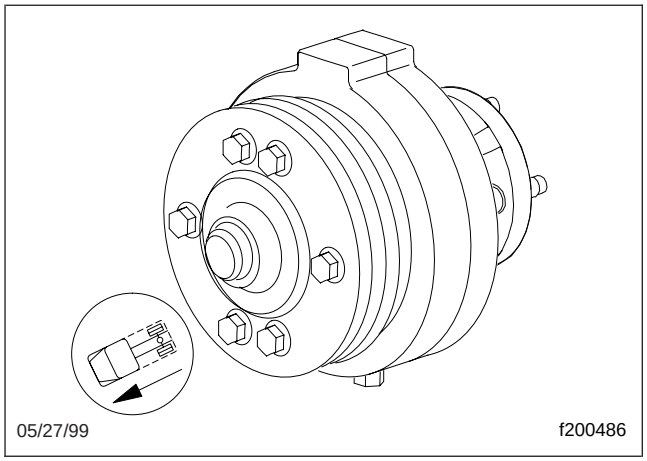
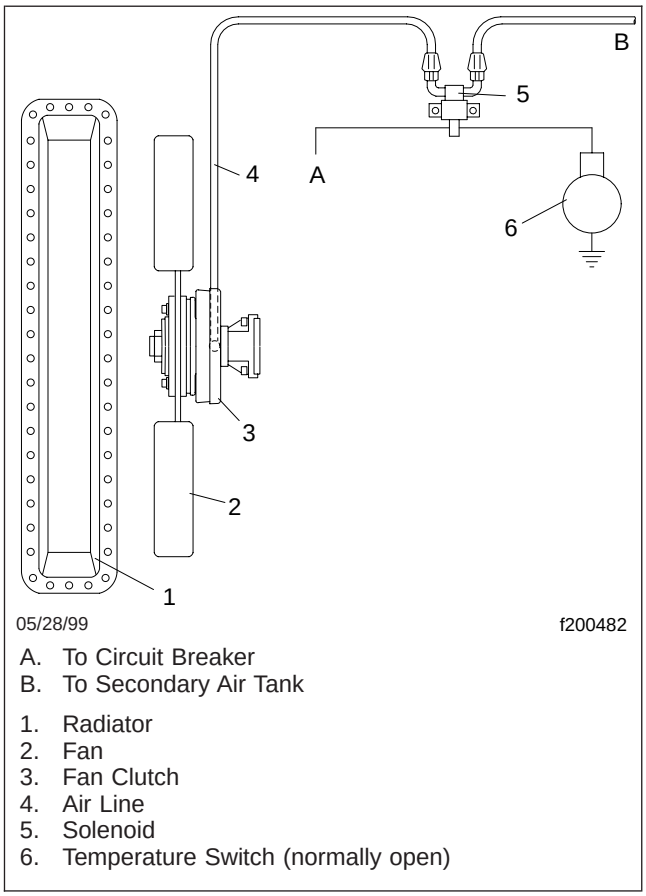


Fig. 1, Horton On/Off Fan Clutch

Air pressure to the fan clutch, which is controlled by a solenoid valve, is controlled by a temperature switch installed in the thermostat housing. See **Fig. 2**.

When a cold engine is started, air pressure to the fan clutch is restricted by the solenoid valve, and it remains disengaged.

When the coolant temperature rises to the temperature switch setting, the solenoid valve releases the compressed air to the fan clutch, and the clutch engages.



A. To Circuit Breaker
B. To Secondary Air Tank

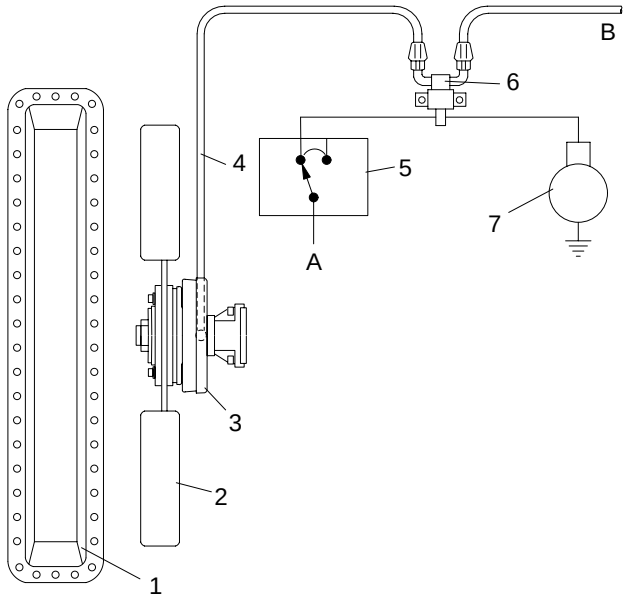
1. Radiator
2. Fan
3. Fan Clutch
4. Air Line
5. Solenoid
6. Temperature Switch (normally open)

Fig. 2, Fan Clutch Piping and Wiring (vehicle without air-conditioning)

When the coolant temperature drops to the temperature switch cutoff setting, compressed air is exhausted from the fan clutch, disengaging it.

On vehicles with air conditioning (**Fig. 3**), 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 opens and supplies power to the solenoid valve, which supplies air to the fan clutch.

General Information



A. To Circuit Breaker
B. To Secondary Air Tank

1. Radiator
2. Fan
3. Fan Clutch
4. Air Line
5. Fan Cycling Switch at Receiver-Drier (normally open)
6. Solenoid
7. Temperature Switch (normally open)

Fig. 3, Fan Clutch Piping and Wiring (vehicle with air conditioning)

Removal (See Fig. 1)

1. Apply the parking brakes, and chock the tires.
2. Tilt the cab. For instructions, see Chapter 3 of the *Cargo Driver's Manual*.

⚠ WARNING

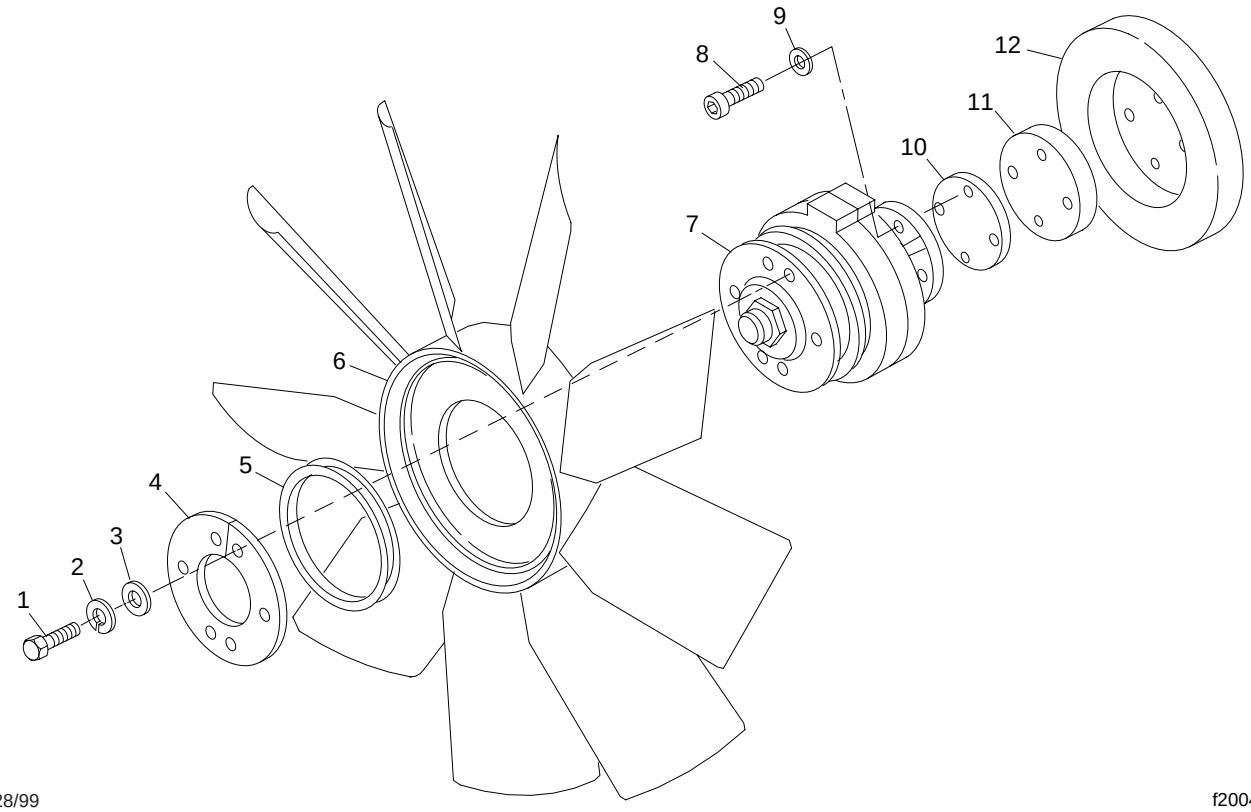
Never disconnect an air line or hose without first draining the air system pressure. Never look directly into an air line. The line may have dirt or sludge in the air stream. If quickly disconnected, the line may whip, possibly causing eye injury or other bodily injury.

3. Drain the air system.
4. Disconnect the air line from the bottom of the fan clutch. See **Fig. 2**.

⚠ WARNING

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

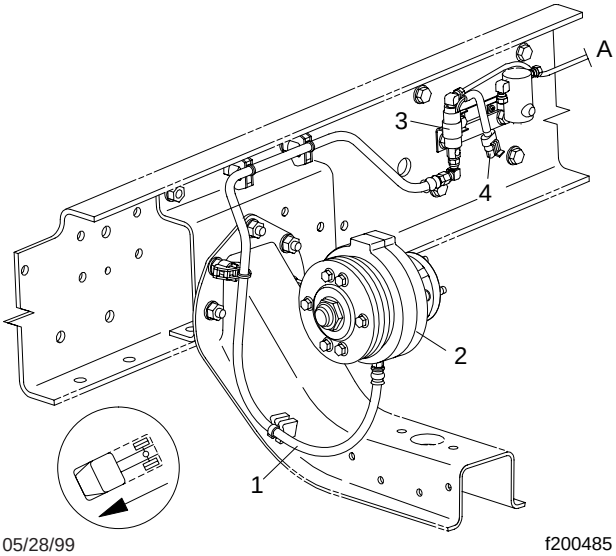
5. Partially drain the coolant. Then remove the upper radiator hose.



1. Hexbolt, M8 (6 qty.)
2. Lockwasher (6 qty.)
3. Flatwasher (6 qty.)
4. Split Ring
5. Rubber Grommet
6. Fan
7. Fan Clutch Assembly
8. Socket-Head Capscrew, M10 (4 qty.)
9. Hardened Washer (4 qty.)
10. Thin Spacer
11. Thick Spacer
12. Crankshaft Vibration Damper (on engine)

Fig. 1, Horton On/Off Fan Clutch (Cummins ISB installation)

Fan Clutch Removal and Installation



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NOTE: Not all components are shown.

A. To Secondary Air Tank
1. Air Line
2. Fan Clutch
3. Solenoid
4. Solenoid Wiring

Fig. 2, Fan Clutch Air Line Connection

6. Remove the coolant recovery line.
7. Remove the six M8 hexbolts and washers that hold the fan to the fan clutch.

IMPORTANT: Do not loosen the large nut on the center stud of the fan clutch assembly. It has been torqued by the manufacturer and does not need to be removed in order to remove the fan from the fan clutch.

8. Remove the split ring from the fan.
9. Remove the fan and grommet assembly from the fan clutch.
10. Remove the four socket-head capscrews and hardened washers that attach the fan clutch assembly to the crankshaft vibration damper.
11. Remove the fan clutch and the two spacers.

Installation (See Fig. 1)

1. Install the two spacers onto the crankshaft vibration damper, making sure the thick spacer goes on first, and all the holes are aligned.
2. Apply Loctite® 620, or an equivalent, on the threads of the socket-head capscrews.
3. Position the fan clutch onto the crankshaft vibration damper. Install the four the socket-head capscrews and hardened washers. Tighten the capscrews alternately, and in three stages:
   - First stage: 20 lbf·ft (26 N·m)
   - Second stage: 35 lbf·ft (48 N·m)
   - Final stage: 45 lbf·ft (60 N·m)
4. Install the fan onto the fan clutch. If you are installing a new fan, install a new rubber grommet into the inner edge of the new fan.
   - 4.1 Install the split ring onto the face of the fan, making sure the holes in the split ring line up with those of the fan clutch.
   - 4.2 Install the six M8 hexbolts, flatwashers, and lockwashers. Tighten the hexbolts alternately, and in three stages:
     - First stage: 10 lbf·ft (14 N·m)
     - Second stage: 15 lbf·ft (20 N·m)
     - Final stage: 20 lbf·ft (26 N·m)
5. Attach the air line to the fan clutch and tighten the fitting 84 lbf·in (940 N·cm).
6. Connect the upper radiator hose and the coolant recovery hose.
7. Fill the radiator with the coolant that was drained.
8. Start the engine. Then check the fan clutch for correct operation. If there is a problem, see **Subject 300** for troubleshooting.
9. Shut down the engine.
10. Return the cab to the operating position. For instructions, see Chapter 3 of the *Cargo Driver's Manual*.
11. Remove the chocks from the tires.

Troubleshooting Tables

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.
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 fan clutch is leaking.	Replace the fan clutch.
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—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 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.
There is internal damage to the fan clutch.	Replace the fan clutch.

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 control settings are incorrect.	Check the fan clutch control setting of the temperature switch. Repair or replace the temperature switch as needed.
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.
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.

Troubleshooting

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 in this group.

Specifications

Torque Values	
Description	**Torque lbf·ft (N·m)**
Socket-Head Capscrew, M10 x 1.5	First Stage: 20 (26) * Second Stage: 35 (48) * Final Stage: 45 (60) *
Hexbolt, M8 x 1.25	First Stage: 10 (14) * Second Stage: 15 (20) * Final Stage: 20 (26) *

* Tighten in an alternate pattern.

Table 1, Torque Values

General Description

EASY-PEDAL CLUTCHES

Spicer Easy-Pedal clutches are pull-type clutches of a dry-disc design. They are available in 14-inch (350-mm) and 15-1/2 inch (394-mm) two-plate versions. See **Fig. 1**. Internal clutch adjustments are done manually.

With 14-inch (350-mm) Easy-Pedal clutches, the intermediate plate separating the driven discs is carried on six pins mounted in the flange of a "pot-type" flywheel. In the 15-1/2 inch (394-mm) versions, the intermediate plate separating the driven discs is carried on four lugs within the cover assembly. The cover assembly is mounted on a flat flywheel. All versions have four return springs attached to the cover assembly to retract the pressure plate when the clutch is disengaged.

Easy-Pedal clutches may be specified with ceramic or organic driven discs.

Clutch capacity for the Spicer Easy-Pedal clutches is indicated by the color code of the pressure springs in the cover assemblies. See the appropriate Easy-Pedal clutches table in **Specifications, 400** for color codes.

ANGLE-SPRING CLUTCHES

Spicer Angle-Spring clutches are pull-type clutches of a dry-disc design. They are available in 14-inch (350-mm) single-plate (SAS 1401) and two-plate (SAS 1402) versions. See **Fig. 2**. They may be specified with either a manual- or self-adjusting feature. Both versions are mounted to a flat flywheel.

In the two-plate versions, the intermediate plate separating the driven discs is mounted directly to the flywheel. The flywheel ring carries four drivestraps (Ref. 4) to retract the pressure plate when the clutch is disengaged.

Angle-Spring clutches may be specified with ceramic or organic driven discs.

Clutch capacity for the Spicer Angle-Spring clutches is indicated by the color code of the pressure springs in the cover assembly. See the appropriate Angle-Spring clutches table in **Specifications, 400** for color codes.

SOLO HEAVY-DUTY 15-1/2 INCH CLUTCH

The Spicer Solo Heavy-Duty clutches are pull-type clutches of a dry-disc design. They are available in 15-1/2 inch (394-mm) two-plate assemblies. See **Fig. 3**. Spicer Solo Heavy-Duty 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 cams' movement to let you know when it's time to replace the clutch. See **Fig. 4**. This tab cannot be used as a mechanism for adjusting the clutch.

These clutch assemblies are available with either: ten spring, four or six paddle driven discs; nine spring, six paddle driven discs; seven spring, four paddle driven discs; or, six spring, six paddle driven discs. The driven disc paddles are formed from ceramic facing material. 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 ensure equal plate separation (an equal gap on all sides of the intermediate plate) for long life.

For clutch capacities, see the appropriate Solo Heavy-Duty clutches table in **Specifications, 400**.

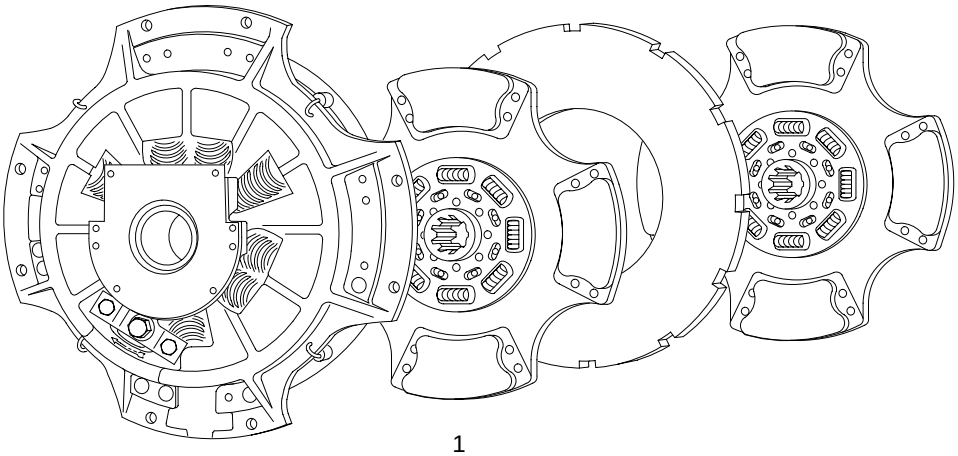
SOLO MEDIUM-DUTY 1401 AND 1402 CLUTCHES

Spicer Solo Medium-Duty 1401 and 1402 are pull-type clutches of a dry-disc design. These 14-inch (355.6-mm) clutch assemblies are available in two versions, which consist of either a single-plate (1401) or a two-plate (1402) design. Both versions are mounted to a flat flywheel.

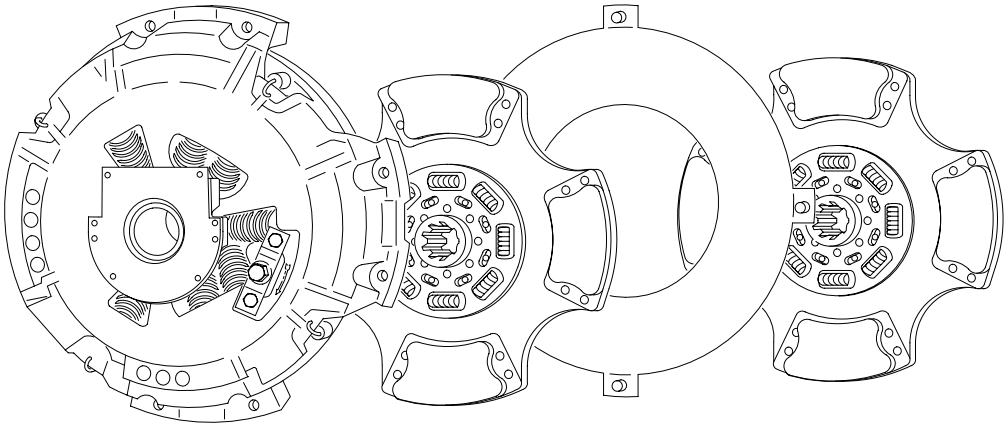
See **Fig. 5**. They may also be specified for either a standard stroke mechanical linkage system or a short stroke hydraulic linkage system.

Spicer Solo Medium-Duty 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

General Information



1



2

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1. 14-Inch Easy-Pedal Clutch
2. 15-1/2 Inch Easy-Pedal Clutch

Fig. 1, Spicer Easy-Pedal Clutches

cams' 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.

In the two-plate versions, the intermediate plate separating the driven discs is mounted directly to the flywheel. The flywheel ring carries four drivestraps (**Fig. 5**, Ref. 3) to retract the pressure plate when the clutch is disengaged. The clutch assembly has four positive separator pins that ensure equal plate separation (an equal gap on all sides of the intermediate plate) for long life.

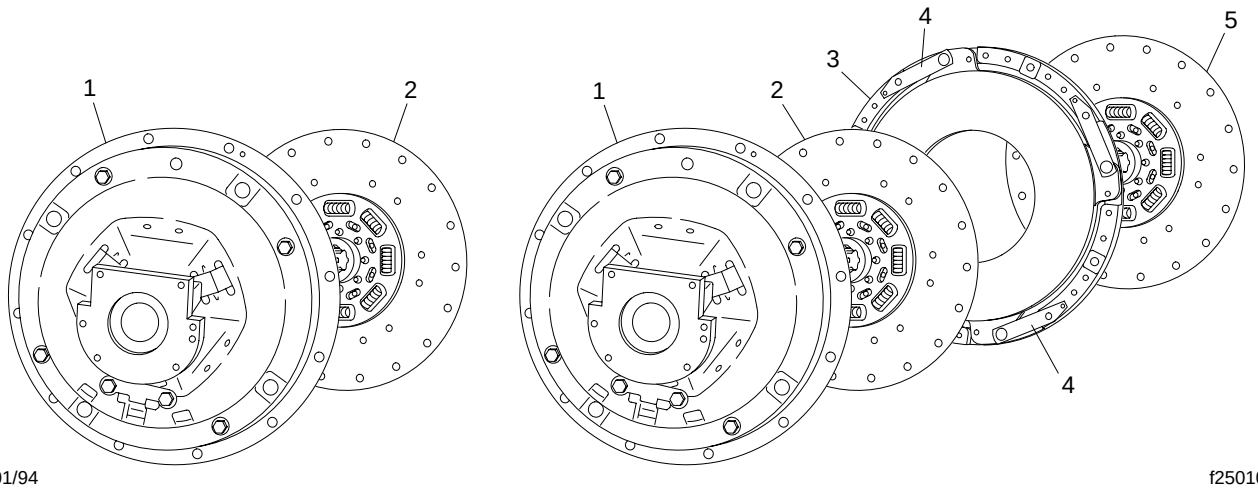
Solo Medium-Duty clutches may be specified with ceramic or organic driven discs.

For Clutch capacities, see the appropriate Solo Medium-Duty clutches table in **Specifications, 400**.

Principles of Operation

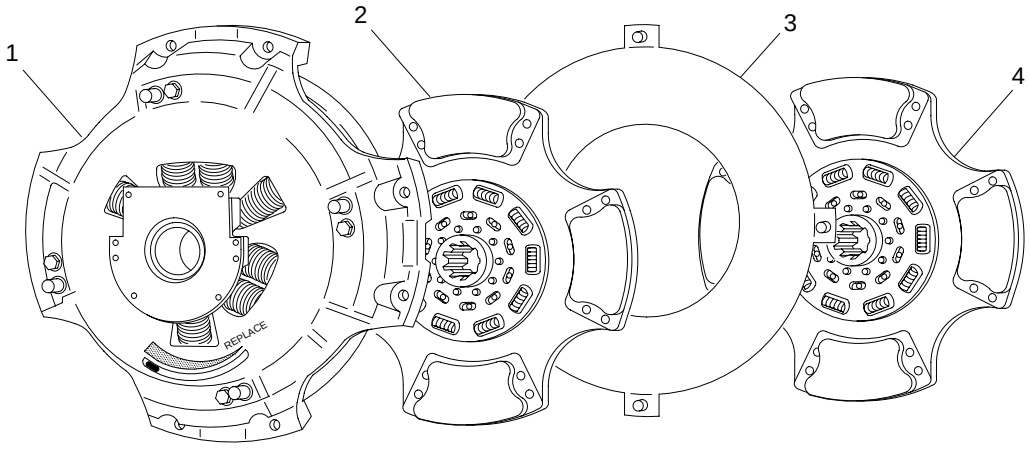
Mounted directly on the flywheel, the domed clutch-cover assembly houses most of the components, including the pressure plate. Six pressure springs inside the cover provide the force necessary to push the pressure plate forward and engage the clutch.

The transmission input shaft projects through the cover assembly and driven discs, and rests in a pilot bearing in the center of the flywheel. The splined



1. Cover Assembly
2. Clutch Disc (Driven Disc)
3. Intermediate Plate
4. Drivestrap
5. Front Disc

Fig. 2, Spicer Angle-Spring Clutches



1. Clutch Cover
2. Rear Driven Disc
3. Intermediate Plate
4. Front Driven Disc

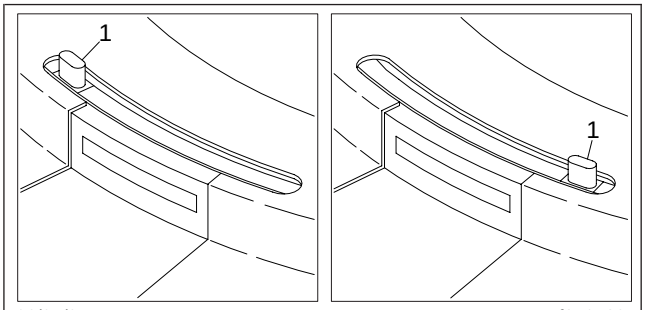
Fig. 3, Spicer Solo Heavy Duty 15-1/2 Clutch

hubs of the driven discs mesh with the splined input shaft to provide the direct link between the engine and the transmission. This allows the rest of the clutch assembly to spin freely around the input shaft when the clutch pedal is depressed.

When the vehicle is stationary, a clutch brake permits shifting into first gear or reverse gear without severe gear clash. 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.

When starting a vehicle moving, and when upshifting the transmission, the engine flywheel is turning faster than the transmission input shaft. The clutch intermediate plate and pressure plate (driving discs) are at-

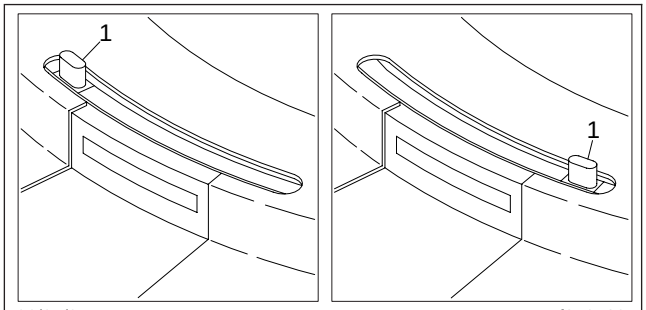
General Information



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1. Wear Indicating Tab

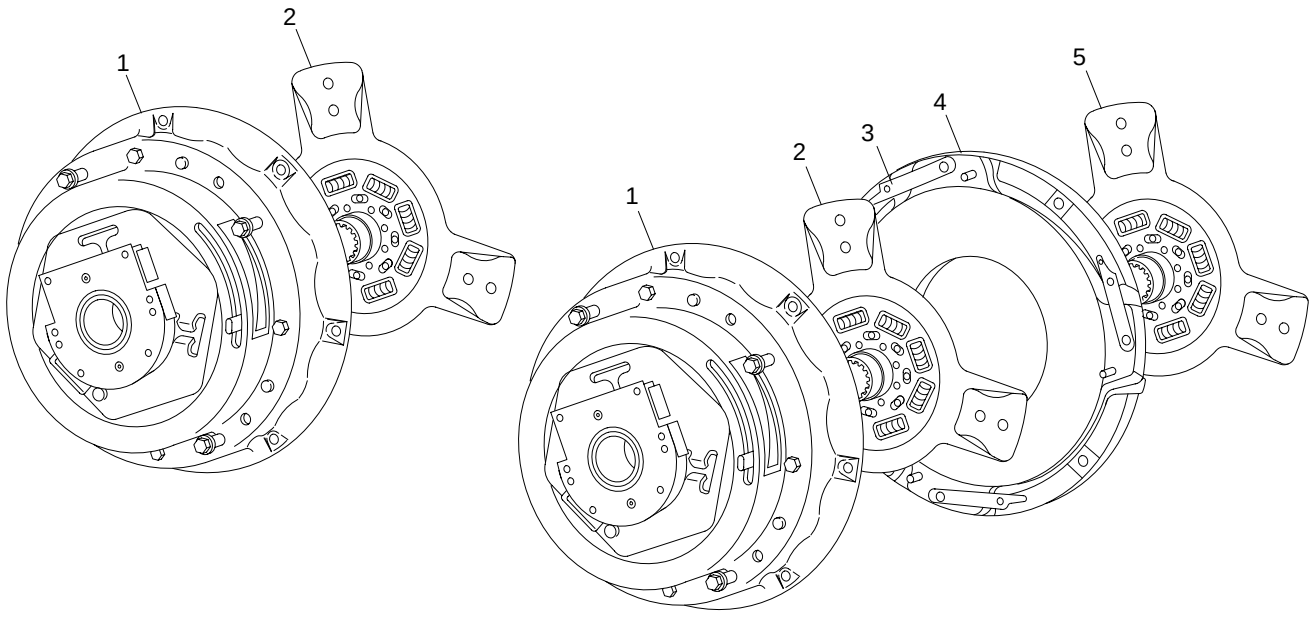
Fig. 4, Wear Indicator



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1. Wear Indicating Tab

Fig. 6, Wear Indicator



06/16/97 f250431

1. Cover Assembly
2. Front Disc
3. Drivestrap
4. Intermediate Plate
5. Rear Disc

Fig. 5, Spicer Solo Medium-Duty Clutches

tached to and turn at the same speed as the flywheel. The clutch driven discs are meshed with and turn at the same speed as the transmission input shaft.

When the clutch pedal is depressed, the release bearing (connected inside the cover assembly) pulls away from the pressure plate. This compresses the pressure springs, and allows the driven discs to slip freely, at a different speed than the driving discs.

As the pedal is being released, the pressure springs force the pressure plate toward the engine flywheel, squeezing the driven discs. Slippage occurs between the driving and driven discs because of the difference in their speeds. As the pedal is further re-

leased, the friction between 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.

The clutch is a friction-operated unit that allows smooth coupling and uncoupling of the engine (driving member) and the transmission (driven member).

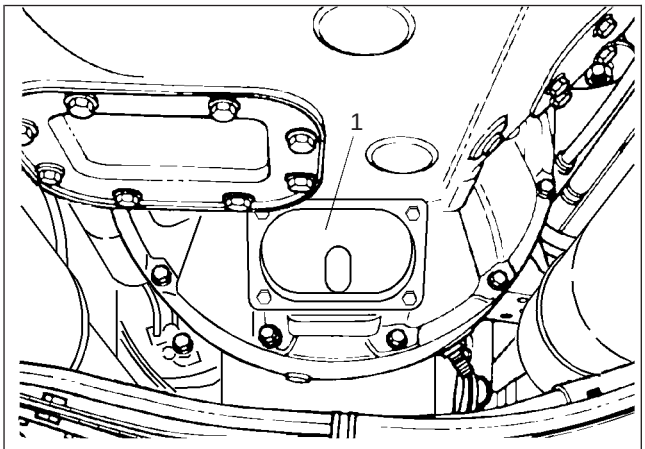
Clutch brake engagement occurs approximately during the last 1 to 1-1/4 inches (25 to 33 mm) of downward pedal travel. The clutch brake is between the release-bearing housing and the transmission bearing cap, and is engaged by tangs to the transmission input shaft. When the pedal is fully depressed, the clutch brake is squeezed between the release-bearing housing and the transmission bearing cap, stopping the rotation of the main drive gear.

Release-Bearing Clearance Check

NOTE: Spicer Solo Heavy-Duty and Medium-duty clutches are adjustment free. Therefore, the following procedures apply only to the Spicer Angle-Spring and Easy-Pedal clutches.

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.

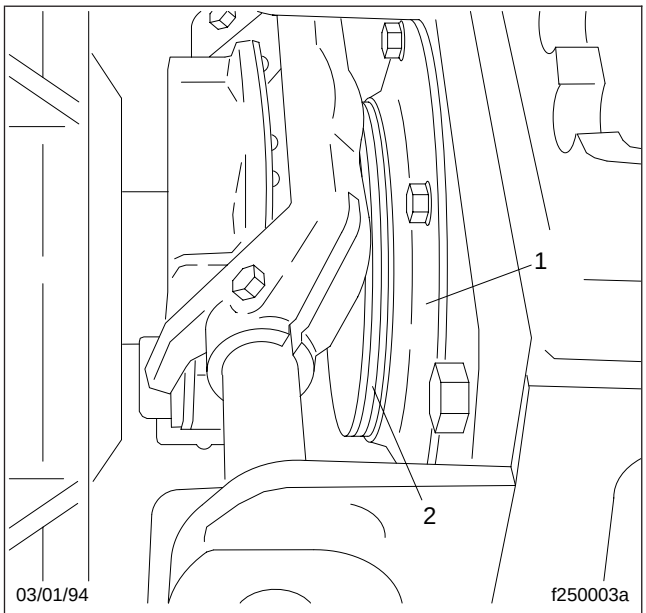
1. Apply the parking brakes, and chock the tires.
2. Remove the clutch inspection cover from the bottom of the transmission clutch housing. See **Fig. 1**.



1. Clutch Inspection Cover

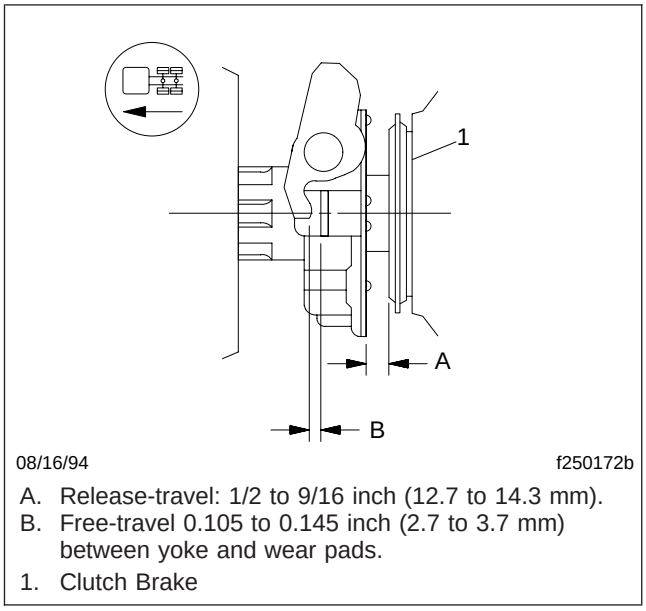
Fig. 1, Remove the Clutch Inspection Cover

3. Slide the clutch brake discs and washer, or torque-limiting clutch brake, tight against the transmission input shaft bearing cap. See **Fig. 2**. Also, slide the release-bearing as far as possible towards the transmission.
4. Measure the clearance between the aft face of the release-bearing and the forward face of the clutch brake disc, or torque-limiting clutch brake. This 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. 3**.



1. Transmission Input Shaft Bearing Cap
2. Clutch Brake Discs and Washer

Fig. 2, 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

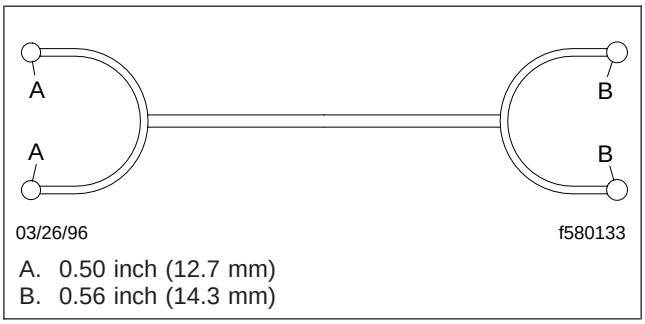
Fig. 3, Clutch Travel Adjustments

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. 4**. One end of

Clutch Adjustments

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:



A. 0.50 inch (12.7 mm)
B. 0.56 inch (14.3 mm)

Fig. 4, Inspection Tool A02-12419

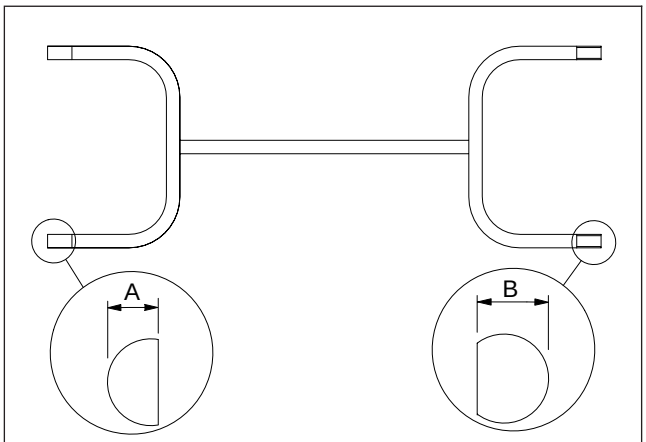
5.1 Insert the blue 0.56-inch (14.3-mm) end. If it fits loosely, the gap is too wide and adjustment is needed. Go to "Internal Adjustment: Manual Adjusting Clutch" or "Internal Adjustment: Self-Adjusting Clutch."

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 "Internal Adjustment: Manual Adjusting Clutch" or "Internal Adjustment: Self-Adjusting Clutch."

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. 3** and **Fig. 5**. 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:



A. 0.105 inch (2.7 mm)
B. 0.145 inch (3.7 mm)

Fig. 5, Inspection Tool A02-12254

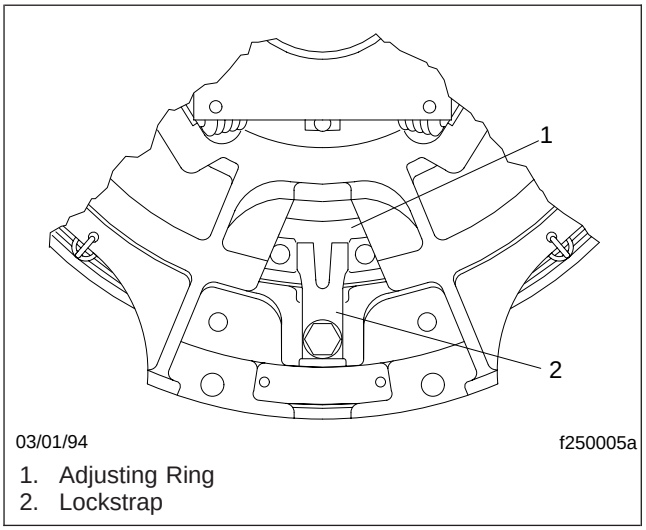
6.1 Insert the blue 0.145-inch (3.7-mm) end. If it fits loosely, the gap is too wide and adjustment is needed. Go to the section on clutch linkage adjustment in this group.

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.

6.3 If the green end of the tool can't be inserted in the gap, adjustment is needed. Go to the section on clutch linkage adjustment in this group.

Internal Adjustment: Manual Adjusting Clutch

Angle-Spring and Easy-Pedal clutches are adjusted with either a lockstrap (**Fig. 6**), or with the Spicer Kwik-Adjust® (**Fig. 7**).



1. Adjusting Ring
2. Lockstrap

Fig. 6, Clutch Equipped with a Lockstrap

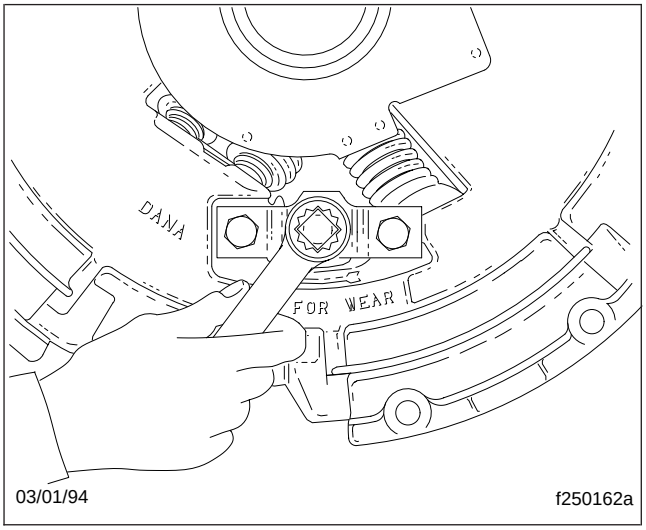


Fig. 7, Clutch Equipped with Kwik-Adjust

ADJUSTMENT ON 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. 6**.
2. Remove the lockstrap. See **Fig. 6**.
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 large screwdriver, 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. Proceed to the section on clutch linkage adjustment in this manual.

ADJUSTMENT ON CLUTCHES WITH A KWIK-ADJUST

1. Turn the engine flywheel until the lockstrap is aligned with the clutch inspection-cover opening. See **Fig. 1** and **Fig. 7**.
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.

   Proceed to the section on clutch linkage adjustment in this manual.

Internal Adjustment: Self-Adjusting Clutch

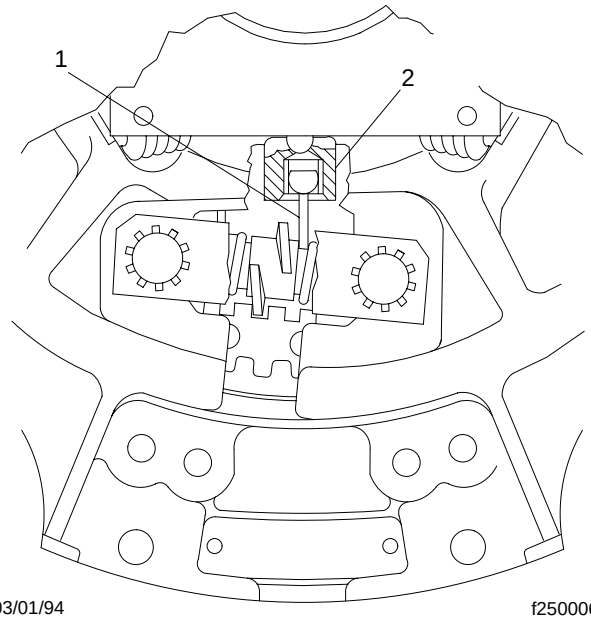
IMPORTANT: The self-adjusting clutch normally compensates for wear, and should only need adjustment when it is first installed. If the release-bearing clearance check shows the self-adjusting clutch to be out of adjustment, be sure that:

A. the actuator arm is correctly inserted into the release-bearing sleeve retainer (see **Fig. 8**);

B. the adjuster arm is not bent;

C. the release-bearing has at least 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.



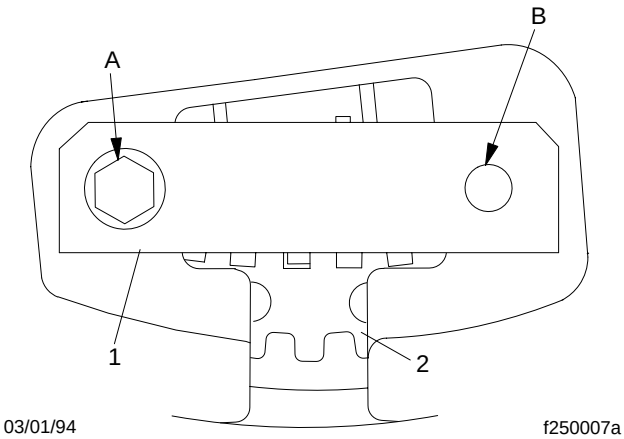
1. Actuator Arm
2. Release-Bearing Sleeve Retainer

Fig. 8, Correct Actuator Arm Insertion

If the clutch is damaged, replace it.

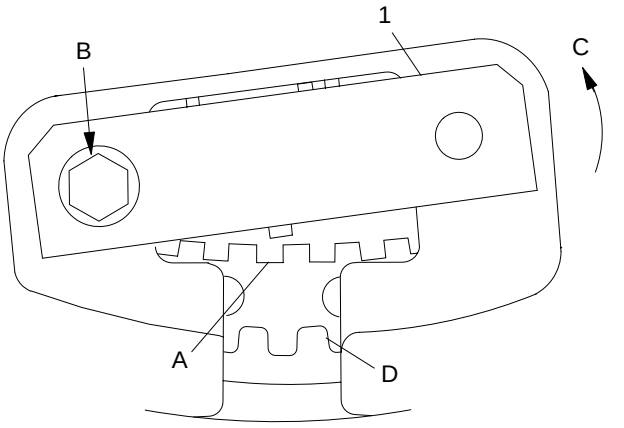
If adjustment is needed, do the following:

1. Turn the engine flywheel until the adjuster assembly is in line with the clutch inspection-cover opening. See **Fig. 1** and **Fig. 8**.
2. Remove the right-side bolt from the adjuster assembly, and loosen the left-side bolt one turn. See **Fig. 9**.
3. To allow manual adjustment, rotate the adjuster assembly upward. See **Fig. 10**. 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 large screwdriver 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. 10**.



A. Loosen this bolt.
B. Remove this bolt.
1. Adjuster Assembly
2. Adjusting Ring

Fig. 9, Remove the Right-Side Bolt



A. Do not pry on the innermost teeth.
B. Tighten the bolt.
C. Rotate up.
D. Use a large screwdriver in the lower teeth.
1. Adjuster Assembly

Fig. 10, Rotate the Adjuster Assembly

CAUTION

Do not pry on the innermost gear teeth of the adjusting ring. See Fig. 10. 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. 8**. 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, go to the section on clutch linkage adjustment.

Clutch Removal

REMOVING THE SPICER ANGLE-SPRING AND EASY-PEDAL CLUTCHES

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. For instructions, see **Group 26** in this manual.

⚠ 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. 2**. An old transmission input shaft may be used for this purpose.

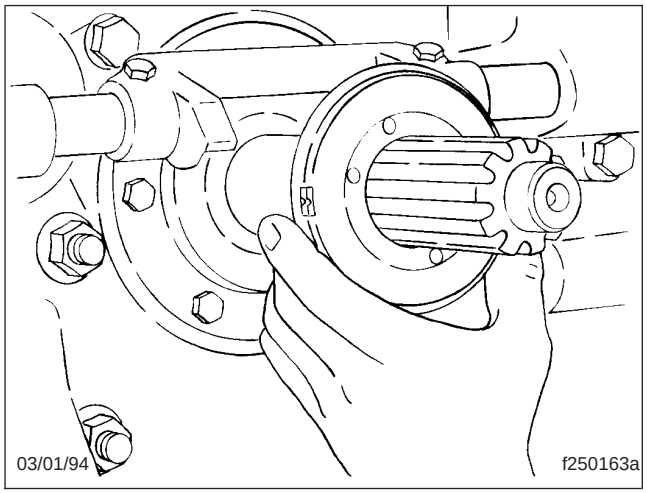


Fig. 1, Clutch Brake Removal

4. Insert two wooden spacer blocks between the flywheel ring and the release-bearing housing.

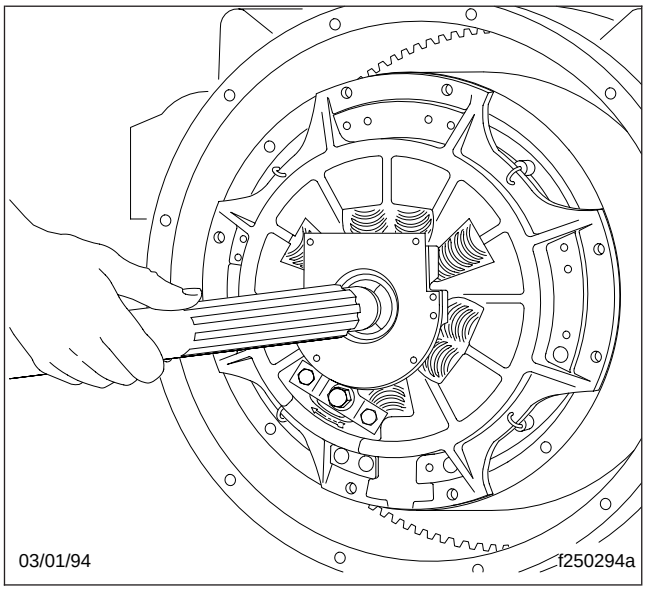
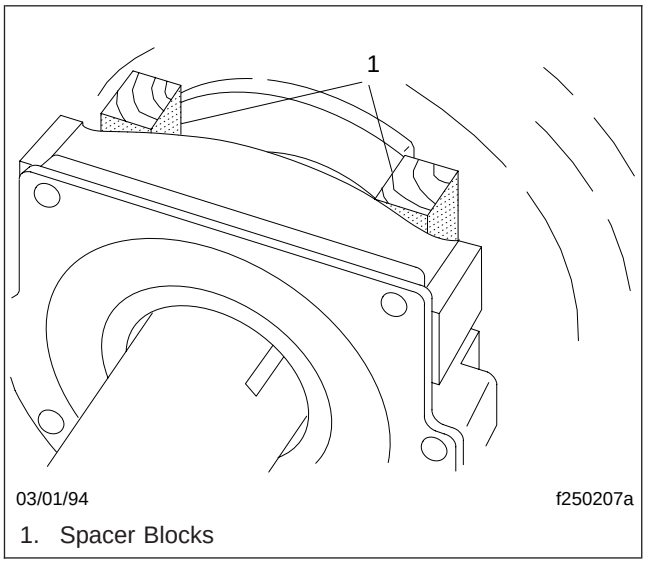


Fig. 2, Installing a Spline Aligning Tool

The spacer blocks relieve the internal spring load in the clutch assembly, and facilitate clutch removal.

On Angle-Spring clutches, use two 1-1/2 inch (38-mm) spacer blocks. See **Fig. 3**.

On Easy-Pedal clutches, use a release tool to pull the bearing back, and use two 5/8-inch (16-mm) spacer blocks. See **Fig. 4**.



1. Spacer Blocks

Fig. 3, Insert Two Spacer Blocks

Clutch Removal

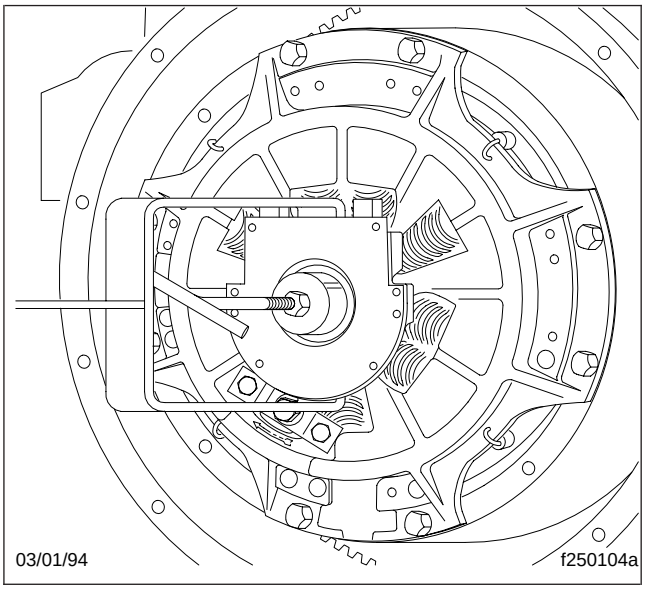


Fig. 4, Pull the Bearing Back

5. Remove the two top mounting capscrews from the cover assembly. Install guide studs in the open holes to help support the clutch assembly during removal. For 14-inch (355.6-mm) clutches, use 3/8-16 by 2-1/2 inch guide studs. For 15-1/2 inch clutches, use 7/16-14 by 5-inch guide studs. See **Fig. 5** or **Fig. 6**.

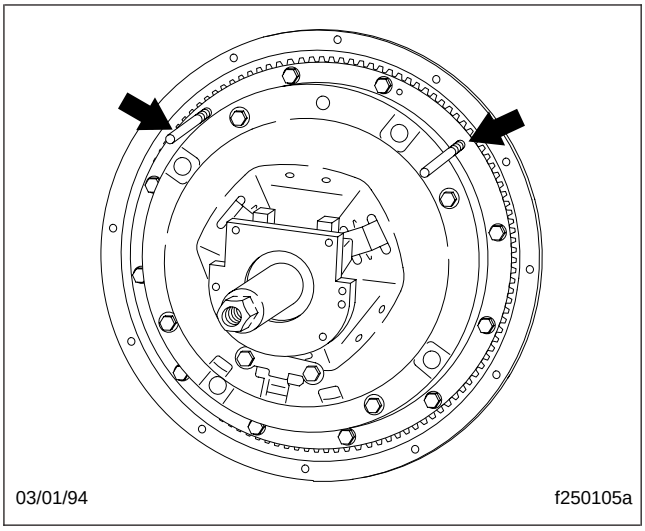


Fig. 5, Stud Position (14-inch clutch)

6. Progressively loosen each of the capscrews in the pattern shown in **Fig. 7** or **Fig. 8**. This will prevent warping or bending within the clutch, and will ease removal of the clutch-mounting capscrews.

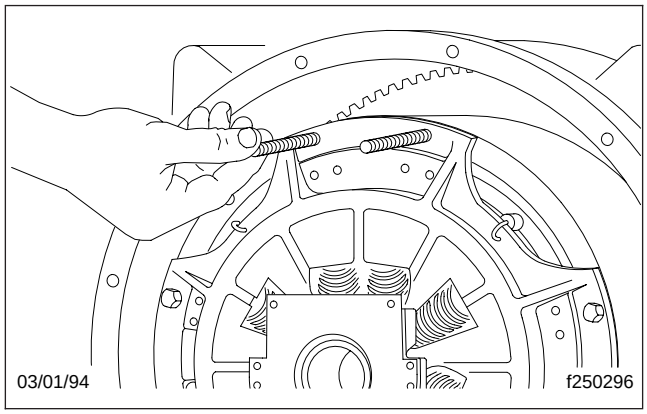


Fig. 6, Stud Position (15-1/2 inch clutch)

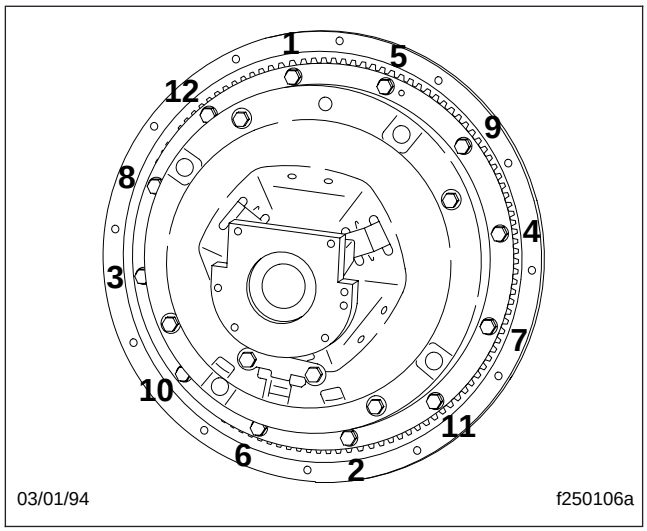


Fig. 7, 12-Bolt Pattern

WARNING

The pressure plate and cover assembly is heavy and 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.

   With two-plate clutches, be careful to keep the spline aligning tool in place to retain the discs

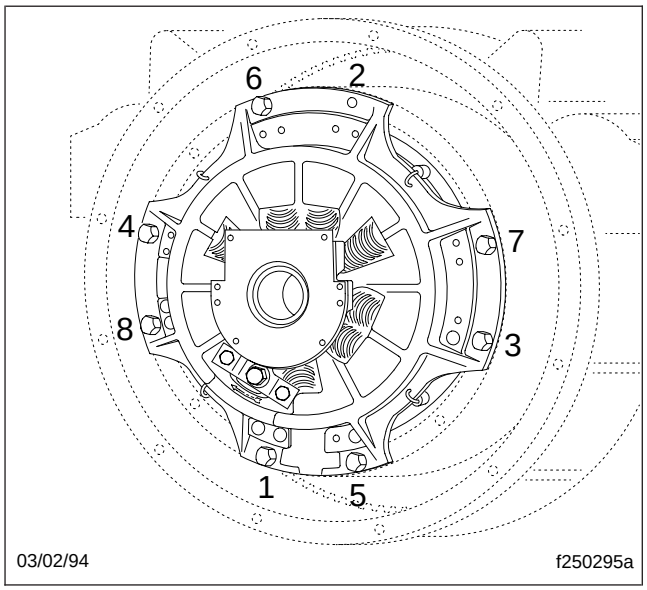


Fig. 8, 8-Bolt Pattern

and intermediate plate. Remove the spline aligning tool, the rear driven disc, the intermediate plate, and the front driven disc.

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 puller to remove the pilot bearing.

   Inspect the old pilot bearing. Correct the cause of any unusual wear or damage. Discard the bearing.

REMOVING A SPICER SOLO HEAVY-DUTY 15-1/2 INCH CLUTCH

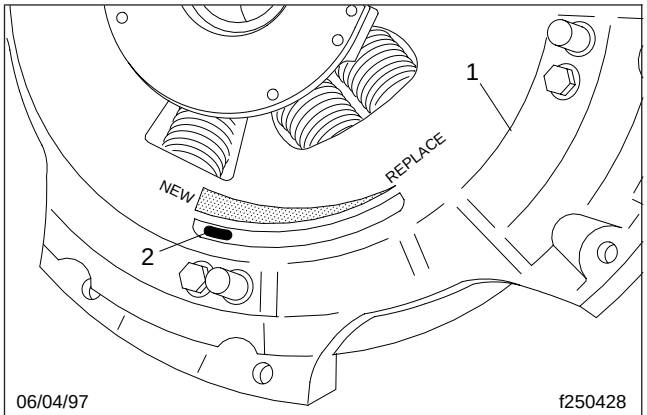
IMPORTANT: If clutch is to be reinstalled, take note of the position of the wear indicating tab on the clutch cover. If the wear indicating tab is near the replace position of the indicator, the clutch should be replaced.

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. Reset the wear indicating tab.

   1.1 Fully depress the clutch pedal in the cab. Hold the clutch pedal in the depressed position until the wear indicating tab is reset.

   1.2 Through the inspection opening of the transmission, slide the wear indicating tab to the left until it is at the new position of the indicator. See **Fig. 9**.



1. Clutch Cover
2. Wear Indicating Tab

Fig. 9, Resetting the Wear Indicating Tab

   1.3 Release the clutch pedal in the cab. At this point, the wear indicating tab will stay at the new position of the indicator.

2. Remove the transmission. For instructions, see **Group 26** in this manual.

⚠ 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**.

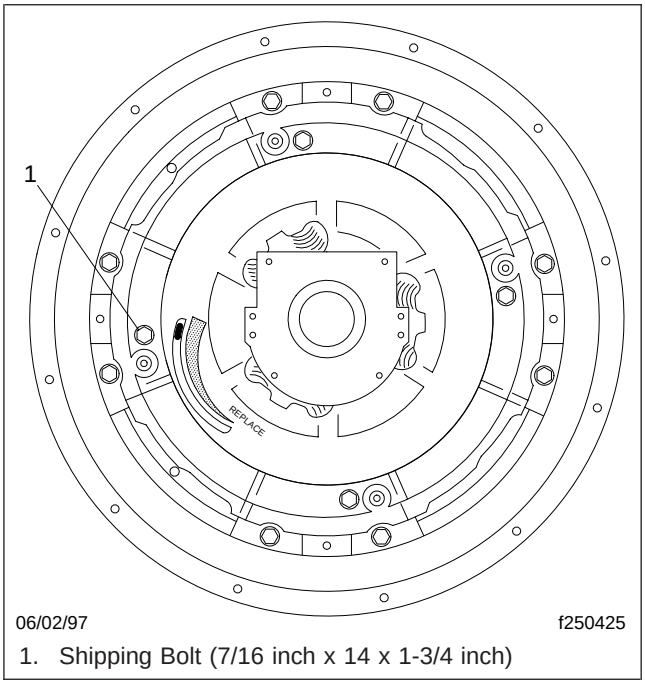
4. Install a spline aligning tool into the release-bearing assembly, and through the driven discs. See **Fig. 2**. An old transmission input shaft may be used for this purpose.

5. Locate four 7/16-inch by 14 by 1-3/4 inch hex-head machine screws (shipping bolts). These

Clutch Removal

shipping bolts were installed on the clutch cover prior to installation.

6. Install the four 7/16-inch by 14 by 1-3/4 hexhead machine screws (shipping bolts) into the four clutch cover holes; turn them finger tight. See **Fig. 10**.



1. Shipping Bolt (7/16 inch x 14 x 1-3/4 inch)

Fig. 10, Install the Shipping Bolts

7. Remove the two top mounting capscrews from the cover assembly. Install two guide studs (7/16–14 by 5-inch long) in the open holes to help support the clutch assembly during removal. See **Fig. 6**.

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.

⚠ WARNING

The clutch assembly is heavy and should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

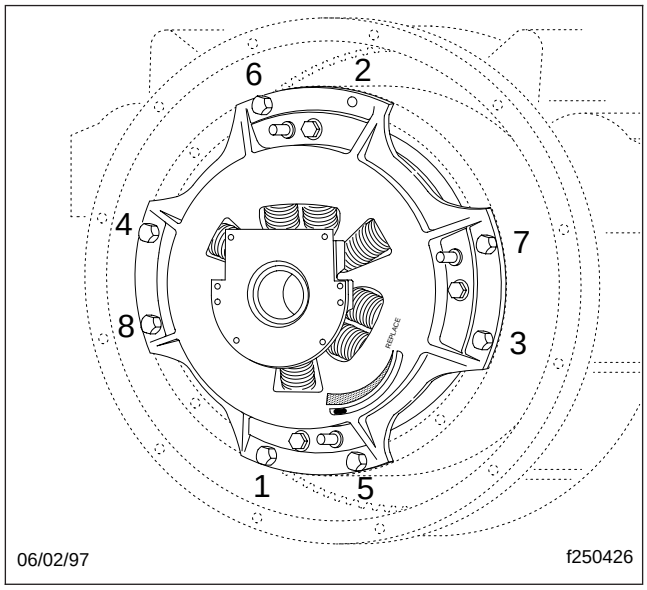
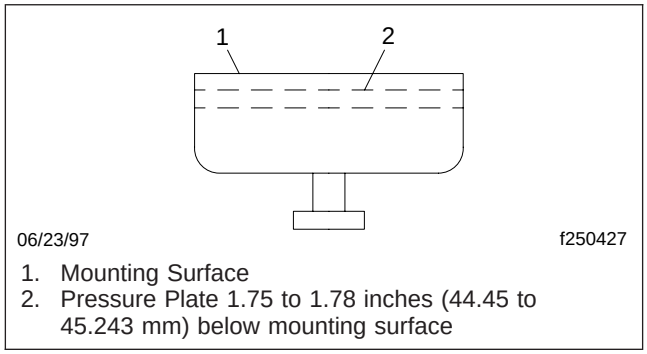


Fig. 11, Loosening Sequence

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. Progressively tighten, in a crisscross pattern, the four shipping bolts until the face of the pressure plate is 1.75 to 1.78 inches (44.45 to 45.243 mm) below the mounting surface. See **Fig. 12**.



1. Mounting Surface
2. Pressure Plate 1.75 to 1.78 inches (44.45 to 45.243 mm) below mounting surface

Fig. 12, Reset Wear Pins

NOTE: The previous step will reset the pressure plate wear pins and, as a result, allow the clutch to release after the installation.

11. Use an appropriate puller to remove the pilot bearing. Inspect the old pilot bearing for any unusual wear or damage. Discard the old pilot bearing.

    Whenever the clutch assembly is serviced or the engine is removed, the pilot bearing in the flywheel should be removed and replaced.

Resetting the Wear Indicating Tab

CAUTION

The wear indicating tab on the Solo clutch should be reset before the transmission is removed. If the transmission and clutch were removed without following the correct removal procedure (the wear indicating tab was not reset), this procedure must be performed before installation. If this procedure is not performed before installation, the clutch will not release and damage to the clutch may result.

1. Remove the four shipping bolts, if they have been 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 four 7/16 inch by 14 by 1-3/4 inch hexhead machine screws (shipping bolts).
6. Install the four 7/16 inch by 14 by 1-3/4 hexhead machine screws (shipping bolts) into the four clutch cover holes; turn them finger tight. See **Fig. 10**.

NOTE: You may need to temporarily install slightly longer bolts to allow access of the shipping bolts.

7. Progressively tighten, in a crisscross pattern, the four shipping bolts until the face of the pressure plate is 1.75 to 1.78 inches (44.45 to 45.243 mm) below the mounting surface. See **Fig. 12**.

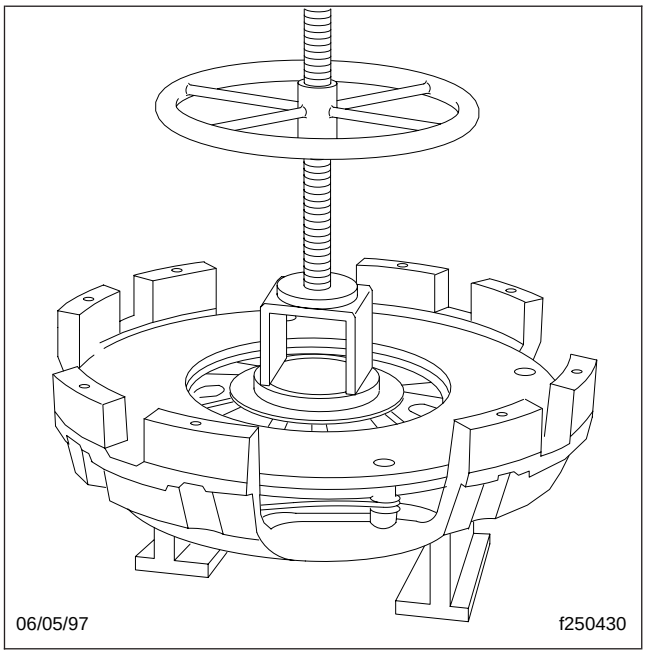


Fig. 13, Arbor Press Setup

NOTE: The previous step will reset the pressure plate wear pins and, as a result, allow the clutch to release after the installation.

REMOVING A SPICER SOLO MEDIUM-DUTY 1401 AND 1402 CLUTCHES

IMPORTANT: If clutch is to be reinstalled, note the position of the wear indicating tab on the clutch cover. If the wear indicating tab is near the replace position of the indicator, the clutch should be replaced.

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. Reset the wear indicating tab.
   1.1 Fully depress the clutch pedal in the cab. Hold the clutch pedal in the depressed position until the wear indicating tab is reset.

Clutch Removal

1.2 Through the inspection opening of the transmission, slide the wear indicating tab to the left until it is at the new position of the indicator. See **Fig. 14**.

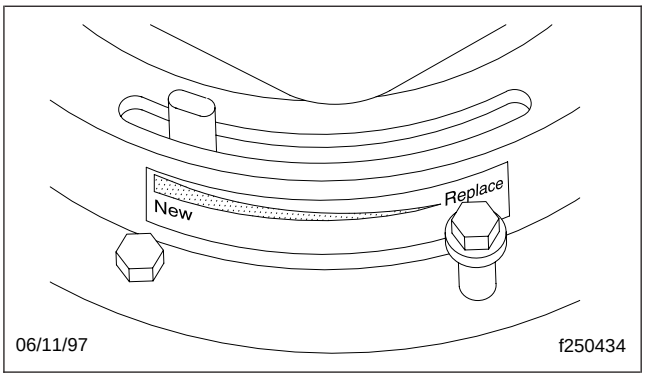


Fig. 14, Reset Wear Indicating Tab

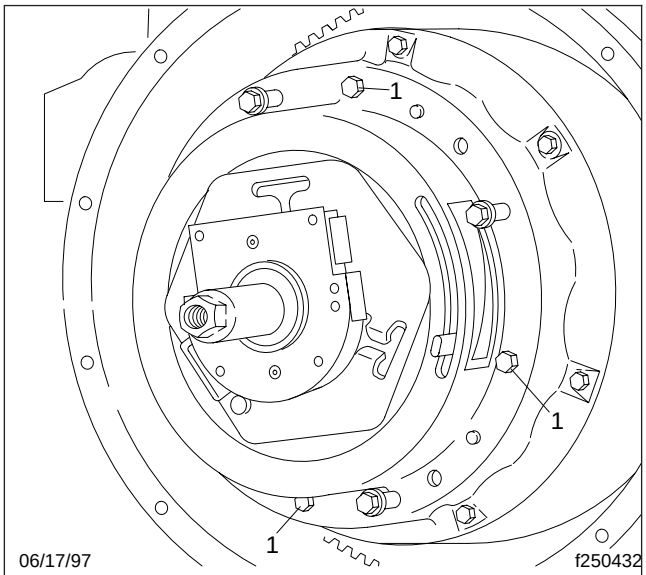
1.3 Release the clutch pedal in the cab. At this point, the wear indicating tab will stay at the new position of the indicator.

2. Remove the transmission. For instructions, see **Group 26** in this manual.

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. This step only applies to non-synchronized transmissions that use a clutch brake. See **Fig. 1**.
4. Install a spline aligning tool into the release-bearing assembly, and through the driven discs. See **Fig. 2**. An old transmission input shaft maybe used for this purpose.
5. Locate four 3/8-inch by 16 by 1-1/4 inch hexhead machine screws (shipping bolts). These shipping bolts were installed on the clutch cover prior to installation.
6. Install the four 7/16-inch by 14 by 1-3/4 hexhead machine screws (shipping bolts) into the four clutch cover holes; turn them finger tight. See **Fig. 15**.



1. Shipping Bolt (3/8 inch x 16 x 1-1/4 inch)

Fig. 15, Install the Shipping Bolts

7. Remove the two top mounting capscrews, at the 11 and 1 o'clock positions of the cover assembly, from the cover assembly. Install two guide studs (3/8–16 by 3-inch long) in the open holes to help support the clutch assembly during removal. See **Fig. 16**.

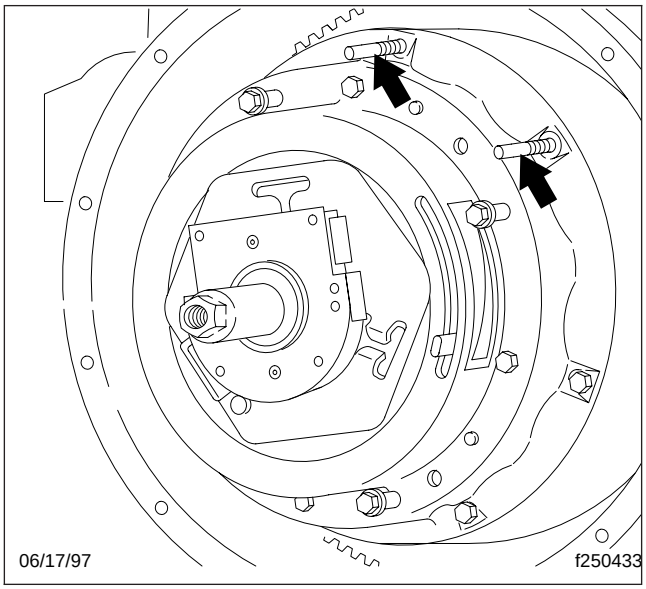


Fig. 16, Guide Stud Installation

8. Progressively loosen each of the mounting capscrews in the pattern shown in **Fig. 17**. This will prevent warping or bending within the clutch, and will ease removal of the clutch-mounting capscrews.

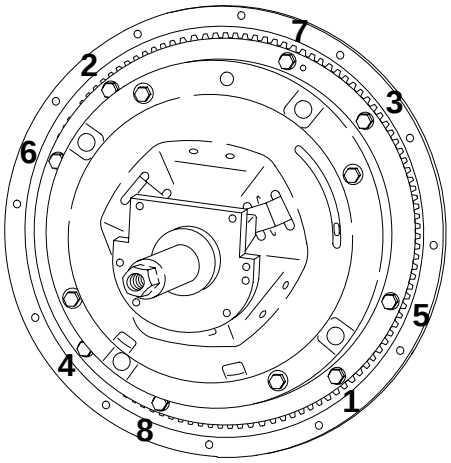


Fig. 17, Loosening Sequence

WARNING

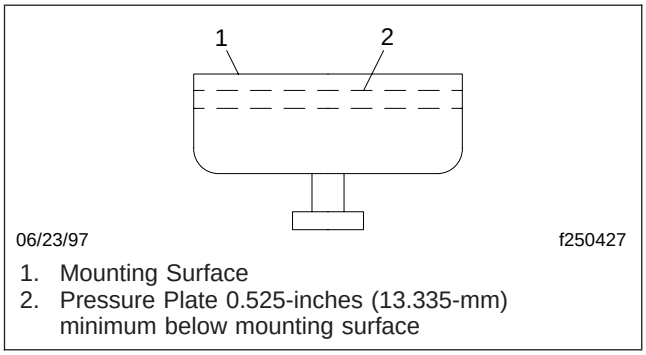
The clutch assembly is heavy and should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

9. Remove the mounting capscrews, and carefully remove the clutch assembly together with the spline aligning tool.

NOTE: For installation of the Splicer Solo Medium-Duty 1402 clutch, mark the proper position of the discs and intermediate plate and adaptor ring.

10. Progressively tighten, in a crisscross pattern, the four shipping bolts until the face of the pressure plate is at least 0.525 inch (13.335 mm) below the mounting surface. See **Fig. 18**.

NOTE: The previous step will reset the pressure plate wear pins and, as a result, allow the clutch to release after the installation.



1. Mounting Surface
2. Pressure Plate 0.525-inches (13.335-mm) minimum below mounting surface

Fig. 18, 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 old pilot bearing.

    Whenever the clutch assembly is serviced or the engine is removed, the pilot bearing in the flywheel should be removed and replaced.

Resetting the Wear Indicating Tab

CAUTION

The wear indicating tab on the Solo clutch should be reset before the transmission is removed. If the transmission and clutch were removed without following the correct removal procedure (the wear indicating tab was not reset), this procedure must be performed before installation. If this procedure is not performed before installation, the clutch will not release and damage to the clutch may result.

1. Support the clutch cover in an arbor press with the release-bearing facing down. When setting up the arbor press, allow at least one inch clearance for both movement of the release-bearing and access to install shipping bolts. See **Fig. 13**.
2. Center the ram and press downward on the retainer until it comes to a stop. Lock the ram in position.
3. Remove the four shipping bolts, if they have been installed.
4. Raise the ram approximately 1 inch (25 mm).
5. Press downward on the retainer until it comes to a stop. Lock the ram in this position.

Clutch Removal

6. With finger pressure, slide the wear indicating tab to the left until it is at the new position of the indicator (**Fig. 14**) and hold it in position.
7. Locate four 3/8 inch by 16 by 1-1/4 inch hexhead machine screws (shipping bolts).
8. Install the four 3/8 inch by 16 by 1-1/4 hexhead machine screws (shipping bolts) into the four clutch cover holes; turn them finger tight. See **Fig. 15**.

NOTE: You may need to temporarily install slightly longer bolts to allow access of the shipping bolts.

9. Progressively tighten, in a crisscross pattern, the four shipping bolts until the face of the pressure plate is at least 0.525 inches (13.335 mm) below the mounting surface. See **Fig. 18**.

NOTE: The previous step will reset the pressure plate wear pins and, as a result, allow the clutch to release after the installation.

Clutch Inspection

The engine and transmission must line up. To check for this, make the following measurements.

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.

Clean the surfaces being measured to ensure accurate measurements.

NOTE: Before measuring the engine 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 maximum, correct it. For specifications and instructions, see the engine manufacturer's service manual.

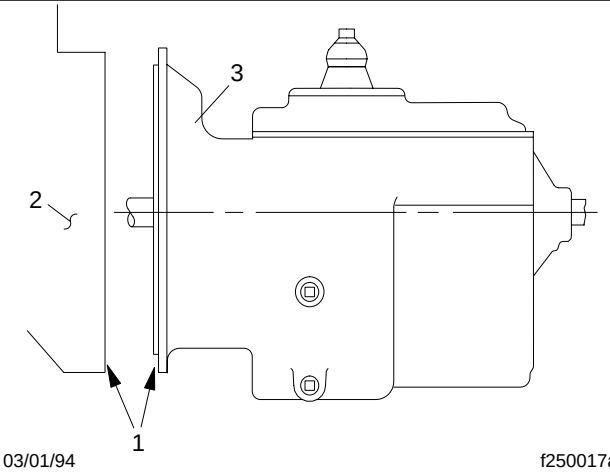
1. Inspect for a worn or corroded pilot (**Fig. 1**) on both the transmission clutch housing, and engine flywheel housing. The 1/8-inch (3.0-mm) deep pilot lip of the clutch housing can wear into the flywheel housing. This can be caused by the transmission loosening up, or by road and engine vibration after high mileage. Any measurable amount of 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. 2**. To check for wear, proceed as follows:

   1.1 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. 3**. 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. 4**.

   The SAE maximum total runout for the flywheel housing pilot is 0.008 inch (0.20 mm). If readings are higher, replace the housing. For instructions, see the engine manufacturer's service manual.

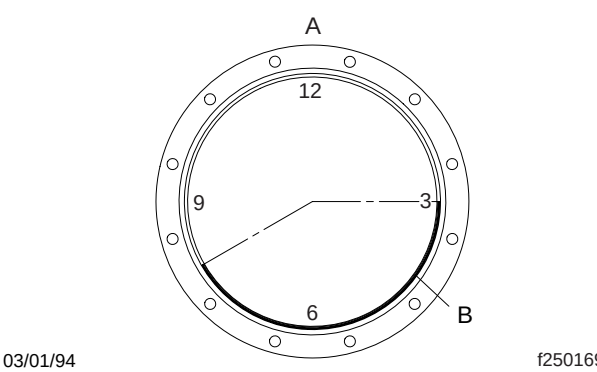
   1.2 Measure the runout of the face of the flywheel housing. With the dial indicator secured to the flywheel (or crankshaft), move the finger to contact the face of the housing. See **Fig. 5**. Mark the high and low points.

   The SAE maximum total runout for the flywheel housing face is 0.008 inch (0.20 mm). If the readings are higher, replace



1. Pilot
2. Engine Flywheel Housing
3. Transmission Clutch Housing

Fig. 1, Inspect the Pilot



A. Top
B. The most common areas of wear are between the 3 o'clock and 8 o'clock positions.

Fig. 2, Checking for Wear

Clutch Inspection

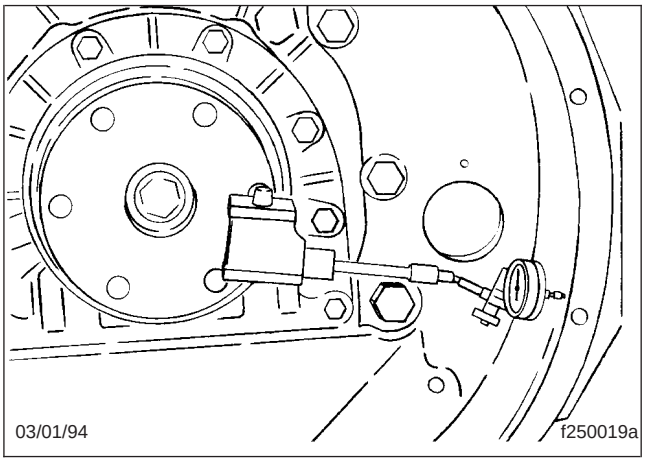
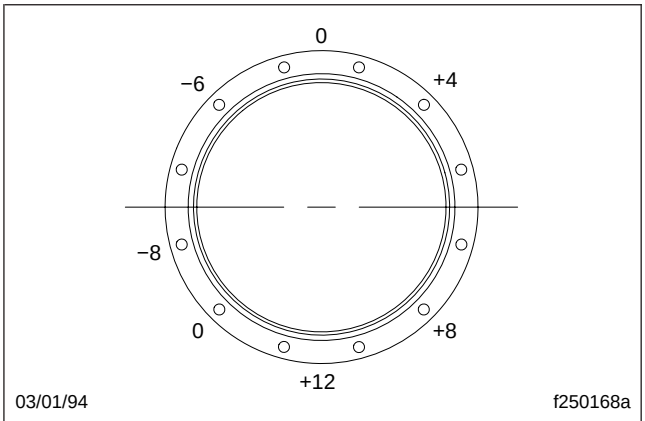


Fig. 3, Check the Pilot Bore Runout



NOTE: Plus 0.012 inch (0.30 mm) and minus 0.008 inch (0.20 mm) gives the housing a total runout of 0.020 inch (0.51 mm)

Fig. 4, Calculating the Runout

the housing. For instructions, see the engine manufacturer's service manual.

NOTE: Only if you have to reposition the flywheel housing is it necessary to mark the high and low runout readings in clock positions.

2. Measure the runout of the flywheel face. Secure the dial indicator to the flywheel housing, with the gauge finger against the face of the flywheel near the outer edge. See **Fig. 6**. Turn the flywheel to obtain readings.

   A 0.0005-inch (0.01-mm) runout or face wobble per inch of flywheel diameter is allowed. For example, if the vehicle has a 14-inch (355.6-mm) clutch, and the readings are taken just off the outer edge of the clutch disc wear area, the maximum tolerance would be 0.007 inch (0.177 mm). If the readings are higher, repair or replace the flywheel. See the engine manufacturer's service manual for instructions.

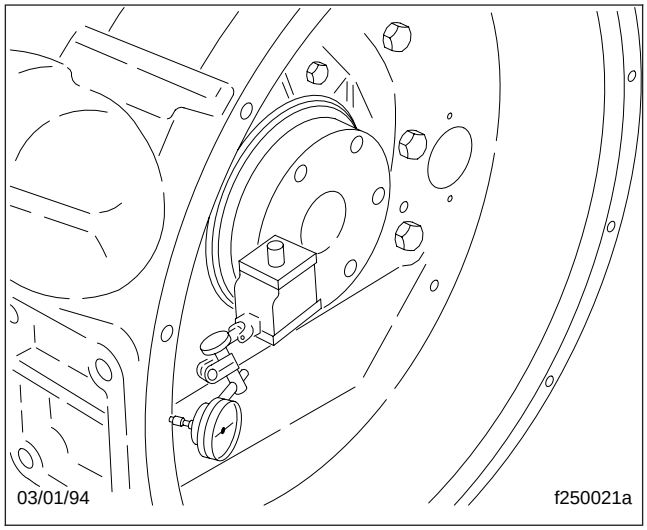


Fig. 5, Check the Housing Face Runout

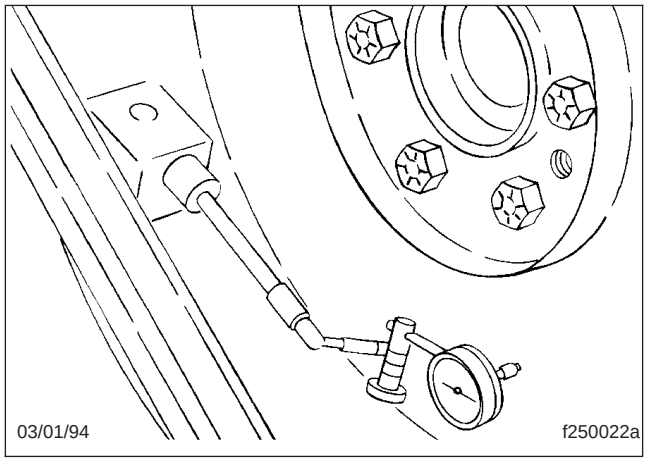


Fig. 6, Check the Flywheel Face Runout

3. 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. 7**. Turn the flywheel to obtain the readings.

The SAE maximum total runout for the pilot-bearing bore is 0.005 inch (0.10 mm). If the readings are higher, see the engine manufacturer's service manual for instructions.

4. Measure the runout of the transmission clutch-housing face and pilot.

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 that are tapped into the front and rear bores of the transmission case, and have very close fits 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.

The SAE maximum runout for the clutch-housing face and pilot is 0.008 inch. If the readings are higher, replace the clutch housing; see the transmission manufacturer's service manual.

5. Remove the flywheel (see the engine manufacturer's service manual), and measure the runout of the flywheel crankshaft face. Secure the dial indicator to the flywheel housing, with the gauge finger against the crankshaft face, near the outer edge. See **Fig. 8**. Turn the crankshaft to obtain readings.

   See the engine manufacturer's service manual for maximum runout, corrective measures, and flywheel installation instructions.

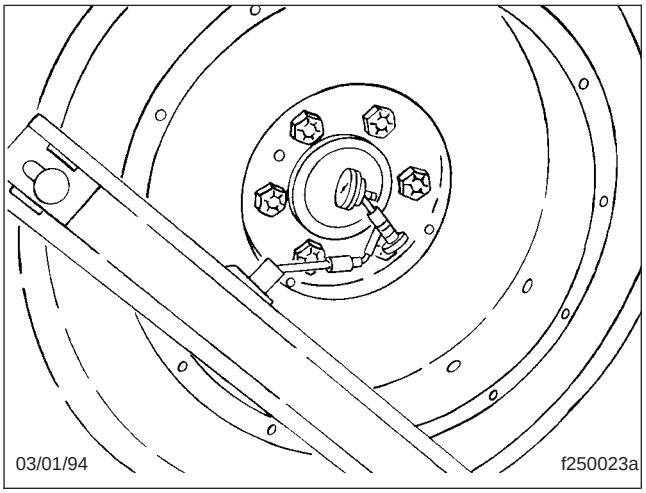


Fig. 7, Check the Pilot-Bearing Bore Runout

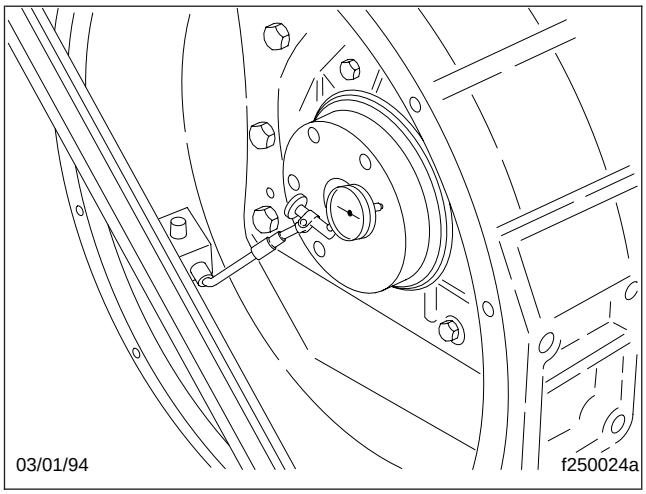


Fig. 8, Check the Crankshaft Face Runout

CAUTION

Misalignment of any parts described in the steps above will cause premature wear of drivetrain components.

Installation

PRE-INSTALLATION CHECKS

Before installing a new, rebuilt, or used clutch, check the following:

1. Inspect the friction surface of the flywheel for smoothness, 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, refer to the engine manufacturer's recommendations concerning flywheel replacement or rebuilding.

2. 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.

3. Check the fit of the splined hubs of the front and rear friction discs by sliding them on the transmission input shaft splines. The hubs 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, refer to the transmission manufacturer's service manual

4. Check the following items for wear: the fingers of the clutch release yoke; the release shafts; the release shaft bushings; and the input shaft bearing cap. Replace any worn parts.

INSTALLING A SPICER 14-INCH EASY-PEDAL POT-TYPE FLYWHEEL CLUTCH

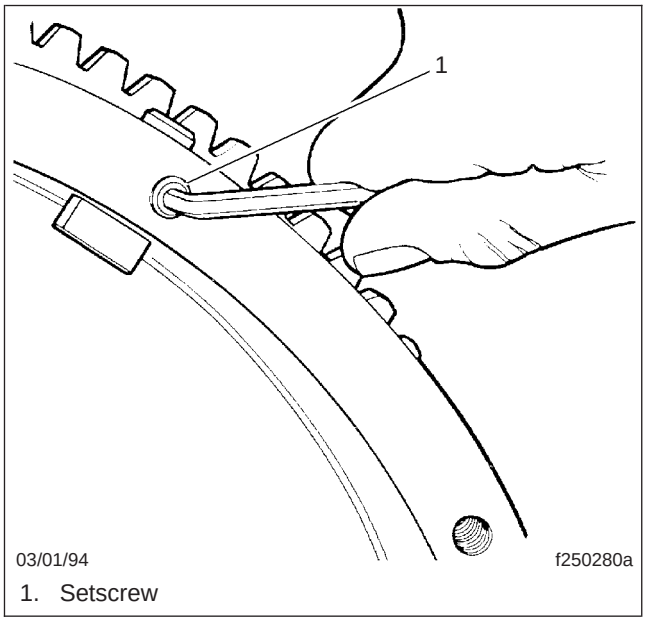
1. Install new drive pins in the flywheel:

   1.1 Remove the flywheel from the engine; for instructions, refer to 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. See **Fig. 1**. Then, using a hammer and punch, remove the drive pins.



1. Setscrew

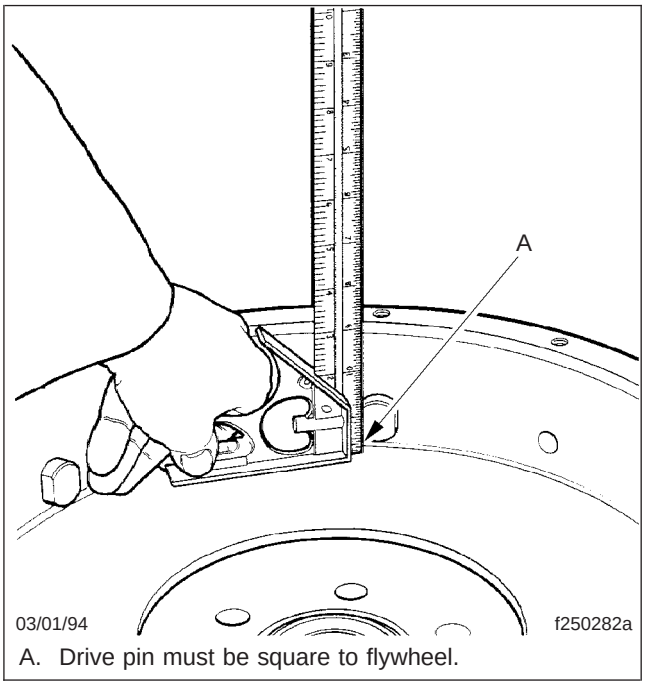
Fig. 1, Remove the Setscrews

1.3 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. See **Fig. 2**.

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.

1.4 Carefully position the intermediate plate over the drive pins. Turn the intermediate plate in one direction as far as it will go. Check the clearance between each drive pin and drive slot. Check the same side of each pin.

Clutch Installation



A. Drive pin must be square to flywheel.

Fig. 2, Install the Drive Pins

The minimum clearance between the drive pins and the drive slots is 0.006 inch (0.152 mm). See **Fig. 3**. If the clearance is correct, remove the intermediate plate, and check the squareness alignment of the drive-pin heads to the friction face.

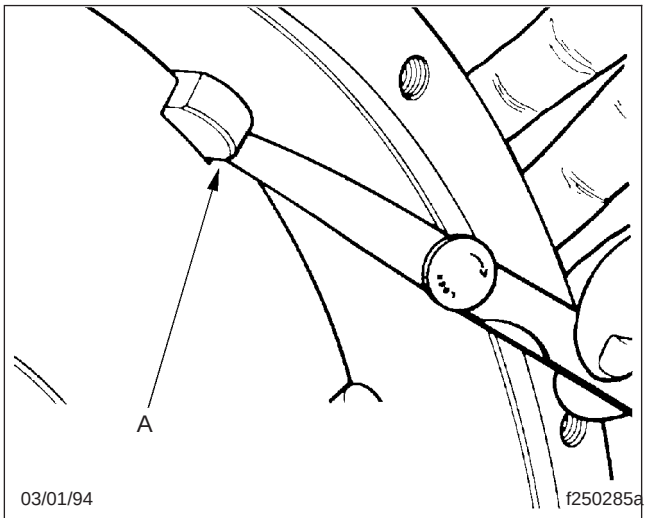
⚠ CAUTION

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.

1.5 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).

1.6 Install the flywheel; for instructions, refer to the engine manufacturer's service manual.



A. Drive Pin-to-Center Plate Minimum Clearance: 0.006 inch (0.152 mm)

Fig. 3, Measure the Clearance

2. Install a new pilot bearing. Make sure the bearing has a press-fit in the flywheel.
3. If the clutch is new, remove the protective coating from the pressure plate and the intermediate plate.
4. Place the front driven-disc assembly in the flywheel, with the side stamped *FLYWHEEL* facing the engine. See **Fig. 4**.

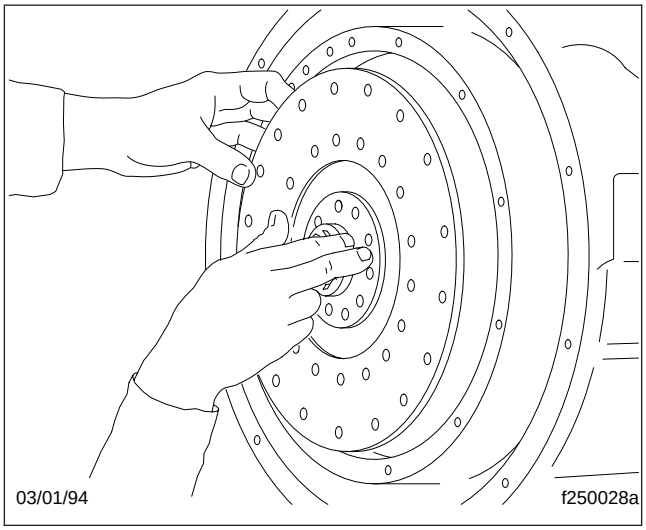


Fig. 4, Position the Front Driven-Disc

5. Install the intermediate plate in the flywheel, locating the drive slots on the drive pins. See **Fig. 5**.

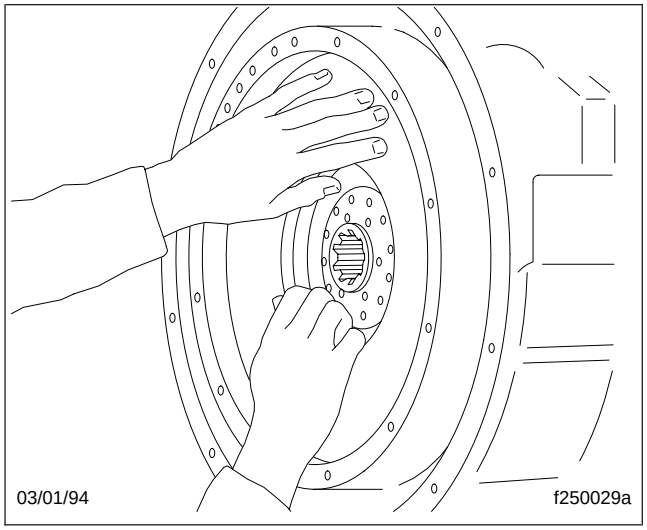


Fig. 5, Install the Intermediate Plate

⚠ WARNING

Wear heavy gloves when installing the anti-rattle springs, otherwise the sharp edges can cut your hands.

6. On 14-inch (355.6-mm) Super Duty clutch installations, use three anti-rattle springs equally spaced between the drive pins. Wearing heavy gloves, install the springs with the rounded sections toward the flywheel face. See **Fig. 6**. Push the springs toward the engine until they bottom against the face of the flywheel.

   The 14-inch (355.6-mm) Super Duty clutches have thicker intermediate plates, and six ceramic buttons on each side of each disc. Do not mix standard and Super Duty discs.

7. Insert a spline aligning tool through the hub of the rear driven disc, with the side stamped *PRESSURE PLATE* facing the transmission. Install the rear driven disc behind the intermediate plate. See **Fig. 7**.

NOTE: The side stamped *PRESSURE PLATE* must face the transmission.

8. Insert the aligning tool through the hub of the front driven disc, and into the pilot bearing.

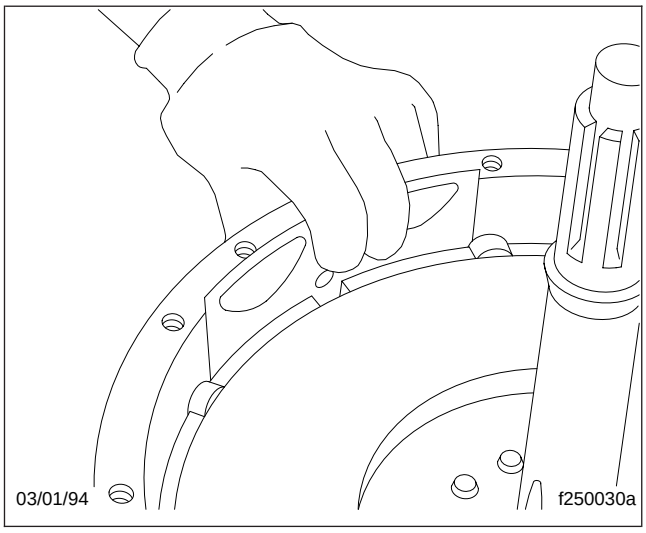
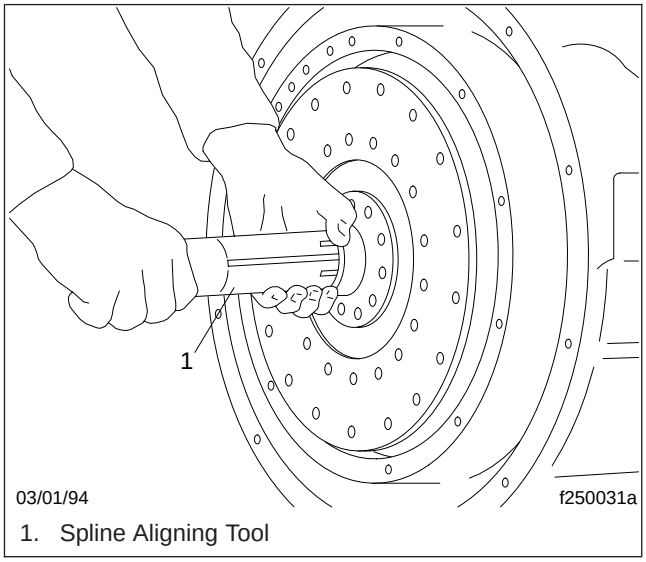


Fig. 6, Install the Anti-Rattle Springs



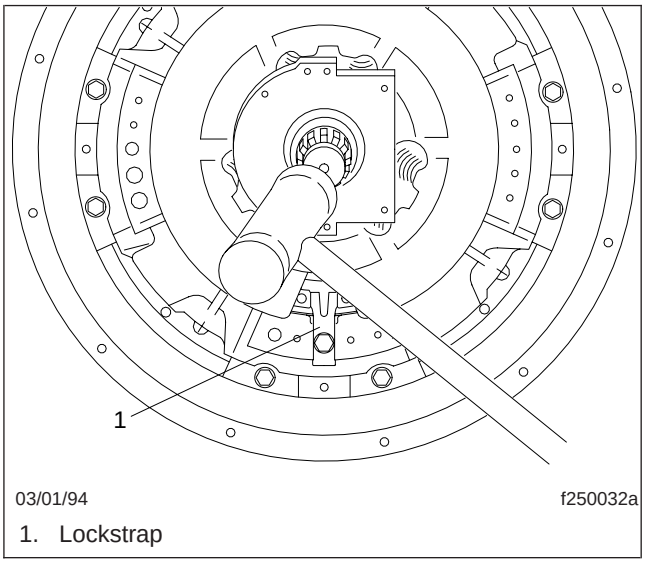
1. Spline Aligning Tool

Fig. 7, Insert the Spline Aligning Tool

9. Position the cover assembly on the flywheel, with the lockstrap aligned with the opening in the transmission clutch housing. See **Fig. 8**. Start the 3/8-inch clutch-mounting capscrews and lockwashers, and tighten them finger-tight to hold the assembly in place. Use capscrews that are 1-1/4 inches long.

10. Tighten the capscrews progressively in the sequence shown in **Fig. 9** to pull the clutch ring into position in the flywheel pilot. For the final

Clutch Installation



1. Lockstrap

Fig. 8, Position the Cover Assembly

torque, progressively tighten all of the capscrews 35 to 40 lbf·ft (47 to 54 N·m).

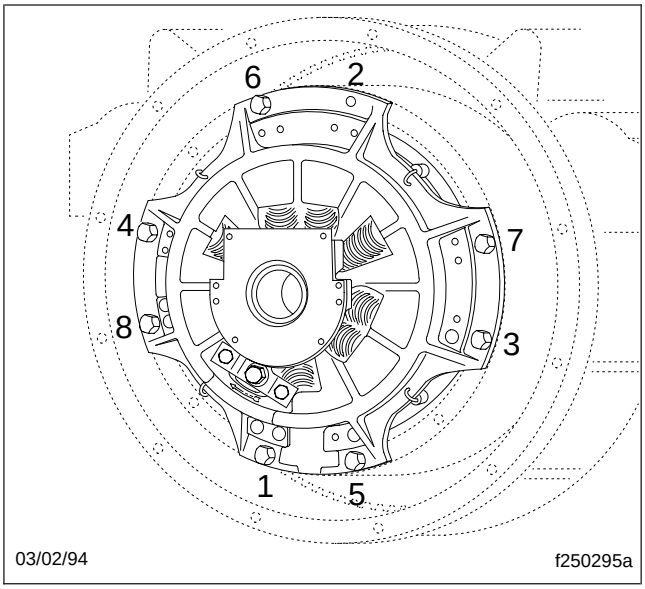


Fig. 9, Tightening Sequence

⚠ CAUTION

Failure to tighten the capscrews as described can cause clutch damage and an out-of-balance condition.

11. As the capscrews are tightened, the release-bearing spacers should fall free. If they don't, remove them. Remove the aligning tool; this may require a tap with a mallet. See **Fig. 8**.
12. Using a clean cloth, remove all grease from the input shaft.
13. Install the clutch brake on the input shaft, as shown in **Fig. 10**. Slide it tight against the input shaft bearing cap.

    Torque-limiting clutch brakes are a one-piece assembly with a large and a small face. When installing a torque-limiting clutch brake on a Spicer transmission, install the larger face toward the transmission; when installing it on a Fuller transmission, install the smaller face toward the transmission.

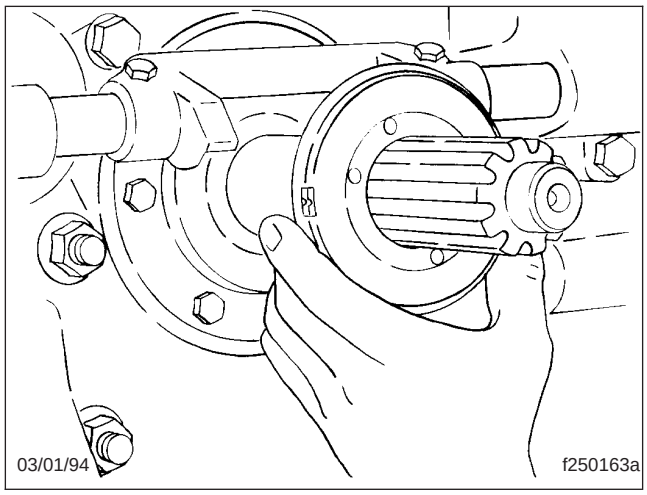


Fig. 10, Install the Clutch Brake

14. Shift the transmission into gear, so the transmission input shaft can be rotated into line with the clutch driven-disc hub splines during assembly.
15. Install the transmission and attach the clutch linkage. For instructions, See **Group 26** in this manual.

⚠ 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. 11**. Align the splines by turning the transmission output shaft.

16. Grease the release-bearing and release shafts. For instructions and recommended lubricants, see Group 25 in the vehicle maintenance manual.

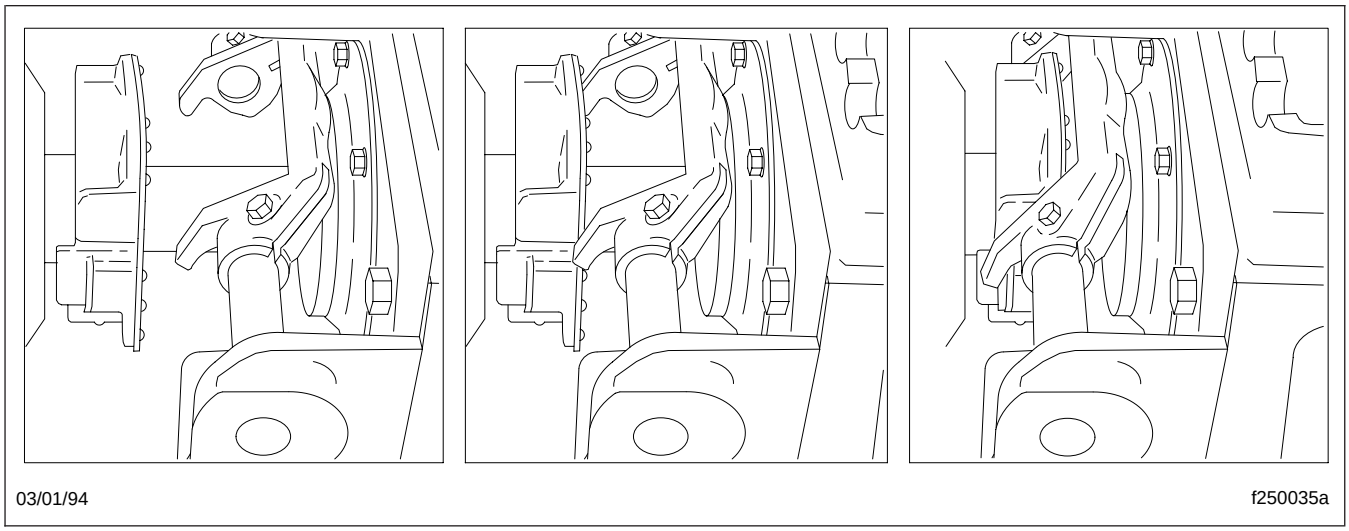


Fig. 11, Make Sure that the Release-Bearing Yoke Clears the Bearing

17. Adjust the clutch and linkage after installing the clutch. Refer to the appropriate section in this manual for procedures.

INSTALLING A SPICER 15-1/2 INCH EASY-PEDAL CLUTCH

NOTE: Do the pre-installation checks in this section before installing the clutch.

1. Install a new pilot bearing. Be sure that the pilot bearing has a press-fit in the flywheel.
2. If not already installed, install two guide studs (7/16–14 by 5-inches long) in the upper mounting holes of the flywheel. See **Fig. 12**. Rotate the flywheel to level the guide studs.

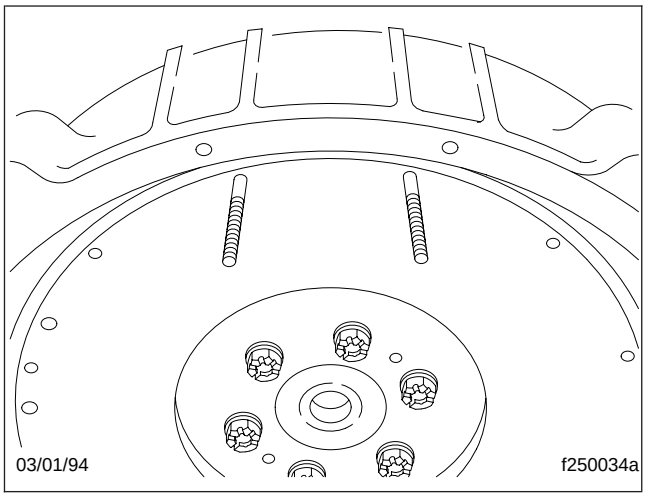


Fig. 12, Guide Stud Installation

3. If the clutch is new, remove the protective coating from the pressure plate and the intermediate plate.
4. Set the clutch cover upright, and insert a spline aligning tool through the release-bearing sleeve. See **Fig. 13**.
5. Install the rear driven disc on the aligning tool, with the side stamped *PRESSURE PLATE* facing the pressure plate. See **Fig. 14**. Place the intermediate plate in the clutch cover; align the driv-

Clutch Installation

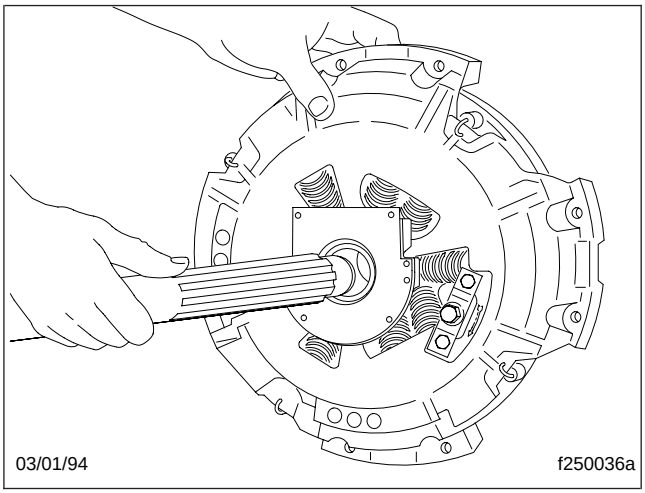


Fig. 13, Insert a Spline Aligning Tool

ing lugs of the plate with the notches in the cover. See **Fig. 15**.

Clutches produced after January 1990 may have positive separator pins; make sure they point toward the flywheel side. See **Fig. 16**. The pins should be flush on the pressure plate side.

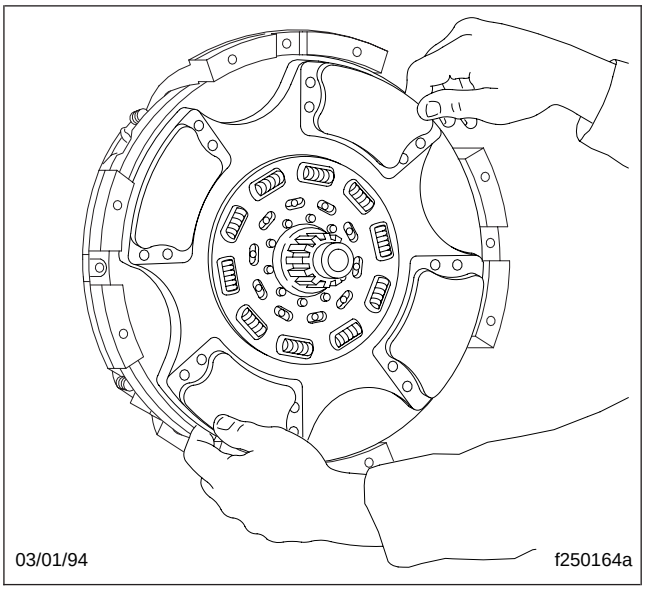


Fig. 14, Installing a Driven Disc

6. Install the front driven disc on the aligning tool, with the side stamped *FLYWHEEL* facing the engine. See **Fig. 17**.

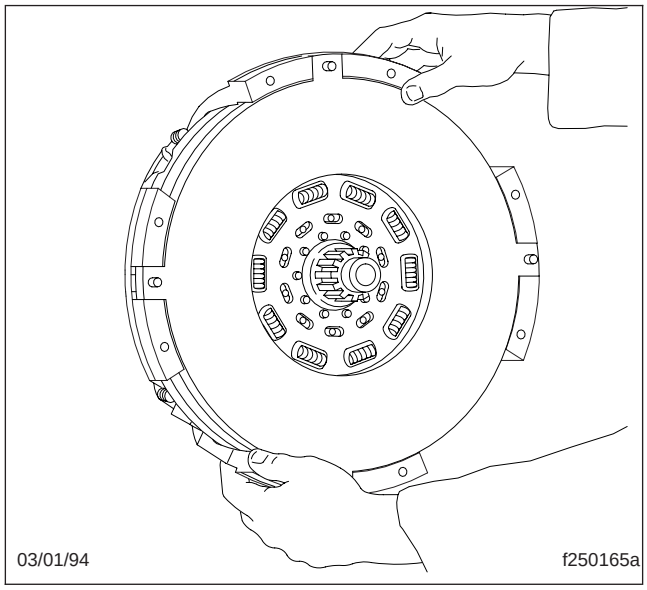


Fig. 15, Position the Intermediate Plate

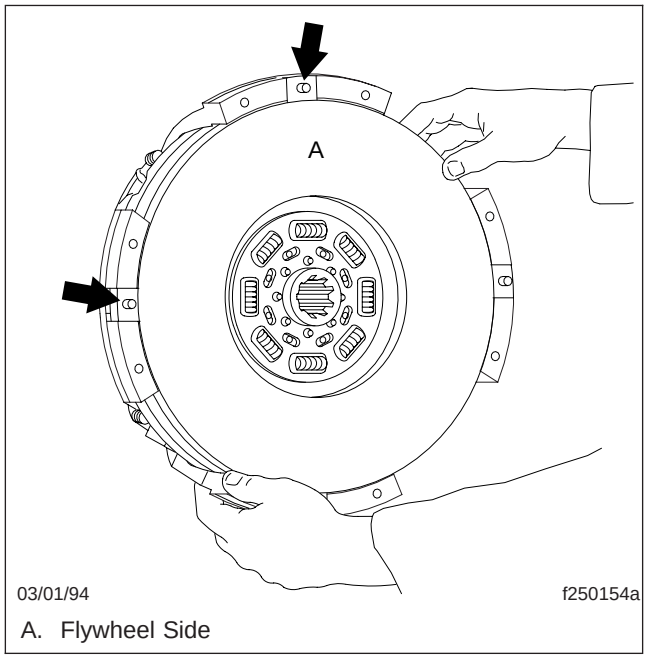


Fig. 16, Positive Separator Pins

Be sure that both driven discs are aligned as shown in **Fig. 18**.

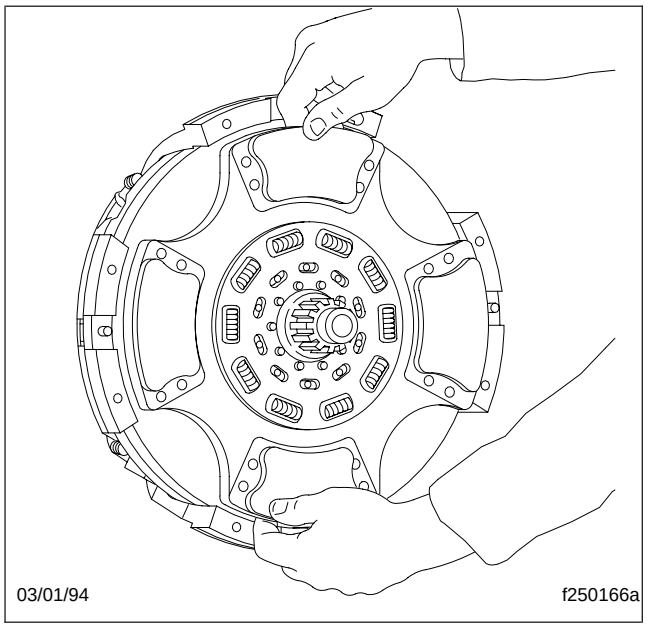
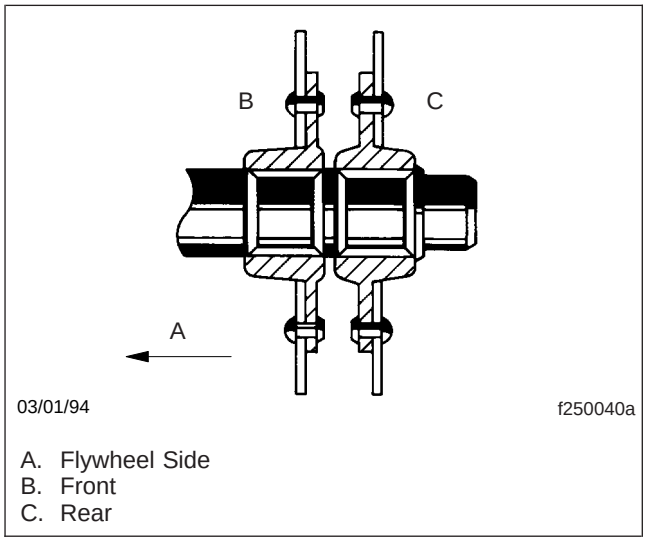


Fig. 17, Installing the Second Driven Disc



A. Flywheel Side
B. Front
C. Rear

Fig. 18, Checking the Disc Alignment

WARNING

The pressure plate and cover assembly is heavy and 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. Position the clutch over the two guide studs (**Fig. 19**), and slide the assembly forward until it starts in the flywheel pilot.

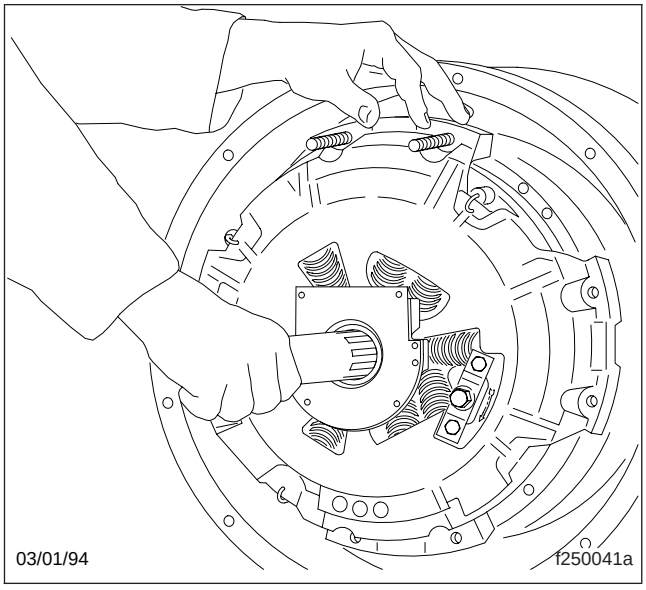


Fig. 19, Positioning the Clutch

8. Start six 7/16–14 (grade 8) capscrews with lockwashers, and tighten them finger-tight. Tap the aligning tool (**Fig. 8**) to make sure it is centered and seated in the pilot bearing, then remove the two guide studs and replace them with 7/16–14 capscrews and lockwashers.
9. Tighten the eight clutch-mounting capscrews progressively, in the sequence shown in **Fig. 20**. The final torque is 45 to 50 lbf·ft (61 to 68 N·m).

CAUTION

If the capscrews are not tightened in sequence, clutch damage and an out-of-balance condition may occur.

10. As the capscrews are tightened, the release-bearing spacers should fall free. If they don't, remove them. Remove the aligning tool; this may require a tap with a mallet.
11. For clutches without the "positive separator," go on to the next step. Otherwise set the positive separator pins.

    11.1 For positive separator clutches locate the pin access holes. See **Fig. 21**.

Clutch Installation

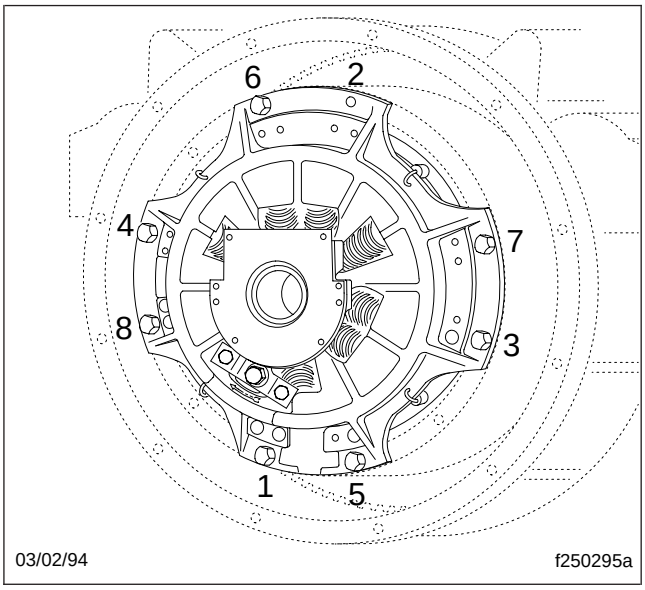


Fig. 20, Tightening Sequence

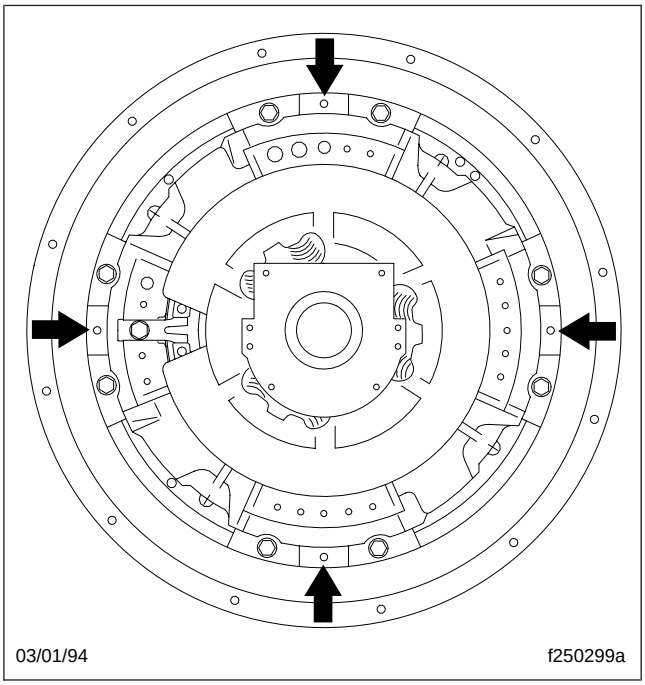
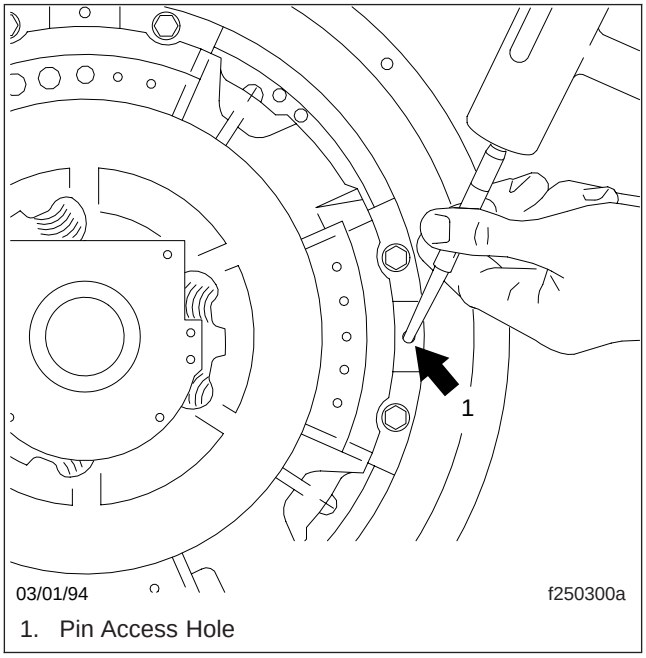


Fig. 21, Pin Access Holes

⚠ 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.

11.2 Using a 1/4-inch (6-mm) diameter driver, *lightly* tap each pin toward the flywheel through the access holes. See **Fig. 22**.



1. Pin Access Hole

Fig. 22, Tapping the Pin

NOTE: The separator pin will allow the intermediate plate to move back 0.025 to 0.030 inch (0.635 to 0.762 mm) when the clutch is released, giving an approximately equal gap on both sides of the intermediate plate. See **Fig. 23**.

12. Using a clean cloth, remove all grease from the input shaft.
13. Install the clutch brake on the transmission input shaft, as shown in **Fig. 24**. Slide it tight against the input shaft bearing cap.

    Torque-limiting clutch brakes are a one-piece assembly with a large and a small face. When installing a torque-limiting clutch brake on a Spicer transmission, install the larger face toward the

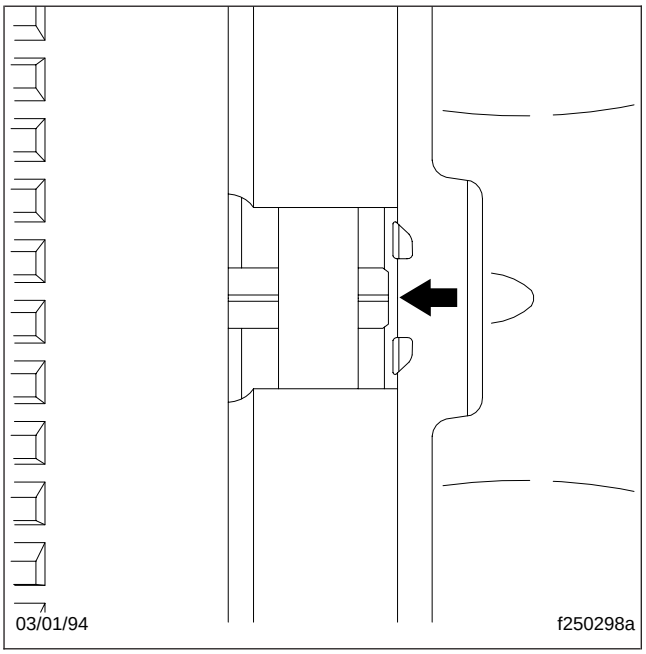


Fig. 23, Intermediate Plate Gap

transmission; when installing it on a Fuller transmission, install the smaller face toward the transmission.

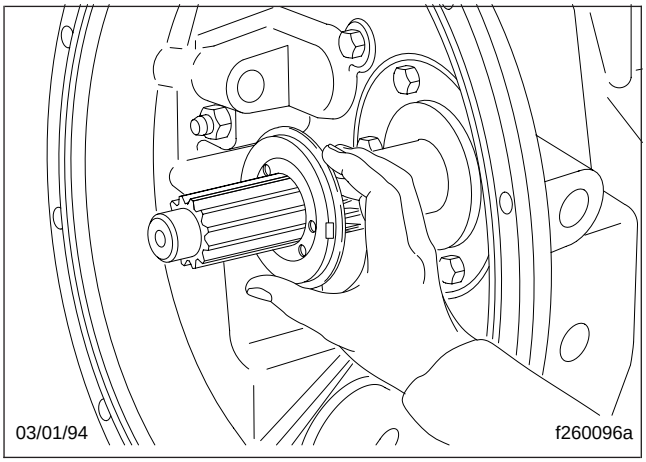


Fig. 24, Install the Clutch Brake

14. Shift the transmission into gear, so that the transmission input shaft can be rotated into line with the clutch driven-disc hub splines, during assembly.
15. Install the transmission and attach the clutch linkage. For instructions, see **Group 26** in this manual.

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. 11**. Align the splines by turning the transmission output shaft.

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.

16. Grease the release-bearing and release shafts. For instructions and recommended lubricants, see Group 25 in the vehicle maintenance manual.
17. Adjust the clutch and the clutch linkage after installing the clutch. See the appropriate section in this group for procedures.

INSTALLING A SPICER ANGLE-SPRING ONE PLATE CLUTCH

NOTE: Do the pre-installation checks in this section before installing the clutch.

1. Install a new pilot bearing. Be sure that the pilot bearing has a press-fit in the flywheel.
2. If the clutch is new, remove the protective coating from the pressure plate.
3. If not already in place, install two 3/8-16 by 2-inch guide studs in two upper mounting holes of the flywheel. See **Fig. 25**.
4. Insert an aligning tool through the splines of the driven disc. Insert the aligning tool into the pilot bearing. See **Fig. 26**. Be sure the side marked *PRESSURE PLATE SIDE* faces the pressure plate. See **Fig. 27** for the driven disc installed position.

Clutch Installation

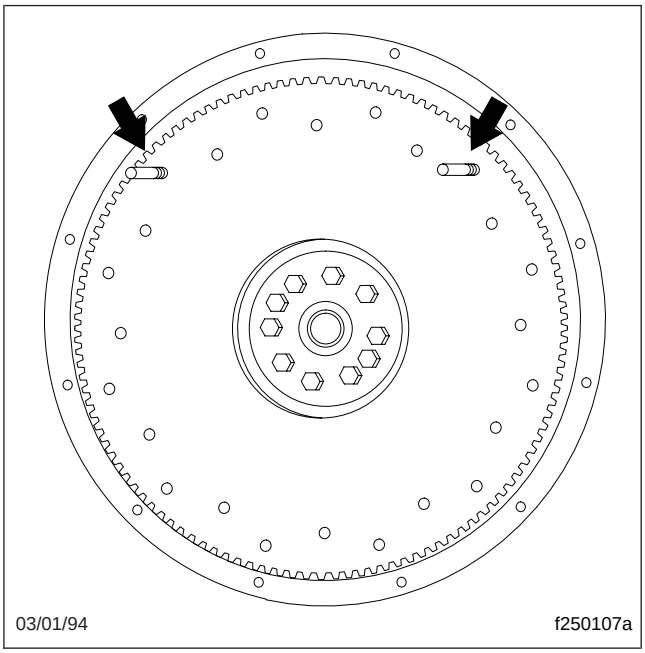


Fig. 25, Install the Guide Studs

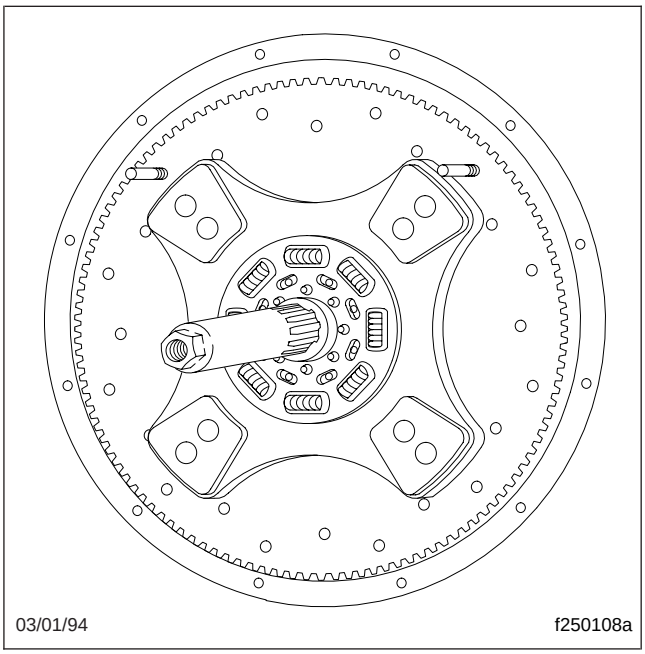


Fig. 26, Insert an Aligning Tool

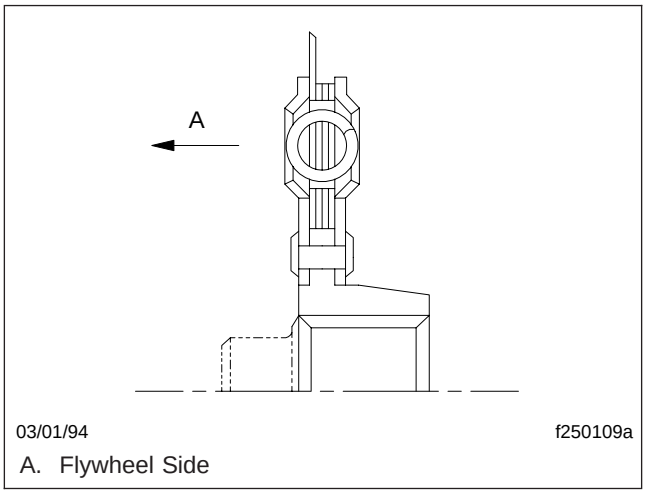


Fig. 27, Driven Disc Installed

WARNING

The pressure plate and cover assembly is heavy and should be removed and installed with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

5. With the aligning tool still in place, slide the cover assembly over the aligning tool. Align the lockstrap or self-adjuster with the access opening in the bell housing. See **Fig. 28**.
6. Start ten 3/8–16 grade 8 capscrews with lockwashers in the cover plate. Tighten them snugly. Remove the guide studs. Install two 3/8–16 grade 8 capscrews with lockwashers. Then, following the sequence shown in **Fig. 29**, tighten the capscrews 35 to 40 lbf·ft (47 to 54 N·m).

CAUTION

If the capscrews are not tightened in the sequence shown, clutch damage and an out-of-balance condition may result.

7. Remove the alignment tool. Remove the wooden spacer blocks.
8. Adjust the clutch and the clutch linkage after installing the clutch. See the appropriate section in this group for procedures.

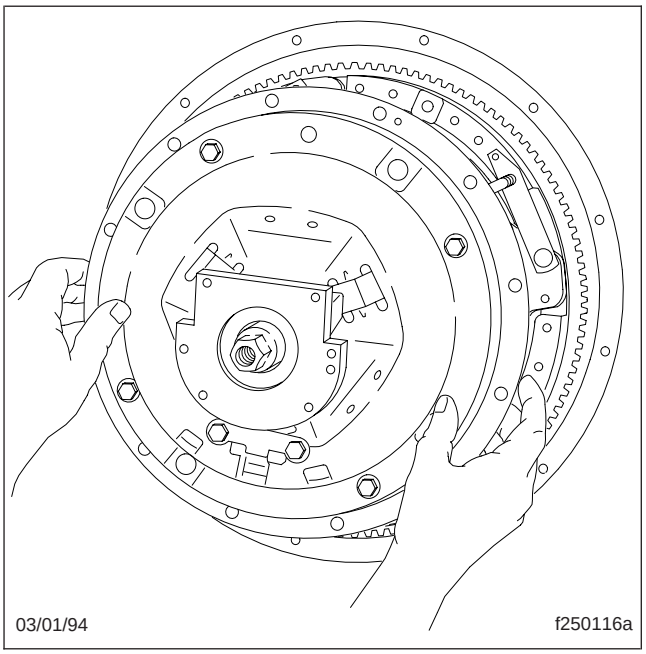


Fig. 28, Position the Clutch Cover

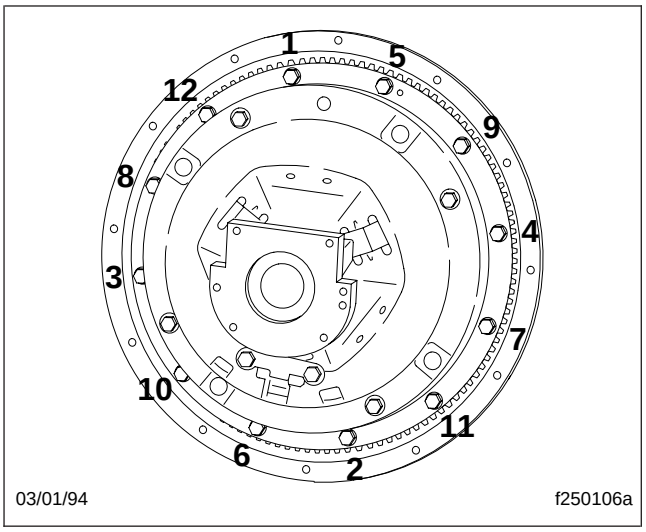


Fig. 29, Tightening Sequence

INSTALLING A SPICER ANGLE SPRING TWO PLATE CLUTCH

NOTE: Do the pre-installation checks in this section before installing the clutch.

1. Install a new pilot bearing. Be sure that the pilot bearing has a press-fit in the flywheel.
2. If the clutch is new, remove the protective coating from the pressure plate.
3. Place the front disc in the bell housing with the side marked *FLYWHEEL SIDE* facing the flywheel. See **Fig. 30**.

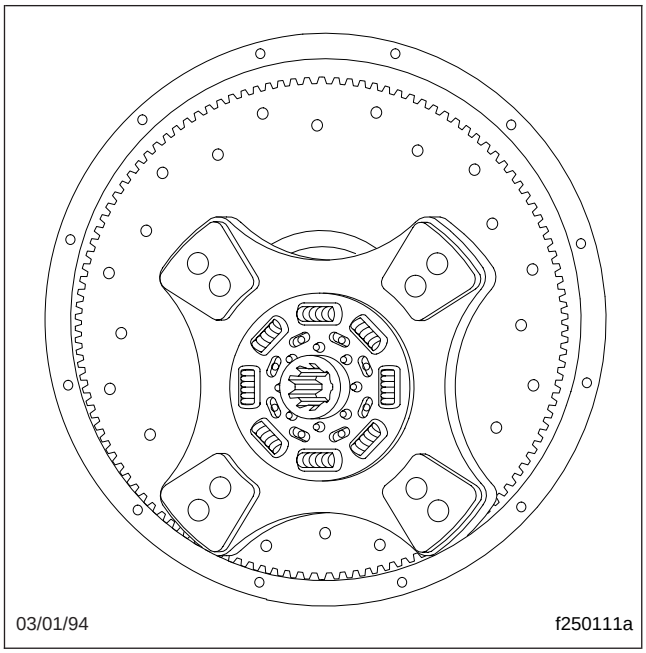


Fig. 30, Position the Front Disc

4. If not already in place, install two 3/8-16 by 2-inch guide studs in two upper mounting holes of the flywheel. See **Fig. 31**.
5. Install the drivestrap intermediate plate over the guide studs. Make sure the side marked *FLYWHEEL SIDE* faces the flywheel. See **Fig. 32**.

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.

6. Raise the front disc to fit into the intermediate plate opening.
7. Install an aligning tool through the splines of the rear disc. Install the rear disc by inserting the aligning tool into the pilot bearing. See **Fig. 33**. Be sure the side marked *PRESSURE PLATE*

Clutch Installation

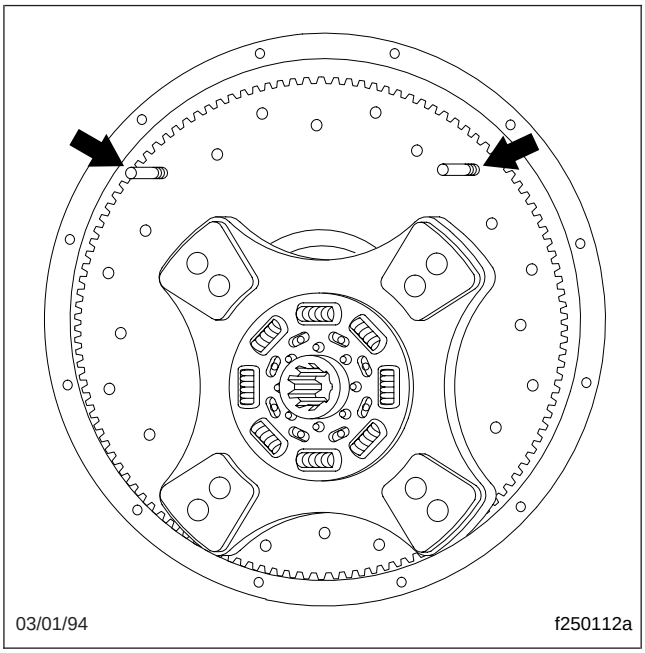


Fig. 31, Install the Guide Studs

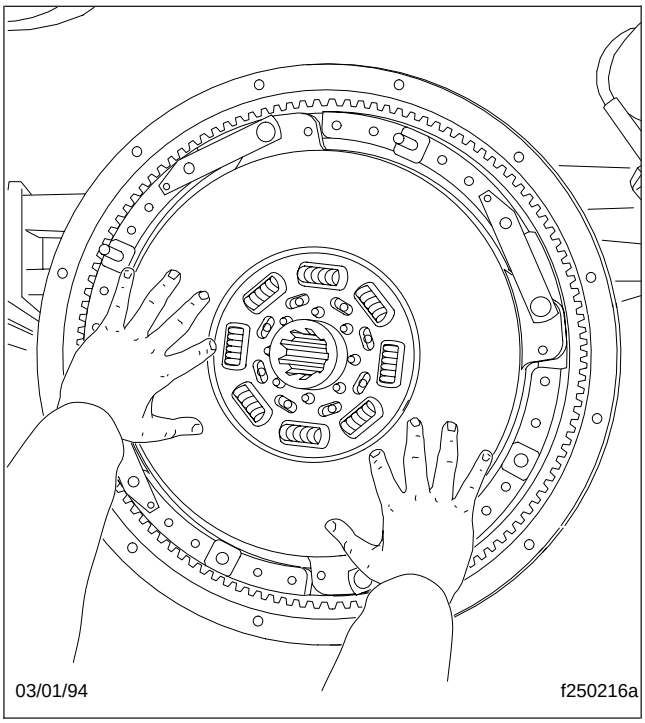


Fig. 32, Install the Intermediate Plate

SIDE faces the pressure plate. See **Fig. 34** for driven disc installed position.

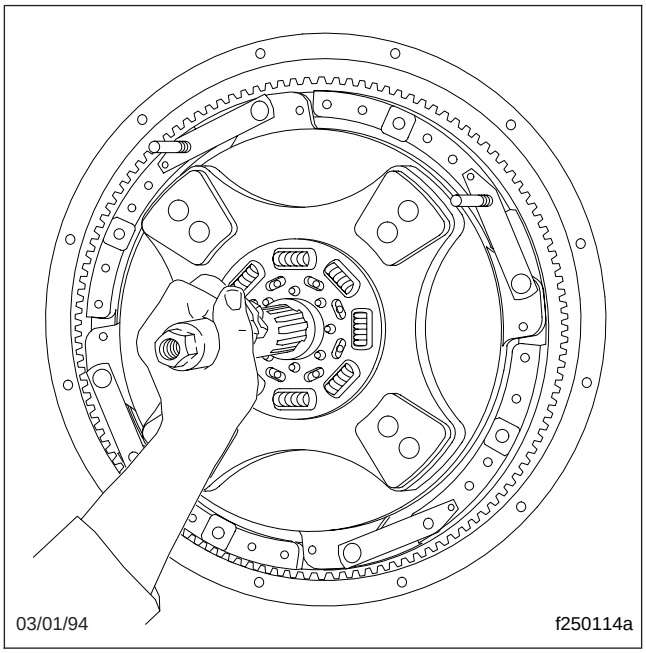


Fig. 33, Install an Aligning Tool

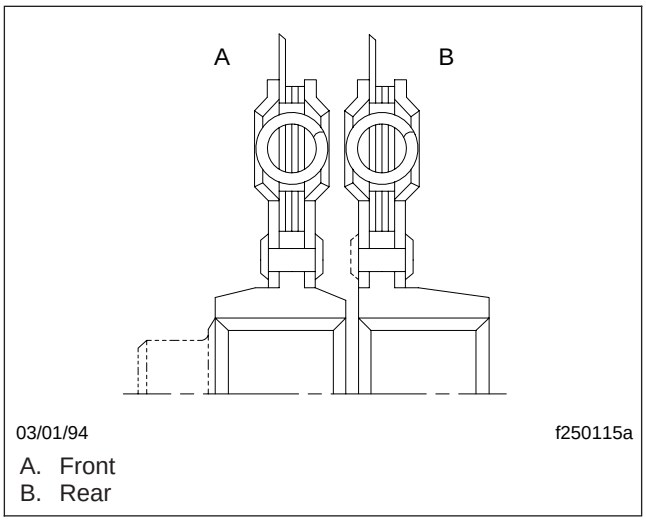


Fig. 34, Driven Discs Installed

WARNING

The pressure plate and cover assembly is heavy and should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

8. With the aligning tool still in place, carefully slide the clutch assembly over the aligning tool. See **Fig. 35**. Align the lockstrap or self-adjuster with the access hole in the bell housing.

   Slide the clutch assembly over the guide studs and against the spacer ring.

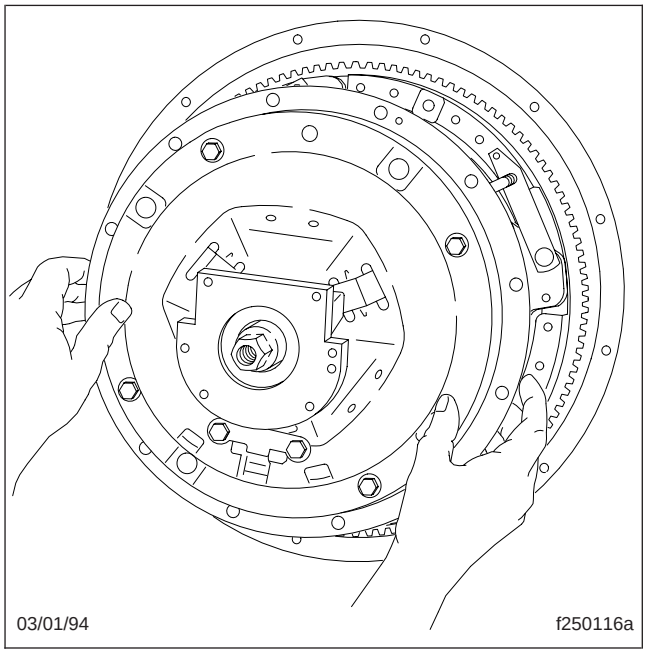


Fig. 35, Position the Clutch Cover

9. Start ten 3/8–16 grade 8 capscrews with lockwashers in the cover plate. Tighten them snugly. Remove the guide studs. Install two 3/8–16 grade 8 capscrews with lockwashers. Then, following the sequence in **Fig. 36**, tighten the capscrews 35 to 40 lbf·ft (47 to 54 N·m).

CAUTION

If the capscrews are not tightened in the sequence shown, clutch damage and an out-of-balance condition may result.

10. Remove the alignment tool. Remove the wooden spacer blocks.
11. Adjust the clutch and the clutch linkage after installing the clutch. See the appropriate section in this group for procedures.

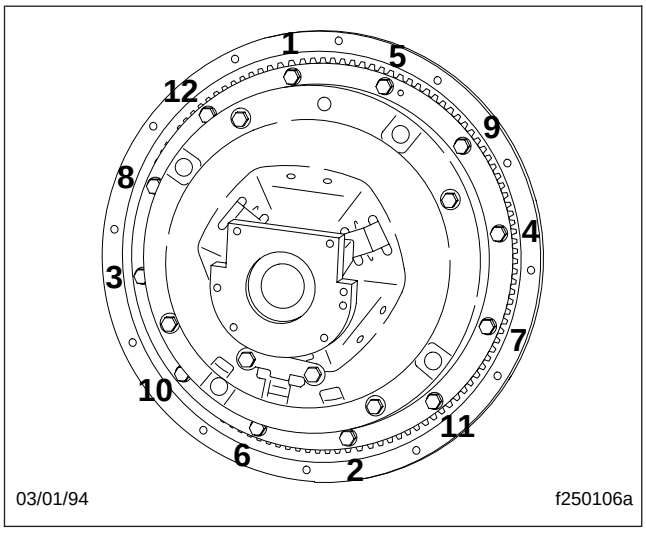


Fig. 36, Tightening Sequence

INSTALLING A SPICER SOLO HEAVY-DUTY 15-1/2 INCH CLUTCH

NOTE: Do the pre-installation checks in this subject before installing the clutch.

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 cause damage to the pilot bearing.

NOTE: Spicer Clutch strongly recommends the use of a premium grade pilot bearing. The operating temperatures that the pilot bearing sees has increased in the last several years. This creates operating conditions that are no longer acceptable to the standard pilot bearings and grease. In addition, the life of the clutch has increased. Failure of the pilot bearing usually results in a warranty claim for drag or clutch noise.

2. Verify diameter of the flywheel cavity (this is the recessed area for the flywheel mounting bolts). The ten spring driven discs require a minimum diameter of 8-9/16 inches (21.749 cm). The six

Clutch Installation

spring (VCT) driven discs require a minimum diameter of 9-3/4 inches (24.765 cm). The seven spring driven discs require a minimum diameter of 9-3/4 inches (24.765 cm). And, the nine spring driven discs require a minimum diameter of 9-3/4 inches (24.765 cm).

3. If not already installed, install two guide studs (7/16–14 by 5-inches long) in the upper mounting holes of the flywheel. See **Fig. 37**. Rotate the flywheel to level the guide studs.

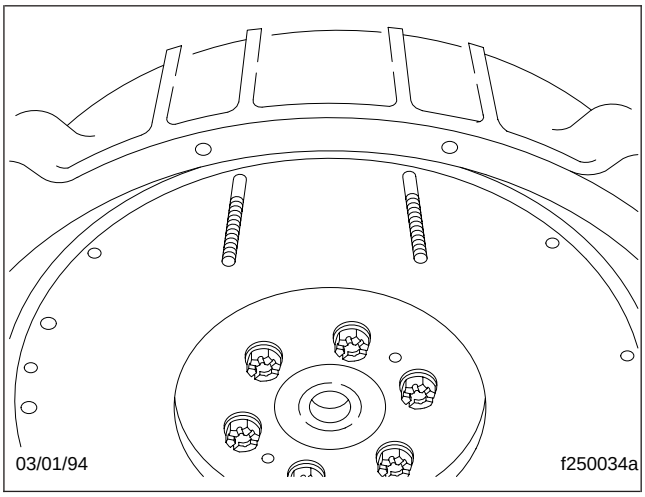


Fig. 37, Install the Guide Studs

4. If the clutch is new, and if a protective coating has been applied to the surfaces of the pressure plate and the intermediate plate, remove the protective coating from the pressure plate and the intermediate plate.
5. Set the clutch cover upright, and insert a spline aligning tool through the release-bearing sleeve of the new clutch. See **Fig. 38**.
6. Install the rear driven disc on the aligning tool, with the side stamped *INTERMEDIATE PLATE SIDE* facing the intermediate plate. See **Fig. 39**.

NOTE: The previous step describes the specific procedure for installing a six spring or seven spring rear driven disc. When installing either the nine or ten spring rear driven disc, follow the instructions stamped on the rear disc. These instructions will ensure proper orientation toward the pressure plate. Installing the disc backwards or switching the front and rear discs with each other will prevent the clutch from functioning properly (i.e. the clutch doesn't release, or cannot obtain proper adjustment, etc.). The six spring and seven spring discs require no special orientation. These front and rear discs share the same part number and are symmetrical (mirror image).

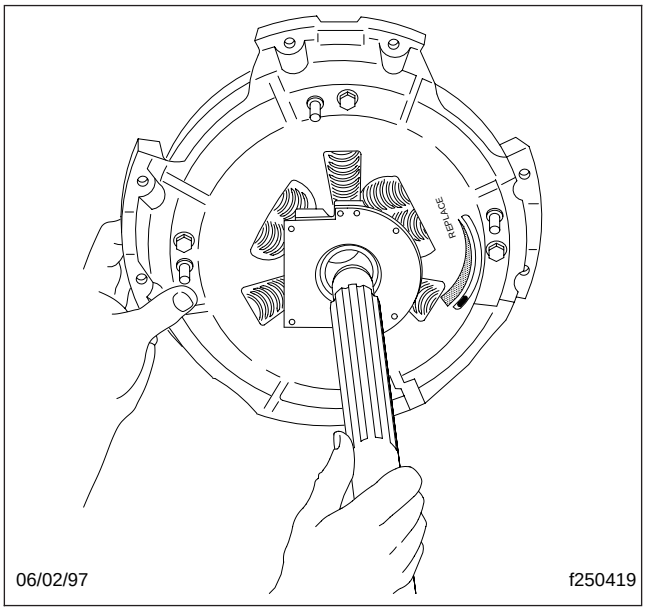


Fig. 38, Insert an Aligning Tool

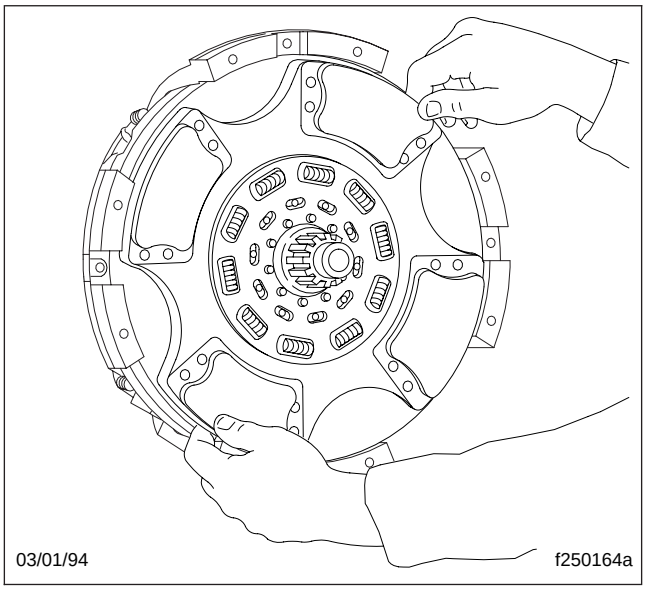
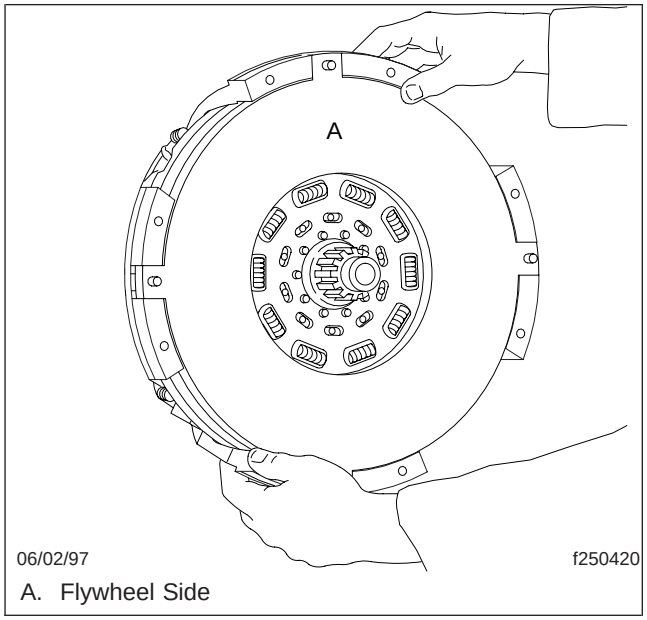


Fig. 39, Installing a Driven Disc

7. Place the intermediate plate into the four slots of the clutch cover, with the side stamped **FLYWHEEL SIDE** facing the flywheel. See **Fig. 40**.



A. Flywheel Side

Fig. 40, Position the Intermediate Plate

8. Install the front driven disc on the aligning tool, with the side stamped *INTERMEDIATE PLATE SIDE* facing the Intermediate plate. See **Fig. 41**.

NOTE: The previous step describes the specific procedure for installing a six spring or seven spring front driven disc. When installing either the nine or ten spring front driven disc, follow the instructions stamped on the front disc. These instructions will ensure proper orientation toward the flywheel. Installing the disc backwards or switching the front and rear discs with each other will prevent the clutch from functioning properly (i.e. the clutch doesn't release, or cannot obtain proper adjustment, etc.). The six spring and seven spring discs require no special orientation. These front and rear discs share the same part number and are symmetrical (mirror image).

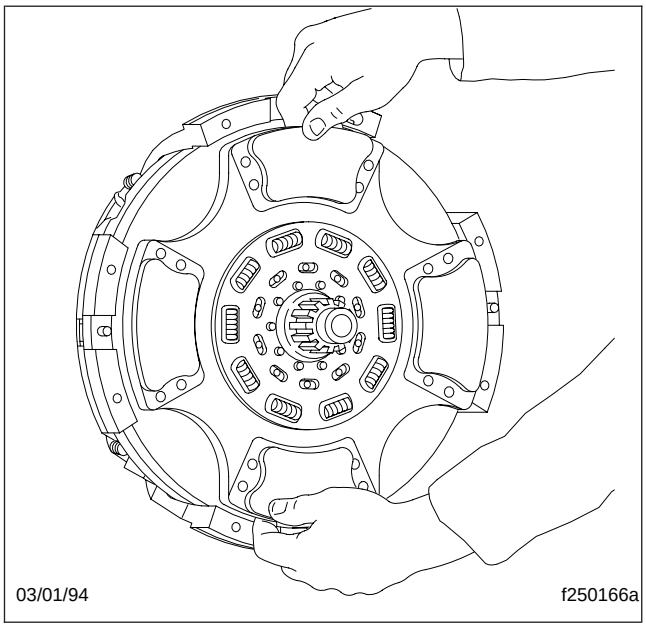


Fig. 41, Installing the Second Driven Disc

WARNING

The clutch assembly should be removed and installed with a lifting device. The assembly is heavy, it weighs approximately 150 pounds. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.

9. Position the clutch over the two guide studs (**Fig. 42**), and slide the assembly forward until contact is made with the flywheel surface.

10. Start six 7/16 x 2-1/4 inch (grade 5 or better) mounting capscrews with lockwashers, and tighten them finger-tight. Tap the aligning tool (**Fig. 43**) to make sure it is centered and seated in the pilot bearing, then remove the two guide studs and replace them with two remaining 7/16 x 2-1/4 inch mounting capscrews and lockwashers.

11. Tighten the eight mounting capscrews progressively, in a crisscross pattern as shown in **Fig. 44**. The final torque is 40 to 50 lbf·ft (54 to 68 N·m).

Clutch Installation

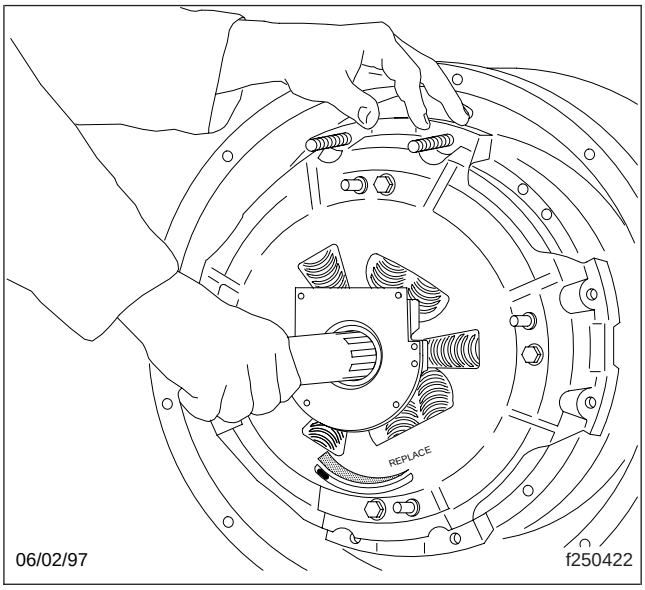


Fig. 42, Positioning the Clutch Cover

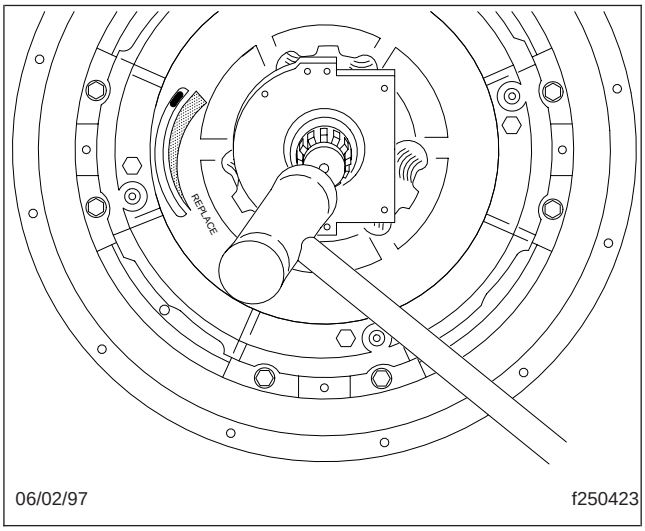


Fig. 43, Tap Aligning Tool

⚠ CAUTION

Failure to tighten these bolts in this manner can: prevent the clutch cover from centering into the pilot area of the flywheel; cause the clutch assembly to be out-of-balance with the flywheel; cause permanent damage to the clutch cover.

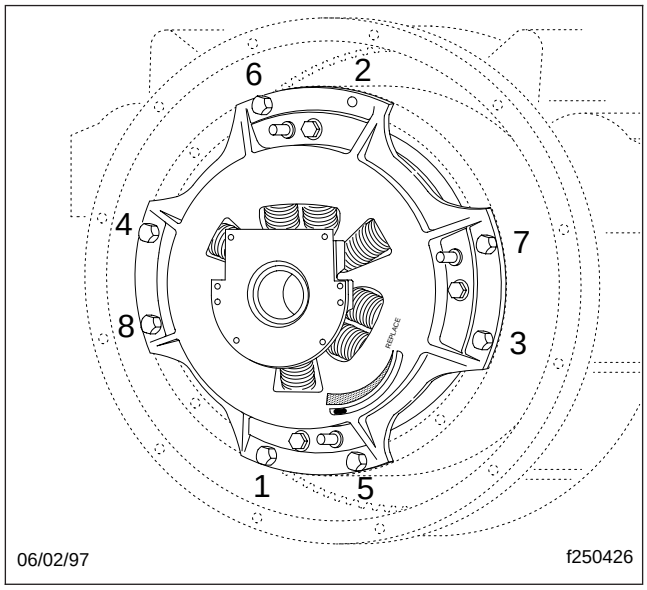


Fig. 44, Tightening Sequence

12. Remove, in a crisscross pattern, the four yellow colored shipping bolts from the clutch cover. See **Fig. 45**.

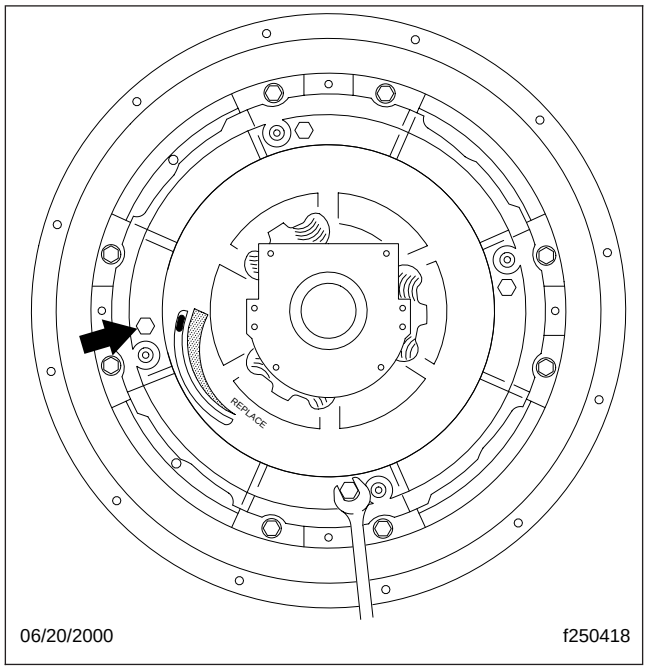


Fig. 45, Remove the Shipping Bolts

NOTE: If this is a new clutch, save these four yellow colored shipping bolts. These bolts will

be needed in the future to both remove and re-install the clutch.

13. Remove the aligning tool; this may require a tap with a mallet.

NOTE: Do not be concerned if the release-bearing housing touches the clutch cover.

14. Set the positive separator pins:

    14.1 Locate the pin access holes. See **Fig. 46**.

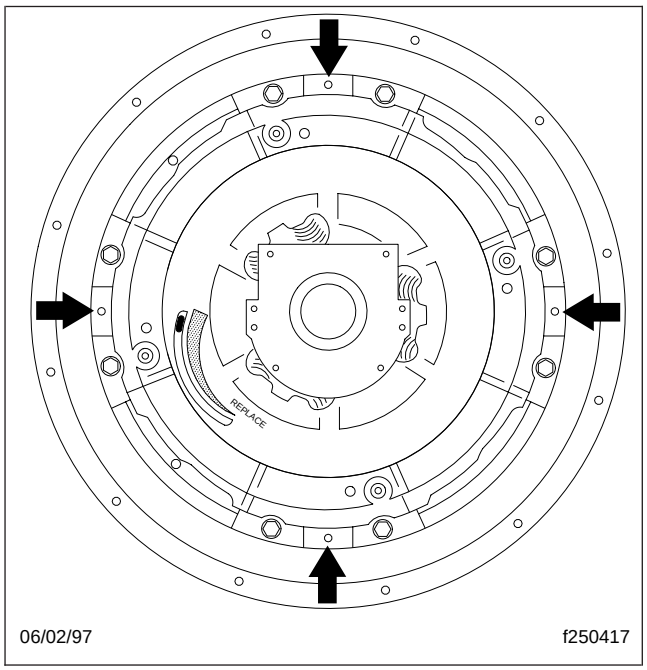


Fig. 46, Pin Access Holes

⚠ 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.

    14.2 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. 47**.

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.

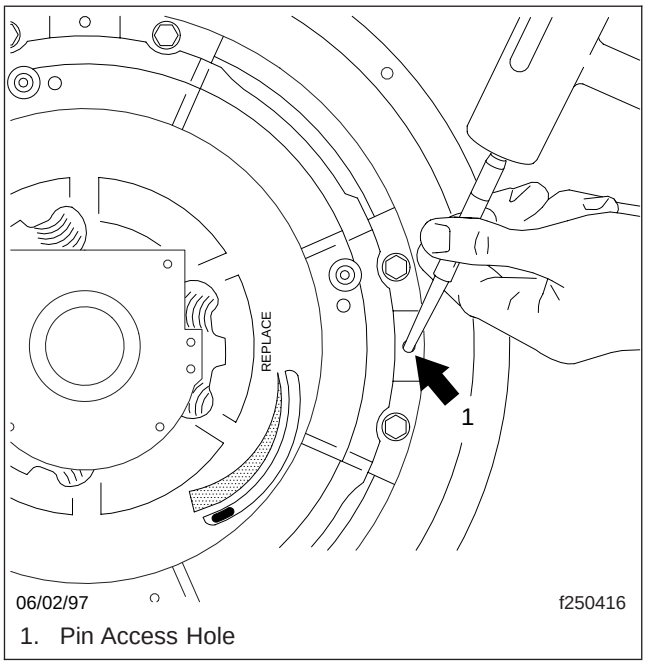


Fig. 47, Tapping the Pin

15. Using a clean cloth, remove all grease from the input shaft.

16. Install the clutch brake on the transmission input shaft, as shown in **Fig. 48**. Slide it tight against the input shaft bearing cap.

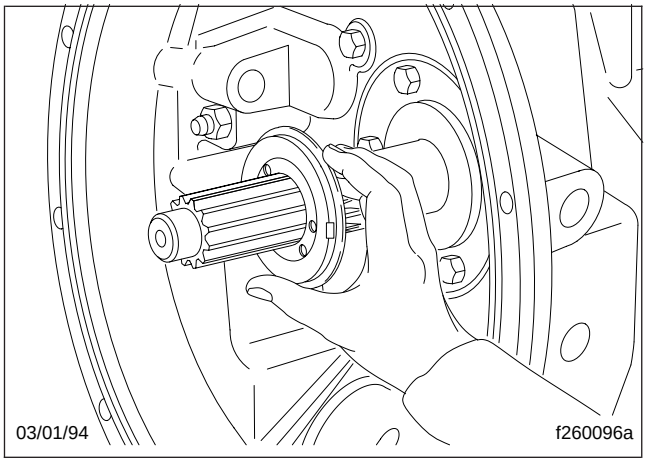


Fig. 48, Install the Clutch Brake

Clutch Installation

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 a Spicer transmission, install the larger face toward the transmission; when installing it on a Fuller transmission, install the smaller face toward the transmission.

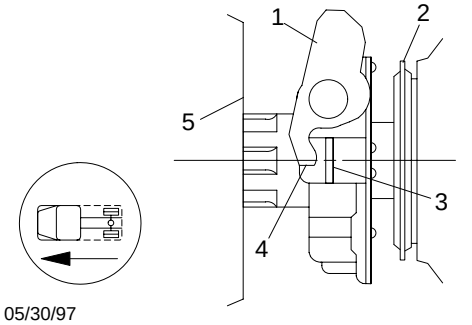
17. Shift the transmission into gear so that during assembly the transmission input shaft can be rotated into line with the clutch driven-disc hub splines.
18. Install the transmission and attach the clutch linkage. For instructions, see **Group 26** in this manual.

⚠ CAUTION

Avoid springing the driven discs when the transmission is being installed. Do not excessively force the transmission into the clutch assembly or engine housing. If it doesn't enter freely, investigate the cause of the problem and then make any necessary changes. Don't let the transmission drop or hang unsupported in the driven discs. if this should occur, the rear disc will become bent or distorted, causing the clutch to drag (won't release).

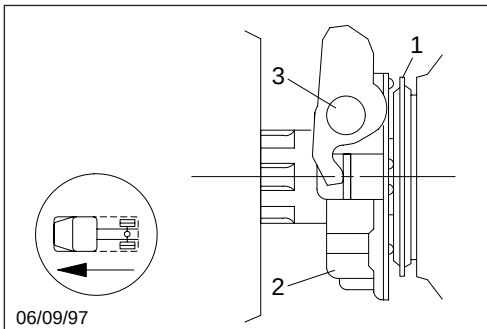
IMPORTANT: Be sure the release-bearing yoke clears the bearing, and is rotated over the wear pads as the transmission is moved forward. See **Fig. 11**. Align the splines by turning the transmission output shaft.

19. Adjust the clutch linkage until the fingers of the release yoke contact the release-bearing wear pads. You should have zero free play at the clutch pedal when this step has been completed. See **Fig. 49**.
20. Fully depress the clutch pedal a minimum of five times. As a result, the clutch pedal will establish free play. If no free play is achieved, investigate the linkage system to determine what (if anything) is preventing the linkage from being fully stroked.
21. If necessary, repeat the previous two steps until the release-bearing squeezes the clutch brake. See **Fig. 50**. This release-bearing to clutch brake contact will ensure that the clutch is adjusted, and the linkage is capable of pulling the bearing far enough to obtain clutch brake squeeze.



1. Release Yoke (Clutch Pedal in Up Position)
2. Clutch Brake
3. Wear Pad
4. Yoke Finger
5. Clutch Cover

Fig. 49, Zero the Clutch Free Play

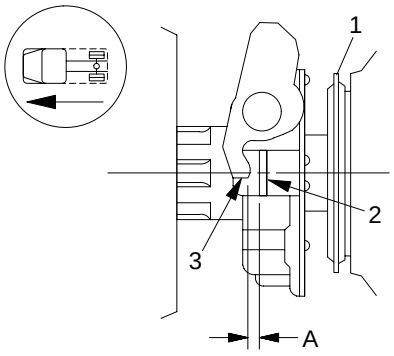


1. Clutch Brake
2. Release-Bearing
3. Cross Shaft

Fig. 50, Clutch Brake Squeeze

NOTE: Instead of performing the previous three steps above, there is an alternative technique to ensure that the clutch is adjusted. Completion of the following technique will require an adequate amount of clearance surrounding the cross shaft release lever. This alternative technique proceeds as follows: position a pipe or similar tool over the cross shaft release lever and rotate it until the release-bearing comes to a complete stop against the clutch brake. See **Fig. 50**. Repeat this procedure a minimum of five times.

22. Readjust the clutch linkage until you obtain a 1/8-inch (3.2-mm) measure of free play between the release yoke fingers and the release-bearing wear pads. See **Fig. 51**. This will result in the correct amount of free play at the clutch pedal.



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A. Free Travel: 1/8 inch (3.2 mm)
1. Clutch Brake
2. Wear Pad
3. Finger

Fig. 51, Adjust Free Travel

NOTE: The free play may increase, then stabilize during the break-in period.

23. Verify that the clutch brake is being squeezed approximately 1/2 to 1 inch (12.7 to 25.4 mm) from the bottom of the clutch pedal stroke. If you cannot obtain any clutch brake squeeze, you will need to increase the overall clutch pedal travel. To do this, use the adjustable pedal stop. Again, readjust the linkage to obtain a 1/8-inch (3.2-mm) measure of free travel.
24. Lubricate the release-bearing and cross-shaft bushings. For instructions and recommended lubricants, see Group 25 in the vehicle maintenance manual.

INSTALLING A SPICER SOLO MEDIUM-DUTY 1401 CLUTCH

NOTE: Do the pre-installation checks in this subject before installing the clutch.

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 cause damage to the pilot bearing.

NOTE: Spicer Clutch strongly recommends the use of of a premium grade pilot bearing. The operating temperatures that the pilot bearing sees has increased in the last several years. This creates operating conditions that are no longer acceptable to the standard pilot bearings and grease. In addition, the life of the clutch has increased. Failure of a pilot bearing usually results in a warranty claim for a clutch drag or clutch noise.

⚠ WARNING

Before proceeding to the next step, see the label on the shipping box to verify that the clutch's maximum torque rating is greater than the engine's peak torque rating. Premature failure (a slipping clutch) will occur if the engine's torque rating exceeds that of the clutch.

2. If the clutch is new, and if a protective coating has been applied to the surface of the pressure plate, remove the protective coating from the pressure plate.
3. If not already in place, install two 3/8–16 by 3-inch guide studs in the two upper mounting holes (the 11 and 1 o'clock positions) of the flywheel. See **Fig. 52**.
4. Insert an aligning tool through the splines (**Fig. 53**) of the driven disc. Together, insert the aligning tool and the driven disc into the pilot bearing. Be sure the side marked *PRESSURE PLATE SIDE* faces the pressure plate.
5. With the aligning tool still in place, slide the cover assembly over the aligning tool and the two guide studs. See **Fig. 54**.
6. Start six 3/8-16 grade 5 or better mounting capscrews in the cover plate. Tighten them snugly. Remove the guide studs. Install the two remaining 3/8-16 mounting capscrews. Then, following the sequence in **Fig. 55**, progressively tighten the capscrews 41 to 47 N·m (30 to 35 lbf·ft).

Clutch Installation

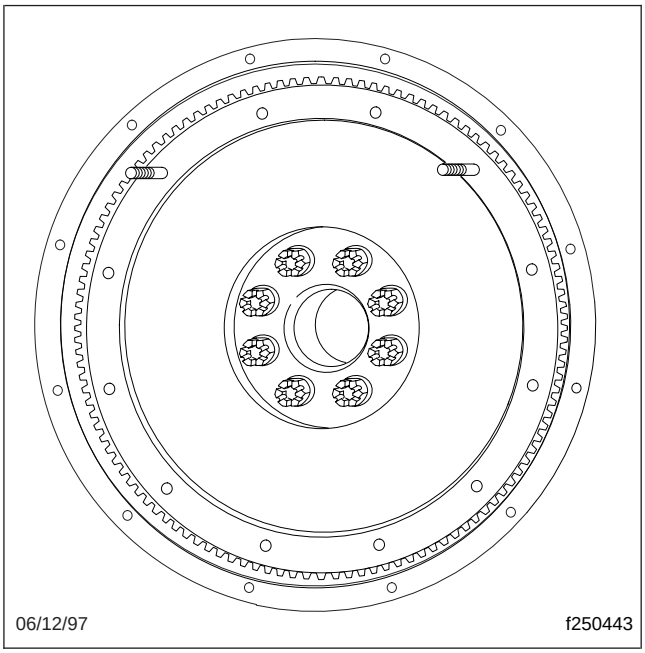


Fig. 52, Install the Guide Studs

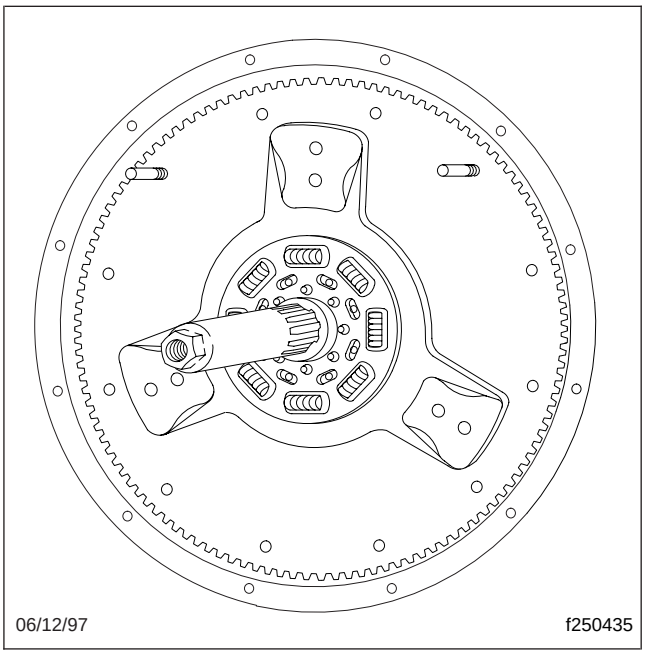


Fig. 53, Position the Driven Disc

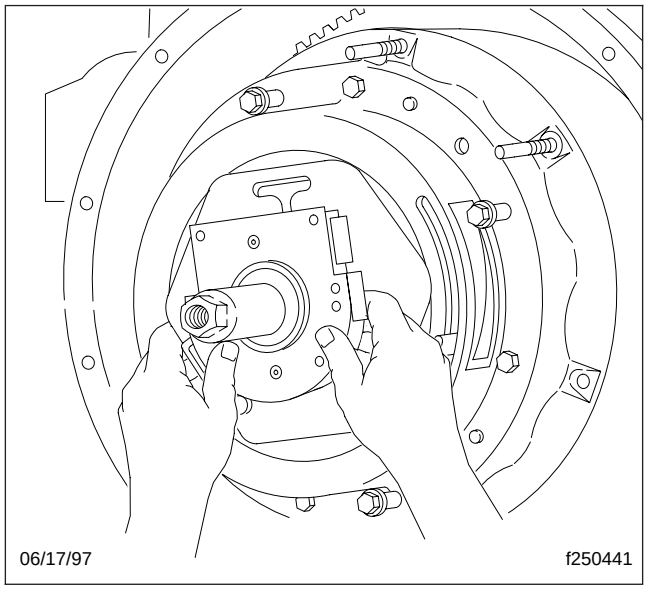


Fig. 54, Positioning the Clutch Cover

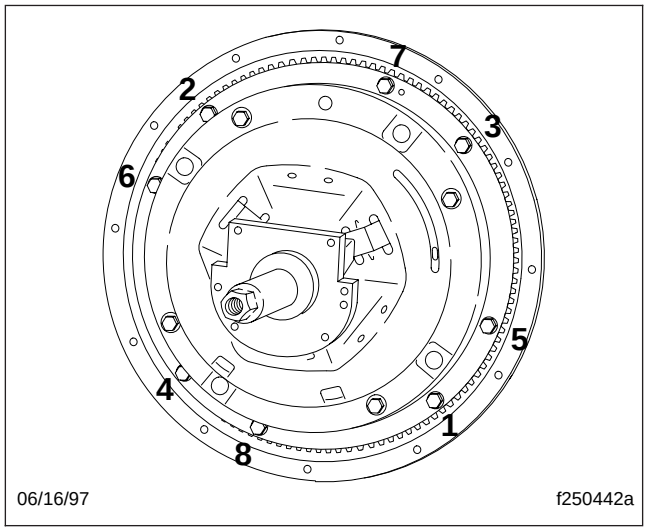


Fig. 55, Tightening Sequence

⚠ CAUTION

If the capscrews are not tightened in the sequence shown, clutch damage and an out-of-balance condition may result.

7. Using a 9/16-inch socket, remove the four yellow colored shipping bolts in a crisscross pattern from the clutch cover. See **Fig. 56**.

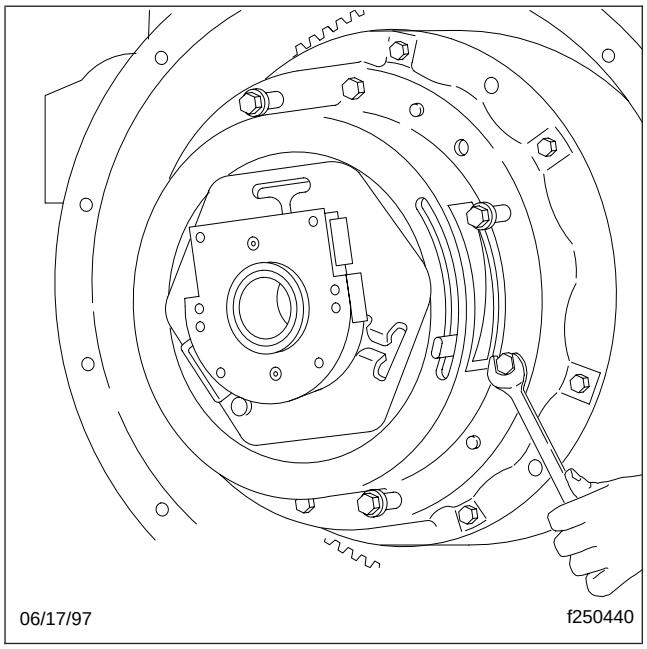


Fig. 56, Remove the Shipping Bolts

NOTE: Save the four shipping bolts for future use. Should the clutch ever need to be removed and re-installed, the shipping bolts will need to be re-installed before the clutch is removed.

8. Remove the alignment tool.
9. Using a clean cloth, remove all grease from the input shaft.
10. Install the clutch brake on the transmission input shaft. Slide it tight against the input shaft bearing cap. This step only applies to non-synchronized transmissions that use a clutch brake.

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 a Spicer transmission, install the larger face toward the transmission; when installing it on a Fuller transmission, install the smaller face toward the transmission.

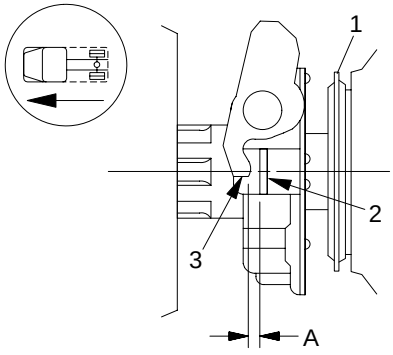
11. Shift the transmission into gear so that during assembly the transmission input shaft can be rotated into line with the clutch driven-disc hub splines.
12. Install the transmission. For instructions, see **Group 26** in this manual.

⚠ CAUTION

Avoid springing the driven disc when the transmission is being installed. Do not excessively force the transmission into the clutch assembly or engine housing. If it doesn't enter freely, investigate the cause of the problem and then make any necessary changes. Don't let the transmission drop or hang unsupported in the driven disc. if this should occur, the driven disc will become bent or distorted, causing the clutch to drag (won't release).

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. 11**. Align the splines by turning the transmission output shaft. Also, do not use the cross shaft release lever to pull the transmission into its final position. Doing so may cause the Spicer Solo clutch to over adjust in its new environment.

13. 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. Performing this will ensure that the Spicer Solo clutch is adjusted.
14. Reconnect and adjust clutch linkage system. See **Fig. 57**.



A. Free Travel: 1/8 inch (3.2 mm)
1. Clutch Brake
2. Wear Pad
3. Finger

Fig. 57, Adjust Free Travel

15. This step only applies to non-synchronized transmissions with a clutch brake. Verify that the clutch brake is being squeezed approximately 1/2 to 1 inch (12.7 to 25.4 mm) from the bottom of the clutch pedal stroke. If you cannot obtain any clutch pedal squeeze, you will need to increase the over all clutch pedal travel. To do this, use the adjustable pedal stop. After the proper clutch pedal squeeze is obtained, re-adjust the clutch linkage free travel.
16. Lubricate the release bearing and the cross shaft bushings. For instructions and recommended lubricants, see Group 25 in the vehicle maintenance manual.

INSTALLING A SPICER SOLO MEDIUM-DUTY 1402 CLUTCH

NOTE: Do the pre-installation checks in this subject before installing the clutch.

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 cause damage to the pilot bearing.

NOTE: Spicer Clutch strongly recommends the use of of a premium grade pilot bearing. The operating temperatures that the pilot bearing sees has increased in the last several years. This creates operating conditions that are no longer acceptable to the standard pilot bearings and grease. In addition, the life of the clutch has increased. Failure of a pilot bearing usually results in a warranty claim for a clutch drag or clutch noise.

⚠ WARNING

Before proceeding to the next step, see the label on the shipping box to verify that the clutch's maximum torque rating is greater than the engine's peak torque rating. Premature failure (a slipping clutch) will occur if the engine's torque rating exceeds that of the clutch.

2. If the clutch is new, and if a protective coating has been applied to the surface of the pressure plate, remove the protective coating from the pressure plate.
3. If not already in place, install two 3/8–16 by 3-inch guide studs in the two upper mounting holes (the 11 and 1 o'clock positions) of the flywheel. See **Fig. 58**.

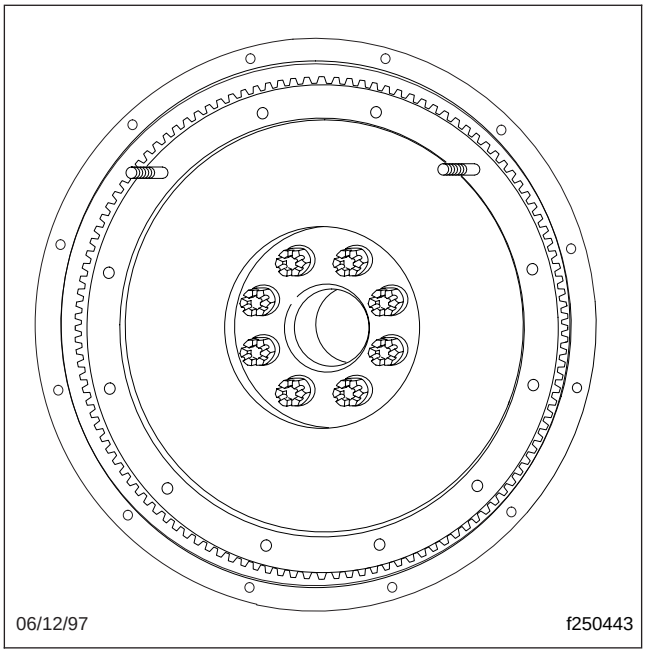


Fig. 58, Install the Guide Studs

4. Insert an aligning tool through the splines of the front driven disc. Together, insert the aligning tool and the front driven disc into the pilot bearing. See **Fig. 59**. Be sure the side marked *FLYWHEEL SIDE* faces the flywheel.
5. Install the intermediate plate assembly over the two guide studs and slide it forward until it touches the flywheel. Make sure the side marked *PRESSURE PLATE SIDE* faces the pressure plate. See **Fig. 60**.

IMPORTANT: The drivestraps of the intermediate plate must face the pressure plate.

6. Remove the aligning tool and install it through the splines of the rear driven disc. Now, together, insert the aligning tool and the rear driven disc through the front driven disc and also through the pilot bearing bearing. See **Fig. 61**. Be sure

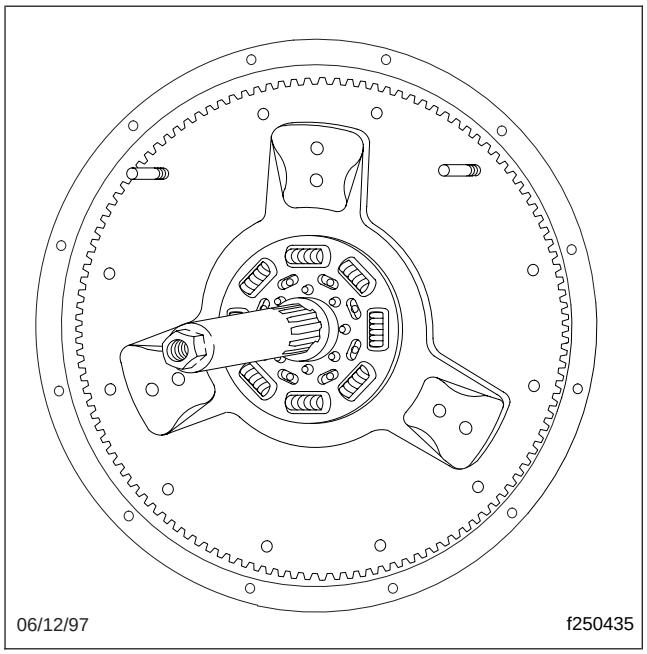


Fig. 59, Position the Front Driven Disc

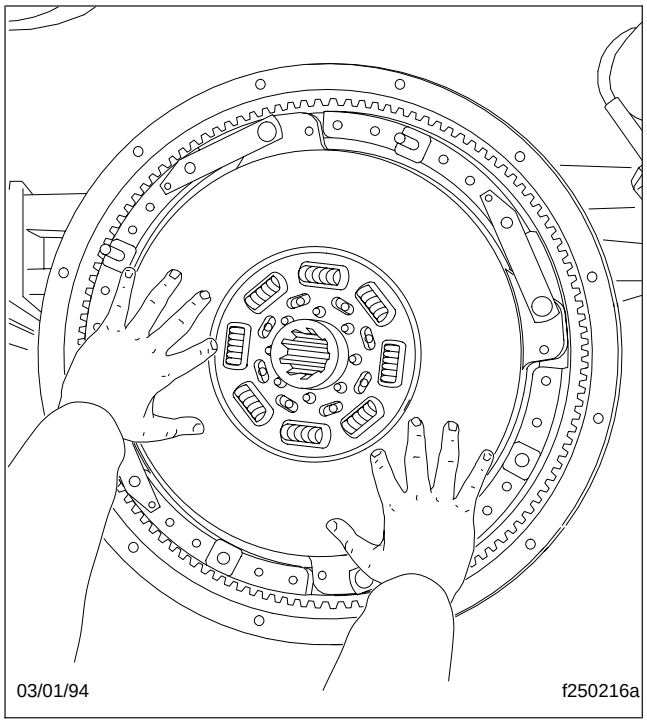


Fig. 60, Install the Intermediate Plate

the side of the rear disc marked *PRESSURE PLATE SIDE* faces the pressure plate. As you complete this step, ensure that the ceramic buttons align with each other as closely as possible. See **Fig. 62**. Doing so will aid the function of the positive separator pins.

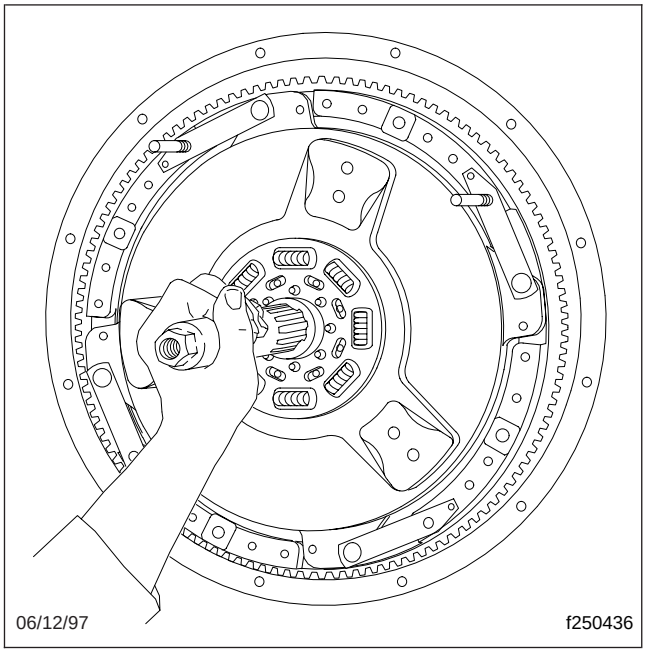
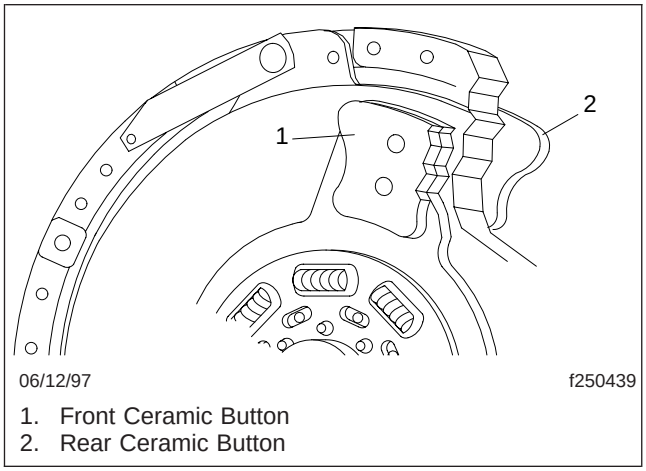


Fig. 61, Position the Rear Driven Disc



1. Front Ceramic Button
2. Rear Ceramic Button

Fig. 62, Driven Disc Alignment

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. 63**.

Clutch Installation

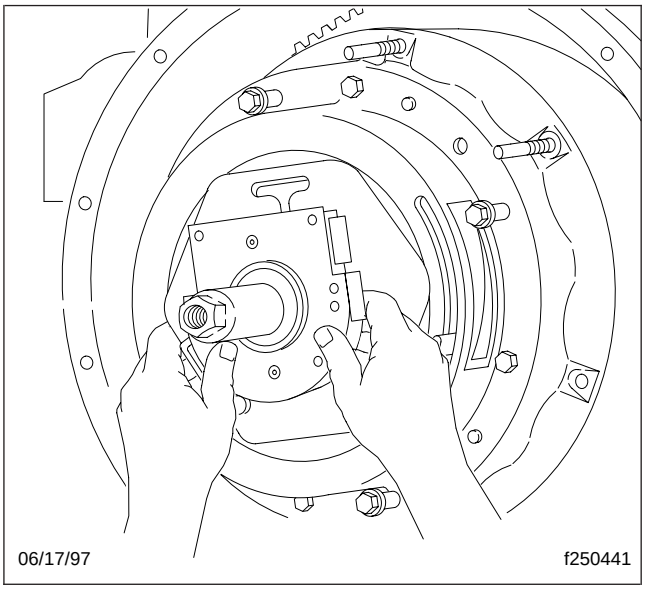


Fig. 63, Position the Clutch Cover

8. Start six 3/8-16 grade 5 or better mounting capscrews in the cover plate. Tighten them snugly. Remove the guide studs. Install the two remaining 3/8-16 mounting capscrews. Then, following the sequence in **Fig. 64**, progressively tighten the capscrews 30 to 35 lbf·ft (41 to 47 N·m).

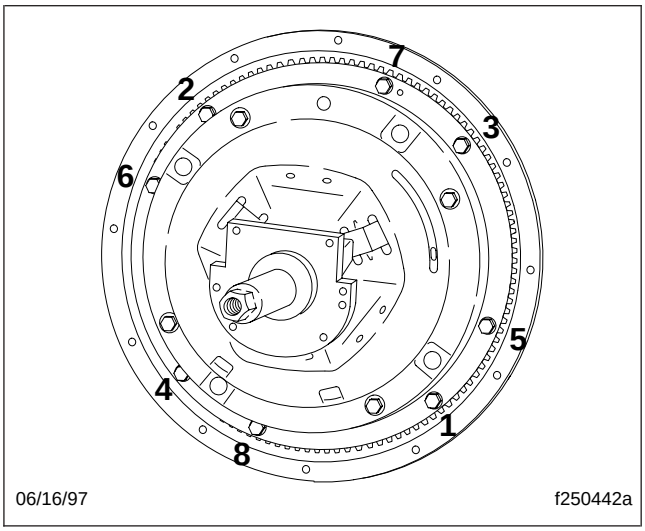


Fig. 64, Tightening Sequence

CAUTION

If the capscrews are not tightened in the sequence shown, clutch damage and an out-of-balance condition may result.

9. Using a 9/16-inch socket, remove the four yellow colored shipping bolts in a crisscross pattern from the clutch cover. See **Fig. 65**.

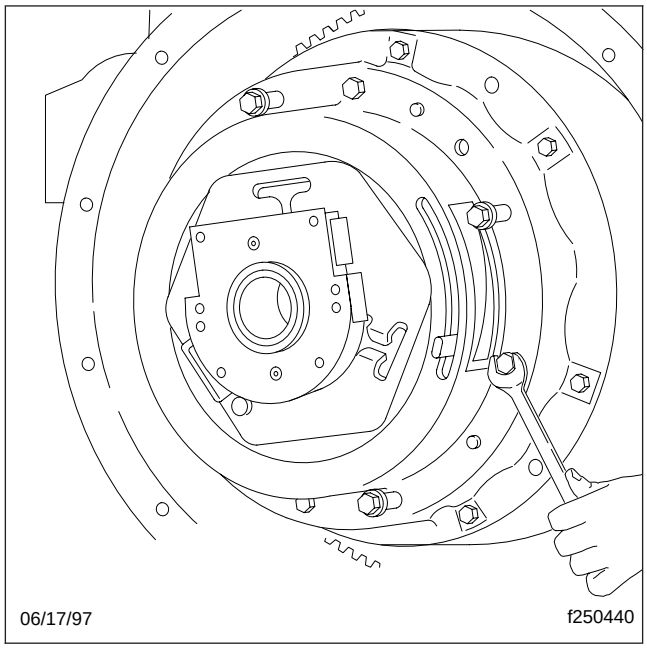


Fig. 65, Remove the Shipping Bolts

NOTE: Save the four shipping bolts for future use. Should the clutch ever need to be removed and re-installed, the shipping bolts will need to be re-installed before the clutch is removed.

10. Remove the alignment tool.

11. Set the positive separator pins:

    11.1 Locate the positive separator pin access holes. See **Fig. 66**.

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.

    11.2 Lightly tap the four positive separator pins, role pins, through the access holes of the

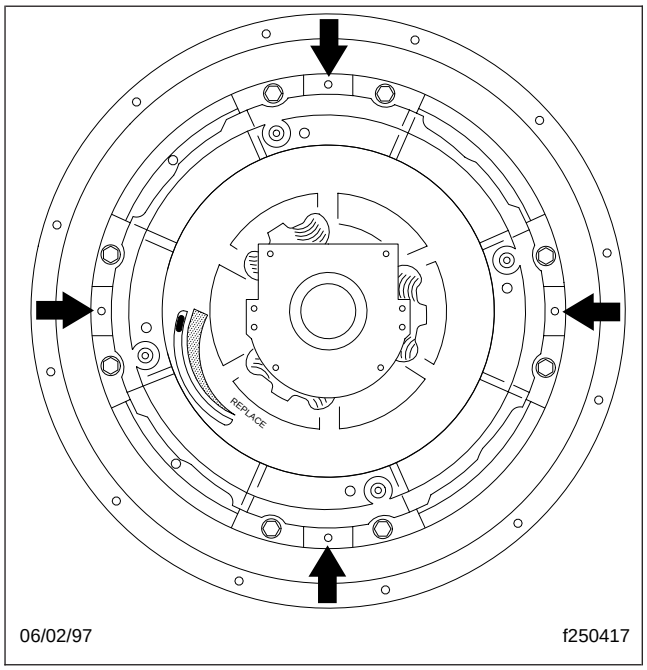


Fig. 66, Pin Access Holes

clutch cover. Do this using a light weight hammer (approximately twelve oz.) and a 1/4-inch (6-mm) flat nose punch. See **Fig. 67**. Performing this step will ensure that all four role pins are against the flywheel, thus allowing an equal gap on all sides of the intermediate plate during clutch disengagement.

⚠ CAUTION

Notice that only a small portion of the roll pin is visible through the access hole. Consequently, the roll pins can become damaged if struck with excessive force. See Fig. 68.

12. Using a clean cloth, remove all grease from the input shaft.
13. Install the clutch brake on the transmission input shaft. Slide it tight against the input shaft bearing cap. This step only applies to non-synchronized transmissions that use a clutch brake.

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 a Spicer transmission, install the larger face toward the transmission; when installing it on a Fuller transmission, install the smaller face toward the transmission.

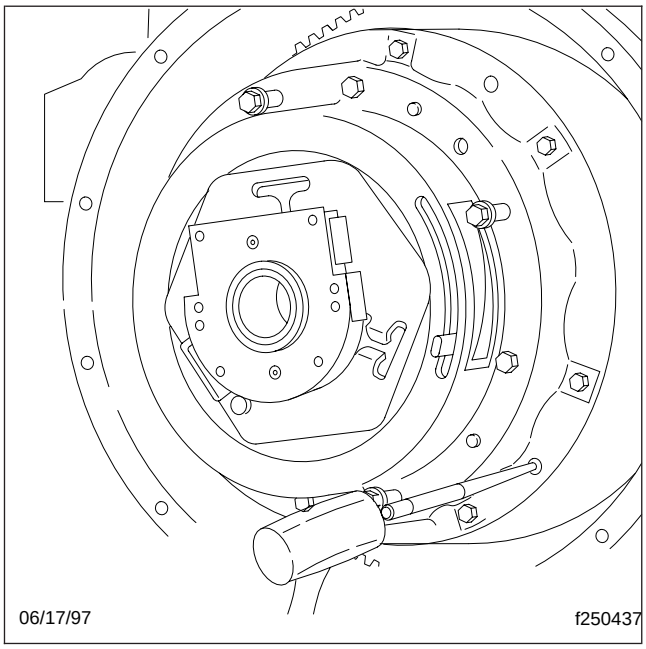
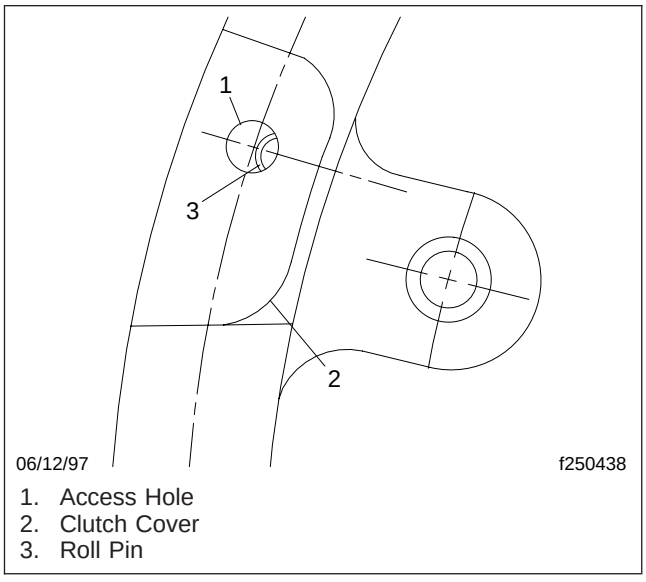


Fig. 67, Setting Positive Separator Pin



1. Access Hole
2. Clutch Cover
3. Roll Pin

Fig. 68, Positive Separator Pin

Clutch Installation

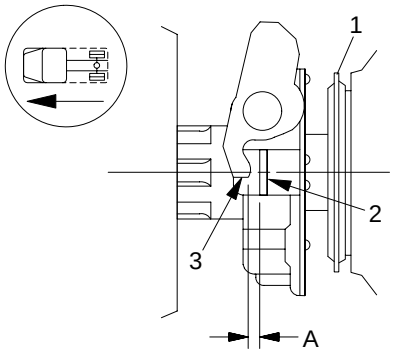
14. Shift the transmission into gear so that during assembly the transmission input shaft can be rotated into line with the clutch driven-disc hub splines.
15. Install the transmission. For instructions, see **Group 26** in this manual.

⚠ CAUTION

Avoid springing the driven disc when the transmission is being installed. Do not excessively force the transmission into the clutch assembly or engine housing. If it doesn't enter freely, investigate the cause of the problem and then make any necessary changes. Don't let the transmission drop or hang unsupported in the driven disc. if this should occur, the driven disc will become bent or distorted, causing the clutch to drag (won't release).

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. 11**. Align the splines by turning the transmission output shaft. Also, do not use the cross shaft release lever to pull the transmission into its final position. Doing so may cause the Spicer Solo clutch to over adjust in its new environment.

16. 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. Performing this will ensure that the Spicer Solo clutch is adjusted.
17. Reconnect and adjust clutch linkage system. See **Fig. 69**.
18. This step only applies to non-synchronized transmissions with a clutch brake. Verify that the clutch brake is being squeezed approximately 1/2 to 1 inch (12.7 to 25.4 mm) from the bottom of the clutch pedal stroke. If you cannot obtain any clutch pedal squeeze, you will need to increase the over all clutch pedal travel. To do this, use the adjustable pedal stop. After the proper clutch pedal squeeze is obtained, re-adjust the linkage free travel.
19. Lubricate the release bearing and the cross shaft bushings. For instructions and recommended lubricants, see Group 25 in the vehicle maintenance manual.



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A. Free Travel: 1/8 inch (3.2 mm)
1. Clutch Brake
2. Wear Pad
3. Finger

Fig. 69, Adjust Free Travel

Troubleshooting Tables

Problem—Poor Clutch Release

Problem—Poor Clutch Release	
Possible Cause	**Remedy**
The intermediate plate is sticking on drive lugs due to cocked drive pins (Easy-Pedal & Angle Spring only).	The drive pins must be ninety degrees square to the flywheel surface with a 0.006-inch (1.524-mm) minimum clearance between drive pins and intermediate plate slots.
The pressure plate is not fully retracting (Easy-Pedal & Angle Spring only).	Check the pressure plate return springs for being bent, stretched, or broken. Note: These springs can be replaced through the inspection opening of the transmission. Transmission removal is not necessary.
The release bearing travel is excessive and is causing the lever to contact the pressure plate (Easy-Pedal & Angle Spring only).	Adjust the release bearing travel from 1/2 to 9/16 inch (12.7 to 14.3 mm).
Incorrect clutch pedal height.	Set the clutch pedal height so you can obtain: 1/2 to 9/16 inch (12.7 to 14.3 mm) release bearing travel; 1/8 inch (3.175 mm) free travel at the release yoke; 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 spacer ring and the intermediate plate assembly were bolted up backwards onto the flywheel (Solo and Angle-Spring 1402 only).	If the clutch cover has already been bolted to the flywheel, it is important that it be replaced with a new intermediate plate assembly. The reason is that permanent damage may have occurred to the drivestraps and spacer ring. Also, thoroughly inspect the clutch cover for any damage and replace it if damaged.
The intermediate plate and or pressure plate is either cracked or broken.	Replaced any damaged parts
A side loading condition exists; the cross shafts protrude through the release yoke.	Check for protruding cross shafts.
A side loading condition exists; the release yoke fingers are bent.	Install a new release yoke.
A side loading condition exists; the engine housing to transmission housing are misaligned.	Check for loose transmission mounting bolts. Tighten the transmission mounting bolts to the proper torque.
A side loading condition exists; the clutch linkage is set up improperly.	Thoroughly examine the clutch linkage to determine if it can be contributing to a side loading condition.
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.

Troubleshooting

Problem—Poor Clutch Release	
Possible Cause	**Remedy**
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.
The pilot bearing is dry or damaged.	Replace the pilot bearing.
The three anti-rattle springs are not installed (Easy-Pedal and Angle-Spring super duty clutches only).	Always install the new anti-rattle spring package with each 14-inch super duty clutch.
The three anti-rattle springs were installed backwards (Easy-Pedal and Angle-Spring super duty clutches only).	Install the anti-rattle springs so the rounded sections are pointed toward the flywheel/engine.
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.
The clutch brake is damaged and/or not functioning.	Install a new clutch brake.
The input shaft spline is coated with grease, never seize, etc..	The input shaft spline should be clean and dry before installation.
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 on the internal workings of the clutch cover (dirt, chaff, salt, etc.).	Remove the foreign material and make sure the transmission inspection hole cover is installed.

Problem—Rattling/Noisy Clutch

Problem—Rattling/Noisy Clutch	
Possible Cause	**Remedy**
There is excessive flywheel runout.	Repair or replace the flywheel. Consult the engine manufacturer’s service 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.
An over stroking condition exists, the bridge of the release yoke is hitting the clutch cover.	Check for a worn, broken or missing clutch brake. Also, check the release yoke and input shaft retainer 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 transmission inspection hole cover is not installed.	Re-install the transmission inspection hole cover.

Problem—Rattling/Noisy Clutch	
Possible Cause	**Remedy**
The anti-rattle springs are not installed (Easy-Pedal and Angle-Spring super duty clutches only).	Always install the new anti-rattle spring package with each 14-inch super duty clutch.
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 itself is rattling excessively.	Clean, lubricate and reassemble or replace missing/worn parts.
An idle gear rattle is coming from the transmission.	Specify driven disc assemblies which feature the Free-Travel design. Check the engine for correct idle speed. Consult the engine manufacturer's service manual.
Resulting from the wrong clutch installation, the dampener 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 & Angle-Spring only).	Adjust the clutch internally (via the adjusting ring).

Problem—Vibrating Clutch

Problem—Vibrating Clutch	
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.
Improper phasing of the driveshaft.	Investigate for correct yoke phasing.
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.	See the engine manufacturer's service manual.
There is excessive flywheel runout	Repair or replace the flywheel. Consult the engine manufacturer's service manual.
The rivets of the rear driven disc are interfering with the retainer assembly (Easy-Pedal & Angle-Spring clutches only).	Adjust the clutch internally (via the adjusting ring).

Troubleshooting

Problem—Clutch Needs Frequent Adjustments

Problem—Clutch Needs Frequent Adjustments	
Possible Cause	**Remedy**
The clutch linkage 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 an 1/8 inch (3.2) free travel (the distance between the release yoke fingers and the release bearing wear pads).
The clutch application is incorrect.	If a service clutch, determine whether the clutch is properly specified for the vehicle's particular application.
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.
The crankshaft has excessive end play.	Consult the engine manufacturer's service manual.

Problem—Clutch Slippage

Problem—Clutch Slippage	
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 vehicle's particular 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.	Check and deter the driver from riding the clutch pedal.
The input shaft spline is worn.	Replace the input shaft.

Problem—Clutch Grabs/Chatters

Problem—Clutch Grabs/Chatters	
Possible Cause	**Remedy**
The clutch is worn out.	Replace 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.

Spicer 14 and 15-1/2 Inch Standard and Super-Duty Clutch Specifications		
Description	**14-Inch Clutch**	**15-1/2 Inch Clutch**
	inch (mm)	
Flywheel-Housing Pilot Diameter	14.750/14.747 (374.65/374.5738)	17.156/17.15 (435.7624/435.6862)
Flywheel-Housing Bolt Circle	15.500 (393.7)	16.62 (422.275)
Flywheel Pot Depth	2-15/16 (74.6125)	Flat
Driven Disc and Facing Thickness	0.463/0.42 (11.7602/10.8712)	0.487/0.45 (12.3698/11.4808)
Disc Assembly, Maximum Runout	0.015 (0.381)	0.015 (0.381)
Driven Disc Assembly, Maximum Out of Flat	0.020 (0.508)	0.020 (0.508)
Hub Spline Size (inches [mm], number of splines)	1-3/4 (44.45) -10	1-3/4 (44.45) -10
	2 (50.8) -10	2 (50.8) -10
Release-Sleeve Bushing Diameter (new)	1.754/1.750 (44.5516/44.45)	1.754/1.750 (44.5516/44.45)
	2.010/2.008 (51.054/51.0032)	2.010/2.008 (51.054/51.0032)
Intermediate Plates, Driving Pins to Slot Clearance (minimum new/maximum worn)	0.006/0.020 (0.1524/0.508)	0.006/0.020 (0.1524/0.508)
Pressure Plates, Driving Lugs to Slot Clearance (new/maximum worn)	0.004-0.008/0.020 (0.1016-0.2032/0.508)	0.003-0.010/0.021 (0.0762-0.254/0.5334)
Intermediate Plates and Pressure Plates: Out of Flat	0.000-0.004 (0.000-0.1016) Concave	0.000-0.004 (0.000-0.1016) Concave
Scoring: Maximum Depth That Can Be Re-Used	0.015 (0.381)	0.015 (0.381)
Release Sleeve Retainer, Driving Lugs to Slot Clearance (maximum worn)	0.020 (0.508)	0.020 (0.508)

Table 1, Spicer 14 and 15-1/2 Inch Standard and Super-Duty Clutch Specifications

Spicer Solo Heavy-Duty Clutch Specifications					
Spicer Solo Part Number	**Size inch (mm)**	**Spline Size inch (mm)**	**Damper Style**	**Springs**	**Paddles**
109700–91	15.5 (394)	2 (50.8)	Low Rate	9	6
109701–82	15.5 (394)	2 (50.8)	Low Rate	7	4
109701–74	15.5 (394)	2 (50.8)	Coax F.T.	10	4
109701–93	15.5 (394)	2 (50.8)	Coax F.T.	10	6
109701–10	15.5 (394)	2 (50.8)	Vibration Control Technology V.C.T.-Low Rate	6	6
109701–15	15.5 (394)	2 (50.8)	Vibration Control Technology V.C.T.-Low Rate	6	6

Table 2, Spicer Solo Heavy-Duty Clutch Specifications

Specifications

Spicer Solo Medium-Duty Clutch Specifications					
Spicer Solo Model Number	**Size inch (mm)**	**Spline Size inch (mm)**	**Disc(s)**	**Stroke**	**Linkage**
1401	14 (350)	1-3/4 (44.45)	Single	Standard	Mechanical
1401	14 (350)	1-3/4 (44.45)	Single	Short	Hydraulic
1402	14 (350)	1-3/4 (44.45)	Two	Standard	Mechanical
1402	14 (350)	2 (50.8)	Two	Short	Hydraulic

Table 3, Spicer Solo Medium-Duty Clutch Specifications

Spicer Easy-Pedal Clutch Specifications		
Description	**14-Inch Clutch**	**15-1/2 Inch Clutch**
	inch (mm)	
Driven Disc and Facing Thickness (new):		
Disc and Ceramic Facing—Standard	0.445 to 0.455 (11.303 to 11.557)	0.445 to 0.455 (11.303 to 11.557)
Disc and Ceramic Facing—Super Duty	0.355 to 0.365 (9.017 to 9.271)	—
Disc and Organic Facing	0.440 to 0.460 (11.176 to 11.684)	0.440 to 0.460 (11.176 to 11.684)
Intermediate Plate Thickness (new):		
Standard	0.6250 to 0.6300 (15.875 to 16.002)	0.7570 to 0.7620 (19.2278 to 19.3548)
Super Duty	0.8050 to 0.8100 (20.447 to 20.574)	—
14-Inch—Flat Flywheel	0.8050 to 0.8100 (20.447 to 20.547)	—
Driven Disc Assembly:		
Maximum Out-of-Flat	0.050 (1.27)	
Pressure Plate; Driving Lugs to Slot Clearance (maximum worn; minimum new)	0.200 to 0.003 (5.08 to 0.0762)	
Pin Separator Gap (new)	—	0.023 to 0.037 (0.5842 to 0.9398)

Table 4, Spicer Easy-Pedal Clutch Specifications

Spicer Easy-Pedal Clutch Capacity; Spring Color Codes			
Clutch Size	**Spring Color Code**	**Facing**	**Recommended Maximum Engine Torque lbf·ft (N·m)**
14 Inch (350 mm)	Red	Organic	820 (1112)
	Red	Ceramic (3 buttons)	1000 (1356)
	Plain	Organic	1000 (1356)
	Red	Super-Duty Ceramic (4 buttons)	1250 (1695)
	Plain	Super-Duty Ceramic (4 buttons)	1400 (1898)
	Yellow	Organic	1150 (1559)
15-1/2 Inch (394 mm)	Red	Organic	940 (1274)
	Red	Ceramic	1200 (1627)
	Plain	Organic	1070 (1451)
	Plain	Ceramic	1400 (1898)
	Yellow	Organic	1250 (1695)
	Yellow	Ceramic	1650 (2237)
	White	Organic	1400 (1898)
	White	Organic (10-spring)	1450 (1966)

Table 5, Spicer Easy-Pedal Clutch Capacity; Spring Color Codes

Spicer Angle-Spring Clutch Capacity; Spring Color Codes			
Clutch Type	**Spring Color Code**	**Facing**	**Recommended Maximum Engine Torque lbf·ft (N·m)**
SAS 1401 (14-inch [350 mm]; single-plate)	Blue	Organic	350 (475)
	Purple	Organic	400 (542)
	Blue	Ceramic	500 (678)
	Purple	Ceramic	560 (759)
SAS 1402 (14-inch [350 mm]; two-plate)	Blue	Organic	560 (759)
	Green	Ceramic	800 (1085)
	Blue	Ceramic	800 (1085)
	Purple	Organic	800 (1085)
	Purple	Ceramic	800 (1085)

Table 6, Spicer Angle-Spring Clutch Capacity; Spring Color Codes

Specifications

Spicer Solo Heavy-Duty 15-1/2 Inch Clutch Capacity			
Spicer Solo Part Number	**Plate Load lbf (N)**	**Torque lbf·ft (N·m)**	**Facing Material**
109700–91	3600 (16013.592)	1650 (2237)	Ceramic
109701–82	3600 (16013.592)	1650 (2237)	Ceramic
109701–74	3600 (16013.592)	1650 (2237)	Ceramic
109701–93	4000 (17792.88)	1860 (2522)	Ceramic
109701–10	4000 (17792.88)	1860 (2522)	Ceramic
109701–15	4000 (17792.88)	2050 (2780)	Ceramic

Table 7, Spicer Solo Heavy-Duty 15-1/2 Inch Clutch Capacity

Spicer Solo Medium-Duty 14 Inch Clutch Capacity			
Spicer Solo Model Number	**Plate Load lbf (N)**	**Torque lbf·ft (N·m)**	**Facing Material**
1401	3000 (13344.66)	680 (920)	Ceramic
1401	2500 (11120.55)	580 (780)	Ceramic
1401	3000 (13344.66)	445 (600)	Organic
1402	2000 (8896.44)	900 (1220)	Ceramic
1402	2800 (12455.016)	800 (1080)	Organic

Table 8, Spicer Solo Medium-Duty 14 Inch Clutch Capacity

Clutch-to-Flywheel Torque Values			
Angle-Spring lbf·ft (N·m)	**Easy-Pedal lbf·ft (N·m)**	**Solo Heavy Duty lbf·ft (N·m)**	**Solo Medium Duty lbf·ft (N·m)**
35–40 (47–54)	45–50 (61–68)	40–50 (54–68)	30–35 (41–47)

Table 9, Clutch-to-Flywheel Torque Values

Clutch Pedal Height Settings			
Release Bearing Travel * inch (mm)	**Release Yoke Free Travel † inch (mm)**	**Initial Release Bearing Travel Adjustment ‡ inch (mm)**	**Clutch Brake Squeeze (Pedal Adjustment) inch (mm)**
1/2 to 9/16 (12.7 to 14.3)	1/8 (3.2)	3/4 (19)	1/2 to 1 (12.7 to 25.4)

* The internal adjustment, the distance between the release bearing and the clutch brake.

† The external adjustment, the distance between the release yoke fingers and the release bearing wear pads.

‡ The distance between the release bearing and the clutch cover, preset before installing transmission.

Table 10, Clutch Adjustments

General Description

Spicer Angle-Ring 13-inch (310 mm) and 14-inch (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 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.

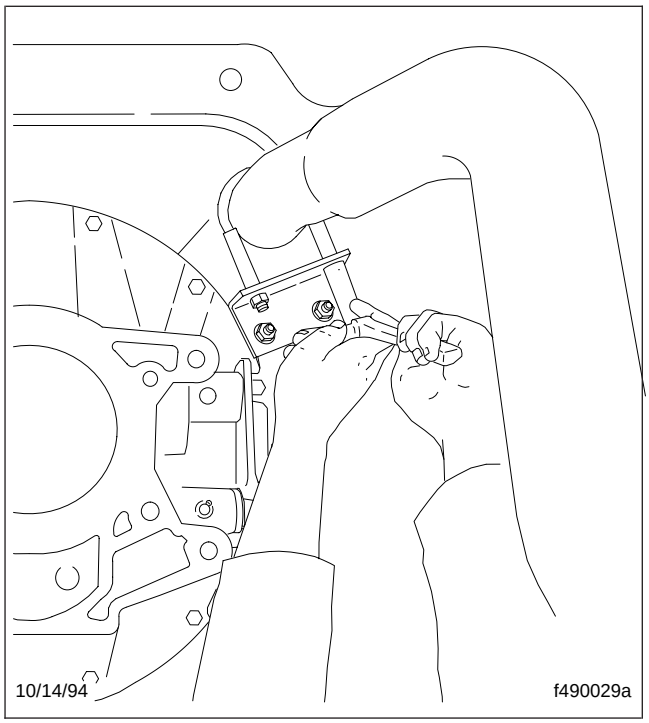


Fig. 1, Exhaust Pipe Support

   - 3.2 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.

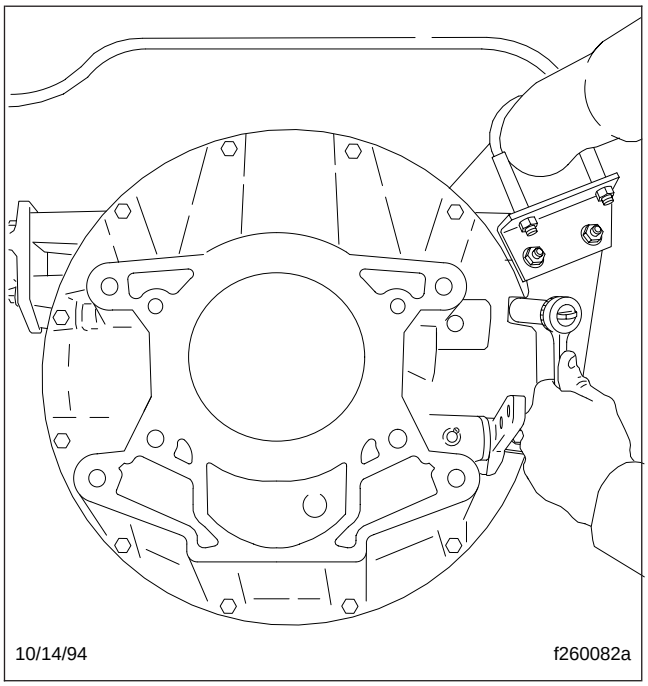


Fig. 2, Bracket Bolts

   - 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 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.

Clutch Removal, Inspection, and Installation

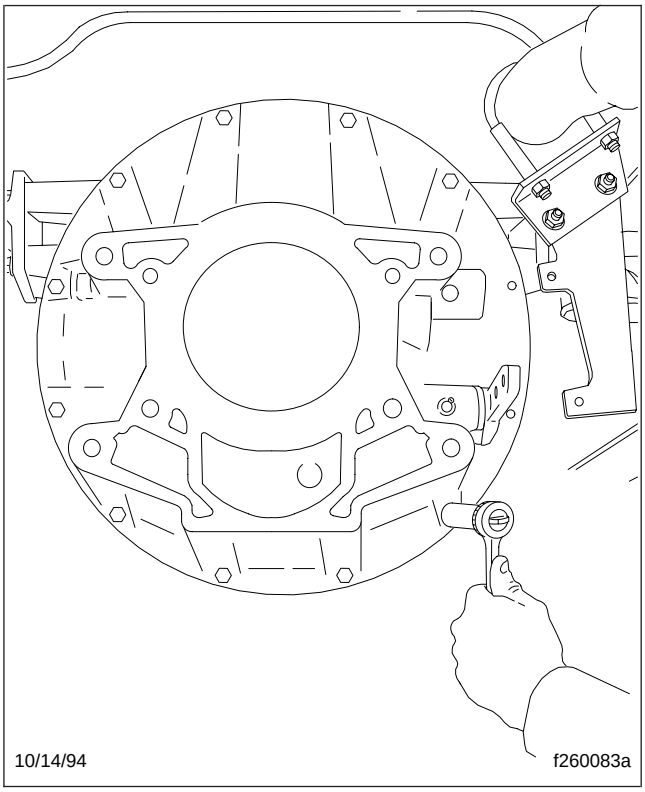


Fig. 3, Bell Housing Capscrews

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 maximum, 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;

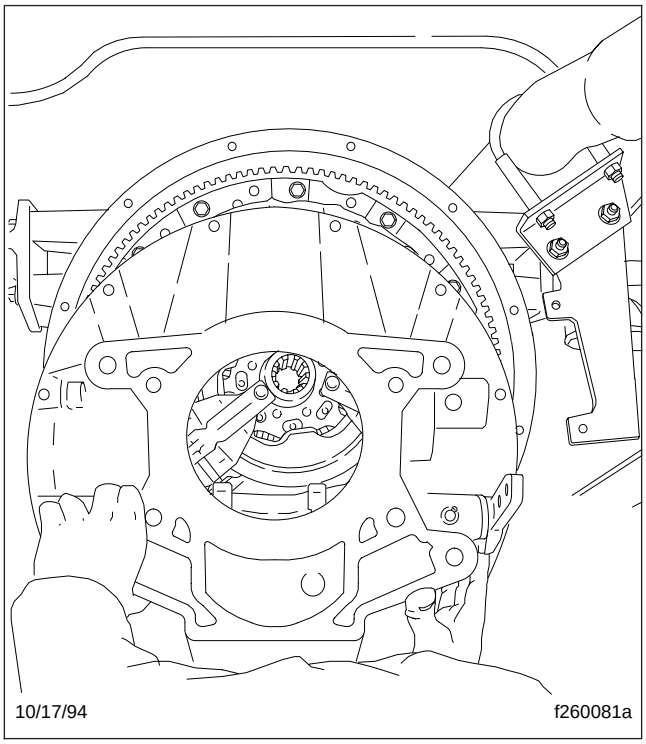


Fig. 4, Lift Off the Housing

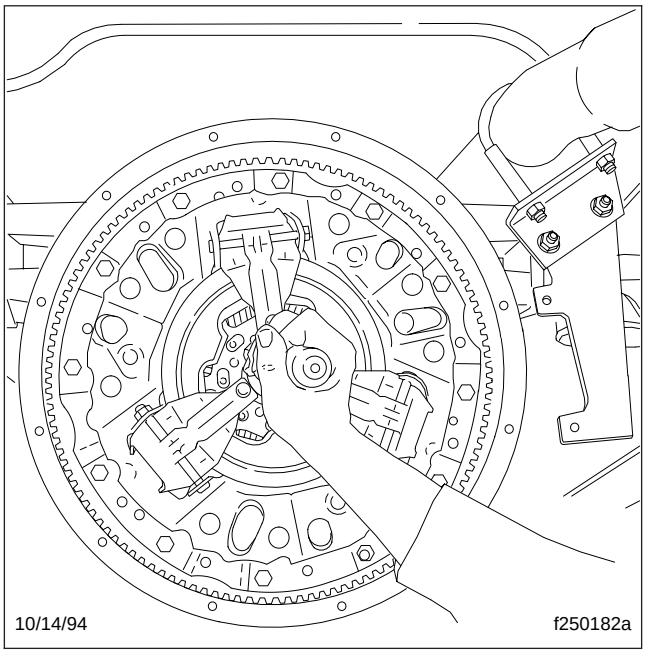


Fig. 5, Pilot Tool Inserted

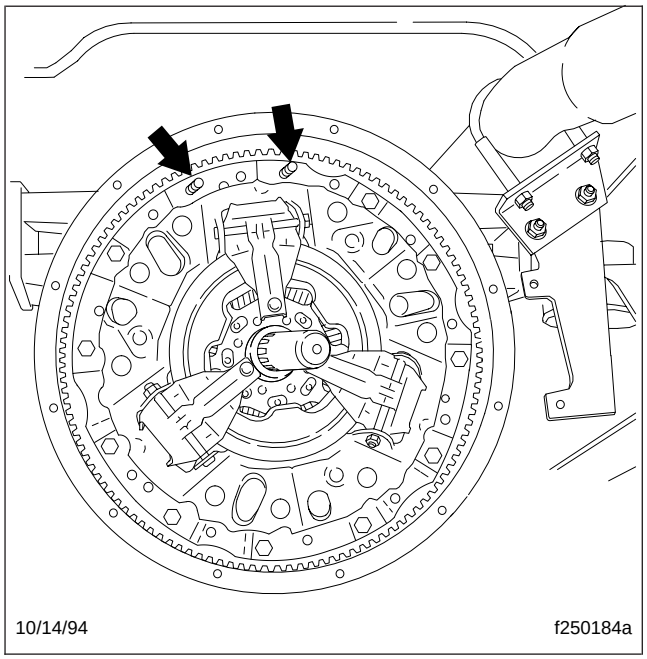


Fig. 6, Dowels Installed

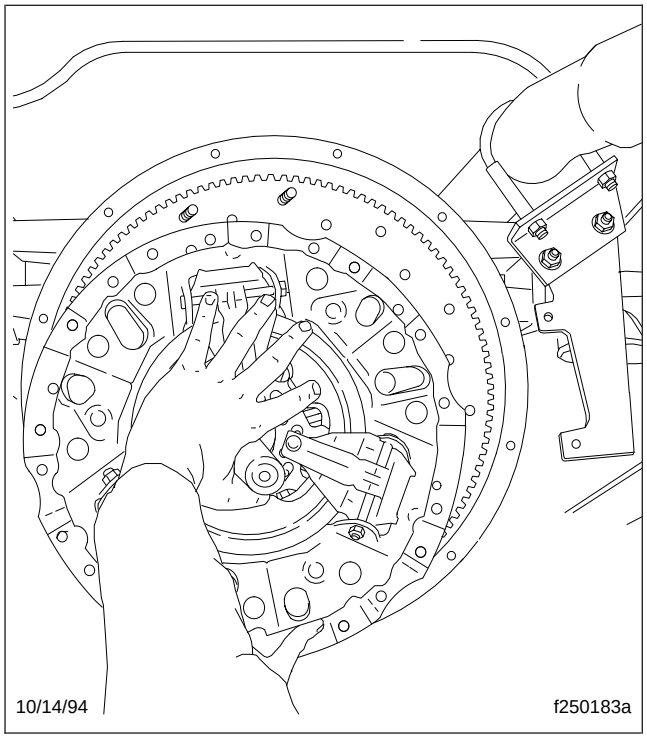


Fig. 7, Removing the Clutch Disc

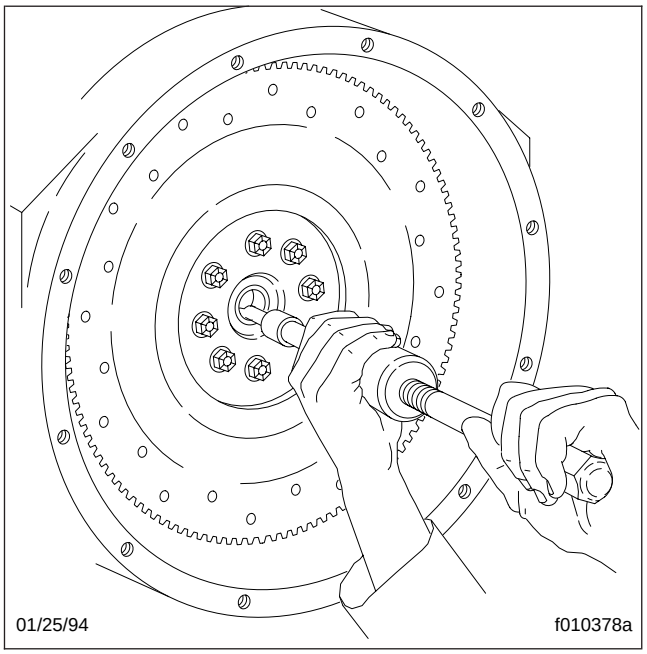
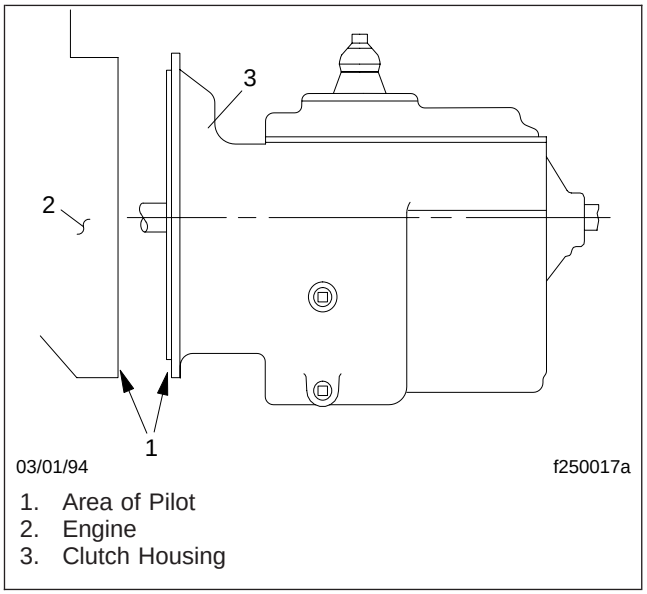


Fig. 8, Remove the Pilot Bearing

replace the part. Wear may first appear between the 3 o'clock and 8 o'clock positions. See **Fig. 10**.

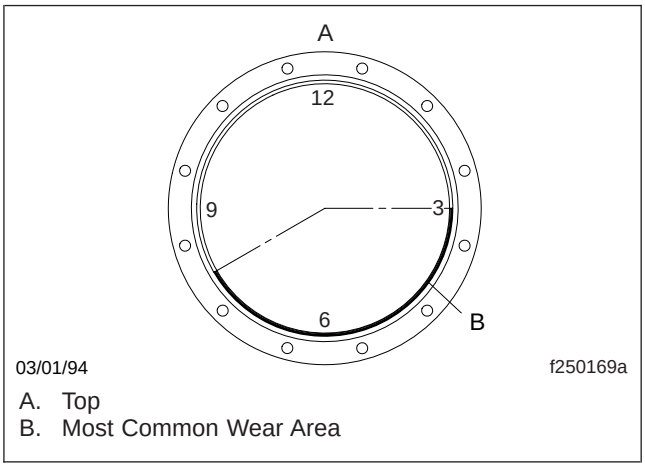


1. Area of Pilot
2. Engine
3. Clutch Housing

Fig. 9, Inspect the Pilot Area

3.1 Measure the runout of the pilot (bore) of the flywheel housing. Secure the dial indi-

Clutch Removal, Inspection, and Installation



A. Top
B. Most Common Wear Area

Fig. 10, Wear Areas

cator 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 0.008 inch (0.2 mm). 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 0.008 inch (0.2 mm). If the readings are higher, replace the housing. For instructions, see the engine manufacturer's service manual.

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 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 0.007 inch (0.18 mm) for the 14-inch (350-mm) clutch and 0.006 inch (0.17 mm) for the 13-inch (310-mm) clutch. If the readings are higher, repair or replace the flywheel. See the engine manufacturer's service manual for instructions.

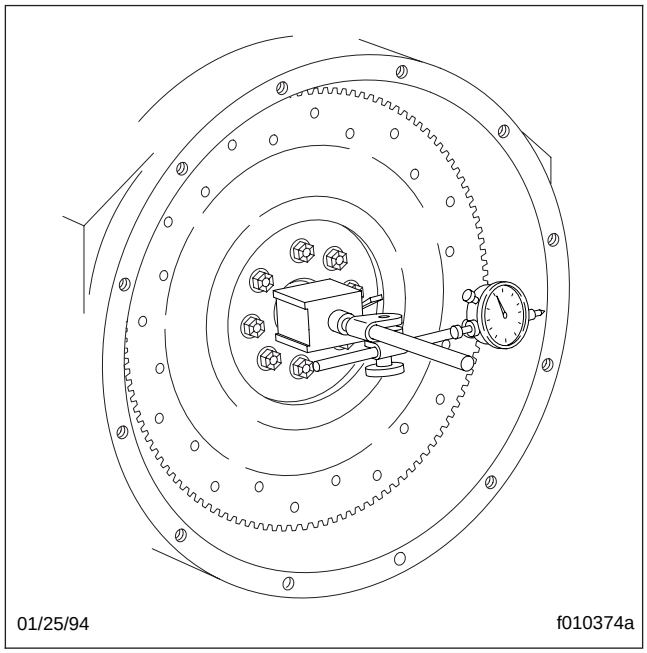
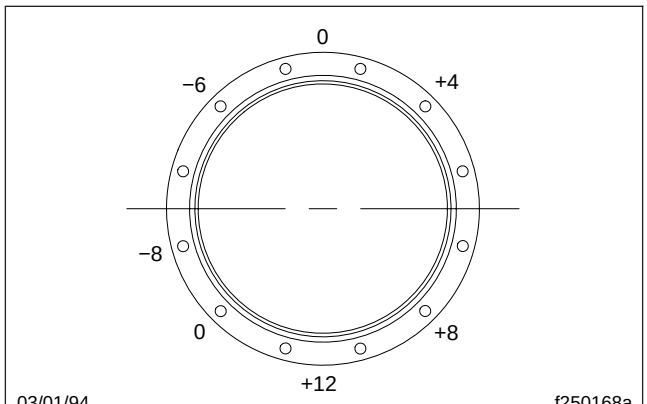


Fig. 11, Dial Indicator in Position



NOTE: Plus 0.012 and minus 0.008 gives the housing a total runout of 0.020.

Fig. 12, Points for Measuring Runout

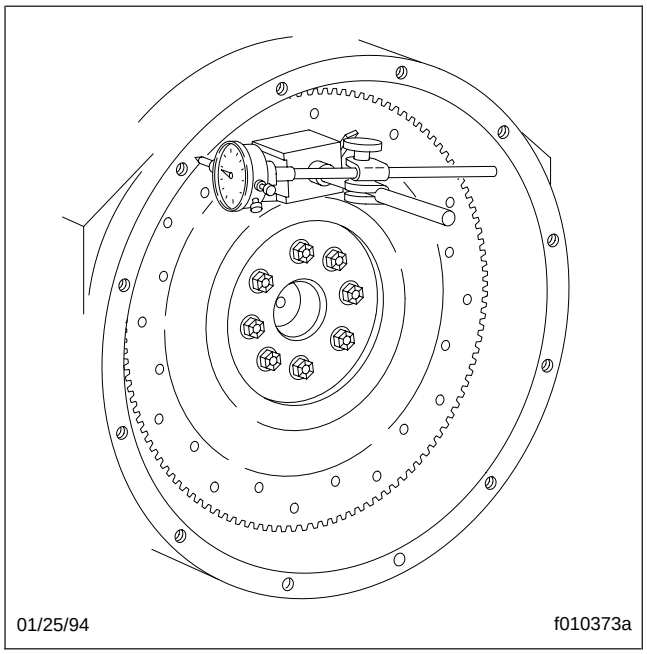


Fig. 13, Dial Indicator for Face Runout

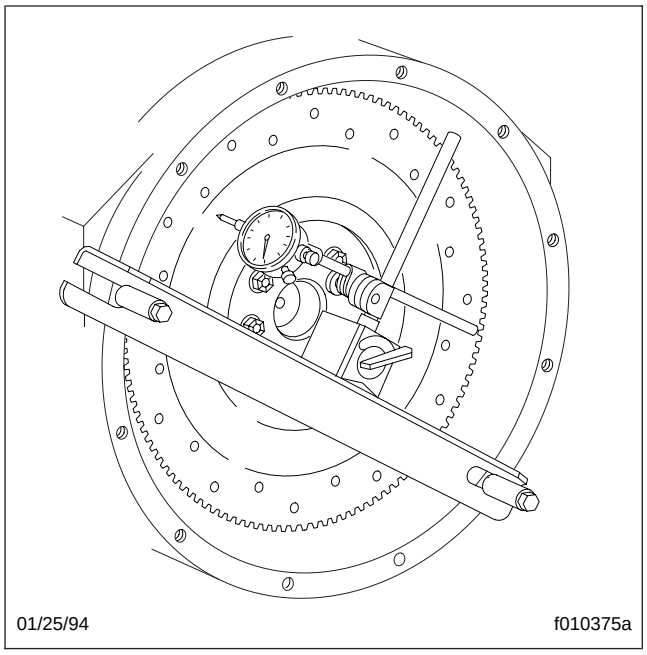


Fig. 14, Measuring Face Runout

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 0.005 inch (0.13 mm). If the readings are higher, see the engine manufacturer's service manual for instructions.

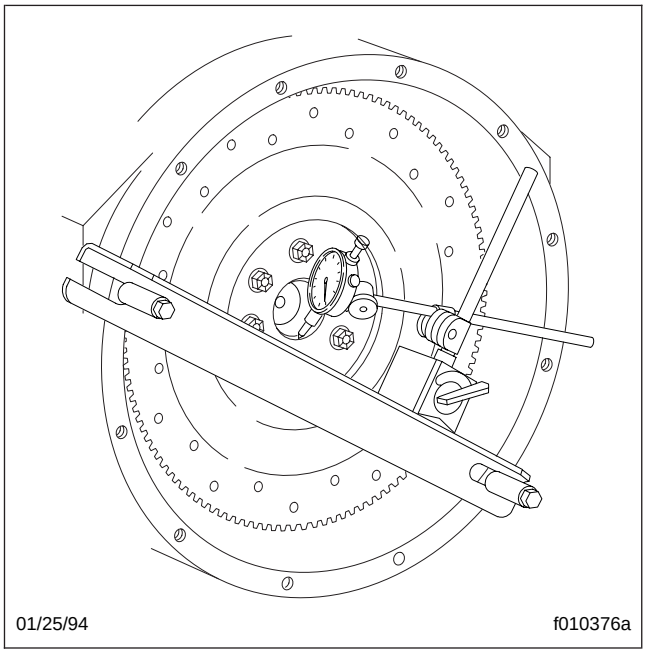


Fig. 15, Measuring Bore Runout

6. Measure the runout of the transmission clutch-housing face and pilot.

   The SAE maximum runout for the clutch-housing face and pilot is 0.008 inch (0.20 mm). If the readings are higher, replace the clutch housing; see the transmission manufacturer's service manual.

⚠ 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**.
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.

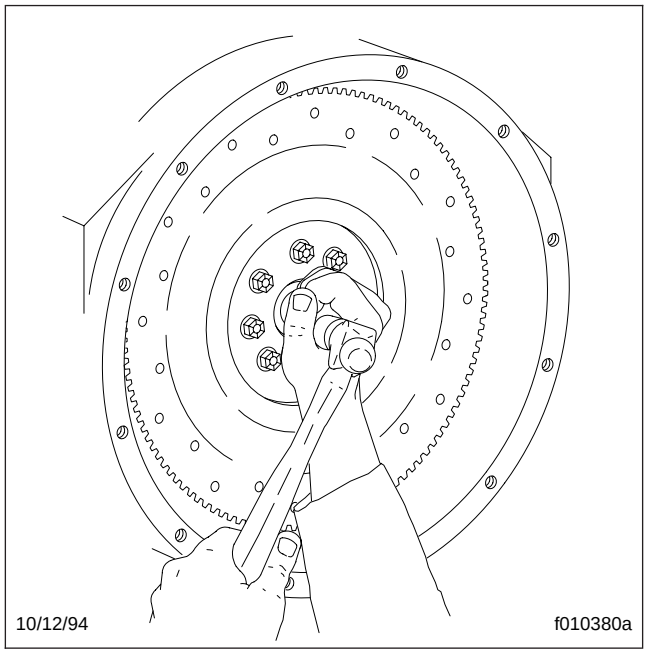


Fig. 16, Pilot Bearing Installation

   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 33 lbf·ft (45 N·m) 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 40 lbf·ft (54 N·m).

NOTE: 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.

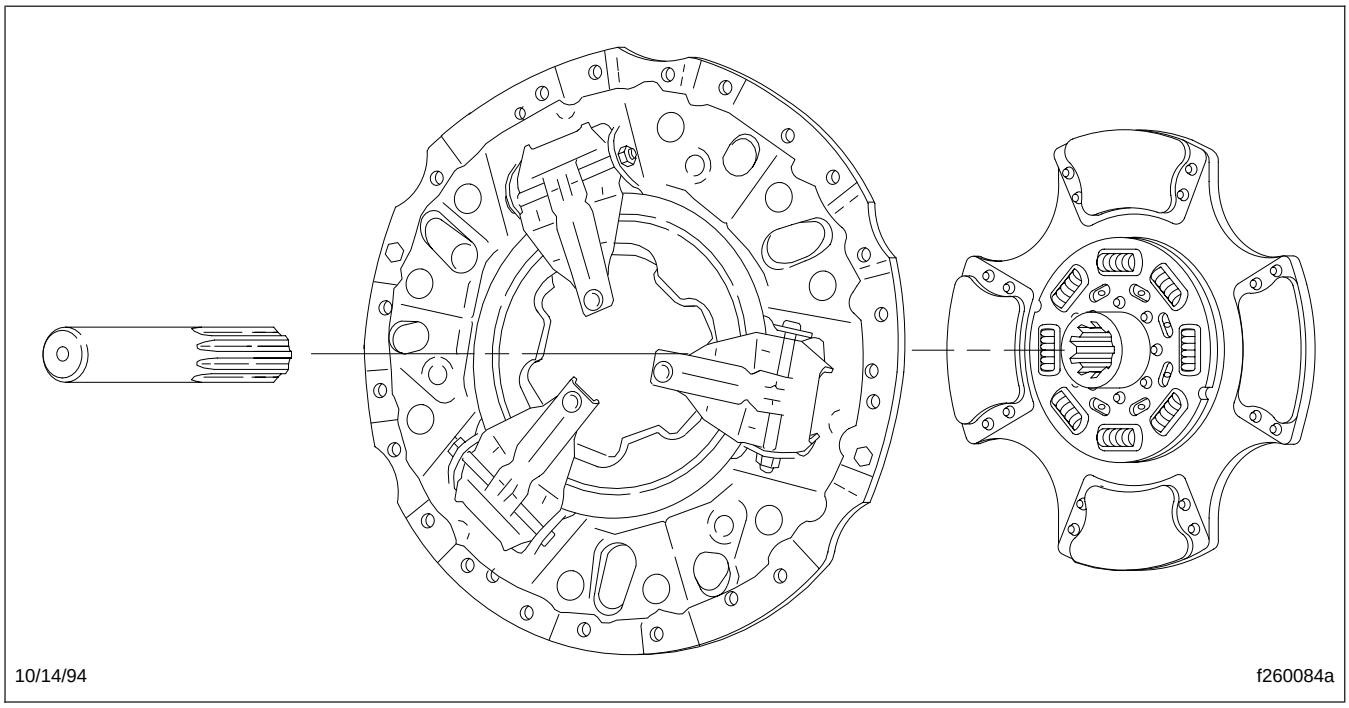


Fig. 17, Clutch Assembly

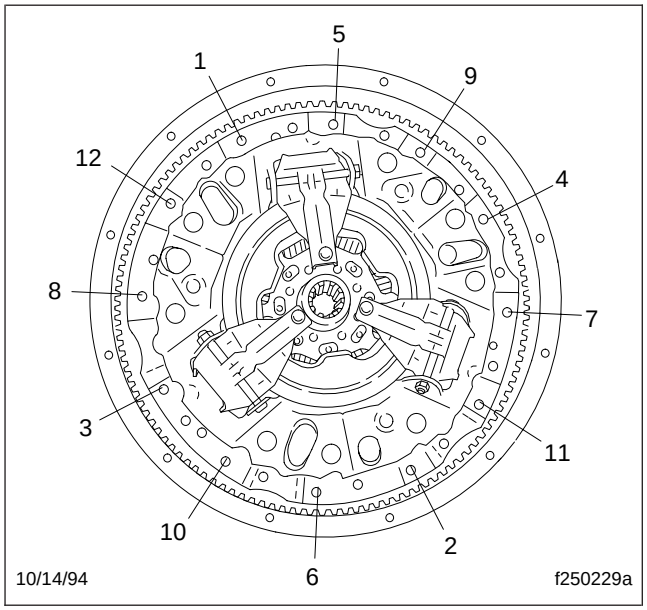


Fig. 18, Torque Sequence

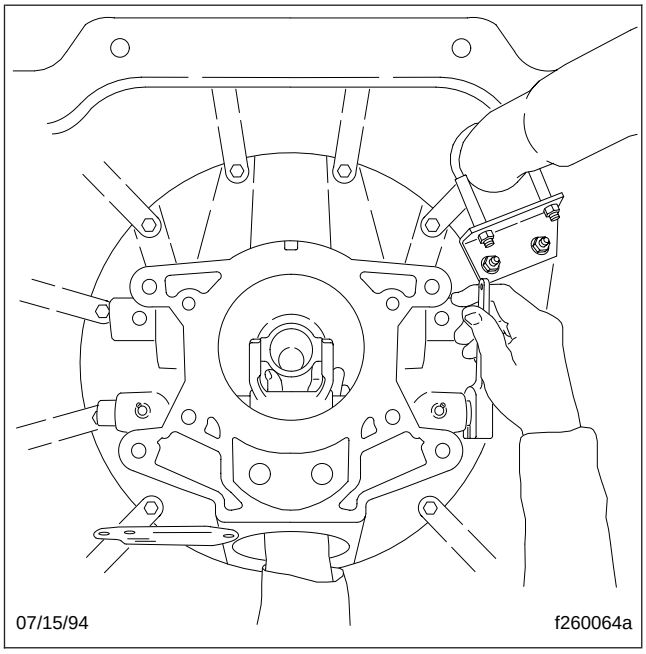


Fig. 19, Position the Release Bearing

Troubleshooting Tables

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

Torque Values		
Description	**Size (inches)**	**Torque lbf·ft (N·m)**
Clutch-to-Flywheel Mounting Bolts	3/8	33 (45)
Transmission-to-Bell Housing Bolts	3/8	40 (54)

Table 1, Torque Values

Spicer Clutch Specifications		
Description	**Clutch Size**	
	310 mm (13 inch)	**350 mm (14 inch)**
Lever Height from Flywheel Surface	2-1/16 inches (52.38 mm)	2-7/16 inches (61.93 mm)
Bolt Circle Diameter	14-5/8 inches (371.47 mm)	15-1/2 inches (393.7 mm)
Rated Plate Load	2400 lbf (10 700 N)	2400 lbf (10 700 N)
Number of Splines	10	10
Spline Diameter	1-1/2 inches (38.1 mm)	1-1/2 inches (38.1 mm)
Driven Disc Facing Material	Ceramic	Ceramic
Facing Thickness (new)	0.400 inch (10.16 mm)	0.400 inch (10.16 mm)
Hub Type	Dampened 6-Spring	Dampened 8-Spring

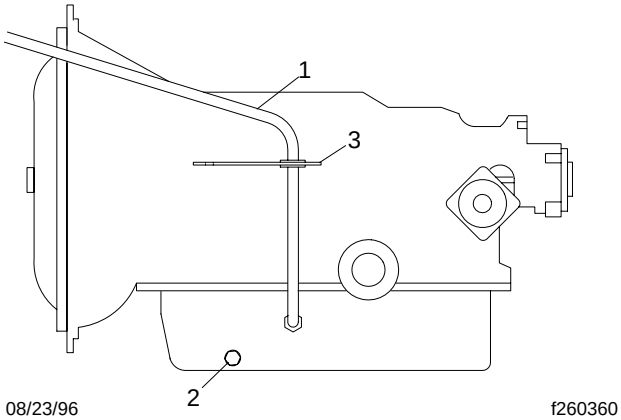
Table 2, Spicer Clutch Specifications

Removal

1. Apply the parking brake, chock the tires, disconnect the batteries, and tilt the cab.

NOTE: For better drainage, do the next step when the transmission is warm.

2. Remove the transmission drain plug and drain the automatic transmission fluid (ATF). See **Fig. 1**. Install the drain plug and tighten it 15 to 20 lbf·ft (20 to 27 N·m).



1. Fill/Dipstick Tube
2. Drain Plug
3. Support Bracket

Fig. 1, Transmission Drain Plug (typical)

NOTE: On Model AT–542 transmissions, the drain plug is located on the right-hand side of the oil pan. On AT–545 and MT transmission models, it is on the left-hand side.

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 driveline 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.

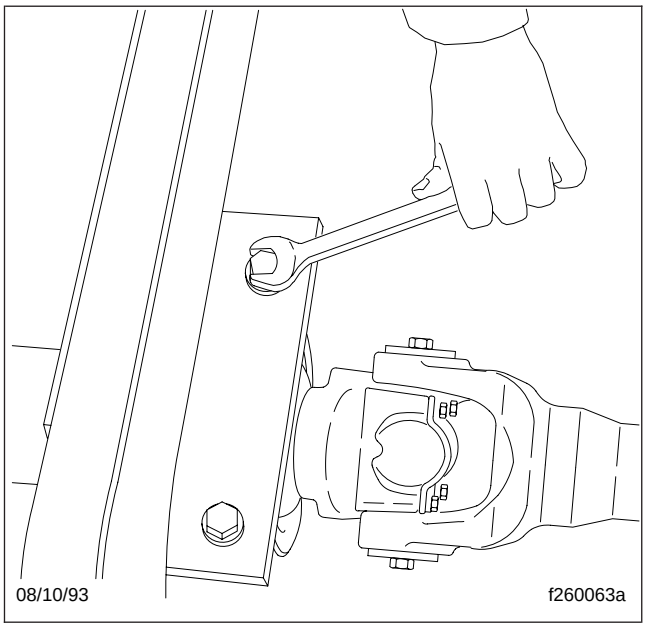


Fig. 2, Loosening the Midship Bearing Bracket Bolts

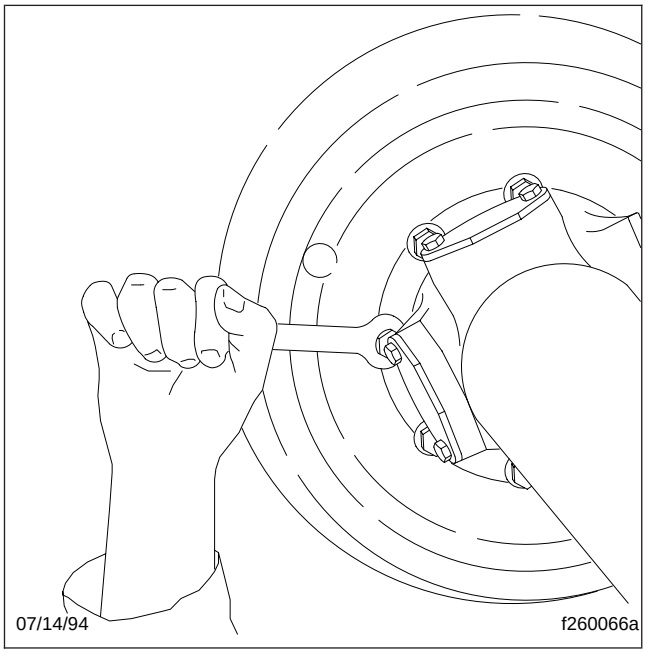


Fig. 3, Removing the Nuts on the Brake Flange

4.3 Slide the front of the driveline off the driveline brake flange or out of the transmission output yoke.

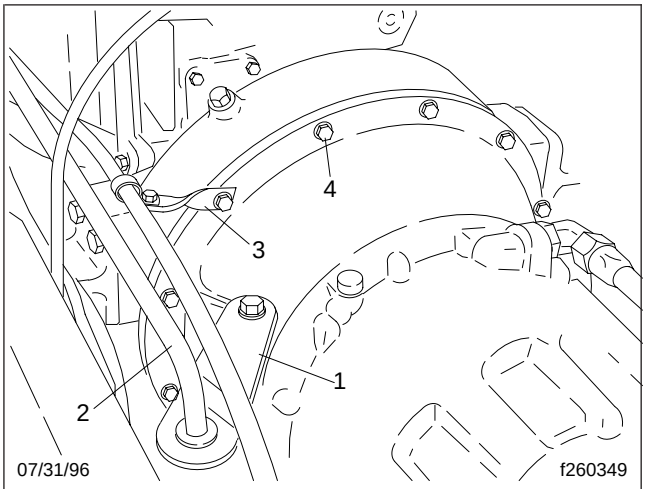
Automatic Transmission Removal and Installation

NOTE: It may be necessary to remove the mounting bolts from the midship bearing bracket so the driveline can be moved back far enough.

4.4 Support the disconnected driveline and tie it to the frame rail.

5. Disconnect the three electrical connections to the transmission. The back-up light sensor (on the right-hand side) and the neutral start switch (on the left-hand side) are located low on the transmission case, above the oil pan. The vehicle speed sensor is located on the rear cover.

6. Remove the ATF fill/dipstick tube. See **Fig. 4**.



1. Support Bracket
2. ATF Fill/Dipstick Tube
3. Forward Air Line Standoff Bracket
4. Flange Bolt

Fig. 4, Removing the Fill/Dipstick Tube

6.1 Remove the forward standoff bracket holding the air line away from the transmission case.

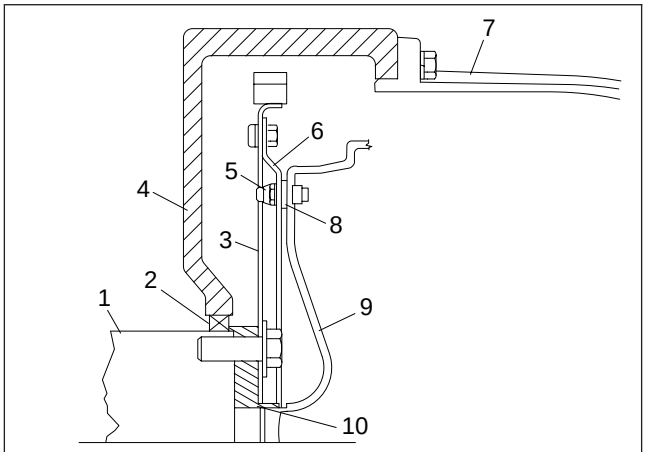
6.2 Remove the bolt and support bracket holding the fill/dipstick tube.

6.3 Pull the fill/dipstick tube, with dipstick attached, out of the transmission case.

6.4 Plug the hole with a clean rag to prevent entry of foreign material.

6.5 Remove the turbo outlet pipe and the exhaust pipe back to the muffler.

7. Disconnect the flexplate from the transmission. See **Fig. 5**.



1. Engine Crankshaft
2. Double Lip Seal
3. Flexplate
4. Engine Flywheel Housing
5. Flexplate Drive Capscrew
6. Ring
7. Torque Converter Housing
8. Washer
9. Torque Converter
10. Flexplate Adaptor

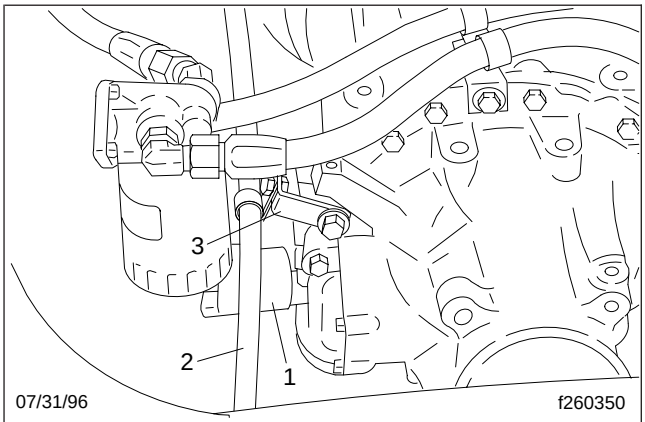
Fig. 5, Disconnecting the Flexplate

7.1 Remove the capscrews holding the ring gear access cover. Then, remove the cover.

7.2 Using a small prybar, turn the ring gear until one of the flexplate drive capscrews holding the flexplate 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.

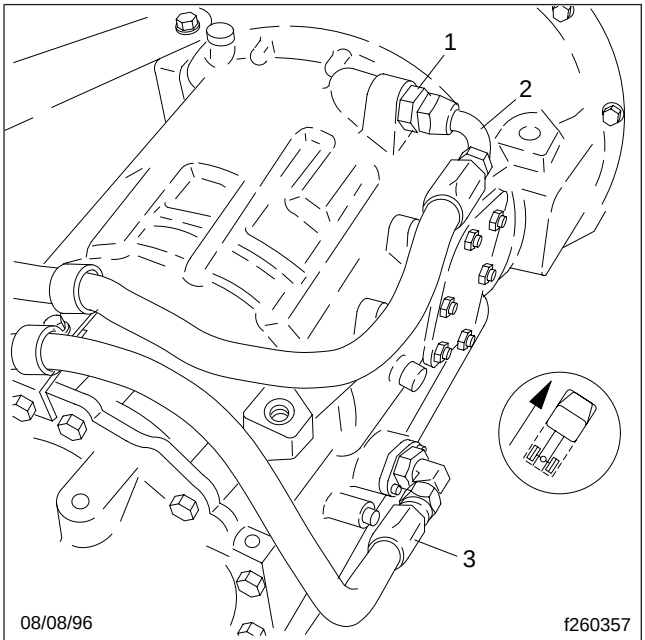
8. Remove the electronic modulator (**Fig. 6**) on the left-hand side of the transmission and disconnect the electrical connector. Remove the aft air line standoff bracket.

9. Disconnect the ATF cooler lines (**Fig. 7**) from the transmission and drain the remaining ATF.



1. Electronic Modulator
2. Air Line
3. Aft Standoff Bracket

Fig. 6, Removing the Electronic Modulator



1. Inlet Line
2. 90° Elbow
3. Outlet Line

Fig. 7, ATF Cooler Lines

NOTE: On model AT transmissions, both ATF cooler lines are on the top of the case on the right-hand side, with the inlet line slightly to the rear.

10. Place a piece of plywood on a transmission jack to support the transmission.
11. 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. See **Fig. 8**.

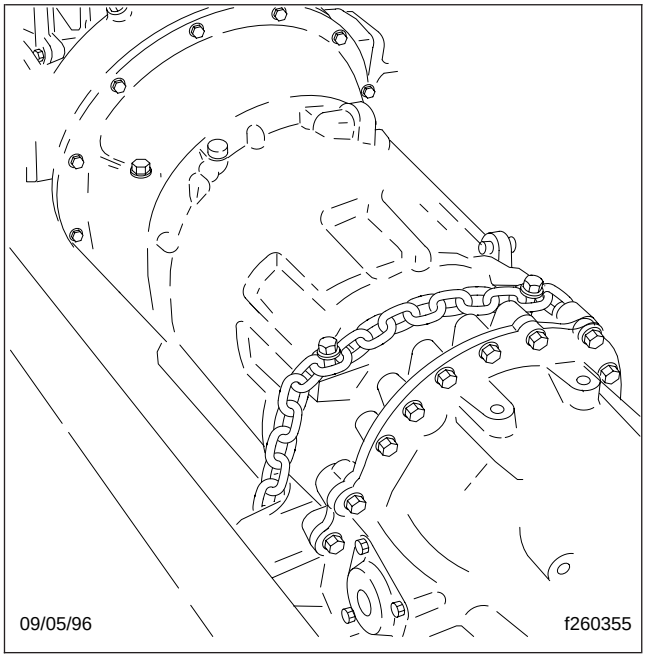


Fig. 8, Securing the Transmission With Chain

12. Remove the twelve transmission flange bolts. See **Fig. 9**.

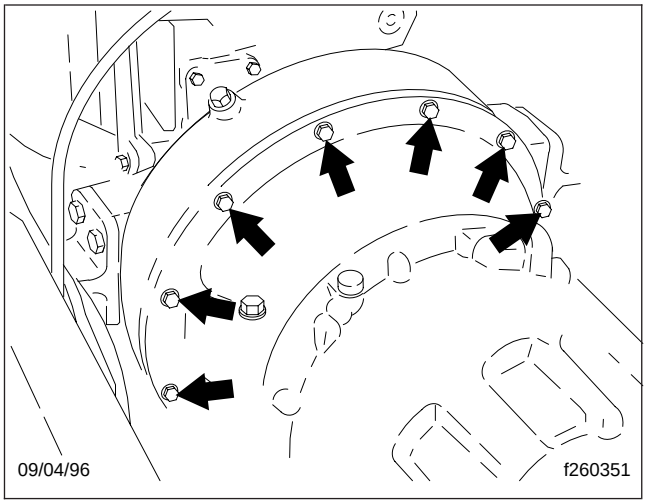


Fig. 9, Transmission Flange Bolts

13. 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.
14. Place jack stands under the raised front of the vehicle.
15. Roll the transmission jack back and remove the transmission.

Installation

IMPORTANT: Before installing the transmission, make sure the rear tires are chocked and the 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.
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. Align the transmission and flexplate.
   - 3.1 Raise the jack until the transmission lines up with the flexplate.
   - 3.2 Push the transmission toward the engine until it seats squarely against the engine flywheel 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.

   - 3.3 Install the transmission flange bolts finger-tight.
   - 3.4 Remove the chain holding the transmission to the transmission jack.
   - 3.5 Lower the transmission jack and remove it.
4. Connect the ATF cooler lines to the transmission. Tighten the fittings 45 lbf·ft (61 N·m). See **Fig. 7**.
5. Install the twelve flexplate adaptor capscrews.

   NOTE: Be careful not to drop the capscrews inside the torque converter cover. The transmission must be removed to get them out.

   - 5.1 Turning the ring gear for access, install all the capscrews through the access hole. Don't tighten them now.

   IMPORTANT: To prevent cocking of the flexplate adaptor, install all the capscrews before tightening any of them.

   - 5.2 Using a star pattern, tighten the capscrews 37 lbf·ft (50 N·m) until all twelve are tightened.
   - 5.3 Install the access cover and its capscrews.
6. Using a star pattern, tighten the twelve M10 transmission flange bolts (**Fig. 9**) 41 lbf·ft (56 N·m).
7. Connect the driveline.
   - 7.1 Slide the front of the driveline into the transmission output yoke or onto the driveline parking brake flange, if so equipped.
   - 7.2 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 driveline flange onto the studs in the parking brake. Install the nuts, and tighten them 40 lbf·ft (54 N·m).
   - 7.3 If the midship bearing bracket bolts and nuts were removed, install them. Tighten the nuts 95 lbf·ft (129 N·m).
8. Install the ATF fill/dipstick tube.
   - 8.1 Inspect the fill/dipstick tube seal. Replace it if damaged.
   - 8.2 Insert the fill/dipstick tube through the support bracket and into the transmission case.
   - 8.3 Install the fill/dipstick tube support bracket. Tighten the capscrew 28 lbf·ft (38 N·m).
9. Install the forward and aft air line standoff brackets on the left side of the transmission.

Make sure the air line and the wiring harness are securely attached to the standoff brackets.

10. Fill the transmission with ATF. Use Dexron II automatic transmission fluid. Add 16 quarts (15.1 liters).
11. Connect all electrical lines to the transmission.
    - 11.1 Connect the vehicle speed sensor to the port on the rear cover.
    - 11.2 Connect the neutral start switch to the port low on the transmission case, right-hand side.
    - 11.3 Connect the back-up light sensor to the port low on the transmission case, left-hand side.
    - 11.4 Using tie straps, secure the cables where necessary.
12. Connect the batteries, remove the chocks from the tires, and return the cab to the operating position.
13. Start the engine, and check for any leaks. Repair leaks as needed.
14. Check the ATF level. Add fluid as needed.
15. Road test the vehicle, and check for correct transmission operation.

Fastener Torques	
Description	**Torque lbf·ft (N·m)**
Transmission Drain Plug	136 (184)
ATF Cooler Hose Fittings	40–50 (54–68)
Flexplate Adaptor 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)

Table 1, Fastener Torques

Manual Transmission Removal and Installation

Removal

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

NOTE: For disassembly, repair, and assembly of the transmission, refer to the manufacturer's service literature.

2. Drain the vehicle system at the air reservoirs.
3. Disconnect the transmission air supply and signal lines. Label the lines for reconnection.
4. Remove the shift lever from the transmission.
   - 4.1 Remove the control rod ball joint-to-remote shift lever retaining nut and bolt.
   - 4.2 Remove the rod bracket-to-remote shift lever control top retaining bolts.
   - 4.3 Remove the lower ball joint and rod bracket.
   - 4.4 Position a suitable drain pan under the transmission. Remove the drain plug and drain the transmission oil.
   - 4.5 Reinstall the drain plug and tighten 45 to 55 lbf·ft (61 to 75 N·m).
   - 4.6 Cover the opening in the shift bar housing to prevent the entry of dirt.
5. Disconnect the driveshaft from the transmission.
   - 5.1 Loosen the bolts holding the midship bearing bracket so the driveshaft can slide to the rear. See **Fig. 1**.
   - 5.2 Slide the front of the driveshaft off the driveline brake flange or out of the transmission output yoke.

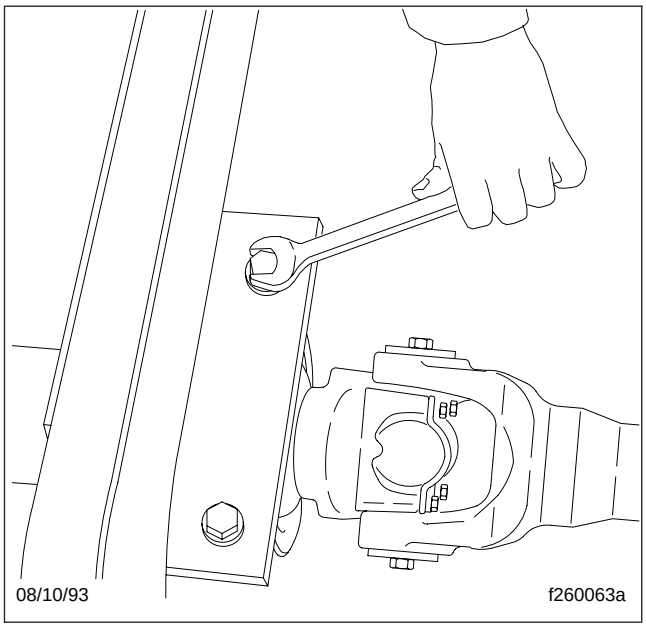


Fig. 1, Midship Bearing Bracket

NOTE: It may be necessary to remove the bolts from the midship bearing bracket so the driveshaft can be moved far enough back.

- 5.3 Support the disconnected driveshaft or tie it out of the way.

6. Remove all electrical connections from the transmission.
   - 6.1 Disconnect the back-up light cables. See **Fig. 2**.
   - 6.2 Disconnect the electrical cable from the speedometer sensor. See **Fig. 3**.
   - 6.3 Loosen the capscrews holding the speedometer sensor wiring harness to the transmission. Move the harness out of the way.
7. Disconnect and move the clutch slave cylinder.
   - 7.1 Remove the cotter pin holding the slave cylinder clevis to the clutch release lever. See **Fig. 4**.
   - 7.2 Remove the two capscrews holding the clutch slave cylinder bracket to the transmission. Remove the slave cylinder, and support it. See **Fig. 5**.
8. Support the transmission with a jack.

Manual Transmission Removal and Installation

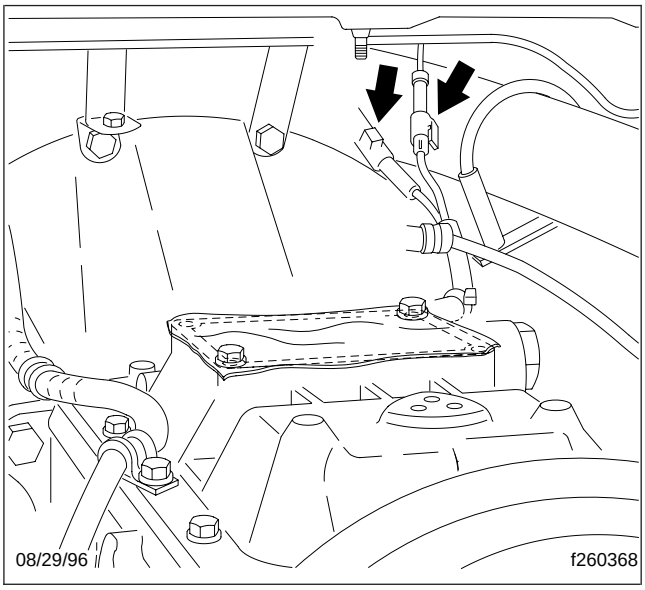


Fig. 2, Back-up Light Cables

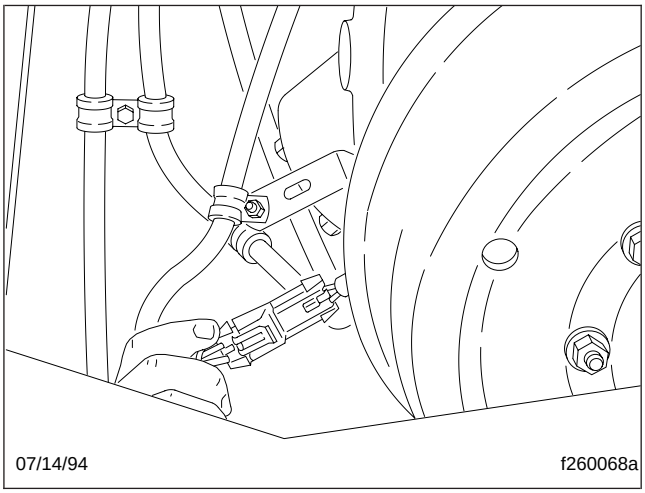


Fig. 3, Speedometer Sensor

8.1 Position a transmission jack under the transmission and raise its support plates against the bottom of the transmission.

8.2 Adjust the support plates to cradle the transmission.

8.3 Using a chain, secure the transmission to the jack.

9. Remove the transmission.

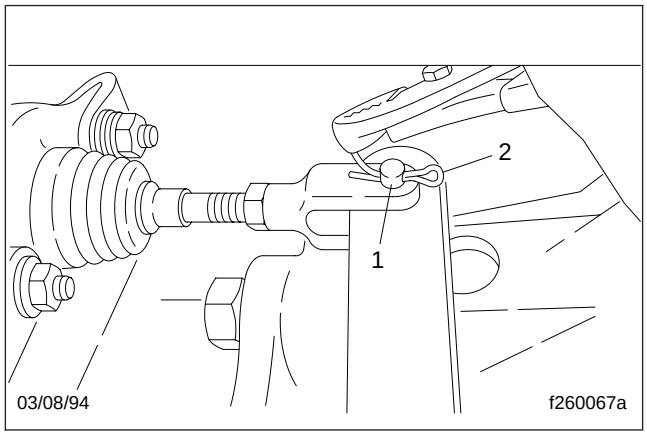


Fig. 4, Slave Cylinder Clevis Pin



Fig. 5, Clutch Slave Cylinder Bracket

9.1 Remove the capscrews that hold the transmission to the clutch housing. See **Fig. 6**.

9.2 Pull the transmission and jack straight back, until the transmission input shaft is clear of the clutch.

9.3 If required, lower the jack supporting the transmission. Raise the front of the truck and slide the transmission and jack out from under the truck.

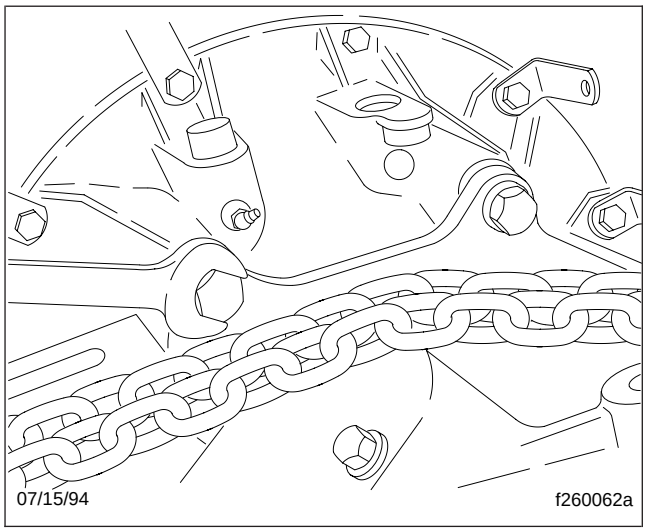


Fig. 6, Transmission and Clutch Housing

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 disc(s). Keep the flange of the clutch housing parallel (all 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).

Installation

IMPORTANT: Before installing the transmission, make sure that the rear tires are chocked and that the transmission is securely chained to the transmission jack support plates.

1. Install the transmission.
   - 1.1 Shift the transmission into gear, so that the transmission input shaft can be rotated during assembly to line it up with the clutch driven-disc hub splines.
   - 1.2 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 align.
   - 1.3 Push the transmission and jack straight forward making sure the flanges remain parallel.
   - 1.4 Reach through the access hole in the bottom of the bell housing and hold the throwout bearing in place by hand. See **Fig. 7**.

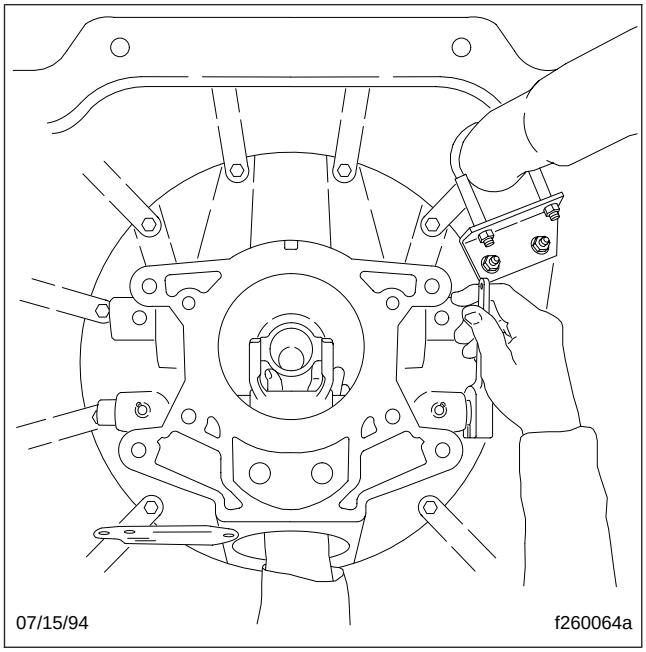


Fig. 7, Clutch Release Yoke Throwout Bearing

   - 1.5 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.

   - 1.6 Install the capscrews holding the transmission to the clutch housing. Tighten them to 150 lbf·ft (203 N·m).
   - 1.7 Remove the chain securing the transmission to the jack, then remove the jack.
2. Install and connect the clutch slave cylinder.

Manual Transmission Removal and Installation

2.1 Install the two capscrews holding the clutch slave cylinder bracket to the transmission. Tighten them to 40 lbf·ft (54 N·m).

2.2 Attach the slave cylinder clevis to the clutch release lever; then, insert and lock the cotter pin.

3. Connect all electrical lines to the transmission.

3.1 Connect the back-up light cables.

3.2 Connect the electrical cable to the speedometer sensor.

3.3 Install the speedometer sensor wiring harness. Install the capscrews fastening it to the transmission. Tighten them to 40 lbf·ft (54 N·m).

4. Connect the driveshaft.

4.1 Slide the front of the driveshaft into the output yoke.

4.2 Install the yoke U-joint end caps. Tighten the bolts to 45 lbf·ft (61 N·m).

4.3 Install the capscrews and nuts on the midship bearing bracket. Tighten them to 95 lbf·ft (129 N·m).

5. Install the shift lever.

5.1 Remove the covering from the opening in the shift tower.

5.2 Install the lower ball joint and rod bracket to the remote shift lever control top. Install and tighten the retaining bolts 20 to 29 lbf·ft (27 to 39 N·m).

5.3 Install the control rod ball joint to the remote shift lever. Install and tighten the retaining bolt and nut 85 to 115 lbf·in (8 to 10 N·cm).

6. If applicable, connect the air signal and supply lines to the transmission.

Specifications

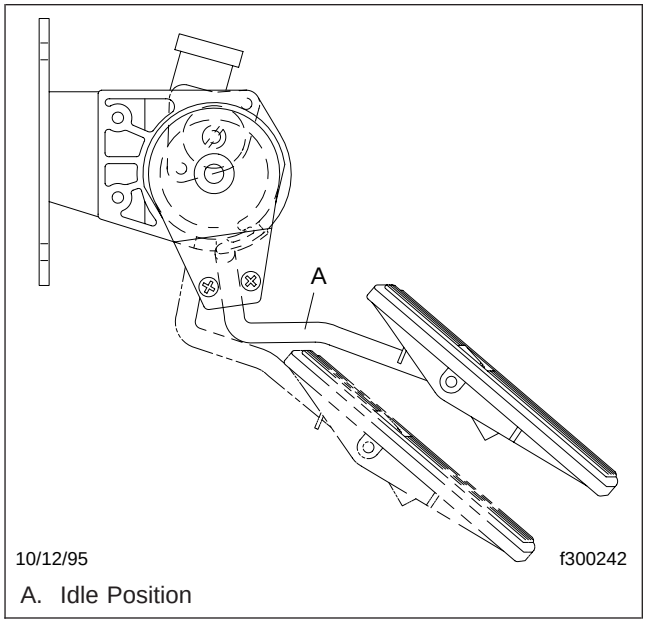
Tightening Torques	
Description	**Torque lbf·ft (N·m)**
Shift Lever Plate Capscrews	28 (38)
Transmission-to-Clutch-Housing Capscrews	150 (203)
Clutch-Housing-to-Flywheel-Housing Capscrews	34 (46)
Fuel Cross-Over Line Mounting Bolts	95 (129)
Fuel Cross-Over Line Mounting Clamps	40 (54)
Fuel Tank Drain Plug	finger-tight + 1-1/2 turns
Clutch Slave Cylinder Bracket Mounting Bolts	40 (54)
Speedometer Sensor Wiring Harness Clamp Mounting Capscrews (see Transmission Top Cover Capscrews)	—
Transmission Top Cover Capscrews	40 (54)
U-Joint End Cap Bolts	45 (61)
Midship Bearing Bracket Capscrews	95 (129)

Table 1, Tightening Torques

Electronic Throttle Pedal Removal and Installation

Removal

1. Park the vehicle, and set the parking brakes.
2. Disconnect the batteries.
3. Remove the throttle pedal. See **Fig. 1** and **Fig. 2** for information about the throttle pedal.



A. Idle Position

Fig. 1, Electronic Throttle Pedal

3.1 Remove the carpeting around the pedal mounting.

3.2 Disconnect the wiring to the pedal.

3.3 Remove the two locknuts and washers that hold the pedal assembly on the mounting studs.

3.4 Remove the pedal assembly from the vehicle.

Installation

1. Install the pedal.

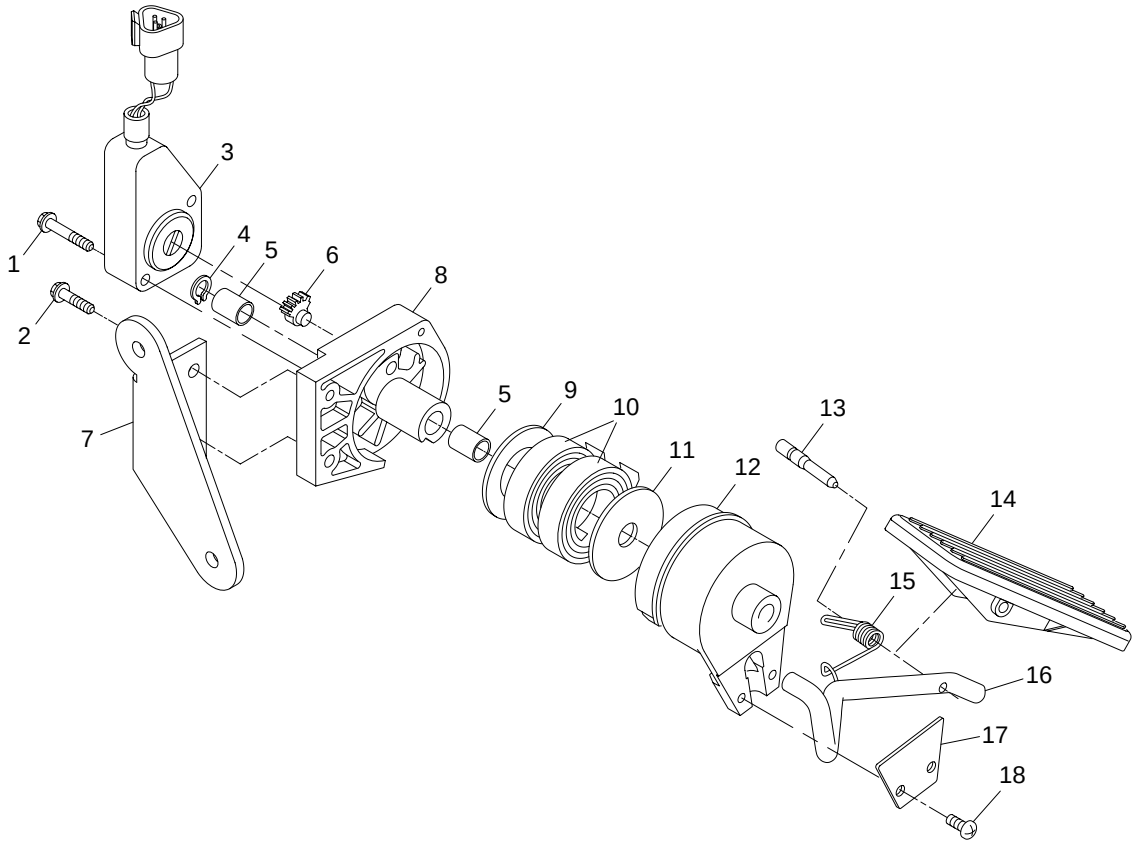
1.1 Position the pedal assembly on the mounting studs, and use two flatwashers and locknuts to secure it.

1.2 Connect the wiring to the pedal.

1.3 Position the carpet back around the pedal mounting.

2. Connect the batteries.

Electronic Throttle Pedal Removal and Installation



1. Screw, #10–32 UNF-2A x 1.25"
2. Screw, Hex 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, #10–32 UNF-2A x 0.50"

Fig. 2, Electronic Throttle Pedal Assembly (exploded view)

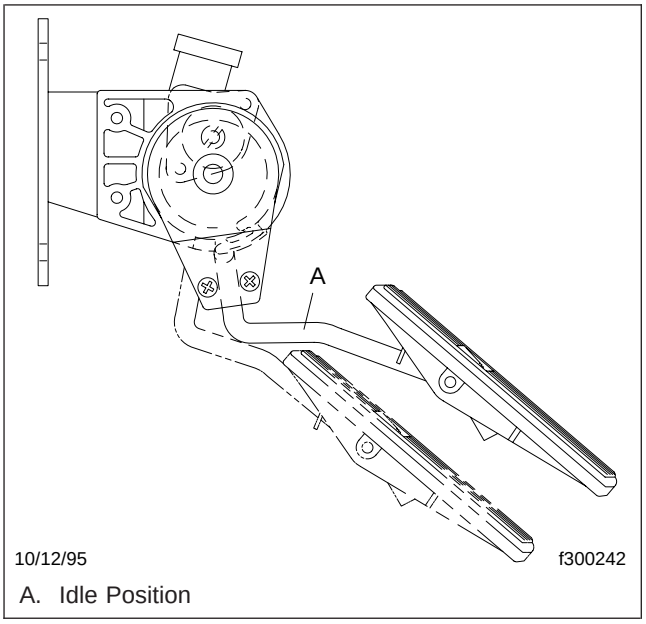
General Information (See Fig. 1 and Fig. 2)

The suspended pedal assembly mounts to the inside of the cab bulkhead, and communicates with the engine through a wiring harness.

As the driver presses the pedal, the drive lever is forced downward, rotating the pinion gear which meshes with the pedal sensor (sometimes called the "potentiometer"). As the drive lever moves down and rotates the pinion gear, the sensor, attached to the outboard side of the assembly, monitors how far the pinion gear rotates. Depending on how much the driver presses the pedal - and the pedal rotates the pinion gear - the sensor tells the electronic engine control how much fuel to deliver to the engine.

When the driver stops pressing the pedal, return springs within the pedal assembly lift the pedal back to the original idle position.

Only the pedal sensor is serviceable. If any other part of the pedal malfunctions, replace the entire pedal assembly.



A. Idle Position

Fig. 1, Electronic Throttle Pedal, Side View

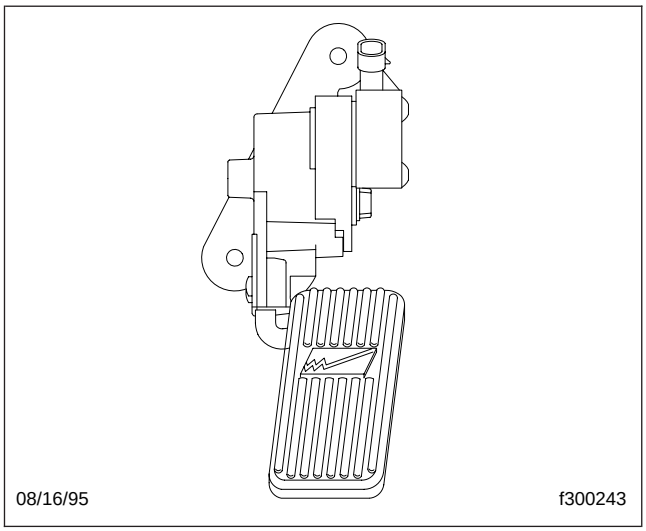


Fig. 2, Electronic Throttle Pedal, Front View

General Information

IMPORTANT: This service manual *does not cover* the procedures and calculations necessary to perform frame modifications. For basic information, see the vehicle body builder's manual.

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 (mounted on that frame rail) is measured. There are two frame stations along the frame rails: station zero and station 850.

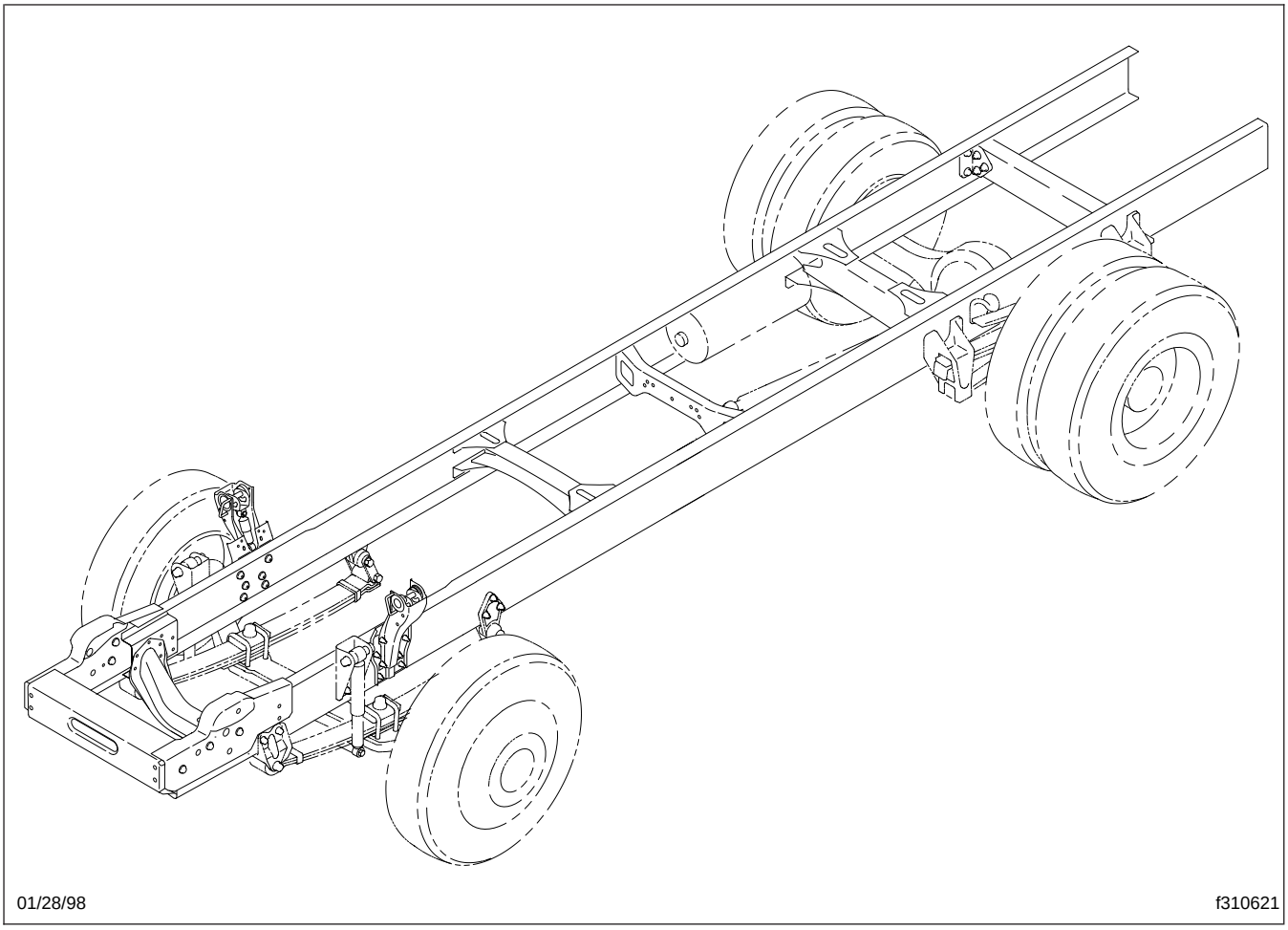
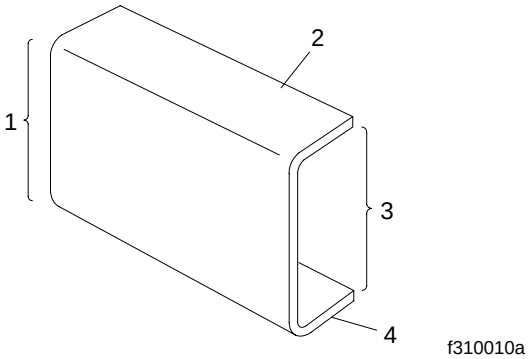


Fig. 1, Frame Assembly

General Information



1. Web
2. Upper Flange
3. Channel
4. Lower Flange

Fig. 2, Frame Terminology

Station zero is located about 35-3/4 inches (900 mm) forward of the front axle centerline. Station 850 is located about 33-15/32 inches (850 mm) to the rear of station zero.

Station 850 is used when station zero is not accessible because of vehicle assembly. Station 850 is identified by a 1-1/16 inch (27 mm) 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 375, then that component is installed on the frame rail about 14-3/4 inches (375 mm) aft of station zero, or 18-3/4 inches (475 mm) forward of station 850.

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

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

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 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

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.

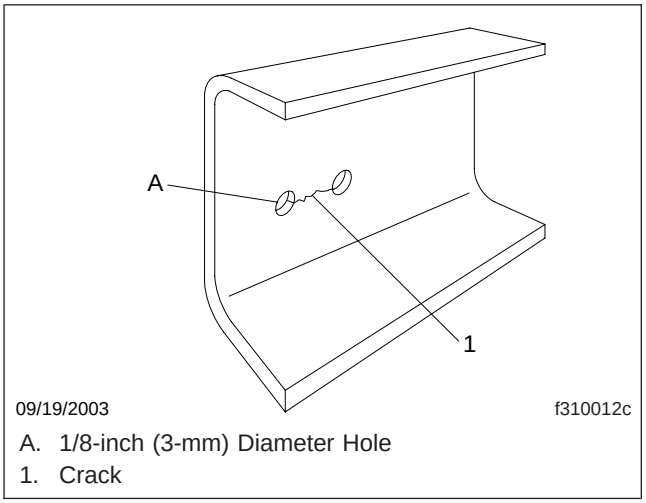
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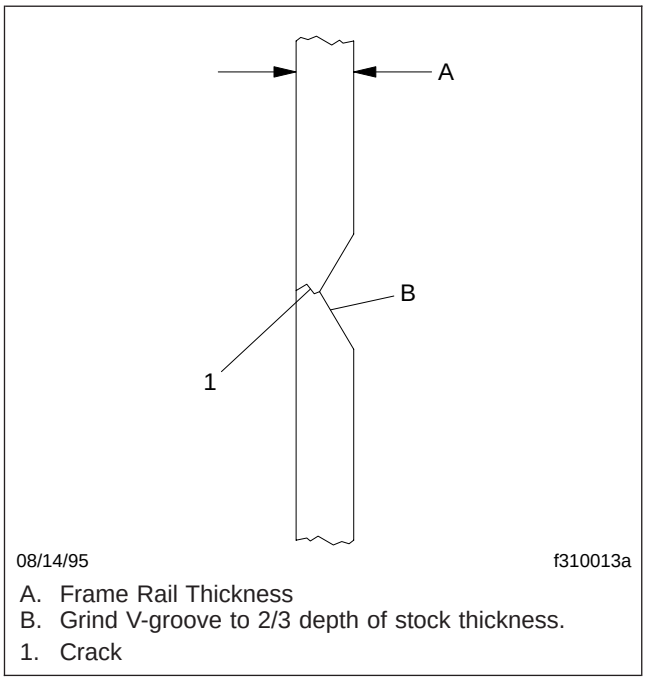
1. Drill a 1/8-inch (3-mm) diameter hole at each end of the crack to prevent further spreading of the crack. See **Fig. 1**.



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**.



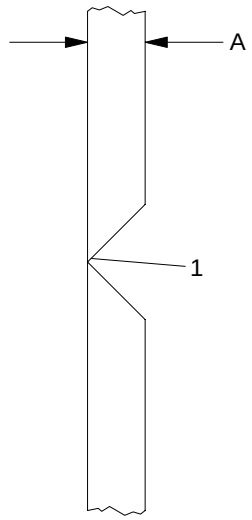
A. Frame Rail Thickness
B. Grind V-groove to 2/3 depth of stock thickness.
1. Crack

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**.

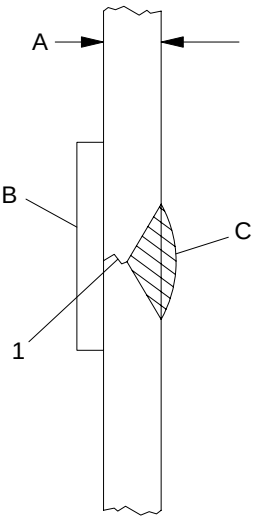
Repairing Frame Rails



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A. Frame Rail Thickness
1. V-Groove (Full Depth)

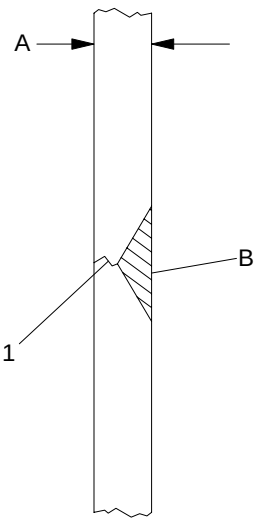
Fig. 3, Full Depth Groove



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A. Frame Rail Thickness
B. Clamp the "chill" strip on the opposite side of the groove.
C. Deposit weld material.
1. Crack

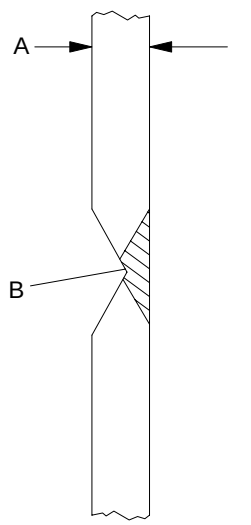
Fig. 4, Using a Chill Strip



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A. Frame Rail Thickness
B. Grind the weld flush with the frame rail.
1. Crack

Fig. 5, Weld Ground Flush



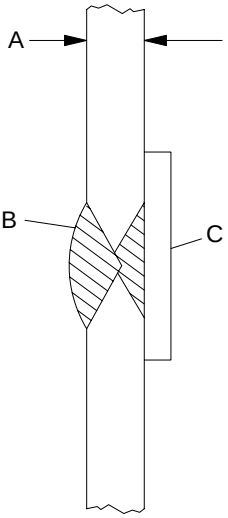
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A. Frame Rail Thickness
B. Grind a vee groove deep enough to reach weld.

Fig. 6, Cross-Section View

Filling Unused Holes

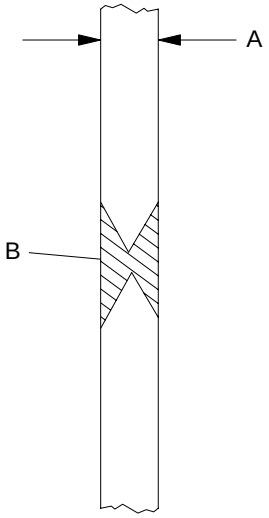
1. Fill all unused holes in the frame assembly with the applicable nut, washer, and bolt combination.



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A. Frame Rail Thickness
B. Deposit weld material to penetrate the opposite weld.
C. Clamp the "chill" strip on the opposite side of the groove.

Fig. 7, Second Weld



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A. Frame Rail Thickness
B. Grind the weld flush with the frame rail.

Fig. 8, Second Weld Ground Flush

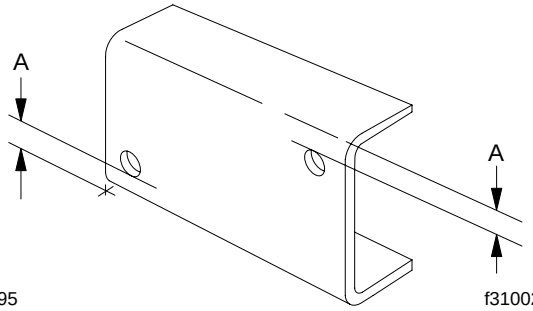
2. If the diameter of a hole is less than 3/8 inch (9.5 mm), enlarge it to 3/8 inch (9.5 mm), and fill it with the applicable nut, washer, and bolt combination.
3. Tighten the fasteners to the applicable torque value. For proper frame fastening instructions, refer elsewhere in this group.

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).



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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

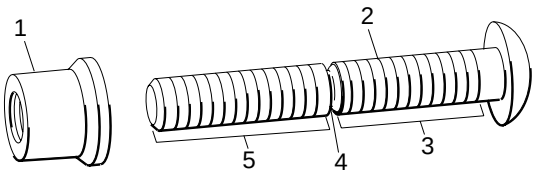
Replace hexhead bolts and locknuts with identical fasteners. See the vehicle parts book for fastener specifications.

Apply Alumilastic® compound, or an equivalent, to all bolts, nuts, and washers that contact aluminum parts.

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 three threads and a maximum of 3/4-inch (19 mm) bolt length.



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. See **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.

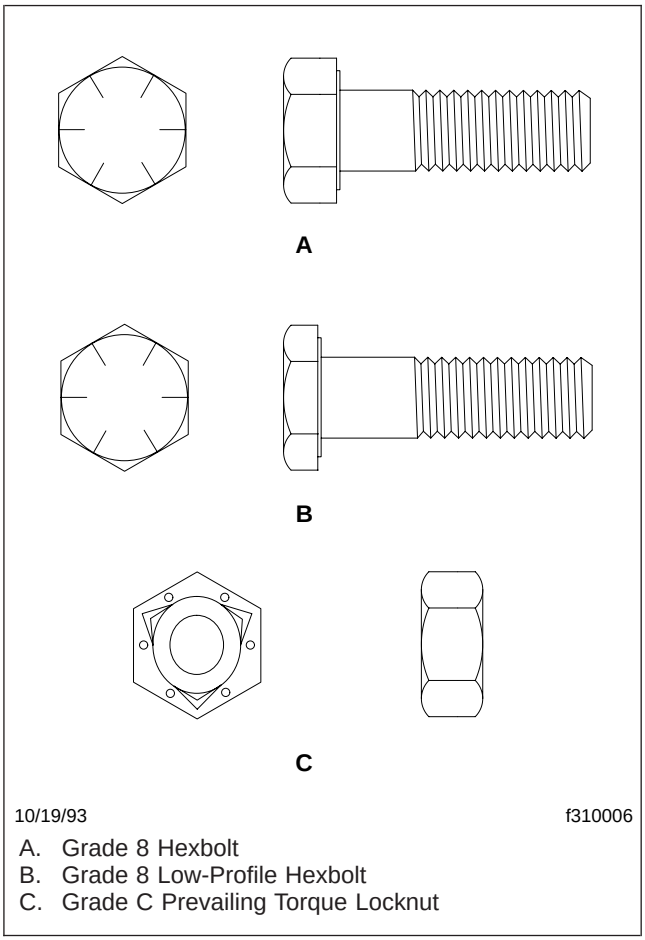
CAUTION

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.

Huckbolt Installation

NOTE: Huckbolts cannot be installed without the proper Huckbolt installation equipment.

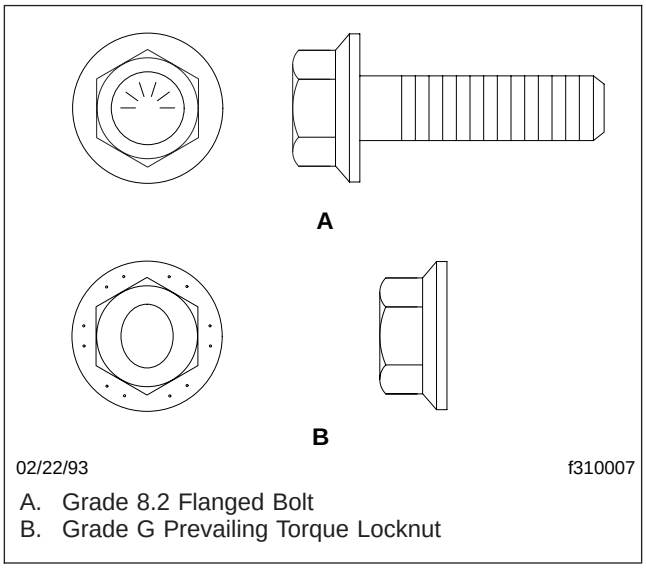
Frame Fasteners



A. Grade 8 Hexbolt
B. Grade 8 Low-Profile Hexbolt
C. Grade C Prevailing Torque Locknut

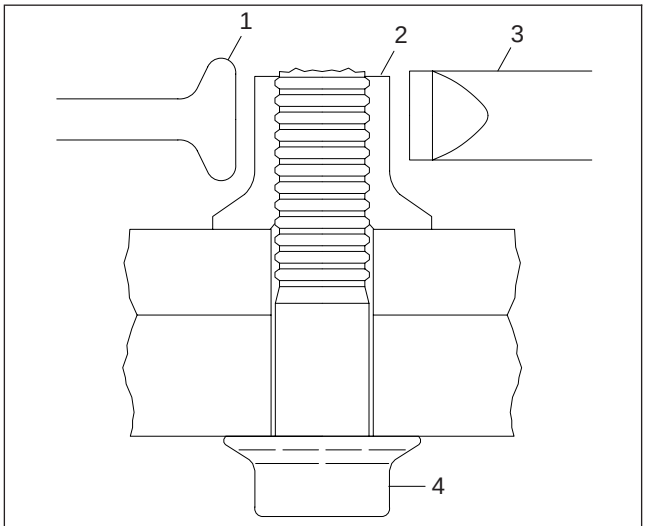
Fig. 2, Hexhead Fasteners

1. Insert the pintail through the prepared hole in the frame or other component. See **Fig. 5**.
2. Place the collar over the pintail.
3. Place the Huck installation tool nose assembly over the pintail. See **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. See **Fig. 7**.



A. Grade 8.2 Flanged Bolt
B. Grade G Prevailing Torque Locknut

Fig. 3, Flanged Hexhead Fasteners



1. Anvil
2. Lockbolt Collar
3. Chisel
4. Lockbolt

Fig. 4, Huckbolt Removal

5. The pintail breaks (see **Fig. 8**), freeing the nose assembly anvil from the swaged collar.

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;

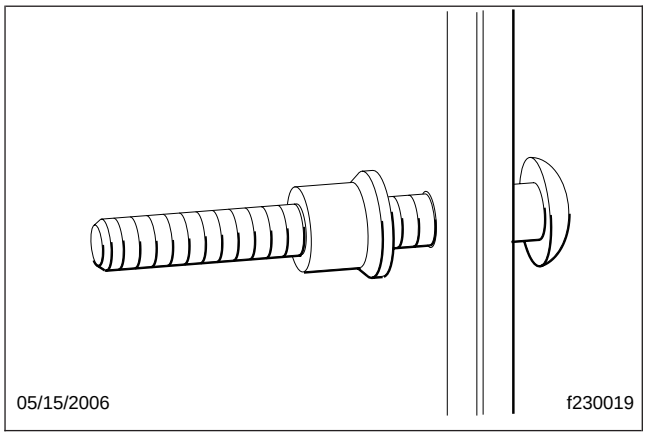


Fig. 5, Positioning the Collar

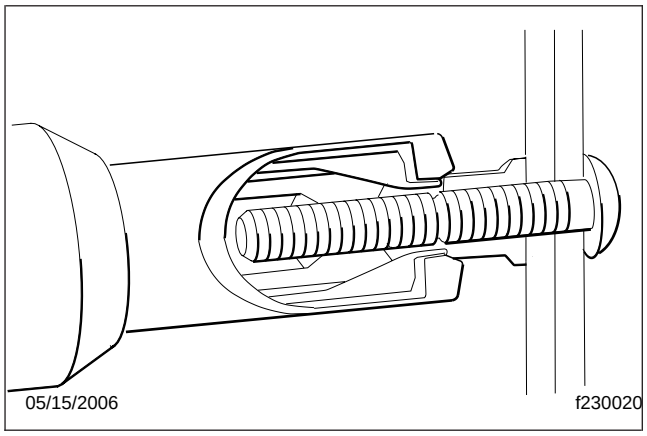


Fig. 6, Positioning the Tool

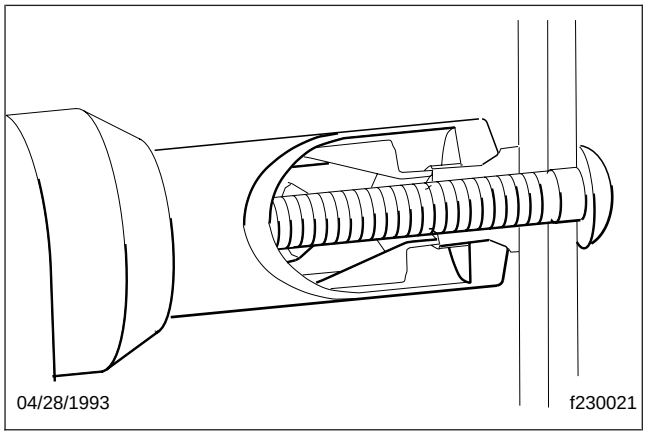


Fig. 7, Securing the Pintail

the pintail should break flush with the top of the collar. No more than two grooves should be visible on the collar after installation. See **Fig. 9** for examples of acceptable and unacceptable MAGNA-GRIP pintail breaks.

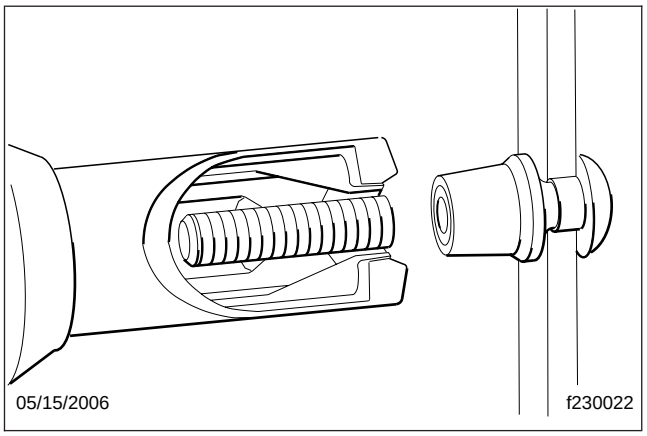


Fig. 8, Installed Huckbolt Fastener

Frame Fastener Tightening

CAUTION

Tighten standard frame fasteners periodically. Continued vehicle operation with loose fasteners could result in component, bracket, and frame damage.

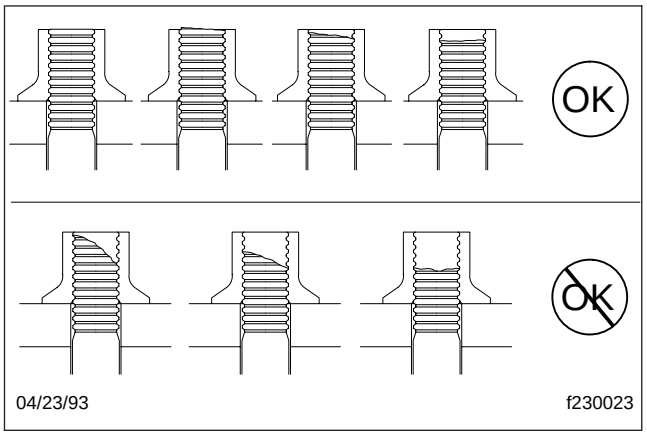


Fig. 9, Pintail Breaks

Tighten hexhead bolts and locknuts periodically to offset the effects of "bedding in" (seating). See the Maintenance Schedule in Group 00, and the frame section in Group 31 in the vehicle maintenance manual for intervals.

Frame Fasteners

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, see **Section 00.04** in this manual.

NOTE: Huck fasteners do not require periodic tightening.

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, dealers must contact their Regional Service Office for instructions and approval. All others must contact a 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 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.
4. Using a cutting torch, cut the crossmember channel in two. A 3-inch (76 mm) cut will make removal easier.
5. Remove the fasteners that attach the crossmember halves to the frame rails, and remove the crossmember.

Rear-Closing Crossmember

(See Fig. 3)

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.

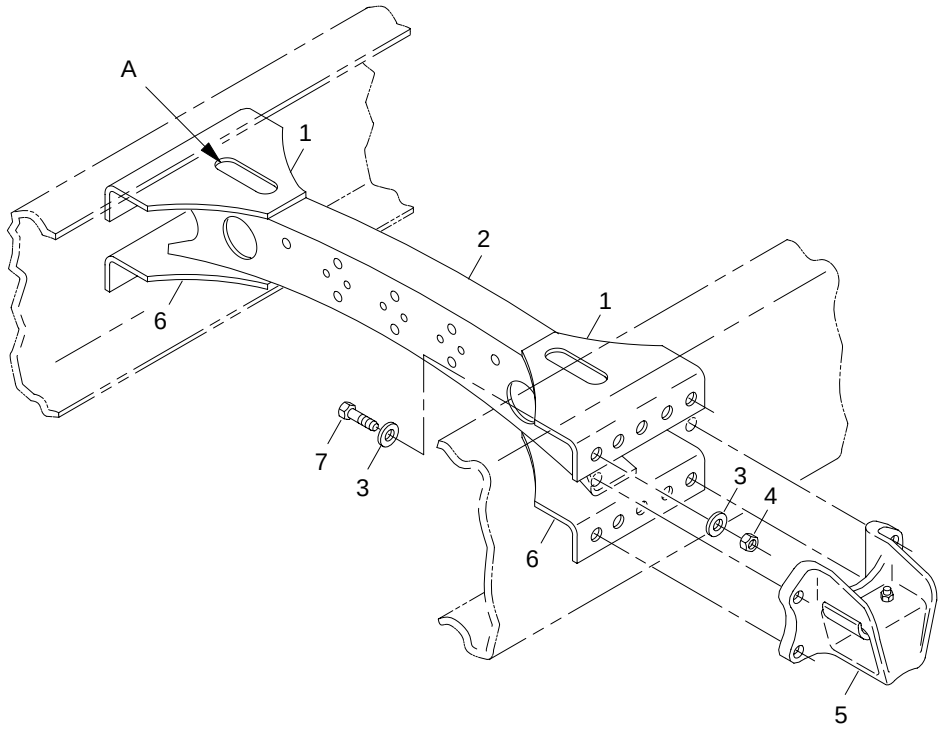
   Remove any clamps that attach air lines or wiring to the crossmember.

   If the leveling valve for an AirLiner suspension is attached to the crossmember, remove the valve. For instructions, see **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. 4)**

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.
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.

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

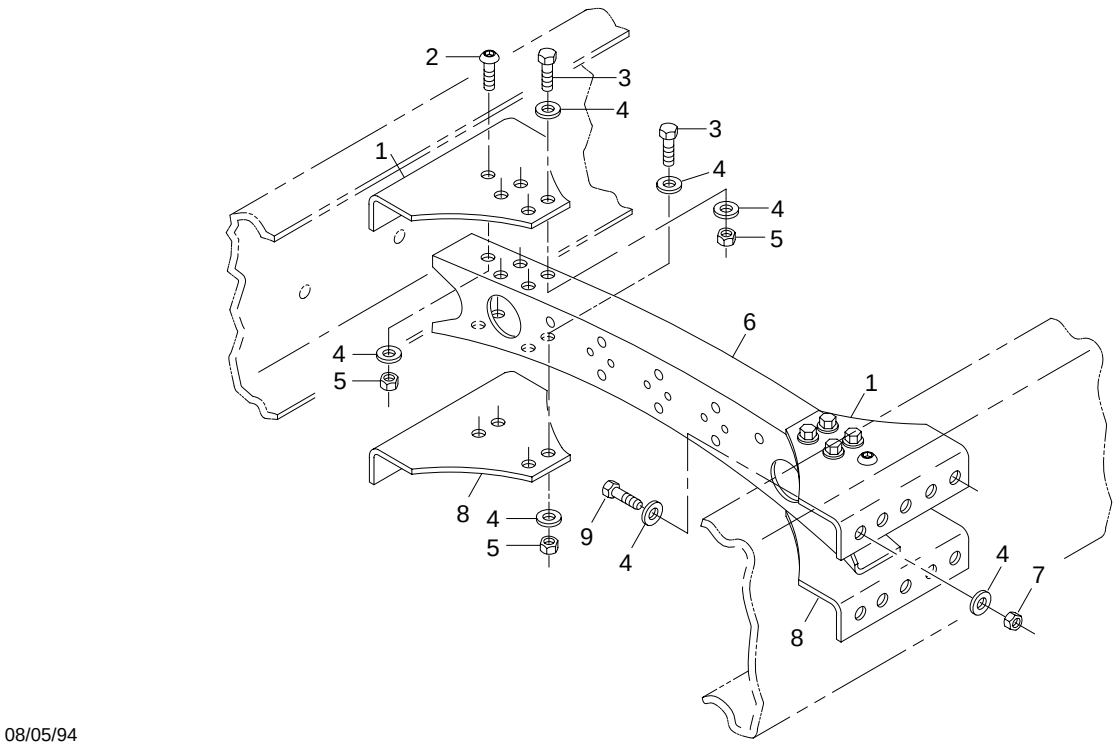
Fig. 1, 5-Piece (Welded) Crossmember Assembly

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. 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 68 lbf·ft (92 N·m).
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 136 lbf·ft (184 N·m). Then, tighten



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, 5-Piece (Bolted) Crossmember Assembly

the fasteners that attach the gussets to the crossmember channel 68 lbf·ft (92 N·m).

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. Tighten the cab support bracket fasteners 68 lbf·ft (92 N·m). Remove the supports from under the cab, fuel tanks, and cab-access steps.

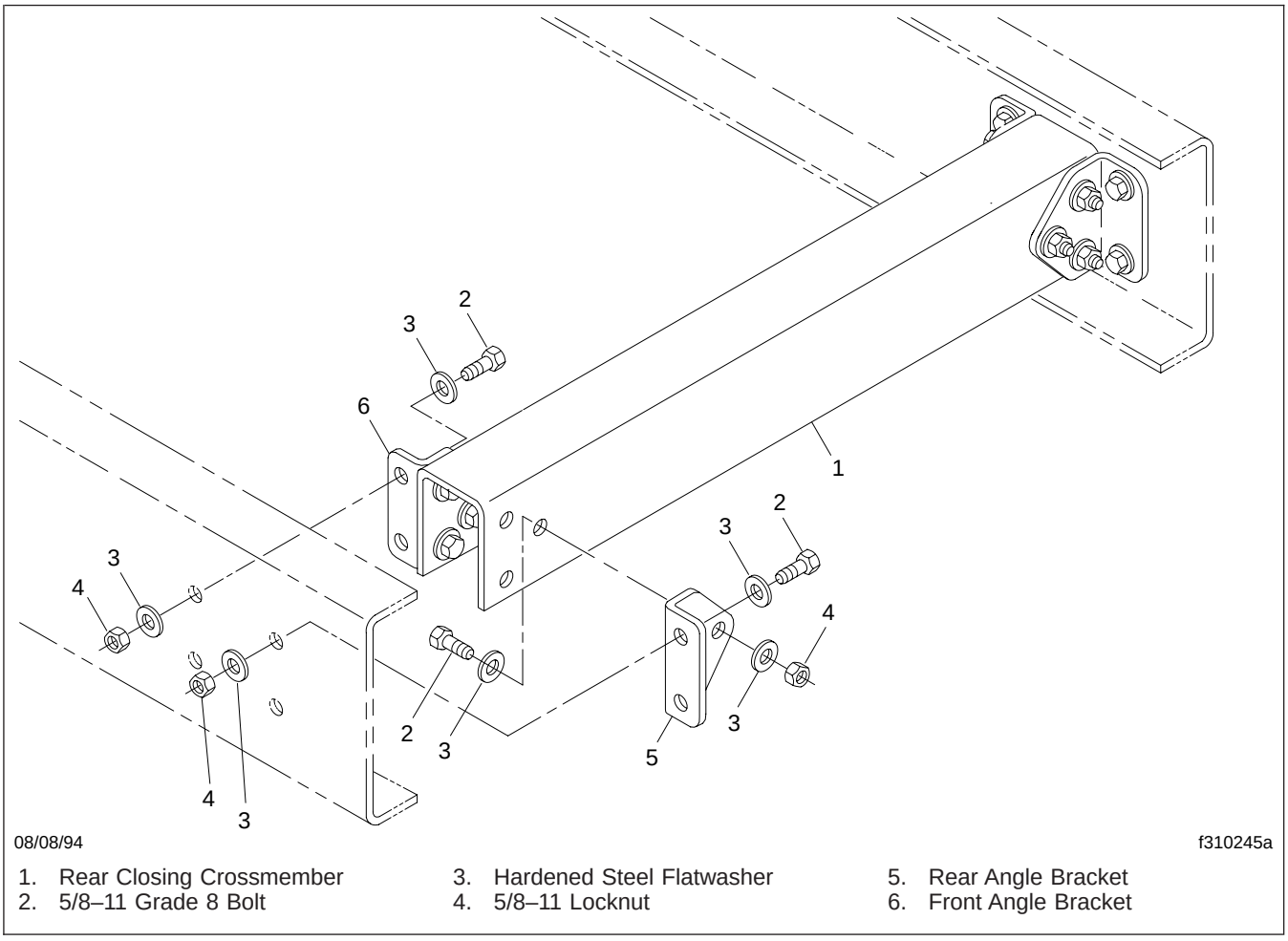
10. Remove the chocks.

Rear-Closing Crossmember

(See Fig. 3)

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.

Crossmember Removal and Installation



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. 3, Rear-Closing Crossmember Installation

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, see **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 136 lbf·ft (184 N·m).
7. Remove the chocks.

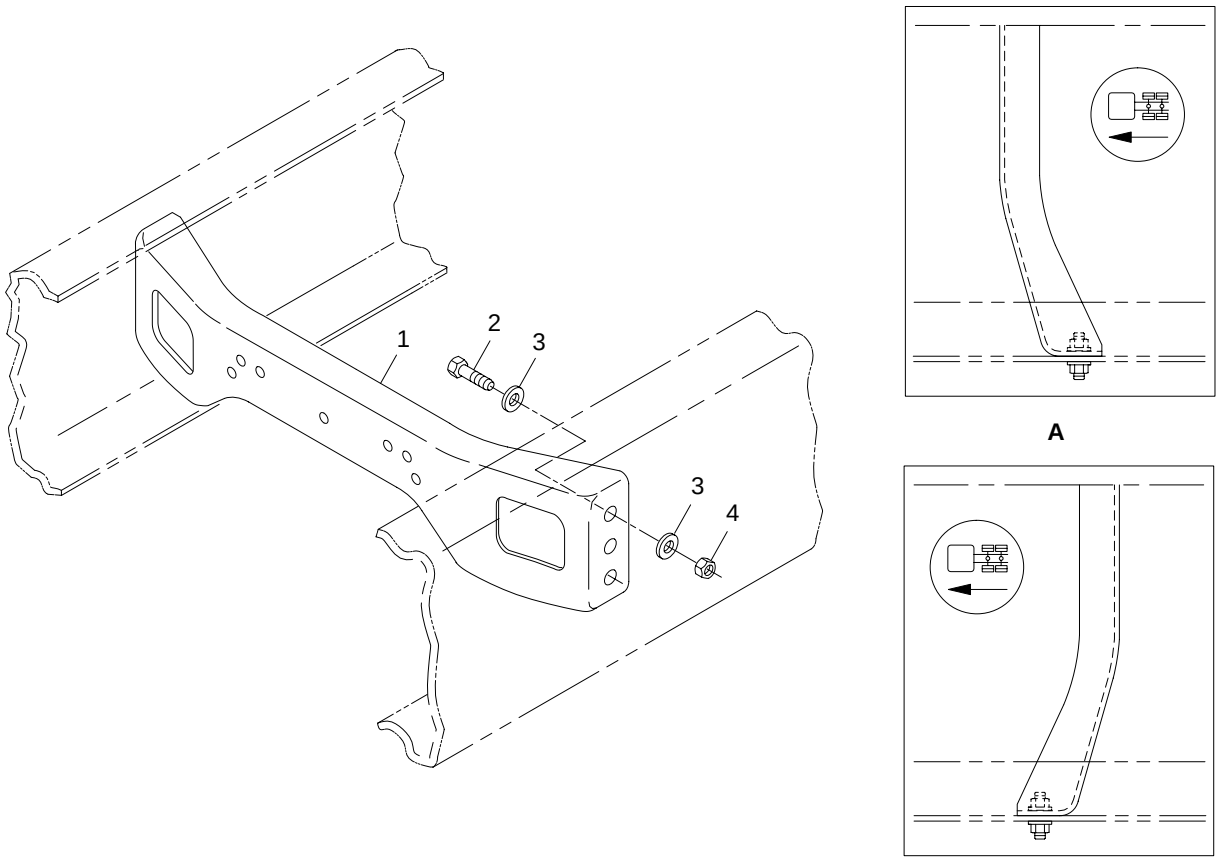
Splayed Crossmember **(See Fig. 4)**

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.

2. Install the fasteners in that end of the crossmember and frame rail, but tighten the locknuts finger-tight only.

Crossmember Removal and Installation



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A. Top Views

1. Splayed Midship Crossmember
2. 1/2–13 Grade 8 Bolt
3. Hardened Steel Flatwasher
4. 1/2–13 Locknut

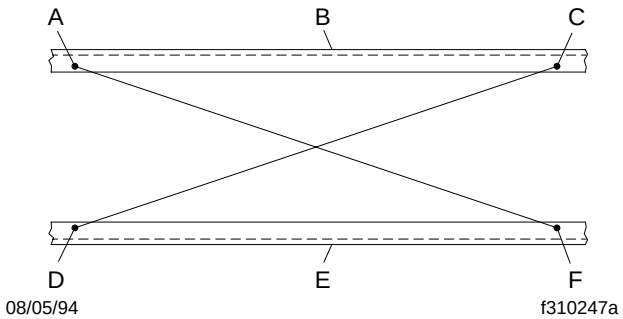
Fig. 4, Splayed Crossmember

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; see **Section 00.04** in this manual.
6. Remove the chocks.

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.



A. Right Forward Point
B. Right Frame Rail
C. Right Rear Point
D. Left Forward Point
E. Left Frame Rail
F. Left Rear Point

Fig. 1, Checking Frame Rail Alignment

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, then chock the tires.

NOTE: Frame station 5350 is located 17 feet 6-5/8 inches from frame station zero.

2. For each frame rail, project the exact vertical centerline of the 5/8-inch (16-mm) manufacturing hole at frame station 5350, 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 5350 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; see 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

Frame Rail Alignment

point on its opposite frame rail. Compare the two measurements.

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; see Specifications in **Section 00.04** in this manual.
12. Again, check the frame rail alignment.
13. When the measurements are within specifications, install the fifth wheel and deck plate (as equipped); see the applicable section in this group for instructions.
14. If the frame rails needed aligning, check the axle alignment; see the appropriate suspension section in **Group 32** for instructions.
15. Remove the chocks.

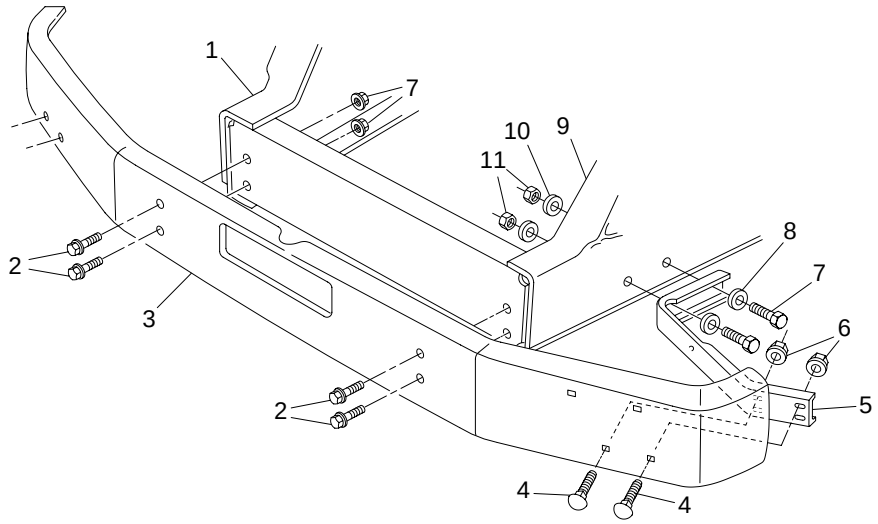
Bumper Removal and Installation

Removal (See Fig. 1)

1. Remove the four bolts attaching the bumper to the support bracket.
2. Remove the four bolts attaching the bumper to the frame.
3. Remove the bumper.

Installation (See Fig. 1)

1. Attach the bumper to the support bracket with the retaining bolts, nuts and washers. Tighten 21 to 31 lbf·ft (28 to 42 N·m).
2. Position the bumper on the frame and install the four retaining bolts and washers. Tighten 59 to 73 lbf·ft (80 to 100 N·m).



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1. Right-Hand Frame Extension
2. 3/4-inch (19-mm) Screw and Washer
3. Front Bumper
4. 1/2-inch (13-mm) Bolt
5. Front Bumper Support Bracket
6. 1/2-inch (13-mm) Nut and Washer
7. 3/4-inch (19-mm) Bolt
8. 3/4-inch (19-mm) Washer
9. Left-Hand Frame Extension
10. 3/4-inch (19-mm) Washer
11. 3/4-inch (19-mm) Nut

Fig. 1, Front Bumper Assembly

Specifications

Bumper Torque Values		
Description	**lbf·ft**	**N·m**
Bolt, Bumper to Frame	59–73	80–100
Bolt, Bumper to Support Bracket	21–31	28–42

Table 1, Bumper Torque Values

General Information

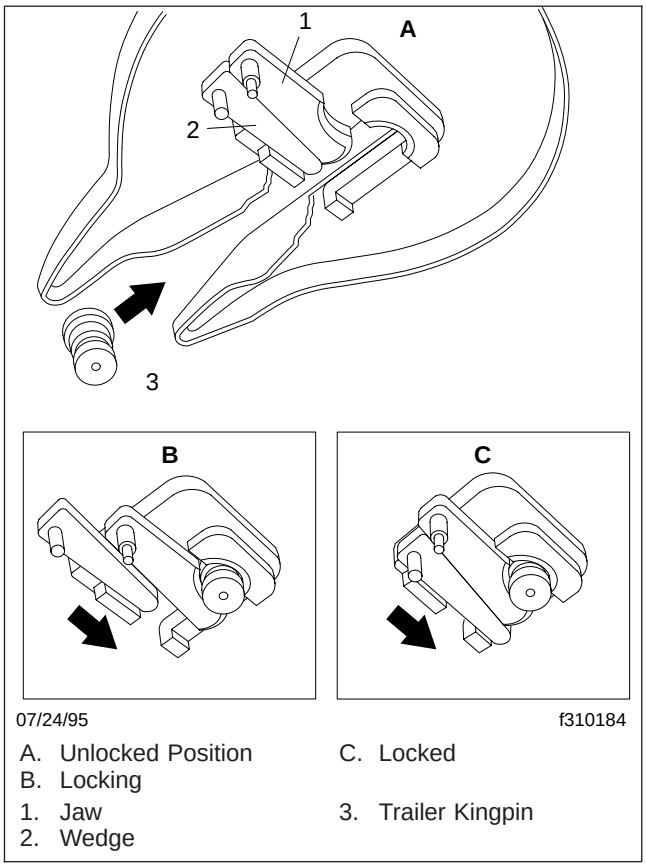
The Fontaine 6000 series fifth wheel couples to trailers having the standard kingpin. The fifth wheel is bracket-mounted to the tractor frame in a position that best distributes the trailer load over the tractor axles.

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 pulling a manual lock control handle located on either the right side or the left side of the fifth wheel. Kingpin lockup 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. See **Fig. 1**. The jaw will move behind the kingpin, followed by the wedge. The wedge reinforces the jaw and automatically adjusts for slack around the kingpin.

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 Chapter 11 in the *Cargo Driver's Manual* for complete operating instructions.

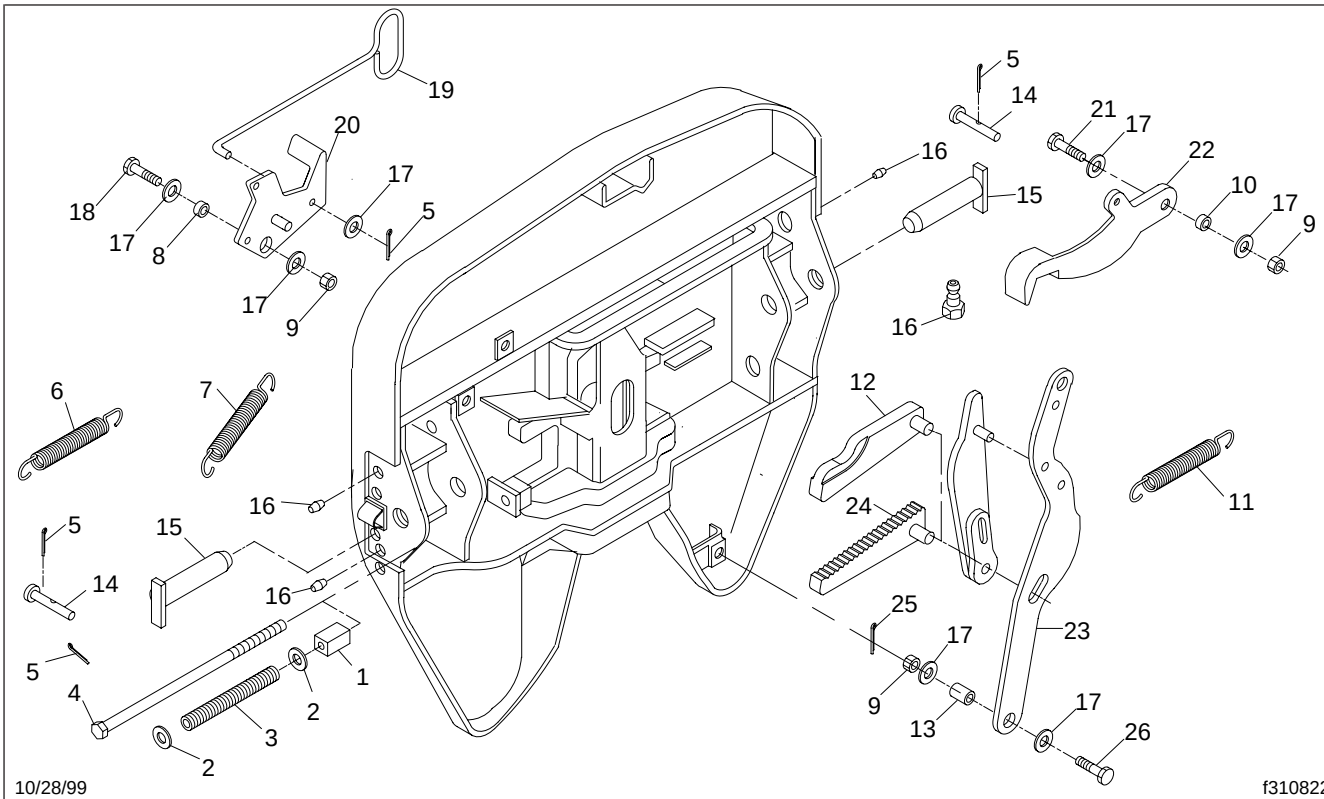


A. Unlocked Position
B. Locking
C. Locked
1. Jaw
2. Wedge
3. Trailer Kingpin

Fig. 1, Fontaine Kingpin Lock Mechanism

Removal and Disassembly

(See Fig. 1)



1. Wedge Stop Rod Nut
2. Flat Washer, 5/8-Inch
3. Wedge Stop Rod Spring
4. Wedge Stop Rod
5. Cotter Pin, 3/16 x 1-Inch
6. Bumper Spring
7. Handle Spring
8. Bushing, 7/16-Inch
9. Hex Locknut, 1/2–13, Grade B
10. Bushing, 5/16-Inch
11. Timer Spring
12. Jaw
13. Bushing
14. Bracket Retainer Pin
15. Bracket Pin
16. Grease Fitting
17. Flat Washer, 1/2-Inch i.d., 1-3/8 Inch o.d.
18. Hexhead Bolt, 1/2–13 x 1-1/2 Inch, Grade 5
19. Pull Handle
20. Secondary Lock
21. Hexhead Bolt, 1/2–13 x 1-3/4 Inch, Grade 5
22. Bumper
23. Operating Handle
24. Wedge
25. Hair Pin Cotter
26. Hexhead Bolt, 1/2–13 x 2-1/4 Inch

Fig. 1, Fontaine 6000 Series Fifth Wheel (left-side release shown)

⚠ WARNING

All fifth wheel maintenance, adjustment and rebuilding must be done by a qualified mechanic. Improper or incomplete procedures could 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. Failure to do so can result in personal injury, due to parts ejecting with force.

Fifth Wheel Removal and Disassembly

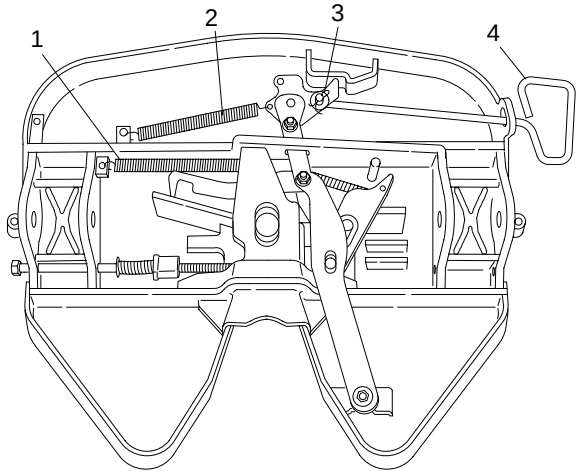
1. Steam clean the top plate. Remove it from the mount by removing the cotter pins from the retaining pins. Remove the retaining pins and bushing pins from both sides of the top plate.
2. Using an overhead hoist, lift the fifth wheel off the mount and tractor frame.
3. Turn the fifth wheel upside down.

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. Remove the handle spring. See **Fig. 2**. Remove the cotter pin and flat washer holding the pull handle to the secondary lock and remove the pull handle. Remove the bumper spring.

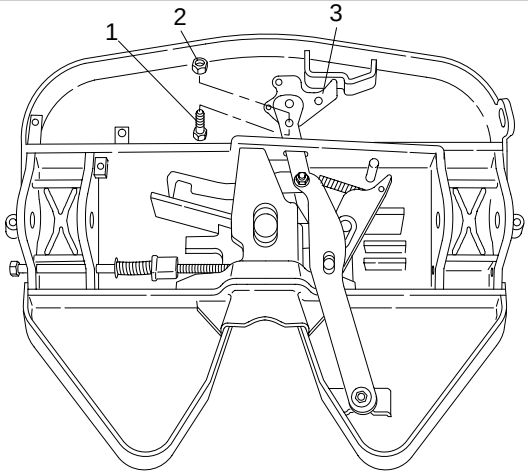


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1. Bumper Spring
2. Handle Spring
3. Secondary Lock
4. Pull Handle

Fig. 2, Pull Handle Removal

5. Unbolt and remove the secondary lock from the operating handle. See **Fig. 3**.

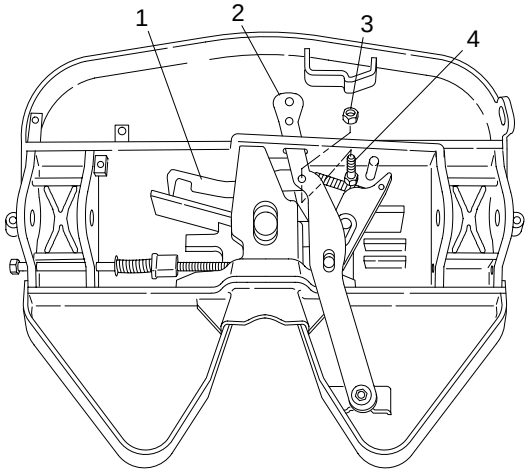


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1. Hexhead Bolt, 1/2–13, 1-1/2 Inch
2. Locknut, 1/2–13
3. Secondary Lock

Fig. 3, Secondary Lock Removal

6. Unbolt and remove the bumper from the operating handle. See **Fig. 4**.

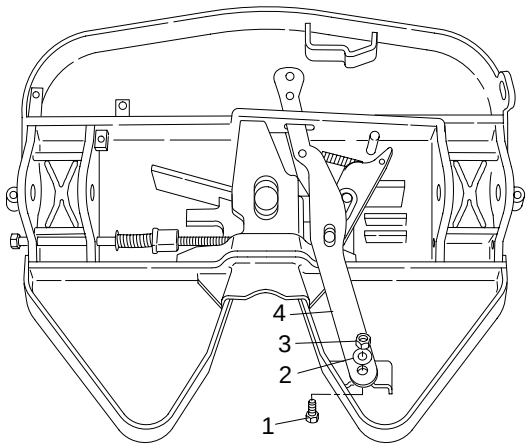


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1. Bumper
2. Operating Handle
3. Locknut, 1/2–13
4. Hexhead Bolt, 1/2–13, 1-3/4 Inch

Fig. 4, Bumper Removal

7. Unbolt the operating handle from the pivot mount and remove the operating handle. See **Fig. 5**.

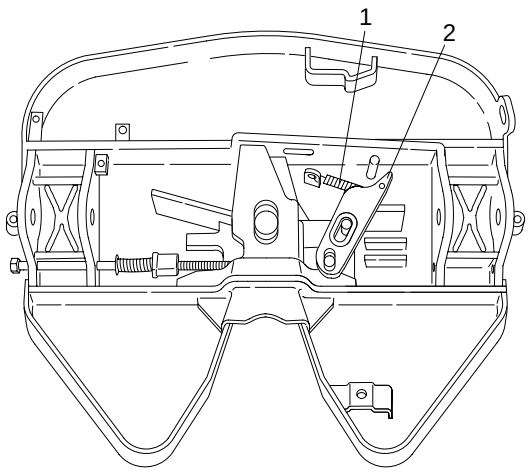


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1. Hexhead Bolt, 1/2–13, 2-1/4 Inch
2. Flat Washer
3. Locknut, 1/2–13
4. Operating Handle

Fig. 5, Operating Handle Removal

8. Remove the timer spring and timer. See **Fig. 6**.

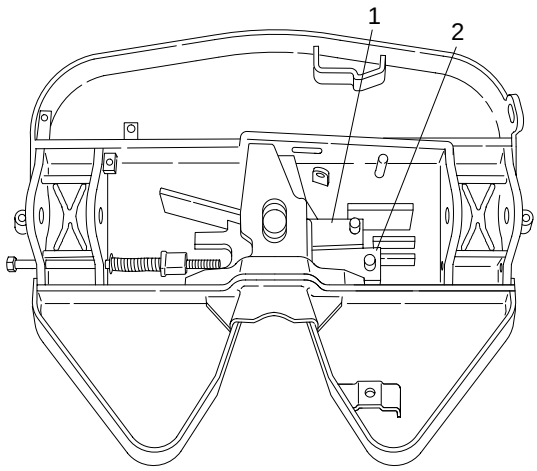


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1. Timer Spring
2. Timer

Fig. 6, Timer Spring and Timer Removal

9. Remove the jaw and wedge. See **Fig. 7**.



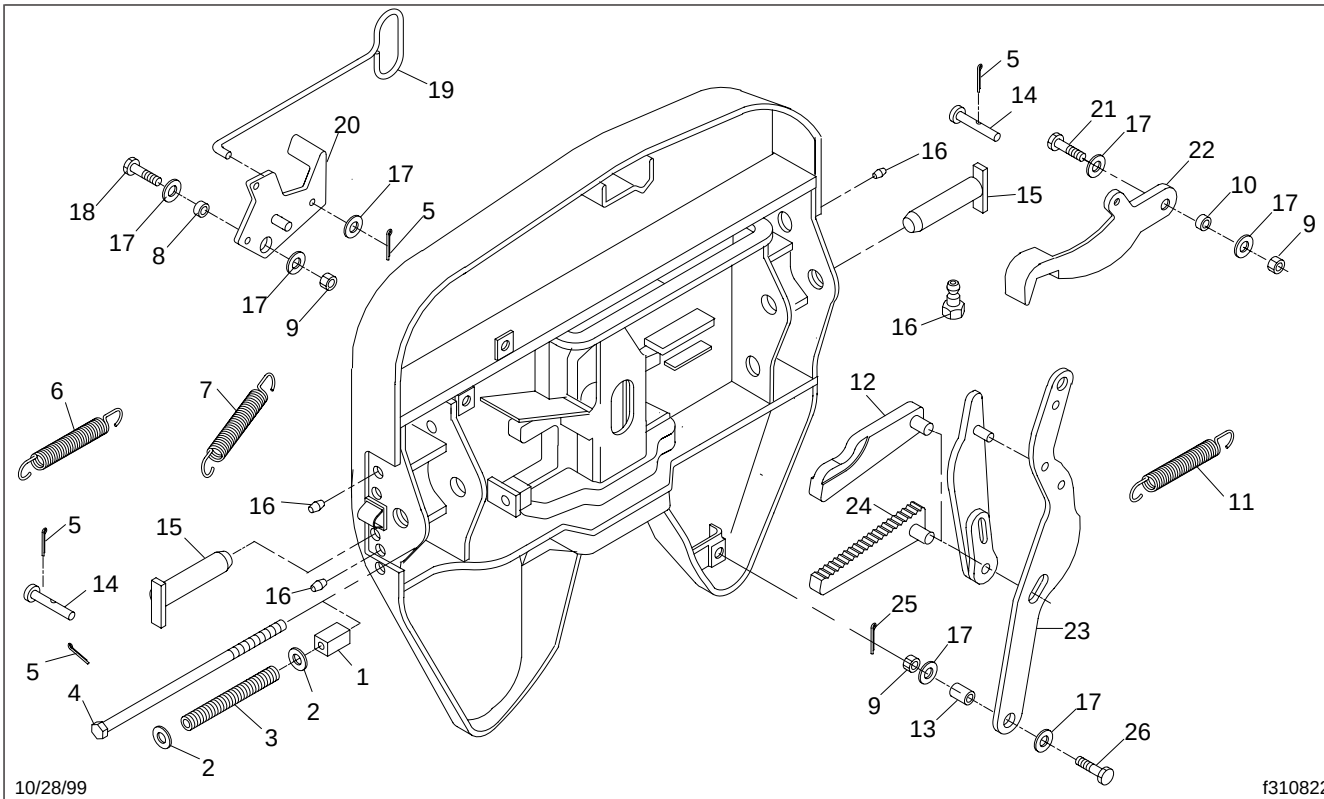
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1. Jaw
2. Wedge

Fig. 7, Jaw and Wedge Removal

Assembly and Installation

(See Fig. 1)



1. Wedge Stop Rod Nut
2. Flat Washer, 5/8-Inch
3. Wedge Stop Rod Spring
4. Wedge Stop Rod
5. Cotter Pin, 3/16 x 1-Inch
6. Bumper Spring
7. Handle Spring
8. Bushing, 7/16-Inch
9. Hex Locknut, 1/2–13, Grade B
10. Bushing, 5/16-Inch
11. Timer Spring
12. Jaw
13. Bushing
14. Bracket Retainer Pin
15. Bracket Pin
16. Grease Fitting
17. Flat Washer, 1/2-Inch i.d., 1-3/8 Inch o.d.
18. Hexhead Bolt, 1/2–13 x 1-1/2 Inch, Grade 5
19. Pull Handle
20. Secondary Lock
21. Hexhead Bolt, 1/2–13 x 1-3/4 Inch, Grade 5
22. Bumper
23. Operating Handle
24. Wedge
25. Hair Pin Cotter
26. Hexhead Bolt, 1/2–13 x 2-1/4 Inch

Fig. 1, Fontaine 6000 Series Fifth Wheel (left-side release shown)

⚠ WARNING

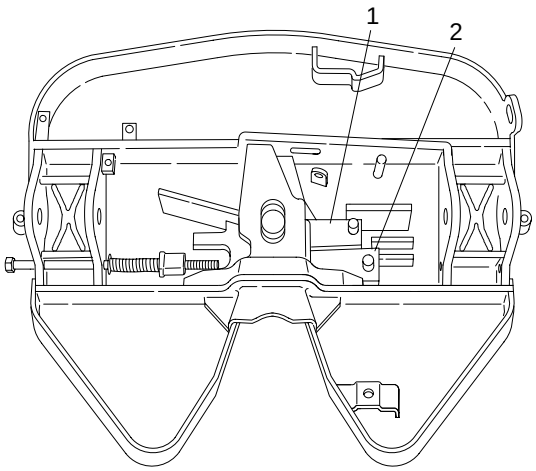
All fifth wheel maintenance, adjustment and rebuilding must be done by a qualified mechanic. Improper or incomplete procedures could result in possible disengagement of the trailer from the tractor, leading to personal injury and property damage.

Fifth Wheel Assembly and Installation

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.

1. Clean all moving parts with No. 2 diesel fuel before assembly.
2. Insert the jaw and wedge. See **Fig. 2**.

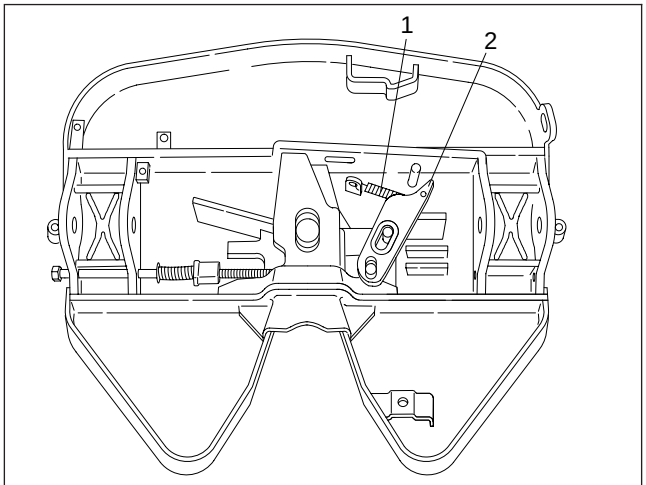


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1. Jaw
2. Wedge

Fig. 2, Wedge and Jaw Installation

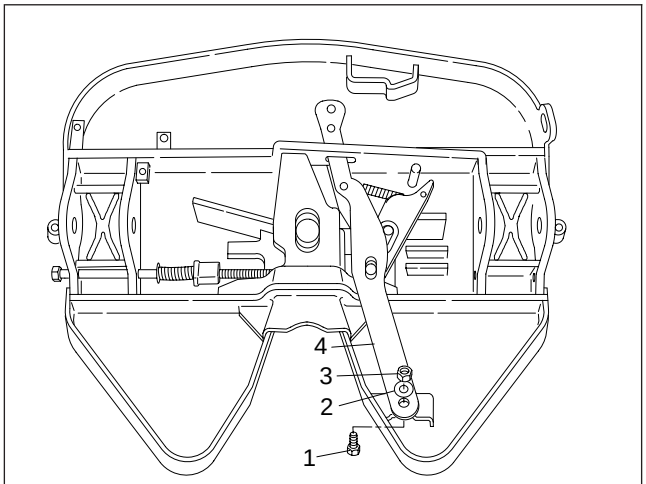
3. Insert the timer and timer spring. See **Fig. 3**.
4. Insert the operating handle and bolt it to the pivot mount. See **Fig. 4**.
5. Install the bumper and bolt it to the operating handle. See **Fig. 5**.
6. Insert the secondary lock and bolt it to the operating handle. See **Fig. 6**.
7. Position the pull handle and install the flat washer and cotter pin. Attach the handle spring and the bumper spring. See **Fig. 7**.



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1. Timer Spring
2. Timer

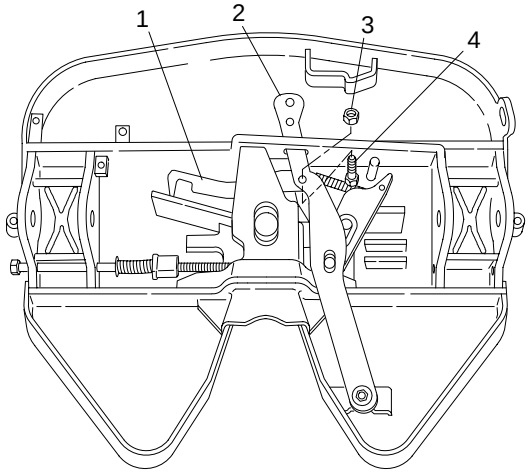
Fig. 3, Timer and Timer Spring Installation



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1. Hexhead Bolt, 1/2–13 x 2-1/4 Inch
2. Flat Washer
3. Locknut, 1/2–13
4. Operating Handle

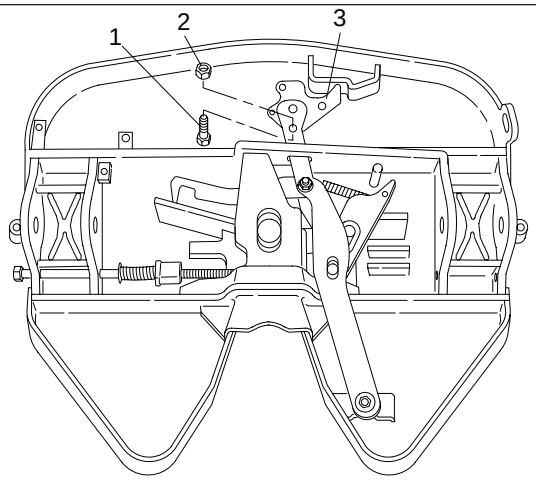
Fig. 4, Operating Handle Installation



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1. Bumper
2. Operating Handle
3. Locknut, 1/2–13
4. Hexhead Bolt, 1/2–13 x 1-3/4 Inch

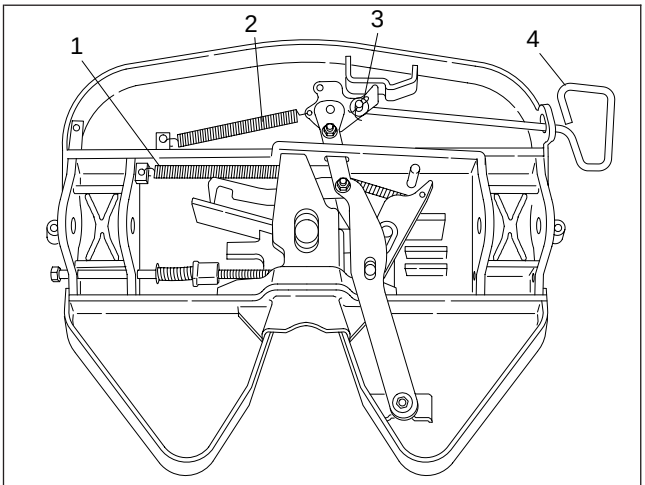
Fig. 5, Bumper Installation



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1. Hexhead Bolt, 1/2–13 x 1-1/2 Inch
2. Locknut, 1/2–13
3. Secondary Lock

Fig. 6, Secondary Lock Installation



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1. Bumper Spring
2. Handle Spring
3. Secondary Lock
4. Pull Handle

Fig. 7, Pull Handle 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.

8. Using an overhead hoist, position the fifth wheel on the mount assembly. Insert the bushing pins. Install the retaining pins and the 1-inch long cotter pins.
9. Close the fifth wheel several times with a standard 2-inch kingpin tool. With the lock closed, adjust the wedge stop rod so the end is 1/4-inch from the wedge. See **Troubleshooting, 300** for additional information.

Troubleshooting Tables

Problem—Difficult Coupling

Problem—Difficult Coupling	
Possible Cause	**Remedy**
Kingpin too high to trip latch	Lower the landing gear.
Damaged trailer plate or kingpin	Check the trailer plate for flatness. Check the kingpin for squareness with the trailer plate.

Problem—Excessive Wear on the Fifth Wheel Top 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—Difficult Uncoupling

Problem—Difficult Uncoupling	
Possible Cause	**Remedy**
Pressure on locking mechanism caused by tractor drifting apart from trailer putting excess pressure on lock.	Back up the tractor 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.

Problem—Slack

Problem—Slack	
Possible Cause	**Remedy**
Improperly adjusted wedge.	Open the fifth wheel and insert a 2-inch kingpin or a shaft with a 2-inch diameter. Trip the lock and adjust the wedge stop rod so that it is 1/4-inch from the end of the wedge.
Undersized kingpin.	Replace the kingpin if it is worn greater than 1/8 inch (3 mm) at the 2-inch (5-cm) diameter.
Worn jaw and wedge.	The jaw and wedge could have excessive wear. Replace them.

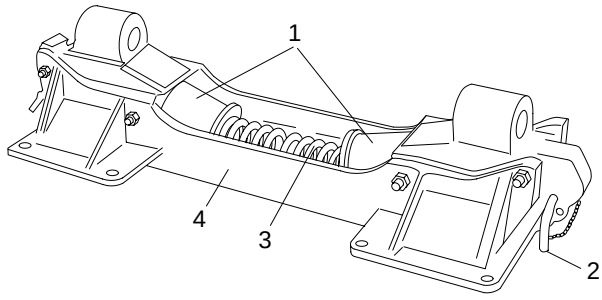
General Information

MODEL XA–351 TOP PLATE

NOTE: The part number prefix for the stationary fifth wheel is FW35.

The Holland 3500 series XA–351 fifth wheel is applicable for general over-the-road use. It is designed to pull trailers having a 2-inch SAE J700b kingpin. It has a capacity of 150,000 lbf (667 000 N) maximum drawbar pull and 55,000 lbf (244 652 N) maximum vertical load. This fifth wheel is available in two different mounting assemblies: the Kompensator® and the stationary mount.

The Kompensator fifth wheel is equipped with a stationary mounting bracket. This fifth wheel is designed for rigid trailers that do not 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 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. 1**.



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1. Urethane Cushions
2. Optional Lockout
3. Compression Springs
4. Kompensator Cradle Design Mounting Bracket

Fig. 1, Kompensator Cradle

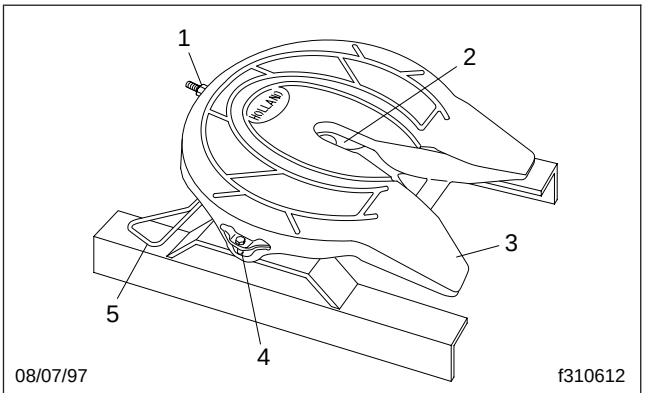
The stationary mount fifth wheel is available with four different mounting bracket styles. The fifth wheel can be equipped with:

- 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;
- Or, a bracket for outboard angle mounting.

The mounting brackets use nylon-lined "up-shock" bushings. This fifth wheel comes in a variety of heights to accommodate many applications.

The 3500 series top plate consists of (see **Fig. 2**):

- The cast steel top plate;
- The bracket pin mount;
- The release handle;
- The infinite lock adjustment nut;
- And, the kingpin lock mechanism.



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1. Infinite Lock Adjustment Nut
2. Kingpin Lock
3. Cast Steel Top Plate
4. Bracket Pin Mount
5. Release Handle

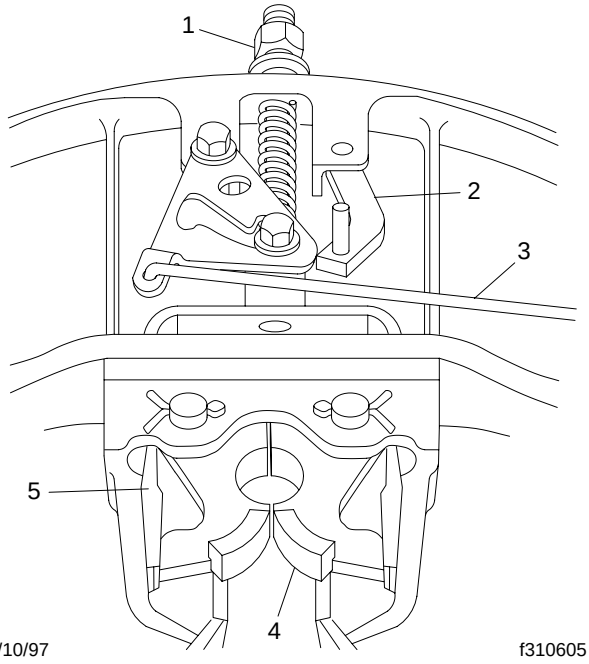
Fig. 2, XA-351 Fifth Wheel

The kingpin lock mechanism consists of (see **Fig. 3**):

- The infinite lock adjustment nut;
- The secondary lock;
- The release handle;

General Information

- The type "B" forged steel split lock;
- And, the yoke.



1. Infinite Lock Adjustment Nut
2. Secondary Lock (Automatic Shown)
3. Release Handle
4. Kingpin Guide
5. Yoke

Fig. 3, 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. If the fifth wheel has an automatic secondary lock, the kingpin is released by manually operating the release handle. If the fifth wheel has a manual secondary lock, the fifth wheel is released by pulling the secondary release handle, hooking the secondary release handle to the top plate casting, and 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 in both the kingpin and the lock jaws.

See Chapter 11 in the *Cargo Driver's Manual* for complete operating instructions.

Model XA–351 Top Plate Removal and Disassembly

WARNING

All fifth wheel maintenance, adjustment and rebuilding must be done by a qualified mechanic. Improper or incomplete procedures could result in the loss of the 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. The part numbers for the rebuild kits are:

- RK-351AL (left-side release with automatic secondary lock);
- RK-351A02L (left-side release with manual secondary lock);
- RK-351A (right-side release with automatic secondary lock);
- RK-351A02 (right-side 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.

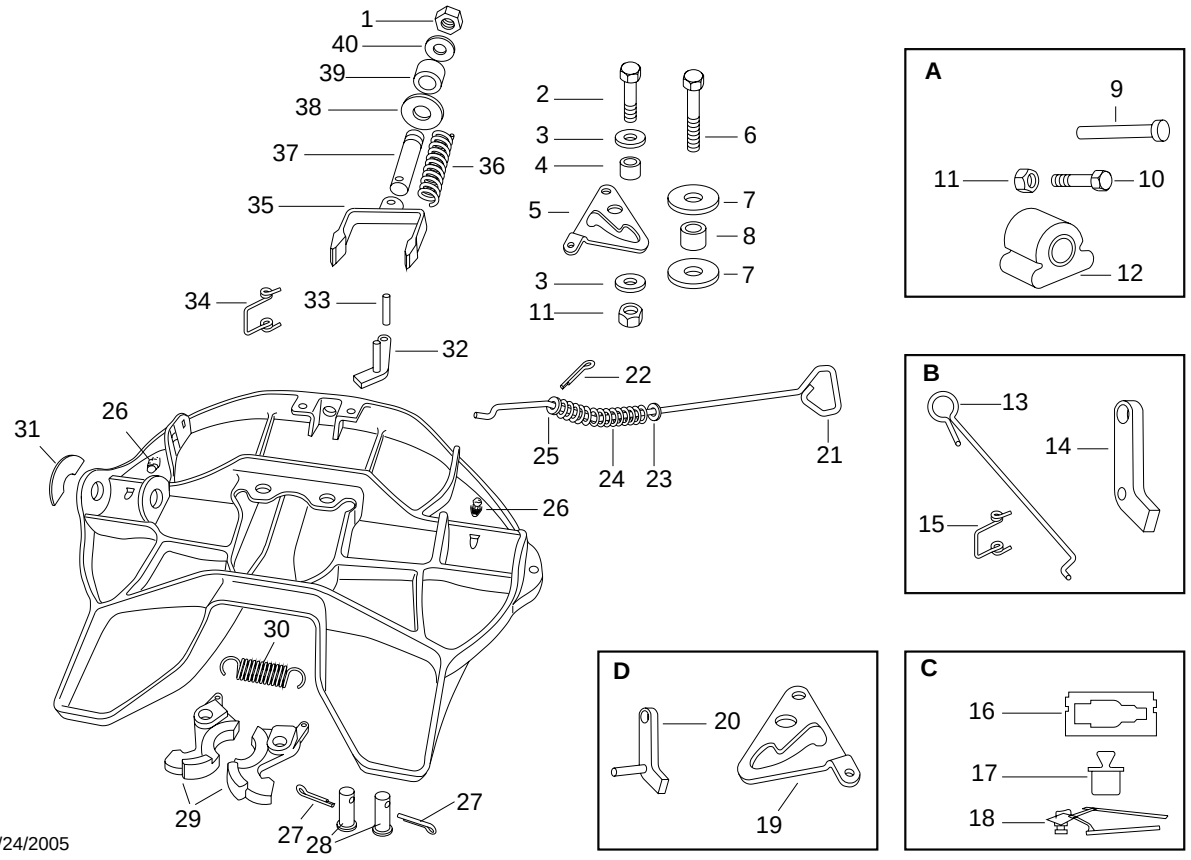
Rebuilding the fifth wheel may be unnecessary. Review **Troubleshooting, 300** before rebuilding the fifth wheel. If the troubleshooting section does not correct the problem, the fifth wheel may need rebuilding.

While disassembling the fifth wheel, check for cracks and for missing or damaged parts. Discard all used components.

Removal and Disassembly

1. Steam clean the top plate.
2. Remove the top plate from the bracket assembly. See **Fig. 1**.
   - 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. If not, remove the manual secondary release handle by passing the "S" bend of the release handle through the large hole in the secondary lock and 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 **Fig. 8**. This will free the lock jaw assembly. Remove the lock jaws and lock spring.

Model XA–351 Top Plate Removal and Disassembly

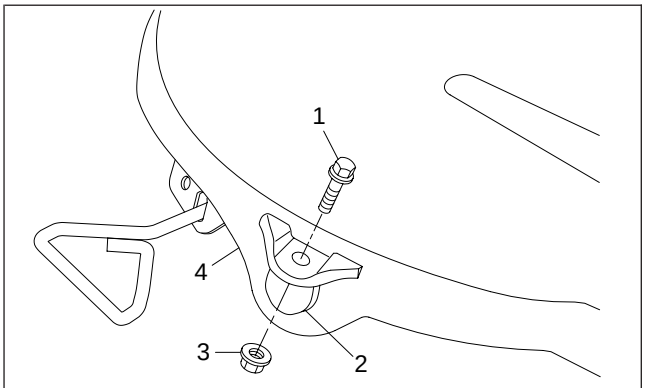


A. Bushing Pin Assembly
B. Manual Secondary Lock Assembly
C. Fifth Wheel Accessories
D. Right-Side Secondary Lock Assembly

1. Locknut, 3/4–16
2. Capscrew, 1/2–20 x 1-3/4
3. Washer, 1-3/4 Inch o.d. x 9/16-Inch i.d.
4. Roller, 1/2-Inch 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-Inch i.d.
9. Bracket Bushing Pin
10. Capscrew, 1/2–20 x 1-1/4
11. Locknut, 1/2–20
12. Rubber Bushing
13. Manual Secondary Lock Release Handle
14. Manual Secondary Lock
15. Torsion Spring
16. Kingpin Gauge
17. 2-Inch Lock Gauge (Plug)
18. Kingpin Lock Tester
19. Cam Plate (right-side)
20. Secondary Lock (right-side)
21. Release Handle
22. Cotter Pin, 1/8 x 1-1/4
23. Washer, 1-3/8 Inch o.d. x 9/16-Inch i.d.
24. Compression Spring
25. Washer, 1-1/16 Inch o.d. x 5/8-Inch i.d.
26. Grease Zerk
27. Cotter Pin, 1/4 x 2
28. Lockpin
29. Lock Jaw Set
30. Extension Spring
31. Operation Tag
32. Secondary Lock (left-side)
33. Roll Pin, 1/2 x 2-3/4
34. Torsion Spring
35. Yoke
36. Compression Spring
37. Yoke Shaft
38. Lock Adjustment Tag
39. Rubber Washer
40. Washer 1-1/2 Inch o.d. x 13/16-Inch i.d.

Fig. 1, Holland 3500 Series XA-351 Fifth Wheel and Accessories (bottom view)

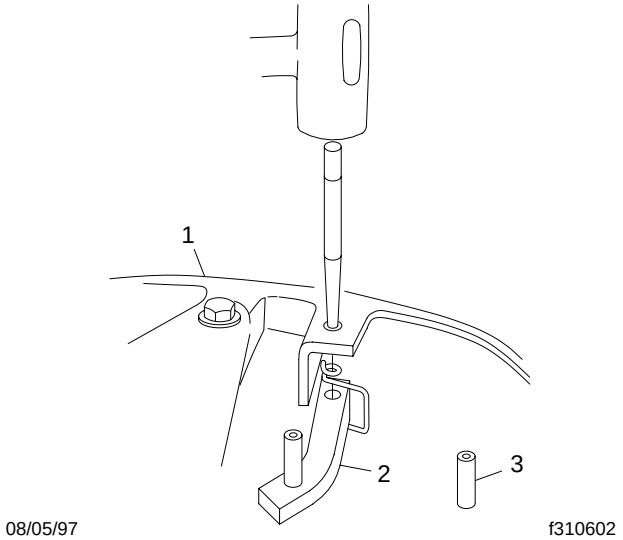
Model XA–351 Top Plate Removal and Disassembly



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1. Capscrew
2. Bushing Pin
3. Locknut
4. Top Plate

Fig. 2, Remove the Bushing Pin



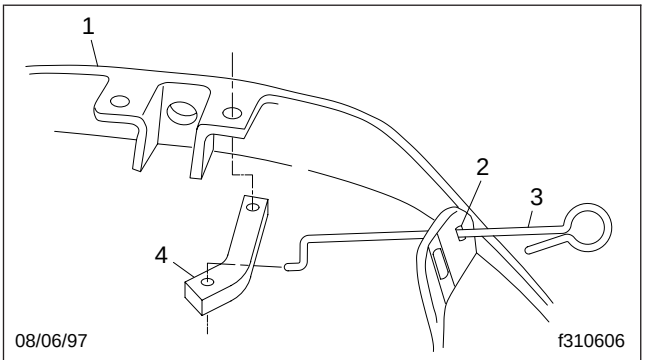
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1. Top Plate
2. Secondary Lock
3. Roll Pin

Fig. 3, Disassemble the Secondary Lock

⚠ WARNING

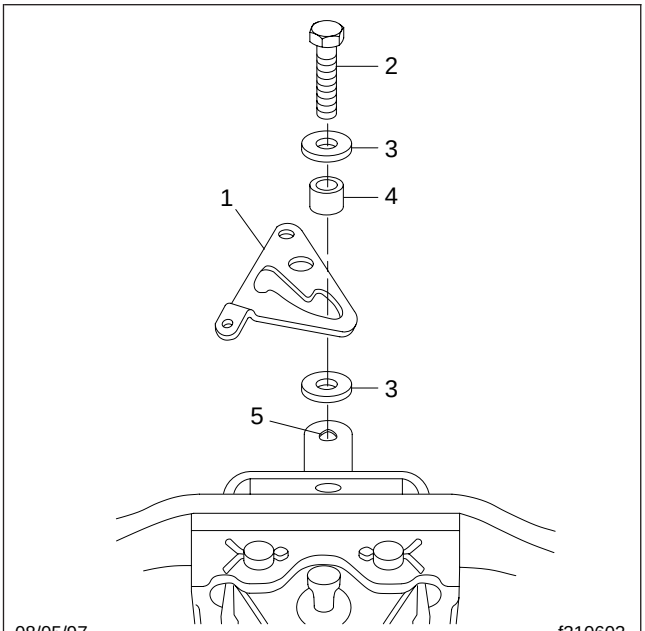
Do not attempt to repair or rebuild the top plate if it is cracked or if the lockpin does not fit tightly. The top plate could fail or the locks could malfunction. This could result in the loss of the trailer connection during vehicle travel, possibly causing bodily injury and property damage.



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1. Top Plate
2. Guide Hole
3. Release Handle
4. Secondary Lock

Fig. 4, Remove the Release Handle

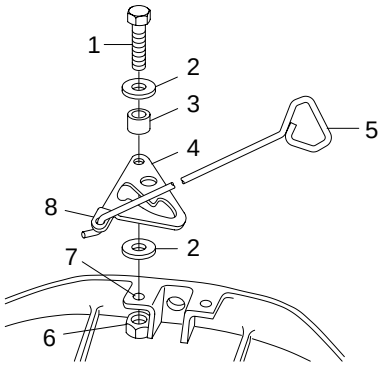


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1. Cam Plate
2. Capscrew, 5/8–20
3. Washer
4. Roller
5. Threaded Hole in Yoke

Fig. 5, Remove the Capscrew from the Yoke

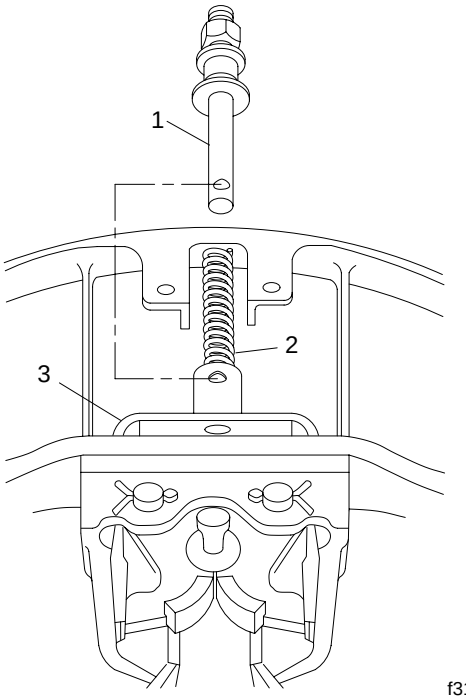
Model XA–351 Top Plate Removal and Disassembly



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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

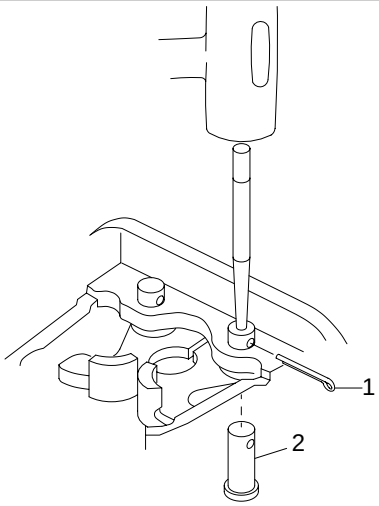
Fig. 6, Disassemble the Cam Plate



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1. Yoke Shaft Assembly
2. Compression Spring
3. Yoke

Fig. 7, Remove the Yoke Shaft Assembly



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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 by a qualified mechanic. Improper or incomplete procedures could result in the loss of the 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. The part numbers for the rebuild kits are:

- RK-351AL (left-side release with automatic secondary lock);
- RK-351A (right-side release with automatic secondary lock);
- RK-351A02L (left-side release with manual secondary lock);
- RK-351A02 (right-side 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 **Troubleshooting, 300** before rebuilding the fifth wheel. If the troubleshooting section does not correct the problem, the fifth wheel may need rebuilding.

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 the loss of the trailer connection during vehicle travel, possibly causing bodily injury and property damage.

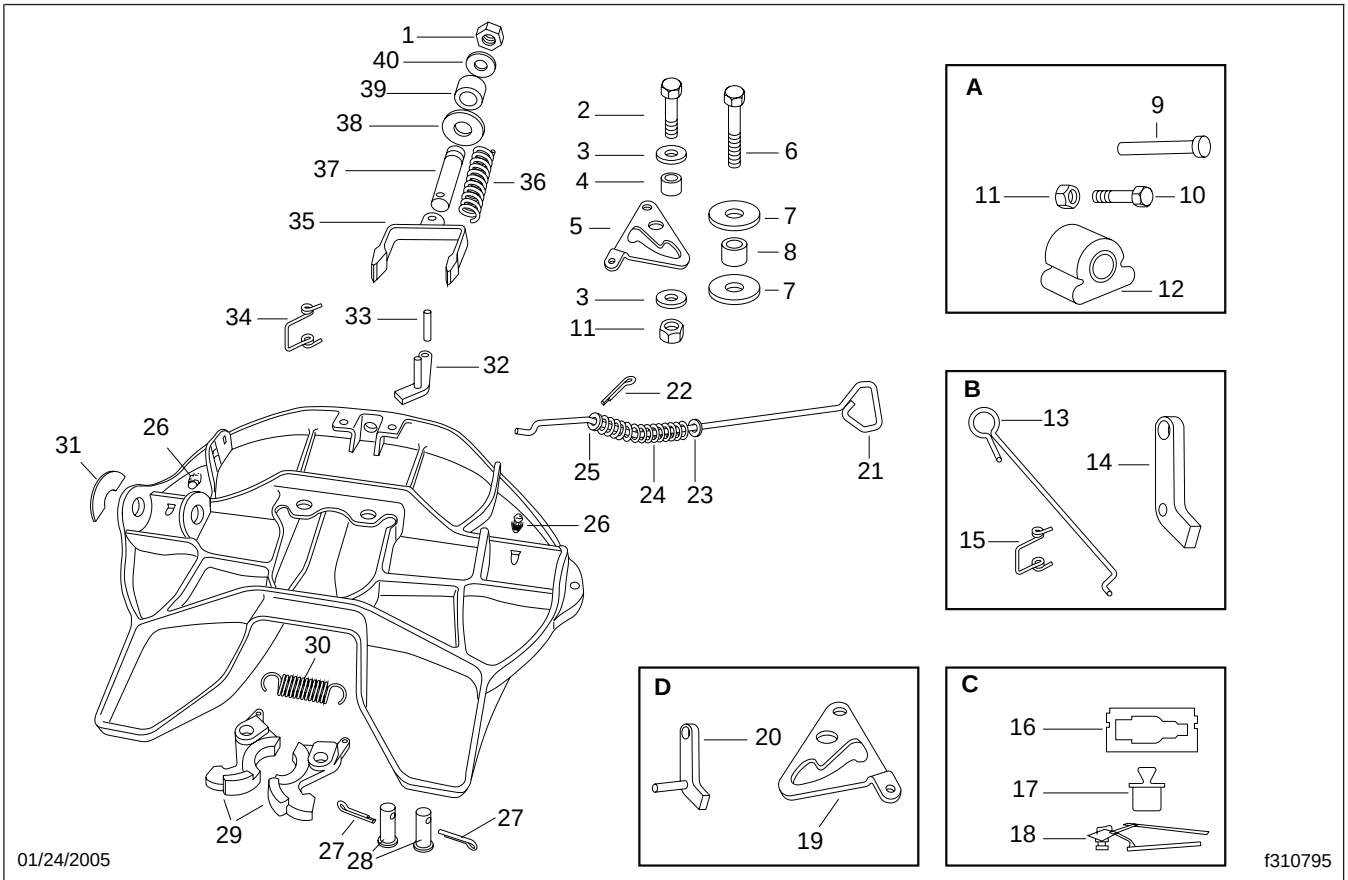
1. Inspect the top plate.
   - 1.1 If necessary, turn the fifth wheel upside down.
   - 1.2 Inspect the front lock surface for burrs or cracks. See **Fig. 2**. The front lock surface must be free of any burrs or cracks.
2. Install the lock.
   - 2.1 Lubricate the lockpin holes of the lock jaws with Never-Seez® (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 the ends.
   - 2.5 Check that the lock jaws move freely.

Model XA–351 Top Plate Assembly and Installation



A. Bushing Pin Assembly
B. Manual Secondary Lock Assembly
C. Fifth Wheel Accessories
D. Right-Side Secondary Lock Assembly

1. Locknut, 3/4–16
2. Capscrew, 1/2–20 x 1-3/4
3. Washer, 1-3/4 Inch o.d. x 9/16-Inch i.d.
4. Roller, 1/2-Inch i.d.
5. Cam Plate (left-side)
6. Capscrew, 5/8–18 x 3/4
7. Washer, 2-5/8 x 21/32
8. Roller, 5/8-Inch i.d.
9. Bracket Bushing Pin
10. Capscrew, 1/2–20 x 1-1/4
11. Locknut, 1/2–20
12. Rubber Bushing
13. Manual Secondary Lock Release Handle
14. Manual Secondary Lock
15. Torsion Spring
16. Kingpin Gauge
17. 2-Inch Lock Gauge (Plug)
18. Kingpin Lock Tester
19. Cam Plate (right-side)
20. Secondary Lock (right-side)
21. Release Handle
22. Cotter Pin, 1/8 x 1-1/4
23. Washer, 1-3/8 Inch o.d. x 9/16-Inch i.d.
24. Compression Spring
25. Washer, 1-1/16 Inch o.d. x 5/8-Inch i.d.
26. Grease Zerk
27. Cotter Pin, 1/4 x 2
28. Lockpin
29. Lock Jaw Set
30. Extension Spring
31. Operation Tag
32. Secondary Lock (left-side)
33. Roll Pin, 1/2 x 2-3/4
34. Torsion Spring
35. Yoke
36. Compression Spring
37. Yoke Shaft
38. Lock Adjustment Tag
39. Rubber Washer
40. Washer, 1-1/2 Inch o.d. x 13/16-Inch i.d.

Fig. 1, Holland 3500 Series XA-351 Fifth Wheel and Accessories (bottom view)

Model XA–351 Top Plate Assembly and Installation

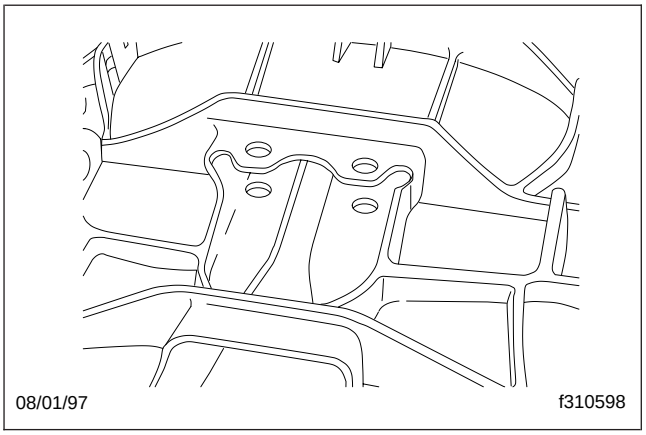
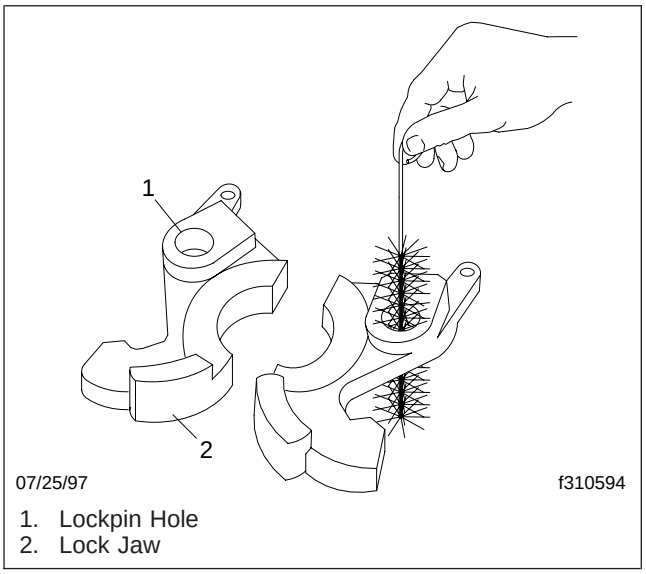


Fig. 2, Front Lock Surface Inspection



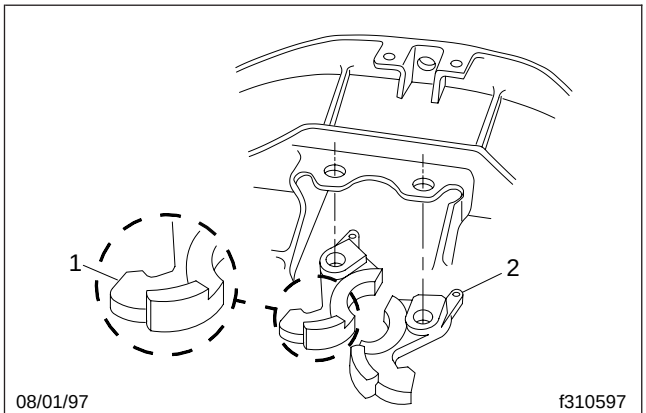
1. Lockpin Hole
2. Lock Jaw

Fig. 3, Lubricate the Lockpin Holes

⚠ WARNING

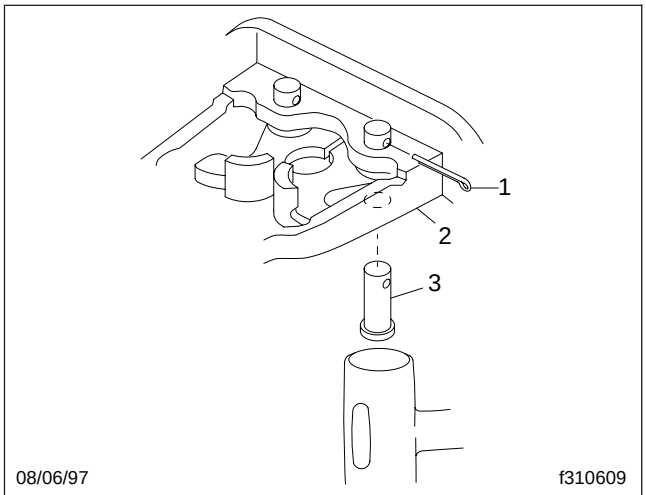
You must use a Holland lock gauge (TF-0237) or a precision plug that is 2.000 ± 0.005 inch (5.08 ± 0.0127 cm) for proper installation of the locking mechanism. If the proper plug is not used, the lock could malfunction or fail. This could result in the loss of the trailer connection during vehicle travel, 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.



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

3. Install the yoke.

   3.1 Lubricate the surface area of the yoke tips with light grease. With the threaded 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 than a 1/2

Model XA–351 Top Plate Assembly and Installation

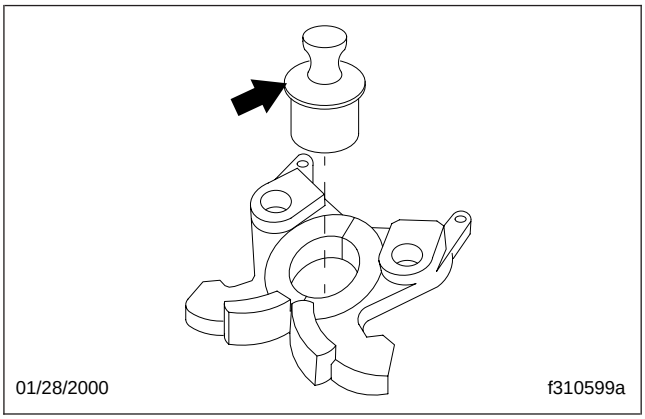
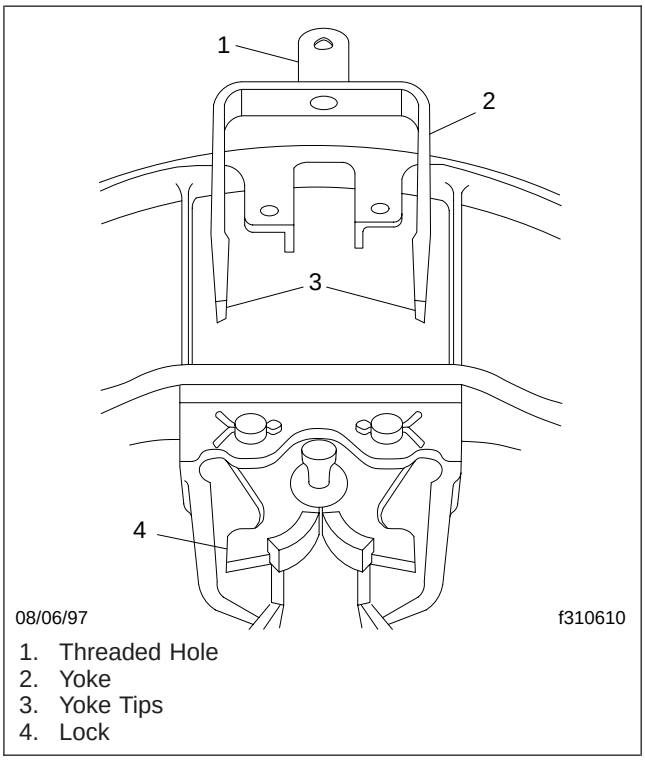


Fig. 6, Lock Gauge (Plug)

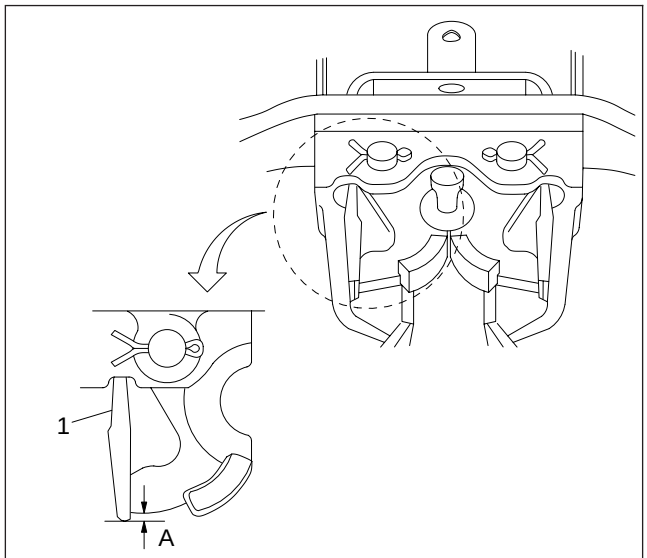


1. Threaded Hole
2. Yoke
3. Yoke Tips
4. Lock

Fig. 7, Install the Yoke

inch (12.7 mm) past the locks. See **Fig. 8**. If the new yoke extends more than a 1/2 inch (12.7 mm) past the locks, *do not use it*. Discard it and order part number XA-07295-THK from your nearest Holland distributor.

3.3 Install the lock spring. See **Fig. 9**.



A. Measurement: 1/2 Inch (12.7 mm) Maximum
1. Yoke Tip

Fig. 8, Measure the Yoke Tip Engagement

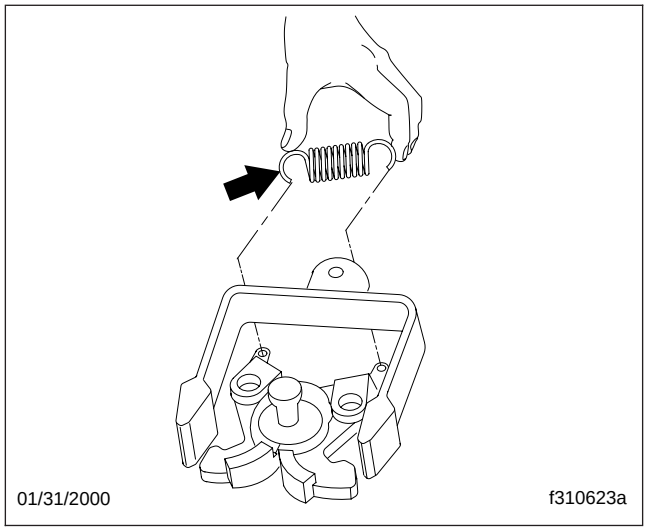
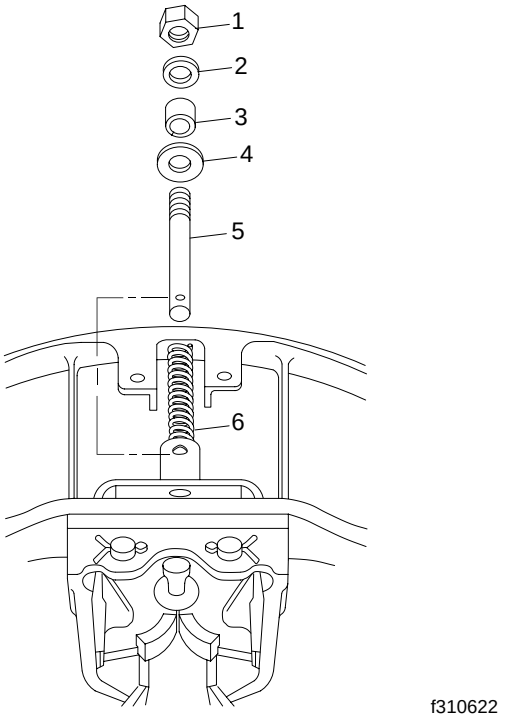


Fig. 9, Lock Spring

3.4 Install the yoke spring. Slide the yoke shaft into the casting, through the yoke spring and into the yoke. Align the recessed 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 washer

Model XA–351 Top Plate Assembly and Installation



1. Locknut, 3/4–16
2. Washer, 1-1/2 Inch o.d. x 13/16-Inch i.d.
3. Rubber Washer
4. Lock Adjustment Tag
5. Yoke Shaft
6. Yoke Spring

Fig. 10, Install and Assemble the Yoke Shaft

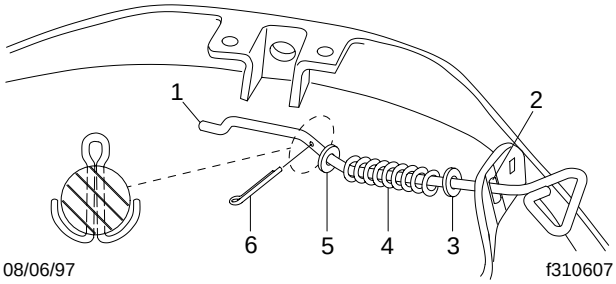
onto the yoke shaft. Start the locknut and finger-tighten it. See **Fig. 10**.

4. Install the release handle.

   4.1 Slide the release handle through the hole in the casting (on the left side for left-side release or on the right side for right-side 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 Inch o.d. x 9/16-Inch i.d.
4. Compression Spring
5. Washer, 1-1/16 Inch o.d. x 5/8-Inch i.d.
6. Cotter Pin, 1/8 x 1-1/4

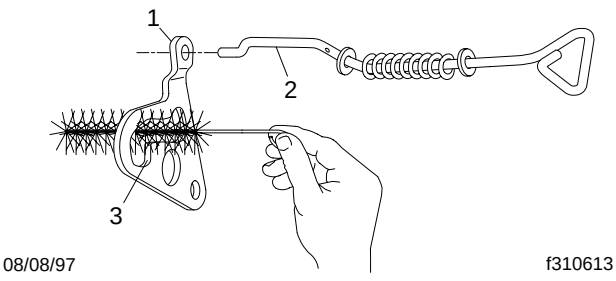
Fig. 11, Install the Release Handle

   4.4 Insert the cotter pin. Spread the ends of the cotter pin and wrap them 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. Connect the raised tab in the cam plate to the "S" bend in the release handle. See **Fig. 12**.



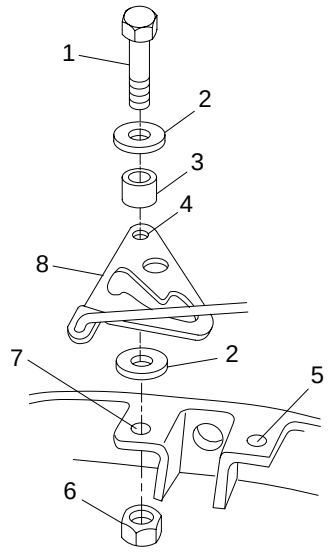
1. Cam Plate Raised Tab
2. Release Handle
3. Cam Plate Track

Fig. 12, Lubricate the Cam Plate

   5.3 Position the cam plate attachment hole over the proper casting lug hole. 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. Install the 1/2-inch roller into the cam plate and

Model XA–351 Top Plate Assembly and Installation

place the second 1-3/4 inch washer on top of the roller with the rounded side facing the cam plate. See **Fig. 13**.



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1. Capscrew, 1/2–20 x 1-3/4
2. Washer, 1-3/4 Inch o.d. x 9/16-Inch i.d.
3. Roller, 1/2 Inch 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

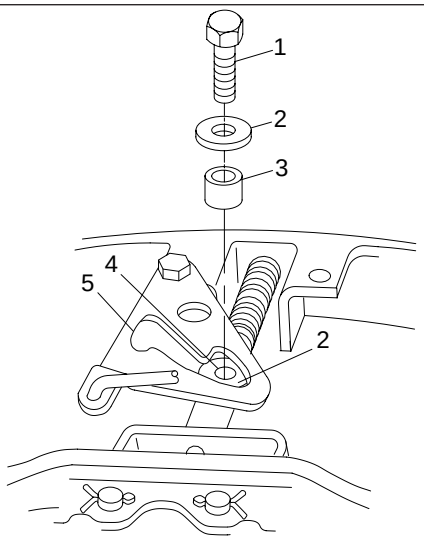
Fig. 13, Install the Cam Plate

5.4 Install the 1/2-inch capscrew through the washers, roller and top plate lug. 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. 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. 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**.



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1. Capscrew (5/8–18 x 1-3/4 Inch)
2. Washer (2-5/8 x 21/32 Inch)
3. Roller (5/8-Inch 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. 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. Tighten the capscrew securely. See **Fig. 14**.

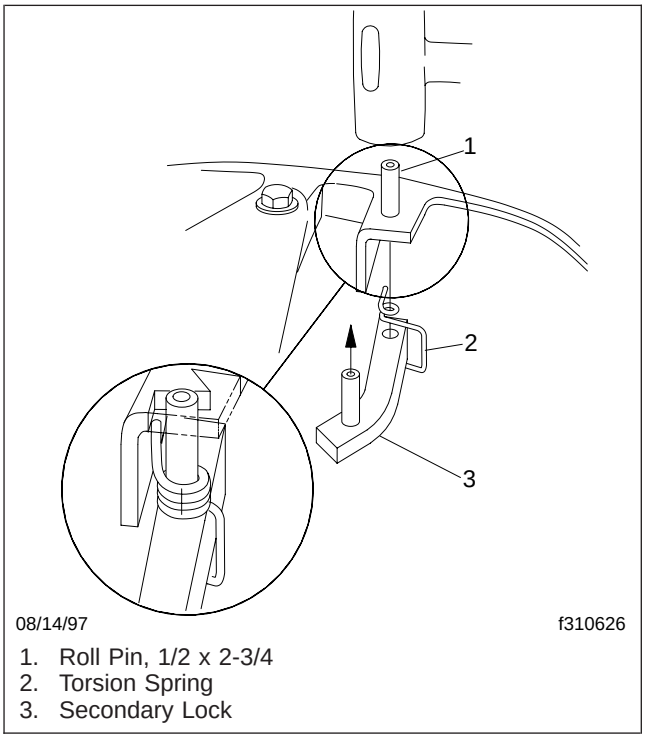
5.8 Check for free movement of the cam plate.

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. 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

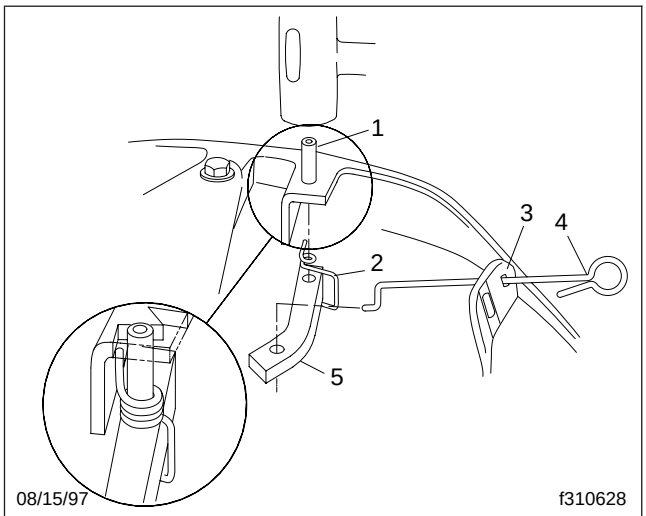
Fig. 15, Install the Secondary Lock

6.2 If equipped with the manual version, pass the "S" bend of the manual secondary release handle through the casting guide hole. Pass the "S" bend of the release handle through the large hole in the secondary lock. See **Fig. 16**.

6.3 If equipped with the manual version, start the roll pin into the hole in the top plate opposite the cam attachment capscrew. 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 If equipped with the manual version, use a suitable hammer to drive the roll pin through the torsion spring and secondary lock until the roll pin is flush with the casting. See **Fig. 16**.

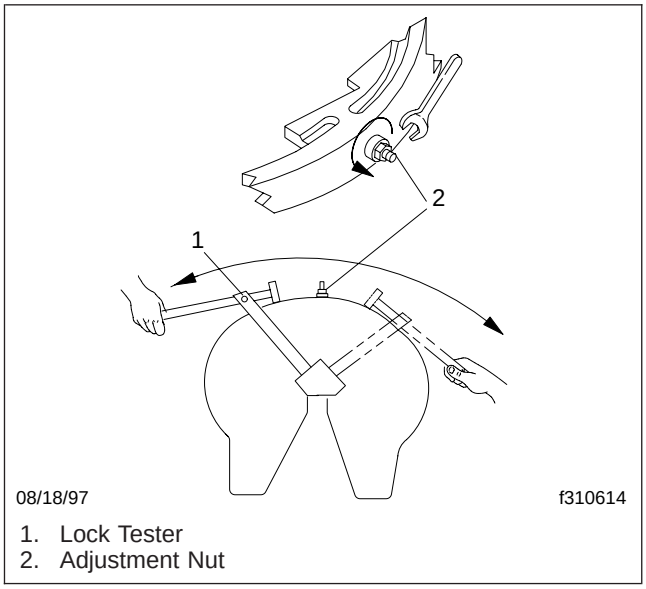
6.5 Check the lock spring for tension and lock for free movement.



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

7.1 If equipped, pull the secondary release handle and hook it on the casting. Pull the primary release handle to open the locks. Remove the 2-inch plug.

Model XA–351 Top Plate Assembly and Installation

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

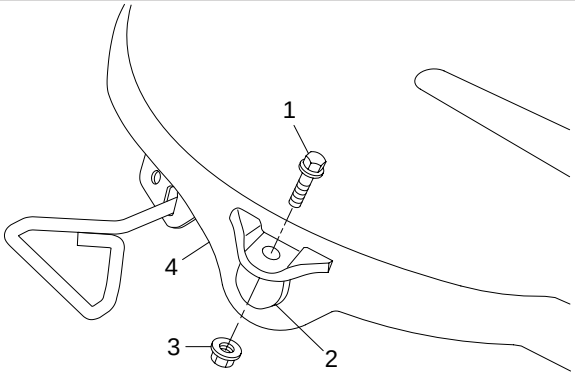
If the fifth wheel does not operate properly, do not use it. Either disassemble it and repeat the rebuilding procedure or contact your nearest Holland representative for assistance. Never use a fifth wheel that does not operate properly. The fifth wheel could malfunction, resulting in bodily injury or 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. Install and tighten securely the 1/2–20 bushing pin capscrews and locknuts. See **Fig. 18**. Remove the overhead hoist.



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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 in the *Cargo Maintenance Manual*.

Troubleshooting Tables

Problem—Difficult Coupling

Problem—Difficult Coupling	
Possible Cause	**Remedy**
Trailer too high; kingpin not entering locks properly.	Lower the trailer landing gear until the bolster plate contacts the fifth wheel.
Closed locks.	Pull the release handle and pry open the locks.
Rust or grime interfering with lock operation.	Spray a light lubricant or diesel fuel on all moving parts including the release handle. Operate the release mechanism several times.
Fifth wheel locks too tight.	Check the lock adjustment. Correct as needed.
Bent release handle, bent kingpin, or damaged bolster plate interfering with lock movement.	Check the release handle, kingpin, and bolster plate. Replace parts as required.
Damaged locks.	Inspect the locks and replace parts as required.
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**
Secondary lock 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.
Tractor putting pressure against locks	Set trailer brakes. Back the tractor into the trailer to relieve pressure and lock the tractor brakes before pulling the release handle.
Rust or grime on interfering with locking mechanism.	Spray a light lubricant or diesel fuel on all moving parts including the release handle. Operate the release mechanism several times.
Bent release handle, bent kingpin or damaged bolster plate interfering with lock movement.	Check the kingpin using the Holland TF-0110 kingpin gauge. Check the bolster plate using a 48-inch (122-cm) straight edge. Check kingpin. Repair or replace parts as required.
Fifth wheel locks too tight, locks damaged	Inspect the locks and replace parts as required. Check the lock adjustment. Correct as needed.
Release handle will not stay out or must be held out when unlocking	Replace the cam or release arm and the release handle spring.
Fifth wheel needs rebuilding.	Rebuild the fifth wheel using the parts in the appropriate rebuild kit. Repaire or replace as required. *
Trailer too high; kingpin not entering locks properly.	Lower the trailer landing gear until the bolster plate contacts the fifth wheel.

* Refer to **Subject 400**, for specific kit applicable to specific fifth wheel assembly.

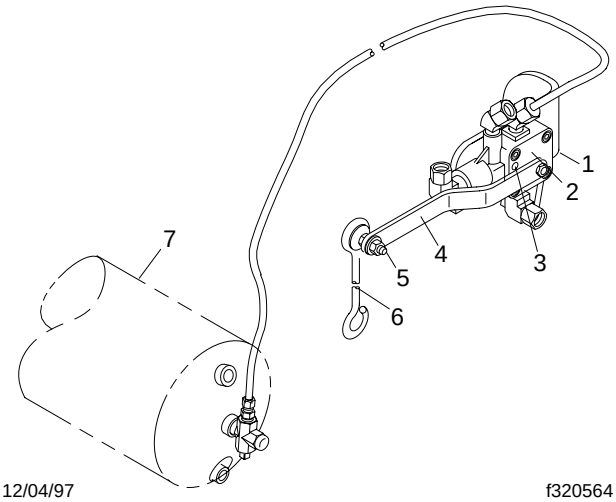
General Information

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**), located in the air line to the height control valve, is preset to maintain a minimum pressure of 65 psi (448 kPa) in the vehicle secondary air system if a leak should occur in the air suspension system.



1. Valve Mounting Bracket
2. Height Control Valve
3. Pilot Hole
4. Lever Rod
5. Stud Bolt
6. Linkage Rod
7. Secondary Air Reservoir

Fig. 1, Height Control Valve Assembly

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.

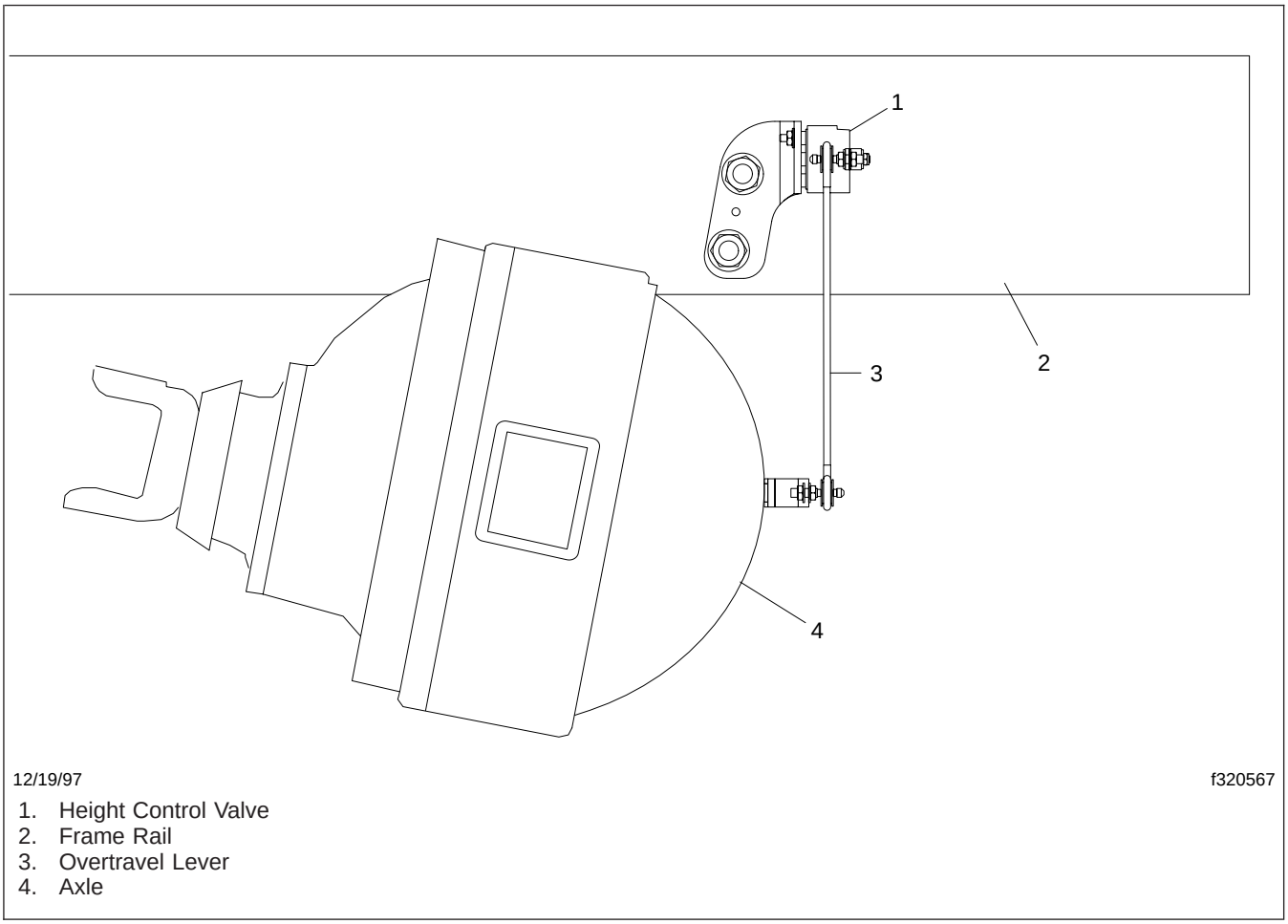
The height control valve is mounted on a frame crossmember. An overtravel lever extends horizontally from the end of the height control valve control shaft to a linkage arm that connects to the height control valve linkage bracket welded to the differential housing. See **Fig. 2**.

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 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



1. Height Control Valve
2. Frame Rail
3. Overtravel Lever
4. Axle

Fig. 2, Height Control Valve Assembly

General Guidelines

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. See Group 32 of the vehicle maintenance manual for maintenance operations.

⚠ 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.

Use only SAE grade 8 bolts, grade C prevailing torque locknuts, and hardened washers to attach spring hangers and brackets to the frame.

For suspension component inspecting, lubricating, and fastener torque checking intervals and instructions, see Group 00 and Group 32 in the vehicle maintenance manual.

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. 1**.

3. Measure the distance between the left forward-most axle stop and the suspension as indicated; see **Table 1**, **Table 2**, **Table 3**, **Table 4**, and **Table 5** 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).

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.

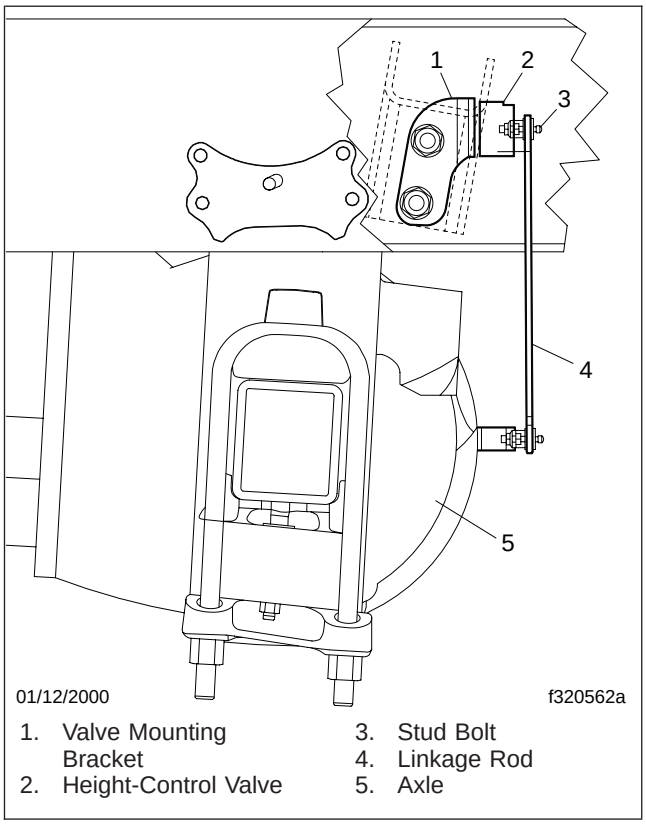
   5.3 Center the lever arm on the valve by inserting a 4-mm pin, or drill bit, into the hole in the lever arm and aligning the pilot hole with the valve body.

   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.

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.

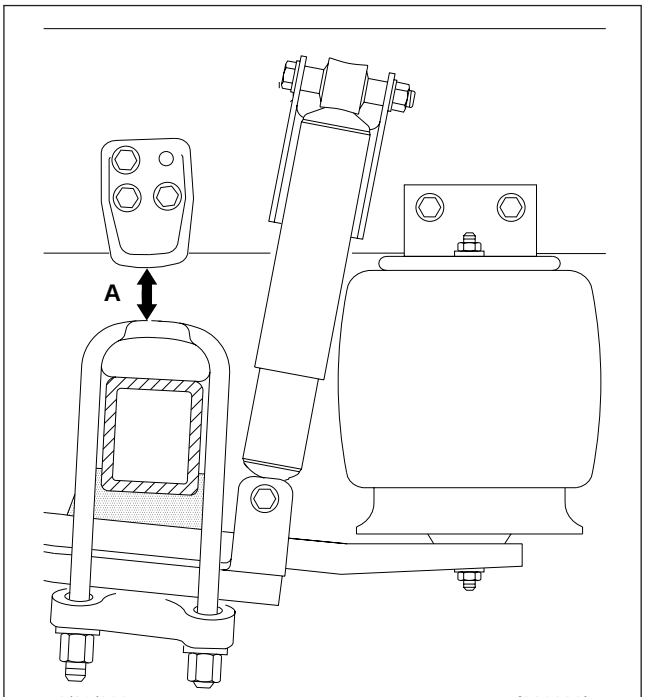
   Park the vehicle using a light brake application. Chock the tires on one axle only, and put the transmission in neutral. Do not apply the parking brakes.



1. Valve Mounting Bracket
2. Height-Control Valve
3. Stud Bolt
4. Linkage Rod
5. Axle

Fig. 1, Barksdale Height-Control Valve Installation (side view)

Suspension Ride Height Adjustment



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 1, Suspension Ride Height Measurement, Dual-Leaf Spring, 20k/40k High Ride

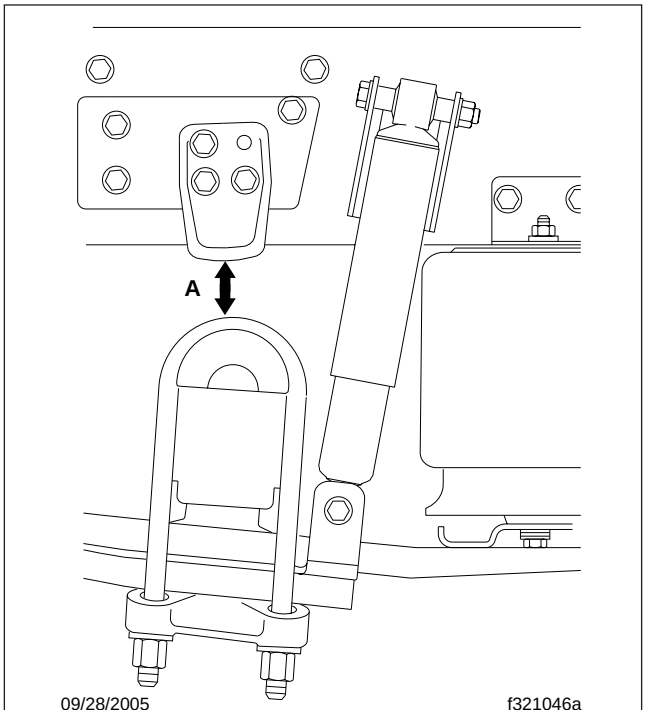
7. Check the distance between the bottom of the left axle stop and the top of the axle U-bolt or U-bolt pad.

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).

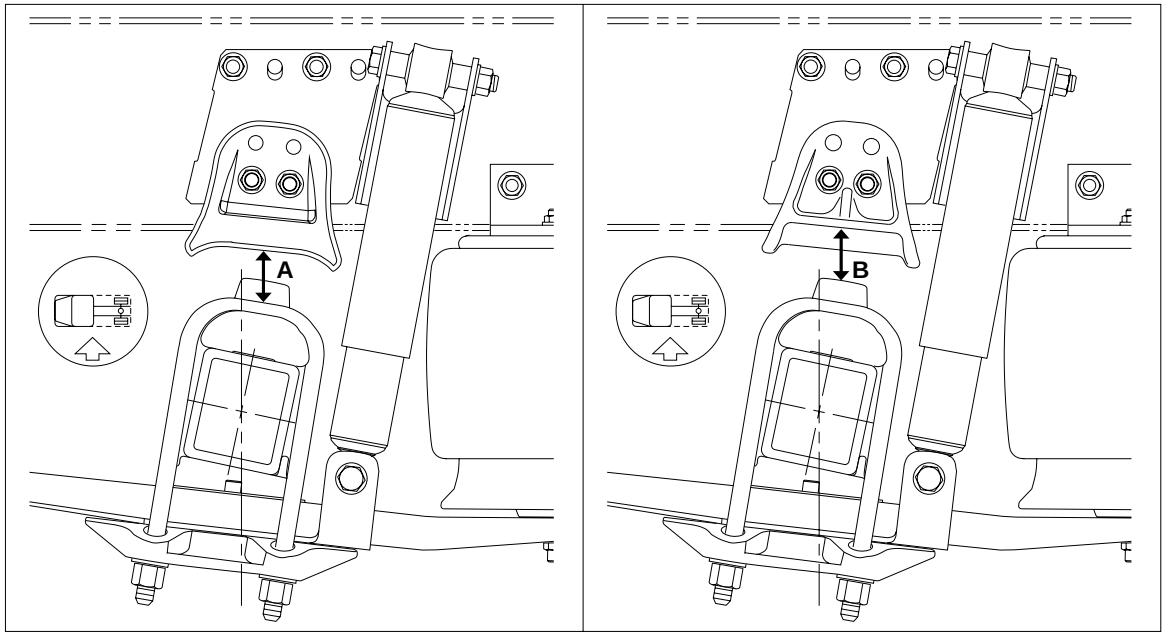
8. If the distance is within the acceptable range, apply the parking brakes, then remove the chocks from the tires.

   If the distance is not within the acceptable range, repeat the adjustment procedure.



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 2, Suspension Ride Height Measurement, Dual-Leaf Spring, 23k/46k/69k High Ride

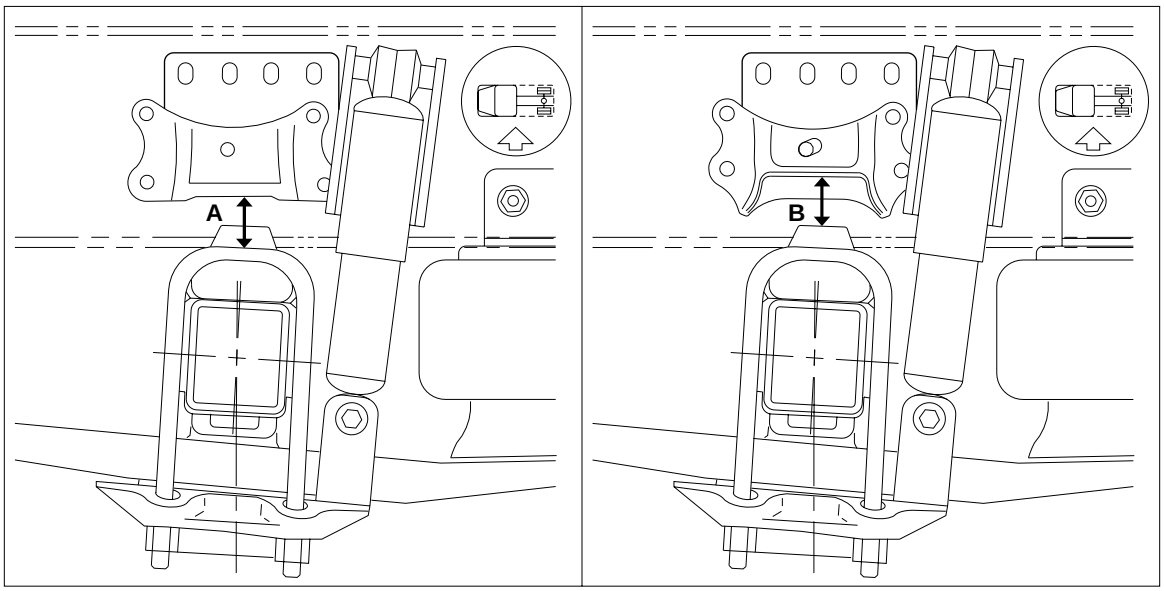


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Measure Point	Suspension Height Measurement (A or B)		
	Min	Target	Max
A = Measure Here if Built Before August 24, 2001 B = Measure Here if Built After August 24, 2001	2-3/8 inch (60 mm)	2-5/8 inch (67 mm)	2-7/8 inch (73 mm)

Table 3, Suspension Ride Height Measurement, Single-Leaf Spring, 20k/40k, High Ride Height

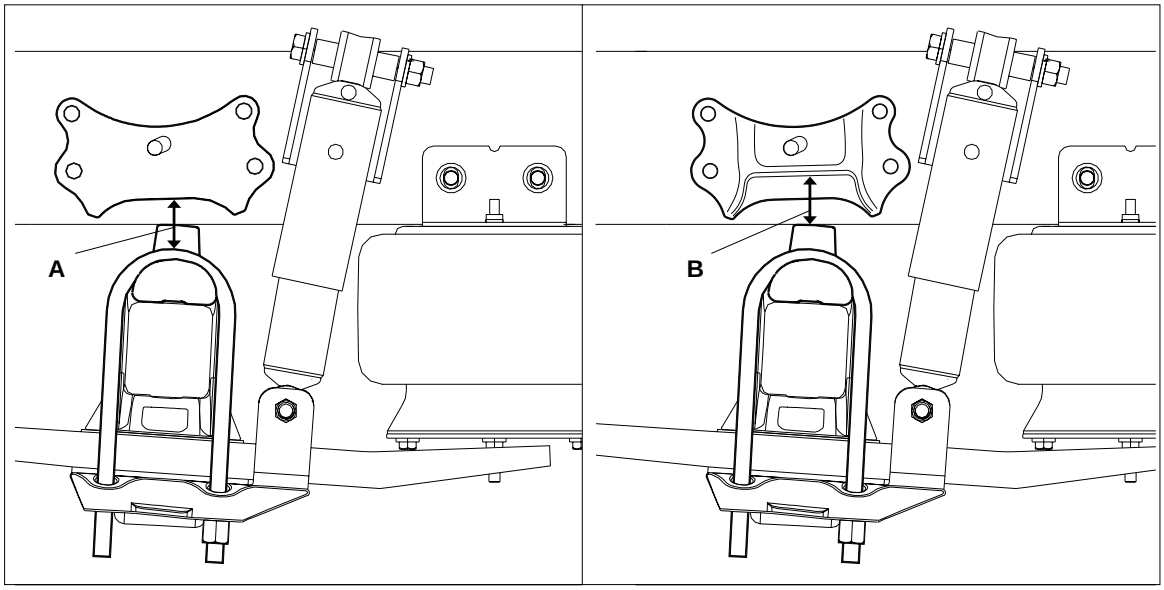
Suspension Ride Height Adjustment



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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 4, Suspension Ride Height Measurement, Single-Leaf Spring, 10k/12k/15k/18k Mid Ride Height and 40k Low and Mid Ride Height



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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 5, 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.

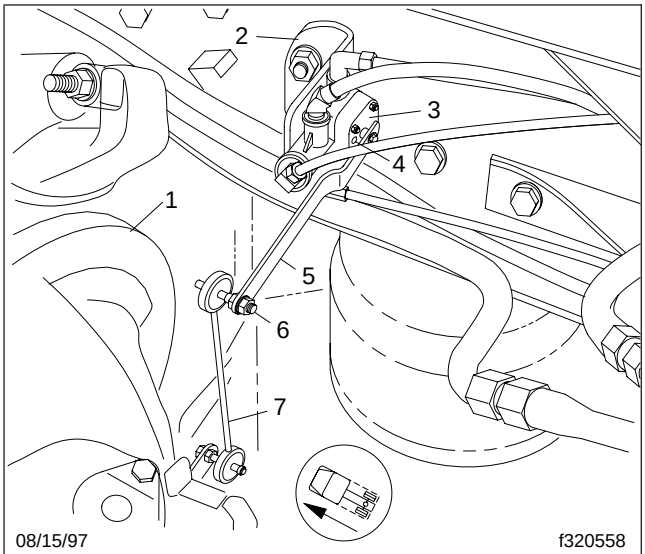
Carefully check the valve before replacing it. Do the following steps to see if a valve is working correctly.

1. Disconnect the leveling valve linkage from the lever arm.
2. Pull the lever arm up about 45 degrees. If air passes through the valve, that section of the valve is working.
3. Return the valve to the neutral position. Air should stop flowing. If so, that section of the valve is working.
4. Push the lever arm down about 45 degrees. 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, see **Subject 110**. If the valve needs replacing, see **Subject 130**.

Height Control Valve Replacement

1. Chock the tires, and drain the air reservoirs.
2. Disconnect the linkage from the lever arm. See **Fig. 1**. Exhaust all air from the air springs by moving the lever arm down.

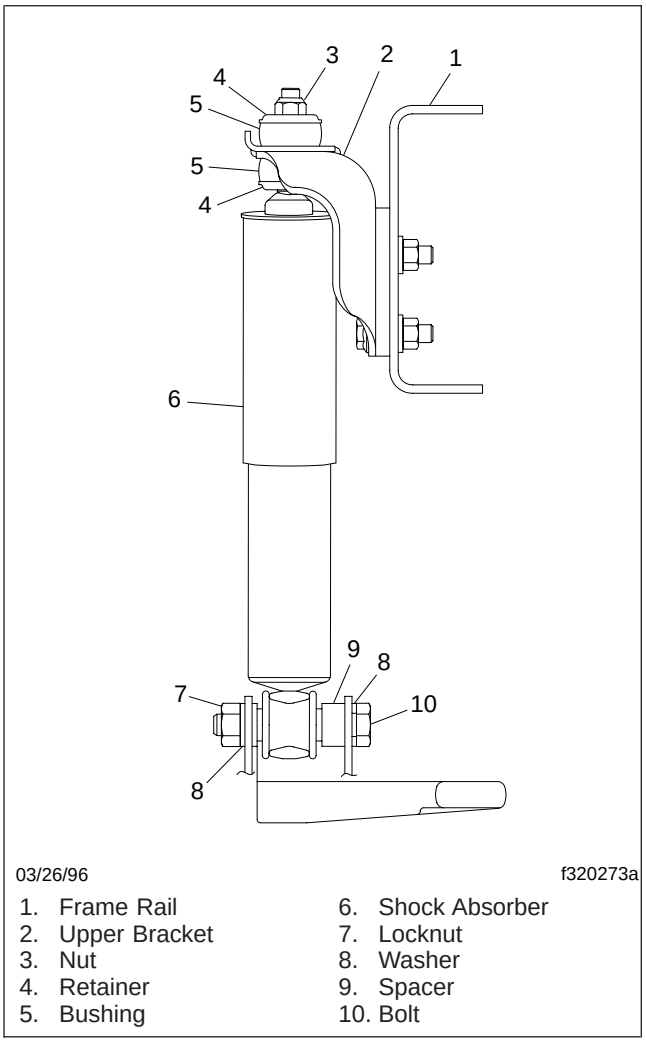


1. Forward Drive Axle
2. Valve Mounting Bracket
3. Height Control Valve
4. Pilot Hole
5. Lever Arm
6. Stud Bolt
7. Linkage Rod

Fig. 1, Height Control Valve Linkage Measurement

3. 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.
4. Remove the height control valve mounting bolts and nuts, and remove the height control valve from the bracket.
5. Remove the lever arm from the height control valve.
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 lever arm. Secure the linkage with a cotter pin.
9. Connect the lever arm to the height control valve.
10. Close the drain cocks on all reservoirs.
11. Build up normal operating pressure in the air system. Check all air lines and connections for leaks. Eliminate all leaks.
12. Adjust the height control valve. For instructions, see **Subject 110**.

Replacement (See Fig. 1)



1. Frame Rail
2. Upper Bracket
3. Nut
4. Retainer
5. Bushing
6. Shock Absorber
7. Locknut
8. Washer
9. Spacer
10. Bolt

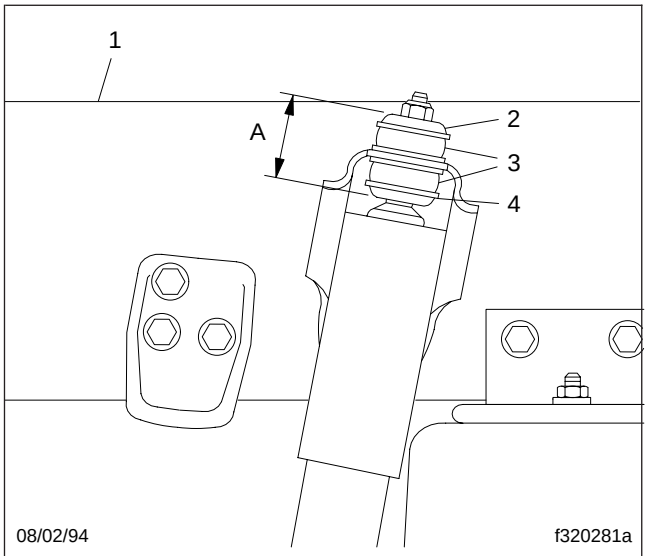
Fig. 1, Shock Absorber Mounting

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**.

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 170 lbf·ft (230 N·m).
7. Tighten the shock absorber upper mounting nut to compress the bushings to the dimension shown in **Fig. 2**.



A. 2-1/2 Inches (64 mm)
1. Frame Rail
2. Upper Retainer
3. Bushings
4. Lower Retainer

Fig. 2, Tighten the Shock Absorber Upper Mounting Nut

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 45 lbf·ft (61 N·m); tighten 1/2–13 locknuts 23 lbf·ft (31 N·m).
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. On wire-braid hose fittings, tighten the nut with a wrench until there is firm resistance, then tighten one-sixth turn more
10. Make sure the air spring bag is fully extended alongside the piston so there are no folds in the bag 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 the bag—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

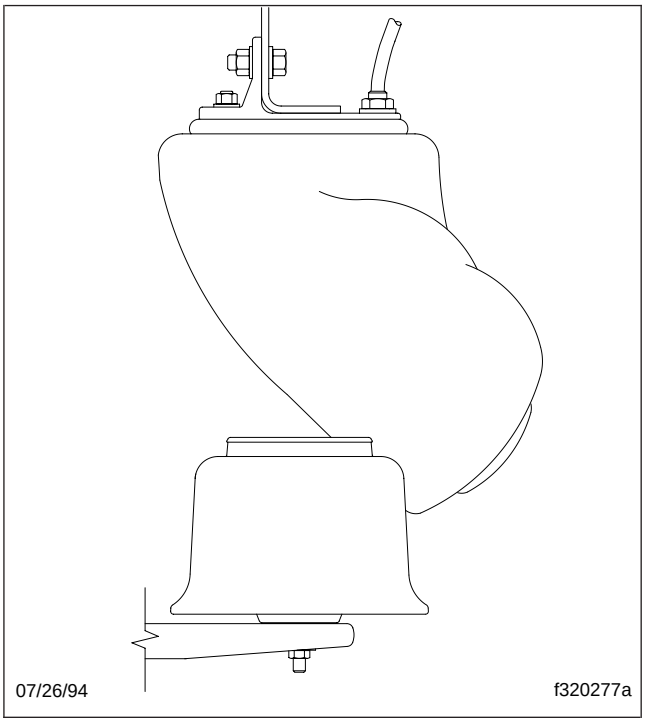


Fig. 1, Air Spring Bag Extended

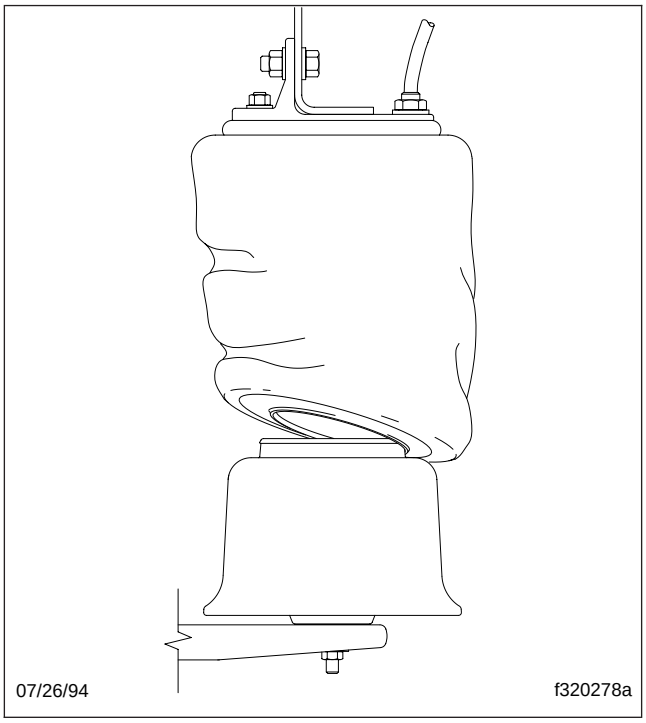


Fig. 3, Air Spring Bag Aligned with Piston

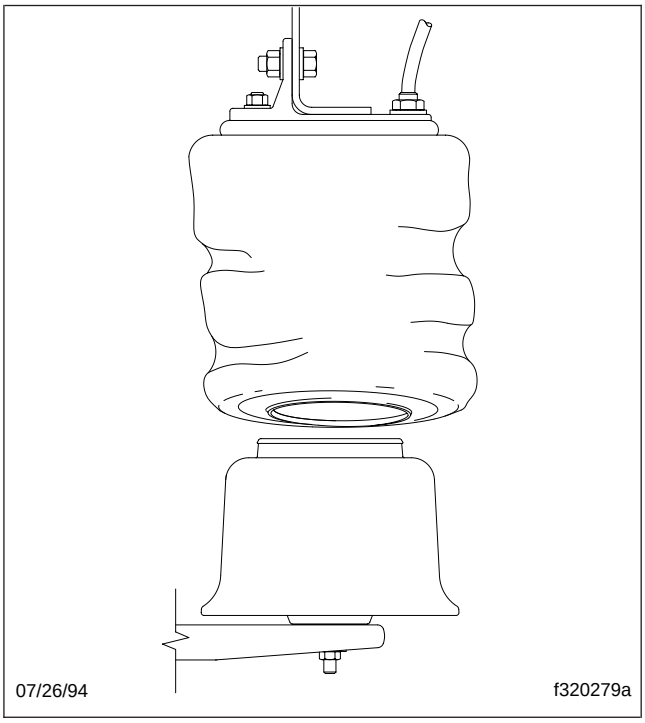


Fig. 2, Air Spring Bag Folded

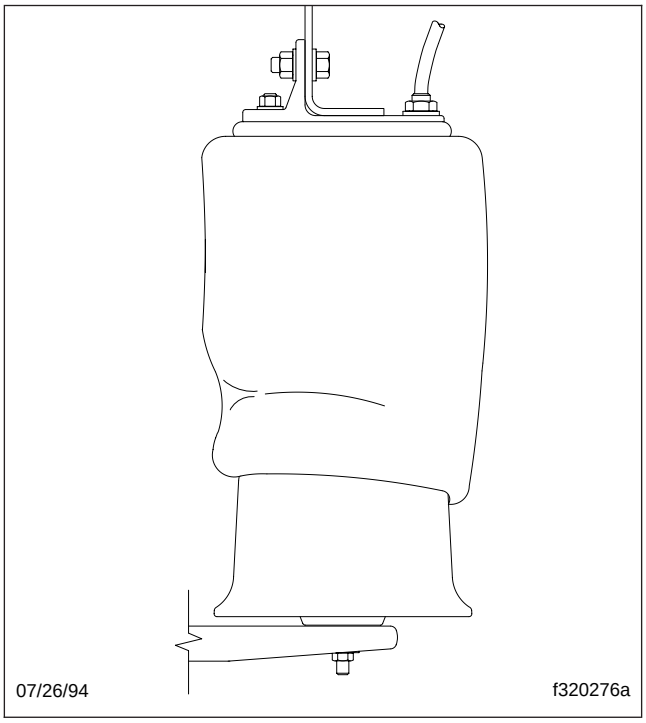
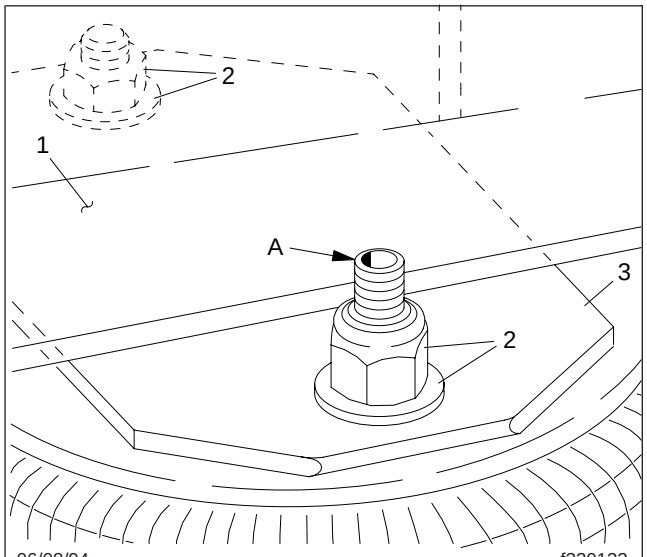


Fig. 4, Air Spring Bag Rolling Onto Piston

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**.

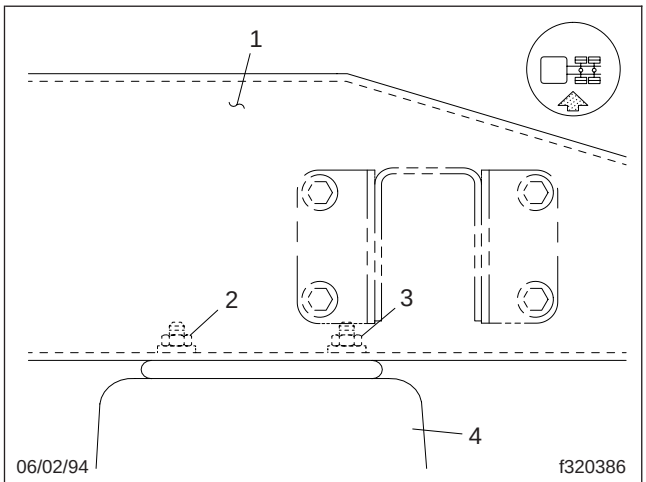


A. Air line connects here.
1. Right Frame Rail Flange
2. Locknut and Washer
3. Upper Mounting Bracket

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

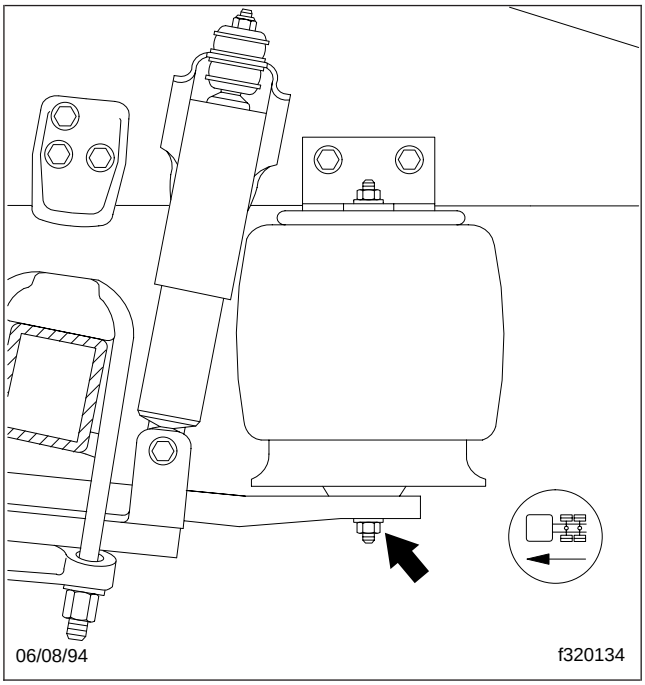
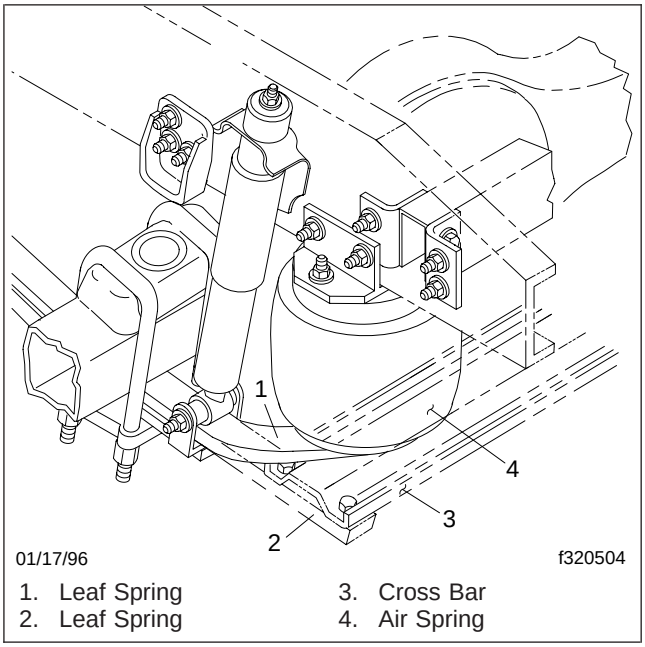


Fig. 3, Capscrew Connecting Leaf Spring and Air Spring

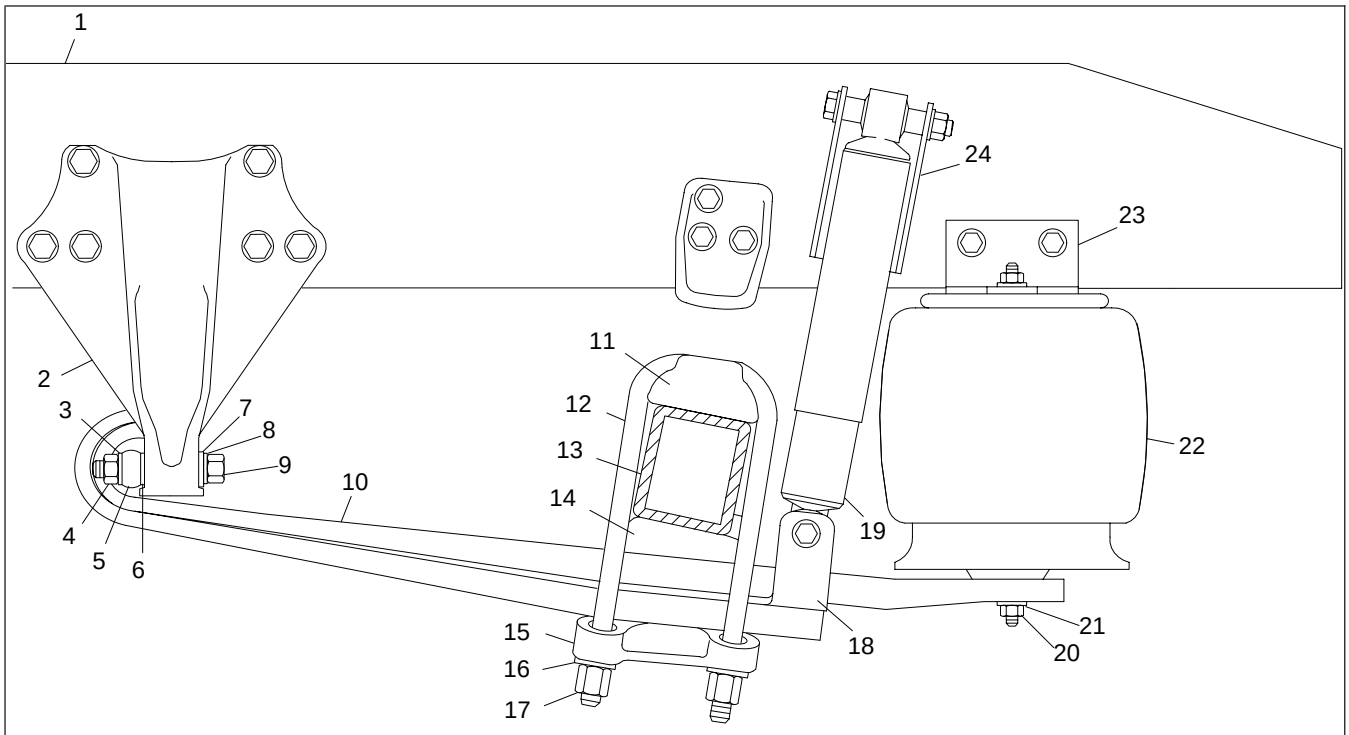


1. Leaf Spring
2. Leaf Spring
3. Cross Bar
4. Air Spring

Fig. 4, Leaf Spring and Air Spring Assembly (23,000- and 46,000-pound suspensions)

Leaf Spring Replacement

(See Fig. 1)



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

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.

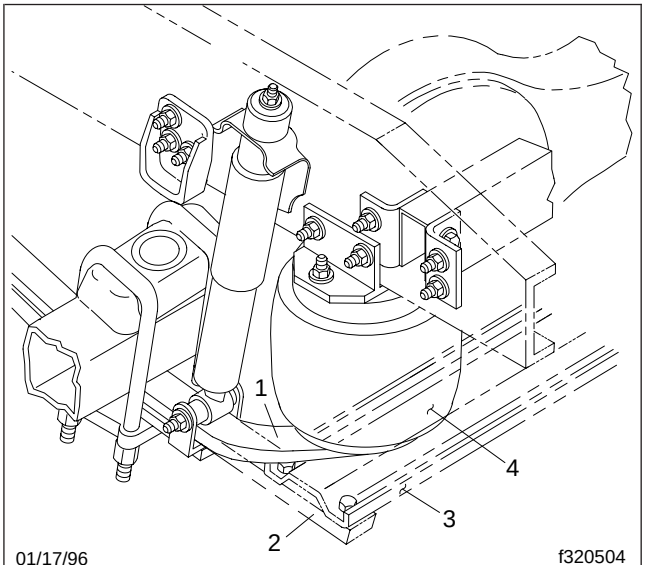
1. Chock the front tires.
2. Raise the rear of the vehicle, and support the rear axle(s) with safety stands. Raise the vehicle so that all weight is removed from the leaf springs, then securely support the frame with safety stands. Remove the wheel and tire assembly to easily access the suspension. For in-

Leaf Spring Replacement

structions, see **Group 40** 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**.



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)

5. Note the number and position of the alignment shims (**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 (**Fig. 1**) must point toward the rear of the vehicle.

On tandem axle suspensions, see **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. Hand tighten the high nuts. In a diagonal pattern, tighten the axle U-bolt high nuts 60 lbf·ft (81 N·m). Then, in the same pattern, tighten them 200 lbf·ft (271 N·m); then, torque to the final value of 400 to 460 lbf·ft (542 to 624 N·m).

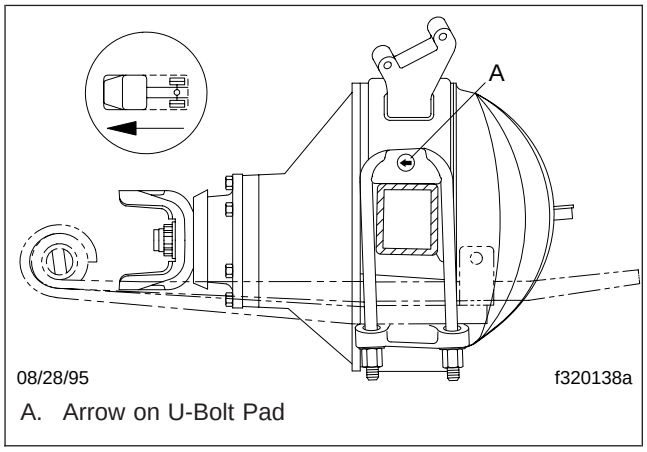
    For the 23,000-pound and 46,000-pound suspensions, tighten the high nuts in a diagonal pattern to a final torque value of 520 to 600 lbf·ft (705 to 813 N·m).

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).

    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, see **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 190**.

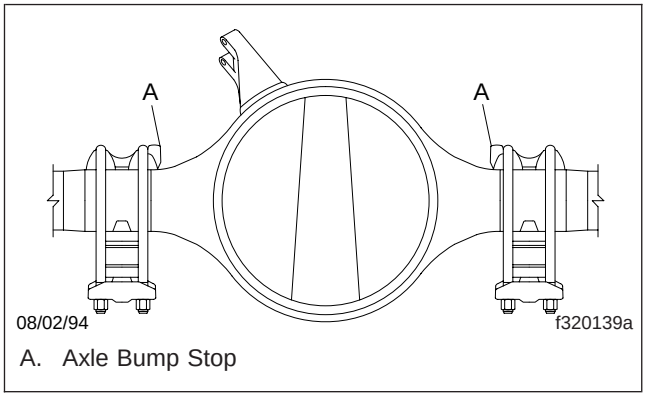
U-Bolt Pad Orientation for Axles		
Axle Designation		**U-Bolt Pad Orientation**
Rockwell SQ 100, SSHD	Forward Rear Axle	No arrow; axle bump stop toward vehicle centerline.
	Rearmost Axle	No arrow; axle bump stop toward vehicle centerline.
Rockwell RT40-145, RT44-145, RT46-160	Forward Rear Axle	No arrow; 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



A. Arrow on U-Bolt Pad

Fig. 3, U-bolt Pad Arrow Positioning



A. Axle Bump Stop

Fig. 4, Axle Bump Stop Positioning

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 **Group 40**.
4. Remove the leaf spring assembly. See **Subject 170** for removal information.

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 Perma-bond 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, see **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.

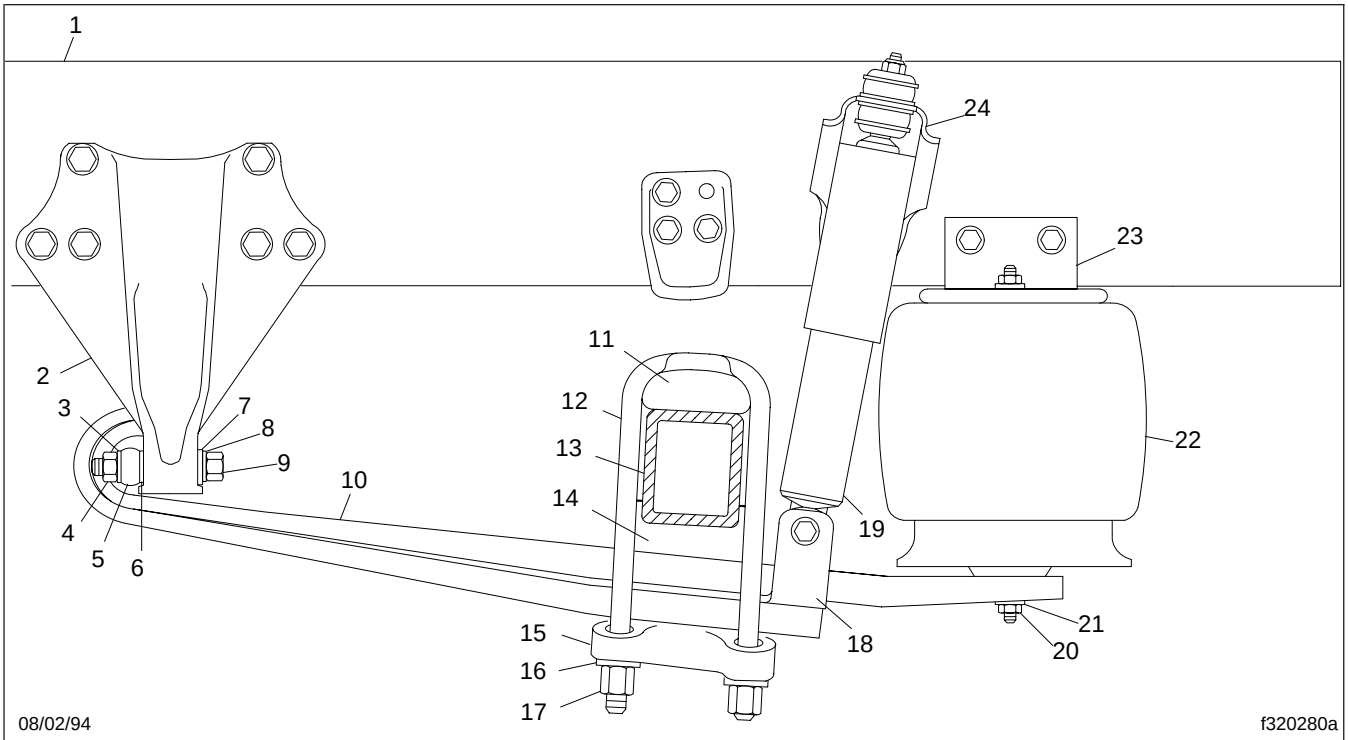
Adjusting

See **Fig. 1**.

Follow the instructions in the rear axle alignment checking section of **Group 35** to see if rear axle alignment adjustment is needed. If it is needed, proceed as follows:

3. When the axle is in alignment, install alignment shim(s) to take up the slack between the spring hanger andthe spring mounting eye pin.

IMPORTANT: Make sure the same number of shims is installed on both ends of the spring mounting eye pin.



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

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.
2. Move the axle forward or backward until it is aligned within the tolerances in the rear axle alignment checking section in **Group 35.**
4. Tighten the spring mounting eye bolts 170 lbf·ft (230 N·m).
5. Check the axle alignment again. If necessary, repeat the above procedure until the alignment is within tolerances.

Rear Axle Alignment Adjusting

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**.

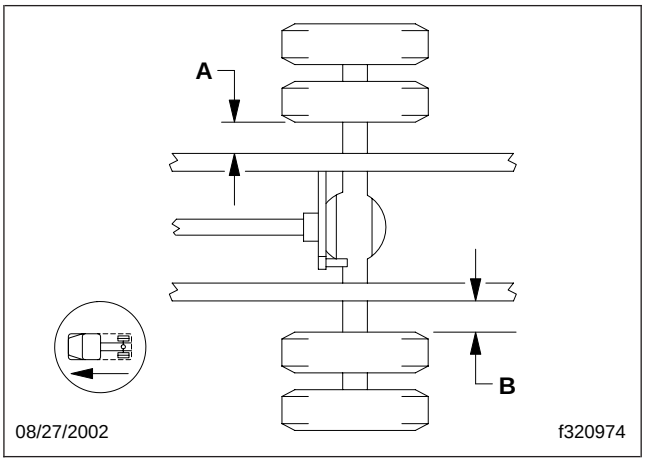


Fig. 2, Rear Axle Tracking Measurements (single axle)

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 (184 N·m).

   For taper-pin style torque rods, tighten the fasteners 165 lbf·ft (224 N·m). See **Fig. 3**.

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**.

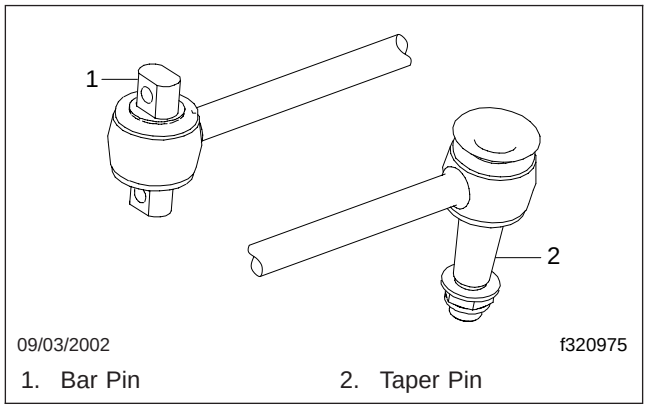


Fig. 3, Torque Rod Types

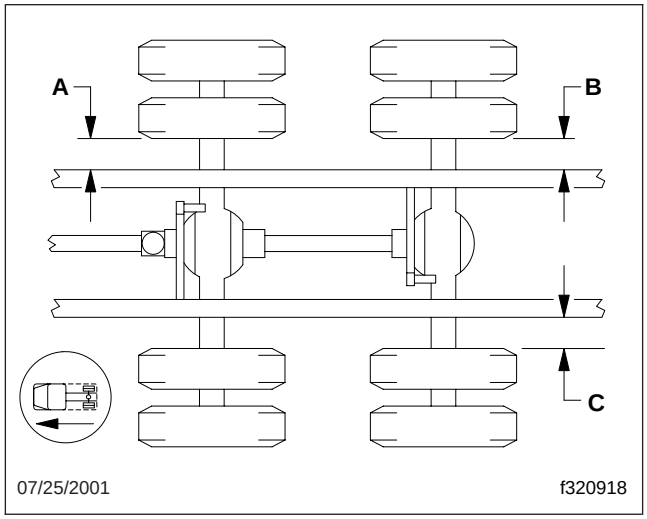


Fig. 4, Rear Axle Tracking Measurements (tandem axles)

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**.

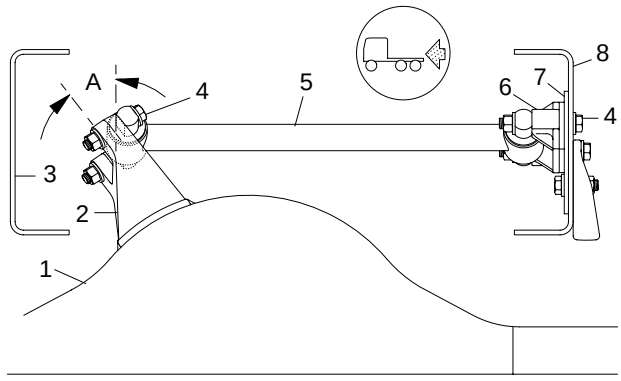
IMPORTANT: Measurements "B" and "C" should not vary by more than 1/4-inch (6 mm) from measurement "A."

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 (184 N·m). For taper-pin style torque rods, tighten the fasteners 165 lbf·ft (224 N·m). See **Fig. 3**.

Replacement

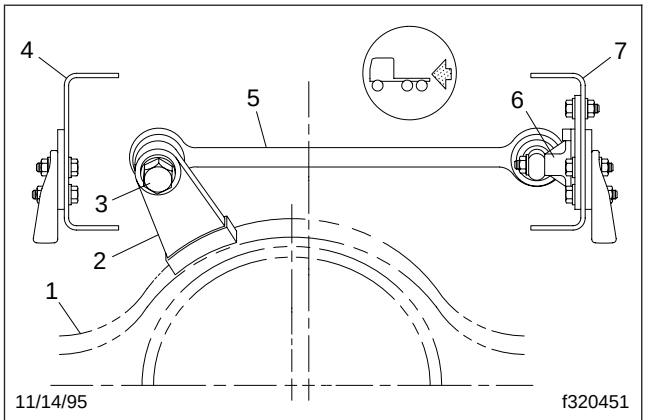
1. Park the vehicle. Shut down the engine, and apply the brakes.
2. Chock the tires. Raise the vehicle. Support the frame rails with jack stands.
3. Remove the fasteners holding the control rod to the frame rail bracket. Remove the shims, and set the shims aside.
4. Remove the control rod.
5. Position 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: 460 (624) *	—
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)	—
Spring Hanger Mounting Locknuts	3/4–10	210 (285)	—

* Tighten in a diagonal pattern.

Table 1, Torque Values

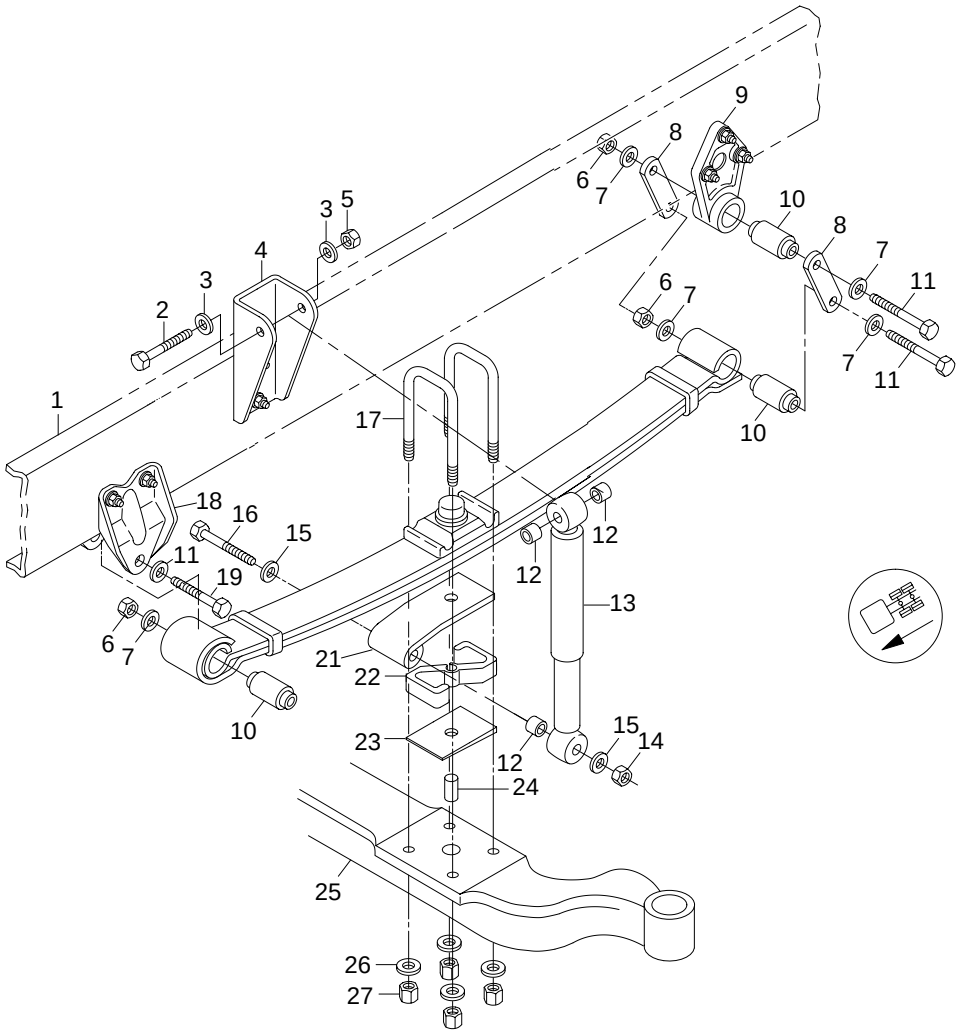
General Information

Freightliner front suspensions use either a taperleaf or a flatleaf assembly. The taperleaf suspensions are available in varying capacities from 6,000 pounds (2722 kg) to 14,000 pounds (6350 kg). Shock absorbers are standard. The flatleaf suspensions are available in varying capacities from 12,000 pounds (5543 kg) to 18,000 pounds (8165 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**, **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.

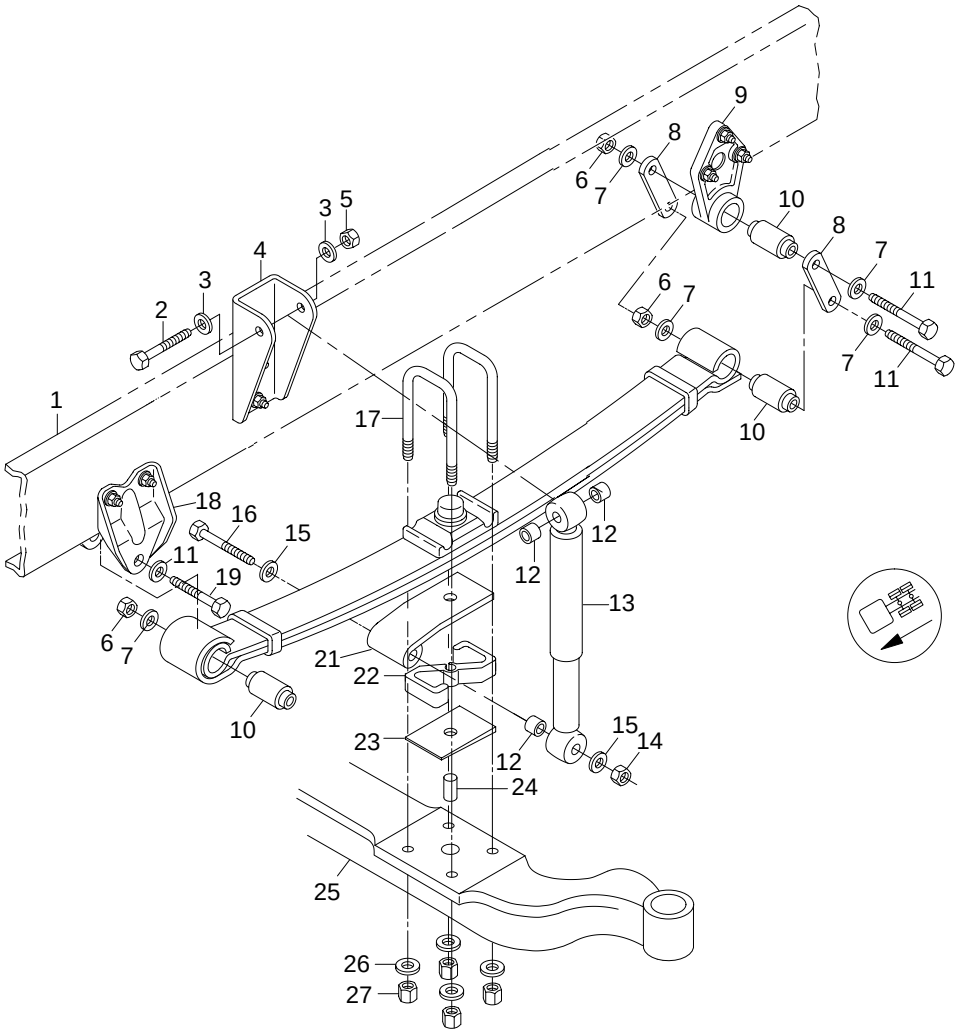
The leaf spring assembly absorbs and stores energy over bumps, releasing it at a controlled rate to smooth the ride. Individual spring leaves are held together by a center bolt. Alignment clips limit the sideways spread and vertical separation of the individual leaves.

General Information



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, Standard Taperleaf Front Suspension (6,000 pound [2722 Kg] capacity shown)

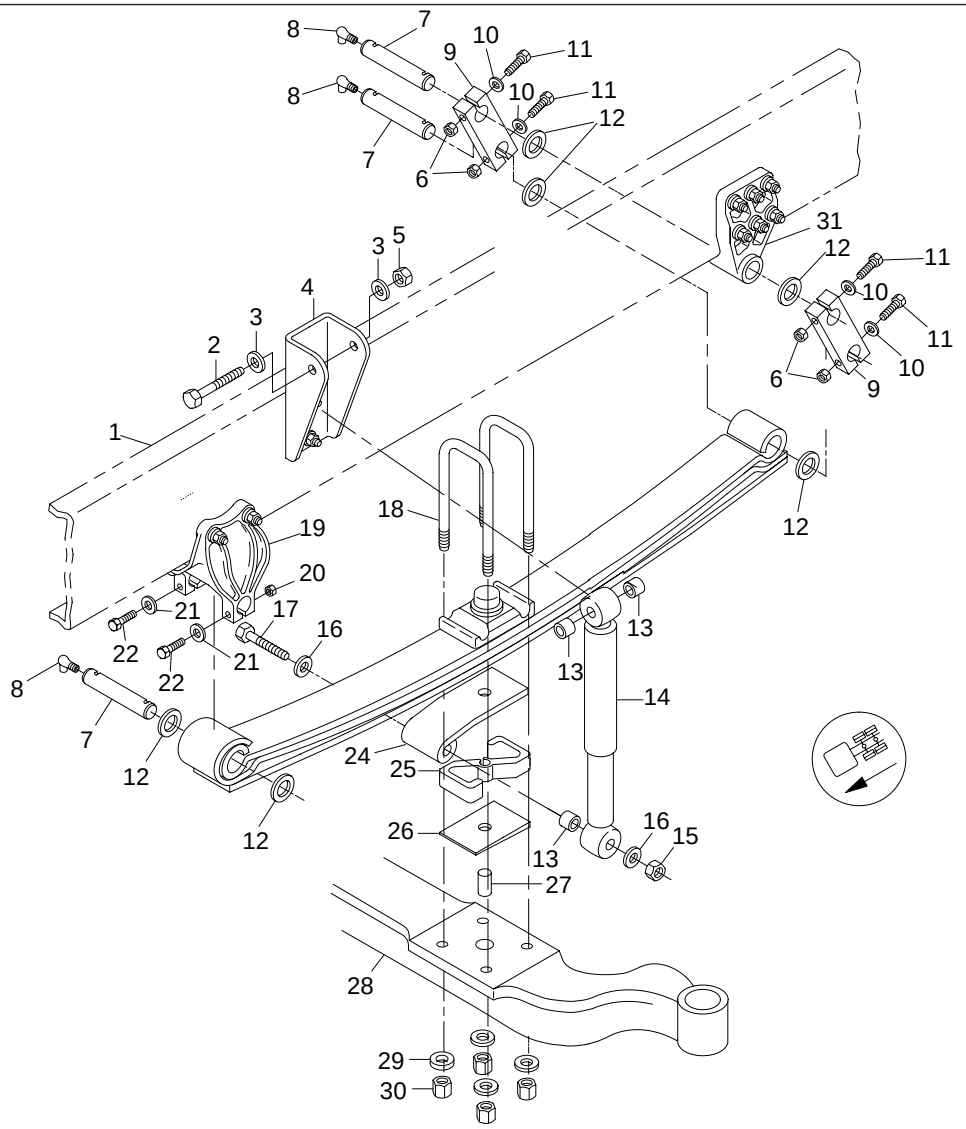


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1. Frame Rail
2. Shock Absorber Upper Mounting Bolt
3. Hardened Washer
4. Shock Absorber Upper Mounting Bracket
5. Hexnut
6. Hexnut, 3/4–10, Grade C
7. Hardened Washer
8. Spring Shackle
9. Shackle Bracket
10. Bushing
11. Spring Shackle Bolt, 3/4–10 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

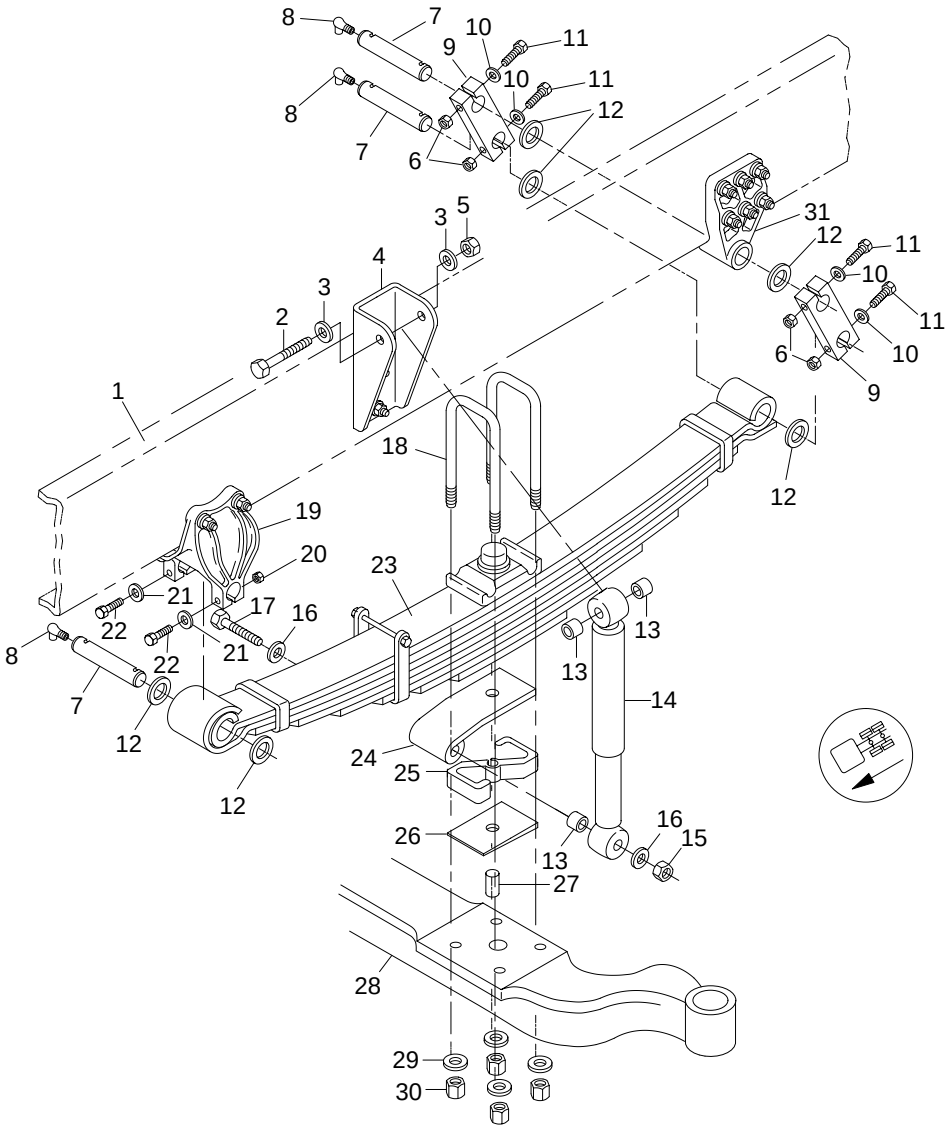
Fig. 2, Standard Taperleaf Front Suspension (12,000 pound [5543 Kg] capacity shown)

General Information



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, Taperleaf Front Suspension (14,000 pound [6350 kg] capacity shown)



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

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

Removal

1. Apply the parking brakes, chock the rear tires, and tilt the cab.
2. Remove the front bumper. Remove the wheel and tire for access to the leaf spring. For instructions, see **Group 40**.
3. Using a floor jack, lift the front of the vehicle by the frame until all weight is off the spring being removed.
4. 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, which could cause serious personal injury and component damage.

5. Remove the leaf spring assembly.

   NOTE: Leaf spring assemblies on vehicles with suspensions manufactured at 14,000 pound (6350 kg) and 18,000 pound (8165 kg) weight ratings have multiple leaf springs, heavy duty brackets, U-bolts, and other components.

   5.1 Remove the U-bolt high nuts and washers; then, remove the U-bolts. See **Fig. 1**.

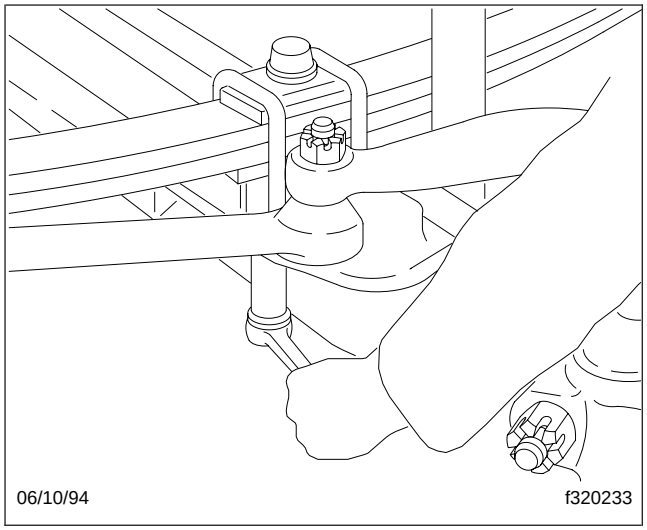
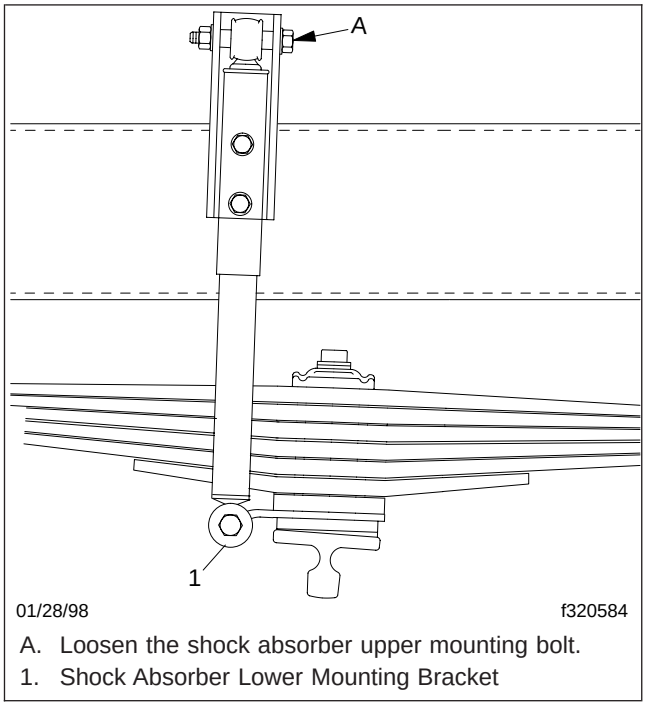


Fig. 1, U-Bolt Removal

   5.2 Loosen the shock absorber upper mounting bolt. Swing the shock absorber and attached lower mounting bracket out of the way. See **Fig. 2**.



A. Loosen the shock absorber upper mounting bolt.
1. Shock Absorber Lower Mounting Bracket

Fig. 2, Shock Absorber Lower Mounting Bracket Removal

   5.3 Remove the spring shackle lower bolt. See **Fig. 3**.

   5.4 Remove the front spring mounting eye bolt. See **Fig. 4**.

   NOTE: If removing the driver's side spring, the steering must be at right full-lock so the bolt can clear the drag link.

   5.5 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 and any caster adjustment shims.

⚠ WARNING

The spring assembly is heavy. To prevent bodily injury, always use two people to remove it.

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

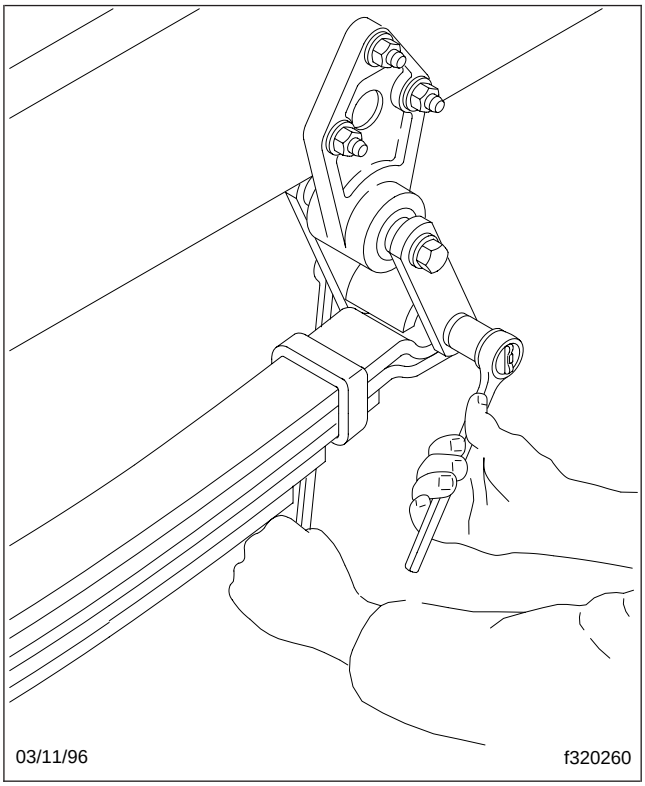


Fig. 3, Spring Shackle Lower Bolt Removal/Installation

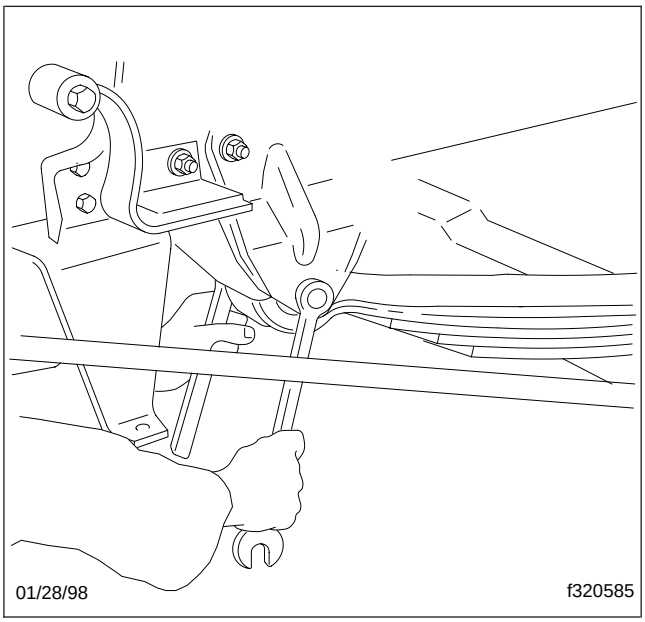


Fig. 4, Spring Eye Bolt Removal/Installation

5.6 Remove the spring by sliding it toward the front of the vehicle. See **Fig. 5** .

6. Remove the shackle upper bolt and nut. See **Fig. 6**. Press out the bushing. Remove the fasteners holding the shackle bracket to the frame. See **Fig. 7**. 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 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. 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

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

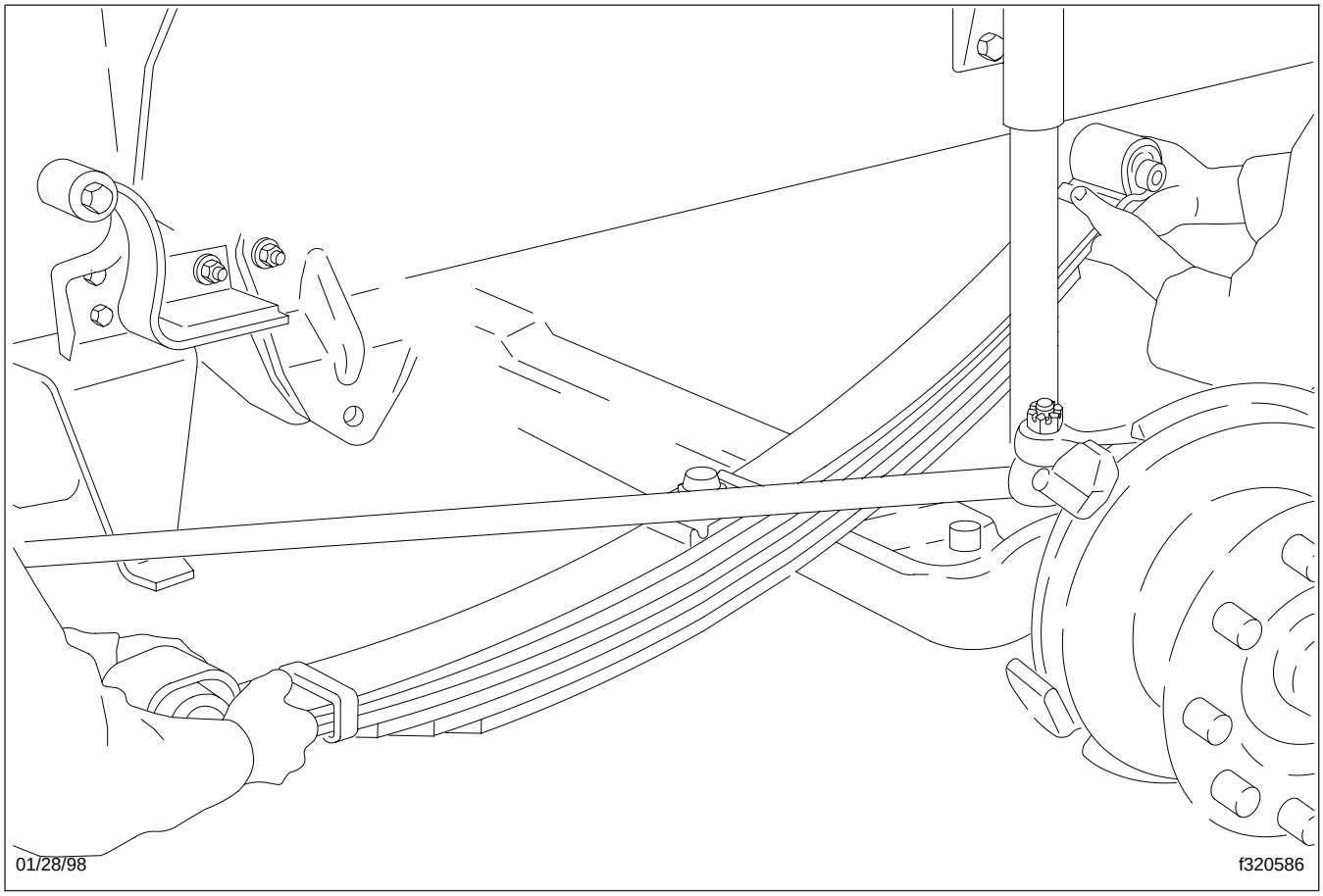


Fig. 5, Spring Removal/Installation

maintain a balanced front suspension system, install identical spring assemblies.

1. If the shackle bracket was removed, install it. See **Fig. 7**. Tighten the mounting bolts 135 lbf·ft (183 N·m).

NOTE: All suspension bracket (frame) fasteners require periodic retightening. See Group 00 of 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.

⚠ 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 (6350 kg) and 18,000 pound (8165 kg) weight ratings have multiple leaf springs, heavy duty brackets, U-bolts, and other components.

3.1 Lift the spring into position. See **Fig. 5**. Install the spring eye bolt at the front of the spring (**Fig. 4**) and the lower bolt in the shackle at the rear of the spring (**Fig. 3**).

3.2 Tighten the spring eye bolt and the bolts at the top and bottom of the shackle 240 lbf·ft (325 N·m).

Leaf Spring and Components Removal, Cleaning and Inspection, and Installation

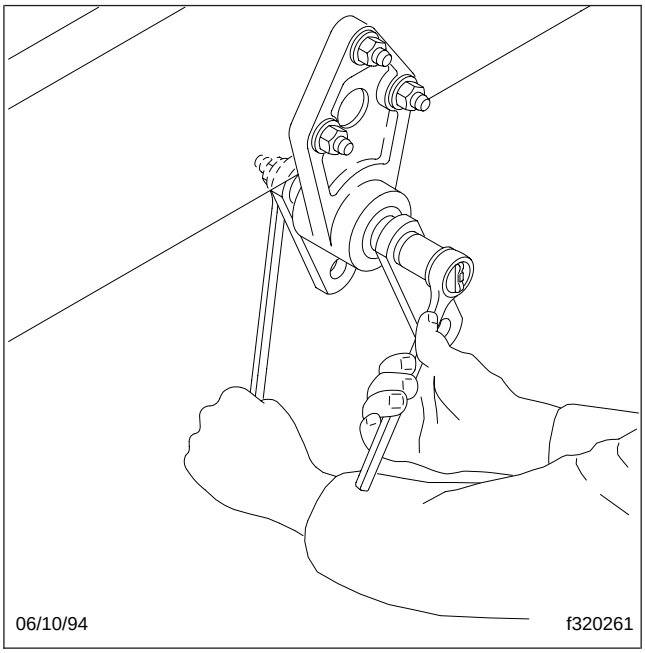


Fig. 6, Spring Shackle Upper Bolt and Nut Removal

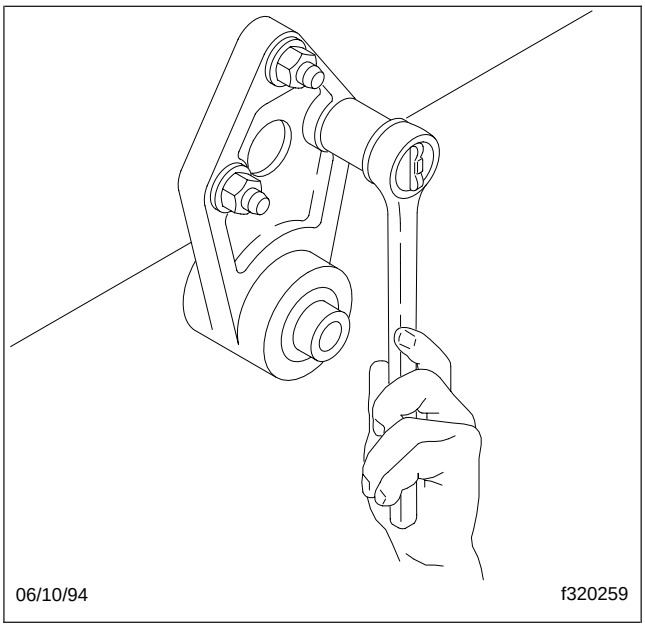


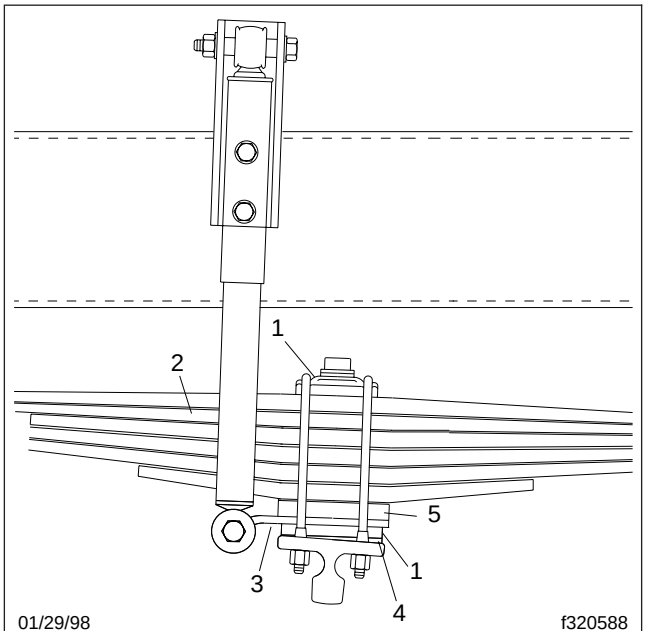
Fig. 7, Shackle Bracket Removal/Installation

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. 8**.



1. U-Bolt Pad
2. Leaf Spring
3. Shock Absorber Lower Mounting Bracket
4. Caster Adjustment Shim
5. Spring Spacer

Fig. 8, Caster Adjustment Shim Location

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.

3.8 Install the U-bolts over the spring leaves, shock absorber lower mounting bracket, spring spacer, caster adjustment shims, and through the front axle.

3.9 Install the high-nuts on the U-bolts and hand tighten them initially. Then tighten them in a diagonal pattern and in stages as follows:

5/8–18 UNF: Tighten the nuts 60 lbf·ft (80 N·m); then tighten them 200 lbf·ft (270 N·m); then tighten them to a final torque of 205 lbf·ft (278 N·m).

3/4–16 UNF: Tighten the nuts 60 lbf·ft (80 N·m); then tighten them 200 lbf·ft (270 N·m); then tighten them to a final torque of 300 lbf·ft (407 N·m).

4. Remove the floor jack and safety stands.
5. Install the wheel and tire. For instructions, see **Group 40**. Install the front bumper.
6. Return the cab to the operating position. Remove the chocks from the tires.

Shackle Bracket Bushing Replacement (See Fig. 1)

1. Apply the parking brakes, chock the rear tires, and tilt the cab.
2. Remove the front bumper. Remove the wheel and tire for access to the leaf spring. For instructions, see **Group 40**.
3. Remove the shackle bracket from the vehicle.
   - 3.1 Jack up the frame until the shackle lower bolt can be removed. Remove the bolt.
   - 3.2 Remove the shackle upper bolt and the spring shackle.
   - 3.3 Remove the shackle bracket from the frame.
4. Using a press, remove the bushing from the shackle bracket.
5. Inspect the shackle bracket and new bushing.
   - 5.1 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.
   - 5.2 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.
6. 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.

7. 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.
8. Install the shackle bracket. Install the fasteners and tighten them 135 lbf·ft (183 N·m).
9. Connect the leaf spring.
   - 9.1 Install the spring shackle and the shackle upper bolt.
   - 9.2 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.
   - 9.3 Install the shackle lower bolt. Tighten it 240 lbf·ft (325 N·m).
10. Install the wheel and tire. For instructions, see **Group 40**. Install the front bumper.
11. Return the cab to the operating position. Remove the chocks from the tires.

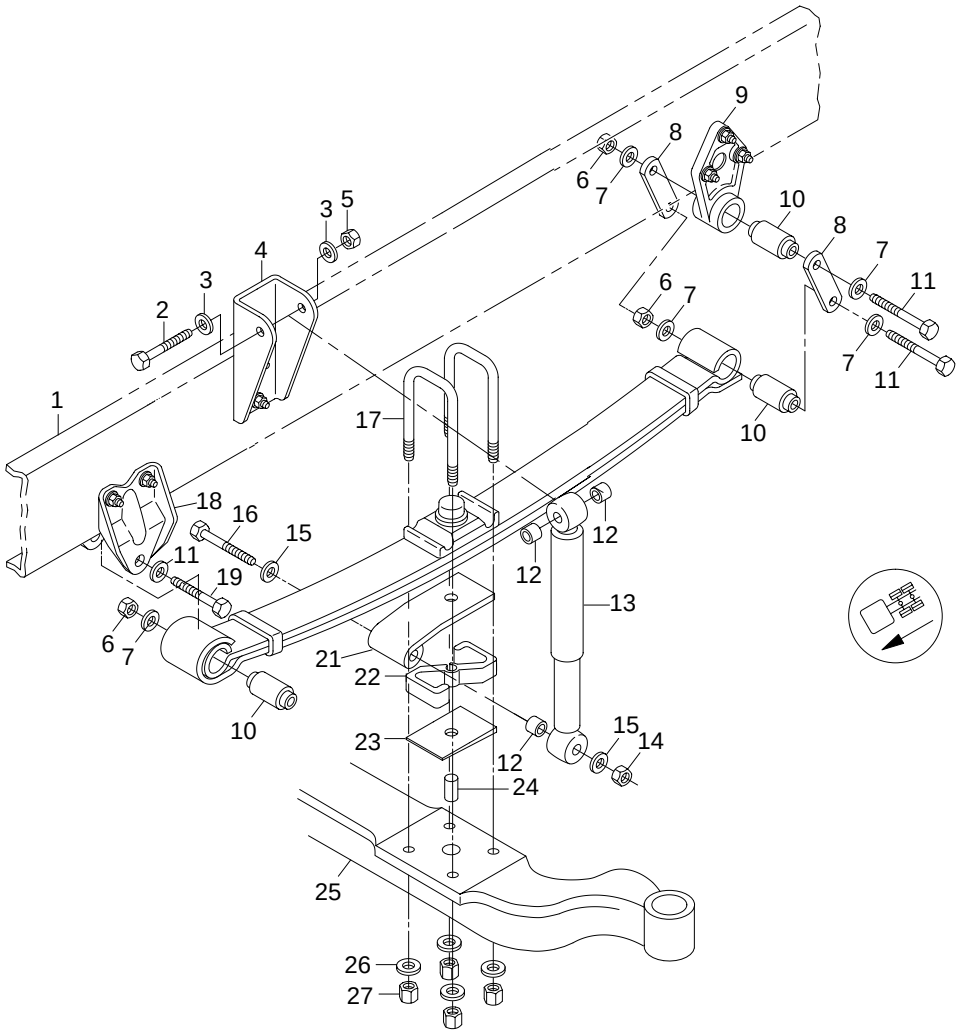
Spring Bushing Replacement

1. Remove the leaf spring from the vehicle. See **Subject 100** for instructions.
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. See **Subject 100** for instructions.

Bushing Replacement



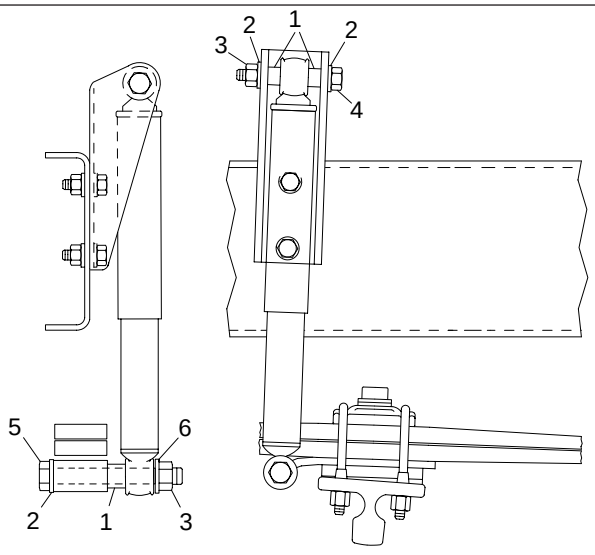
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1. Frame Rail
2. Shock Absorber Upper Mounting Bolt
3. Hardened Washer
4. Shock Absorber Upper Mounting Bracket
5. Hexnut
6. Hexnut, 3/4–10, Grade C
7. Hardened Washer
8. Spring Shackle
9. Shackle Bracket
10. Bushing
11. Spring Shackle Bolt, 3/4–10 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, Standard Taperleaf Front Suspension

Replacement

1. Apply the parking brake, chock the rear tires, and tilt the cab.
2. Remove the shock absorber.
   - 2.1 Remove the locknut from the shock absorber upper mount; then, remove the capscrew, washers, and spacers.
   - 2.2 Remove the locknut from the shock absorber lower mount; then, remove the capscrew, washers, and spacers.
   - 2.3 Remove the shock absorber.
3. Install the new shock absorber as shown in **Fig. 1**. Make sure the 19.5 mm washer is on the lower shock absorber mounting bushing and toward the outside. Tighten the locknuts 110 lbf·ft (149 N·m).
4. Return the cab to the operating position. Remove the chocks from the tires.



A. Front View
1. Spacer
2. Washer, 3/4-inch
3. Locknut, 3/4-inch
4. Capscrew, 3/4–10 x 5.5

B. Side View
5. Capscrew, 3/4–10 x 7
6. Washer, 19.5 mm

Fig. 1, Shock Absorber Mounting

Troubleshooting Tables

Problem—Vehicle Leans to One Side

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

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 **Group 33**.
Caster is incorrect.	Install correct caster shims. See **Group 33** for specifications.
Steering gear is not centered.	Adjust steering using the instructions in the **Group 46**.
Drive axle is out of alignment.	Align the drive axle using the instructions in the **Group 35**.

Problem—Vehicle Bottoms Out

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

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

Problem—Frequent Spring Breakage	
Possible Cause	**Remedy**
A loose spring bolt is allowing spring end-play.	Replace the spring bolt and bushing.

Problem—Noisy Spring

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

Problem—Rough Ride	
Possible Cause	**Remedy**
See the **applicable section** in this group.	

Specifications

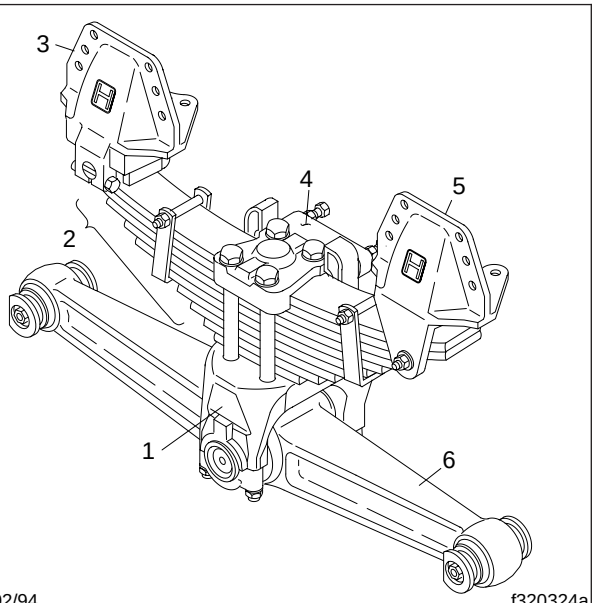
Torque Values		
Description	**Size**	**Torque lbf·ft (N·m)**
Shackle Bracket Bolt	3/4–10	135 (183)
Shackle Bracket Mounting Bolt	5/8–11	135 (183)
Spring Eye Bolt	3/4–10	135 (183)
Shock Absorber Mounting Capscrews	3/4–10	110 (149)
U-Bolt High Nut	5/8–18	Stage 1: Hand tighten Stage 2: 60 (80) * Stage 3: 200 (270) * Stage 4: 205 (278) *
	3/4–16	Stage 1: Hand tighten Stage 2: 60 (80) * Stage 3: 200 (270) * Stage 4: 300 (407) *

* Tighten in a diagonal pattern.

Table 1, Torque Values

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.



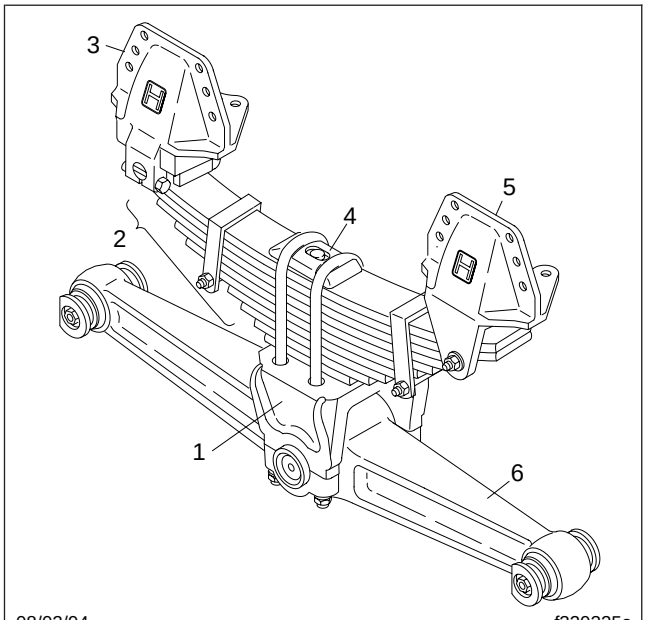
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1. Saddle
2. Spring Assembly
3. Number One Spring Hanger
4. Spring Top Pad
5. Number Two Spring Hanger
6. Equalizing Beam

Fig. 1, RT Suspension

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



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1. Saddle
2. Spring Assembly
3. Number One Spring Hanger
4. Spring Top Pad
5. Number Two Spring Hanger
6. Equalizing Beam

Fig. 2, U Suspension

channels. The pin is also notched to allow two bolts to pass through the spring hanger legs and lock the pin in place.

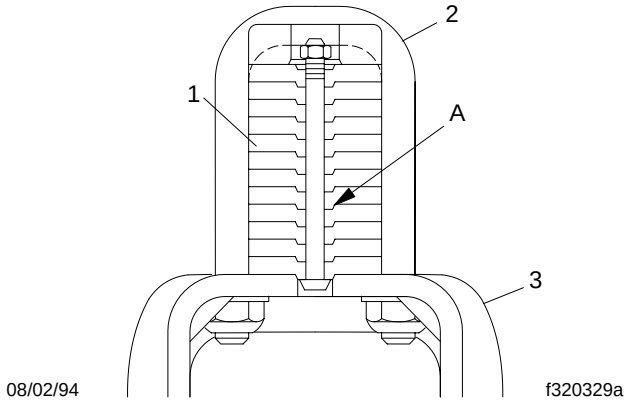
The rear end of the spring assembly isn't fastened to the number two spring hanger; instead, the spring rests against the rounded underside (or cam) of the hanger and is free to rub against the hanger as the spring assembly changes length due to deflection caused by vehicle weight and road shock.

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 (**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.



A. Pilot cups are forged downward for U suspensions.

1. Spring Assembly
2. U-Bolt
3. Saddle

Fig. 3, Pilot Cups (cross-section view of springs)

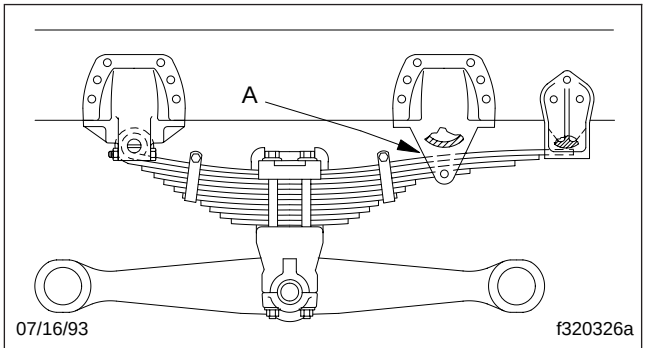
Because of this difference in pilot cups, springs for the two types of suspensions are not interchangeable.

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 (**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.

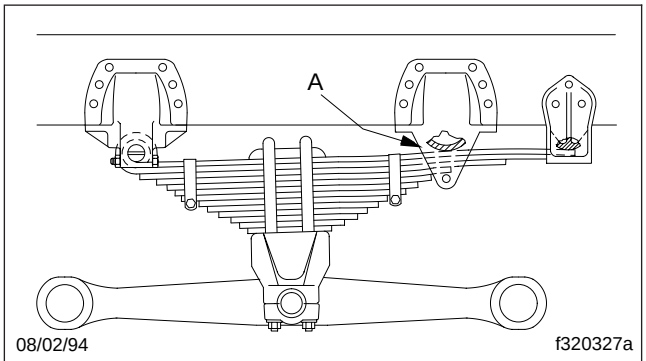
All suspension fasteners require periodic tightening. For suspension inspecting, lubricating, and fastener



NOTE: RTE suspension shown

A. 3/8-inch (10-mm) Gap

Fig. 4, Unloaded Suspension



NOTE: UE suspension shown

A. No Gap

Fig. 5, Loaded Suspension

torque checking instructions, see Group 32 in the vehicle maintenance manual.

⚠ 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.

Removal (Fig. 1 or 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, see **Group 42**.

⚠ 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, see **Subject 180**.

   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 (Fig. 1 or Fig. 2)

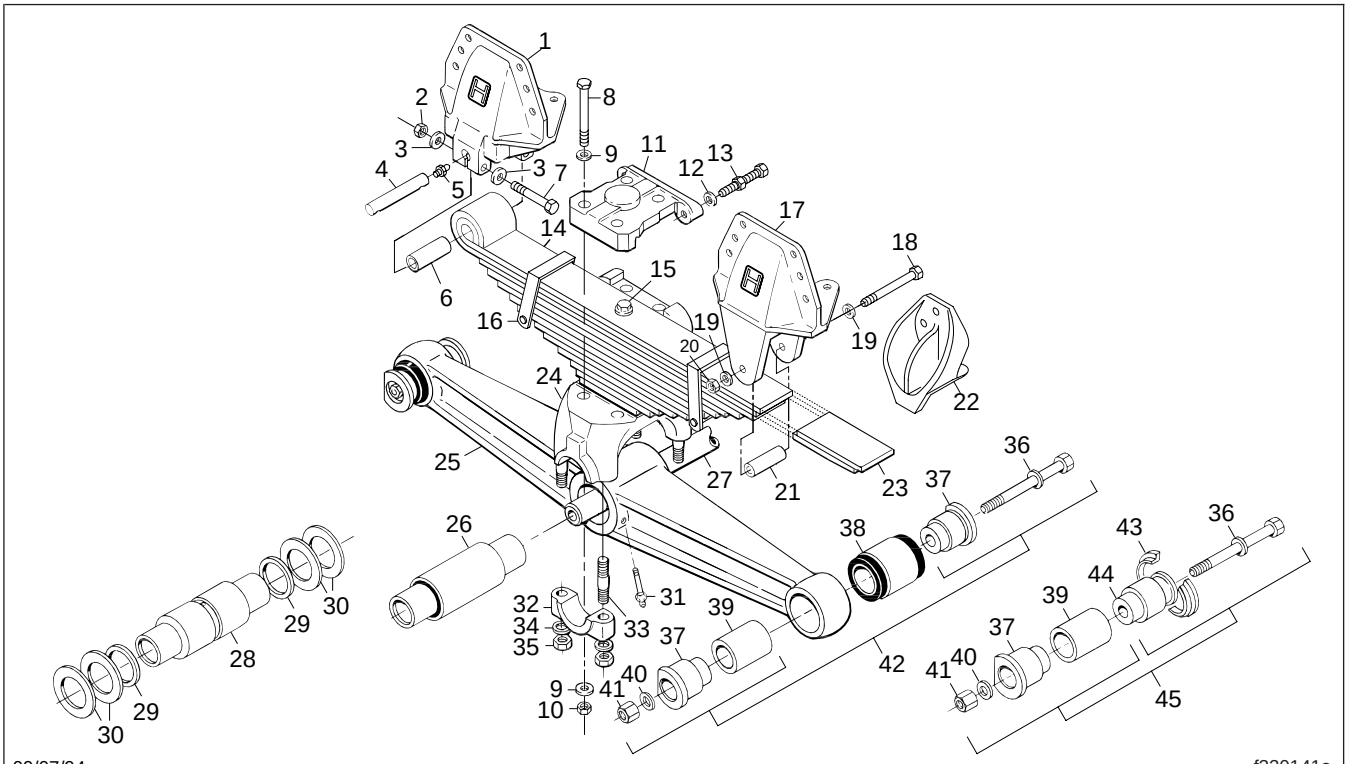
1. Roll the axles under the vehicle frame. Align the center bushing of each equalizer beam with the center of the saddle legs.
2. Raise the vehicle frame off the safety stands, then remove the safety stands.
3. Lower the frame, centering the saddles on the beam center bushings.
4. Lubricate the saddle 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, see **Subject 180**.

   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 (**Fig. 3**).

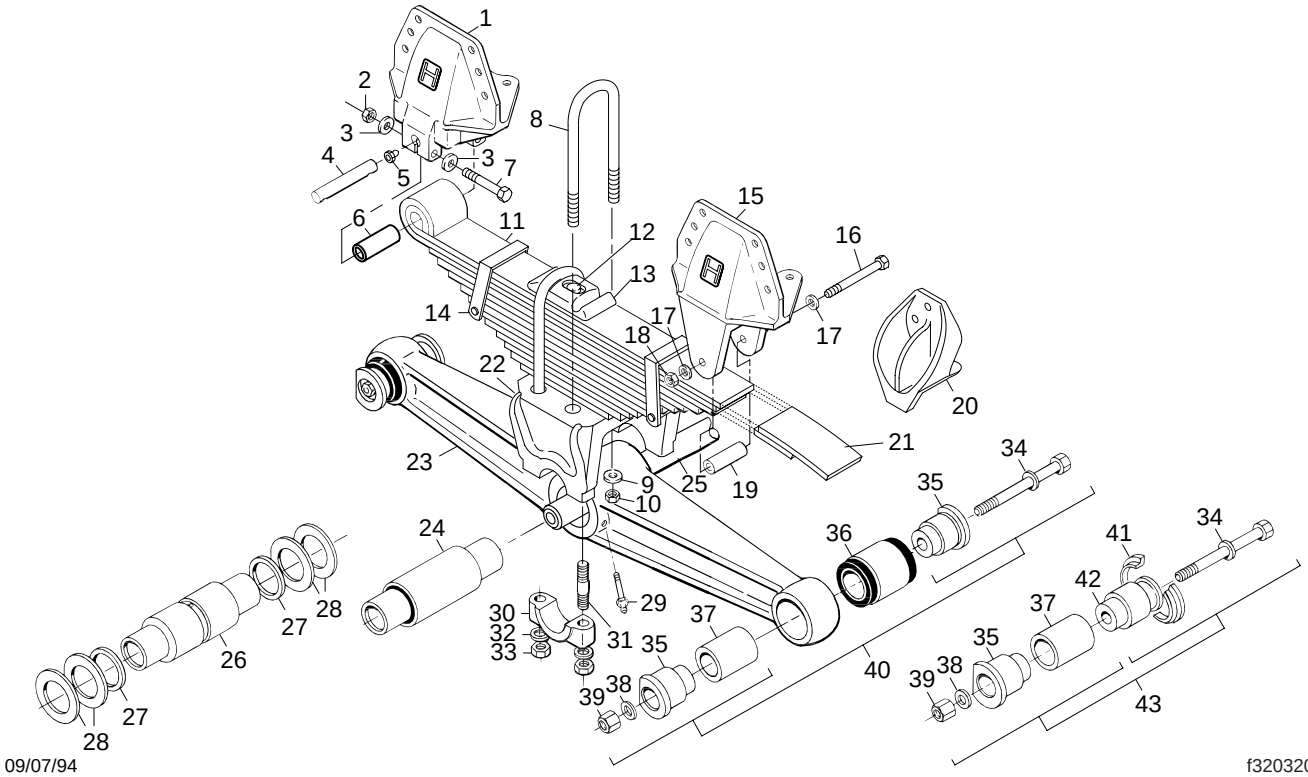
7. Remove the safety stands from under the frame and axle, and lower the vehicle.
8. Manually reset the spring brake chambers. For instructions, see **Group 42**.
9. Connect the driveline rear universal joint to the forward-rear axle. For instructions, see **Group 41**.
10. Uncap all air lines and fittings, then connect the lines leading to the rear axles.

Suspension Removal and Installation



1. Forward (no. 1) Spring Hanger
2. Locknut
3. Washer
4. Spring Pin
5. Grease Fitting
6. Spring Eye Bushing
7. Lock Bolt
8. Top Pad Bolt
9. Top Pad Washer
10. Top Pad Locknut
11. Top Pad
12. Setscrew Washer
13. Setscrew and Locknut
14. Spring Assembly
15. Spring Center Bolt and Nut
16. Spring Alignment Clip
17. Rear (no.2) Spring Hanger
18. Rebound Spacer Bolt
19. Spacer Bolt Washer
20. Spacer Bolt Locknut
21. Rebound Spacer
22. RTE Rear (no. 3) Spring Hanger
23. RTE Spring Extension
24. Saddle Assembly
25. Equalizer Beam Assembly
26. Rubber Center Bushing
27. Crosstube
28. Bronze Center Bushing
29. Bushing Grease Seal
30. Thrustwashers
31. Grease Fitting (Bronze Bushing)
32. Saddle Cap
33. Saddle Cap Stud
34. Saddle Cap Washer
35. Saddle Cap Nut
36. Adaptor Bolt and Washer
37. Adaptor
38. End Bushing
39. Intermediate Tube
40. Adaptor Bolt Washer
41. Adaptor Bolt Nut
42. Adaptor-Type End Support Assembly
43. Split-Ring
44. Adaptor Plug
45. Split-Ring Adaptor Assembly

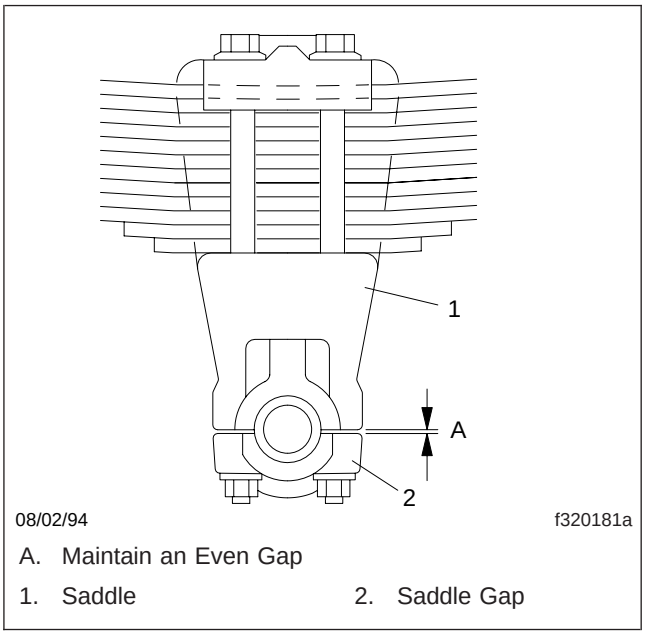
Fig. 1, RT and RTE Series (exploded view)



1. Forward (no. 1) Spring Hanger
2. Locknut
3. Washer
4. Spring Pin
5. Grease Fitting
6. Spring Eye Bushing
7. Lock Bolt
8. U-Bolt
9. U-Bolt Washer
10. U-Bolt Locknut
11. Spring Assembly
12. Spring Center Bolt and Nut
13. Top Pad
14. Spring Alignment Clip
15. Rear (no. 2) Spring Hanger
16. Rebound Spacer Bolt
17. Spacer Bolt Washer
18. Spacer Bolt Locknut
19. Rebound Spacer
20. RTE Rear (no. 3) Spring Hanger
21. RTE Spring Extension
22. Saddle Assembly
23. Equalizer Beam Assembly
24. Rubber Center Bushing
25. Crosstube
26. Bronze Center Bushing
27. Bushing Grease Seal
28. Thrustwasher
29. Grease Fitting (Bronze Bushing)
30. Saddle Cap
31. Saddle Cap Stud
32. Saddle Cap Washer
33. Saddle Cap Nut
34. Adaptor Bolt and Washer
35. Adaptor
36. End Bushing
37. Intermediate Tube
38. Adaptor Bolt Washer
39. Adaptor Bolt Nut
40. Adaptor-Type End Support Assembly
41. Split-Ring
42. Adaptor Plug
43. Split-Ring Adaptor Assembly

Fig. 2, U and UE Series (exploded view)

Suspension Removal and Installation



A. Maintain an Even Gap

1. Saddle
2. Saddle Gap

Fig. 3, Maintain an Even Gap Between the Saddle and the Saddle Gap

Removal

1. Remove the suspension. For instructions, see **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

The leaf spring assembly is heavy. Always use two people when moving it to avoid personal 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 aroundthe spring center-bolt and fit in a pilot hole in the saddle; therefore, springs for RT and U suspensions are not interchangeable.

   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 100 to 150 lbf·ft (135 to 203 N·m). Tighten the setscrew locknuts until the lockwashers are locked.

   Tighten the top pad locknuts 275 to 400 lbf·ft (373 to 542 N·m). Use the tightening sequence shown in **Fig. 2**.

   On U series suspensions, tighten the locknuts evenly 237 to 302 lbf·ft (320 to 410

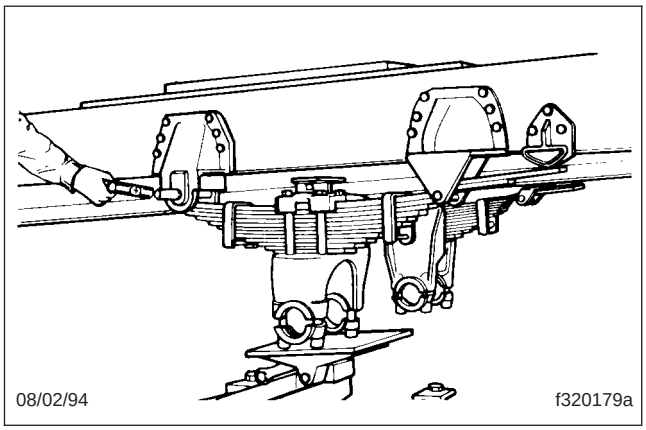
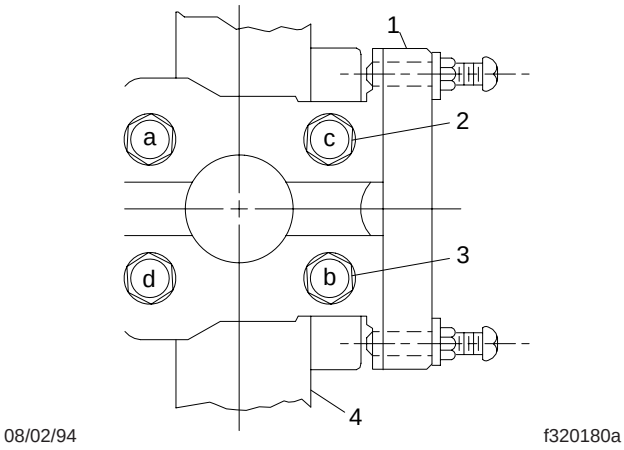


Fig. 1, Spring Pin Removal

Spring and Saddle Removal and Installation

N·m) Using a hammer, tap the tops of the U-bolts to settle the assembly, then tighten the locknuts 237 to 302 lbf·ft (320 to 410 N·m).



1. Top Pad
2. Top Pad Bolt
3. Hardened Washer
4. Spring

Fig. 2, Top Pad Bolt Tightening Sequence

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 45 to 63 lbf·ft (61 to 85 N·m).
9. Position the rebound spacer in the no. 2 spring hanger leg, then install the rebound spacer bolt, lockwasher, and locknut. Tighten the locknut 38 to 45 lbf·ft (51 to 61 N·m).
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, see **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 (**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 1/8 inch (3 mm) 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.

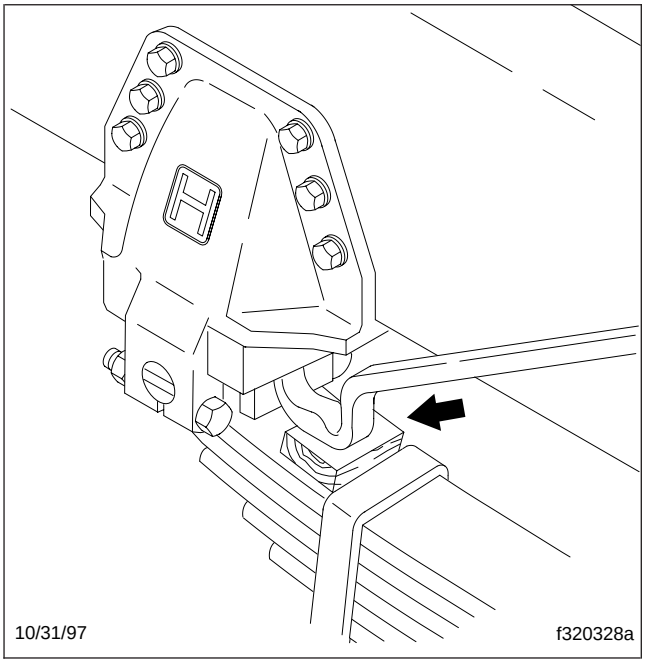


Fig. 1, Place a Block of Wood on the Spring

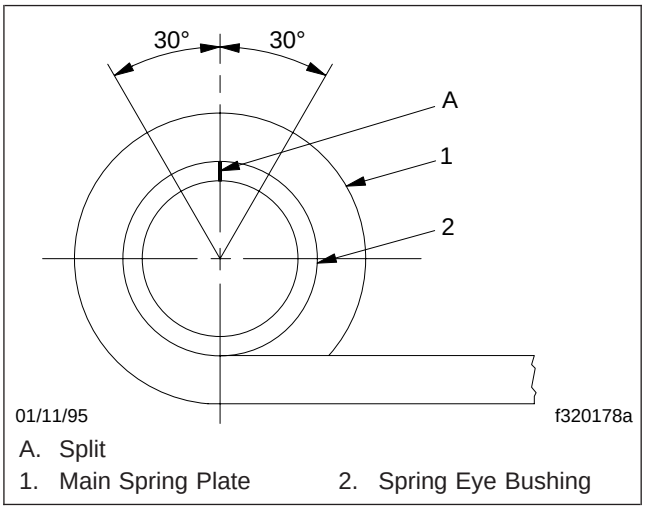
Replacement

1. Remove the spring and saddle assembly. For instructions, see **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.
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 15 lbf·ft (20 N·m).
7. Remove the drift punch. At the bottom of the spring, insert a new center-bolt. Install a new center-bolt nut and tighten to the value in the torque table in **Specifications, 400**.
8. Install the spring and saddle assembly. For instructions, see **Subject 110**.

Spring Leaf, Spring Pin, and Spring Eye Bushing Checking and Replacement



A. Split
1. Main Spring Plate
2. Spring Eye Bushing

Fig. 2, Position the Bushing at the Top of the Spring Eye

Equalizer Beam Adaptor- and Tube-Type End Support Removal and Installation

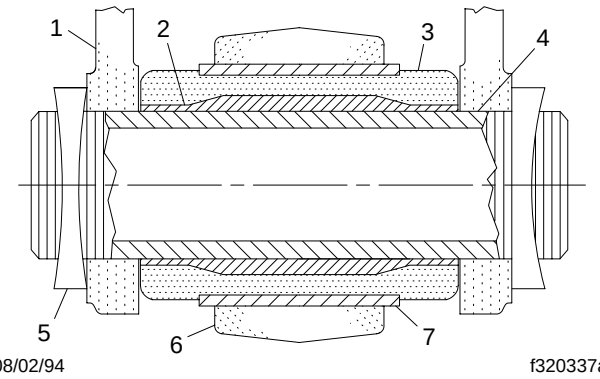
Removal

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 adaptors can be used if a vertical hydraulic press with a 50-ton capacity is available. Dimensions for the shop-made adaptors 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, see **Group 40**.
5. Remove the brake shoes, brake spider, and brake backing plate (dust shield). For instructions, see **Group 35**.
6. Apply a penetrating oil to all beam end connections.
7. On a tube-type end support (**Fig. 1**), remove the tube nuts from both sides of the beam end tube.

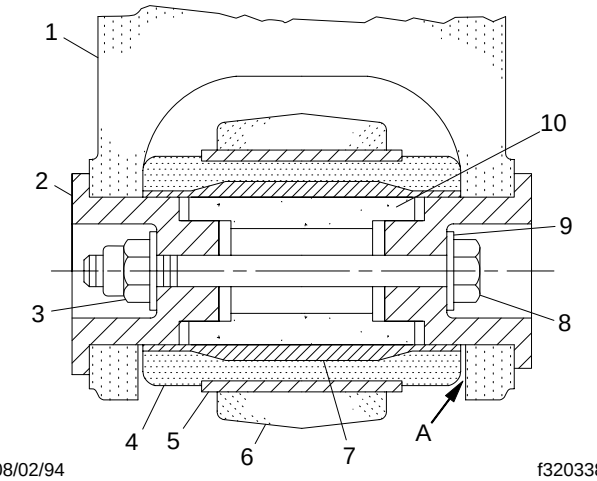
   On an adaptor-type end support (**Fig. 2**), remove the nut, washers, and the adaptor bolt.
8. If using Owatonna tools, remove the tube-type end supports by positioning the receiving tube over the outboard end of the beam end tube. Position the hydraulic ram, pulling screw, speed nut, and the removing adaptor (**Fig. 3**). Connect a hydraulic pumping unit to the ram, and apply pressure to remove the beam end tube.
9. Remove the adaptor-type end supports (if using Owatonna tools).

   9.1 Using either a 7/8- or 15/16-inch hand-tap (**Fig. 4**), tap the adaptor bolt hole (outboard side) to a depth of about 1-1/2 inches (38 mm).



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

Fig. 1, Equalizer Beam Tube-Type End Support



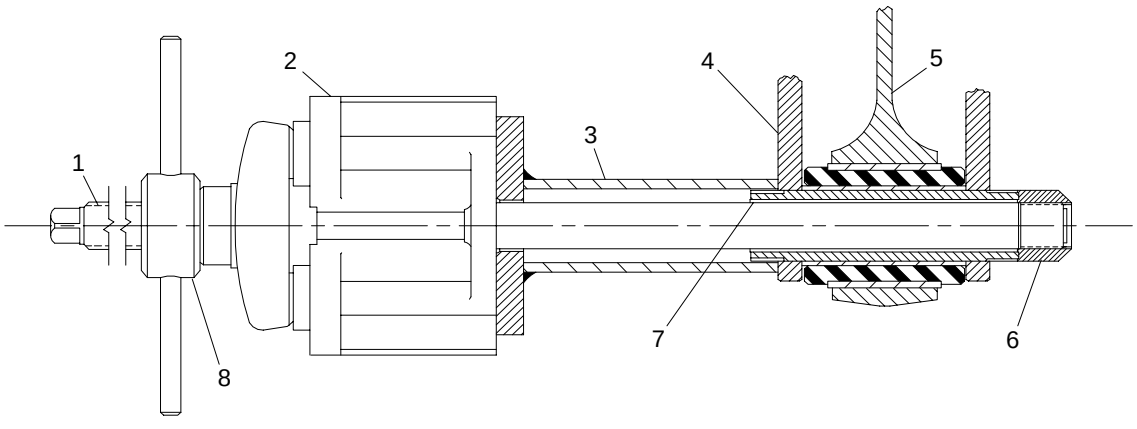
A. New bushing will have a small gap.

1. Axle Beam Hanger
2. adaptor
3. Adaptor Bolt Nut
4. Rubber End Bushing
5. Bushing Outer Sleeve
6. Equalizer Beam
7. Bushing Inner Sleeve
8. Adaptor Bolt
9. Washer (both ends)
10. Intermediate Tube

Fig. 2, Equalizer Beam Adaptor-Type End Support

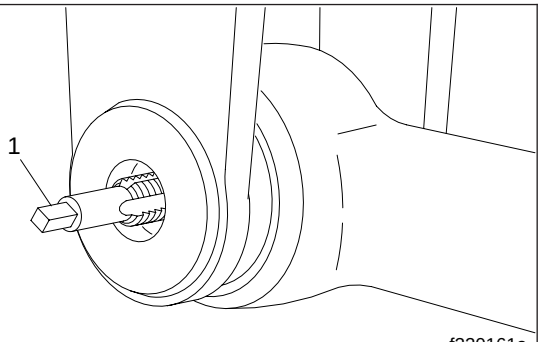
NOTE: Determine the correct size of hand-tap by using the plug gauge. If the gauge

Equalizer Beam Adaptor- and Tube-Type End Support Removal and Installation



1. Pulling Screw
2. Ram
3. Receiving Tube
4. Beam Hanger
5. Equalizer Beam
6. Removing Adaptor
7. Tube-Type Hanger Pin
8. Speed Nut

Fig. 3, Tube-Type Beam End Removal



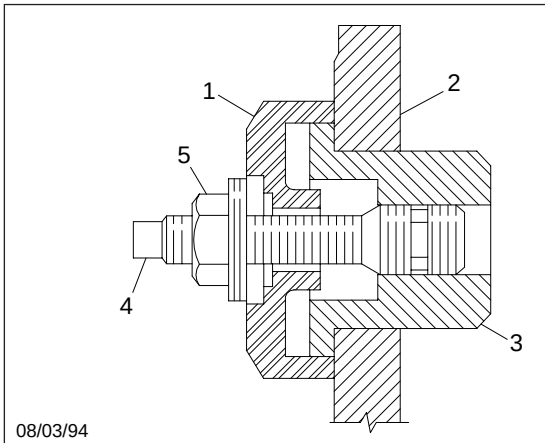
1. Hand-Tap

Fig. 4, Tap the Adaptor Bolt Hole

passes through the adaptor 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 (**Fig. 5**). Turn the hexnut until the adaptor plug breaks loose and bottoms on the inside of the receiving cup. If needed, add spacers to complete removal of the adaptor plug. See **Fig. 6**.

9.3 On the inboard side of the axle, position the receiving cup over the adaptor plug. On the outboard side of the axle, insert



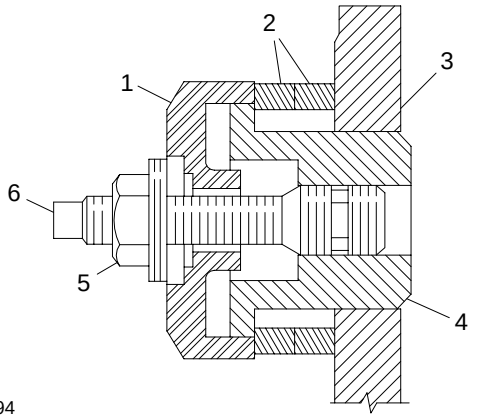
1. Receiving Cup
2. End Beam Hanger
3. End Beam Adaptor Plug
4. Removing Screw
5. Hexnut

Fig. 5, Position the Receiving Cup and Hexnut on the Removing screw

the removing screw through the receiving cup and secure it with the hexnut. See **Fig. 7**.

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 adaptor plug bottoms on the inside of the receiving cup.

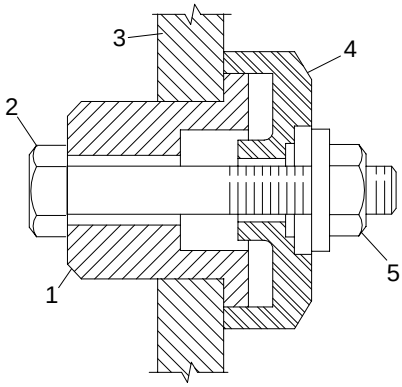
Equalizer Beam Adaptor- and Tube-Type End Support Removal and Installation



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1. Receiving Cup
2. End Beam Hanger
3. End Beam Hanger
4. End Beam Adaptor Plug
5. Hexnut
6. Removing Screw

Fig. 6, Remove the Adaptor Plug



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1. End Beam Adaptor Plug
2. Removing Screw
3. End Beam Hanger
4. Receiving Cup
5. Hexnut

Fig. 7, Insert the Removing Screw through the Receiving Cup

10. Remove the end supports (if not using Owatonna tools).

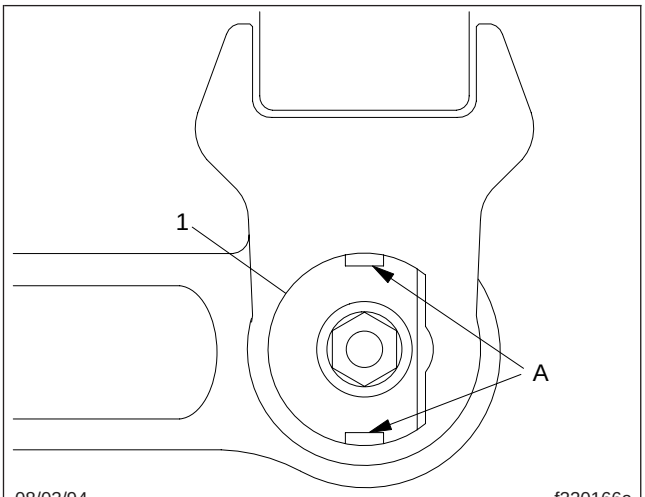
    10.1 For tube-type end supports, install a spacer bushing between one end-tube nut and the beam hanger. Tighten the nut to pull the end tube out of the beam end bushing. If the tube doesn't come loose, use a hacksaw and saw the tube along the inside surface of both axle beam hanger legs.

⚠ 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, causing them to break. This could result in a loss of vehicle control, possible personal injury, or property damage.

    10.2 For adaptor-type end supports, a relief is located on each side of the adaptor (**Fig. 8**). Turn the adaptor with an air chisel, then insert a chisel into the relief on the inboard adaptor. Drive the chisel in and wedge the adaptor out of the beam hanger. Do the same on the outboard adaptor.

    If a split-ring adaptor 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 adaptor plug out of the bushing.



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A. Chisel Reliefs
1. Adaptor

Fig. 8, Adaptor-Type End Supports

Equalizer Beam Adaptor- and Tube-Type End Support Removal and Installation

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 adaptor-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 adaptors, 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 lubricant, 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.

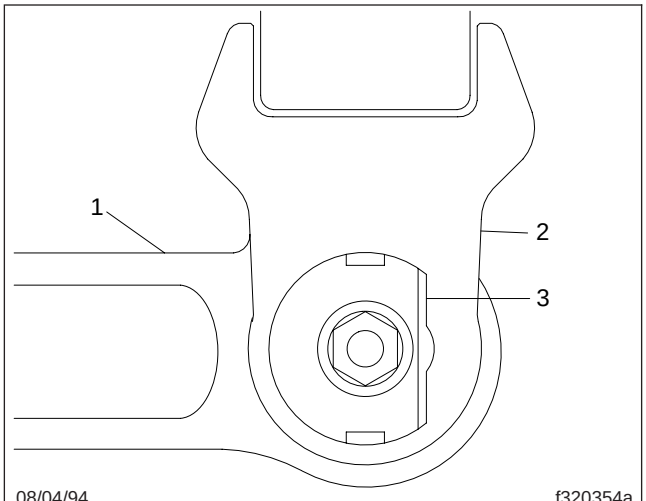
   Using SAE 20 oil, lubricate the threads of the beam end tube, then install the crosstube and thrustwashers in both equalizer beam center bushings.
2. Position the equalizer beam assembly under the axles, then raise the assembly and place the forward ends of each beam in the forward-rear axle beam hangers. Align the beam end bushings with the beam hangers.

   On adaptor-type end supports, install the intermediate tubes, the adaptors, the adaptor 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 adaptor-type end supports, install the intermediate tubes, the adaptors, the adaptor 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 adaptor bolt nuts 210 to 240 lbf·ft (285 to 325 N·m). Make sure the flat section of the adaptor flange is in the vertical position. See **Fig. 9**.



1. Equalizer Beam
2. Axle Bracket
3. Adaptor Flat Side

Fig. 9, Tighten the Adaptor Bolt Nuts

6. Tighten the end tube nuts 375 to 425 lbf·ft (508 to 576 N·m).

⚠ WARNING

The adaptor 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. For instructions, see **Group 35**.
8. Install the wheels and tires. For instructions, see **Group 40**.

Equalizer Beam End Bushing Removal and Installation

Removal

⚠ 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, causing them to break. This could result in a loss of vehicle control, possible personal injury, or property damage.

1. Remove the equalizer beam ends from the axle beam hangers. For instructions, see **Subject 130**.
2. Cut off the protruding rubber from one side of each beam end bushing (**Fig. 1**).
3. Remove the beam end bushings (if using Owatonna tools, see **Fig. 2**).

   3.1 Install the receiving adaptor 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 adaptor on the inboard side of the beam end bushing. Check that the cone-shaped surface of the adaptor 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 adaptor 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 10,000 psi (68 950 kPa) and the bushing has not broken loose, stop and check the alignment of the receiving tool and

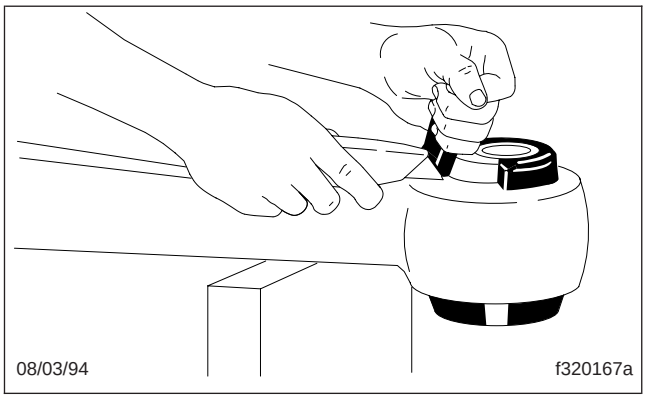
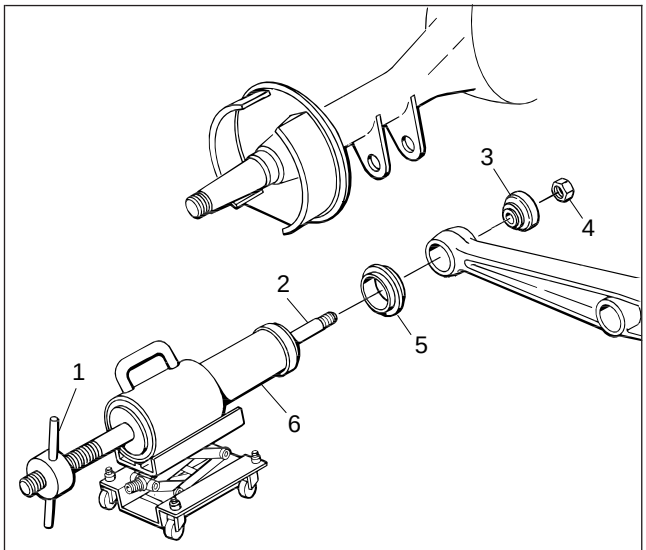


Fig. 1, Remove Rubber from One Side of Each Beam



1. Speed Nut
2. Pulling Screw
3. Removing Adaptor
4. Hexnut
5. Receiving Adaptor
6. Receiving Tube

Fig. 2, Remove the Beam End Bushings

removal adaptor. If both tools are aligned correctly, attach a sledging adaptor on the speed nut end of the pulling screw. Maintaining hydraulic pressure, strike the sledging adaptor with a heavy hammer. A loud noise followed by a sudden drop of the pressure gauge reading indicates the bushing has broken loose.

4. Remove the beam end bushings (if using shop-made adaptors).

Equalizer Beam End Bushing Removal and Installation

4.1 Remove the equalizer beams. For instructions, see **Subject 130**.

4.2 Position the equalizer beam on a 50-ton vertical hydraulic press.

4.3 Center the shop-made adaptor (see the special tools table 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, see **Fig. 3**):

   3.1 Fit the adaptor 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 adaptor on the receiving tube.

   3.3 Position the hydraulic ram and slide the pulling screw through the end bushing.

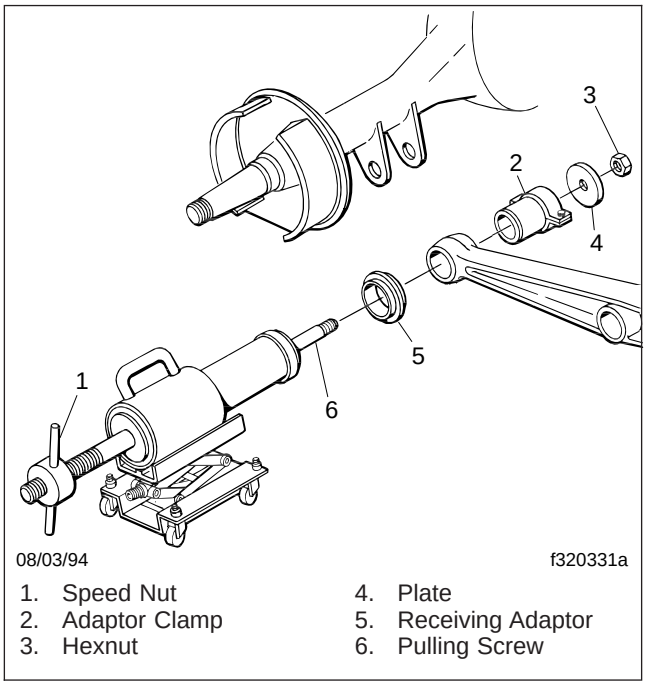
   3.4 Center the adaptor clamp and bushing on the inboard side of the beam end.

   3.5 Install the adaptor 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.



1. Speed Nut
2. Adaptor Clamp
3. Hexnut
4. Plate
5. Receiving Adaptor
6. Pulling Screw

Fig. 3, Install the Beam End Bushings

   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 4000 to 5500 psi (27 580 to 37 920 kPa) during installation. If the reading reaches the operating limit of 10,000 psi (68 950 kPa) 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 adaptor clamp is flush against the beam.

   3.9 Install the equalizer beam ends on the axle beam hangers. For instructions, see **Subject 130**.

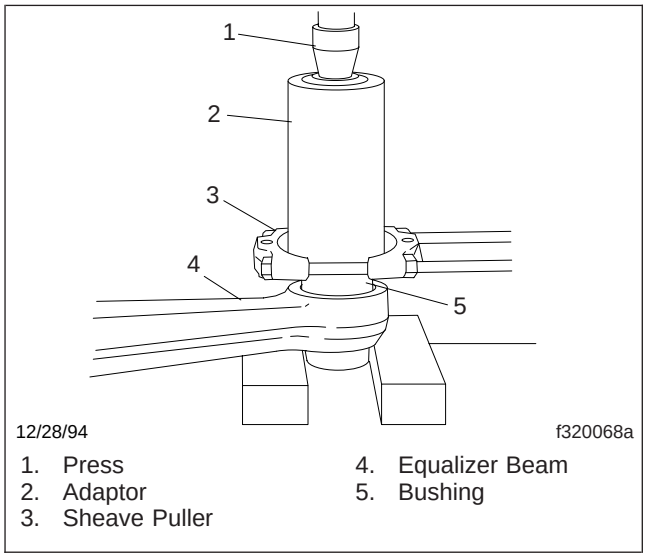
4. Install the beam end bushings (if using shop-made adaptors, see **Fig. 4**).

   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 adaptor (see 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, see **Subject 130**.



1. Press
2. Adaptor
3. Sheave Puller
4. Equalizer Beam
5. Bushing

Fig. 4, Install the Beam End Bushings

Equalizer Beam Bar Pin/Bushing Assembly Removal, Installation, and Alignment

Removal

NOTE: 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, causing them to break. 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.

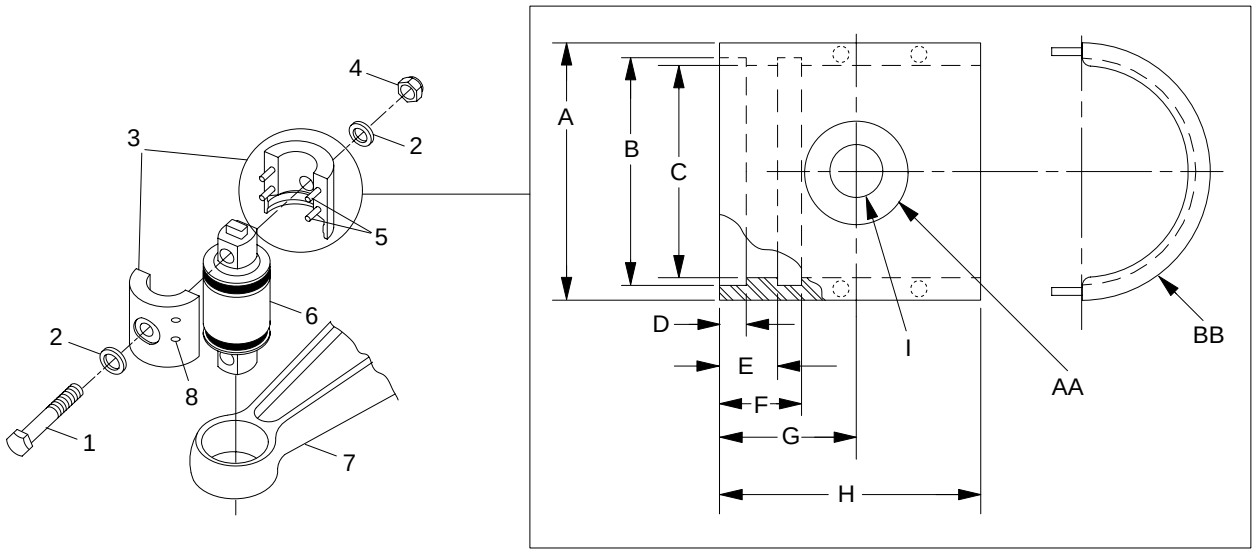
    4.1 Position the equalizer beam on a 50-ton hydraulic press with the beam end bore squarely supported on the bed for safety and to avoid bending the equalizer beam.

    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.

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).

Equalizer Beam Bar Pin/Bushing Assembly Removal, Installation, and Alignment



04/23/96 f320522

NOTE: The material used to make the tool is: 0.50" (13 mm) wall x 5.0" (127 mm) o.d. x 5.0" (127 mm) long steel tubing.
IMPORTANT: The assembly tool must be split in half as shown.

AA. Recess flat counter bore, 2.0" (51 mm) x 0.25" (6 mm) deep.
BB. Tool wall, 0.50" (13 mm), top view.

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)

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

Fig. 1, Assembly Tool (exploded view, with manufacturing information)

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 (**Fig. 1**), cut out the end plug from the center bushing on each side of the suspension, and remove the crosstube.
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, see **Fig. 2**).

   8.1 Position the hydraulic ram and slide the pulling screw through the center bushing.

   8.2 Install the center bushing removing adaptor 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 adaptor 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.

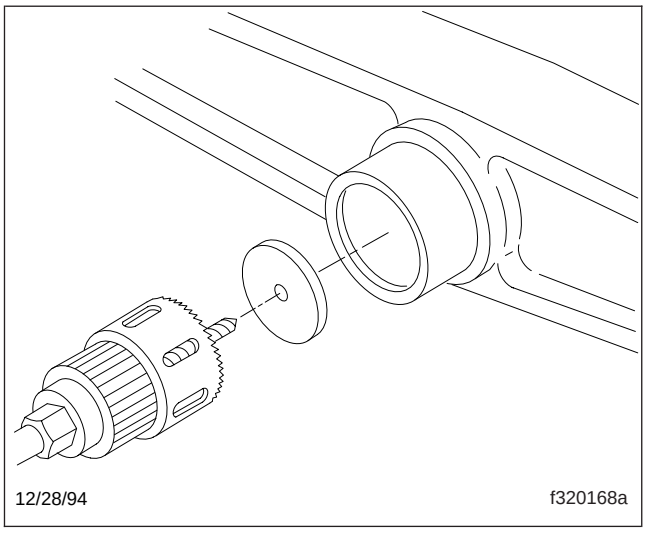
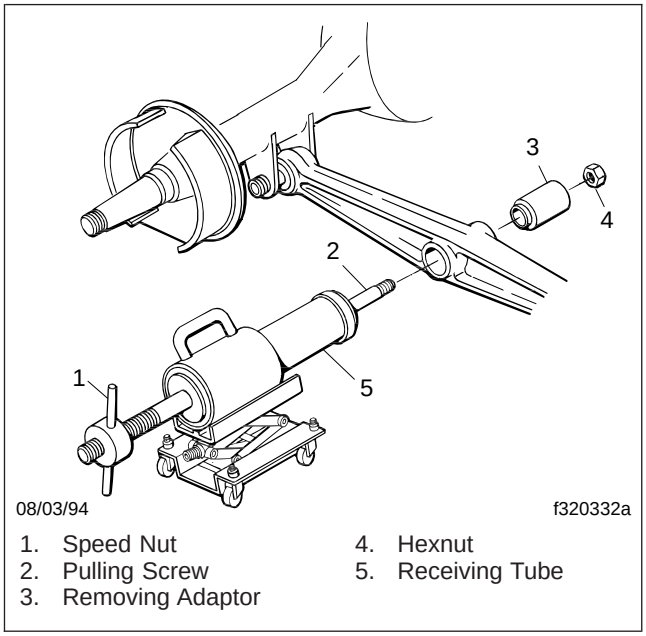


Fig. 1, Remove the Crosstube



1. Speed Nut
2. Pulling Screw
3. Removing Adaptor
4. Hexnut
5. Receiving Tube

Fig. 2, Rubber Center Bushings Removal (using Owatonna tools)

   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.

Equalizer Beam Rubber Center Bushing Removal and Installation

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 10,000 psi (68 950 kPa) and the bushing has not broken loose, stop and check the alignment of the receiving tool and removal adaptor. If both tools are aligned correctly, attach a sledging adaptor on the speed nut end of the pulling screw. Maintaining hydraulic pressure, strike the sledging adaptor 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 adaptors, remove the equalizer beams. For instructions, see **Subject 130**.

9.1 Position the equalizer beam on a 50-ton vertical hydraulic press.

9.2 Center the shop-made adaptor (see 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, see **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.

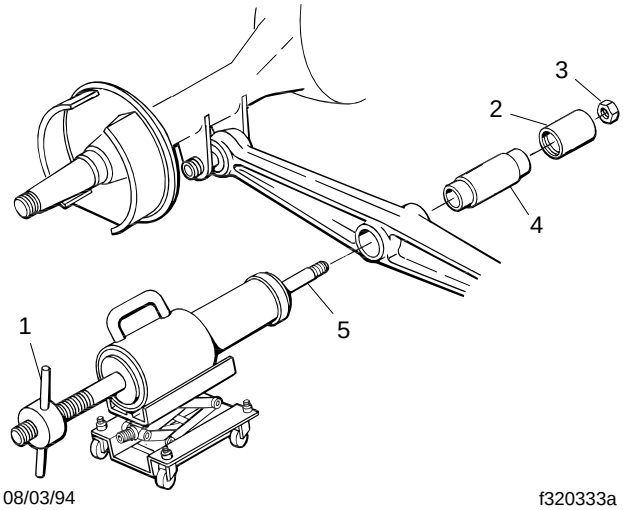
3.3 Fit the installing adaptor over the inner sleeve and against the outer sleeve of the bushing.

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.



1. Speed Nut
2. Installing Adaptor
3. Hexnut
4. Bushing
5. Pulling Screw

Fig. 3, Rubber Center Bushings Installation (using Owatonna tools)

NOTE: The pressure gauge on the pumping unit should read 4000 to 5500 psi (27,580 to 37,920 kPa) during installation. If the reading reaches the operating limit of 10,000 psi (68,950 kPa) 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 adaptor is flush against the beam.

3.8 Position the crosstube in the center bushings.

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 adaptors, 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 adaptor (see the applicable table in **Specifications, 400**) over the inner sleeve of the bushing. Check that the adaptor bottoms against the bushing outer sleeve, then press the new bushing into the beam eye.

5.2 Install the equalizer beams. For instructions, see **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.
6. Remove the bronze center bushing (if using Owatonna tools, see **Fig. 1**).

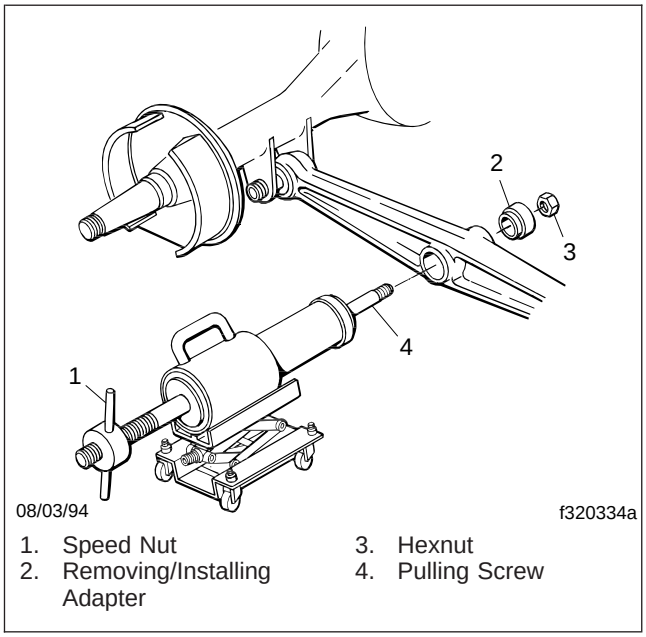
    6.1 Position the hydraulic ram and slide the pulling screw through the center bushing.

    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.

    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.



1. Speed Nut
2. Removing/Installing Adapter
3. Hexnut
4. Pulling Screw

Fig. 1, Remove the Bronze Center Bushing

    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 10,000 psi (68 950 kPa) 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, see **Subject 130**.

    7.1 Position the equalizer beam on a 50-ton vertical hydraulic press.

    7.2 Center the shop-made adapter (see the table in **Specifications, 400**) on the cen-

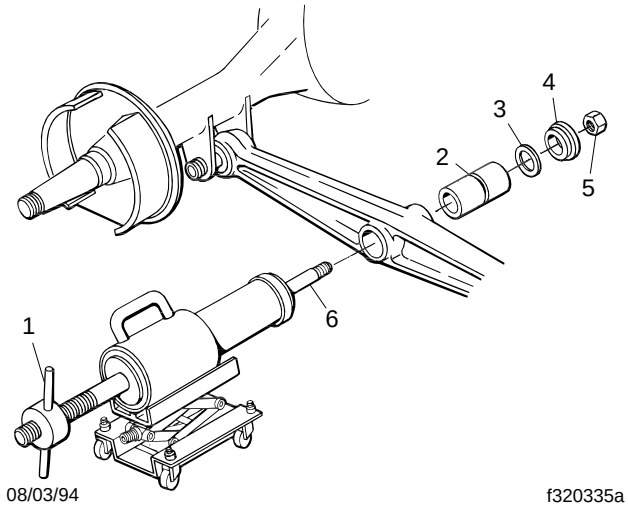
Equalizer Beam Bronze Center Bushing Removal and Installation

ter 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, see **Fig. 2**):

   4.1 Center the hydraulic ram and slide the pulling screw through the beam eye.

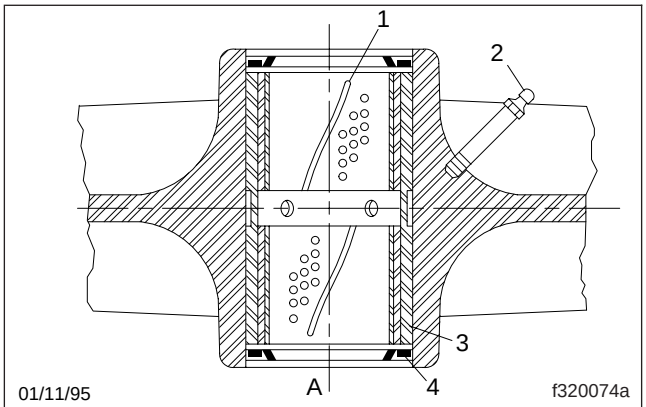


1. Speed Nut
2. Bushing
3. Installing Adapter
4. Removing/Installing Adapter
5. Hexnut
6. Pulling Screw

Fig. 2, Install the Bronze Center Bushings

   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 (**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 (**Fig. 4**).



A. Vertical Centerline of Beam

1. Seal
2. Bushing Lube Grooves
3. Grease Fitting
4. Center Bushing Assembly

Fig. 3, Check the Bushing Grooves

   4.4 Install the hexnut on the pulling screw. Full thread engagement is needed.

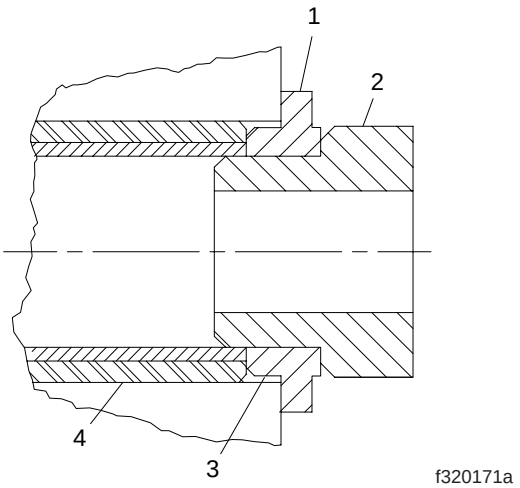
   4.5 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

   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 4000 to 5500 psi (27 580 to 37 920 kPa) during installation. If the reading reaches the operating limit of 10,000 psi (68 950 kPa) and the bushing is not going into the beam, check the alignment of the

Equalizer Beam Bronze Center Bushing Removal and Installation



1. Installing Adapter
2. Removing/Installing Adapter
3. Deep Ridge
4. Bushing

Fig. 4, Position the Deep Ridge of the Installing Adapter Against the Bronze Bushing

bushing, tooling, and hydraulic equipment. Installation is complete when the installing adapter is flush against the beam.

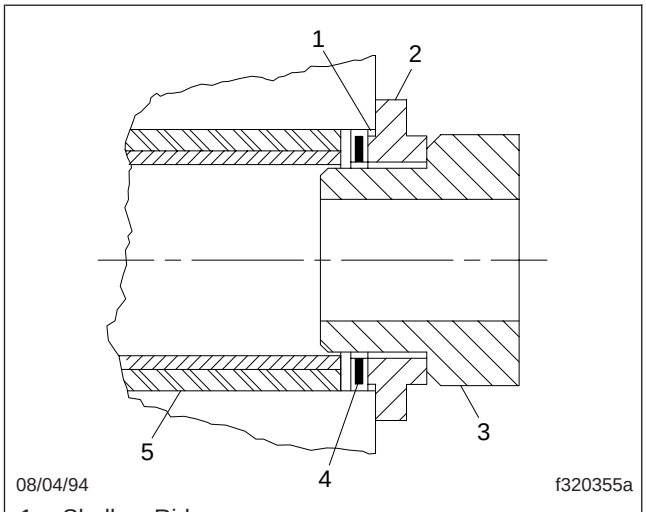
4.8 On the inboard side of the beam, position a grease seal and installing adapter against the center bushing. Make sure the shallow end of the adapter is against the grease seal (**Fig. 5**). Using a hammer, tap the installing adapter until it is flat against the beam. Using the same procedure, install 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.



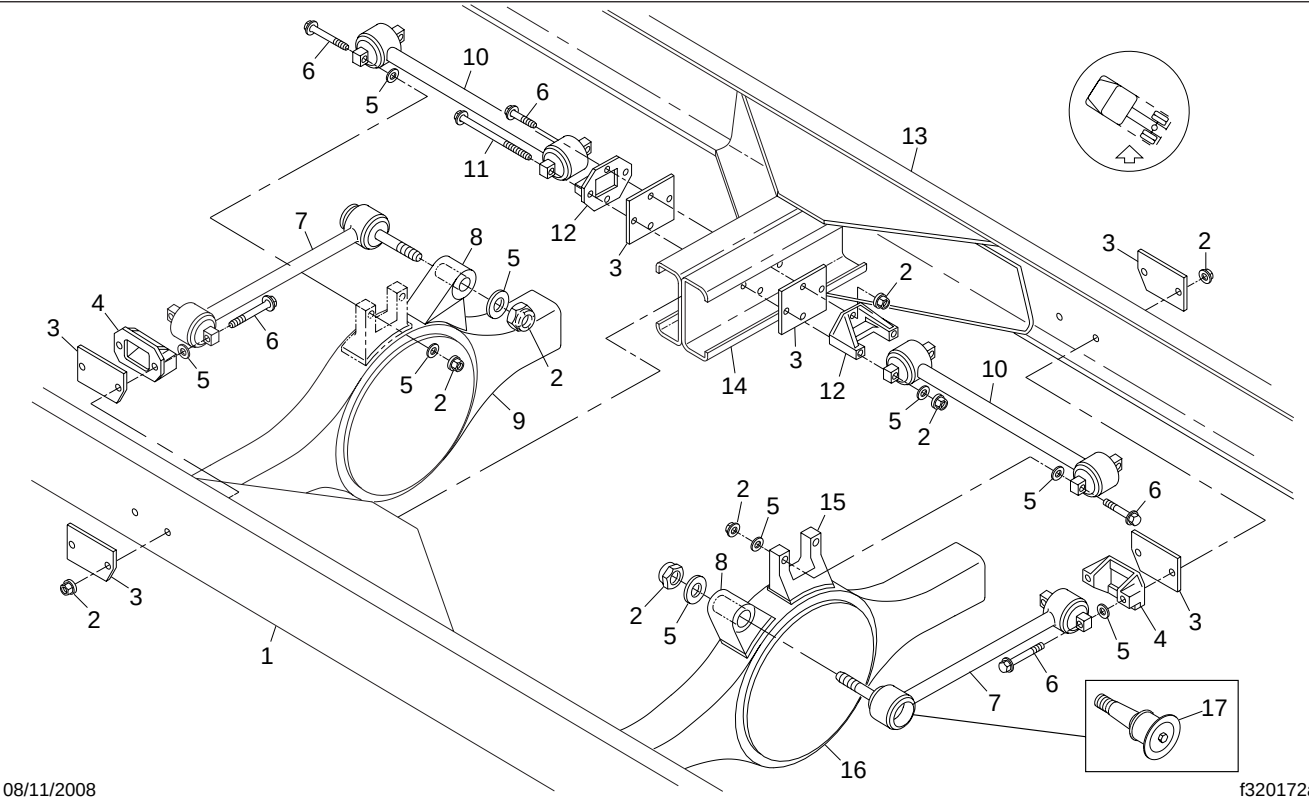
1. Shallow Ridge
2. Installing-Adapter
3. Removing/Installing Adapter
4. Seal
5. Bushing

Fig. 5, Position the Shallow End of the Adapter Against the Grease Seal

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, see **Subject 130**.

Torque Rod Removal, Bushing Replacement, and Installation

Removal (See Fig. 1)



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

Fig. 1, Torque Rod Mounting Assembly

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

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

Torque Rod Removal, Bushing Replacement, and Installation

the crossmember mounting brackets. 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. 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 (**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 (**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 (**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.

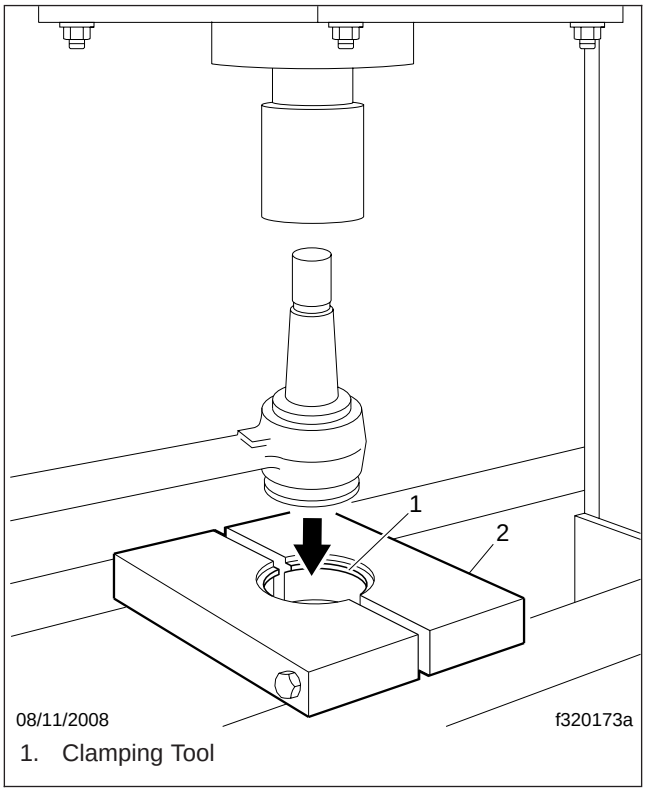


Fig. 2, Loosen the Press Plate Capscrews and Separate the Halves

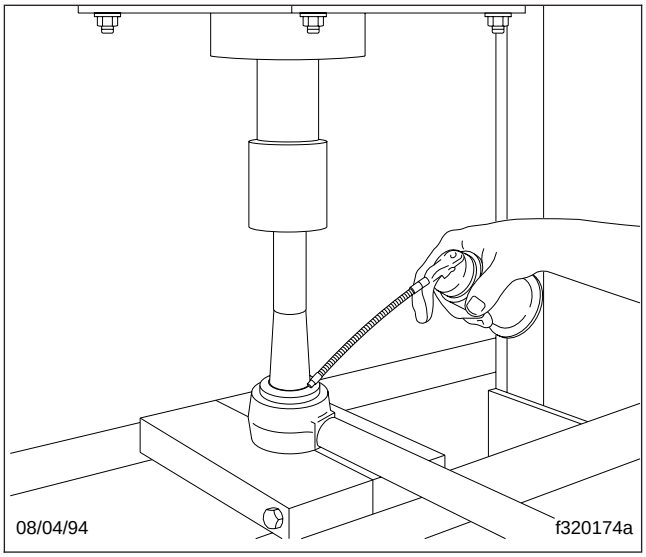


Fig. 3, Apply Lubricating Oil

11. Press the rubber bushing out of the torque rod eye.

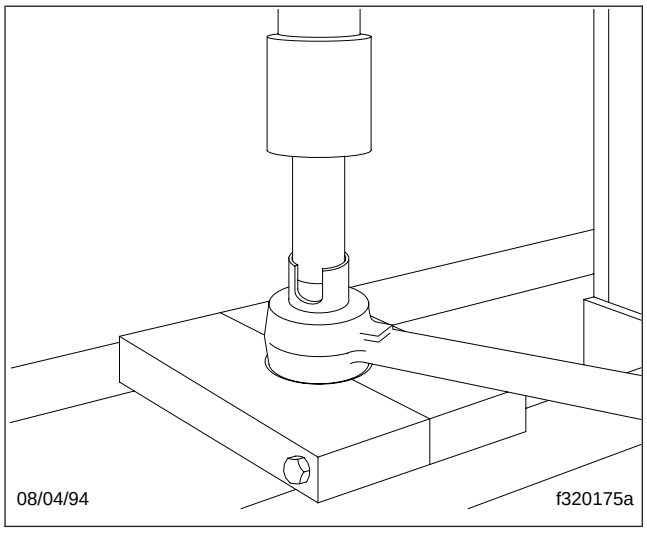


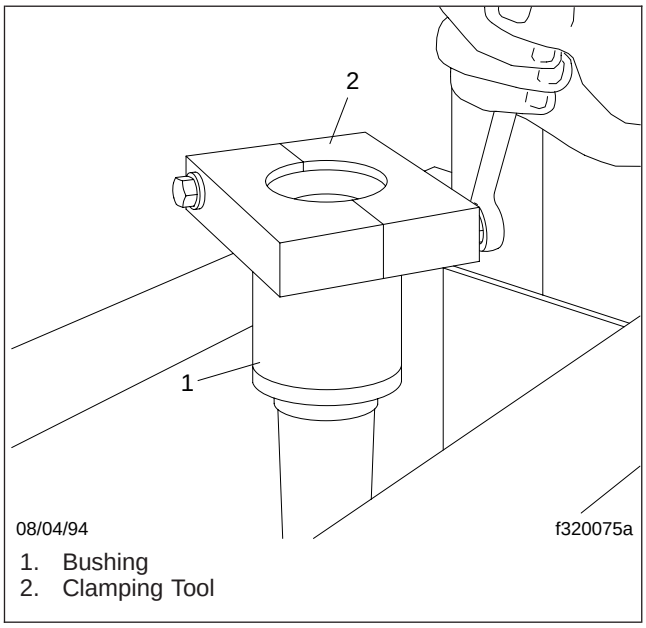
Fig. 4, Straddle Mount Pin Position

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(**Fig. 5**).
4. Place the torque rod end, the bushing, and the clamp on the press plate.
5. Place the remover/replacer tool (**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.

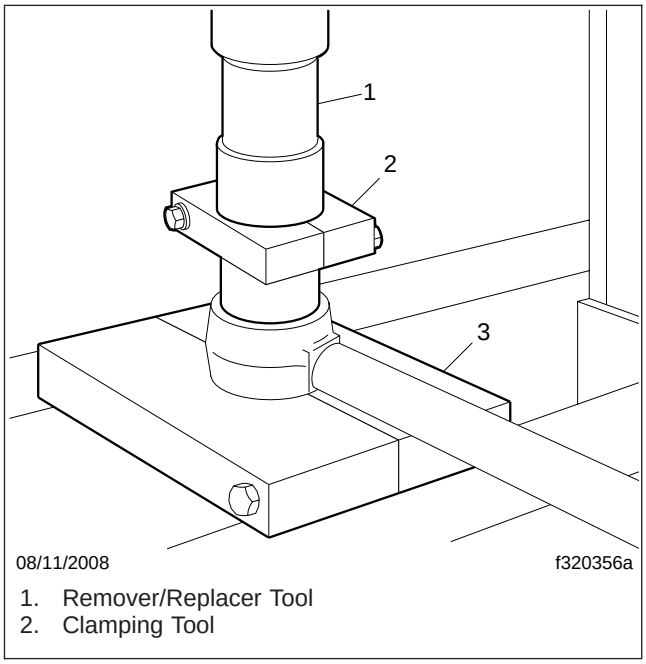
NOTE: When tightening the clamp, make sure that the position of the bushing pin is at a right angle to the center line of the torque rod shank (**Fig. 8**).

7. Place the torque rod end, the bushing, and the clamp on the press plate.



1. Bushing
2. Clamping Tool

Fig. 5, Compress the Rubber

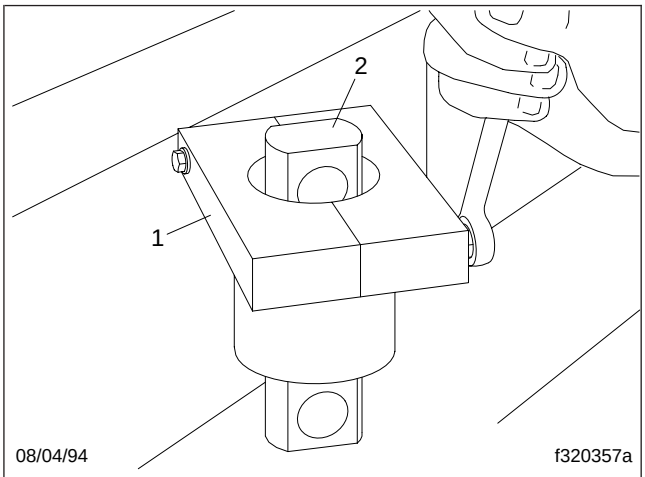


1. Remover/Replacer Tool
2. Clamping Tool

Fig. 6, Push the Bushing in the Torque Rod End

8. Using the larger end of the remover/ replacer tool, position the tool and cap on top of the clamp assembly.

Torque Rod Removal, Bushing Replacement, and Installation



1. Clamping Tool
2. Pin

Fig. 7, Align the Clamping Tool on the Bushing

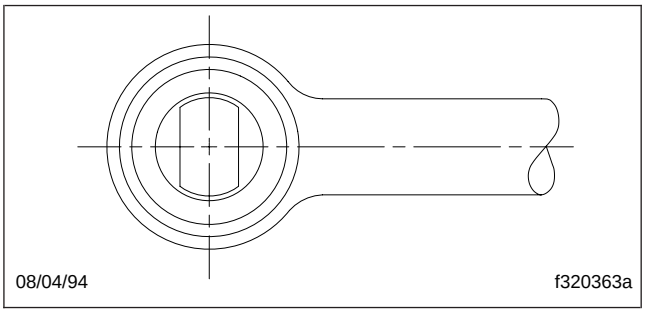


Fig. 8, Bushing Pin Positioning

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 (**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 nut on each bolt, and tighten the nut 190 lbf·ft (260 N·m).
    - 10.2 Position a torque rod straddle mount pin in the rearmost axle bracket. Install the flanged bolts through the axle bracket and the straddle mount pin. Install a spacer and nut on each bolt, and tighten the nut 190 lbf·ft (260 N·m).
    - 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 95 lbf·ft (130 N·m).
    - 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 190 lbf·ft (260 N·m).
11. Install the transverse torque rods (**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 175 to 225 lbf·ft (235 to 305 N·m).
    - 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 190 lbf·ft (260 N·m).
12. Check the axle pinion angle. For instructions, see **Group 41**.

Torque Values		
Description	**Size**	**Torque lbf·ft (N·m)**
Top Pad to Spring Aligning Setscrew (RT/RTE)	—	100–150 (135–200)
Top Pad Nut (RT/RTE)	—	275–400 (375–542)
U-Bolt Locknut (U/UE)	7/8–14	237–302 (321–409)
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)
U/UE	3/4–16	125–145 (169–197)
Adaptor-Type Beam End Locknut	3/4–16	210–240 (285–325)
Spring Center Bolt	7/16–20	50–60 (70–80)
	1/2–20	65–75 (90–100)
	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)

Table 1, Torque Values

Shop-Made Adaptors		
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 Adaptors

Special Tools (Owatonna Tool Company)		
Part Number	**Tool**	**Usage**
1745	Adaptor Puller Set	Adaptor-Type End Support Removal
1761	Torque Rod Set	Torque Rod Bushing Removal and Installation
28536	Installing Adaptor (5-3/4" o.d.)	Bronze Center Bushing and Seal Removal and Installation
44119	Receiving Tube	Center and End Bushing Removal and Installation
45052	Adaptor Clamp	End Bushing Installation
51678	80-Ton Hydraulic Ram	All Operations
51695	Jack	All Operations
206459	Plate	End Bushing Installation

Specifications

Special Tools (Owatonna Tool Company)		
Part Number	**Tool**	**Usage**
302018	Spacer (3 qty.)	Center and End Bushing Removal and Installation
302019	Receiving Adaptor	End Bushing Removal and Installation
302023	Pulling Screw	All Operations
302024	Removing and Installing Adaptor	Bronze Center Bushing Removal and Installation
302026	Installing Adaptor	Rubber Center Bushing Removal and Installation
302027	Removing Adaptor	Rubber Center Bushing Removal and Installation
302028	Hexnut	All Operations
302029	Speed Nut	All Operations
302030	Removing Adaptor	End Bushing Removal and Installation

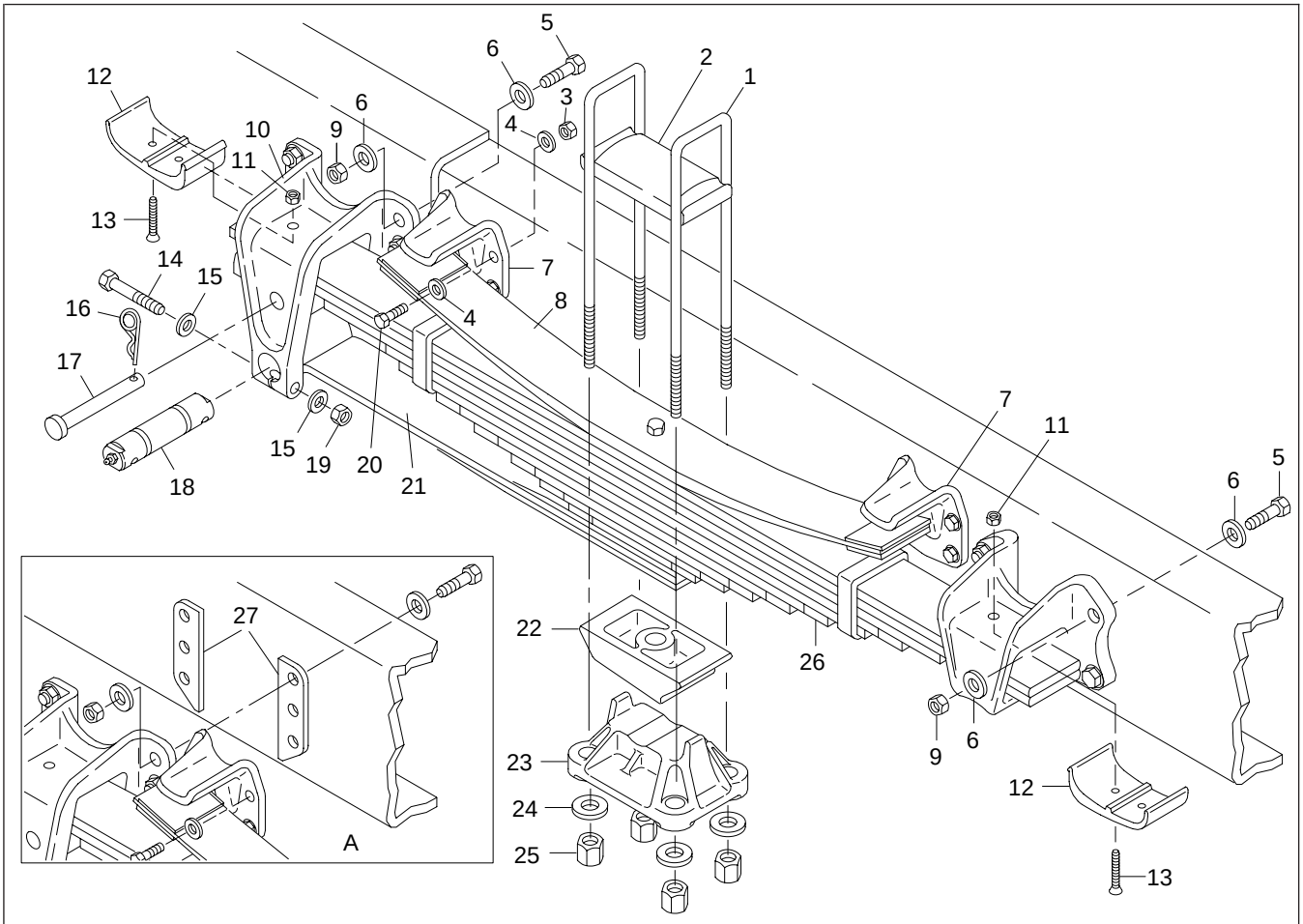
Table 3, Special Tools (Owatonna Tool Company)

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 Information



NOTE: Spacers (Ref. 27) are used when there is no frame rail reinforcement.

1. U-Bolt
2. U-Bolt Pad
3. Helper Spring
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**.

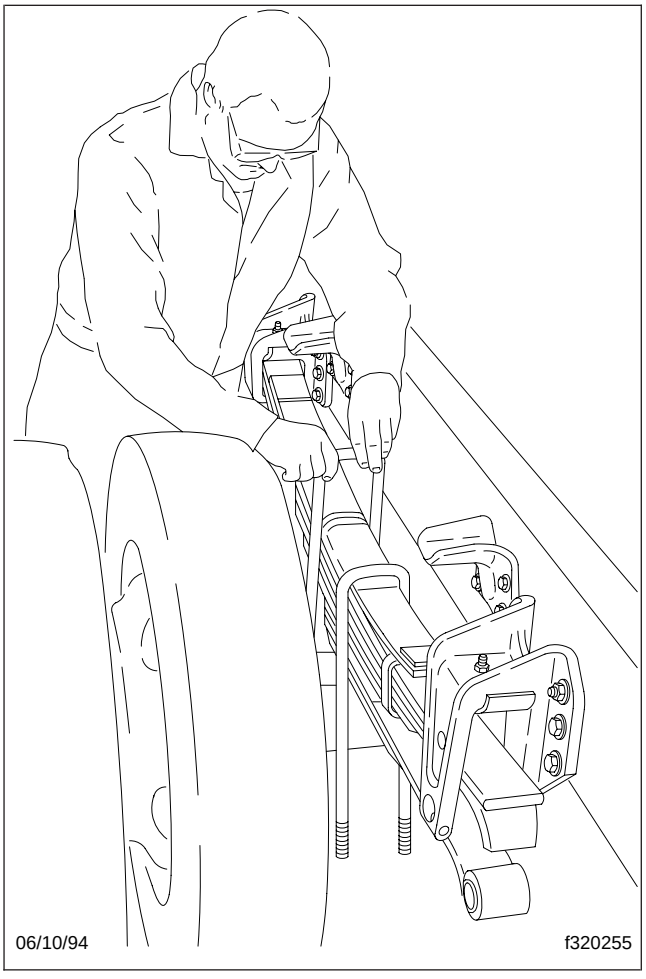


Fig. 1, Remove the U-Bolt

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**.

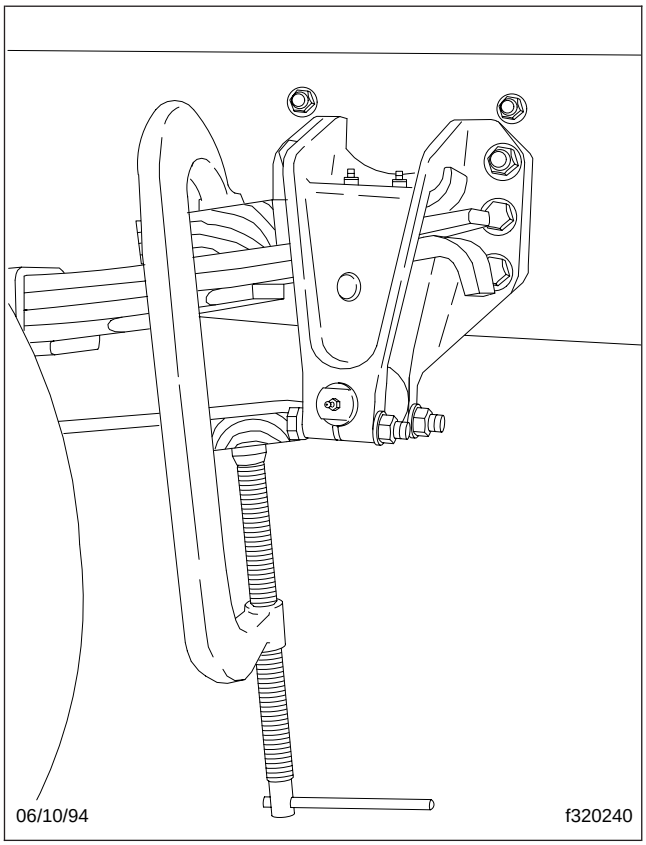


Fig. 2, Take the Load Off the Radius Leaf

⚠ 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

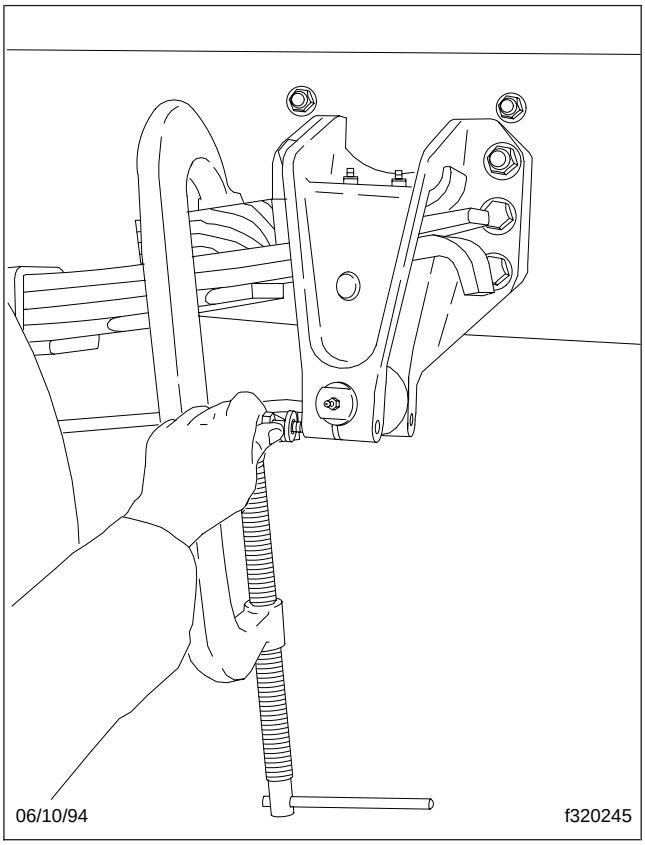


Fig. 3, Remove the Pinch Bolts

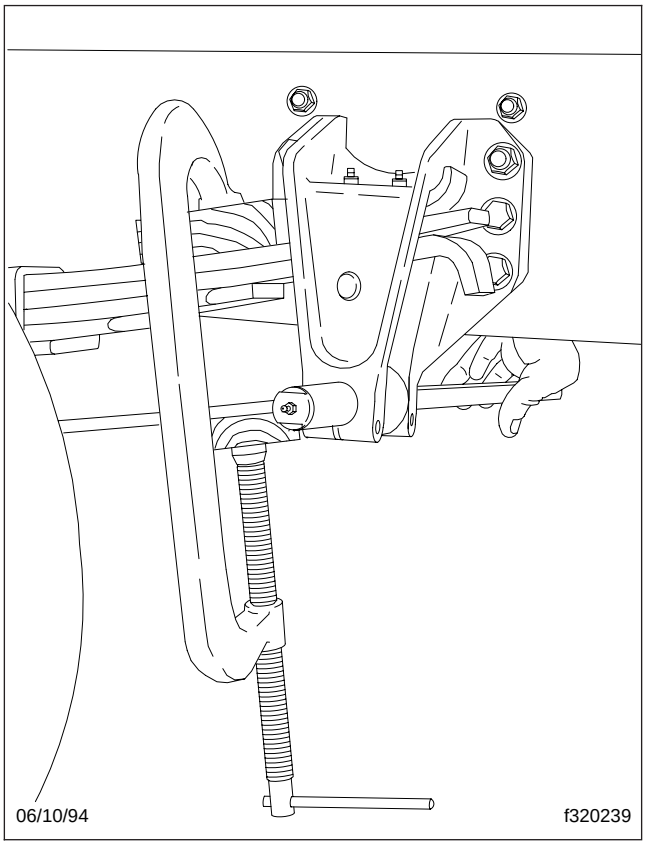


Fig. 4, Tap the Eye Pin Out

5.1 If the vehicle is equipped with the optional helper spring, lift it off.

5.2 Slide the leaf spring assembly forward and remove it from the vehicle. See **Fig. 7**.

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.

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. 8**.

9. Install the U-bolt high nuts (**Fig. 9**), 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. 6**.

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. 2**.

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. 10**.

12.4 Install the pinch bolts and nuts. See **Fig. 11**. Tighten the nuts 32 lbf·ft (43 N·m).

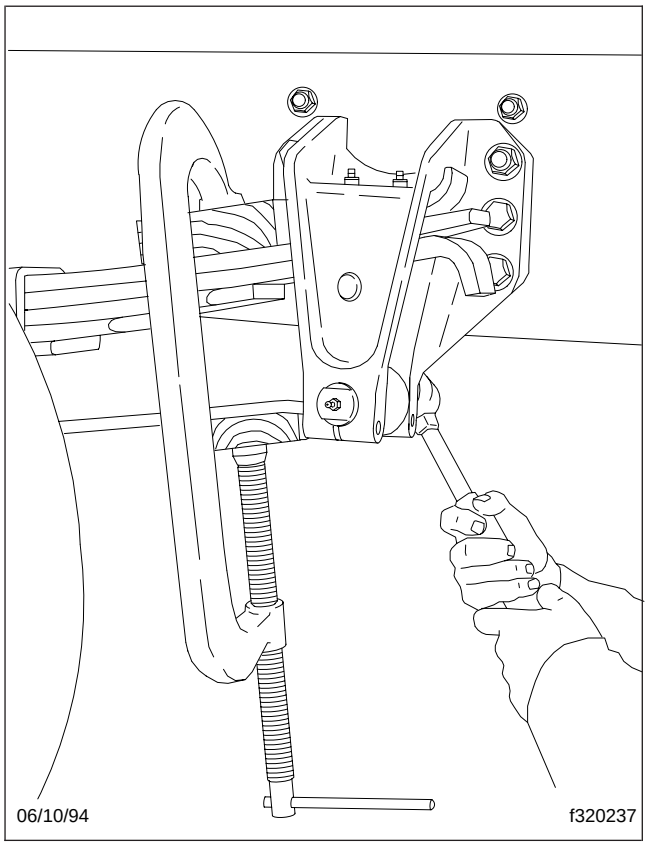


Fig. 5, Clip Removal and Installation

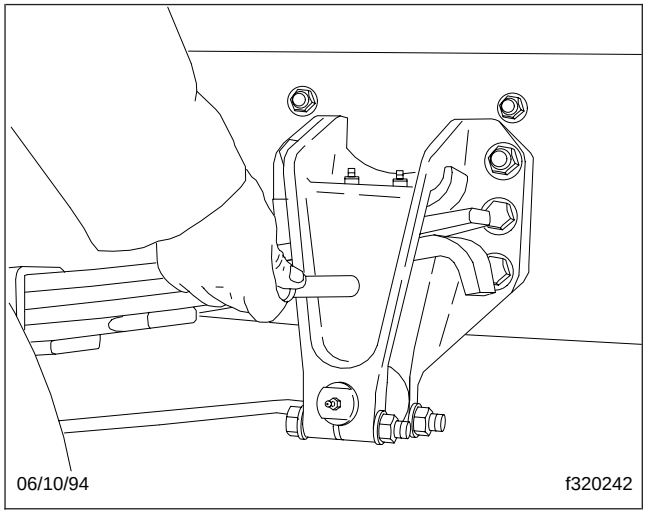


Fig. 6, Spring Retainer Pin Removal and Installation

12.5 Remove the C-clamp.

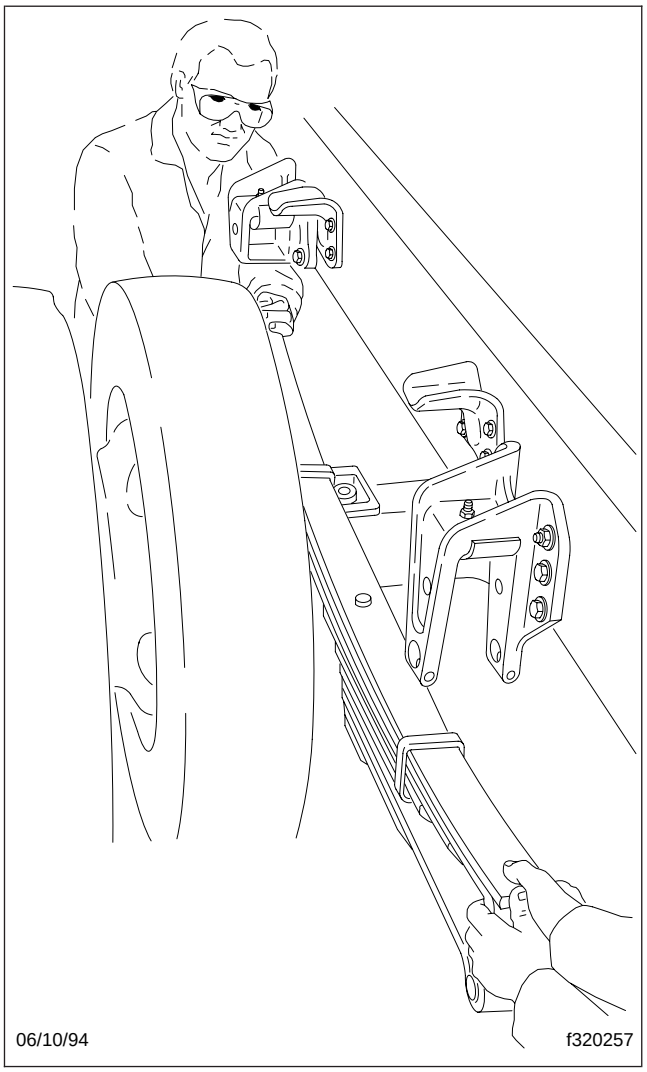
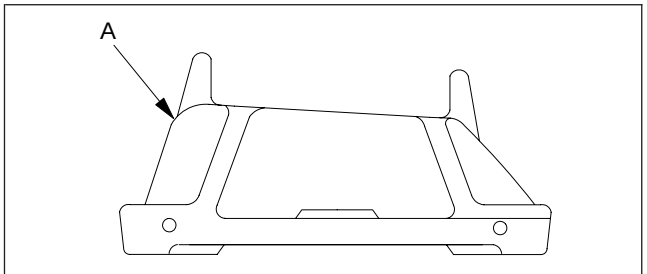


Fig. 7, Remove the Leaf Spring Assembly



A. Taller end must be toward the front of the vehicle.

Fig. 8, Install the U-Bolts and U-Bolt Retainer

Spring Assembly Replacement

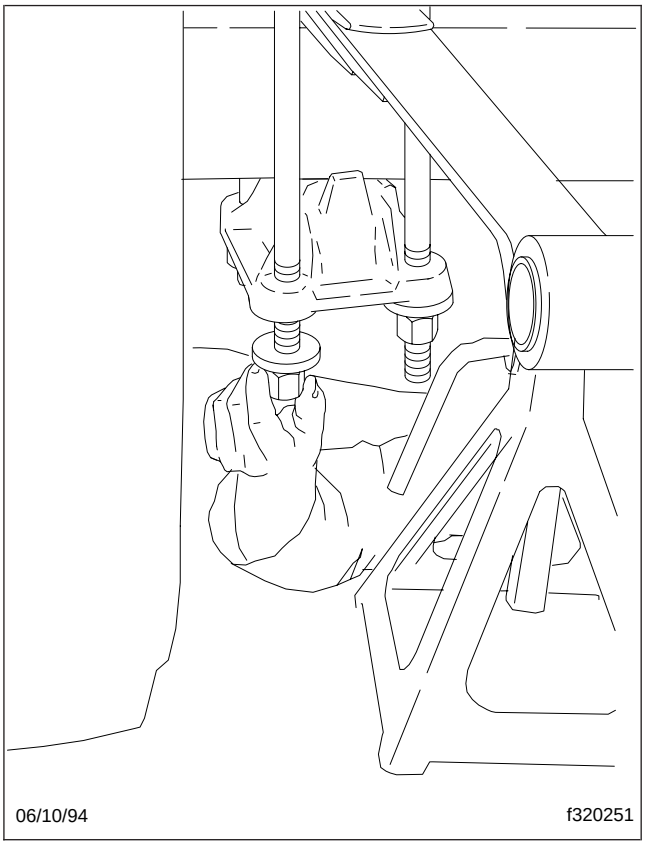


Fig. 9, Install the U-Bolt High Nuts

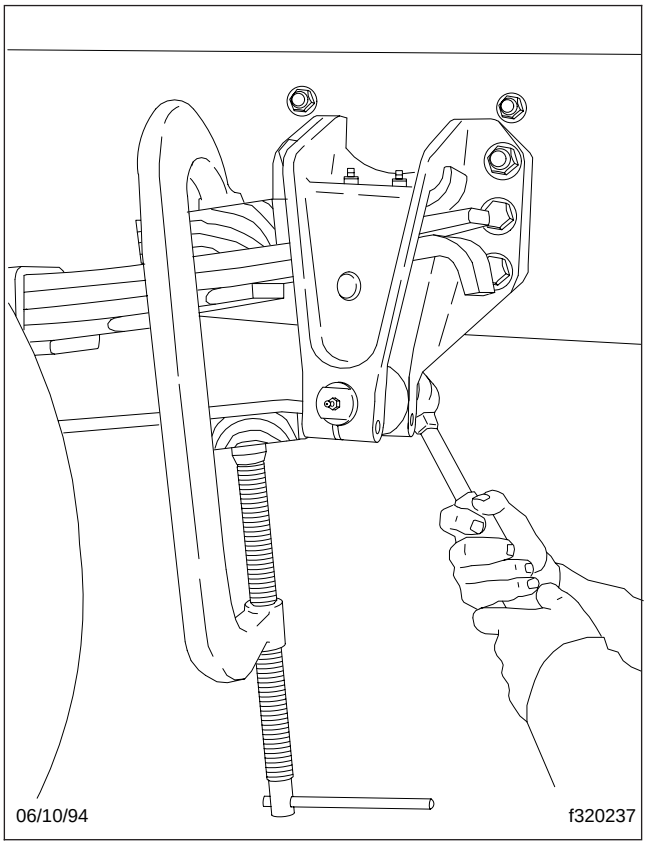


Fig. 10, Tap in the Pin

13. Tighten the U-bolt high nuts diagonally to the torque values in **Specifications, 400**.
14. Remove the jack or safety stands from the rear axle and the frame.

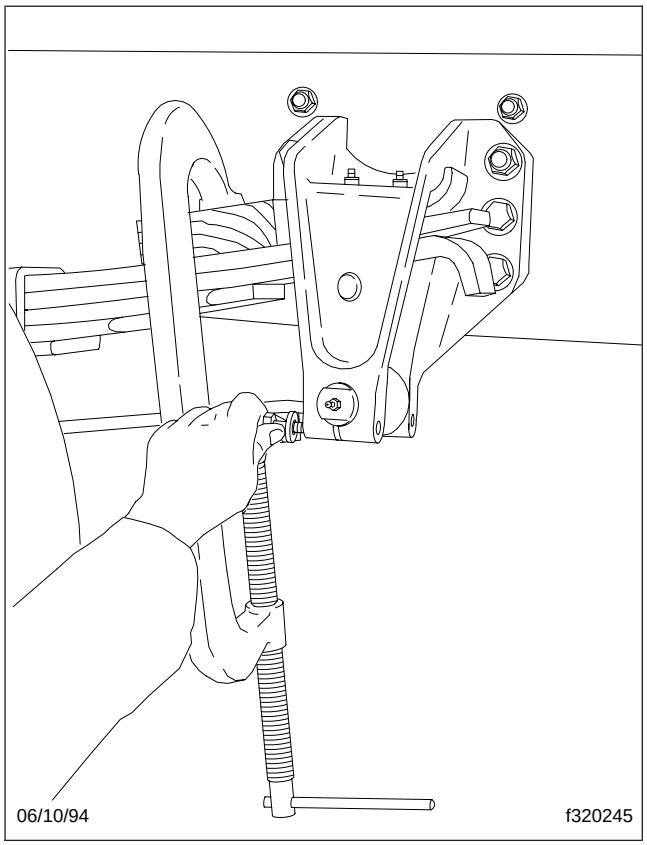


Fig. 11, Install the Pinch Bolts and Nuts

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, see **Subject 130**.
6. Slide the new spring bracket into position.
7. Install the fasteners and tighten them 135 lbf·ft (184 N·m).
8. Lower the frame rail and remove the chocks from the tires.

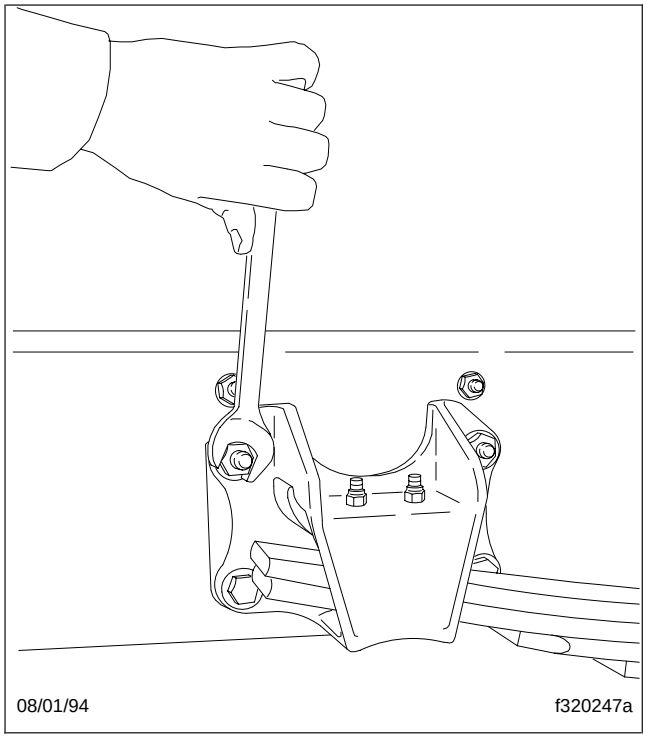


Fig. 1, Remove the Rear Spring Bracket Fastener

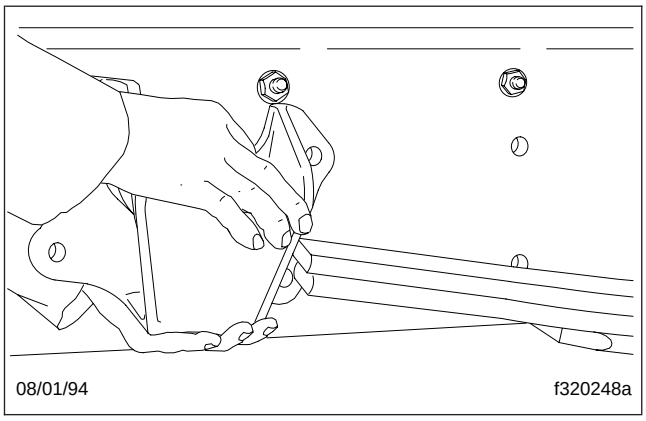


Fig. 2, Slide the Bracket From the Leaf Spring Assembly

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 (**Fig. 6**) and the spring retainer pin (**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 240 lbf·ft (325 N·m).
   - 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

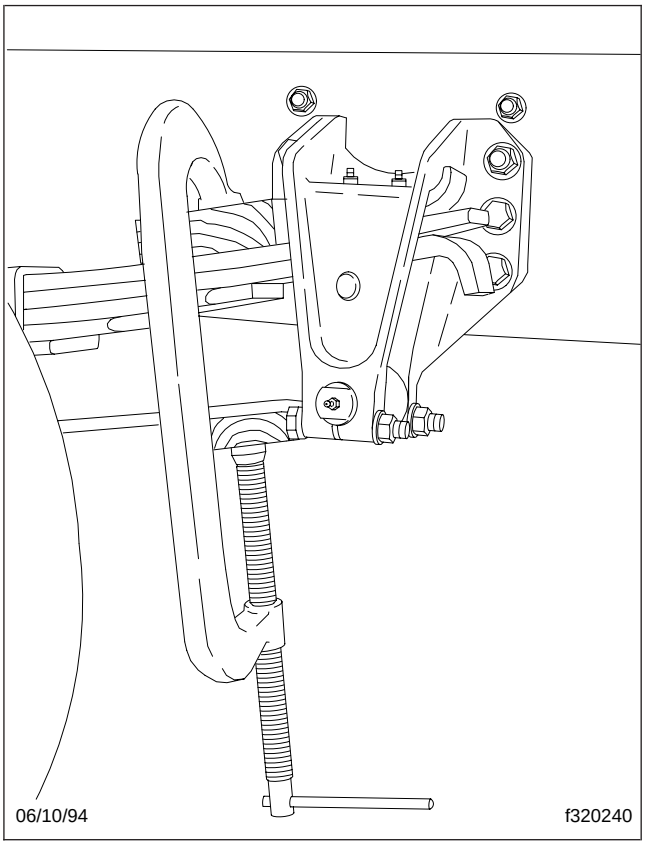


Fig. 3, C-Clamp the Radius Leaf

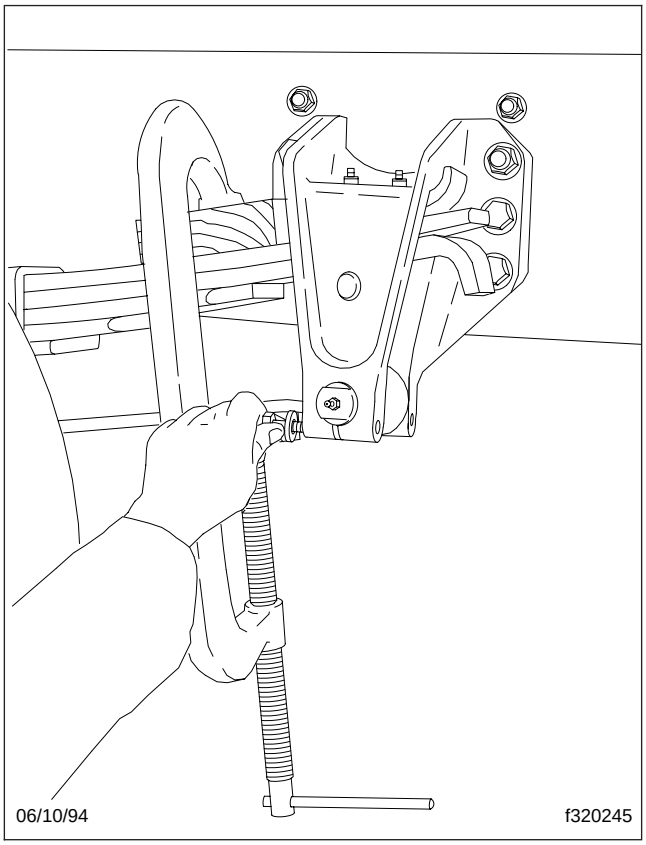


Fig. 4, Remove the Pinch Bolts

4.5 Install the pinch bolts and nuts. Tighten the nuts 32 lbf·ft (43 N·m).

5. Lower the frame rail and remove the chocks from the tires.

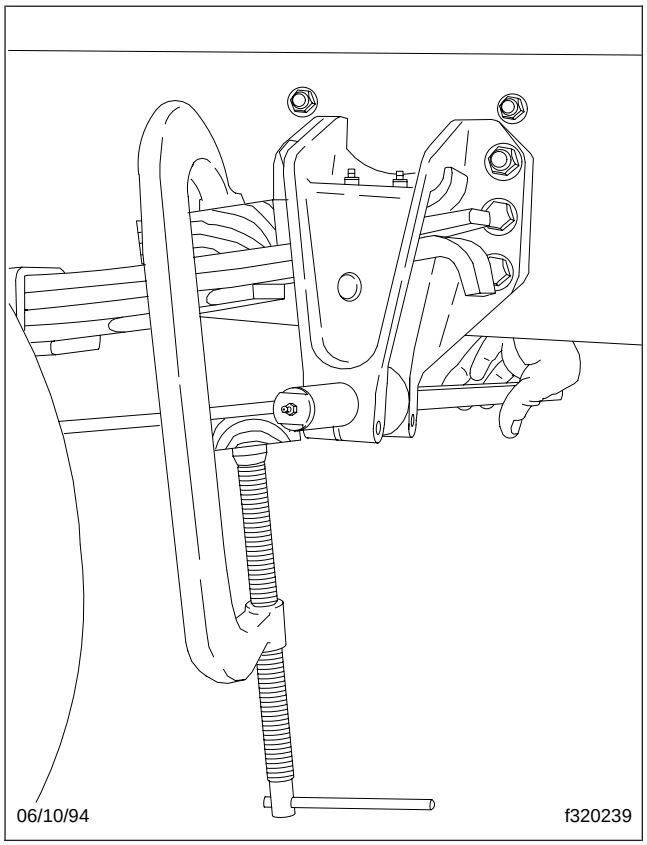


Fig. 5, Tap Out the Spring Eye Pin

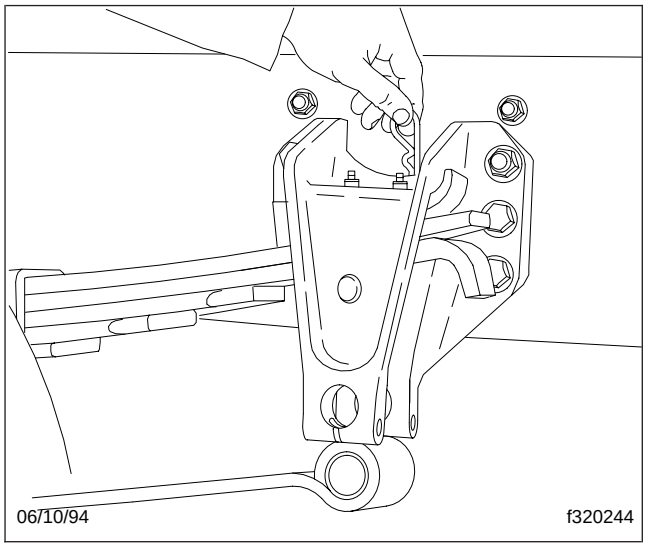


Fig. 6, Remove the Clip

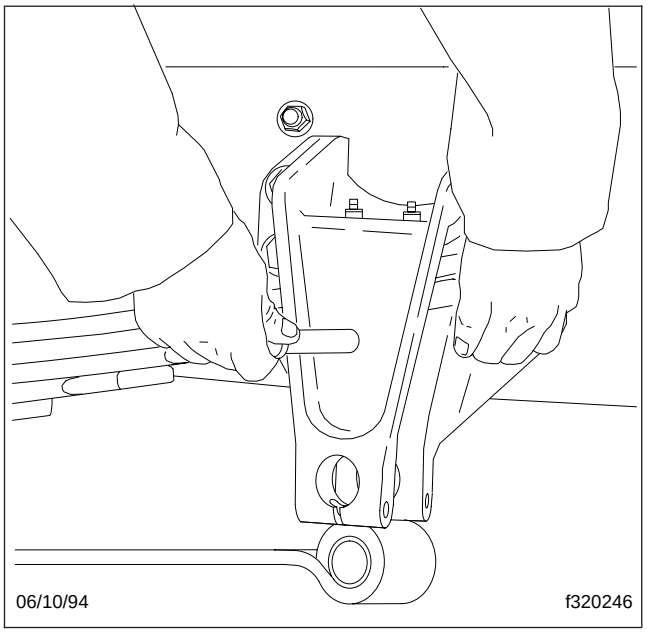


Fig. 7, Remove the Spring Retainer Pin

Spring Bracket Replacement

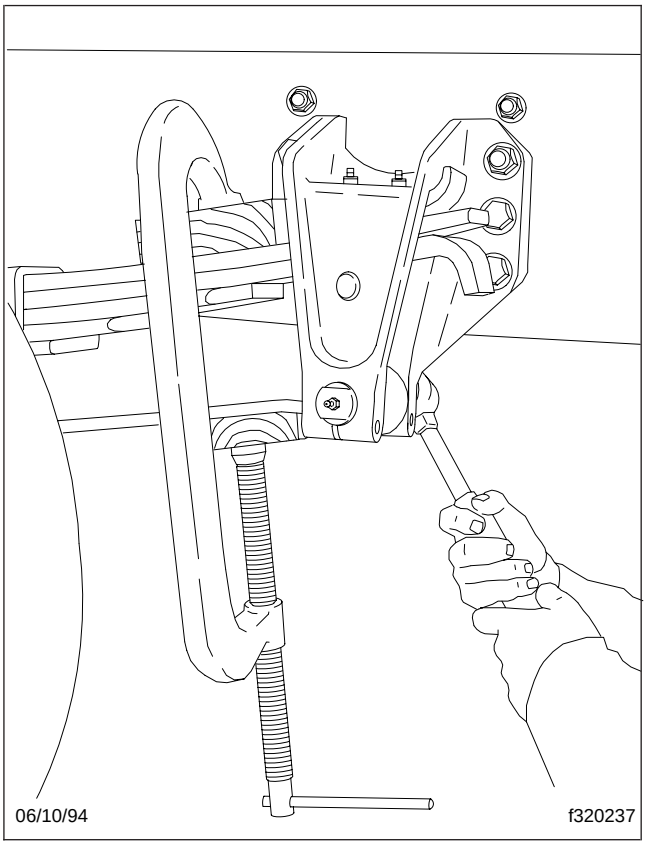


Fig. 8, Install the Spring Eye Pin

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**.

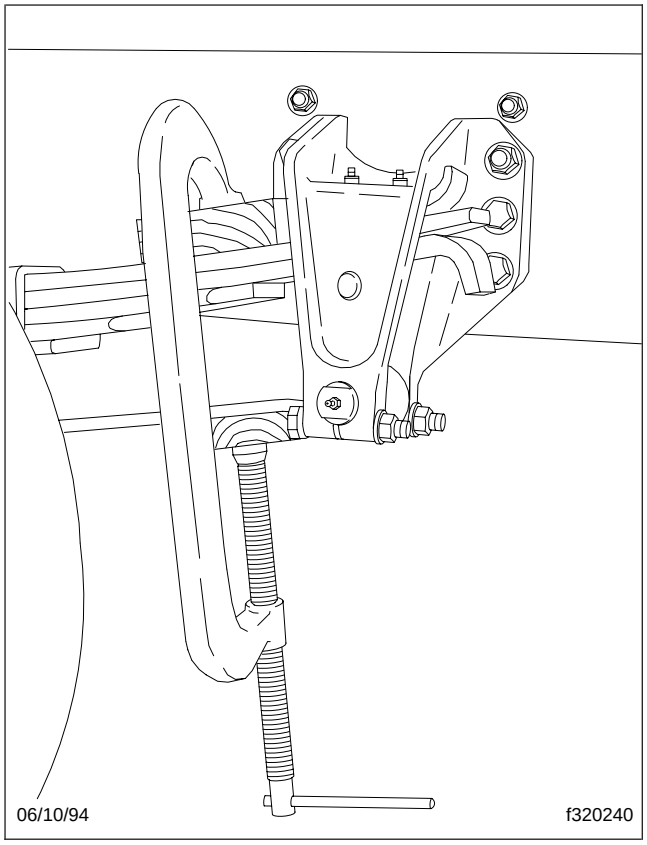


Fig. 1, C-Clamp the Radius Leaf

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 32 lbf·ft (43 N·m).
7. Install a new zerk fitting and the spring eye pin.
8. Remove the C-clamp and lower the jack.

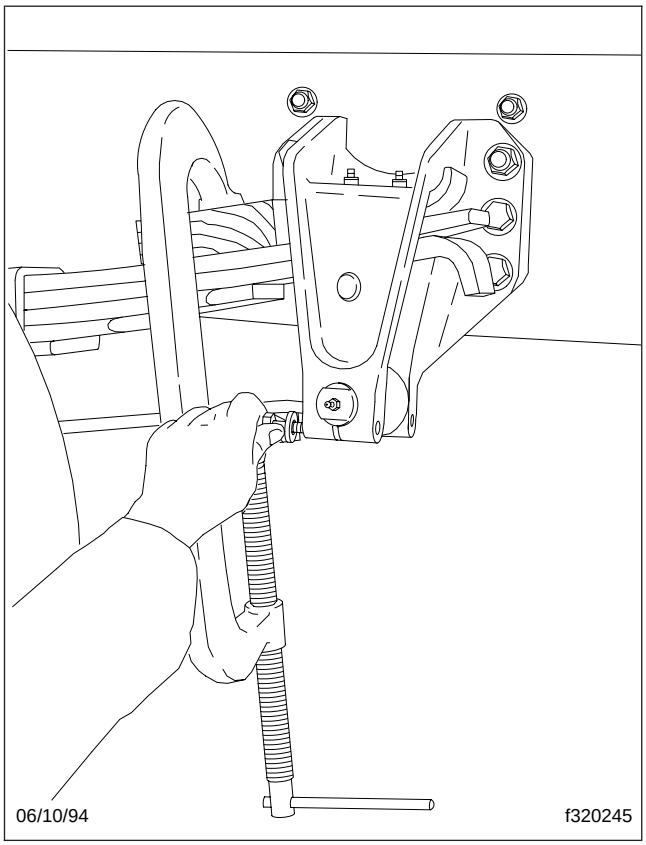


Fig. 2, Loosen and Remove the Pinch Bolts

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

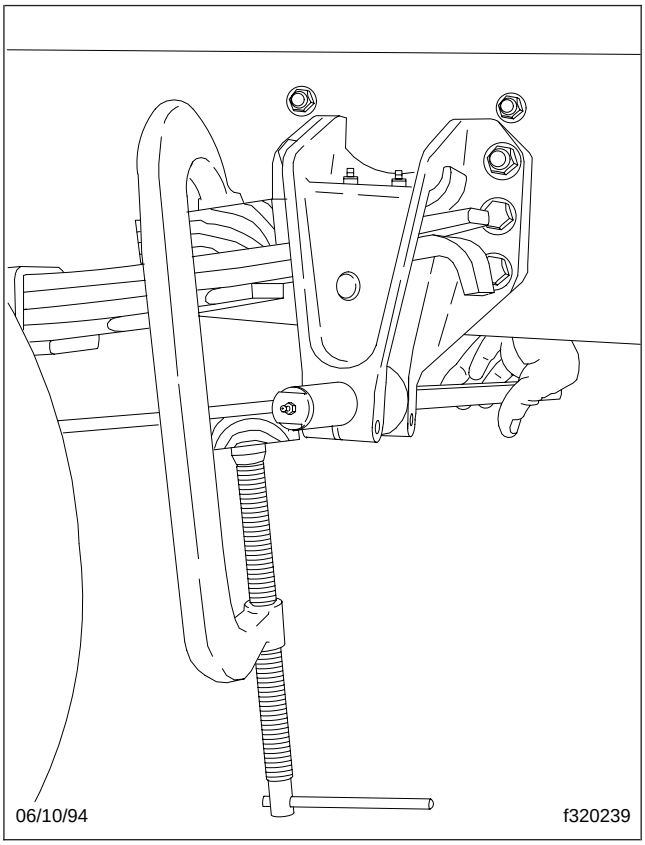


Fig. 3, Tap the Pin Out

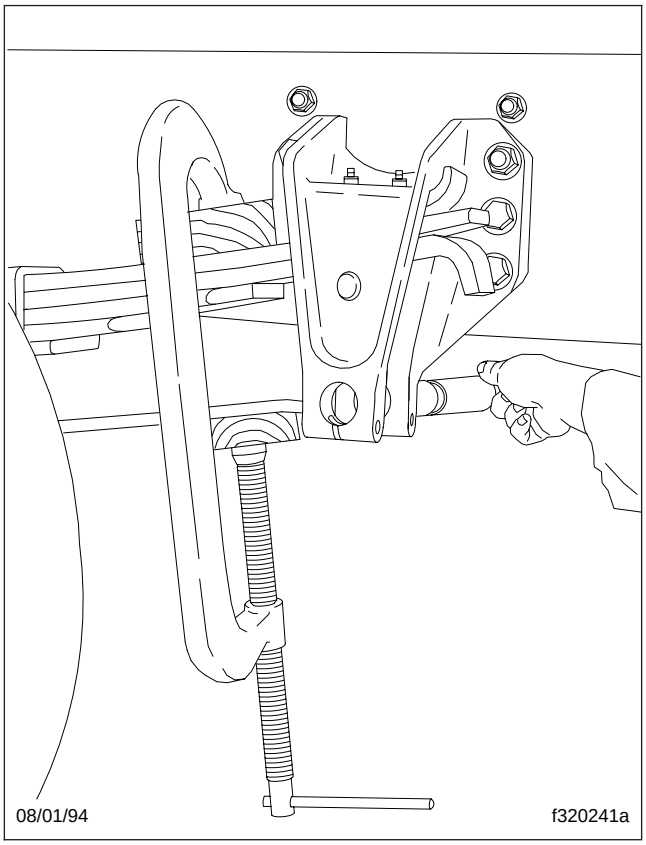


Fig. 4, Grease and Insert a New Pin

Spring Eye Pin Replacement

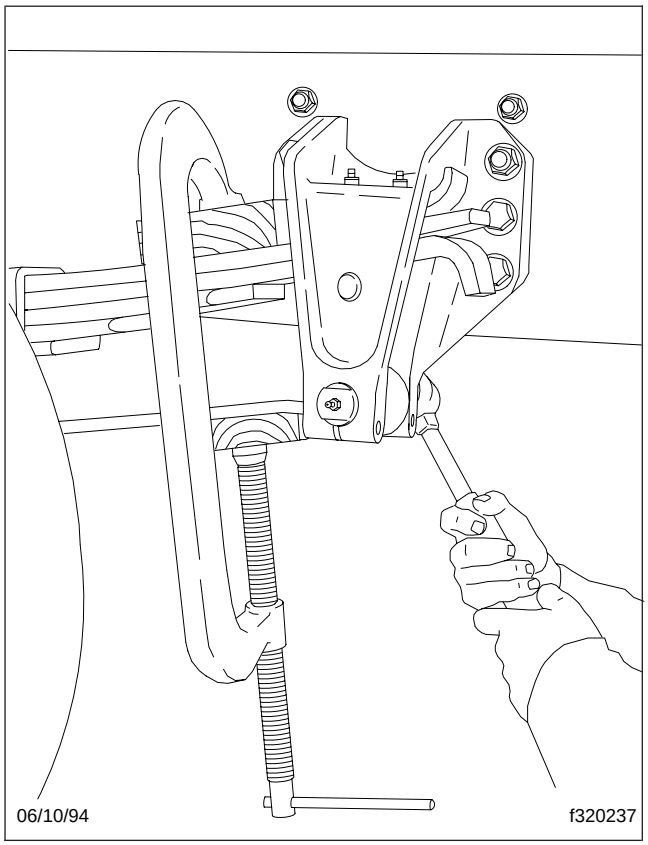


Fig. 5, Drive in the New Pin

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, or **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.

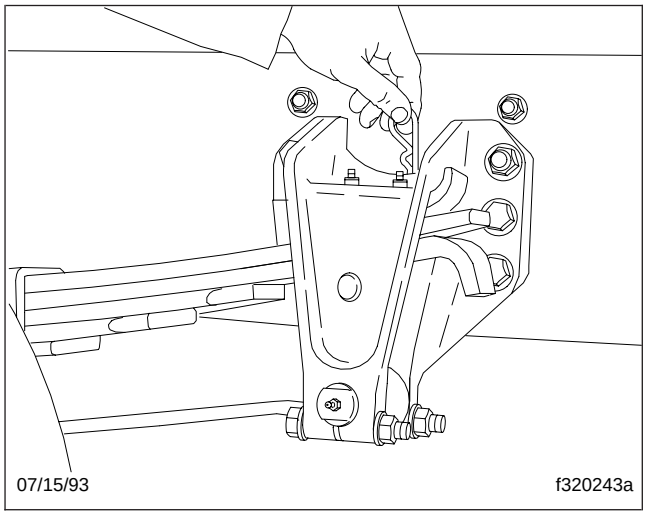


Fig. 1, Remove the Clip

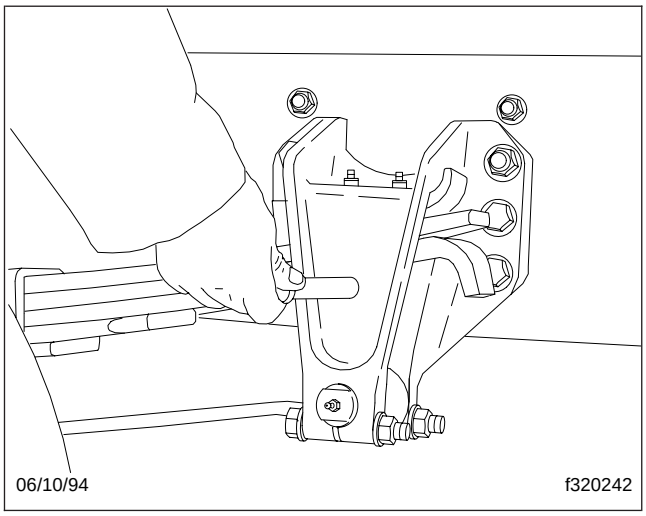


Fig. 2, Remove the Spring Retainer Pin

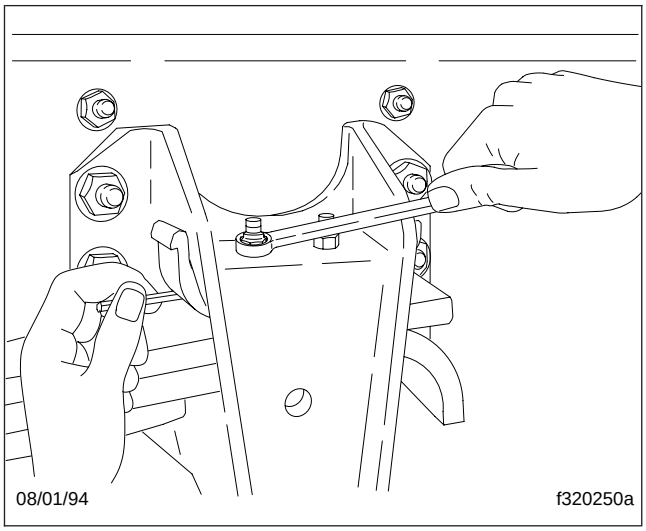
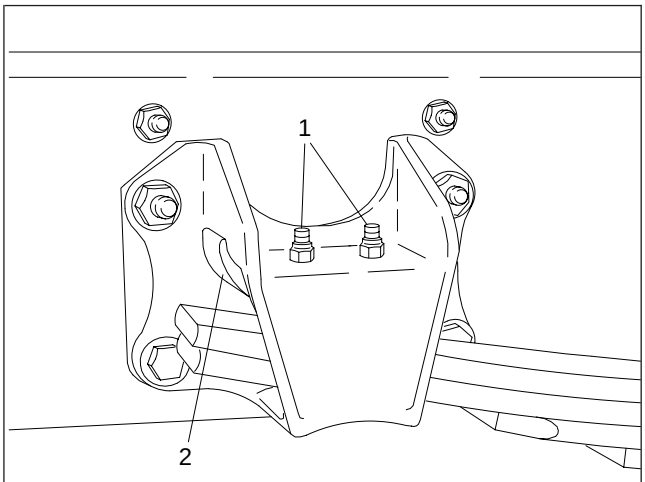


Fig. 3, Remove the Allen-Head Screws

Wear Pad Replacement



1. Allen-Head Screws
2. Wear Pad

Fig. 4, Remove the Allen-Head Screws

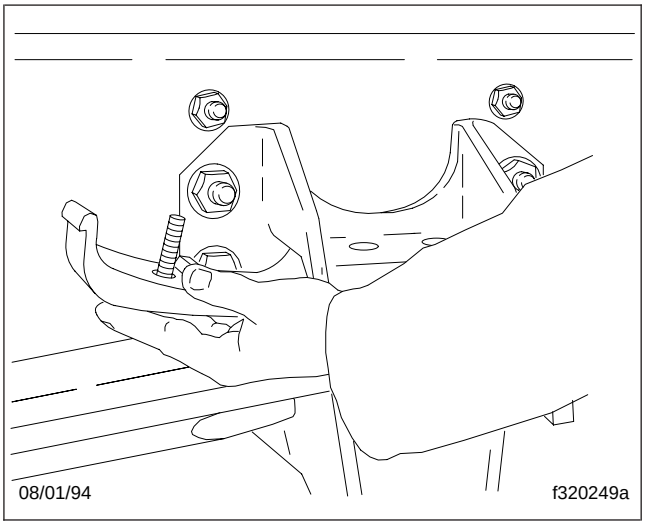


Fig. 5, Install the New Wear Pad (front wear pad shown)

Replacement (See Fig. 1)

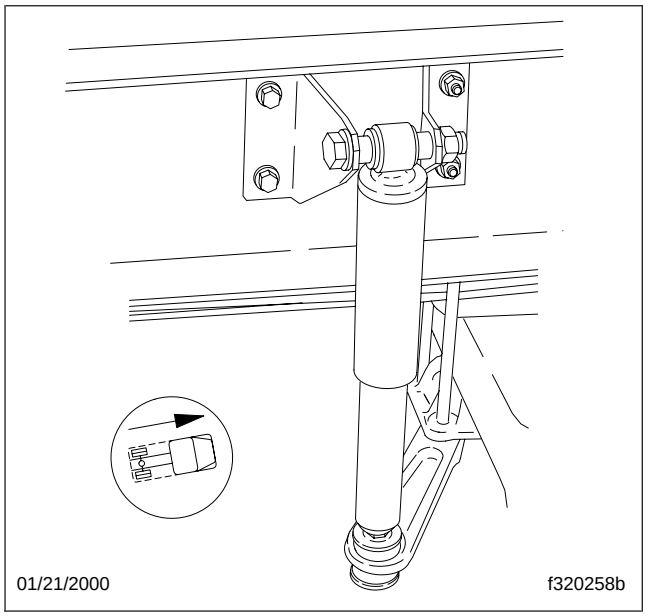


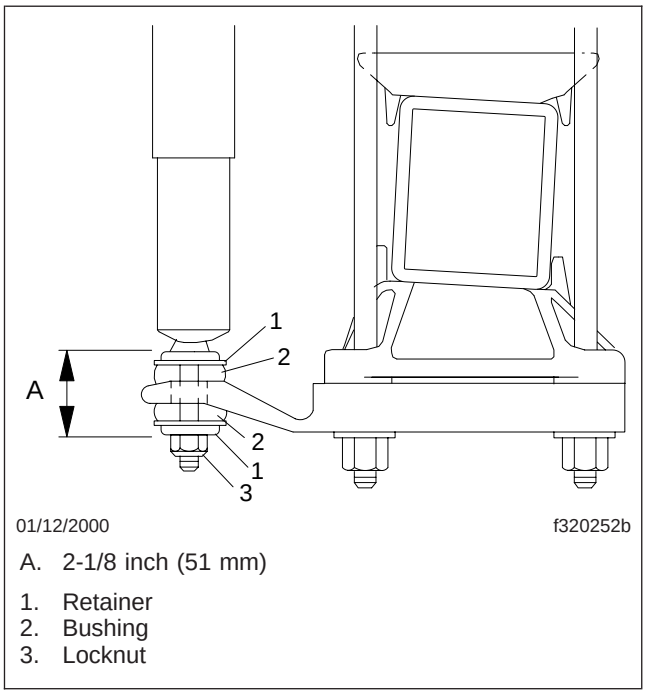
Fig. 1, Shock Absorber

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.

8. Tighten the shock absorber upper mounting locknut 167 lbf·ft (226 N·m).
9. Tighten the shock absorber lower mounting nut to compress the bushings to the dimension shown in **Fig. 2**.



A. 2-1/8 inch (51 mm)

1. Retainer
2. Bushing
3. Locknut

Fig. 2, Install the Replacement Bushings, Retainers, and Locknut

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: 205 (278) †
	3/4–16	C	Stage 1: Hand tighten Stage 2: 60 (81) † Stage 3: 200 (271) † Stage 4: 300 (407) †
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.

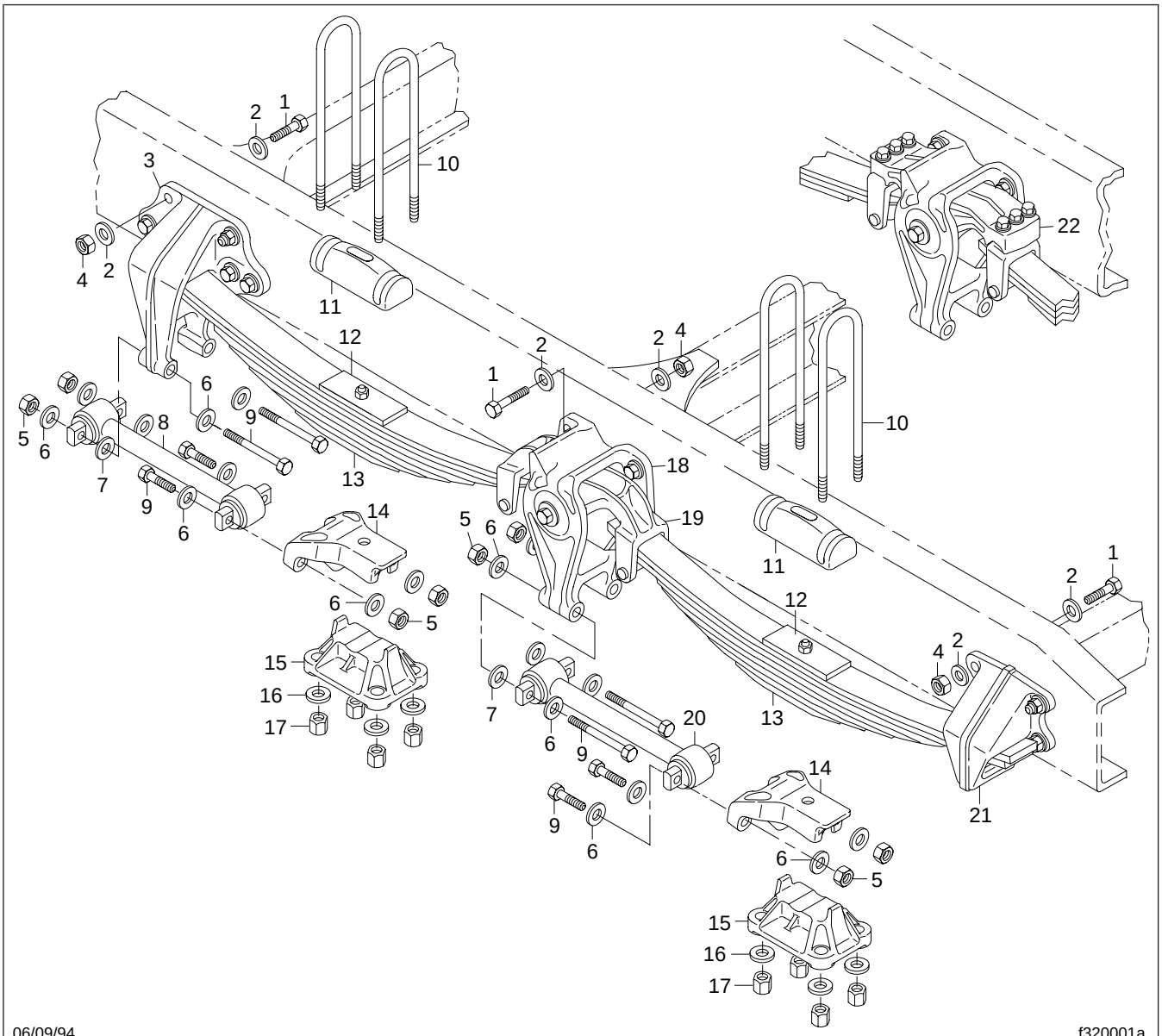
Table 1, Torque Values

General Information

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.

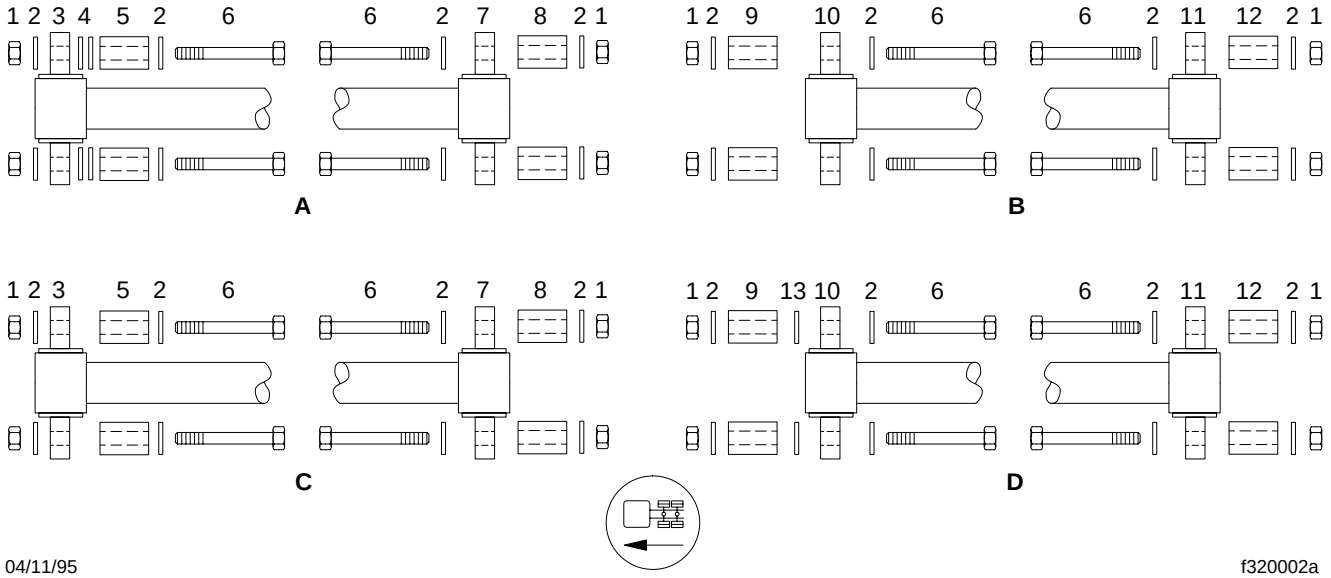
General Information



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

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

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.

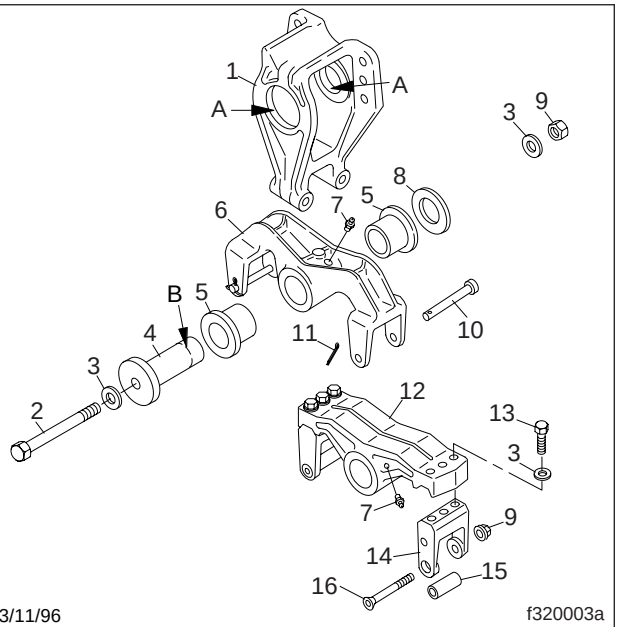
Radius Rod Removal and Installation

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

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**.

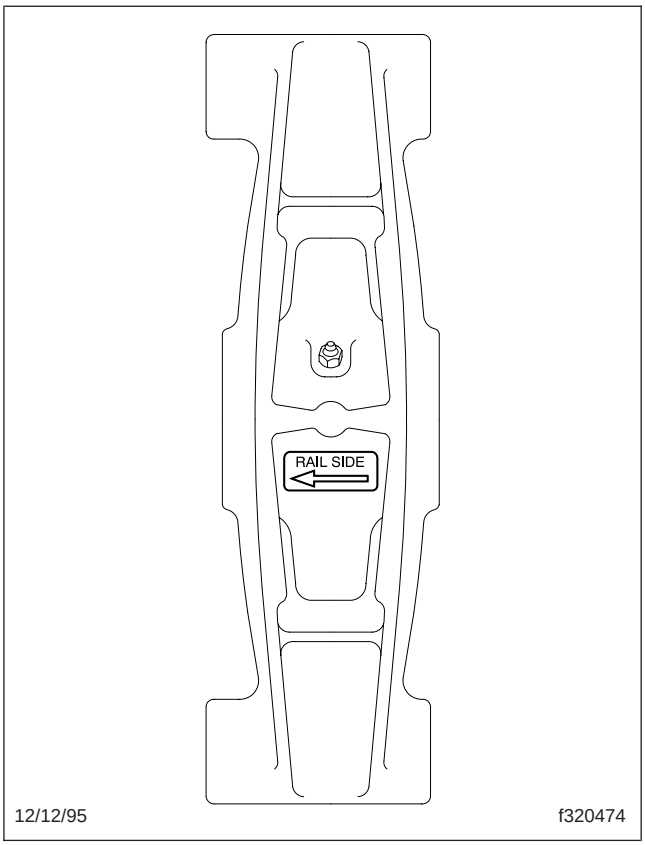


Fig. 2, Equalizer Marking

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** . 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

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, see **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. For instructions, see **Group 40** in this manual.
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.

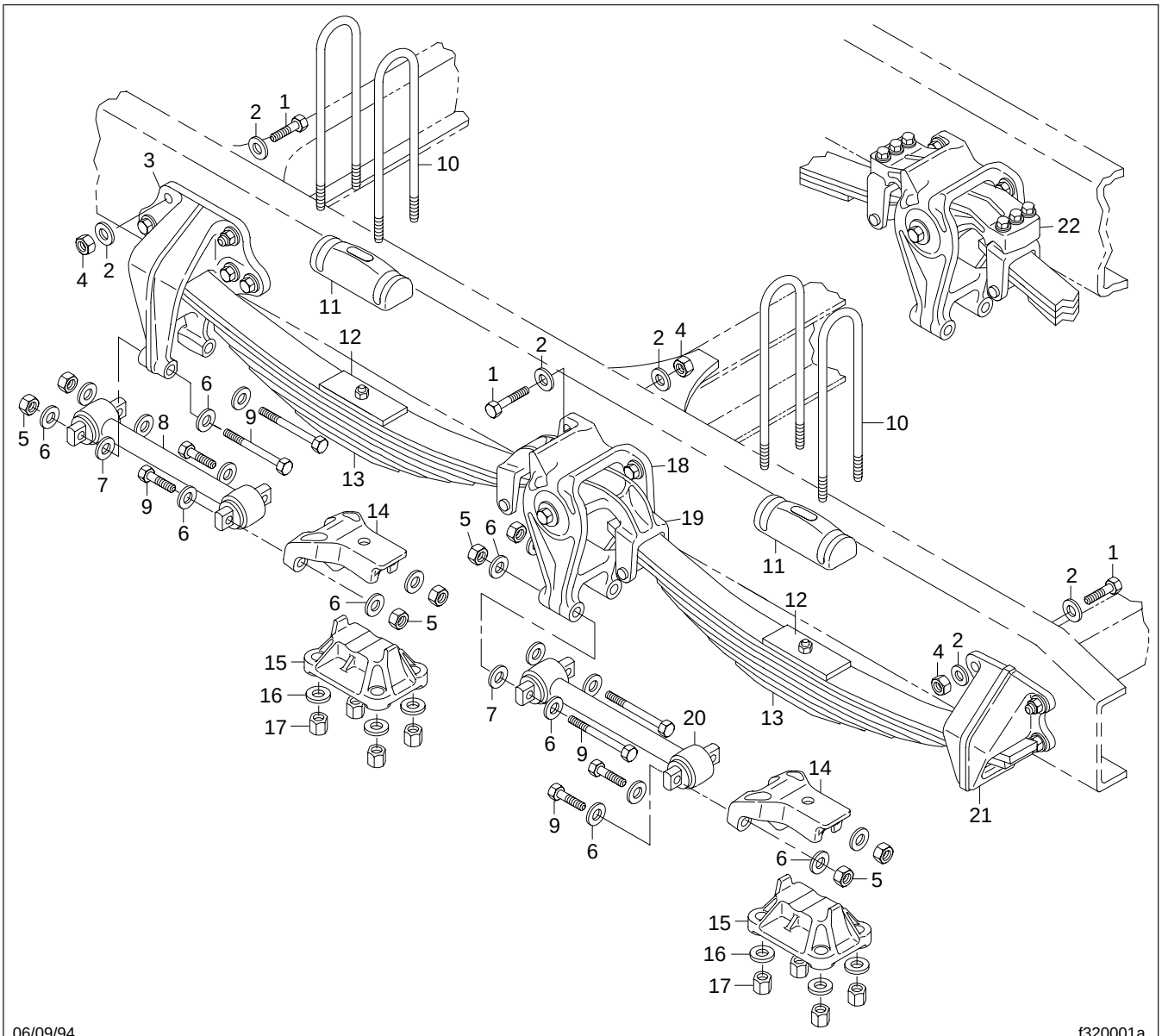
    If installing a spring assembly on a vehicle with a pusher or tag axle, install the side-restraint sleeves and flathead bolts in the wear-shoe side-restraints. Be sure the hooked ends of the spring leaves are above the side-restraint sleeves. Install the nuts, and tighten them to the applicable torque value in **Specifications, 400**.
12. In a diagonal pattern, hand tighten the axle U-bolt high nuts. In the same pattern, tighten them 100 lbf·ft (136 N·m); then, 200 lbf·ft (270 N·m); then, 300 lbf·ft (407 N·m); then, torque to the final value of 420 lbf·ft (569 N·m).

⚠ 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.

Spring Assembly 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

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.
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, see **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

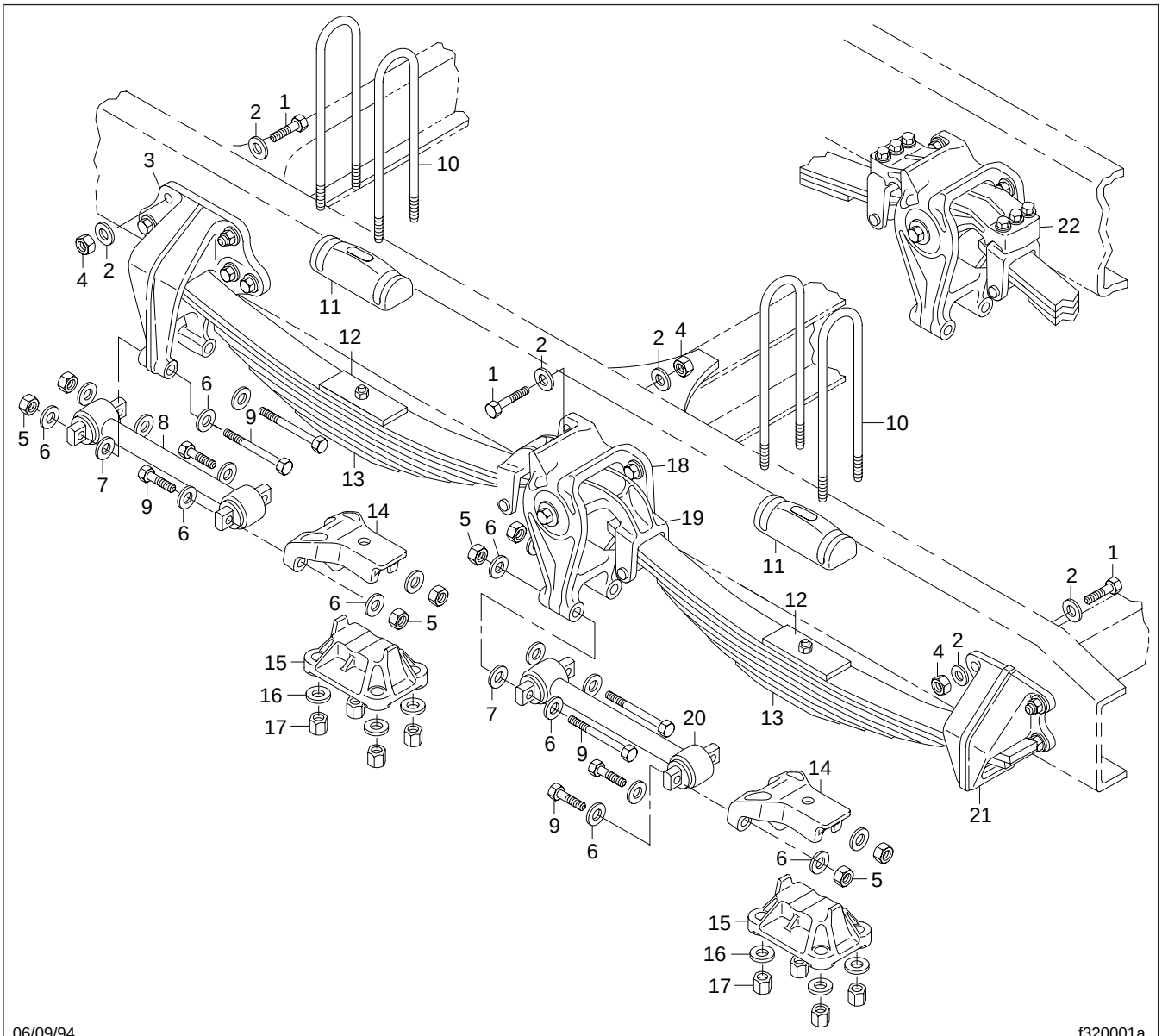
Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 in the vehicle 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**.

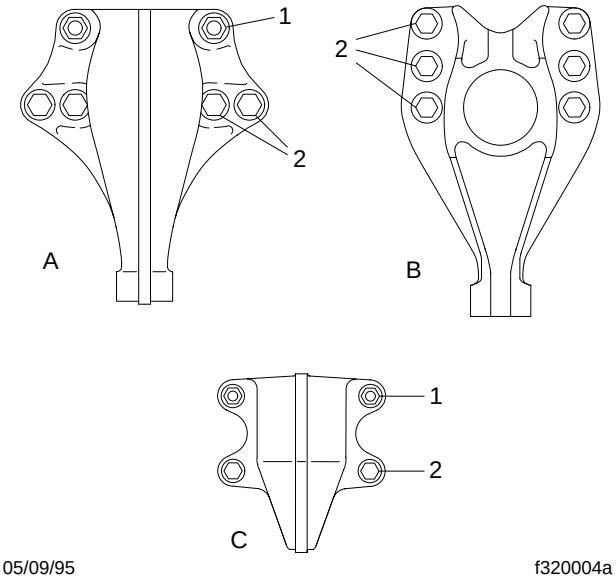
Spring Bracket and Equalizer Bracket Replacement



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

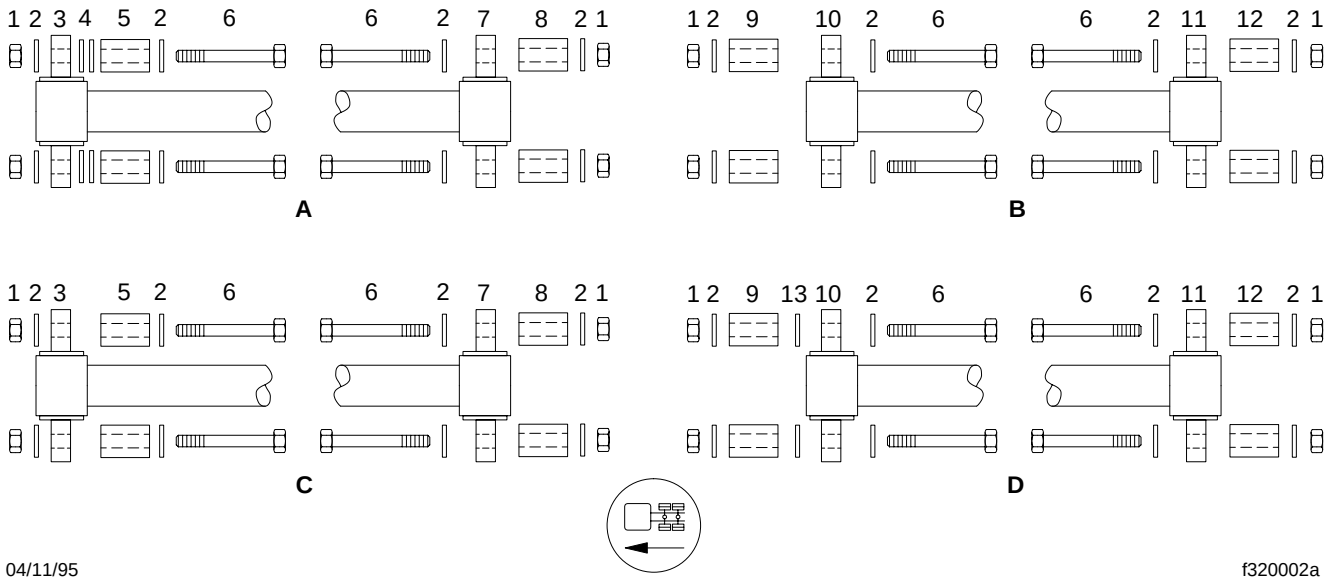


A. Forward Spring Bracket
B. Equalizer Bracket
C. Rear Spring Bracket

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)

Adjustment

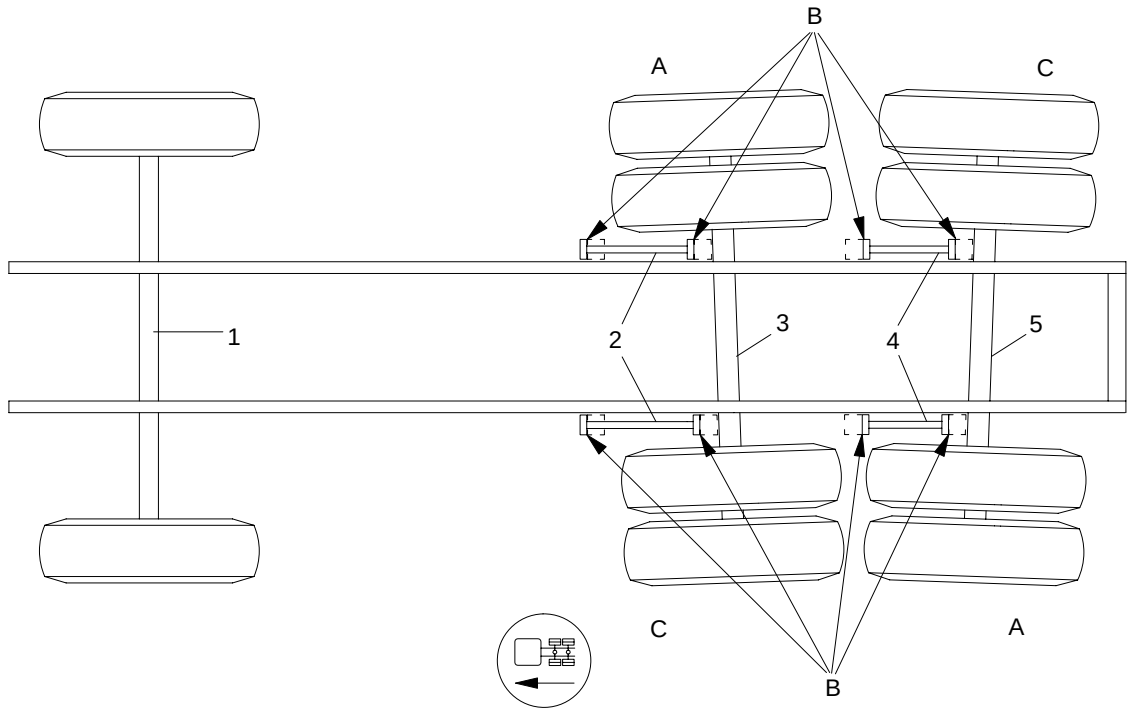
1. Using a straightedge and a tape measure, determine the amount of adjustment needed to align the forward-rear axle at a right angle to the frame. For instructions, see **Group 35**. The difference in measurements between the sides of the vehicle is the approximate amount that the trailing end of the 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.

To move the trailing end of the forward-rear axle forward, *remove* alignment washers from be-



A. Leading End
B. Possible Adjustment Points
C. Trailing End

1. Front Axle
2. Forward-Rear Axle Radius Rod
3. Forward-Rear Axle
4. Rearmost Axle Radius Rod
5. Rearmost Axle

Fig. 1, Tandem Axle, Shown Out of Alignment

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 3/16-inch (4.5 mm) thickness of washers, and the difference in the center-point bar measurements is 1/4 inch (6 mm) less on that side, add an additional 1/4 inch (6 mm) of washers — for a total of 7/16 inch (10.5 mm) — to correct the alignment.

    Or, if one end of the axle was equipped with a 1/4-inch (6 mm) thickness of washers, and the difference in center-point bar measurements is 3/16 inch (4.5 mm) more on that side, install a 1/16-inch (1.6 mm) thickness of washers in place of the 1/4-inch (6 mm) 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 (184)
Axle U-Bolt High Nuts	7/8–14	C	Stage 1: Hand tighten Stage 2: 100 (136) † Stage 3: 200 (270) † Stage 4: 300 (407) † Stage 5: 420 (569) †
Radius Rod Locknut *	5/8–18	C	135 (184)
Equalizer Cap and Tube Assembly Locknut *	3/4–16	C	270 (356)
Equalizer Wear Shoe Capscrew	5/8–11	8	135 (184)
Side-Restraint Sleeve Locknut	1/2–13	C	68 (93)

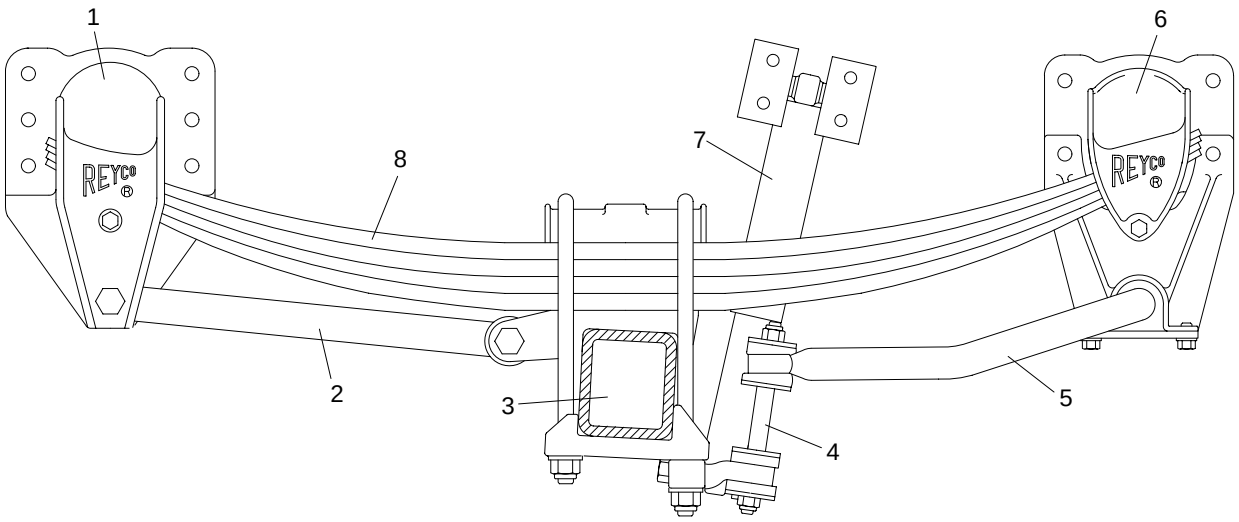
* Cadmium-plated, wax-coated nuts, and grade 8 hexbolts with phosphate- and oil-coated threads; both used with hardened washers.

† Tighten in a diagonal pattern.

Table 1, Torque Values

General Information (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

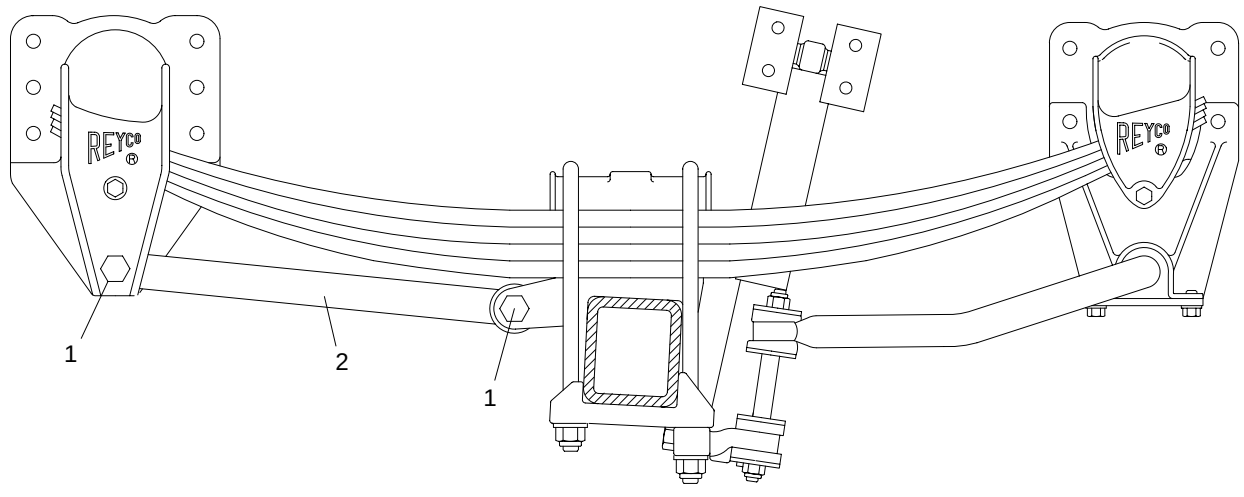
Removal (See Fig. 1)

There are two torque rods installed on the Reyco 79KB suspension. The curb (right) side torque rod is not adjustable (rigid). The left 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**.

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.
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 400 to 450 lbf·ft (540 to 610 N·m).
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**.



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1. Torque Rod Bolt
2. Torque Rod

Fig. 1, Reyco 79KB Torque Rod

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.

⚠ WARNING

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 parking 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** in this manual for instructions.
3. Remove the U-bolt locknuts and washers (**Fig. 1**). Remove the U-bolt mounting plate (**Fig. 1**). Remove the U-bolts (**Fig. 1**), and the upper axle mounting plate (**Fig. 1**).
4. Remove the spring retaining bolts (**Fig. 1**), spring rollers, and nuts.
5. Use a pry tool to lift the leaf spring assembly off of the lower mounting plate. See **Fig. 1**.

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 locknuts. Tighten the locknuts in a diagonal pattern. Tighten 3/4-inch locknuts 300 to 325 lbf·ft (405 to 440 N·m). Tighten 7/8-inch locknuts 400 to 450 lbf·ft (540 to 610 N·m).
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. See **Fig. 1**
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** in this manual 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.

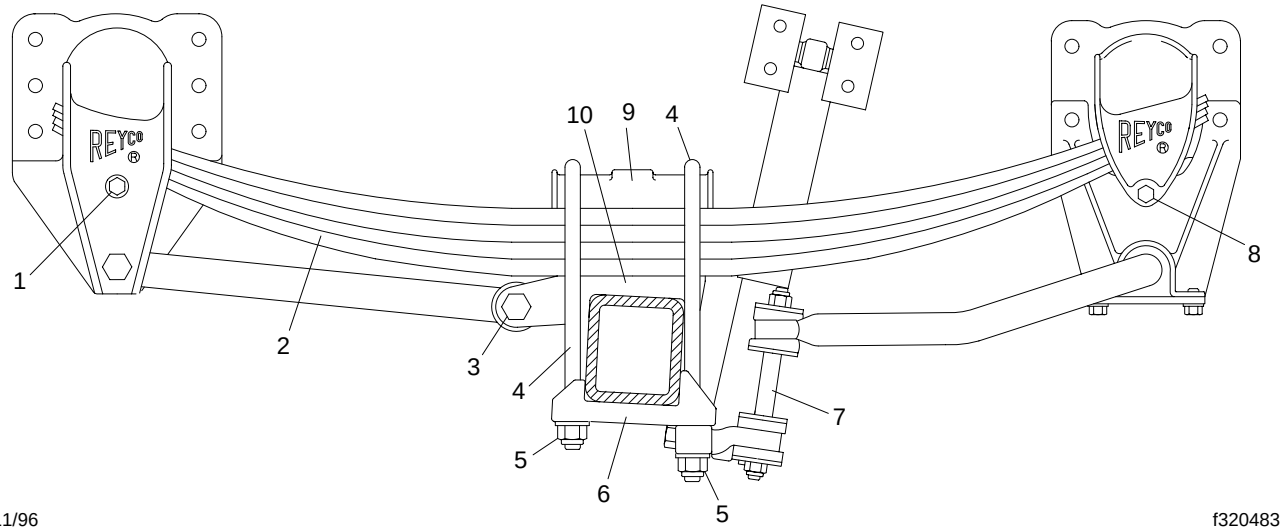
⚠ CAUTION

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, see Group 32 in the vehicle 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 Locknut
6. Axle Clamp
7. Anti–Sway Bar End Link (optional)
8. Rear Hanger Spring Retainer Bolt
9. U-Bolt Pad
10. Spring Seat

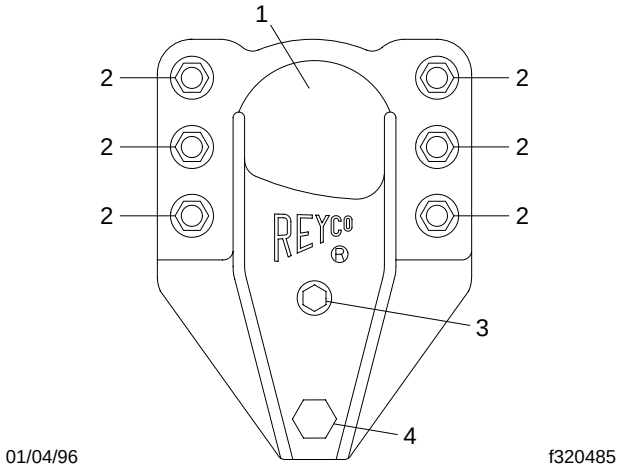
Fig. 1, Reyco 79KB Leaf Spring Replacement

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.

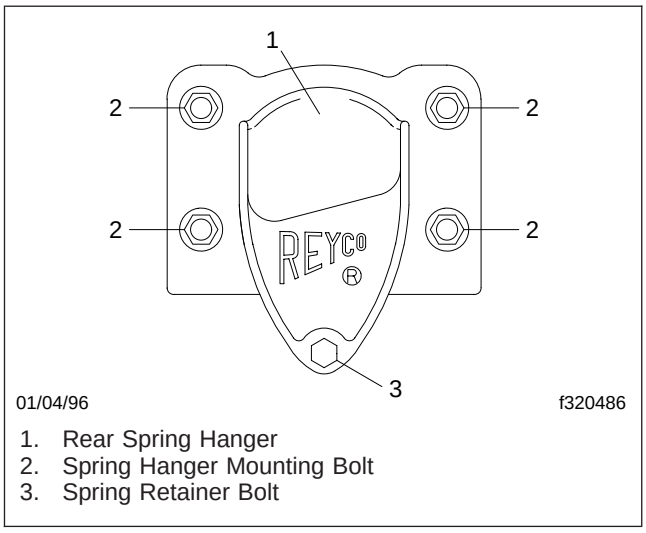
1. Park the vehicle on a level surface. Apply the spring or driveline brakes, and chock the front tires.
2. Place a lifting device under the vehicle frame. Lift the frame until the leaf spring assemblies are no longer in contact with the hangers, and support the frame with safety stands.
3. Remove the torque rod mounting bolt located on the forward hanger. See **Fig. 1**.



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**.
5. Remove the six hanger mounting bolts and nuts. See **Fig. 1**.
6. Remove the forward hanger from the frame rail.
7. Remove the spring retainer bolt from the rear hanger. See **Fig. 2**.



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**.
9. Remove the lower spring hanger mounting bolts (**Fig. 2**) and remove the anti-sway bar mounting bracket, if equipped. See **Fig. 3**.
10. Remove the upper spring hanger mounting bolts (**Fig. 2**) and remove the rear hanger.

⚠ CAUTION

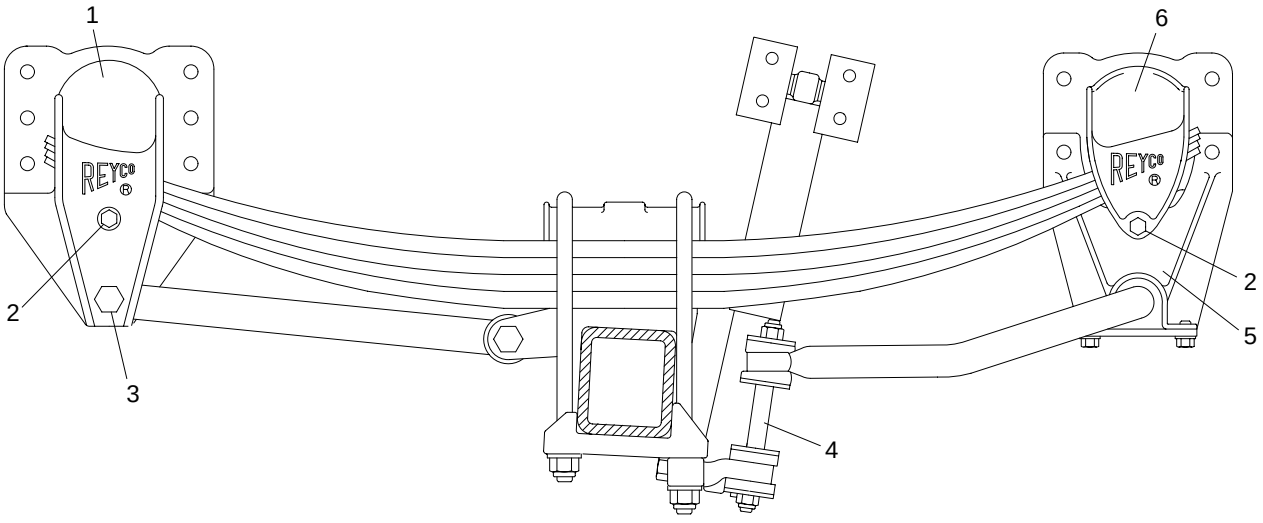
Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see Group 32 in the vehicle maintenance manual.

Installation

1. Install the rear spring hanger on the frame rail, then install the two upper mounting bolts.
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).

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

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 in the vehicle maintenance manual.

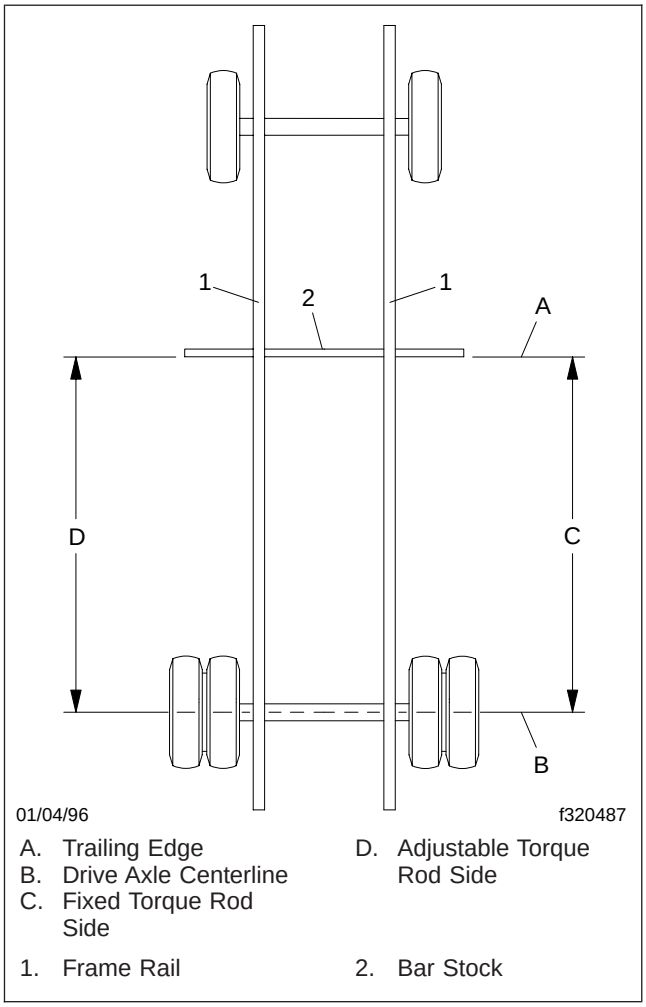
1. Park the vehicle on a level surface. Move the vehicle slowly back and forth several times without using the brakes to free all of the suspension joints. Shut down the engine. Do not apply the spring, or driveline brakes.
2. Chock the front tires.

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 8 foot (2-1/2 m) 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**.

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**.
5. If the distance varies more than 1/8-inch, alignment is necessary.
6. Loosen the torque rod clamp bolts. See **Fig. 2**.
7. Use a pipe wrench or other suitable tool and slowly turn the torque rod.
8. Turn until the measurement on both sides of the axle are within 1/8-inch, then tighten the torque rod clamp bolts 125 to 150 lbf·ft (170 to 203 N·m).

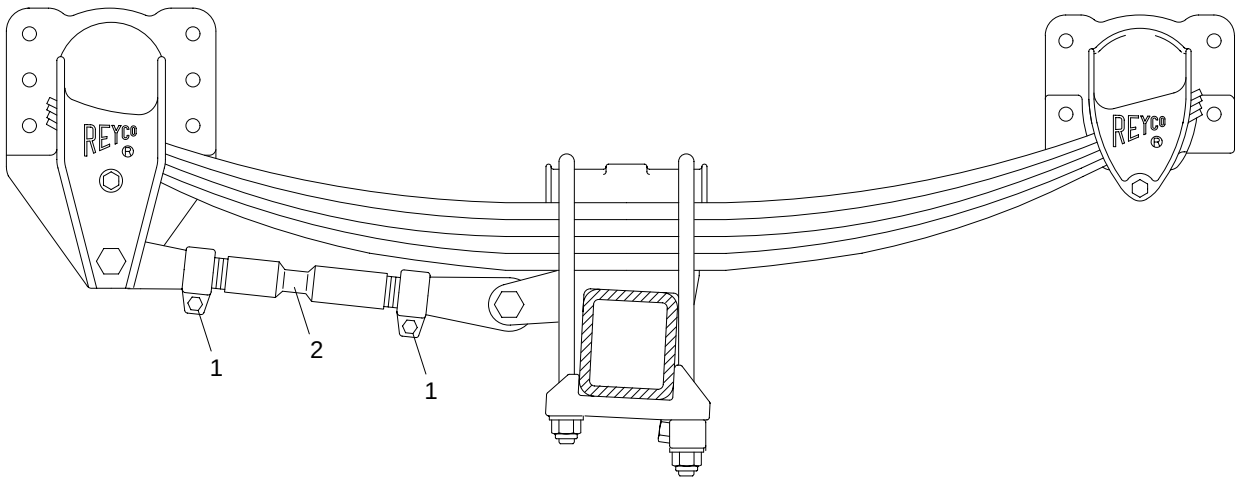


A. Trailing Edge
B. Drive Axle Centerline
C. Fixed Torque Rod Side
D. Adjustable Torque Rod Side
1. Frame Rail
2. Bar Stock

Fig. 1, Measuring Axle Alignment

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 inch**	**Torque lbf·ft (N·m)**
Forward Spring Hanger	5/8	190 (258)
Rear Spring Hanger	5/8	190 (258)
Axle U-Bolt Nuts	3/4	300 to 325 (405 to 440)
	7/8	400 to 450 (545 to 615)
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)

Table 1, Reyco 79KB Torque Values

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 **Group 32**, **Group 33**, or **Group 35**.
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 **Troubleshooting, 300**.

⚠ WARNING

Use safety stands to securely support all of the wheel and frame weight during suspension repairs. Unsecured components may drop when the fasteners are loosened or removed, causing serious personal injury and component damage.

5. Remove the safety stands from under the frame and axle, then lower the vehicle. Perform the remedies in **Troubleshooting, 300**.

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 **Group 32**, **Group 33**, and **Group 35**.
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**.
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.

Troubleshooting Tables

Problem—Harmonic Ride, Tires Off the Ground

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 **Group 40**.
Bent, distorted, or out-of-round brake drums or hubs are causing a rough ride.	Replace damaged components using the instructions in **Group 33** or **Group 35**.
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 **Group 40**.
Worn or distorted rim spacers are causing an out-of-round assembly.	Replace damaged spacers using the instructions in **Group 40**.
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, see **Group 40**.
The driveshaft is bent or imbalanced.	Balance or replace the driveshaft, as necessary. **Problem-Harmonic Ride, Tires Off the Ground**

Problem—Harmonic Ride, Tires On the Ground

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-Harmonic Ride, Tires On the Ground**

Problem—Harsh Ride, Tires Off the Ground

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, see the applicable front suspension section in **Group 32** of this manual. **Problem-Harsh Ride, Tires Off the Ground**

Problem—Harsh Ride, Tires On the Ground

Problem—Harsh Ride, Tires On the Ground	
Possible Cause	**Remedy**
The tires are improperly inflated.	Adjust the tire pressure using the instructions in Group 40 of the maintenance manual.

Troubleshooting

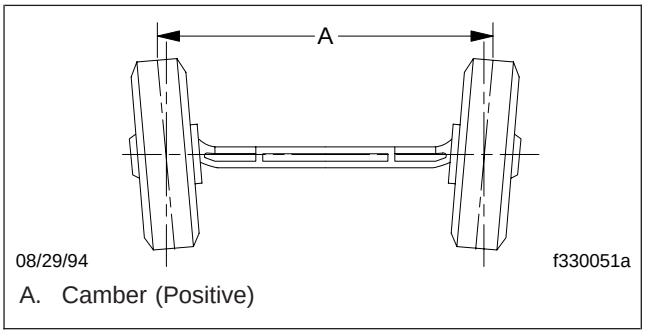
Problem—Harsh Ride, Tires On the Ground	
Possible Cause	**Remedy**
The frame is bottoming out against the suspension.	Check the suspension for weak or damaged springs or components. Inspect the springs for "gull-winging" when the vehicle is loaded. Replace the spring assembly, as necessary, using the instructions in **Group 32**.
	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 **Group 32**.
The vehicle normal loaded weight is markedly below the spring load capacity.	Customers should contact a Cargo dealer for the correct application of a lower rated spring. Replace the spring assembly using the instructions in **Group 32**.
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 Cargo dealer for shackle angle corrective measures. See **Group 32** 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. **Problem-Harsh Ride, Tires On the Ground**

General Description

Correct front axle wheel alignment is needed to ensure long tire life, ease of handling, and steering stability.

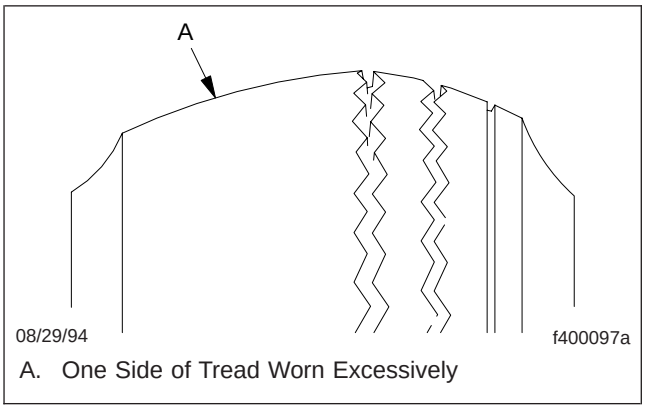
Three factors are involved in wheel alignment: camber angle, caster angle, and wheel toe-in.

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**.



A. Camber (Positive)

Fig. 1, Camber Angle



A. One Side of Tread Worn Excessively

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**.

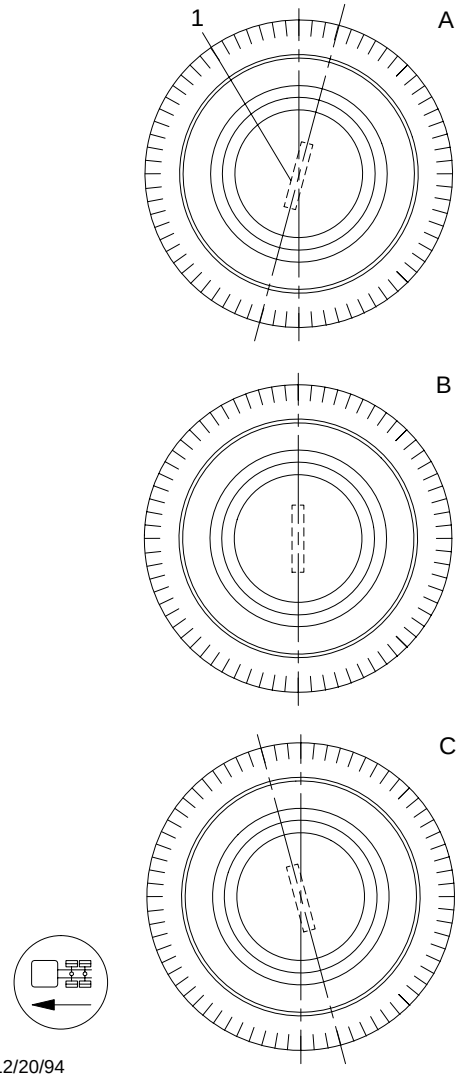
Advanced wear patterns can be seen, but less severe wear patterns are detected only by rubbing the palm of your hand flat across the tire tread.

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: see **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, see Group 40 of the vehicle maintenance manual.

General Information

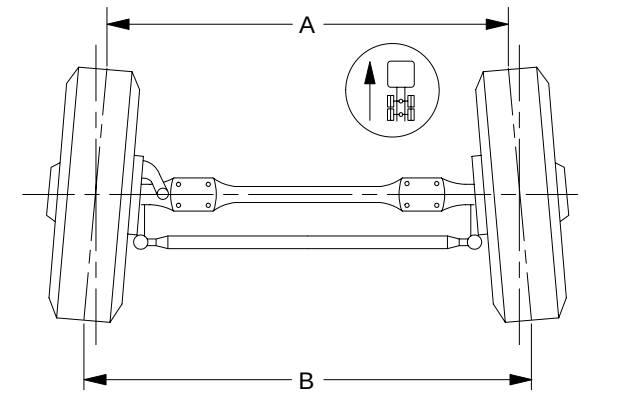


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A. Positive Caster
B. Zero Caster
C. Negative Caster

1. Knuckle Pin (Kingpin)

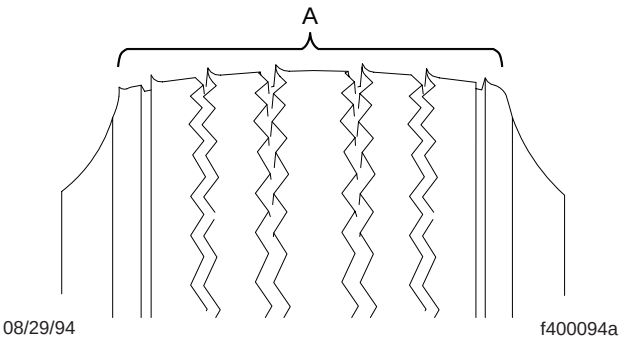
Fig. 3, Caster Angle



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NOTE: B minus A equals Toe-in.

Fig. 4, Wheel Toe-In (overhead view)



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A. Feathered Edge

Fig. 5, Tire Damage Due to Excessive Toe-In or Incorrect Drive Axle Alignment

Preliminary Checks

Precision instruments and equipment are needed for accurately measuring and adjusting wheel alignment. See the operating instructions provided by the wheel alignment equipment manufacturer.

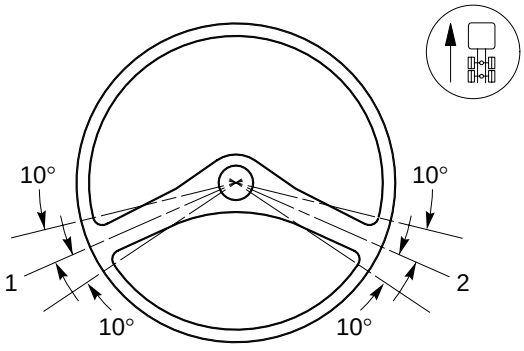
Before checking or correcting wheel alignment, make sure the vehicle is at curb weight. Curb weight is the weight of the unloaded vehicle complete with accessories and full fuel tanks.

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.



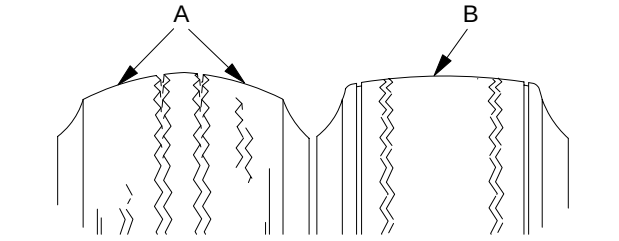
1. 8 o'clock 2. 4 o'clock

Fig. 1, Steering Wheel Position

If there are any problems, see **Troubleshooting 300**.

1. Steering axle wheel assemblies should be balanced, especially for vehicles that travel at sustained speeds of more than 50 mph (80 km/h). 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. See **Group 40** 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. See **Group 40** 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. See **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 **Group 32**.
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 **Group 46**.
8. Check the steering angle, and adjust the axle steering stops, as needed.

Preliminary Checks



A. Underinflation Wear: Shoulder Wear
B. Overinflation Wear: Center Tread Wear

Fig. 2, Tire Damage Due to Underinflated or Overinflated Tires

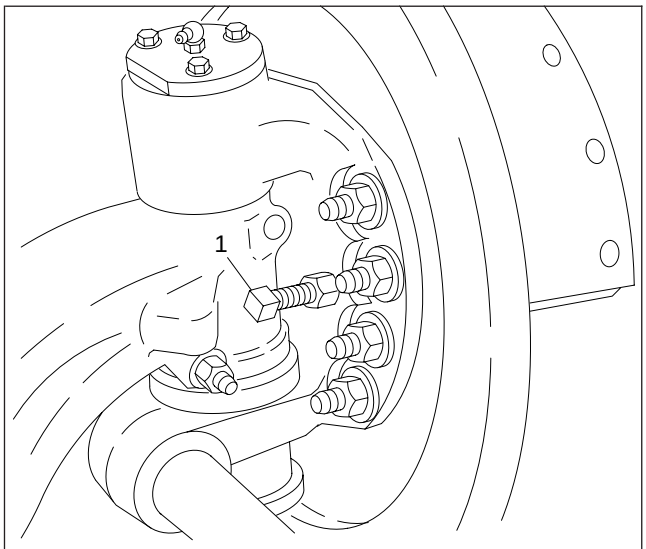
Checking and Adjusting

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. 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 **Group 46**. 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, Front Axle Stops

   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, see the steering gear section in **Group 46**.
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

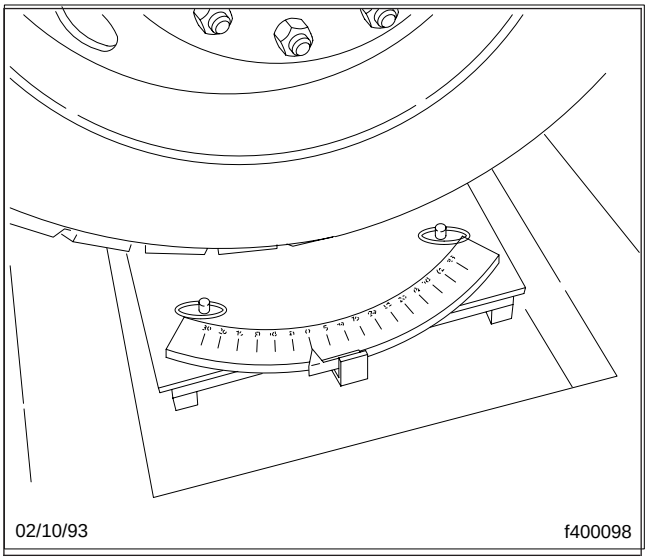
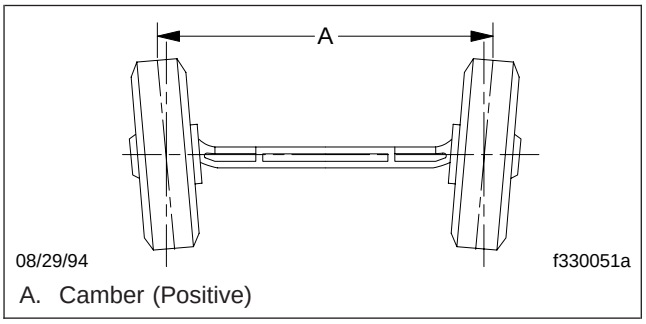


Fig. 2, Turn-Plate (Turntable), Stationary Type

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. 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 **Section 33.01**. If needed, replace or adjust the bearings.
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

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. Dealers must have proof of this calibration history.

Using the alignment equipment manufacturer's operating instructions, measure the front wheel caster.

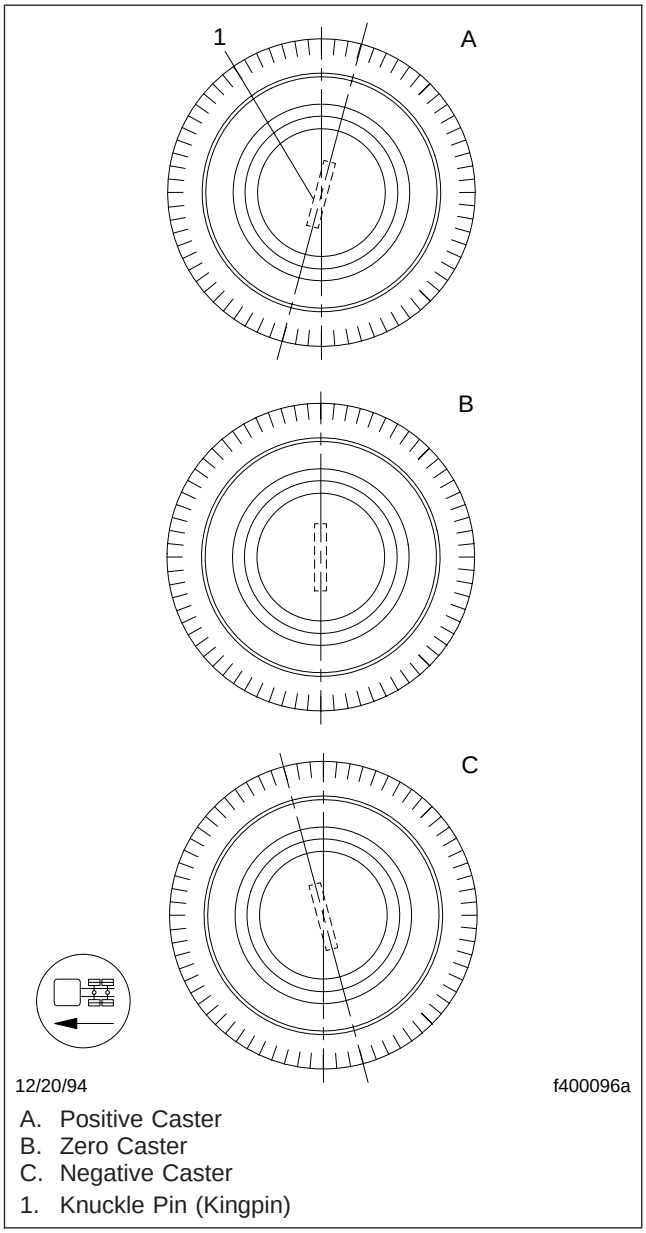
Compare the caster angles with those shown in the applicable table in **Specifications 400**. If needed, adjust the caster angle by placing wedge-shaped shims between the axle spacer and the axle beam, as follows (see **Fig. 2**):

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**.

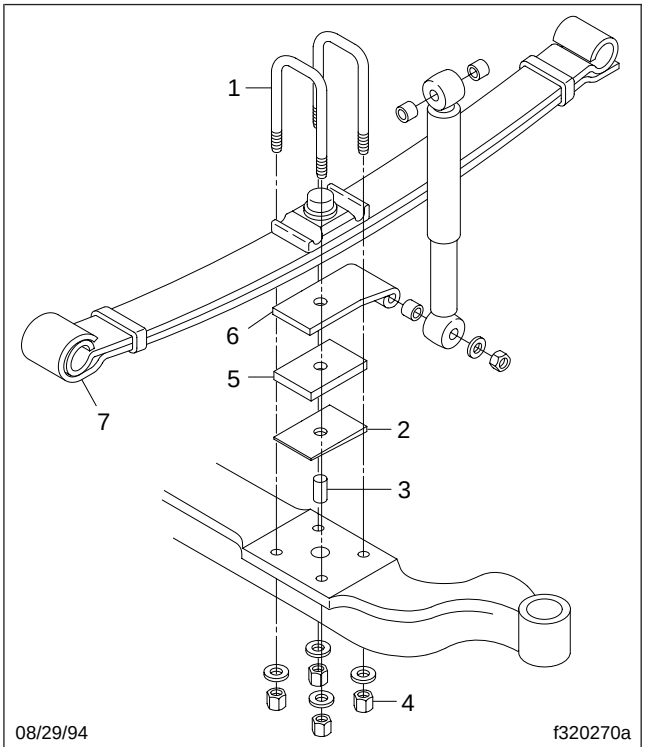


A. Positive Caster
B. Zero Caster
C. Negative Caster
1. Knuckle Pin (Kingpin)

Fig. 1, Caster Angle

U-bolt high nuts need periodic retightening. See 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, Adjustment Shim Placement

⚠ 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. 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 six feet (two meters).

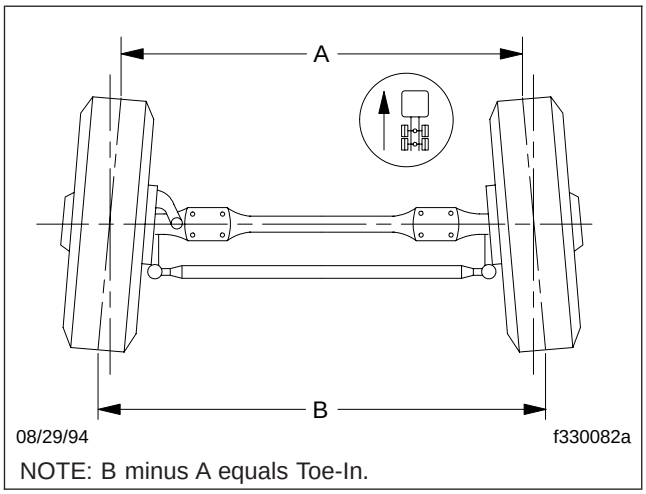


Fig. 1, Wheel Toe-In (overhead view)

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 six feet (two meters). 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

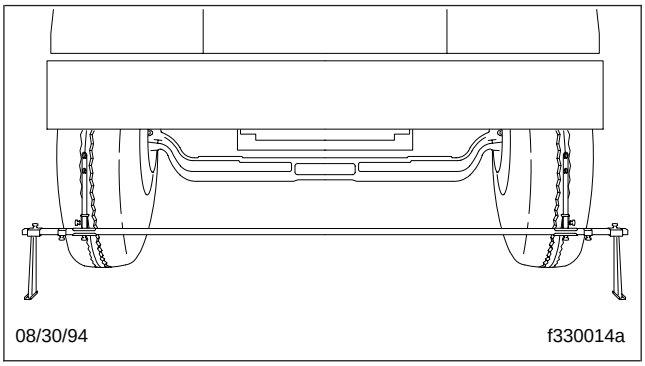


Fig. 2, Trammel Bar Positioning

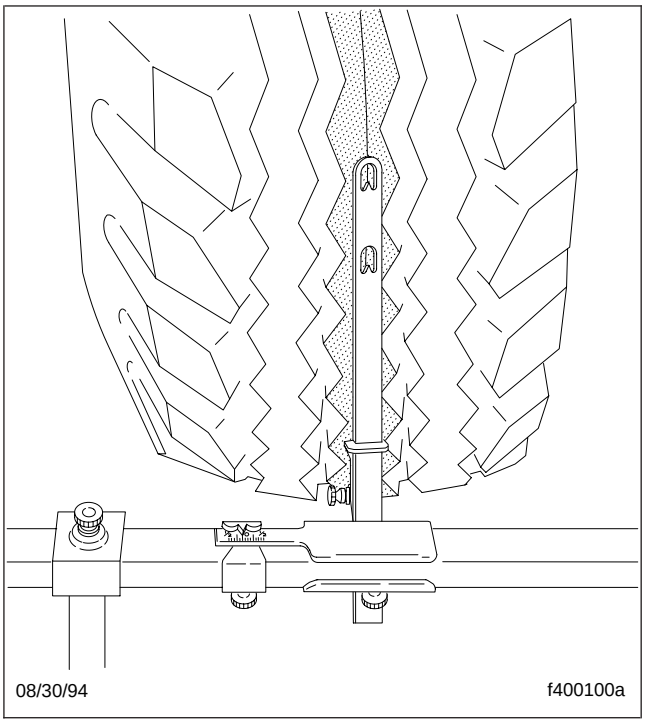


Fig. 3, Calculating Wheel Toe-In

Troubleshooting Tables

Service instructions for most of the remedies below are found by referring to the index in the back of this manual. For axles, see the service literature provided by either Meritor or Eaton Corporation. For tire inflation pressures, see **Group 40** in this manual. For more steering system troubleshooting information, see **Group 46** 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, see **Group 46** in 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, see **Group 32** 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, see **Group 32** 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, see **Group 32** 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, see **Group 46** 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. Refer to **Section 35.00**, Specifications 400.

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-961 FC-965 FD-965	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)

* 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–961, FC–965, FD–965	5/8–11	40–60 (54–81)	40–60 (54–81)
Meritor	FF–961, FC–965, FD–965	5/8–18	40–60 (54–81)	40–55 (54–75)

* All torque values in this table apply to parts lightly coated with rust-preventive type oil.

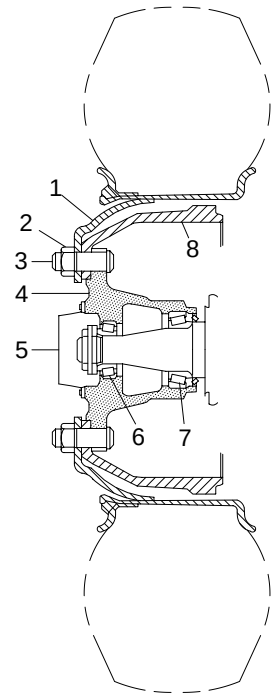
Table 3, Tie Rod Clamp Nut Torque Values

Miscellaneous Torque Values	
Description	**Torque lbf·ft (N·m)**
U-Bolt Nuts 7/8–14	400 (542)
Meritor Stopscrew Locknut	50–65 (68–88)

Table 4, Miscellaneous Torque Values

General Description

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**.



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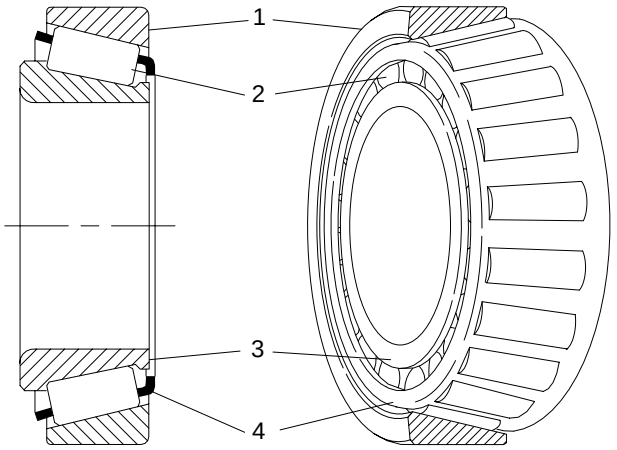
1. Disc Wheel
2. Wheel Nut
3. Wheel Stud
4. Hub
5. Hub Cap
6. Outer Wheel Bearing
7. Inner Wheel Bearing
8. Brake Drum

Fig. 1, Disc Wheel Assembly with Drum Brakes

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**.



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1. Cup
2. Tapered Roller
3. Cone
4. Roller Cage

Fig. 2, Wheel Bearing

WHEEL HUB

The wheel and the brake drum or rotor are mounted on a steel or iron wheel hub (**Fig. 4**).

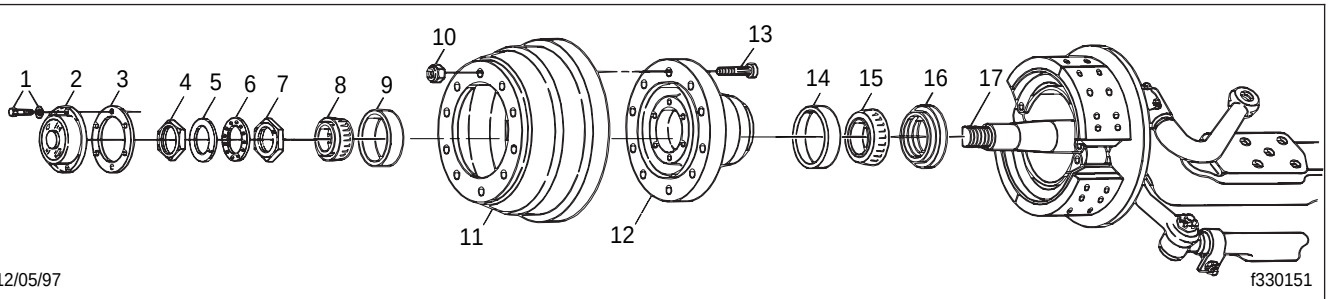
Both the inner and outer wheel bearing cups and the wheel studs are press-fit in the hub.

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.

General Information



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 (Steering Knuckle)

Fig. 3, Disc Wheel, Hub, and Outboard-Mounted Drum Assembly

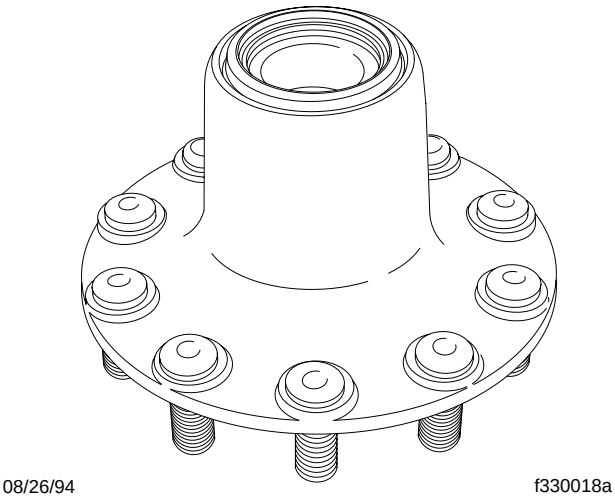
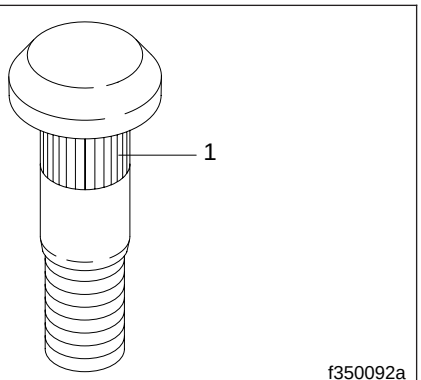


Fig. 4, Front Axle Wheel Hub



1. Serrations

Fig. 5, Wheel Stud

Hub Assembly Removal and Installation, Disc Wheels

Removal

1. Apply the parking brake, and chock the rear tires.
2. Raise the front of the vehicle until the tires clear the ground, then place safety stands under the axle.
3. Remove the wheel and tire assembly. See **Group 40** for instructions.

⚠ WARNING

Breathing brake lining dust (with, or without 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.

4. Use an OSHA-approved cleaning system to clean the dust from the brake drum, brake backing plate, and brake assembly. Do not use compressed air or dry brushing to remove brake dust; either method can disperse potentially harmful material around the area.
5. Remove the brake drum. 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.

6. Remove the capscrews, washers, and hub cap. Remove and discard the hub cap gasket.
7. Remove the axle spindle jam nut, lockwasher, and lockring or cotter pin. See **Fig. 1**, **Fig. 2**, or **Fig. 3**.
8. Back off the wheel bearing adjusting nut about two turns, or enough to allow the weight of the hub to be lifted from the wheel bearings.
9. Lift the hub until all weight is removed from the wheel bearings, and remove the 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.

10. 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, and be careful not to damage the axle spindle threads.
11. Carefully remove the outer wheel bearing. Handle the bearing assembly with clean, dry hands; wrap all bearing assembly parts in clean oil-proof paper or lint-free rags.

⚠ CAUTION

Do not spin the bearing rollers. Dirt or grit can scratch their surfaces and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.

12. Remove the hub from the axle spindle. Be careful not to damage the axle spindle threads as the assembly is removed.
13. Remove the oil or grease seal from the hub with a seal removal tool.
14. Remove the inner wheel bearing from the hub. Handle the bearing assembly with clean, dry hands or gloves.

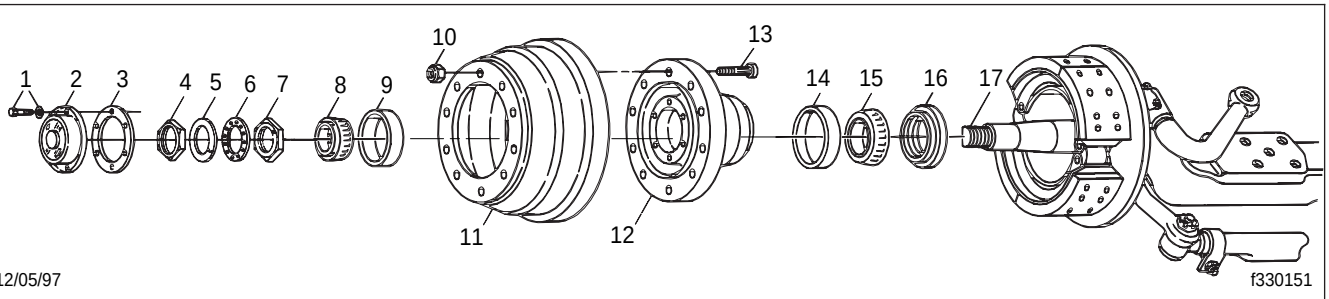
    If the bearing is not easy to remove, place a protective cushion to catch it. Then, use a hardwood drift and a light hammer to tap the bearing (and seal, if needed) gently out of the cup. Wrap all bearing assembly parts in clean, oil-proof paper or lint-free rags.

IMPORTANT: Be careful when cleaning the wheel hub cavity and axle spindle. Dirt, metal filings, or other debris can scratch the bearing roller surfaces, and rapidly wear the bearing assembly.

15. Using an emery cloth or file, remove all burrs from the hub shoulder. See **Fig. 4** or **Fig. 5**.

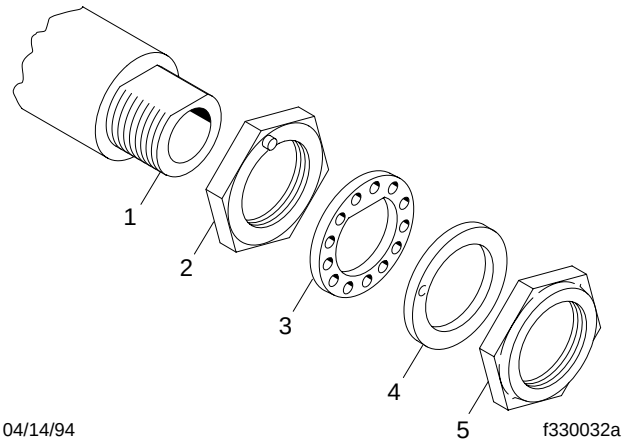
    Clean any metal filings from the parts. For instructions, see **Subject 110**.

Hub Assembly Removal and Installation, Disc Wheels



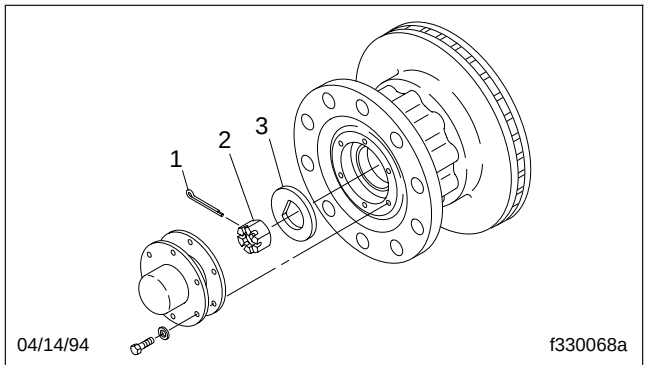
1. Hub Cap Capscrew and Washer
2. Hub Cap
3. Hub Cap Gasket
4. Jam Nut
5. Lockwasher
6. Lockring
7. Wheel Bearing Adjusting Nut
8. Outer Wheel Bearing
9. Outer Wheel Bearing Cup
10. Wheel Nut
11. Brake Drum, Outboard-Mounted
12. Wheel Hub
13. Wheel Stud
14. Inner Wheel Bearing Cup
15. Inner Wheel Bearing
16. Oil Seal
17. Axle Spindle

Fig. 1, Wheel Hub and Outboard-Mounted Drum Assembly



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 Brake Disc

Installation

⚠ WARNING

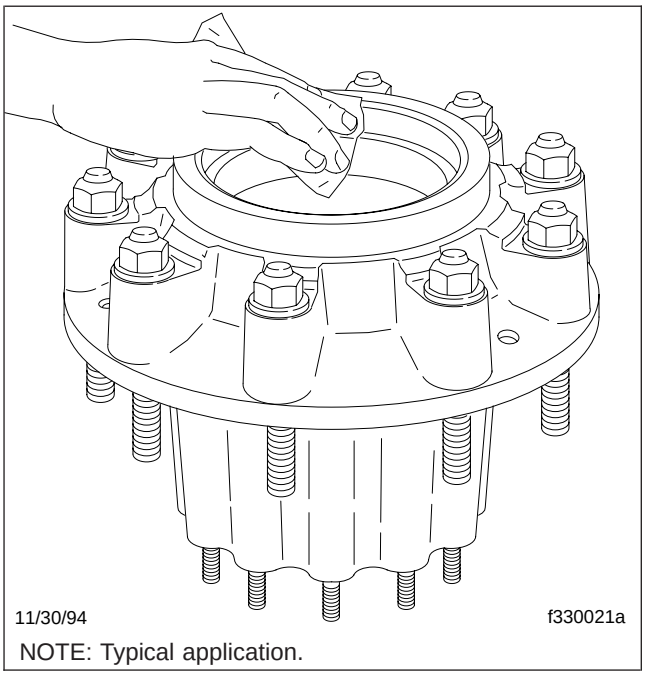
Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels for exposure, and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, continuing through installation of the wheels.

1. Using clean solvent, remove the old oil 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.

⚠ CAUTION

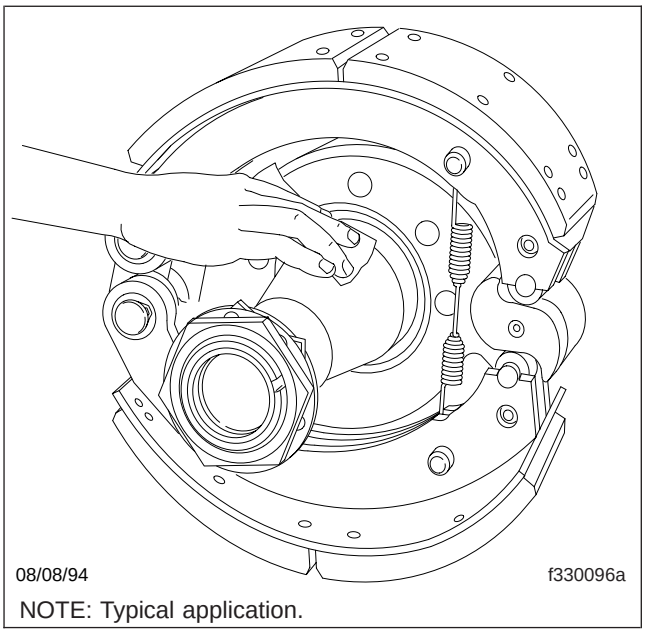
Make sure that both bearing assemblies are coated with fresh oil. Use only fresh oil on the bearing assemblies; old oil could be contaminated with dirt or water (both are corrosives) and

Hub Assembly Removal and Installation, Disc Wheels



NOTE: Typical application.

Fig. 4, Cleaning the Hub Shoulder



NOTE: Typical application.

Fig. 5, Cleaning the Spindle

could cause damage to both wheel bearing assemblies and the wheel hub.

3. 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 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**.

   Install the inner wheel bearing and oil or grease seal. Handle the bearing assembly with clean, dry hands or gloves.

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 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.

   5.2 Insert the centering plug of the tool in the bore of the inner bearing cone. See **Fig. 7**. The plug keeps the seal from cocking in the bore.

   5.3 Hold the tool handle firmly to avoid bounce or unseating of the seal from the adaptor. Strike the tool until the sound of the impact changes as the flange of the tool contacts the hub face. See **Fig. 8**.

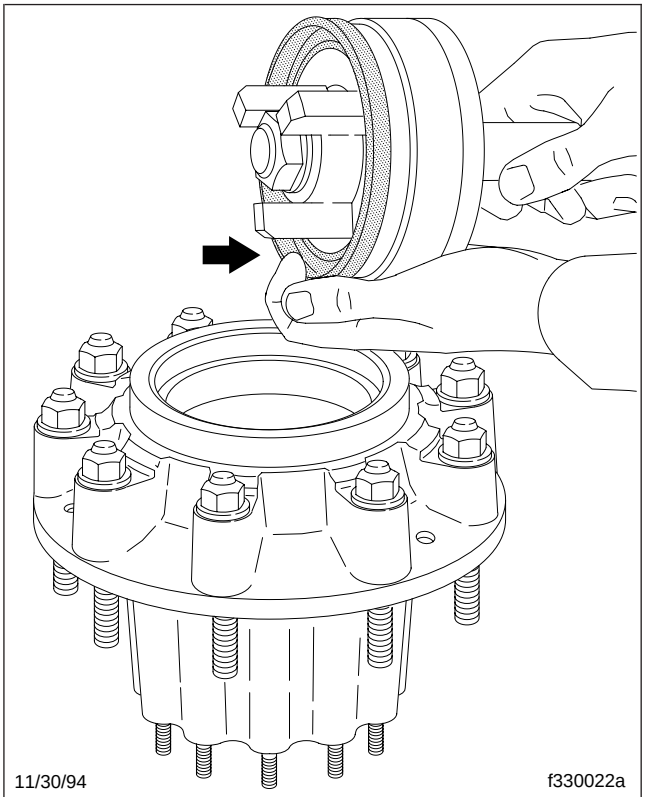
   5.4 After the seal is flush with the hub face, check for freedom of movement by manually moving the interior rubber part of the seal back and forth. Slight movement indicates a damage-free installation.

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 it is 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 while seating

Hub Assembly Removal and Installation, Disc Wheels



NOTE: Typical application.

Fig. 6, Seating the Seal on the Tool

it in the cup. Remove the tape from the axle spindle threads.

8. Install the wheel bearing adjusting nut. Tighten the nut finger-tight. Adjust the bearings (**Fig. 2** or **Fig. 3**).

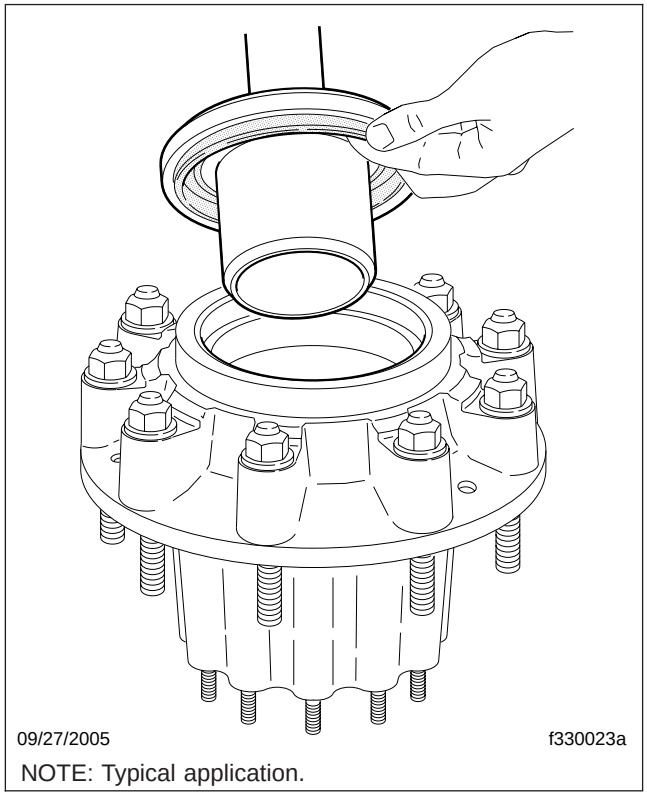
   IMPORTANT: Be sure there is sufficient clearance between the brake shoe and the brake drum, so brake shoe drag will not interfere with bearing adjustment.

   8.1 After the wheel hub and bearings are assembled on the spindle, tighten the inner (adjusting) nut 100 lbf·ft (135 N·m) while rotating the wheel hub assembly.

   8.2 Back off the inner nut one full turn.

   8.3 Tighten the inner nut 20 lbf·ft (25 N·m) while rotating the wheel hub assembly.

   8.4 Back off the inner nut one-third turn (two flats of the adjusting nut).



NOTE: Typical application.

Fig. 7, Inserting the Tool

   8.5 Install a new cotter pin (one lockring, see **Fig. 3**), or install the jam nut and locking device as follows.

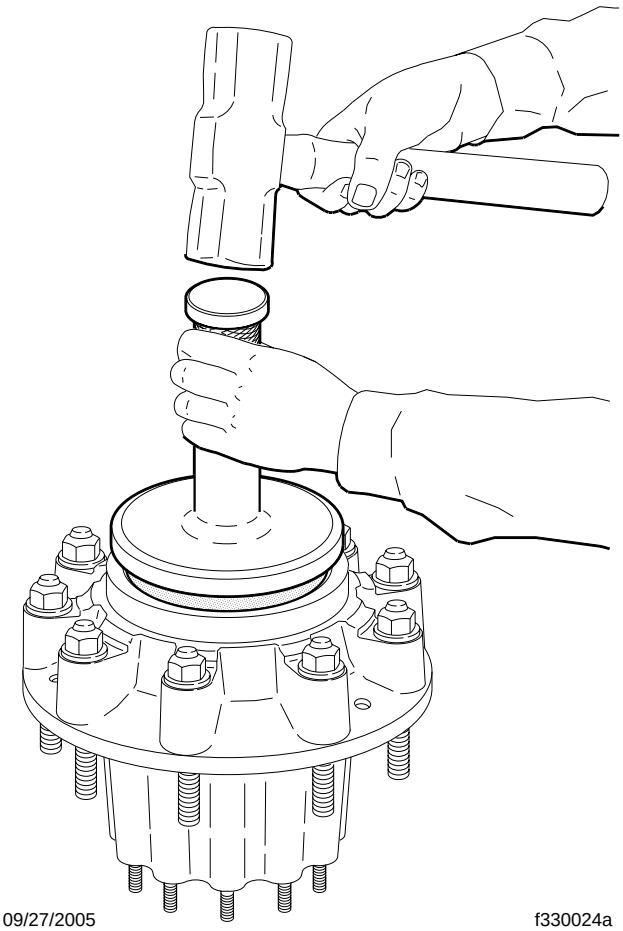
   NOTE: If you are securing the wheel bearings with a pierced lockring, but no hole in the lockring aligns with the dowel on the adjusting nut, remove the lockring, turn it over and install it again. If still no hole aligns with the dowel, loosen the adjusting nut, but only enough to align the dowel with the next available hole in the lockring.

   8.6 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 proper torque value from the table in **Specifications 400**.

Hub Assembly Removal and Installation, Disc Wheels



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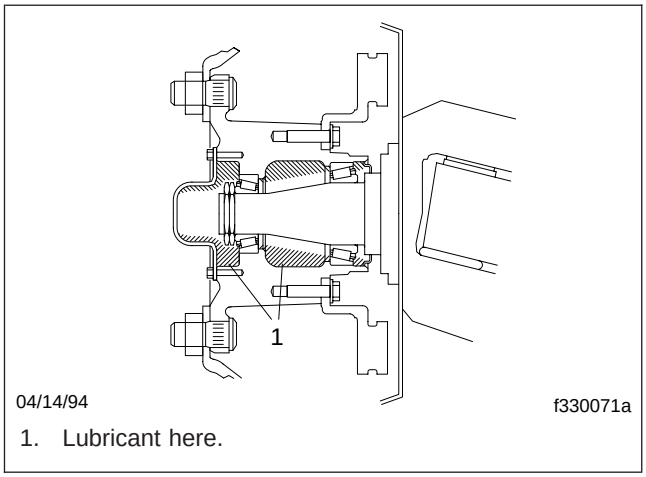
NOTE: Typical application.

Fig. 8, Striking the Tool

IMPORTANT: You cannot accurately adjust or measure bearing end play with the wheel mounted on the hub. Do not attempt to adjust the wheel bearings with the wheel mounted on the hub.

8.7 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.

If the hub is aluminum, 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. Secure the drum, beginning with the stud at the 12 o'clock position, then the studs at about the 4 o'clock and 8 o'clock positions.



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1. Lubricant here.

Fig. 9, Bearing Lubrication Areas

NOTE: If using a stud-piloted hub and a steel drum, install 1-1/4 inch washers between the nuts and the drum.

8.8 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 (and drum, if there is a drum) 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 there is a drum). 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 are using a nut-lock: turning the inner nut 1/4 turn will change the end play about 0.014 inch (0.355 mm).

Hub Assembly Removal and Installation, Disc Wheels

If you are 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 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. 9**.
13. Place the hub cap and a new gasket in position, then install the washers and capscrews. Tighten the capscrews to the proper value from the torque table in **Specifications 400**.

    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

Failure to add oil to the wheel hub after the hub has been serviced will cause the wheel bearings to overheat and seize during vehicle operation. See Fig. 10. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury due to loss of vehicle control.

14. Install the brake drum or caliper on the wheel hub. See **Group 42** for instructions.
15. Install the wheel and tire assembly. See **Group 40** for instructions.

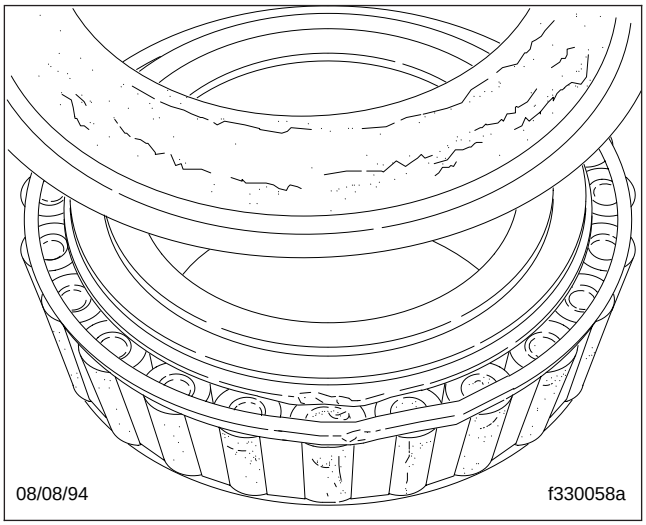


Fig. 10, Bearing Damage Resulting from Inadequate Lubrication

⚠ WARNING

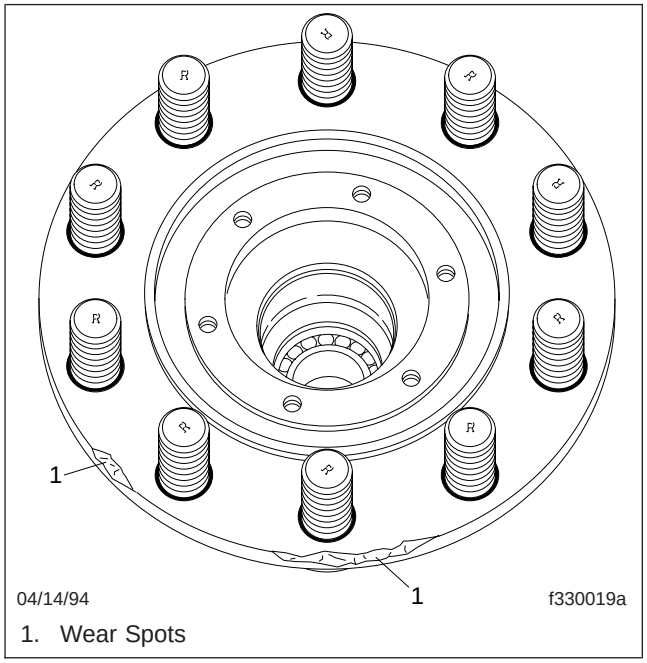
If the wheel nuts cannot be tightened to minimum torque values, the wheel studs may have lost their locking action, and the wheel hub flange is probably damaged. In this case, replace the hub with a new one. Failure to replace the wheel hub assembly when this condition exists could result in the loss of a wheel or loss of vehicle control, and possible personal injury.

16. Adjust the front axle brakes. For instructions, see **Group 42** in the *Cargo Maintenance Manual*.
17. Remove the safety stands from under the axle, and lower the vehicle.
18. 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

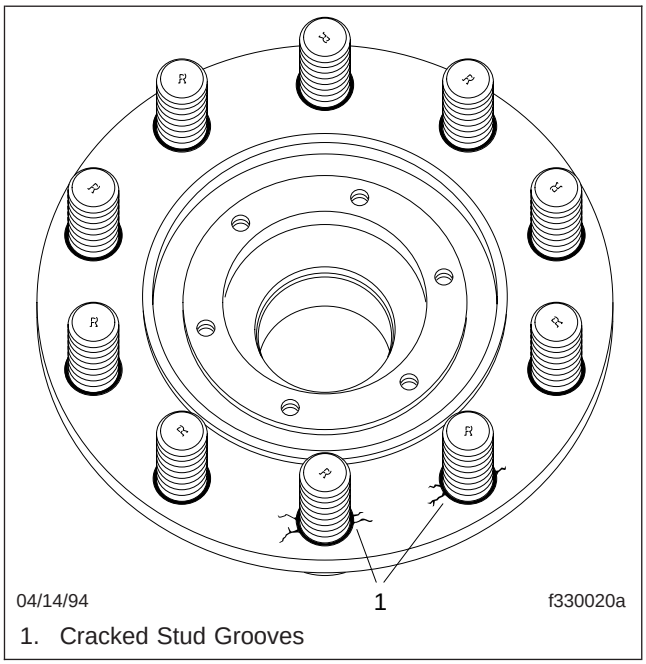
Fig. 1, Damaged Front Axle Wheel Hub

2. Remove all the old oil or grease from the 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. See **Subject 120**.

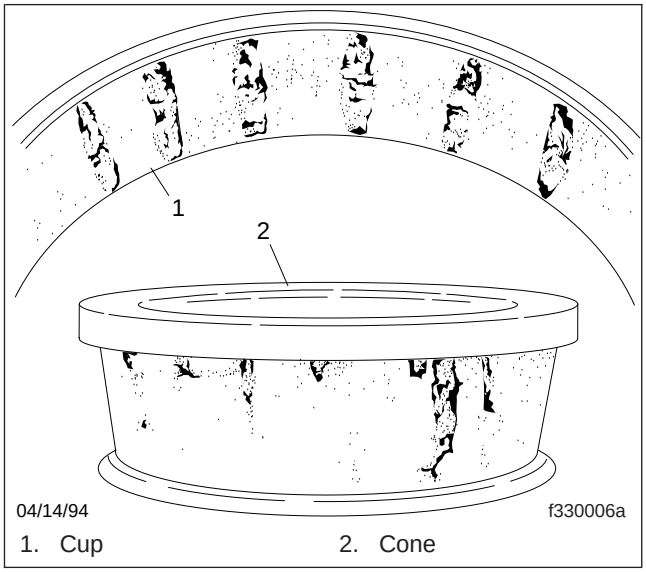
4. Inspect the wheel nuts on disc wheel installations. Damaged nuts (**Fig. 4**), usually caused by inadequate tightening, must be replaced with new ones.

5. Inspect the wheel studs or rim studs. Replace studs that are stripped, broken, bent, or otherwise damaged. See **Subject 130**.



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

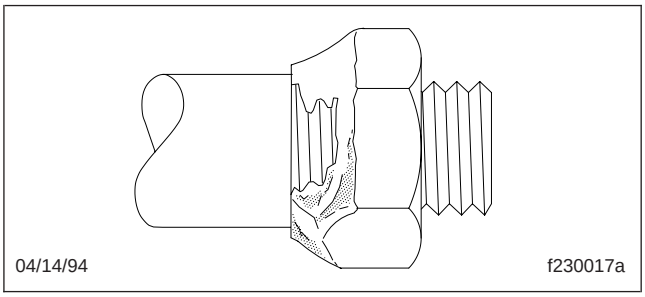


Fig. 4, Damaged Wheel Stud Nut

Wheel Bearing Cleaning and Inspection

CLEANING

⚠ 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 (**Fig. 5**). Before inspecting, clean the bearings, as described below.

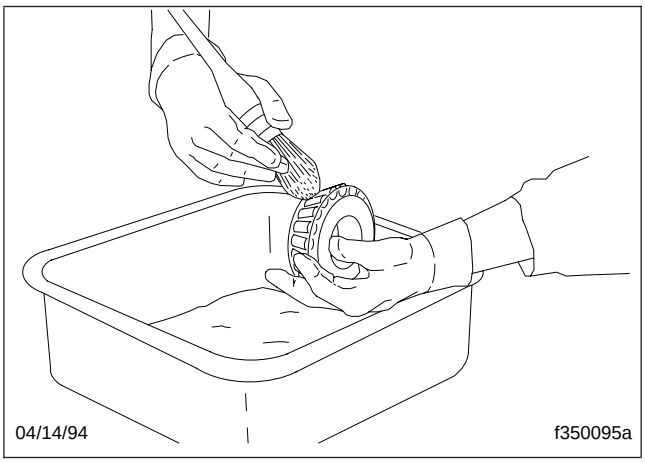


Fig. 5, Wheel Bearing Cleaning

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.
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**.

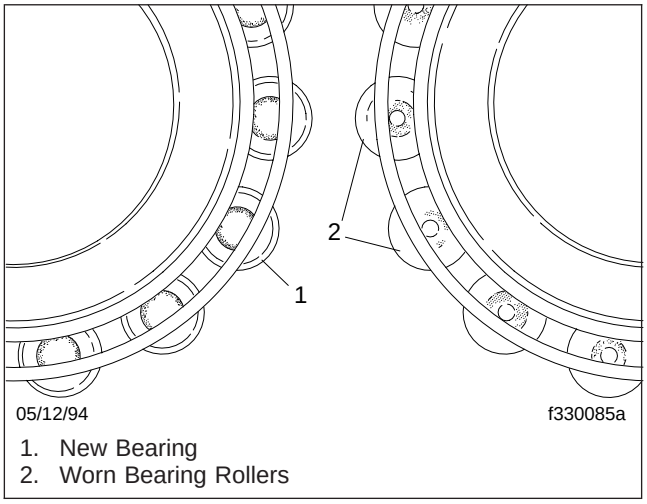


Fig. 6, Wheel Bearing Roller Wear

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.

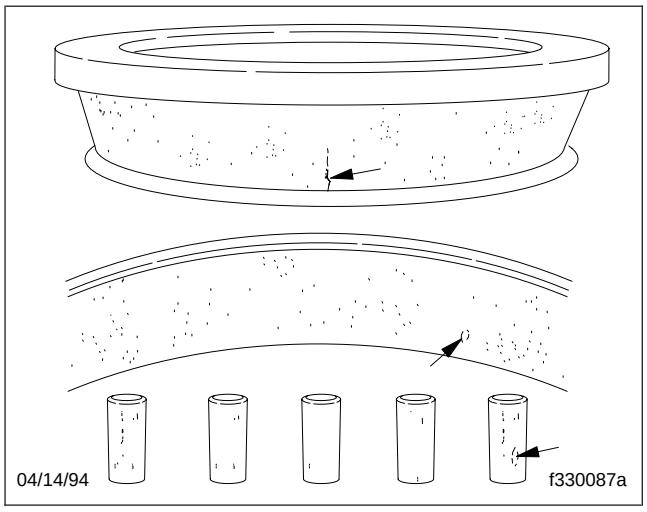


Fig. 7, Indentations, Cracks, or Breaks in Bearing Surfaces

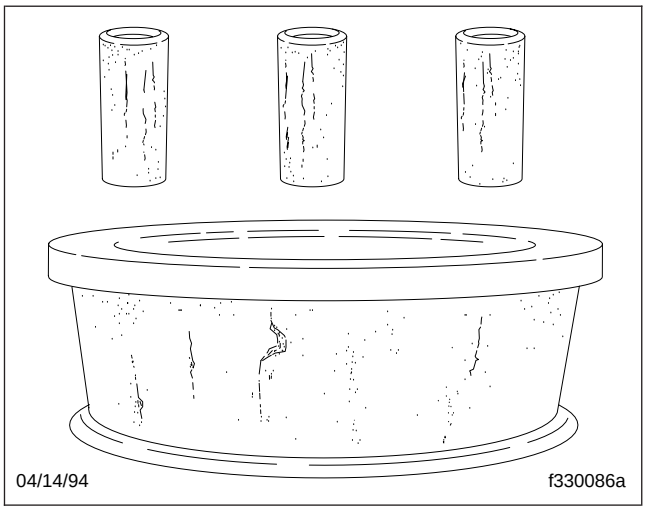


Fig. 9, Etching (Pitting) on Bearing Surfaces

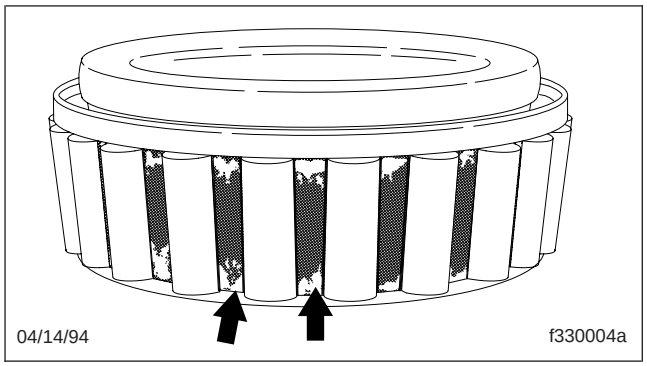


Fig. 8, Rubbing Marks on Bearing Cage

E. Etching or pitting on functioning surfaces. See **Fig. 9**.

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, see **Subject 100** or **Subject 120**.

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.

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.

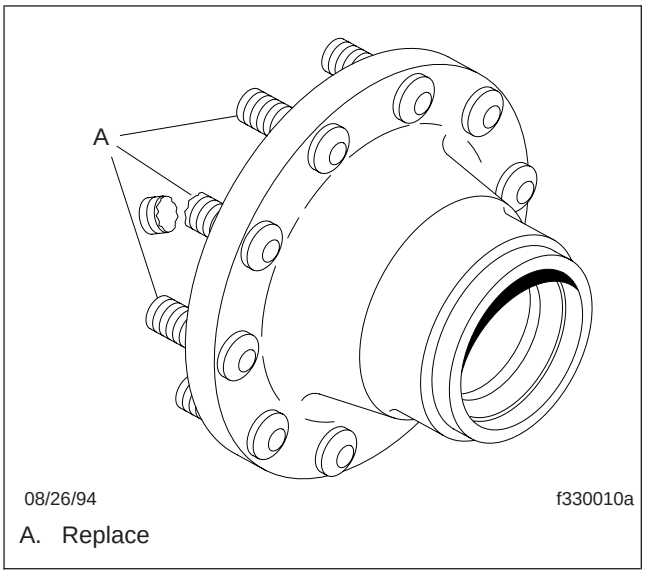
1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly, including the bearing cup bores.
2. Inspect the bearing cup bores of the hub for warpage or uneven surfaces. If a bearing cup bore is damaged, replace the wheel hub assembly.
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.
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

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, see **Subject 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.



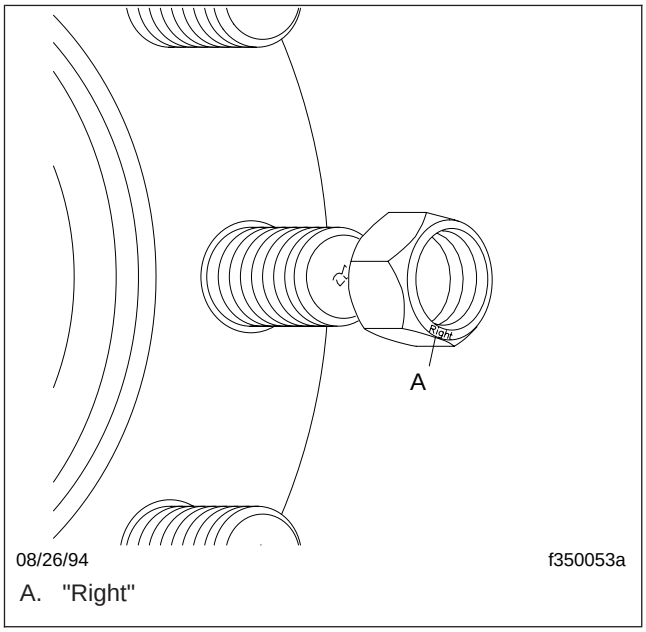
A. Replace

Fig. 1, Studs to Replace

⚠ 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.



A. "Right"

Fig. 2, Nut Threads

⚠ CAUTION

If headed studs with serrations are being installed, 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

Wheel Stud Replacement, Disc Wheels

must be stamped with an "L" (left-hand 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.

⚠ WARNING

Don't embed the wheel stud heads in the wheel hub. 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.

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, see **Subject 100**.

Troubleshooting Tables

Problem—Noisy Bearings or Excessive Bearing Replacement Intervals

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, see **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** 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, see **Specifications 400**.

Problem—Broken Wheel or Rim Studs

Problem—Broken Wheel or Rim Studs	
Possible Cause	**Remedy**
The wheel or rim nuts were overtightened.	Replace the wheel or rim studs. See **Group 40** in this manual for the wheel or rim nut tightening sequence.
An incorrect nut tightening sequence was used.	
The vehicle is being overloaded.	Do not exceed the maximum load-carrying capacity of the vehicle.

Problem—Damaged Hub

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 **Subject 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

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

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 (two flats of the adjusting nut).
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, Torque Values

Rockwell Axles with Oil-Lubricated Bearings		
Lubricant Type	**Viscosity Grade by Ambient Temperature**	
Hypoid Gear Oil API Service Classifications GL–5	SAE 85W–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, Rockwell Axles with Oil-Lubricated Bearings

Rockwell Axles with Grease-Lubricated Bearings	
Lubricant Type	**Grease Specification**
Lithium-Based Wheel Bearing Grease	Standard: 0–617A or equivalent Optional: 0–617B or equivalent

Table 3, 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.

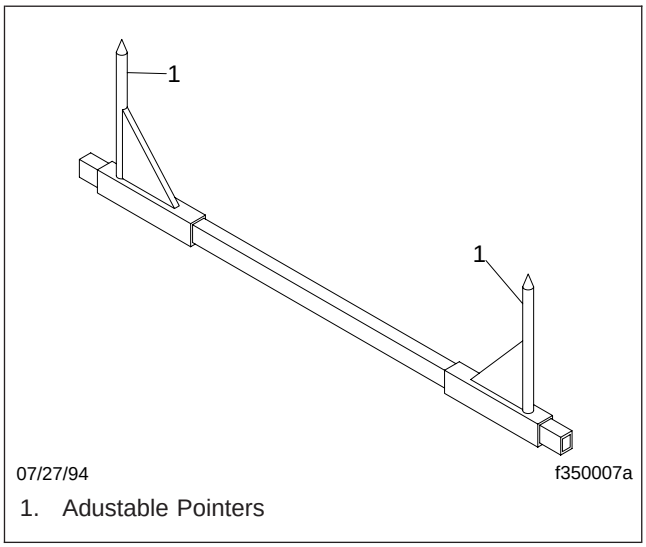
Manufacturers of axle alignment equipment offer a variety of systems to precisely measure and correct rear axle alignment. Alignment specifications for Hunter and Bee Line alignment equipment, and for manual measurement, are in **Specifications 400**.

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**.



1. Adustable Pointers

Fig. 1, Center Point Bar

Checking Thrust Angle (Perpendicularity)

NOTE: Before checking the axle alignment, make sure the wheel bearings are adjusted. For instructions, see 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 **Group 31** 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. 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

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 4 inches (102 mm) 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 4 inches (102 mm), 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.

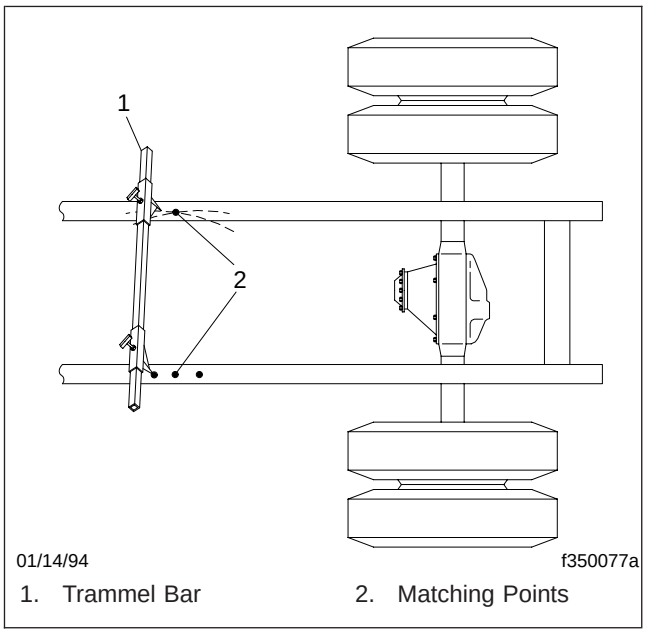


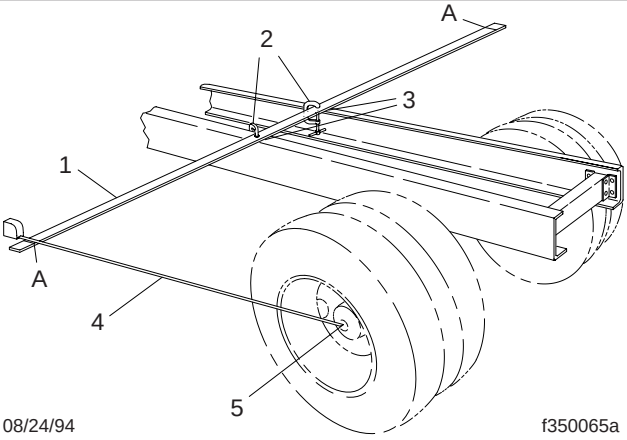
Fig. 1, Marking an Arc With the Trammel Bar

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 3/8 inch (9 mm) or less. If the difference is more

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

than 3/8 inch (9 mm), adjust the axle alignment. For instructions, see **Group 32** 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. 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.

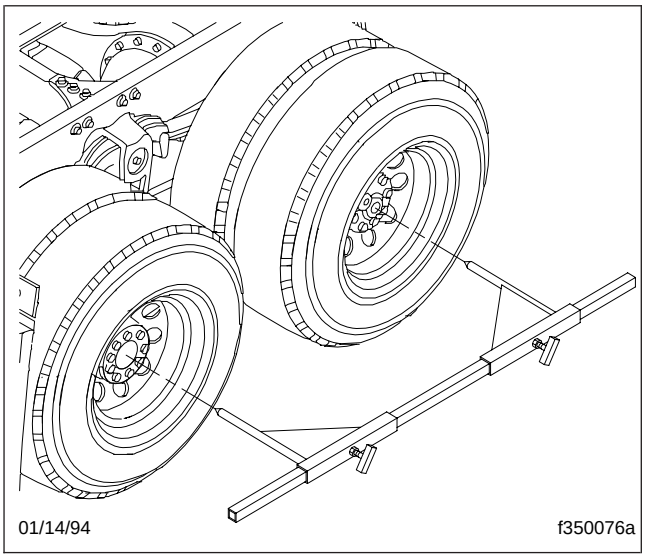
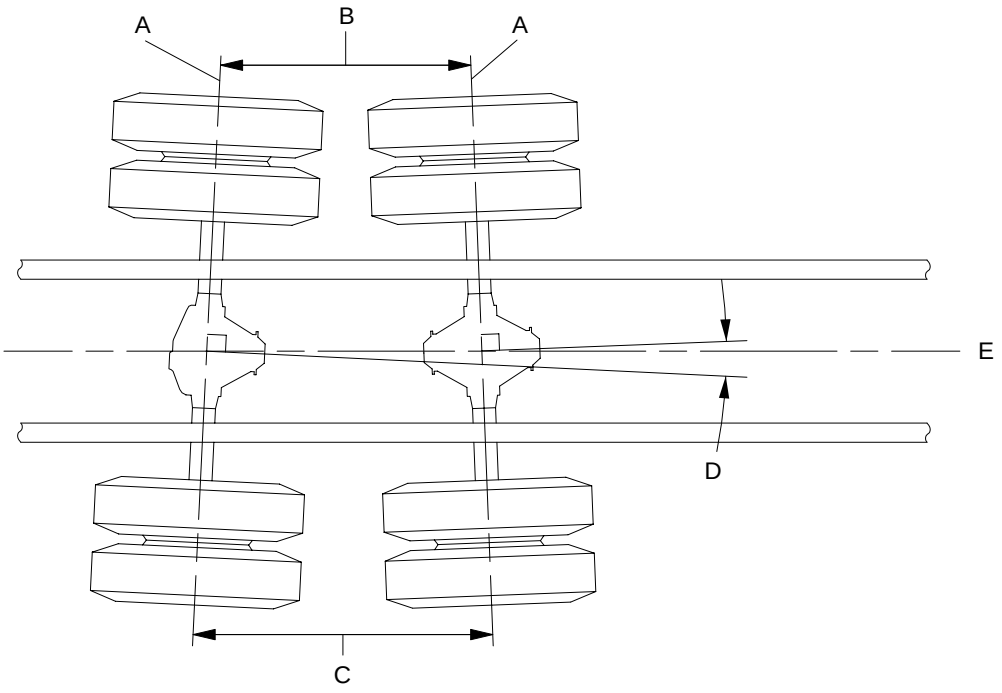


Fig. 1, Setting the Center Point Bar

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, see **Group 32** 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, Checking Tandem Axle Alignment

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

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

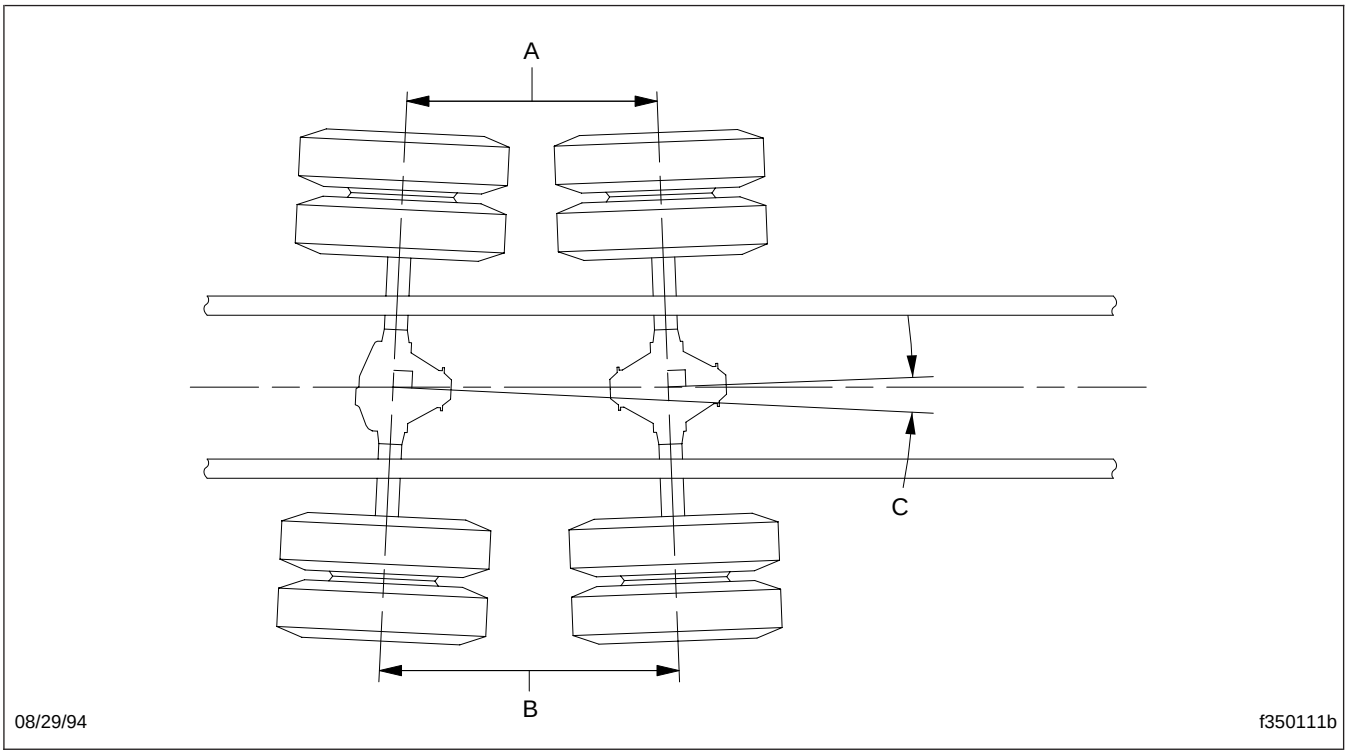
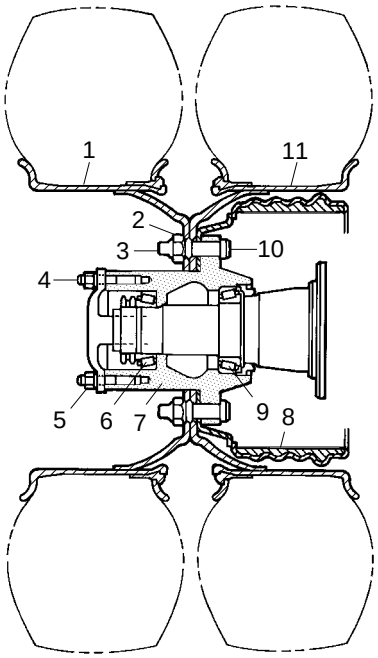


Fig. 1, Tandem Axle Measurements

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**.



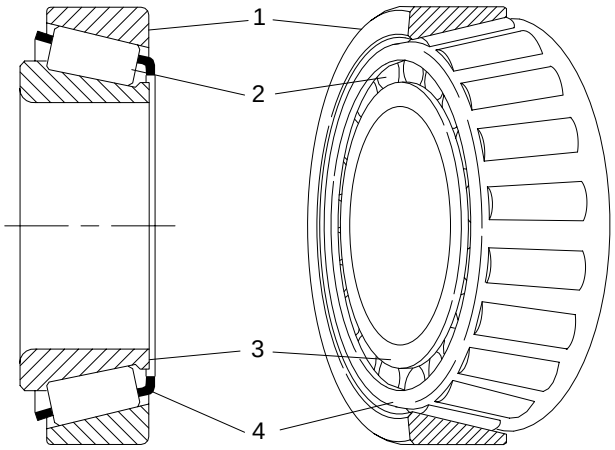
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1. Outer Wheel
2. Outer Wheel Nut
3. Wheel Stud
4. Drive Axle Stud
5. Drive Axle Stud Nut
6. Outer Wheel Bearing
7. Wheel Hub
8. Brake Drum
9. Inner Wheel Bearing
10. Wheel Stud Head
11. Inner Wheel

Fig. 1, Disc Wheel, Wheel Hub, and Brake Drum Assembly

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.

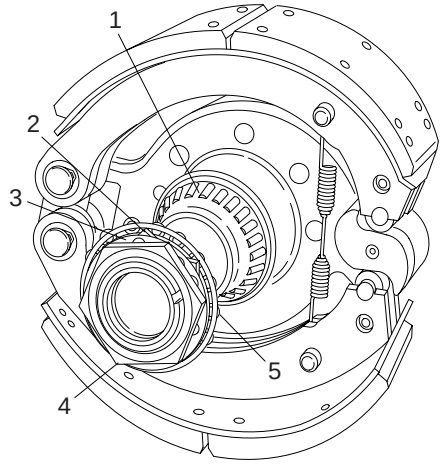


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1. Cup
2. Tapered Roller
3. Cone
4. Roller Cage

Fig. 2, Tapered Wheel Bearing Assembly

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**.



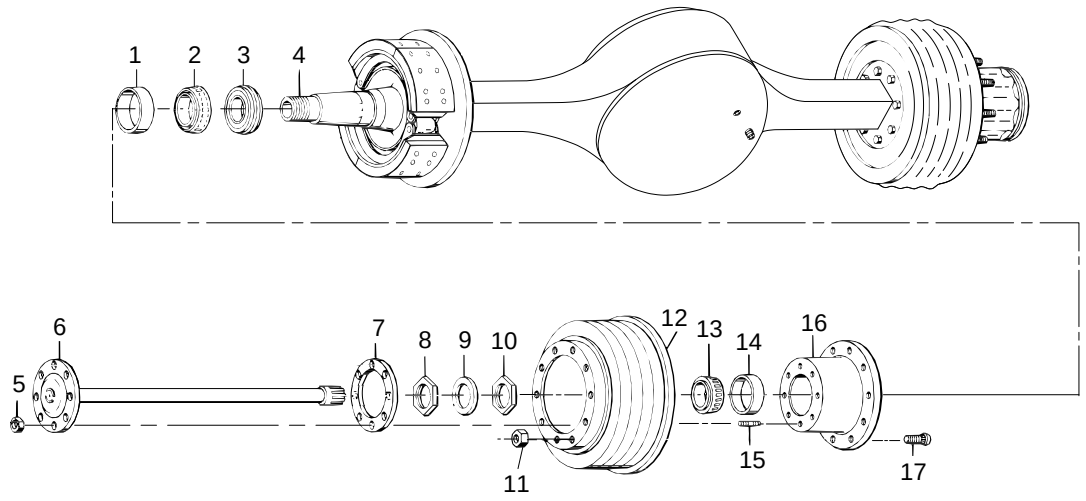
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1. Inner Wheel Bearing
2. Wheel Bearing Inner Adjusting Nut
3. Lockring
4. Axle Spindle Jam Nut
5. Outer Wheel Bearing

Fig. 3, Drive Axle Bearings and Spindle Assembly

DRIVE AXLE SPINDLE ASSEMBLY

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**).



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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. Brake Drum Nut
12. Brake Drum
13. Outer Wheel Bearing
14. Outer Wheel Bearing Cup
15. Drive Axle Stud
16. Wheel Hub
17. Wheel Stud

Fig. 4, Disc Wheel, Hub, and Drum Assembly

The surfaces of the spindle and the nut threads are machined. When these surfaces become damaged, repairs are necessary. There are standard methods for performing those repairs that preserve the proper alignment of the axle spindle assembly. See the axle manufacturer for instructions.

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**). 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**) 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

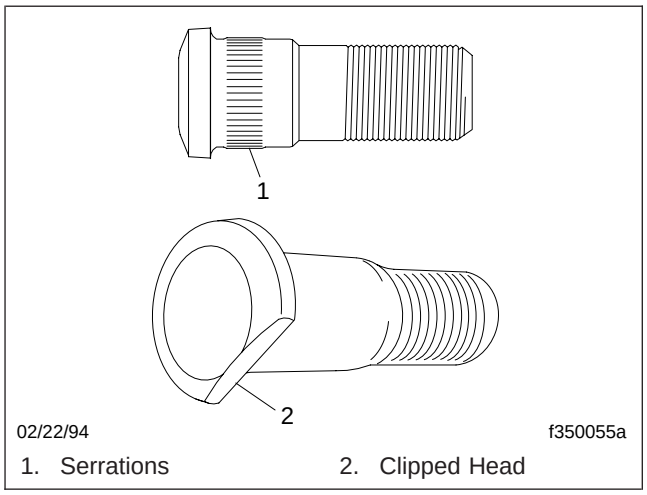
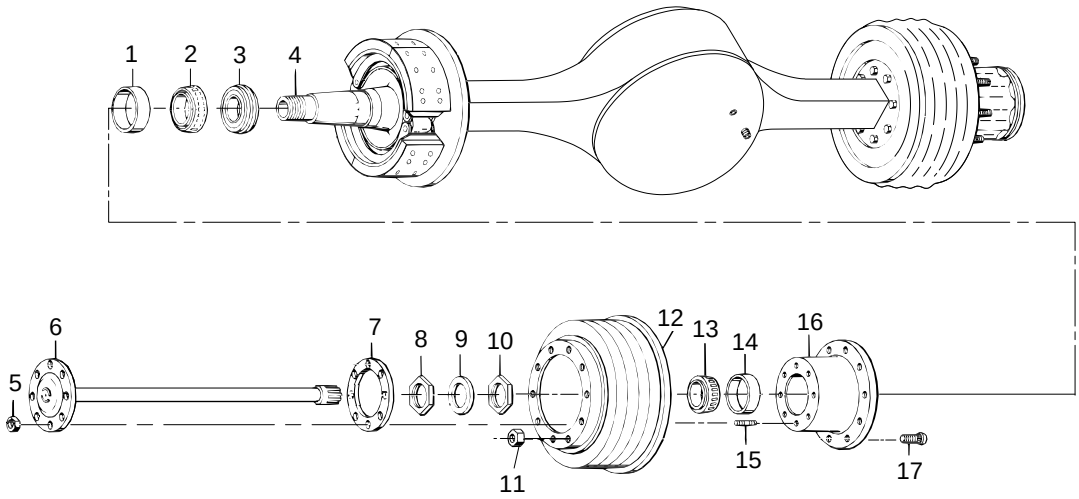


Fig. 5, Typical Headed Wheel Studs

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.

Hub Assembly Removal and Installation, Disc Wheels

Removal (See Fig. 1)



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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. Brake Drum Nut
12. Brake Drum
13. Outer Wheel Bearing
14. Outer Wheel Bearing Cup
15. Drive Axle Stud
16. Wheel Hub
17. Wheel Stud

Fig. 1, Disc Wheel, Hub, and Drum Assembly

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.
3. 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**.
4. Remove both wheel and tire assemblies. For instruction, see **Group 40**.

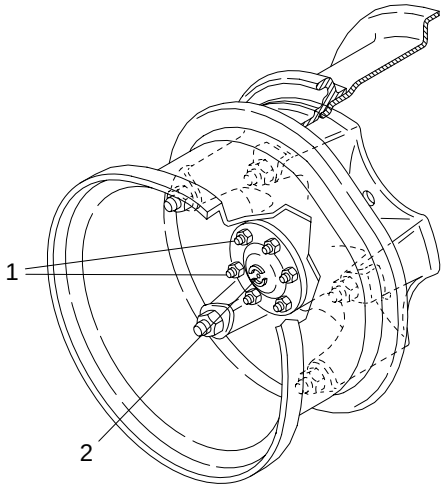
⚠ WARNING

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, starting with removal of the wheels and continuing through assembly.

5. On outboard drums, remove the brake drum. On disc brakes, remove the brake caliper; 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.
6. 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, which should later be safely discarded.
7. Remove the drive axle stud nuts and washers. See **Fig. 2**.

Hub Assembly Removal and Installation, Disc Wheels



1. Drive Axle Studs and Nuts
2. Center Portion of Drive Axle Flange

Fig. 2, Wheel Assembly and Hub

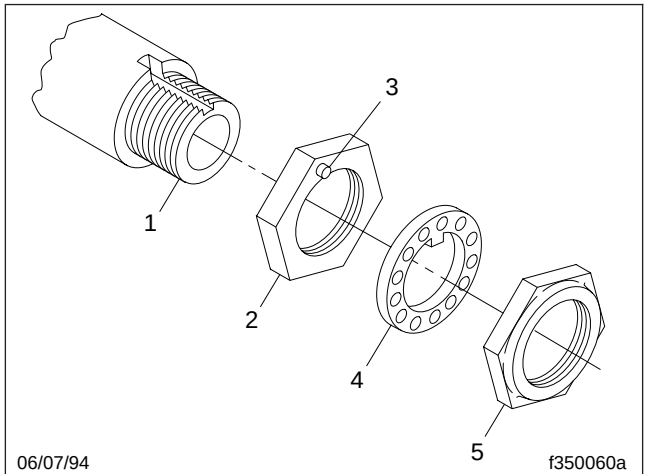
8. Using a hammer and a soft drift, such as one made of brass, sharply tap the center portion of the drive axle flange. See **Fig. 2**. The shaft will usually spring slightly outward after the seal has broken. Remove the drive axle shaft.

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 lockring 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.



1. Axle Spindle
2. Adjusting Nut
3. Pin
4. Pierced Lockring
5. Jam Nut

Fig. 3, Axle Secured With a Lockring

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. If the wheel bearing is dropped, cage warpage or roller damage can occur.

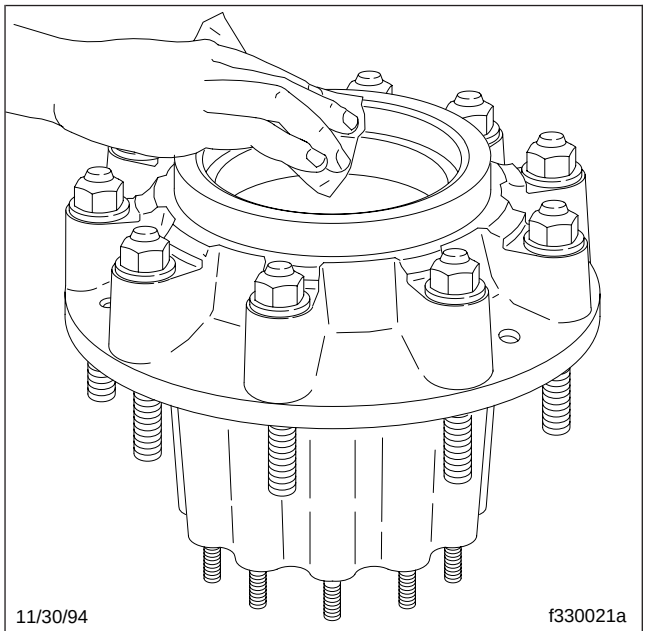
14. Move the hub about 1/2 inch (13 mm) to jar loose the outer wheel bearing (allow the hub-only assembly to rest on the axle spindle; be careful not to damage the axle spindle threads).
15. Carefully remove the outer wheel bearing; handle the bearings with clean, dry hands. Wrap them in either clean oil-proof paper or lint-free rags.

CAUTION

Don't 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. 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. Handle the bearings with clean, dry hands. Wrap them in either clean oil-proof paper or lint-free rags.
19. 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.

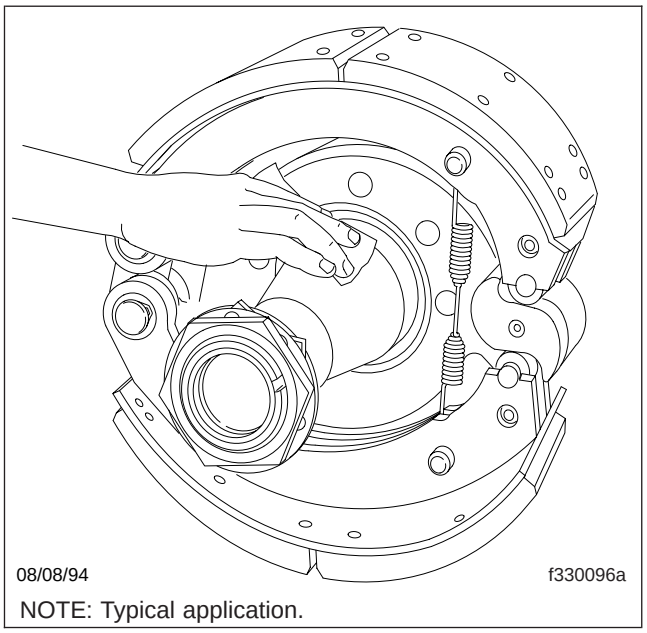


NOTE: Typical application.

Fig. 4, Clean the Hub Shoulder

IMPORTANT: Use extreme care in cleaning the wheel hub cavity and axle. Dirt, metal filings, or other debris can scratch the bearing roller surfaces, and cause premature wear of the bearing assembly.

20. Go to **Subject 110**.



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**.

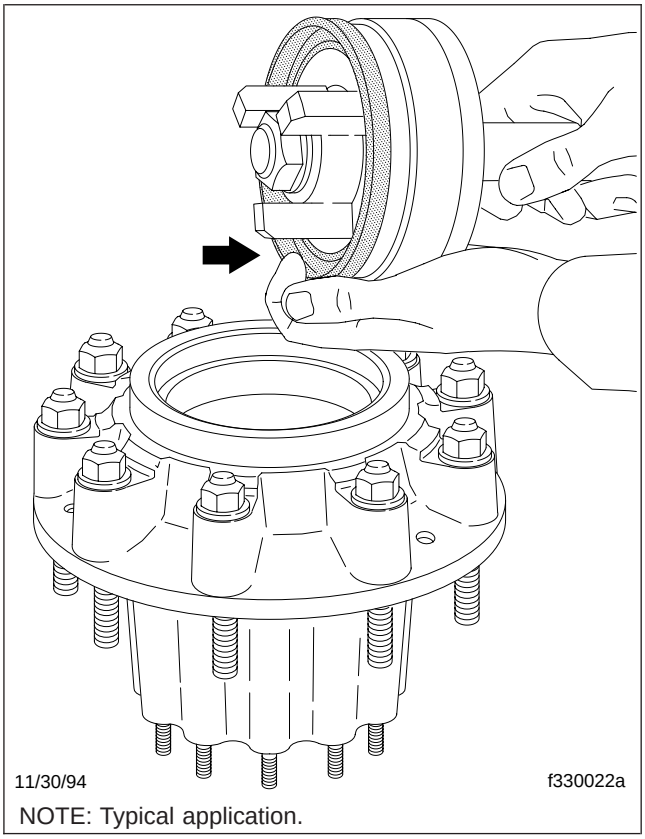
⚠ CAUTION

Use only fresh oil on the bearing assemblies; old oil could be contaminated with dirt or water (both

Hub Assembly Removal and Installation, Disc Wheels

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.



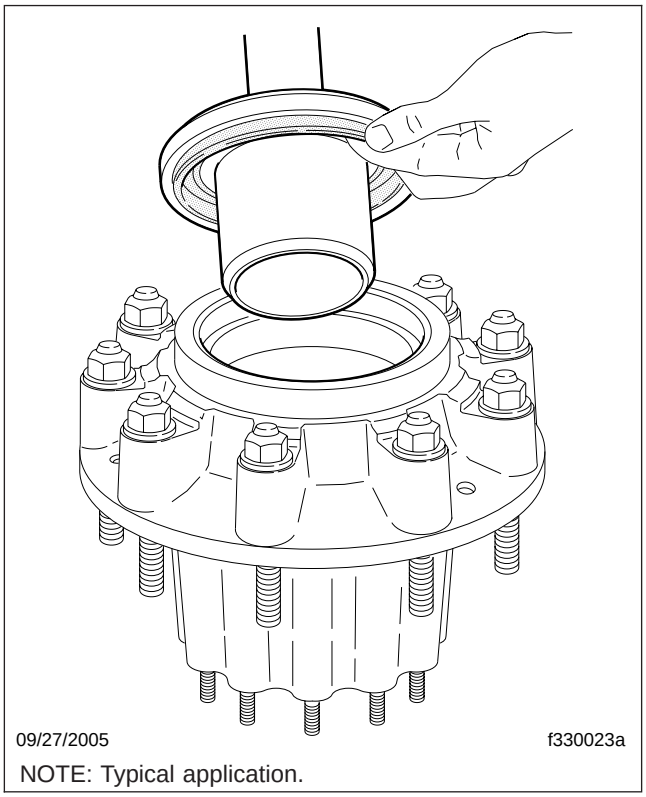
NOTE: Typical application.

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 seal back and forth. A slight movement indicates a damage-free installation.



NOTE: Typical application.

Fig. 7, Insert the Tool

3. Wipe a film of axle oil on the axle spindle to prevent rust from forming behind the inner wheel bearing.

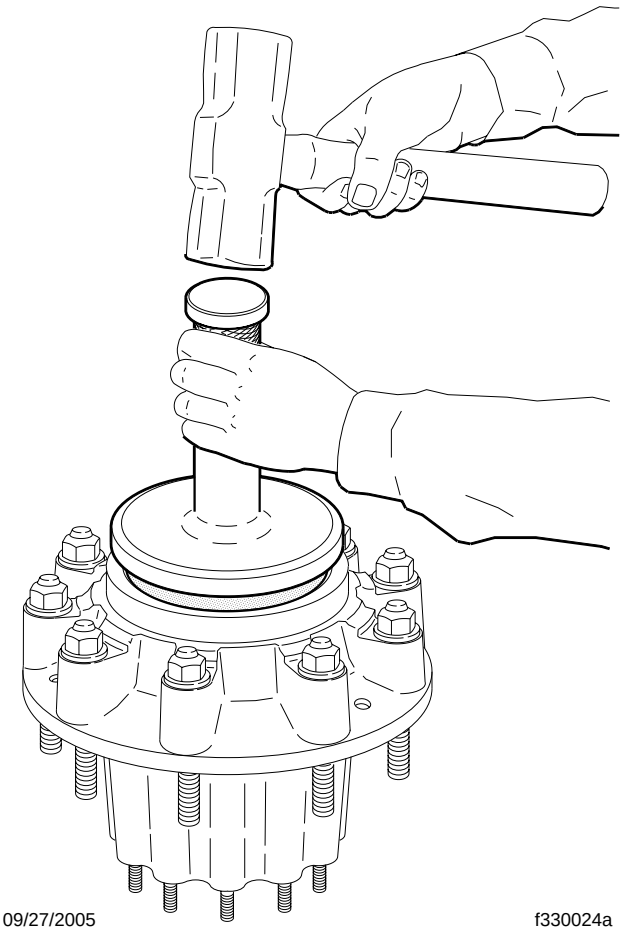
4. Carefully mount the hub and inner wheel bearing assembly on the axle spindle. Be careful not to unseat the inner wheel bearing or seal.

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. 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.

Hub Assembly Removal and Installation, Disc Wheels



NOTE: Typical application.

Fig. 8, Strike the Tool

6.1 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.

6.2 Back off the inner nut one full turn.

6.3 Tighten the inner nut 50 lbf·ft (68 N·m) while rotating the wheel hub assembly.

6.4 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.

6.5 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**.

6.6 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.

6.7 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).

Hub Assembly Removal and Installation, Disc Wheels

Jam Nut Torques		
Locking Device	Torque: lbf·ft (N·m)	
	1-1/8 to 2-1/2 Inch Jam Nuts	2-5/8 Inch or Larger Jam Nuts
Tanged Nut-Lock	200–300 (271–407)	
Lockring		
Tanged Nut-Lock and Lockring	200–300 (271–407)	250–400 (339–542)
Lockwasher and Lockring		

Table 1, Jam Nut Torques

7. 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 one-quarter 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.

8. 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. 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 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**.

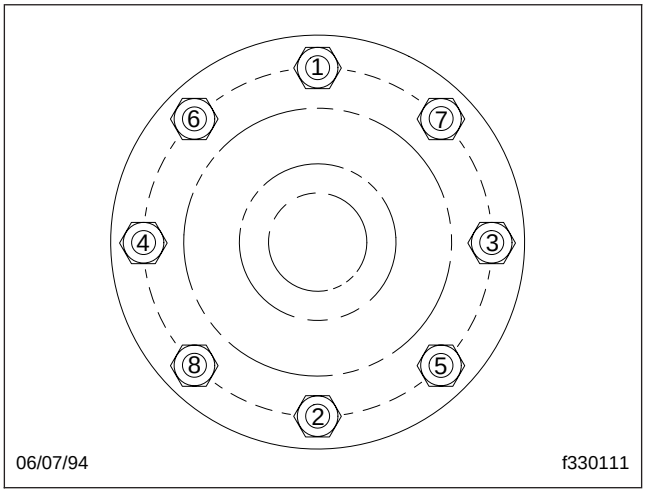


Fig. 9, Axle Shaft Flange Nut-Tightening Sequence

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.

15. 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 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 Pour the recommended drive axle lubricant through the axle housing filler hole (**Fig. 11**) until the lubricant is level with the bottom of the hole. See **Fig. 12**. See **Specifications 400** for the recommended axle lubricants. Tighten the 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.

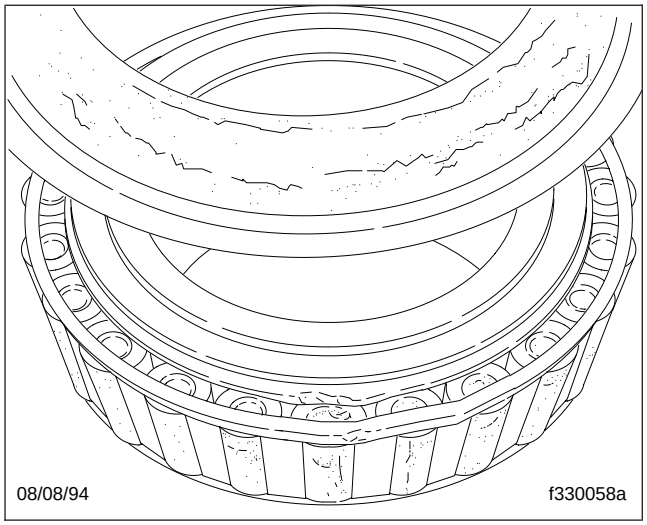
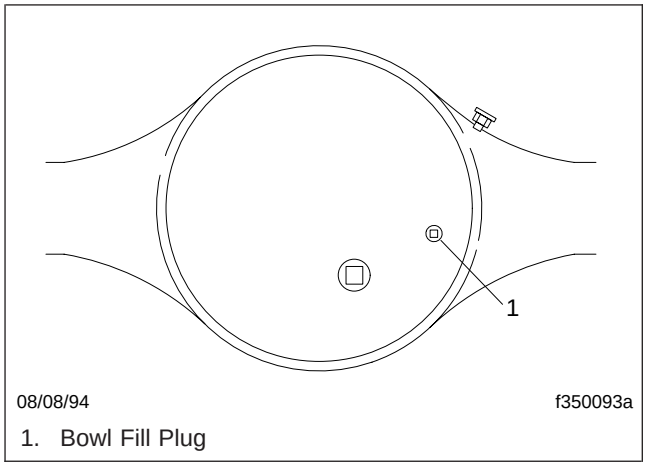
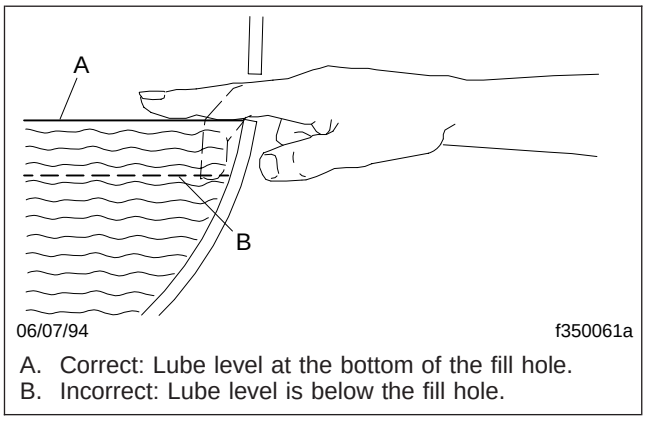


Fig. 10, Bearing Damage Resulting from Inadequate Lubrication



1. Bowl Fill Plug

Fig. 11, Filler Hole



A. Correct: Lube level at the bottom of the fill hole.
B. Incorrect: Lube level is below the fill hole.

Fig. 12, Checking Lubricant Level

15.3 Return the axle to a level position, and add oil through the axle housing fill hole. About one extra liter (two pints) of lubricant will be needed to bring the oil level even with the base of the fill 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** in the vehicle maintenance manual.
18. Remove the safety stands from under the axle, then lower the vehicle.
19. 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, see **Subject 120.**

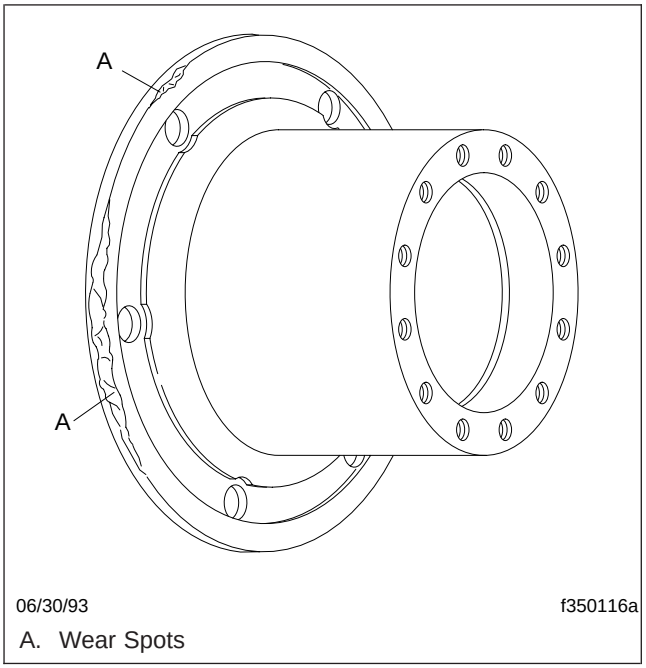


Fig. 1, Typical Wheel Hub, Damaged

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, see **Subject 130**.

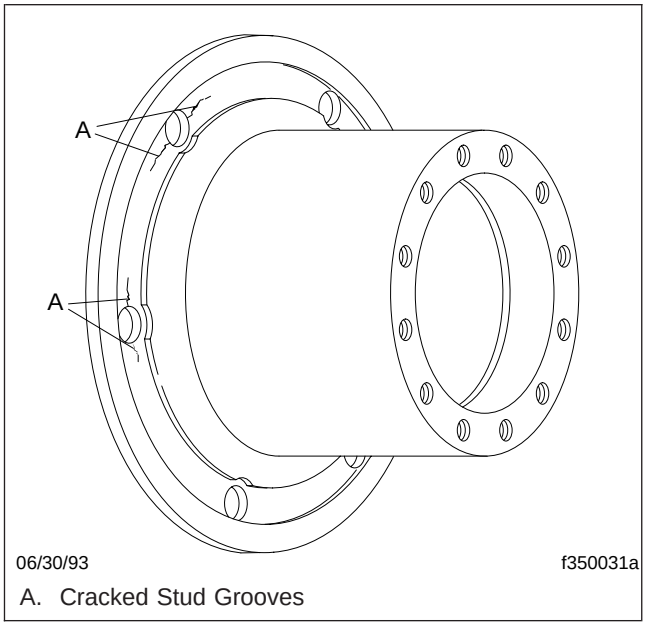


Fig. 2, Typical Wheel Hub, Damaged

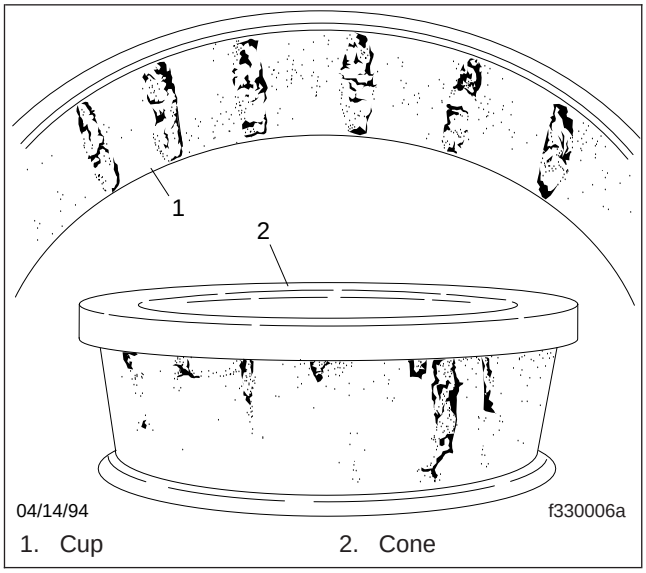


Fig. 3, Spalling (Flaking) of Wheel Bearing Assembly

Axle Components Cleaning and Inspection

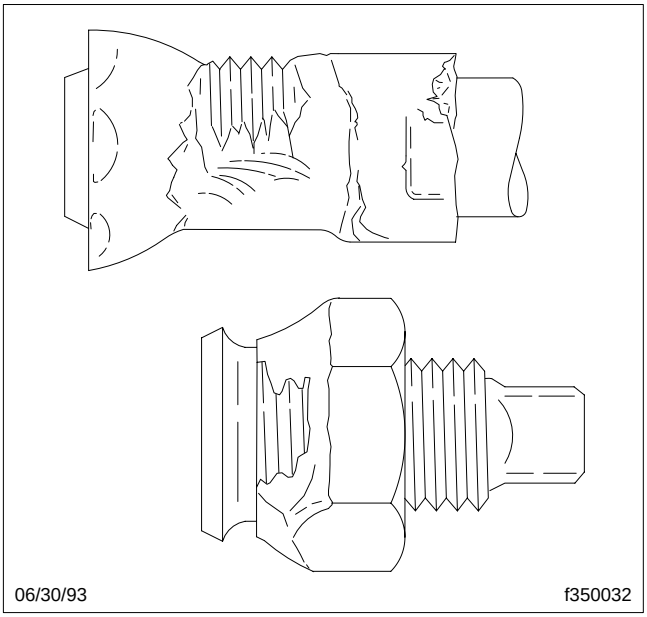


Fig. 4, Damaged Wheel Stud Nuts

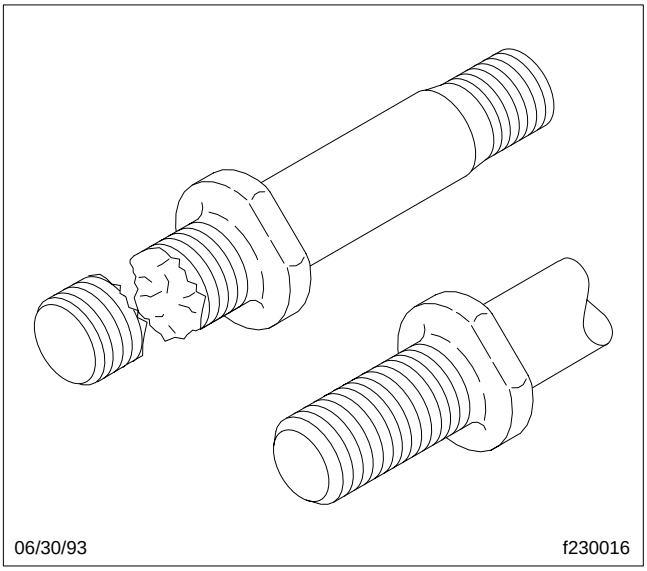


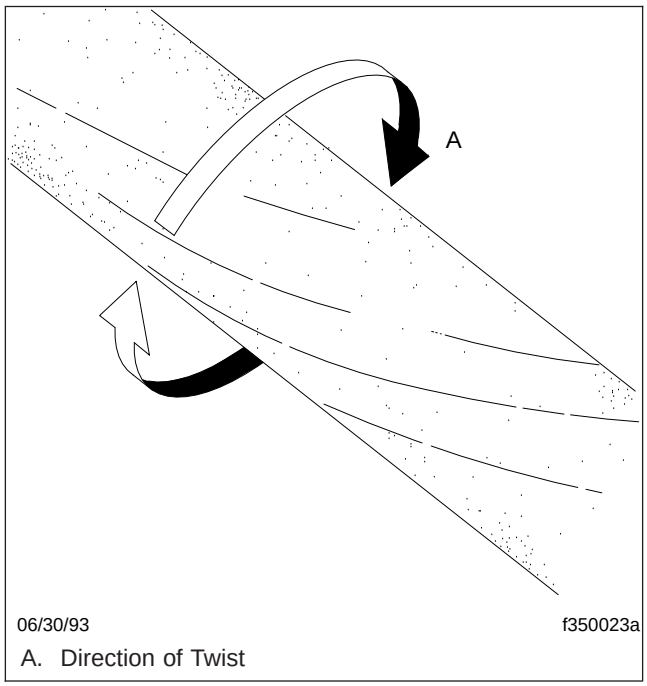
Fig. 5, Damaged Wheel Studs (shouldered type)

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, see **Subject 140**.
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.

⚠ 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.

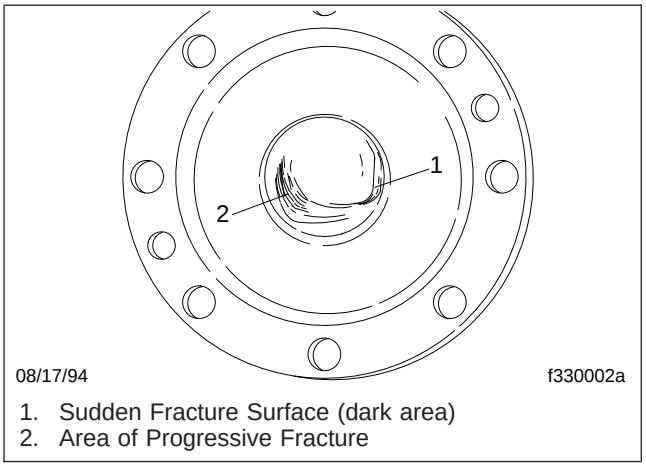
7. Inspect the drive axle shaft-to-flange surface. Loose wheel bearings can lead to progressive fatigue fractures where the shaft and flange meet. See **Fig. 7**. Replace the drive axle assembly if damaged.



A. Direction of Twist

Fig. 6, Twisted Drive Axle Shaft

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.



1. Sudden Fracture Surface (dark area)
2. Area of Progressive Fracture

Fig. 7, Damaged Drive Axle Flange Surface

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.

Wheel Bearing Cleaning and Inspection

CLEANING

⚠ 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 100°F (38°C); 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**.

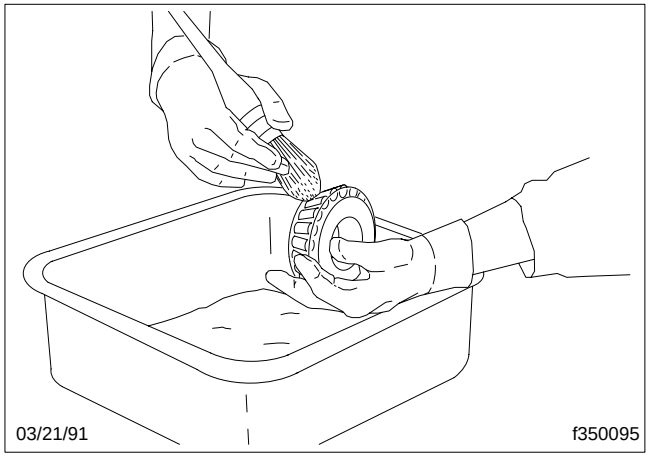
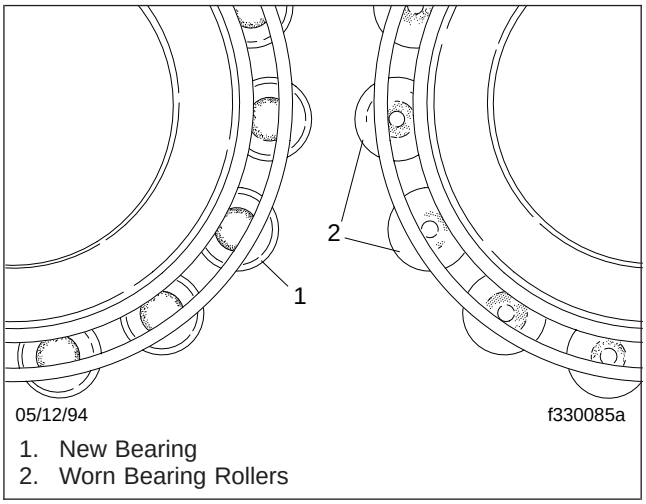


Fig. 8, Clean Wheel Bearings

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**.
3. Bright rubbing marks on the dark phosphate surfaces of the bearing cage. See **Fig. 11**.
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.

Axle Components Cleaning and Inspection



1. New Bearing
2. Worn Bearing Rollers

Fig. 9, Worn Bearing Rollers

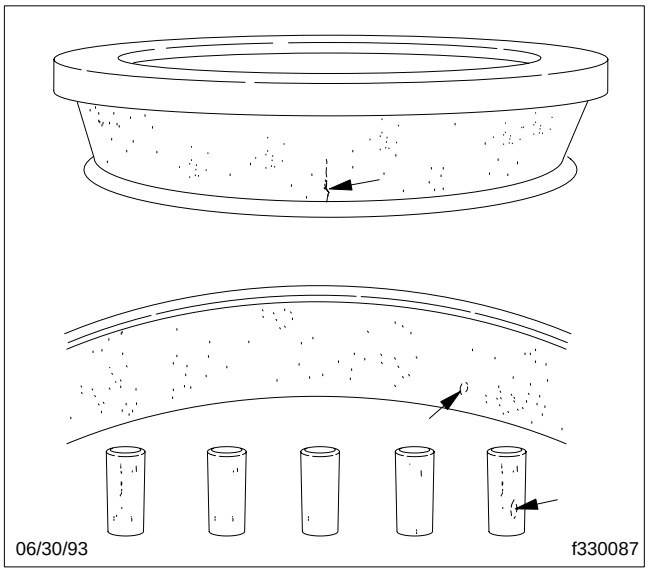


Fig. 10, Indentations, Cracks, or Breaks in Bearing Surfaces

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.

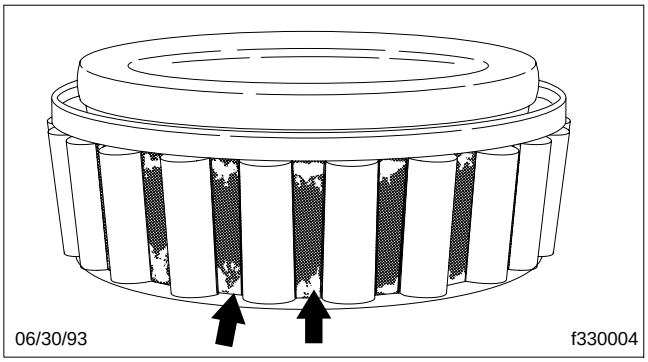


Fig. 11, Rubbing Marks on Bearing Cage

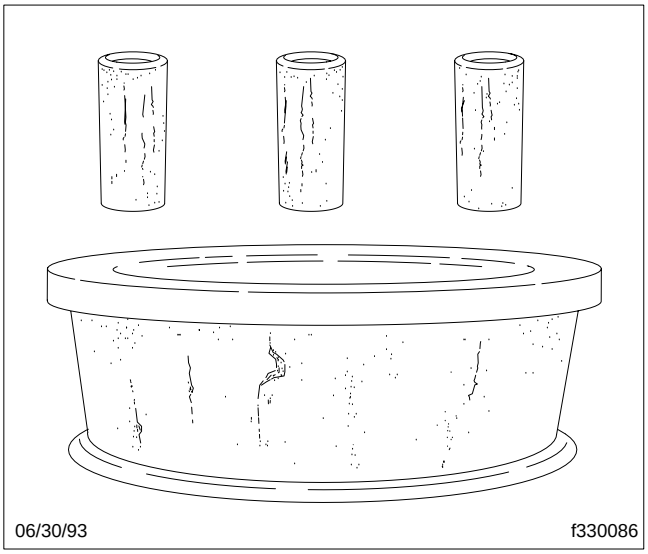


Fig. 12, Etching (Pitting) on Bearing Surfaces

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.

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.

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.
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.

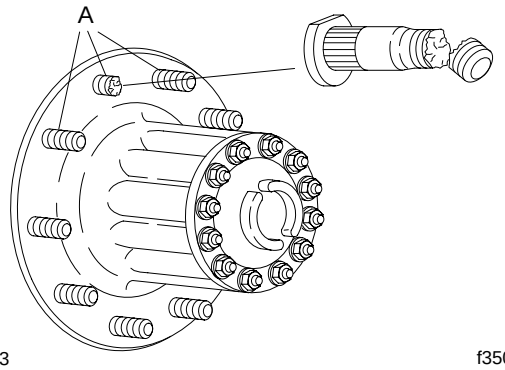
Wheel Stud Replacement, Disc Wheels

Replacement

WARNING

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, see **Subject 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.



A. Replace all three studs.

Fig. 1, Replace Broken Studs

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

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." See **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

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.
10. Install the wheel hub on the axle. For instructions, see **Subject 100**.

Wheel Stud Replacement, Disc Wheels

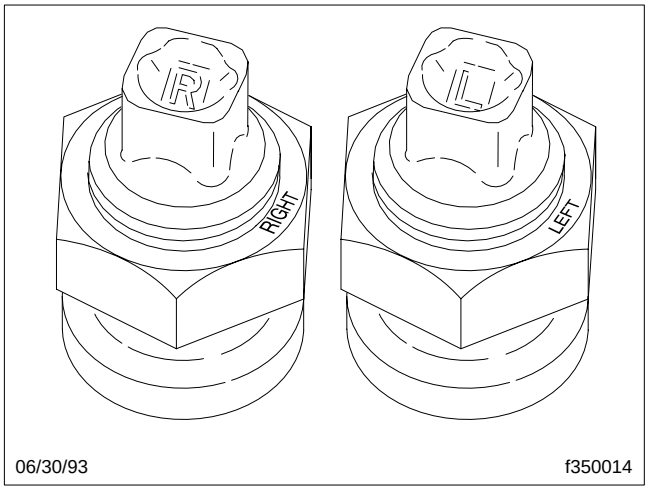
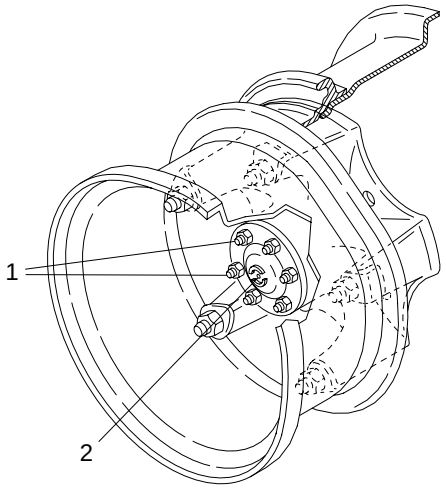


Fig. 2, Wheel Nuts

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.



1. Drive Axle Studs and Nuts
2. Center Portion of Drive Axle Flange

Fig. 1, Wheel Assembly and Hub

   - 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

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 1-1/4 inches (32 mm) 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** 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**.

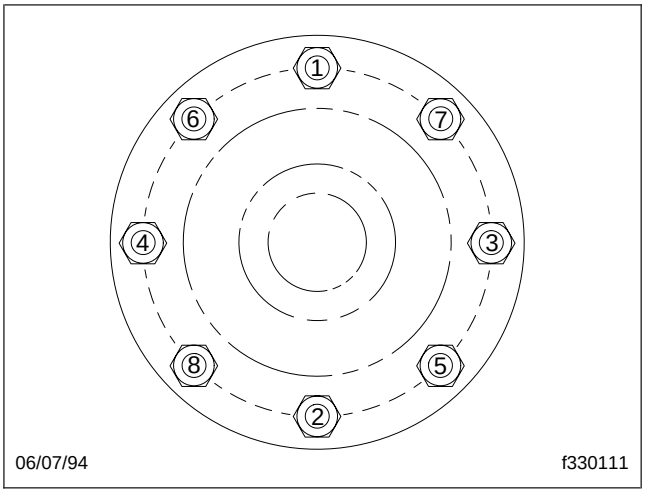


Fig. 2, Axle Shaft Flange Nut-Tightening Sequence

- 11.4 Add fresh oil to the wheel hub. For instructions, see **Subject 100**.

⚠ 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 Tables

Problem—Noisy Bearings or Excessive Bearing Replacement Intervals

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, see **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**.
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, see **Specifications 400**.

Problem—Broken Wheel or Rim Studs

Problem—Broken Wheel or Rim Studs	
Possible Cause	**Remedy**
The wheel or rim nuts were overtightened.	Replace the wheel or rim studs. See **Group 40** 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

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 **Subject 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

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.

Troubleshooting

Problem—Loss of Lubricant From the Wheel Hubs	
Possible Cause	**Remedy**
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 lbf·ft (N·m)**
Hub Cap Capscrews	5/16–18	15 (20)
Drive Axle Studs (to hub)	1/2–13	70 (95)
	5/8–11	135 (185)
Drive Axle Stud Nuts (with or without dowels)	5/8–18	185–200 (250–270)
Rotor Capscrews	9/16–12	130 (175)

Table 1, Torque Values

Meritor Drive Axle Lubricant Capacities, Single Axles					
Axle Type	**Axle Model**	**Capacity * pints (liters)**	**Axle Type**	**Axle Model**	**Capacity * pints (liters)**
Single †	RS–13–120	16 (7.6)	Single †	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)			

* Quantities listed are approximate and include 1 pint (0.5 liter) for each wheel end and with the drive pinion at 3 degrees.

† 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 (one ounce [30 mL] of additive for each 1 pint [0.5 liter] of lube capacity).

Table 2, Meritor Drive Axle Lubricant Capacities, Single Axles

Eaton Drive Axle Lubricant Capacities, Tandem Axles		
Axle Type	**Axle Model**	**Capacity * pints (liters)**
Tandem	RT–34–135	Forward 29.8 (14.1)
		Rear 34 (16.1)
	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, Eaton Drive Axle Lubricant Capacities, Tandem Axles

Specifications

Meritor Drive Axle Recommended Lubricant			
Recommended Lubricant Type	**Ambient Temperature**	**Lubricant SAE Viscosity Grade**	**Meritor Specification**
Hypoid Gear Oil API Service Classification GL–5	+10°F (12.2°C) and up *	85W–140	0–76–A
	–15°F (–26.1°C) and up *	80W–140	0–76–B
	–15°F (–26.1°C) and up *	80W–90	0–76–D
	–40°F (–40°C) and up *	75W–90	0–76–E
	–40°F (–40°C) to +35°F (+2°C)	75W	0–76–J
	–40°F (–40°C) and up *	75W–140	0–76–L
Synthetic Gear Oil	–40°F (–40°C) and up *	75W–90	0–76–N
	–40°F (–40°C) and up *	75W–140	0–76–M

* There is no upper limit on these ambient temperatures, but axle sump temperature must never exceed 250°F (121°C).

Table 4, Meritor Drive Axle Recommended Lubricant

General Description

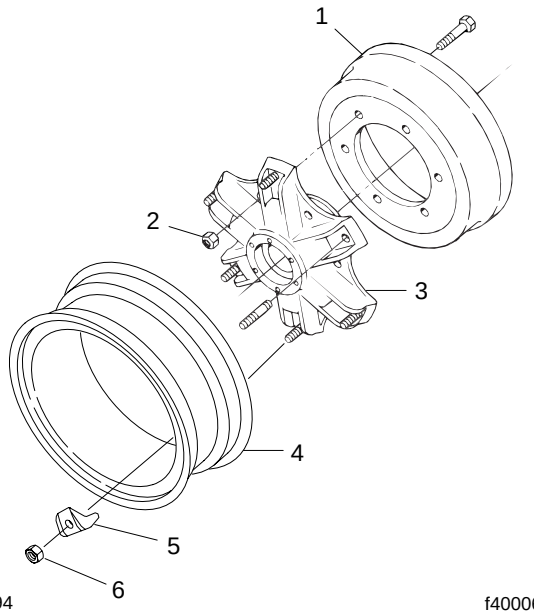
WHEELS AND TIRES

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.



1. Brake Drum
2. Brake Drum Nut
3. Spoke Wheel
4. Rim Base
5. Rim Clamp
6. Rim Nut

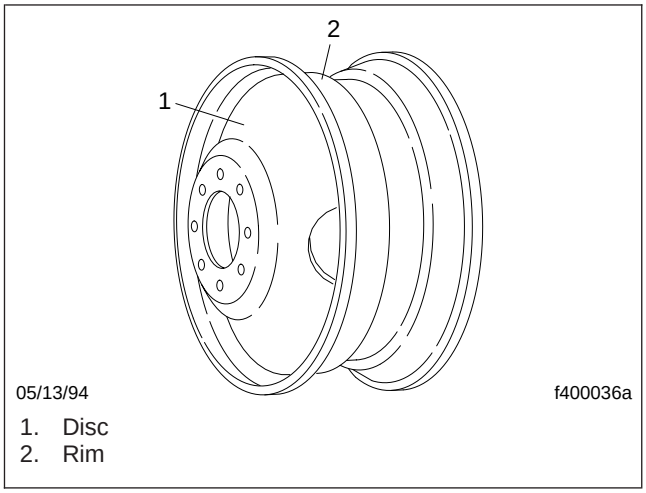
Fig. 1, Spoke Wheel and Brake Drum Assembly

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.



1. Disc
2. Rim

Fig. 2, Disc Wheel

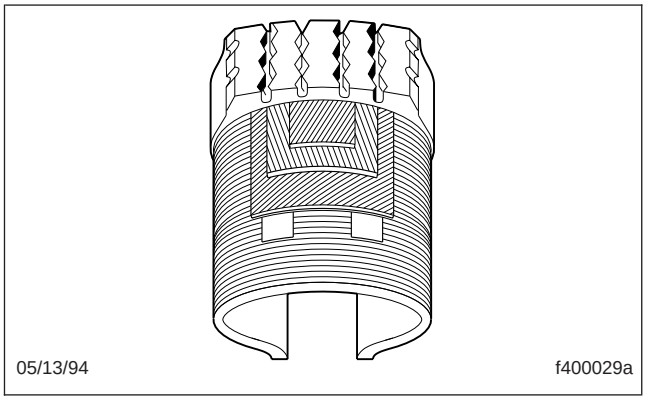


Fig. 3, Radial Ply Tire Construction

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

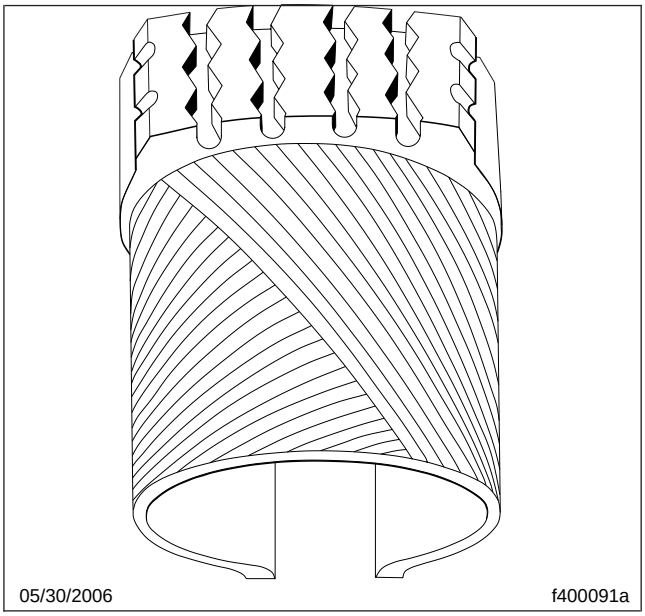


Fig. 4, Bias Ply Tire Construction

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).

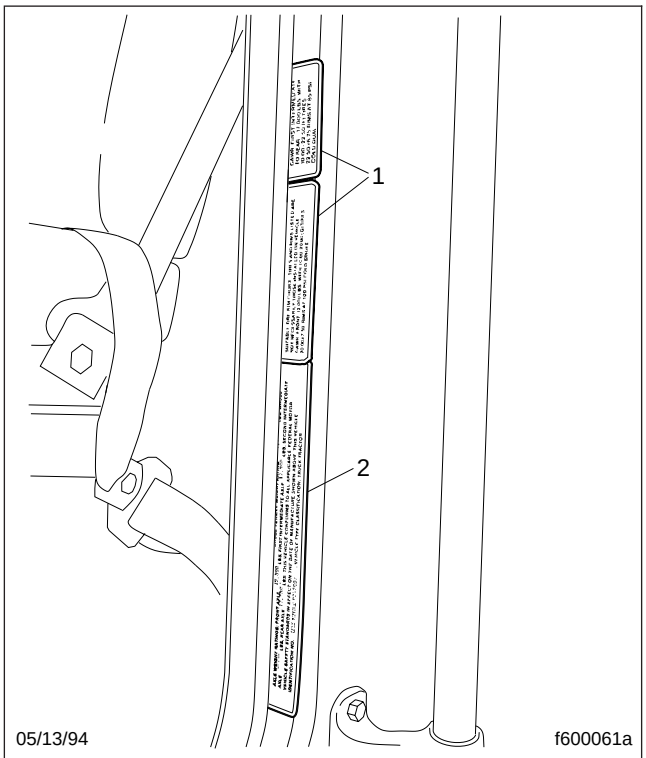


Fig. 5, "Statement of Compliance" Label

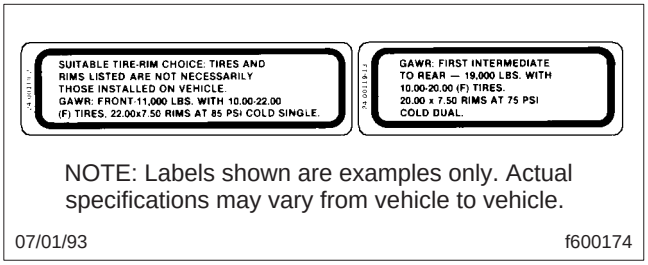


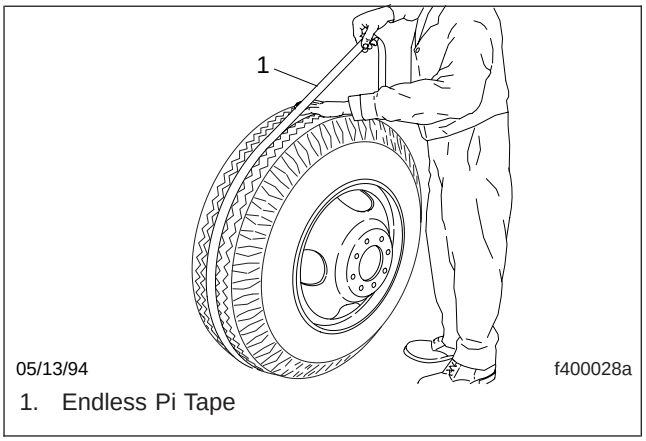
Fig. 6, Tire and Rim Labels

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

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.



1. Endless Pi Tape

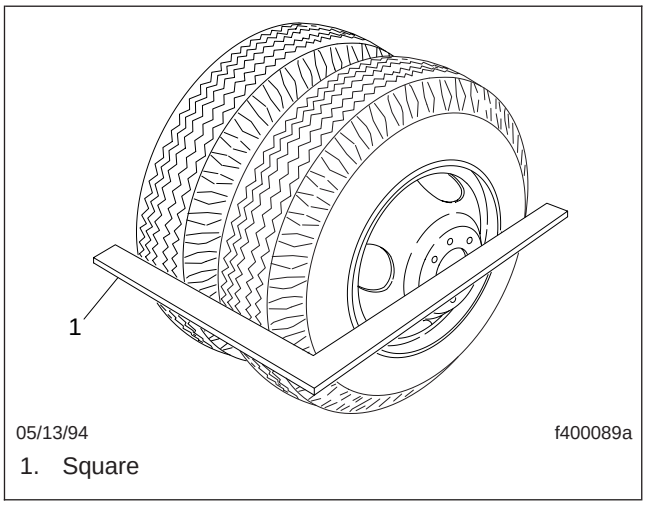
Fig. 7, Endless Pi Tape

When pairing tires of unequal diameters (but within the above limits), mount the larger tire on the outside.

CAUTION

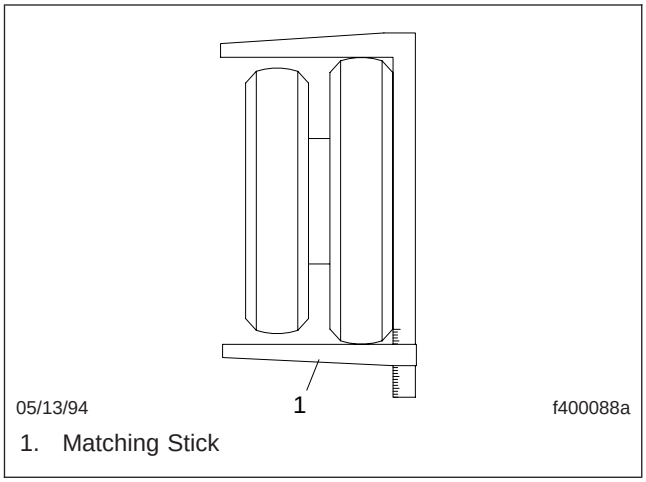
Driving a vehicle on one tire of a dual assembly dangerously exceeds the carrying capacity of the single tire and wheel. Operating in this manner can cause damage to the wheel and tire.

Inflate all tires on an axle to within 5 psi (35 kPa) of one another. For tire inflation specifications, refer to the applicable tables in **Specifications 400**.



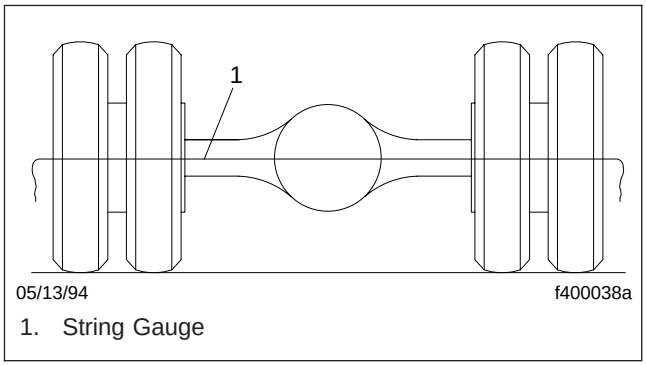
1. Square

Fig. 8, Square



1. Matching Stick

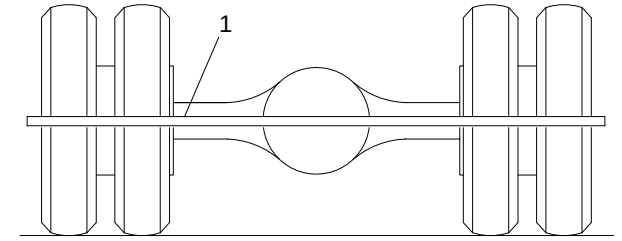
Fig. 9, Matching Stick



1. String Gauge

Fig. 10, String Gauge

General Information



1. Tire Straight Edge

Fig. 11, Tire Straight Edge

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 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 4/32 inch (3 mm) remaining groove depth on a front axle, and tires with less than 2/32 inch (1.5 mm) 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

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 Cone Locknuts; 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 cone locknuts.

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.

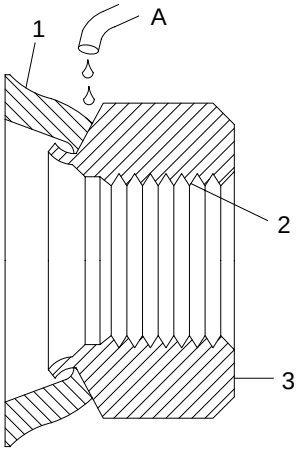
IMPORTANT: On both sides of the vehicle, the cone locknuts have right-hand threads.

6. Remove the wheel. Don't let it drop on or drag across the stud threads.

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 correctly inflated. For instructions, refer to **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 cone locknut. See **Fig. 1**. Wipe off any excess oil.



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NOTE: Apply oil here.

1. Flange
2. Nut Threads
3. Nut Body

Fig. 1, Wheel Studs

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.

8-Hole Disc Wheel With Cone Locknuts; Removal and Installation

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 cone locknut on the top and bottom studs.

CAUTION

The cone locknuts 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 cone locknuts. Then, tighten the cone locknuts 50 to 100 lbf·ft (68 to 135 N·m) following the sequence in **Fig. 2**.
7. Check that the wheel is correctly seated against the hub and on the hub-pilot pads.
8. Following the sequence in **Fig. 2**, tighten the cone locknuts 450 to 550 lbf·ft (610 to 745 N·m).

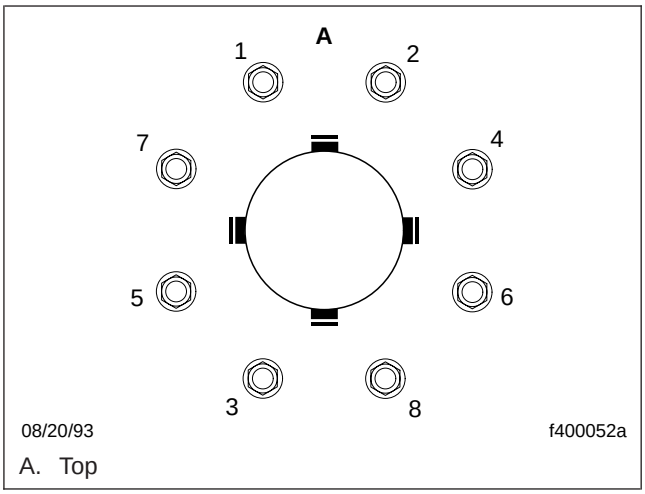


Fig. 2, 8-Stud Disc Wheel Tightening Sequence

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 550 lbf·ft (610 to 745 N·m). Follow the sequence in **Fig. 2**.

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. 2.

IMPORTANT: The cone locknuts seat during vehicle operation. It is necessary to periodically tighten the wheel nuts to the specified torque. Tighten the cone locknuts 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. Chock all tires that will not be serviced to prevent vehicle movement. If removing the front wheels and tires, 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 (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.

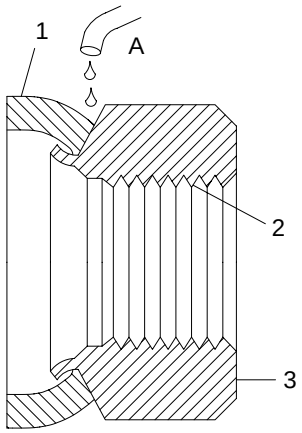
IMPORTANT: On both sides of the vehicle, the two-piece flange nuts have right-hand metric threads.

7. Remove the wheel. Don't let it drop on or drag across the stud threads.

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 all disc faces of dual wheels. Make sure the tire is correctly inflated. For instructions, refer to **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. See **Fig. 1**. Wipe off any excess oil.



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NOTE: Apply oil here.

1. Flange
2. Nut Threads
3. Nut Body

Fig. 1, Wheel Studs

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.

10-Hole Disc Wheel With Two-Piece Flange Nuts; Removal and Installation

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. Then, tighten the nuts 50 lbf·ft (68 N·m) following the sequence in **Fig. 2**.

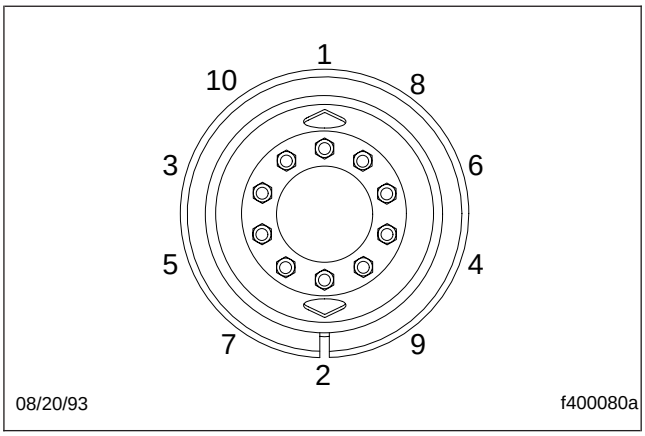


Fig. 2, 10-Stud Disc Wheel Tightening Sequence

7. Check that the wheel is correctly seated against the hub and on the hub-pilot pads.

8. Following the sequence in **Fig. 2**, tighten the two-piece flange nuts 390 to 440 lbf·ft (529 to 597 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 390 to 440 lbf·ft (529 to 597 N·m). Follow the sequence in **Fig. 2**.

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. 2.

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 50 lbf·ft (68 N·m), following the sequence in **Fig. 4**.
5. Following the same sequence, tighten the wheel nuts again. Refer to the applicable table in **Specifications 400**.

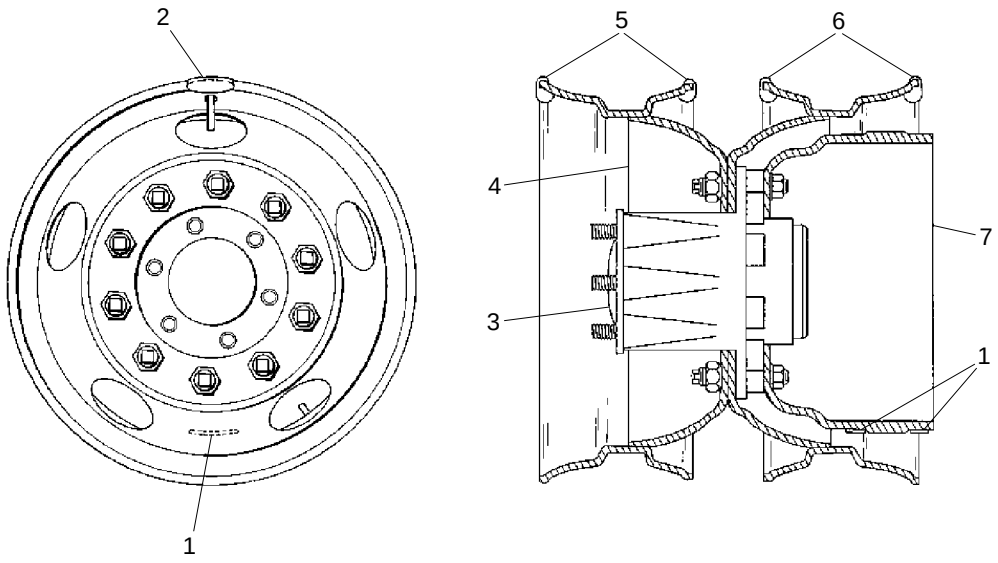
⚠ WARNING

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 Group 33 or Group 35 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 50 to 100 miles (80 to 160 km), retighten the wheel nuts to the torque in the applicable table in **Specifications 400**. Follow the sequence in **Fig. 4**.

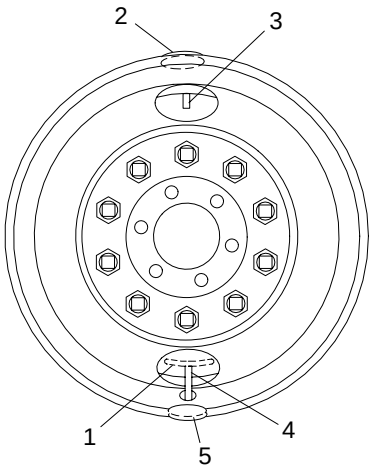
10-Hole Disc Wheel With Inner and Outer Nuts; Removal and Installation



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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

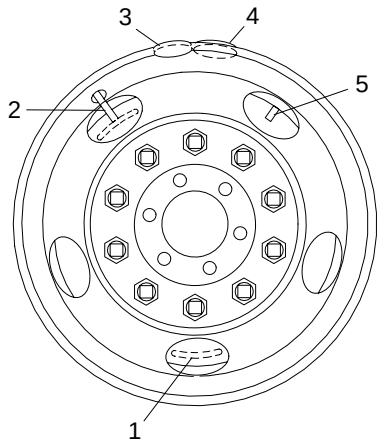
Fig. 1, Recommended Location of Wheel and Brake Drum Balance Weights



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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



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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

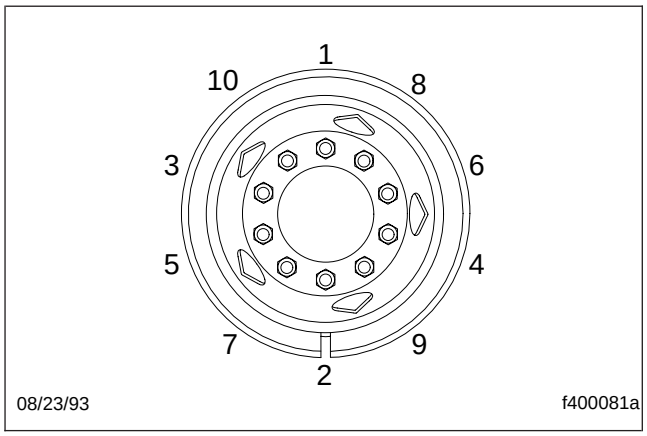


Fig. 4, 10-Stud Disc Wheel Tightening Sequence

⚠ 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

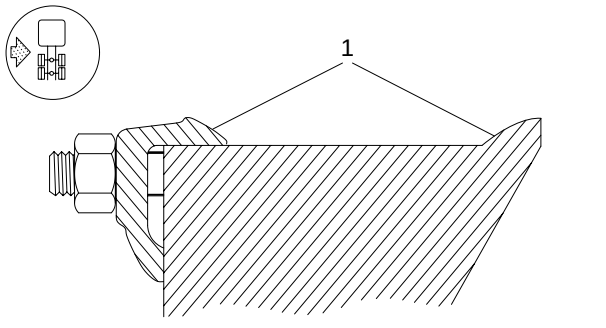
Removal

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**.

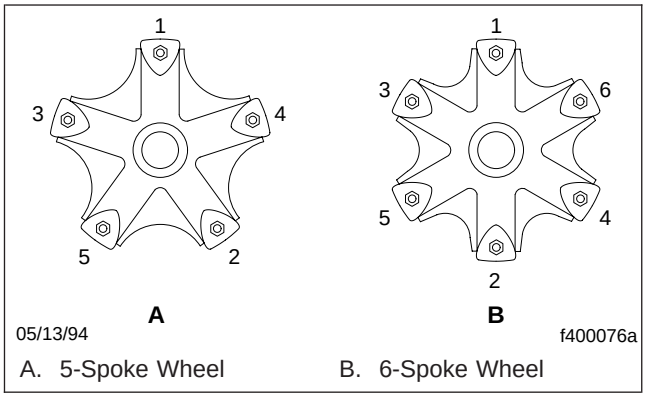
1. Clean the wheel, rim spacer, and rim mounting surfaces. The mounting surface of the wheel is the 28-degree taper on the inboard side of each spoke. See **Fig. 1**.



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. See **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

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 Group 33 or Group 35 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

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.

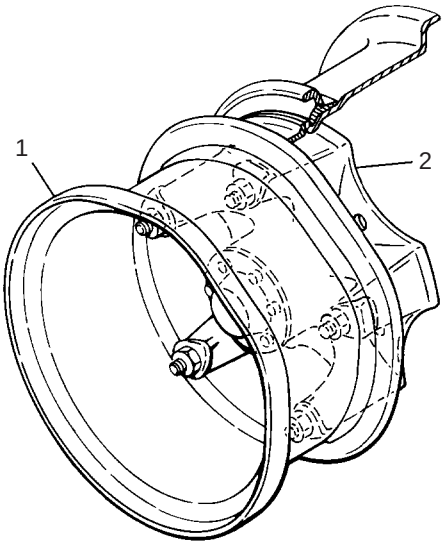
NOTE: When replacing a spoke wheel, contact the wheel manufacturer for the correct torque value for the brake drum nuts attaching the spoke wheel to the brake drum.

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 1/16 inch (1.5 mm) for front rims, or 1/8 inch (3 mm) 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 50 to 100 miles (80 to 160 km), 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

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 8 inch (20 cm) 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.

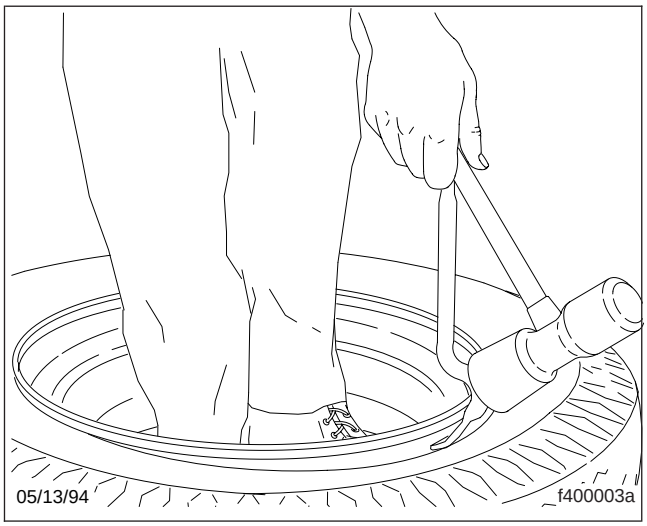


Fig. 1, Loosening the Beads

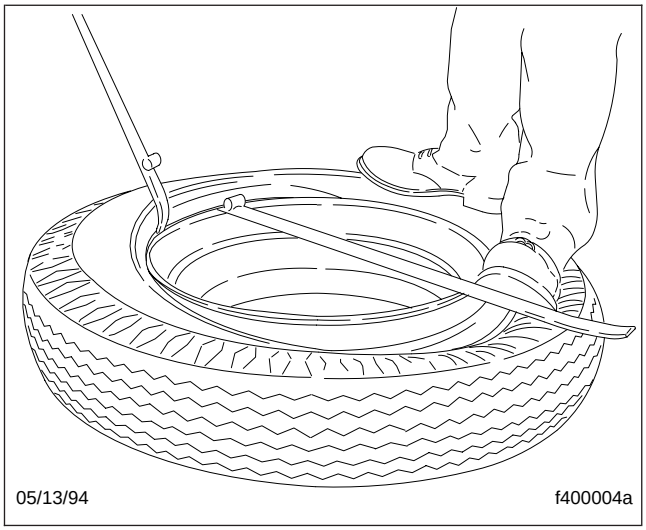


Fig. 2, Forcing Bead into the Rim Well

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

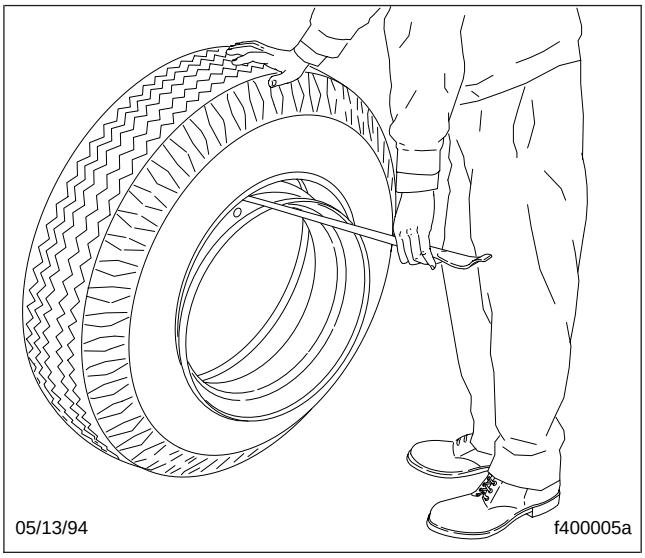


Fig. 3, Prying the Rim Out of the Tire

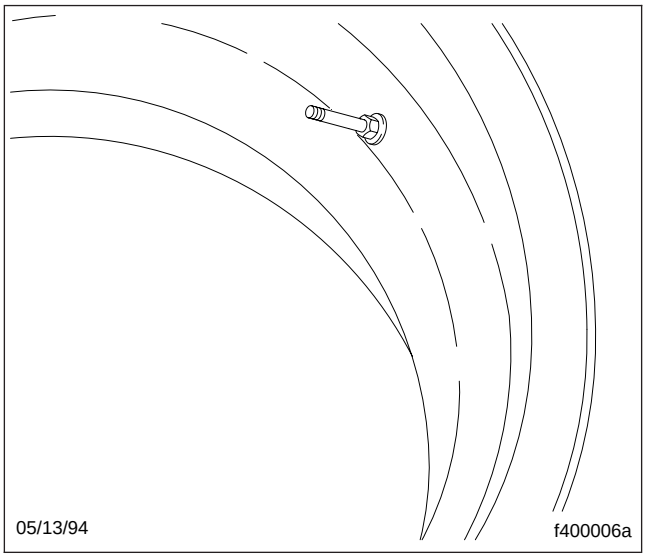


Fig. 4, Valve Stem Installation

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.

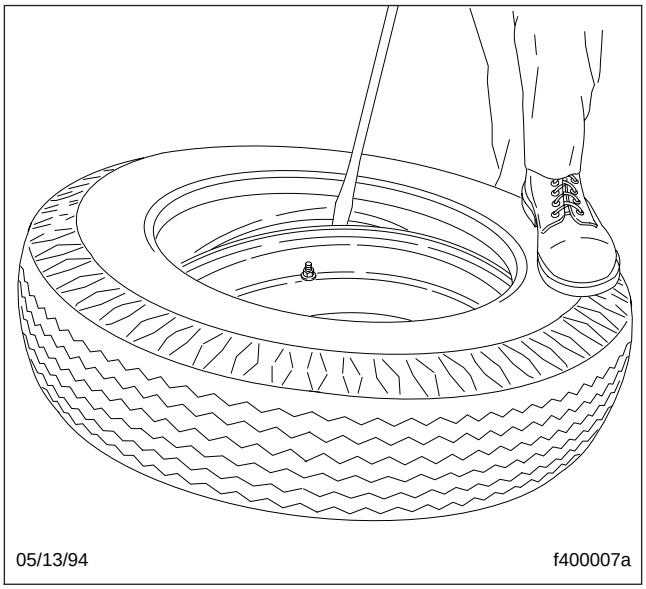


Fig. 5, Working the Lower Bead into the Rim

Demounting and Mounting Tubeless Tires on One-Piece Drop Center Wheels or Rims



Fig. 6, Working the Upper Bead into the Rim

Inspection

⚠ 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.

Examine the wheel or rim, and all parts. Remove any grease, dirt, or rust. Using a wire brush, remove any rubber from the bead seat. Use special care when cleaning the rim gutter. Rust or other foreign matter can prevent the correct fitting of side rings. Replace corroded parts. Paint the rim to prevent corrosion.

NOTE: Don't paint Alcoa aluminum disc wheels. If the wheels are corroded, contact the manufacturer for instructions.

A cracked brake drum, damaged inner or outer wheel nuts (**Fig. 1**), or an out-of-round wheel or rim makes the replacement of the damaged part necessary. Replace the wheel if it has out-of-round stud holes.

NOTE: Refer to the **Group 33** or the **Group 35** for inspection and service procedures for the hub, wheel studs, wheel, and brake drum or disc rotor assemblies. When replacing the spoke wheel or the brake drum, contact the wheel manufacturer for the correct torque value for the brake drum nut that attaches the spoke wheel to the brake drum.

Inspect valve cores for cracks, bends, and air retention. Replace damaged or leaky cores.

The most critical area of a spoke wheel is the 28-degree tapered rim mounting surface (**Fig. 2**). Clean the surface and examine it for damage or excessive wear. Replace the wheel if the mounting surface is damaged or worn below the 28-degree taper.

Check the clamps, rim spacer, rim studs, and spoke-wheel nuts for damage or wear. The clamps must not be excessively worn. The end of the wedge portion must be at least 1/16 inch (1.5 mm) thick (**Fig. 3**). The rim spacer must not be bent, distorted, or crushed. Replace all damaged or broken parts.

Do not attempt to rework, weld, heat, or braze any rim or wheel parts that are cracked, broken, or damaged. Use new parts or parts that are not cracked, broken, or otherwise damaged, and that are of the same size and type.

Remove all foreign matter, such as grease and dirt, from the wheel mounting surface. Smooth any projections on the mounting surface to ensure even pressure when tightening the wheel nuts.

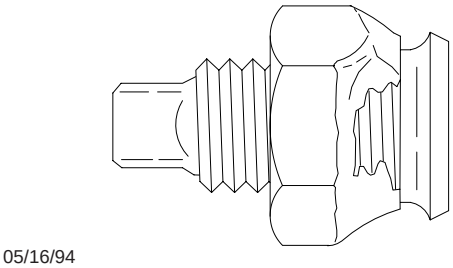
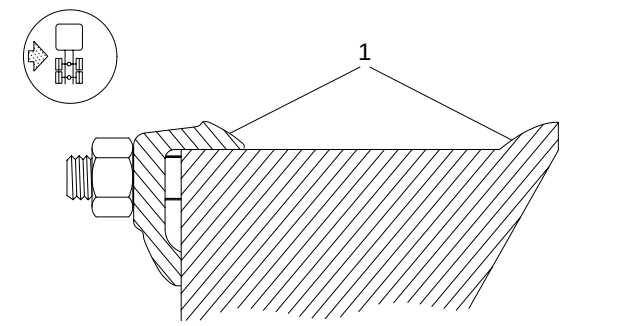
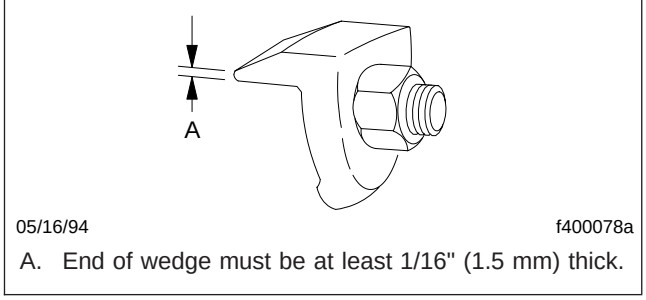


Fig. 1, Damaged Outer Wheel Nut



1. 28-Degree Tapered Rim Mounting Surfaces

Fig. 2, Spoke Wheel Tapered Mounting Surface



A. End of wedge must be at least 1/16" (1.5 mm) thick.

Fig. 3, Rim Clamp

Inspection

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 2/32 inch (1.5 mm) 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

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.

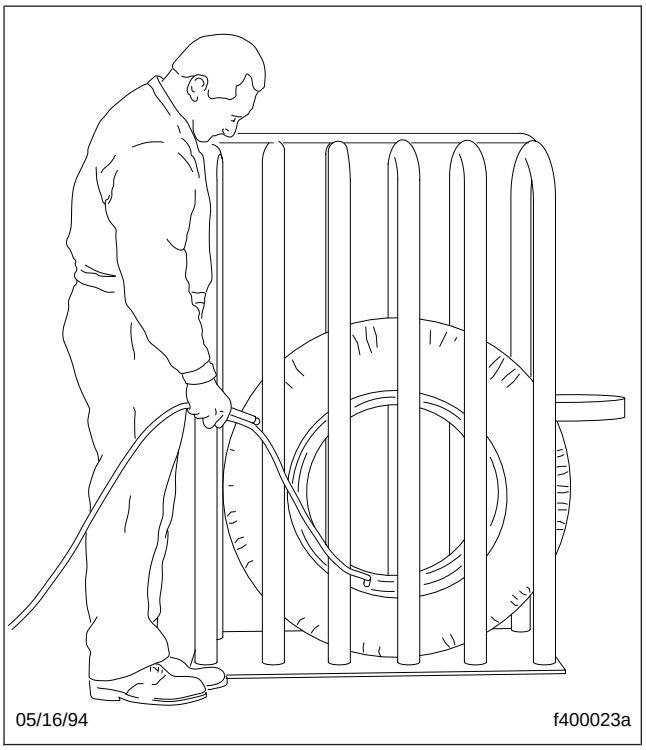


Fig. 1, Safety Cage

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 10 psi (69 kPa). 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 10 psi (69 kPa), 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 90 to 100 psi (620 to 690 kPa) 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

Tire underinflation or overinflation will damage wheels and tires, and could result in a blowout causing possible property damage and personal injury.

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.

Tire Inflation

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 Tables

Problem—Abnormal Tire Wear

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 5 psi (35 kPa). 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 **Group 42**.
Axles are improperly aligned.	Align the axles. **Group 33** and **Group 35** for instructions.
Wheel bearings are loose or damaged, or bushings are excessively worn.	Examine, and repair or replace according to the instructions in **Group 33** and **Group 35**.
Wear is uneven among tire sets.	Rotate the tires according to the instructions in **Group 40** of the vehicle maintenance manual.
Driver is abusing equipment.	Caution the driver.

Problem—Vehicle Vibration

Problem—Vehicle Vibration	
Possible Cause	**Remedy**
Axles are improperly aligned.	Align the axles. Refer to **Group 33** and **Group 35** 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

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.

Tire Pressure

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. If they are not stamped, consult the rim or wheel manufacturer for the correct tire inflation pressure for the vehicle load. If the load exceeds the maximum rim or wheel capacity, the load must be adjusted or reduced.

For further information on rims and tires, and for inflation and load limits, refer to the "Tire and Rim Association Yearbook." Contact the tire manufacturer for further information on their tires.

Disc Wheel Fastener Torque Values

For torque values for disc wheel fasteners, see **Table 1**.

Disc Wheel Fastener Torque for Accuride Wheels		
Description	**Nut Size**	**Torque (dry threads): lbf·ft (N·m)**
8-Hole Disc Wheel With Cone Locknuts		
Front and Rear Wheel Nut	—	450–550 (610–745)*
10-Hole Disc Wheel With Two-Piece Flange Nuts		
Front and Rear Wheel Nut	M20	390–440 (530–600)*
10-Hole Disc Wheel With Inner and Outer Nuts		
Front Wheel Nut	1-1/8–16	400–500 (540–680)† 450–500 (610–680)‡
	3/4–16	450–500 (610–680)*
Rear Wheel Inner Nut	3/4–16	400–500 (540–680)† 450–500 (610–680)
Rear Wheel Outer Nut	1-1/8–16	400–500 (540–680)† 450–500 (610–680)
Wheel Stud Retainer Nut	3/4–16	175–200 (235–270)

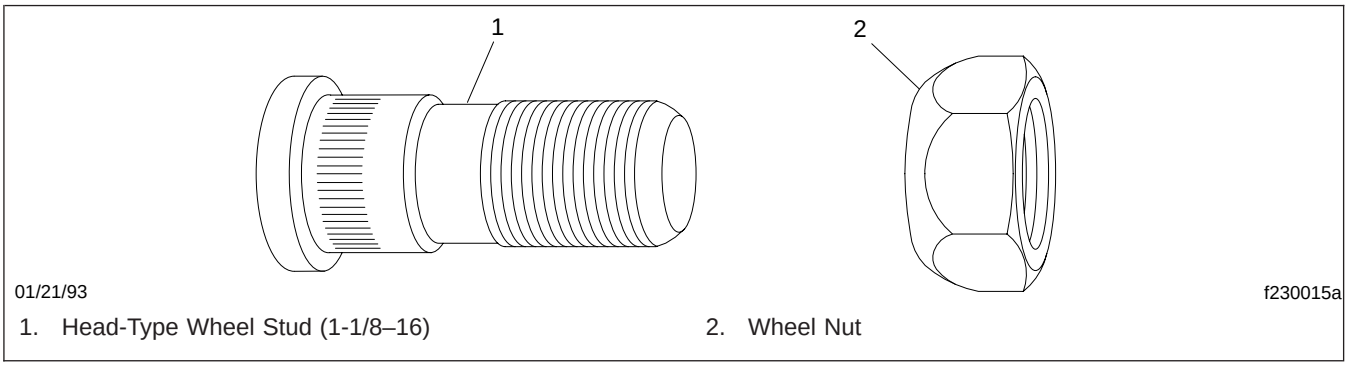
* Torque values are given for lubricated threads.

† Lubricated threads should be tightened 300 to 375 lbf·ft (405 to 510 N·m). 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 capnuts and wheels. Wipe it off if it is applied accidentally.

‡ On 1-1/8–16 wheel studs with a head (**Fig. 1**), tighten the wheel nuts 650 to 750 lbf·ft (880 to 1020 N·m).

Table 1, Disc Wheel Fastener Torque for Accuride Wheels

Specifications



1. Head-Type Wheel Stud (1-1/8–16)
2. Wheel Nut

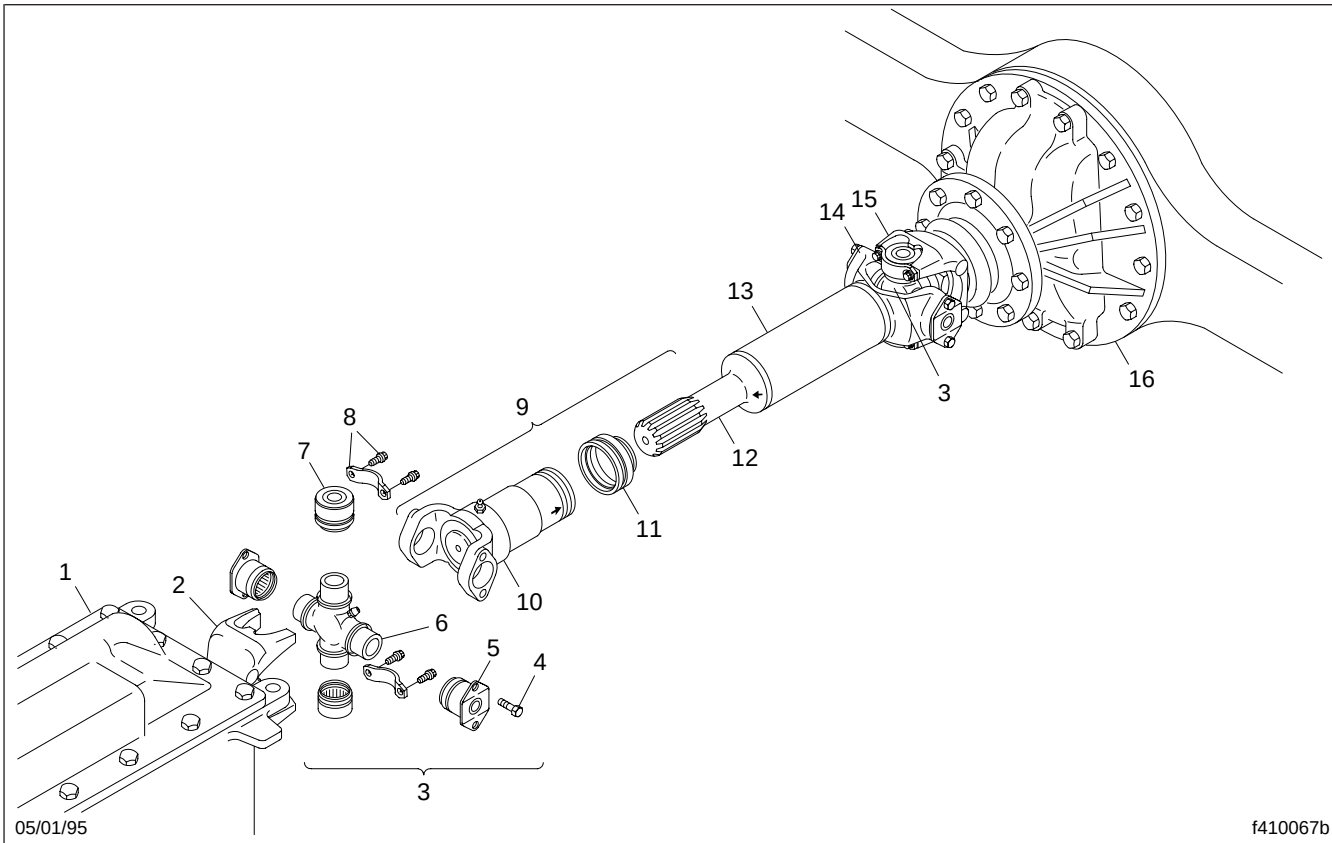
Fig. 1, Head-Type Wheel Nut

General Description

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 an auxiliary 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.

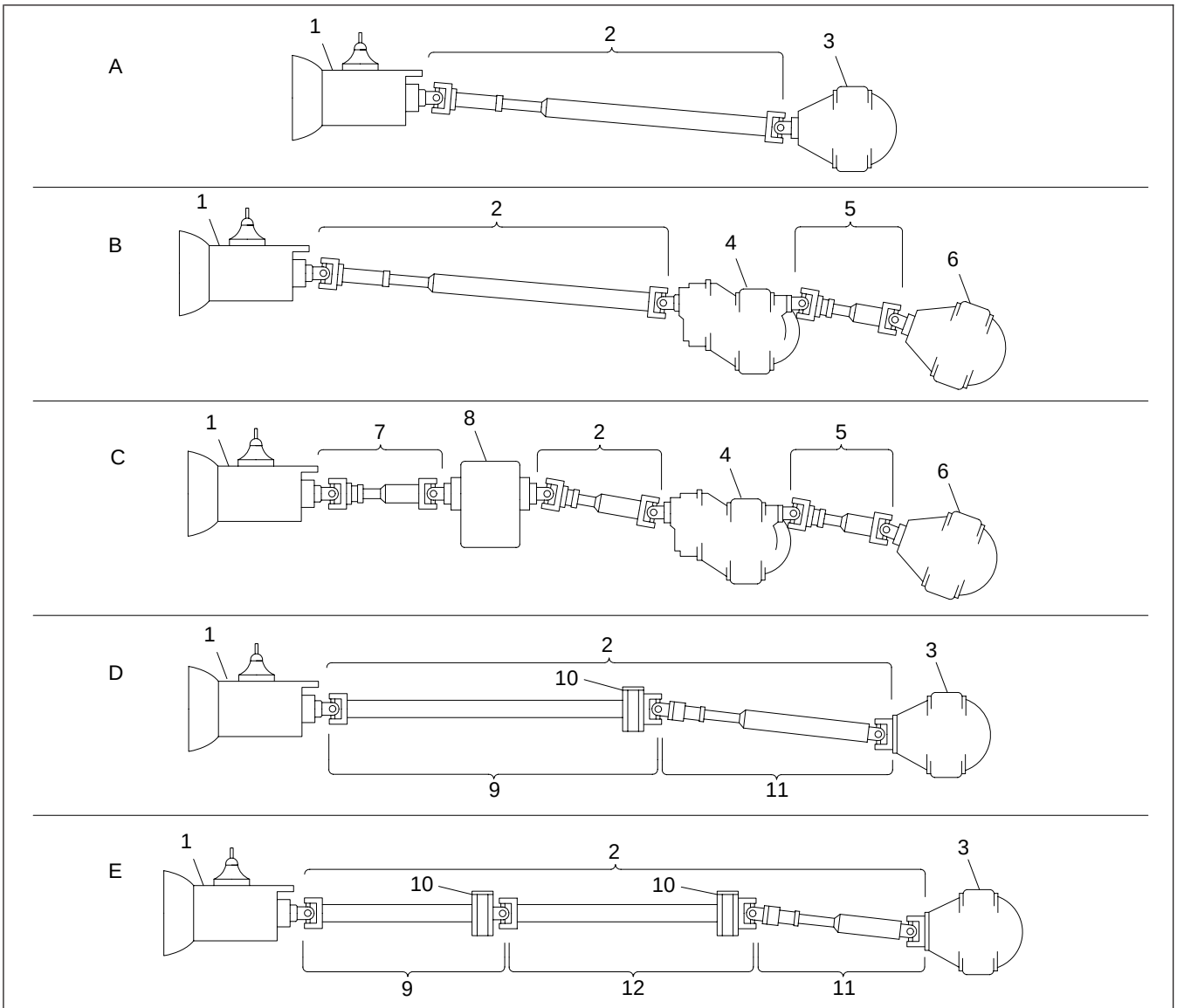
1. Transmission
2. Transmission Output-Shaft End-Yoke (half-round)
3. U-Joint Assembly
4. Bearing Plate Self-Locking Capscrew
5. Bearing Cup (for full-round yoke)
6. U-Joint Cross
7. Bearing Cup (for half-round yoke)
8. Bearing Strap and Bearing-Strap Capscrew
9. Slip-Joint Assembly
10. Sleeve-Yoke (full-round)
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 always referred to as a no. 1 driveline.

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



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

use a midship bearing, mounted on a frame crossmember, 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.

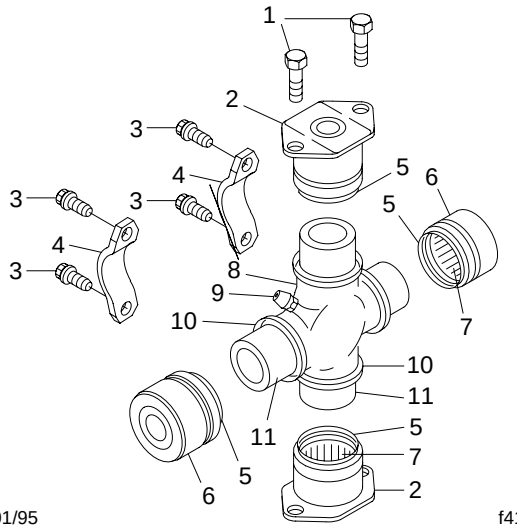
SLIP-JOINTS, U-JOINTS, AND YOKES

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, they ride 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. Coupling shafts do not require a slip-joint.

Motion of the rear axle(s) also causes changes to the relative angles between drivetrain components. U-joints allow 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. 3**. In operation, the four bearing cups are held stationary in a pair of yokes, 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. 4**, Refs. 4 and 9.



NOTE: Components shown are typical of all U-joints installed in 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

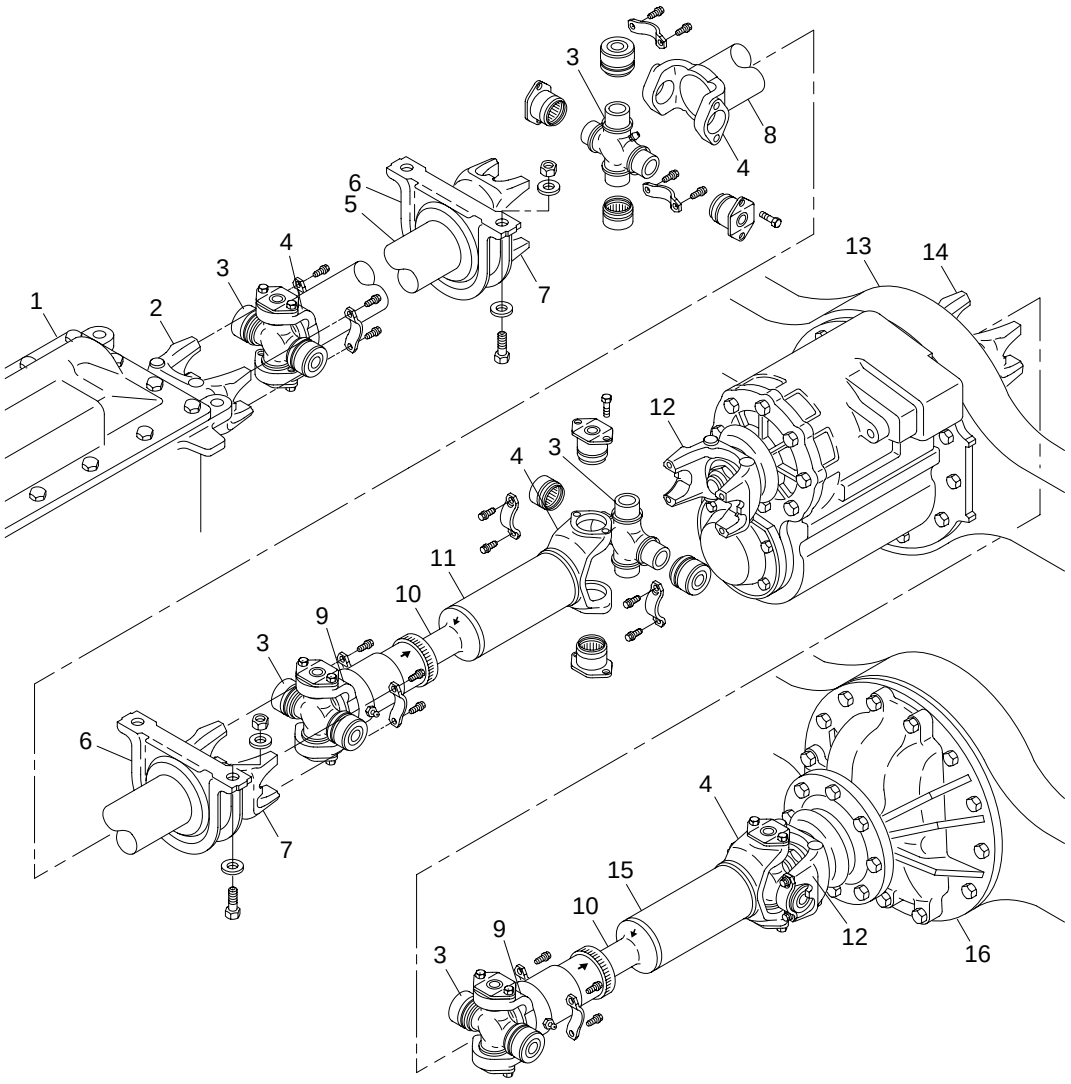
Fig. 3, Typical U-Joint

An end-yoke is an internally splined yoke, held on an externally splined shaft by a locknut. As standard equipment, all end-yokes are half-round; full-round end-yokes are optional. End-yokes are installed on the transmission output shaft, on each axle input and output shaft, and behind the midship bearing of most coupling shafts. See **Fig. 4**, 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. 5**.

Spicer SPL90 (1590), 1610, 1710, 1760, and 1810 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. 6**.

A Spicer SPL90 (1590) U-joint is installed in a full-round tube-yoke or sleeve-yoke by installing the

General Information



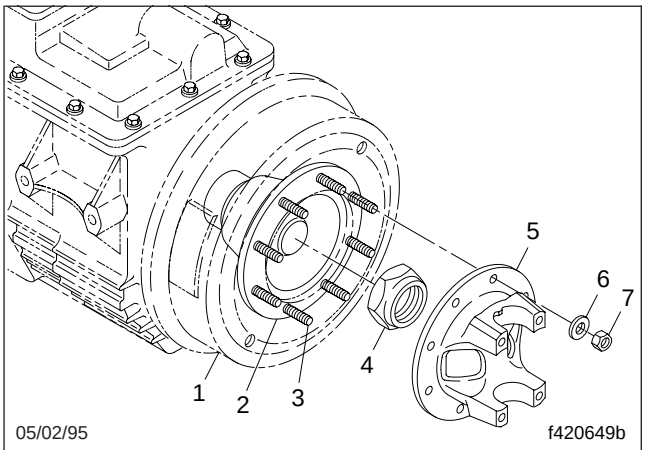
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NOTE: Not all fasteners are shown.

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. 4, Dual-Drive Installation With Primary and Intermediate Coupling Shafts

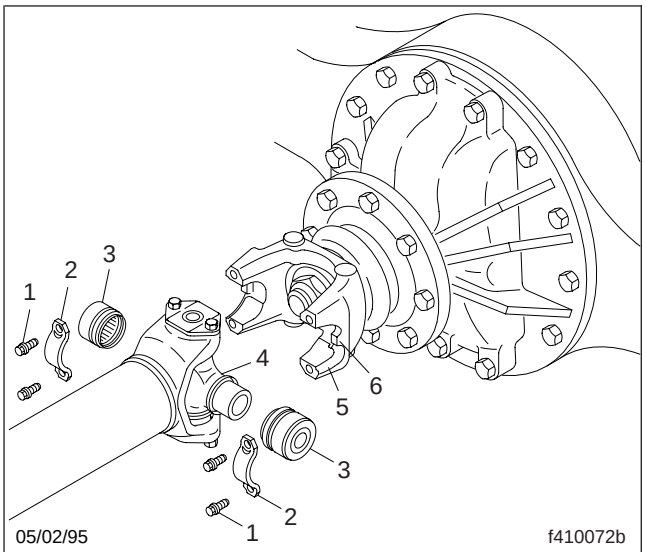
cross and bearing cups into the yoke cross-holes, then installing a snap ring into a groove in each cross-hole. See **Fig. 7**.



NOTE: Not all fasteners are shown.

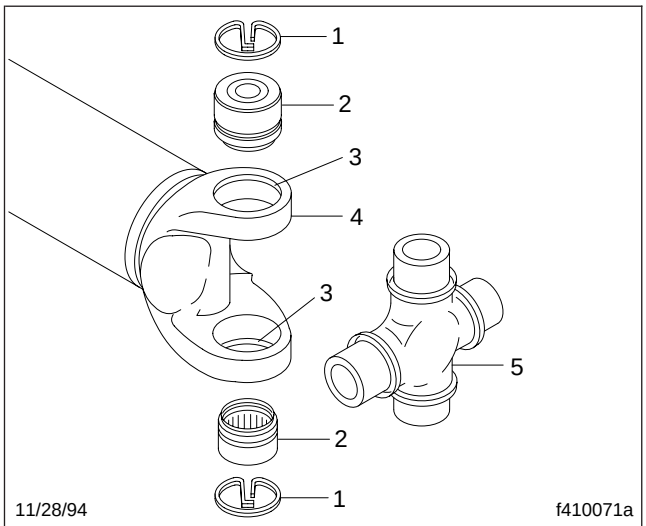
1. Parking Brake Drum
2. Companion Flange
3. 3/8–24 Threaded Stud
4. Companion-Flange Locknut
5. Half-Round Flange-Yoke
6. Bearing Washer
7. Flange-Yoke Locknut

Fig. 5, 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. 6, Coupling of a Spicer 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. 7, Installation of a Spicer SPL90 (1590) U-Joint in a Full-Round Yoke

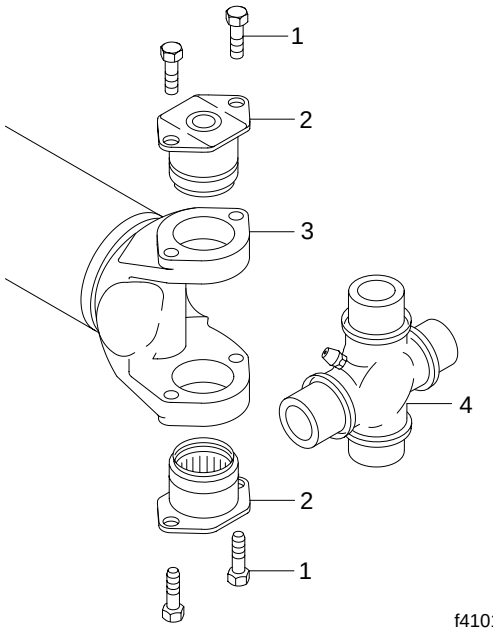
Spicer 1610, 1710, 1760, and 1810 U-joints are installed in full-round tube-yokes, sleeve-yokes, and end-yokes, by inserting the cross through from the inside of both yoke cross-holes, then installing the bearing cups into the outsides of the yoke and over the ends of the trunnions. Capscrews, inserted through a bearing plate at the back of each cup, thread into the yoke to secure the cups. The capscrews are self-locking. See **Fig. 8**.

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. 9**. Because the double oscillating motion of 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 by making U-joint working angles

General Information



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1. Bearing-Plate Self-Locking Capscrew
2. Bearing Cup (bearing-plate-type)
3. Full-Round Yoke
4. U-Joint Cross

Fig. 8, Installation of a Spicer 1610/1710/1760/1810 U-Joint in a Full-Round Yoke

at both ends of the driveshaft approximately equal, with the U-joints in phase. If the yoke lugs at both ends of the shaft are lying in the same plane (a plane which bisects the shaft lengthwise) the U-joints will be in phase. See **Fig. 10**.

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.

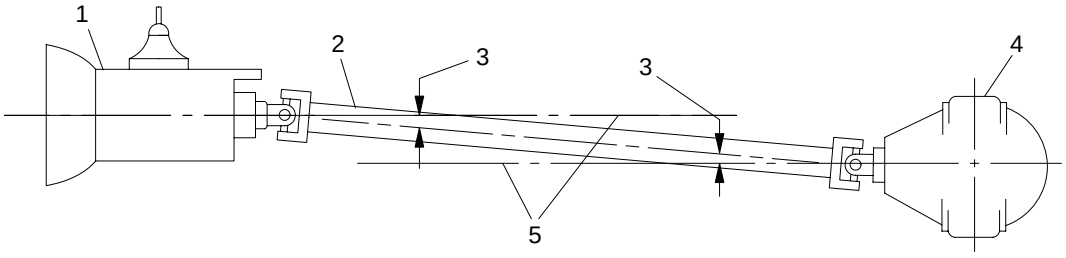
AVOIDING DRIVELINE PROBLEMS

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, or otherwise damaged. Operating a vehicle at speeds which exceed the speed of the driveshaft's design specifications will cause an out-of-balance vibration. Any condition which allows excessive movement of a driveshaft will cause driveline imbalance: loose end-yoke nuts, loose midship bearing mounts, loose U-joint bearing cup retaining capscrews, worn U-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.

To keep a vehicle operating smoothly and economically, the driveline must be carefully checked and lubricated at regular intervals. For inspection and lu-



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1. Transmission
2. No. 2 Driveshaft
3. U-Joint Working Angles
4. Rear Axle
5. Extended Centerlines

Fig. 9, U-Joint Working Angles

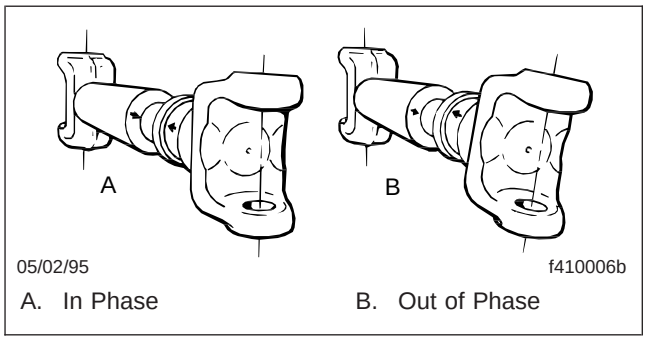


Fig. 10, U-Joint Phasing

brication intervals and procedures, see Group 41in the vehicle maintenance manual.

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)

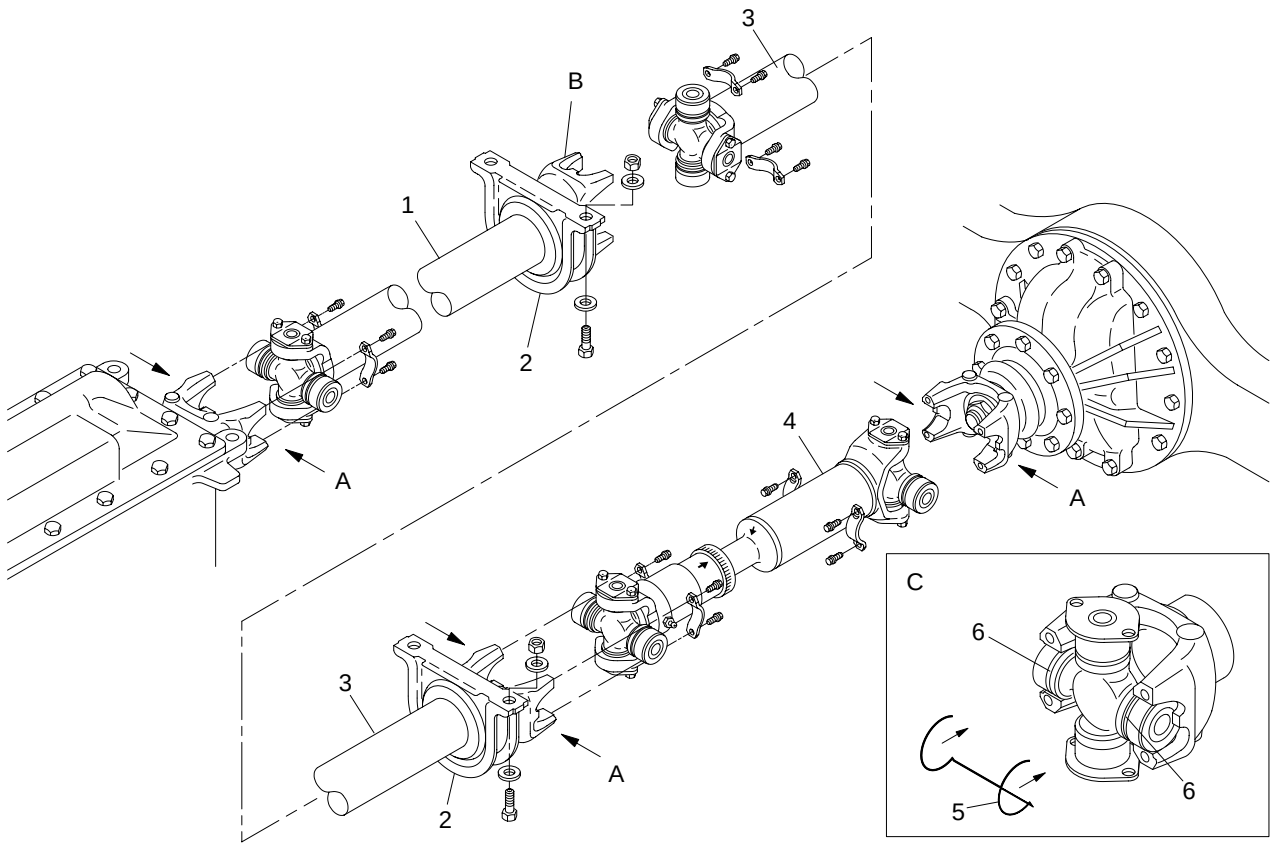
1. Check and clean the end-yoke.
   - 1.1 Check the torque on the end-yoke nut; see the applicable table in **Specifications, 400**.
   - 1.2 Check the end-yoke (or flange-yoke) cross-holes for burrs or raised metal. Using a half-round file, remove burrs or raised metal. See **Fig. 2**.
   - 1.3 Using 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



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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

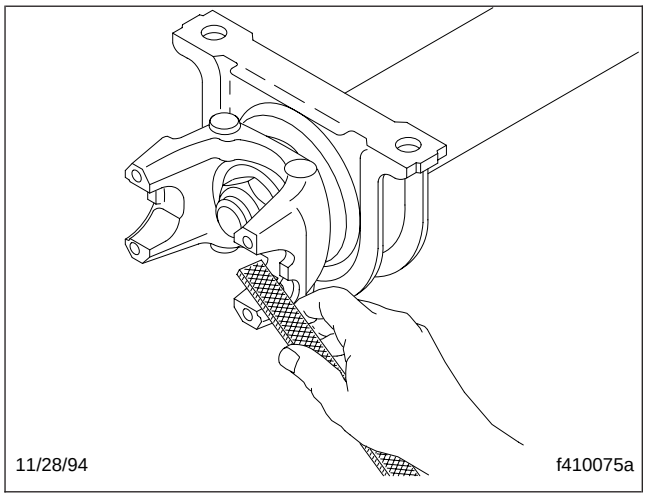
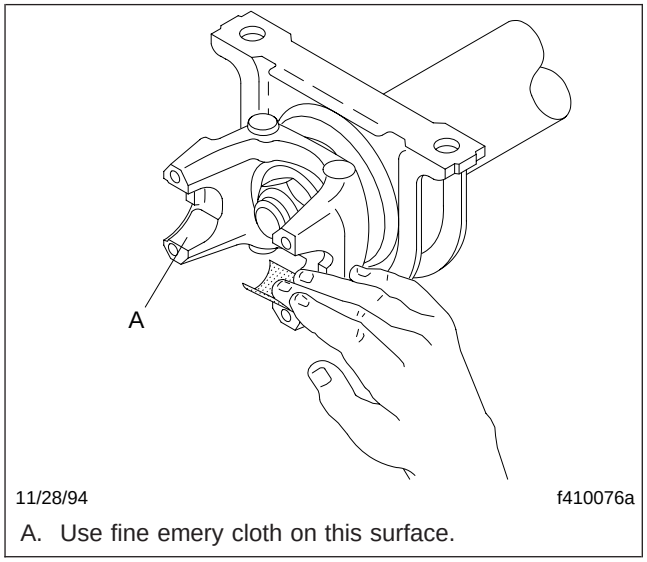


Fig. 2, Removing Burrs From a Half-Round End-Yoke Cross-Hole



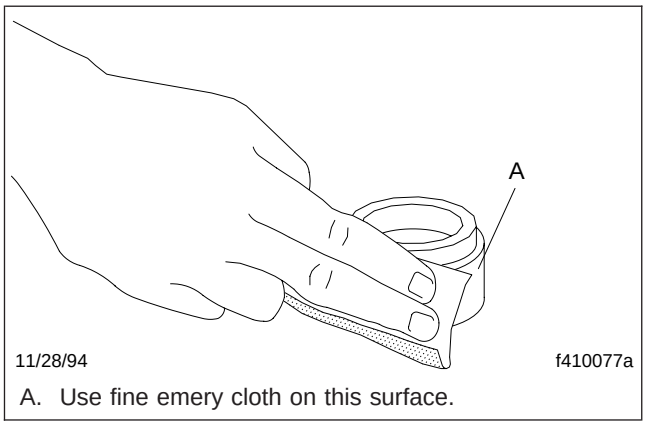
A. Use fine emery cloth on this surface.

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.

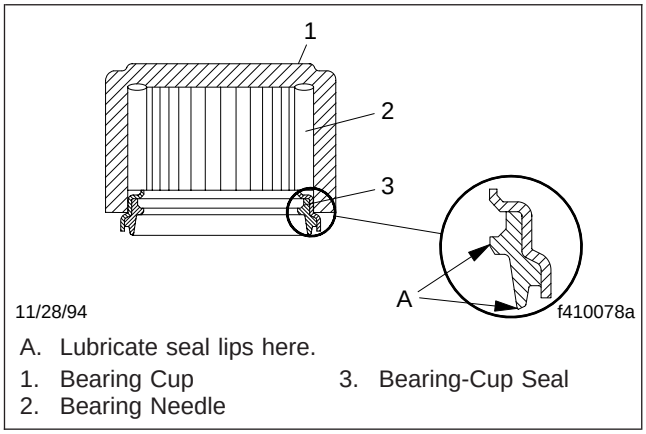
Separation of the driveline can also cause damage to the driveline, driveline components, or other areas of the vehicle.

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

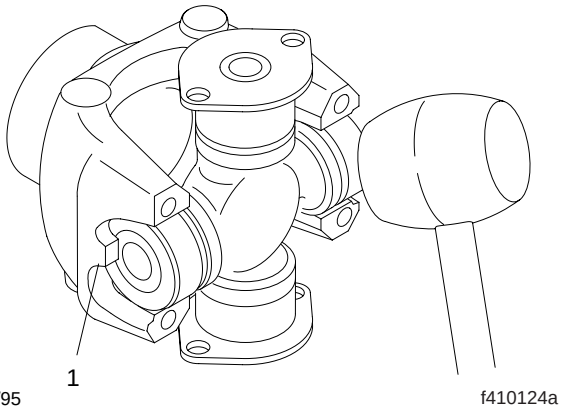


A. Lubricate seal lips here.
1. Bearing Cup
2. Bearing Needle
3. Bearing-Cup Seal

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 vehicle 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 (or flange-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. Remove and discard all four bearing-cup-plate self-locking capscrews.
5. Using one of the U-joint pullers listed in **Specifications 400**, remove both bearing assemblies from the end-yoke cross-holes. See **Fig. 2**.
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)

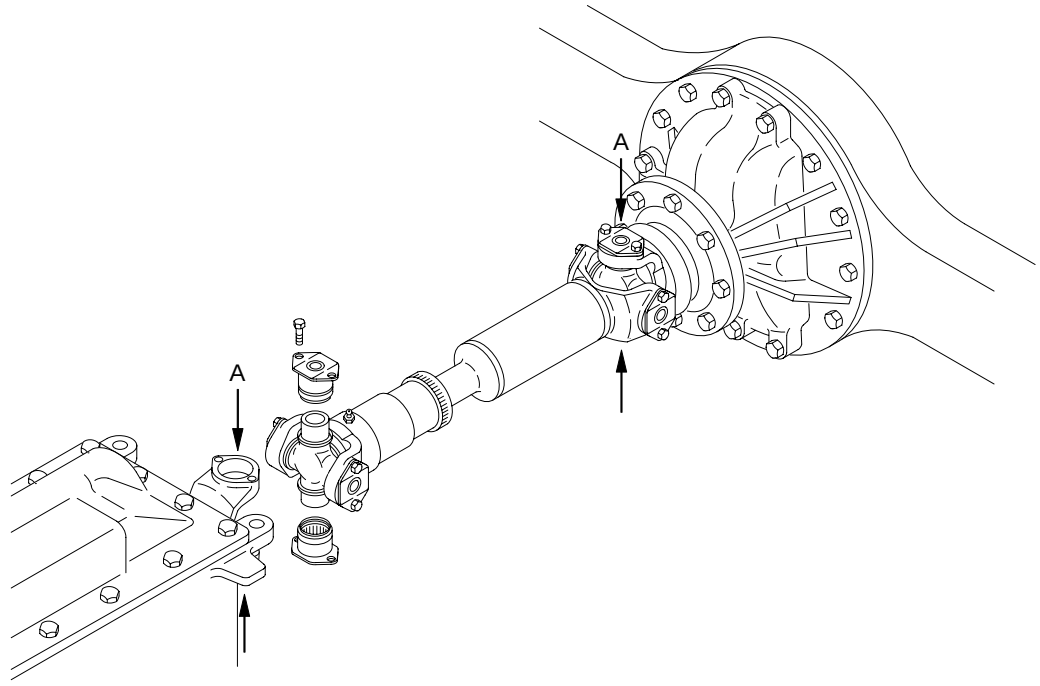
1. Check and clean the end-yoke.
   - 1.1 Check the torque on the end-yoke nut; see the applicable table in **Specifications 400**.
   - 1.2 Check the end-yoke (or flange-yoke) cross-holes for burrs or raised metal. Using a rat-tail or half-round file, remove burrs or raised metal. See **Fig. 3**.
   - 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. 4**.
   - 1.4 Using fine emery cloth, smooth and clean the entire surface of the yoke cross-holes. See **Fig. 5**.
   - 1.5 Turn the end-yoke (or flange-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. 6**.
   - 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. 7**.
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

U-Joint Uncoupling and Coupling With a Full-Round End-Yoke



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

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. 8**.

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. 9**.

3.4 Install *new* bearing-cup-plate self-locking capscrews (**Fig. 10**). 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 causing 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**.

U-Joint Uncoupling and Coupling With a Full-Round End-Yoke

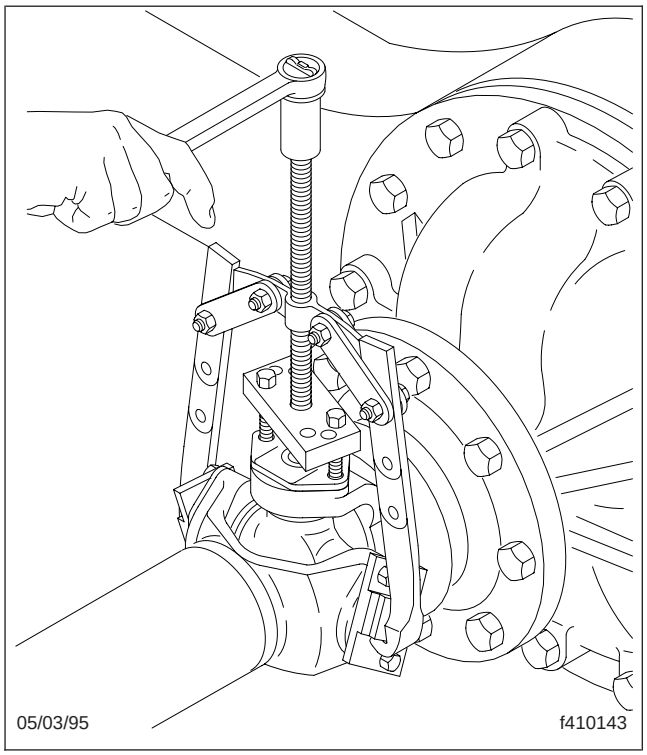


Fig. 2, Removing a Bearing Cup From a Full-Round End-Yoke

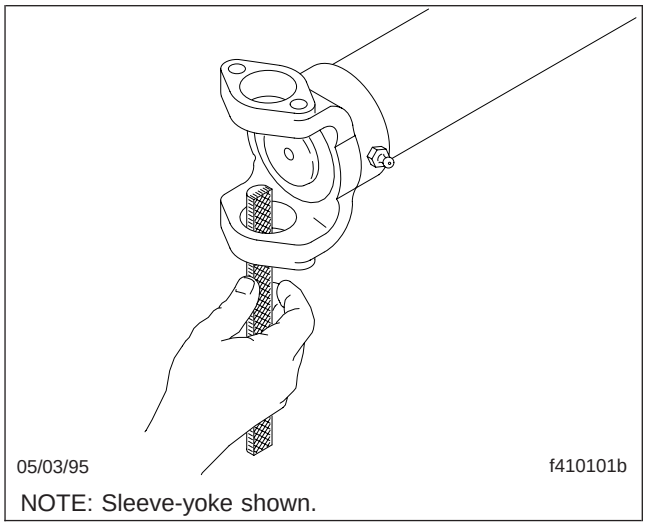


Fig. 3, Removing Burrs From a Full-Round Yoke Cross-Hole

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).

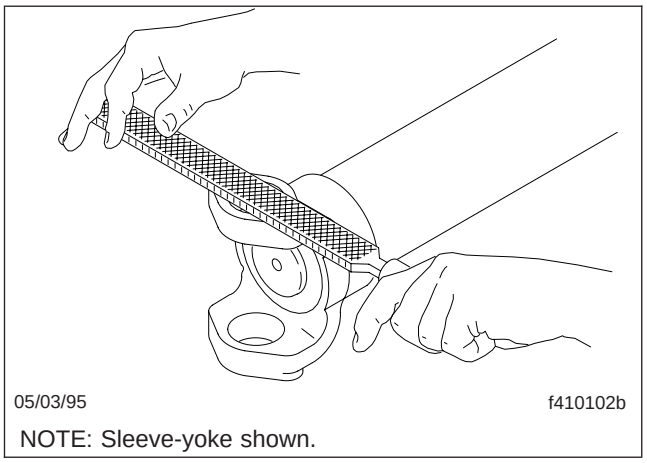


Fig. 4, Removing Burrs From the Machined Surface of a Full-Round Yoke Lug

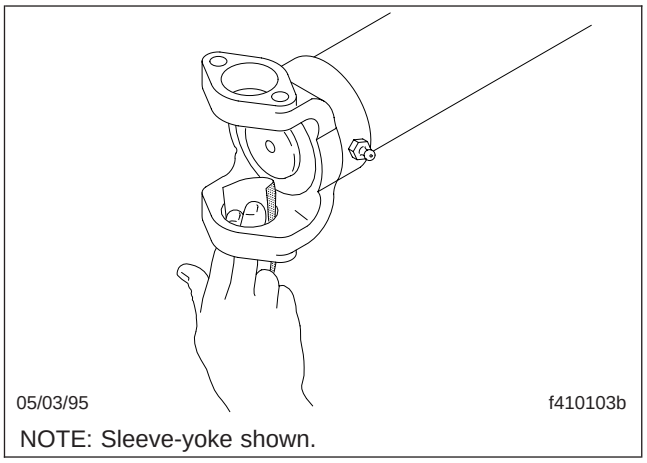


Fig. 5, Smoothing a Full-Round Yoke Cross-Hole

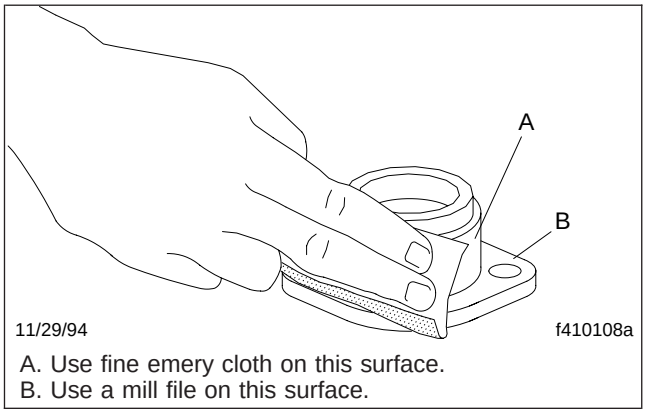
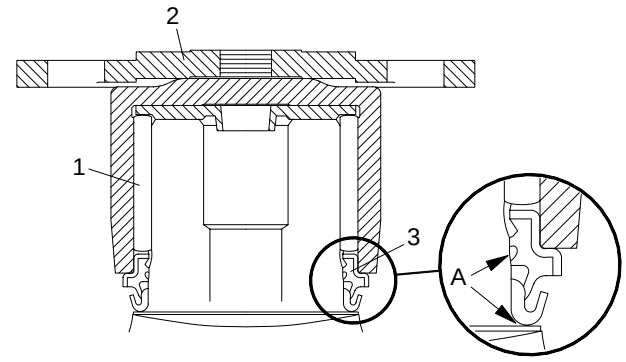


Fig. 6, Smoothing a Full-Round Yoke U-Joint Bearing Cup

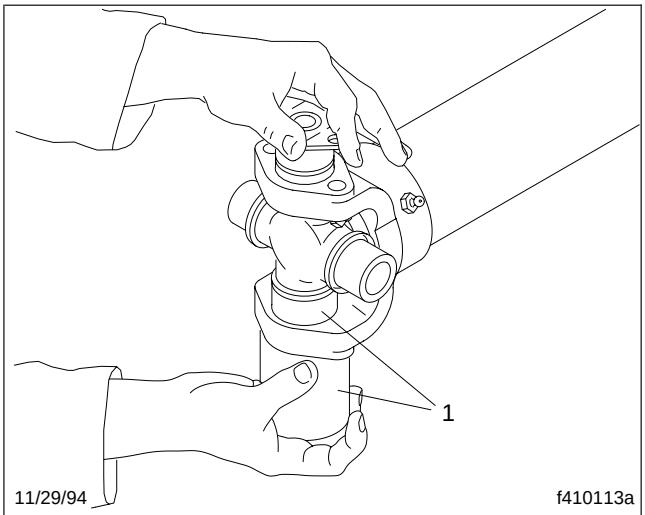
U-Joint Uncoupling and Coupling With a Full-Round End-Yoke



08/02/96 f410145a

A. Lubricate seal lips here.
1. Bearing Needle
2. Bearing-Cup Plate
3. Bearing-Cup Seal

Fig. 7, Sectional View of a Full-Round Yoke U-Joint Bearing Cup

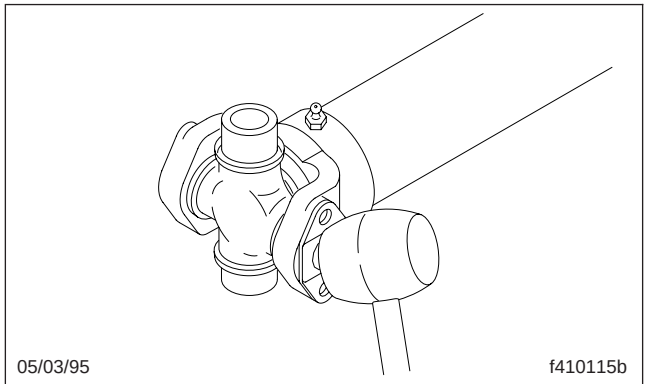


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NOTE: Sleeve-yoke shown.
1. Trunnion Locator

Fig. 8, Using a U-Joint Trunnion Locator

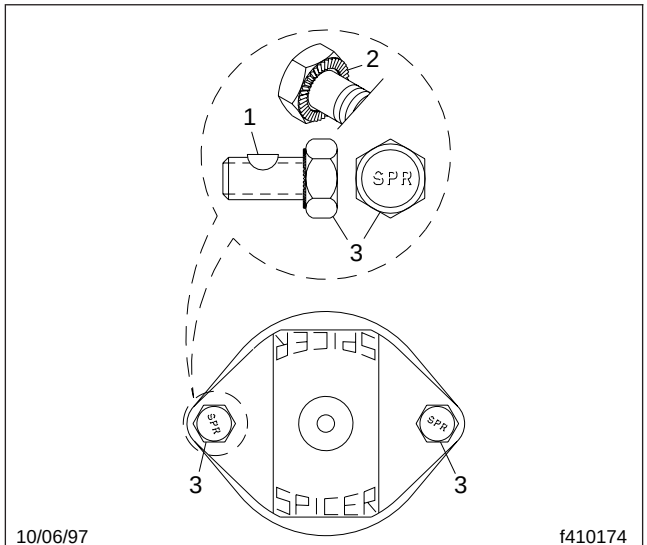
5. Lubricate the U-joint, following the procedure in Group 41 of the vehicle maintenance manual.
6. Remove the nylon support straps, then remove the chocks.



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NOTE: Sleeve-yoke shown.

Fig. 9, Seating a U-Joint Bearing Cup in a Full-Round Yoke



10/06/97 f410174

1. Lock Patch
2. Serrations
3. Self-Locking Capscrew

Fig. 10, Spicer U-Joint Fasteners for Full-Round Yokes

Driveshaft Removal and Installation

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.

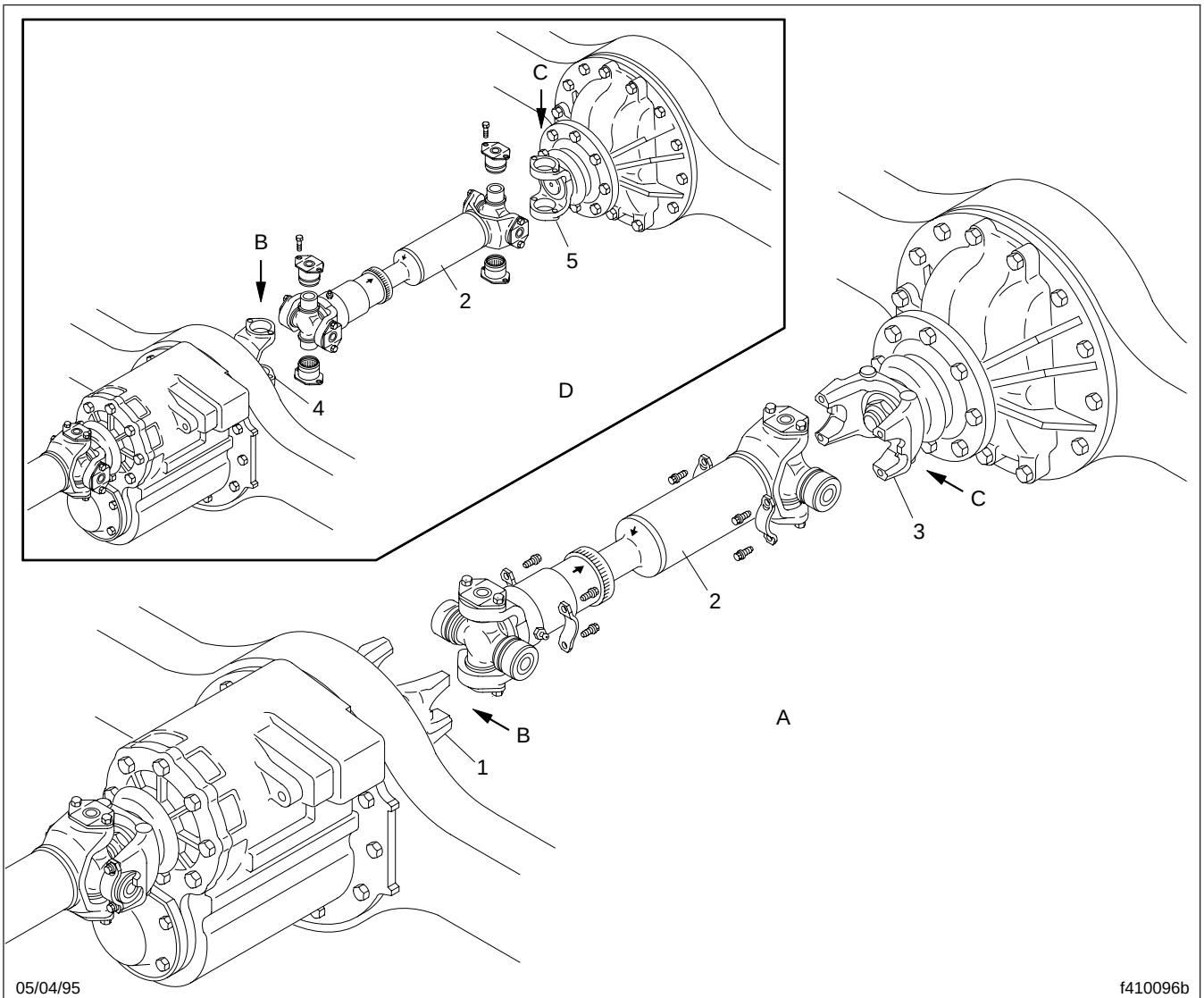
   If the no. 2 driveshaft is not being removed, use a nylon support strap to support its forward end.
2. For a vehicle with a Spicer SPL90 (1590) coupling shaft, use a marking stick or paint to mark the sleeve-yoke and coupling shaft with alignment marks, as shown in **Fig. 3**.

   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**.

4. Lift the intermediate coupling shaft out of the chassis.

Driveshaft Removal and Installation

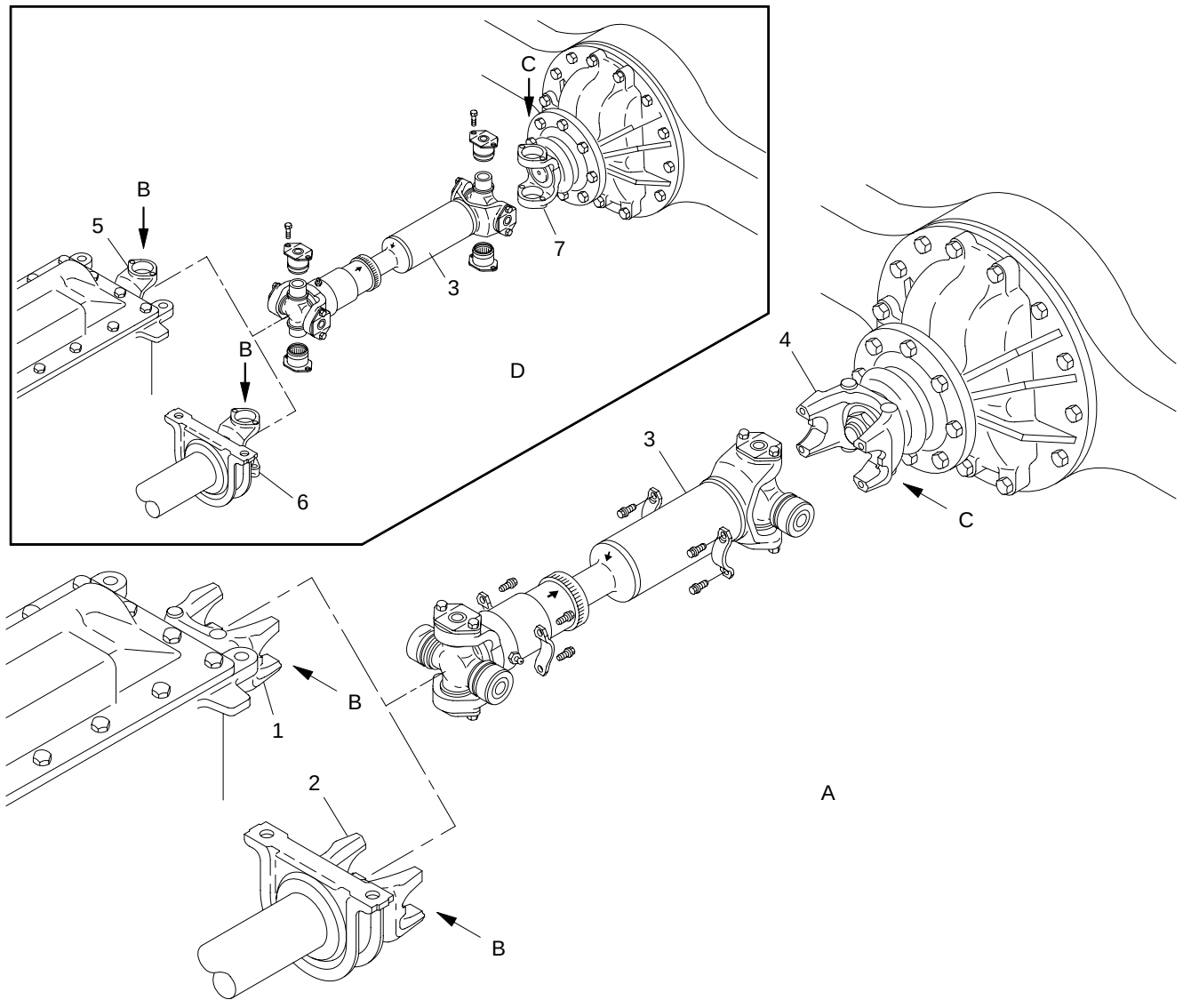


NOTE: Not all fasteners are shown.

A. No. 3 Driveshaft Coupled to Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
C. Uncouple this end first; couple this end last.
D. No. 3 Driveshaft Coupled to Full-Round End-Yokes

1. Forward-Rear Axle Output-Shaft Half-Round End-Yoke
2. No. 3 Driveshaft
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



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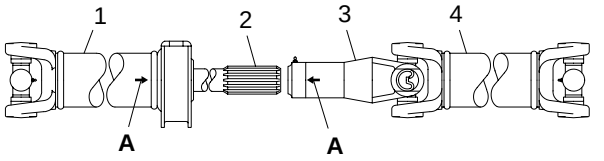
NOTE: Not all fasteners are shown.

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

Primary Coupling Shaft Removal (See Fig. 5)

1. *For a vehicle with one coupling shaft:*

   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)

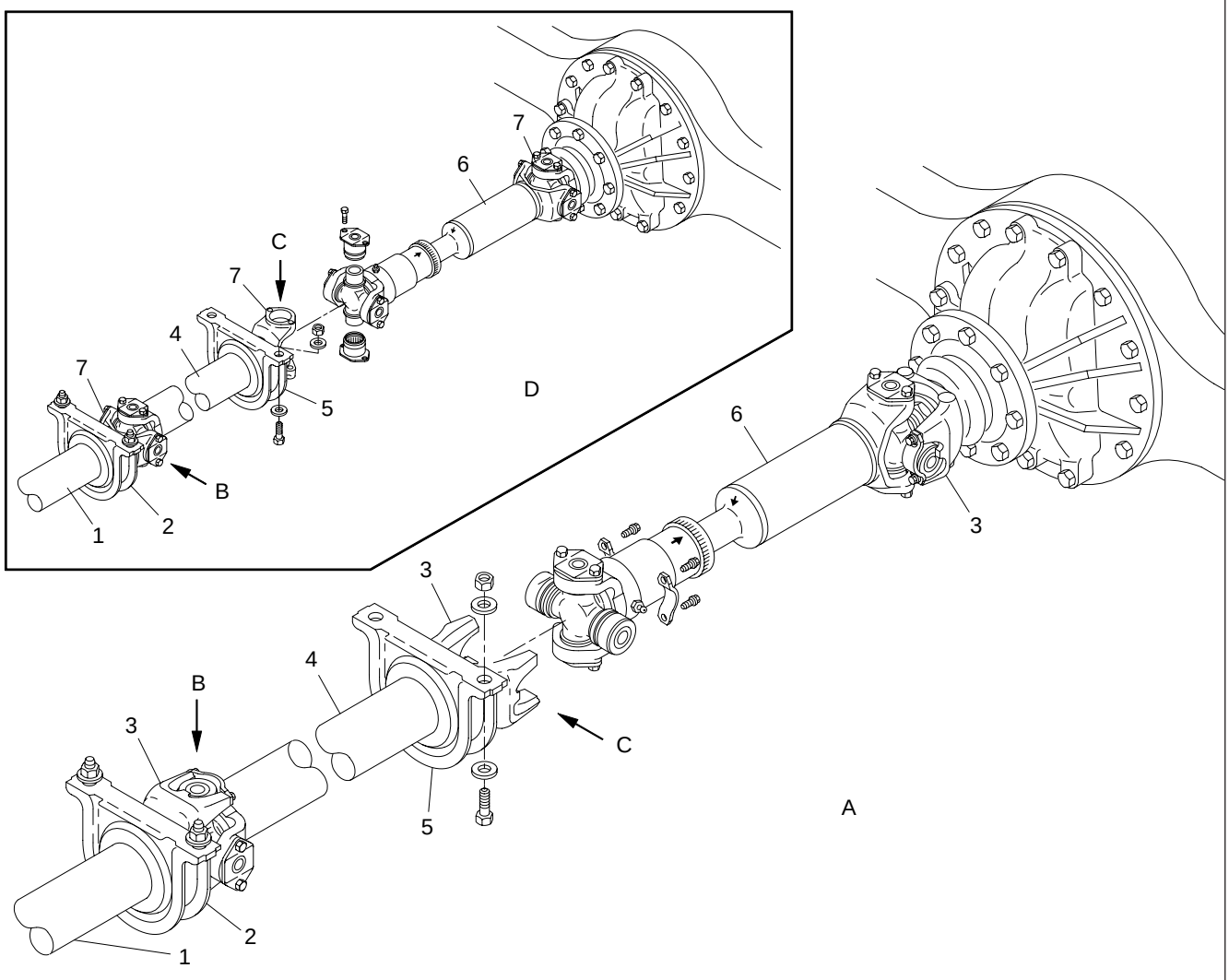
IMPORTANT: Before installing a coupling shaft that has a fixed end-yoke (not a splined reverse-slip shaft), make sure the yokes are aligned to keep the U-joints in phase; see **Fig. 6**.

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:*



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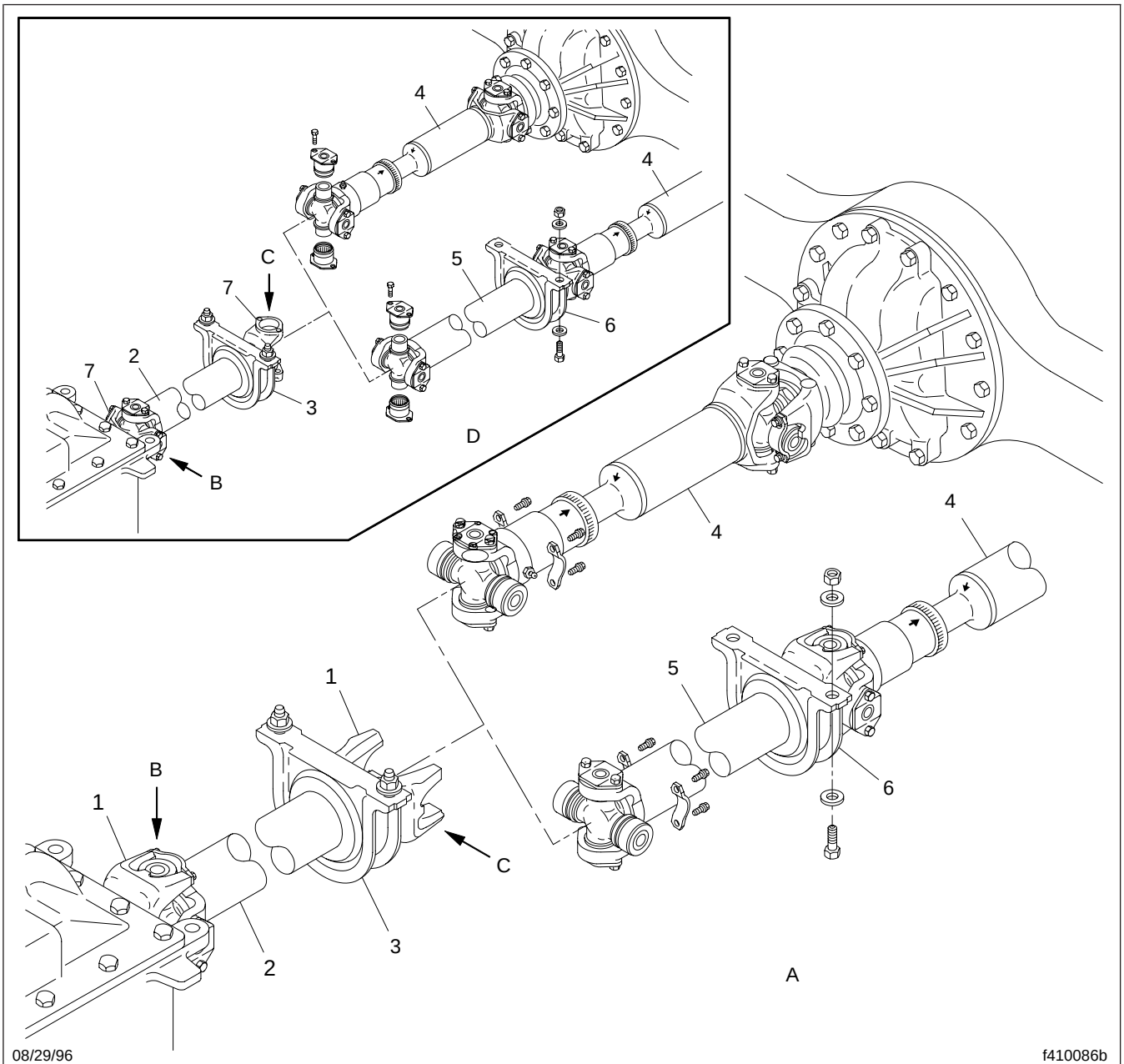
NOTE: Not all fasteners are shown.

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

Driveshaft Removal and Installation

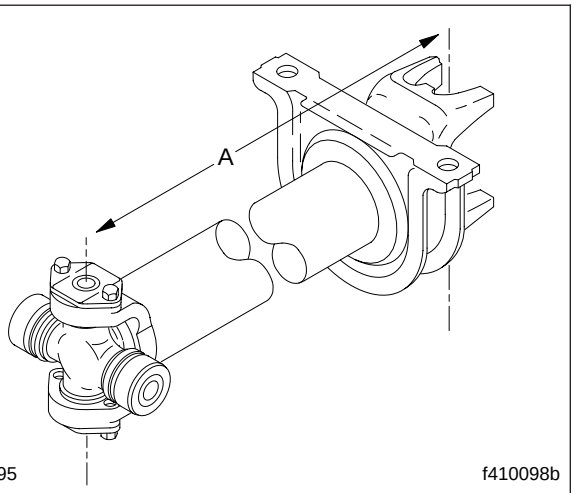


NOTE: Not all fasteners are shown.

A. No. 2 Driveline With Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
C. Uncouple this end first; couple this end last.
D. No. 2 Driveline With Full-Round End-Yokes

1. Half-Round End-Yoke
2. Primary Coupling Shaft
3. Primary Coupling Shaft Midship Bearing
4. No. 2 Driveshaft
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

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 procedure in **Subject 100**. If the primary coupling shaft has a full-round end-yoke, follow the coupling procedure in **Subject 110**.

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**.

1. If a primary coupling shaft was also removed, install it first, as instructed in this subject.
2. If an intermediate coupling shaft was also removed, install it before installing the no. 2 driveshaft.

Driveshaft Removal and Installation

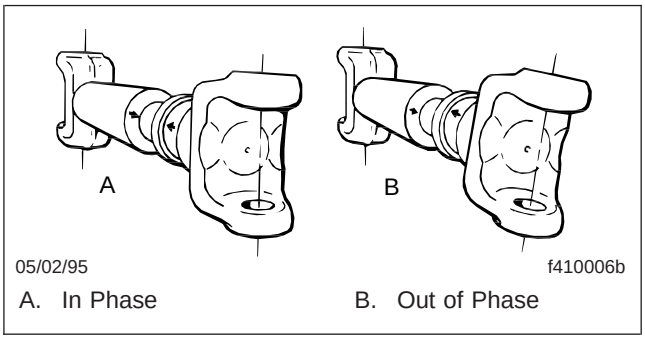


Fig. 7, U-Joint Phasing

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)

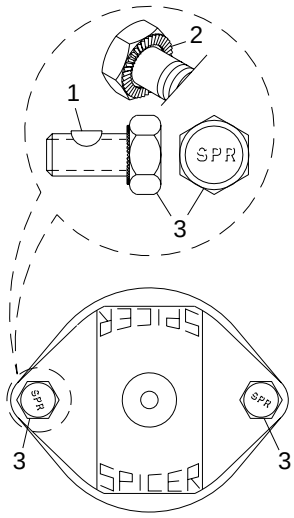
IMPORTANT: Before installing a no. 3 driveshaft, make sure the alignment marks on the slip-joint assembly are aligned, to keep the U-joints in phase; see **Fig. 7**.

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

Spicer 1610/1710/1760/1810 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. Remove and discard all four bearing-plate self-locking capscrews. See **Fig. 1**.



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1. Lock Patch
2. Serrations
3. Self-Locking Capscrew

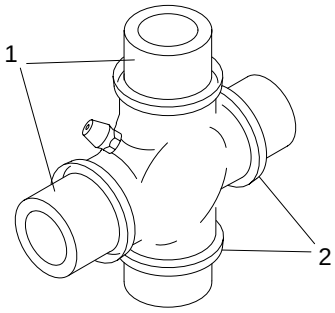
Fig. 1, Spicer U-Joint Fasteners for Full-Round Yokes

IMPORTANT: If the U-joint will be reinstalled, use care not to nick the cross trunnions or damage the slingers. See **Fig. 2**.

4. Using one of the U-joint pullers listed in **Specifications 400**, remove both bearing cups from the yoke cross-holes. See **Fig. 3**. Remove the cross from the yoke.

Spicer SPL90 (1590) U-Joint Removal

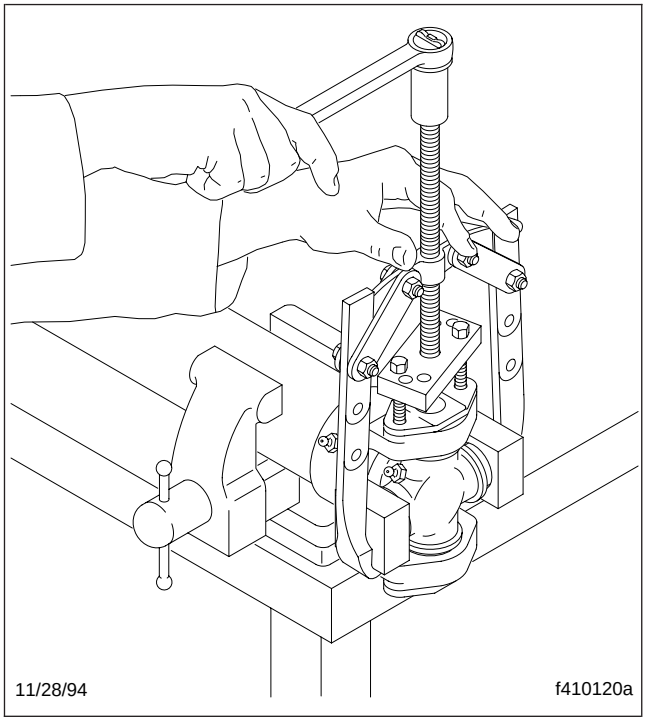
1. Remove the driveshaft from the vehicle; see **Subject 110**.
2. Clamp the driveshaft in a soft-jawed vise; do not distort the tube with excessive grip.



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1. Trunnions
2. Slingers

Fig. 2, U-Joint Cross

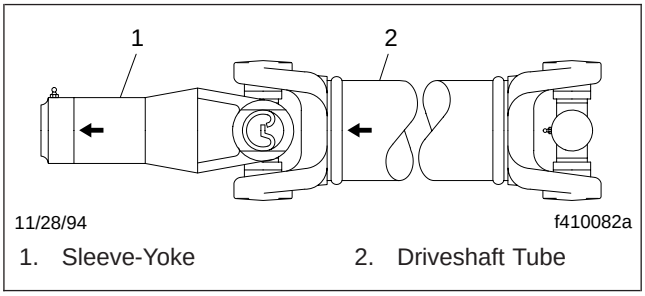


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Fig. 3, Removing a Bearing Cup From a Full-Round Yoke

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. 4**.

Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly



1. Sleeve-Yoke 2. Driveshaft Tube

Fig. 4, Spicer SPL90 (1590) No. 2 Driveshaft (as used with a coupling shaft)

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. 5**. Tap the bearing only hard enough to break the assembly away from the snap ring.

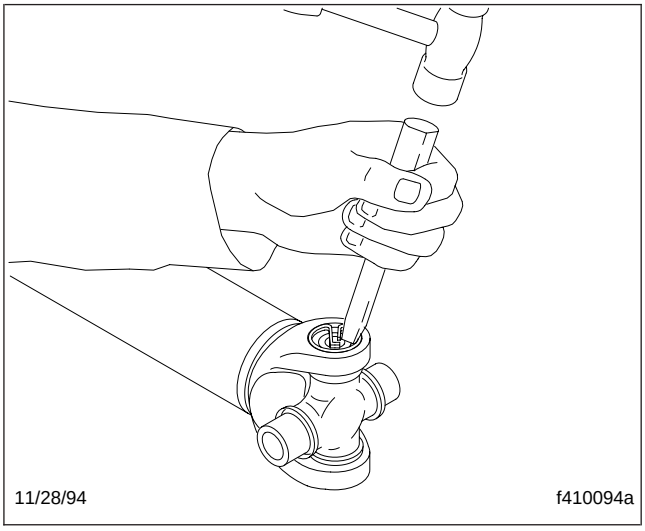


Fig. 5, Loosening a Spicer SPL90 (1590) U-Joint Snap Ring

   3.2 Using pliers, remove the snap ring. See **Fig. 6**.

   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. 7**.

   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. 7**.

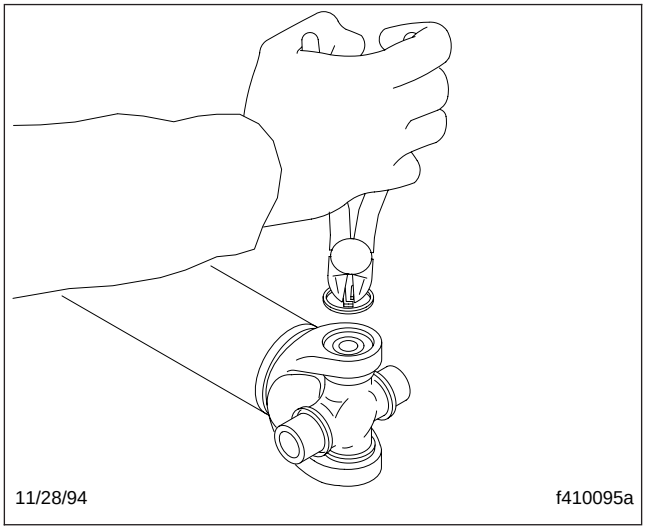


Fig. 6, Removing/Installing a Spicer SPL90 (1590) U-Joint Snap Ring

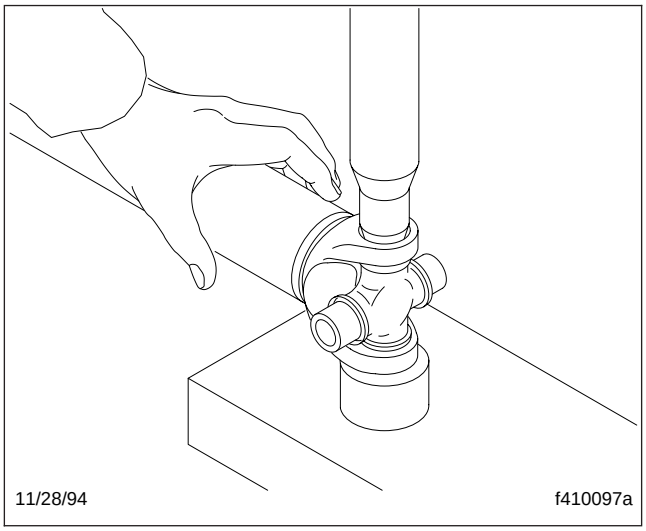


Fig. 7, Pressing a Spicer SPL90 (1590) U-Joint Out-of/ Into a Yoke

   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.

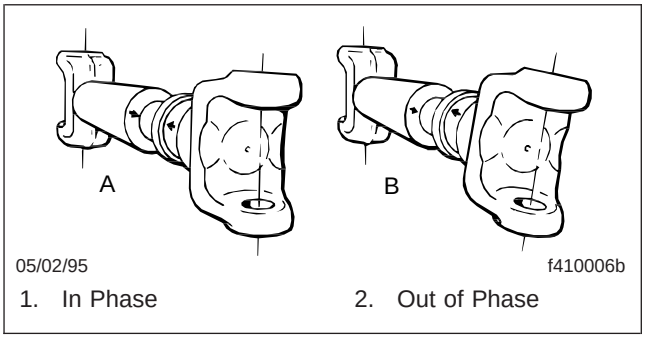
Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly

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.

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. 8**. Using a marking stick or paint, mark the sleeve-yoke and splined shaft with alignment marks, as shown in **Fig. 9**. This will ensure proper alignment of the slip-joint components when the driveshaft is assembled.

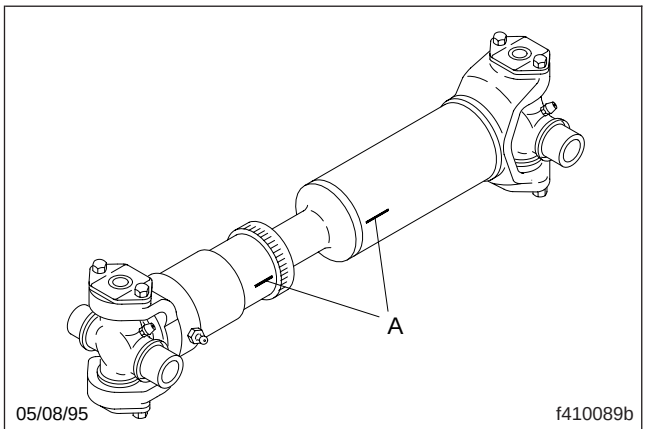


1. In Phase
2. Out of Phase

Fig. 8, U-Joint Phasing

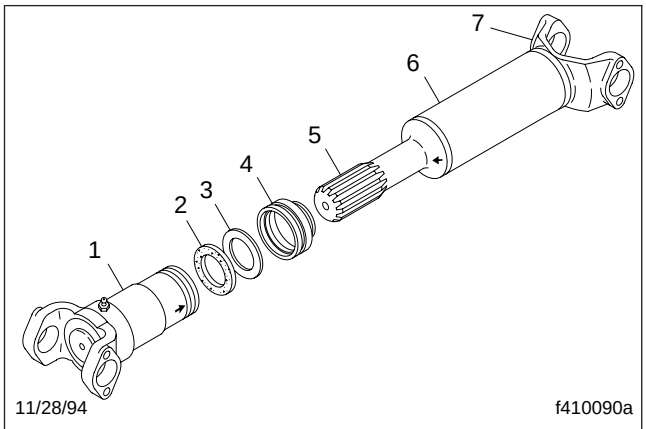
IMPORTANT: Misaligned driveshaft yokes will cause the U-joints to be out of phase, which will cause vibration in the driveline.

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. 10**.



A. Use a marking stick or paint to add alignment marks.

Fig. 9, 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. 10, 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

Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly

a full-round yoke), or remove the driveshaft from the vehicle (**Subject 120**).

2. Remove the end-yoke locknut. See **Fig. 11**.

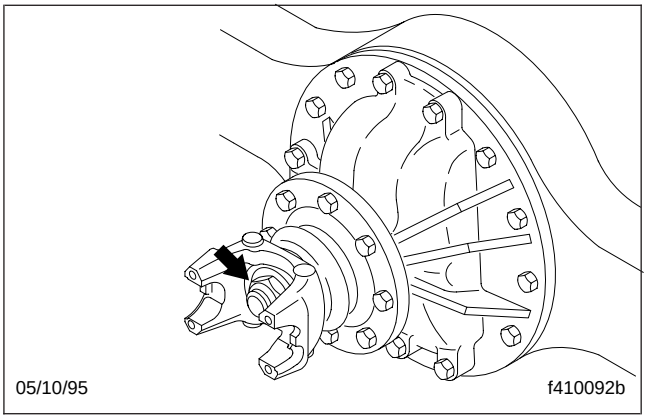


Fig. 11, Axle End-Yoke Locknut

3. Using a yoke puller, remove the end-yoke. See **Fig. 12** for a half-round end-yoke, or **Fig. 13** for a full-round end-yoke.

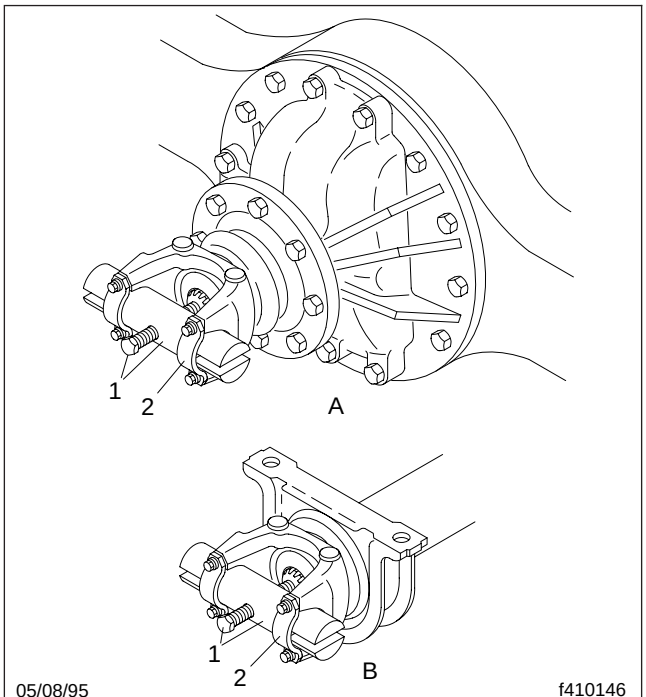
Coupling Shaft End-Yoke and Midship Bearing Removal

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. 14**), 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. 15**), use a hammer and a brass drift to remove the midship bearing and slingers. See **Fig. 16**.
4. If the coupling shaft has an end-yoke, remove the end-yoke; see **Fig. 12** for a half-round end-yoke, or **Fig. 13** for a full-round end-yoke. Then, remove the midship bearing and slingers; see **Fig. 16**.

   4.1 Use a marking stick or paint to mark the end-yoke and coupling shaft with alignment marks. See **Fig. 14**.

   4.2 Remove the coupling shaft end-yoke locknut.



A. Axle End-Yoke
B. Coupling Shaft End-Yoke

1. Yoke Puller
2. Bearing Strap

Fig. 12, Removing a Half-Round End-Yoke

   4.3 Using a yoke puller, remove the end-yoke. See **Fig. 12** for a half-round end-yoke, or **Fig. 13** for a full-round end-yoke.

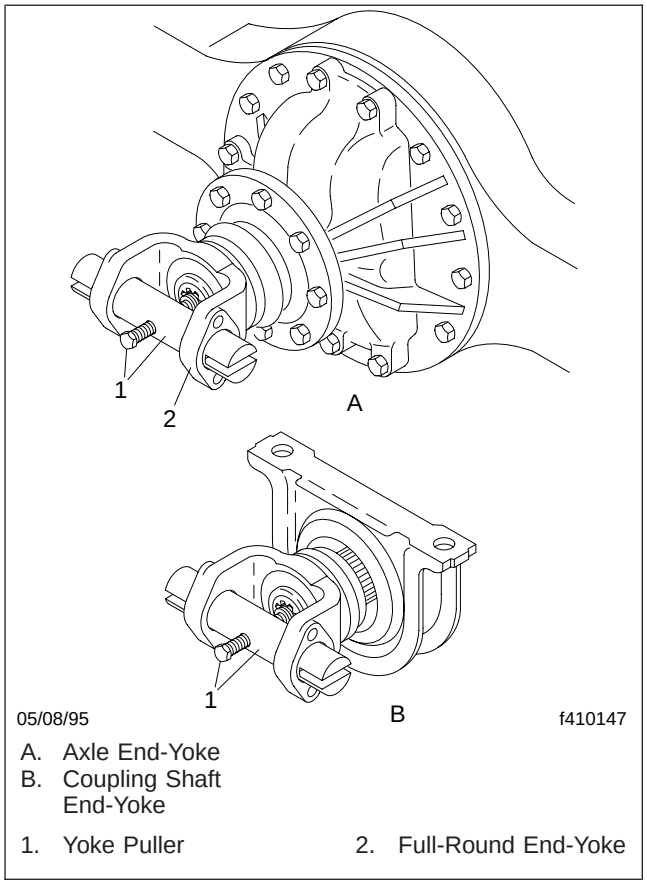
   4.4 Use a hammer and a brass drift to remove the midship bearing and slingers. See **Fig. 16**.

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.

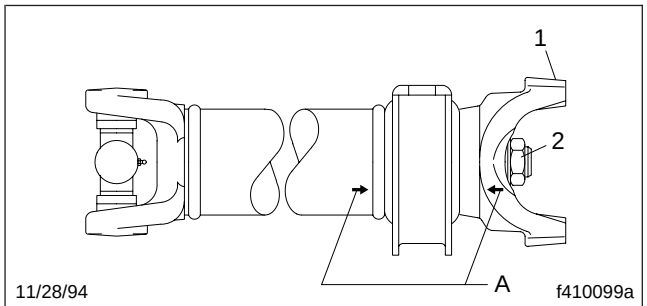
   Replace the driveshaft tube if damaged; see "Driveshaft Tube, Stub Shaft (Slip-Joint), or

Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly



A. Axle End-Yoke
B. Coupling Shaft End-Yoke
1. Yoke Puller
2. Full-Round End-Yoke

Fig. 13, 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. 14, Alignment Marks on a Coupling Shaft With an End-Yoke

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.

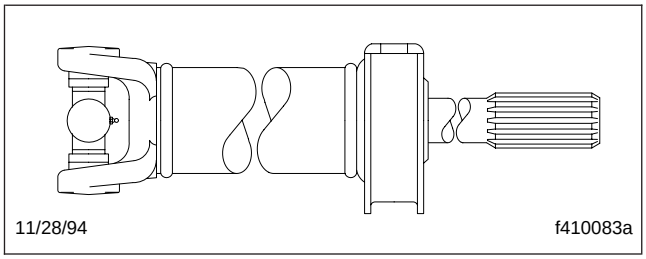
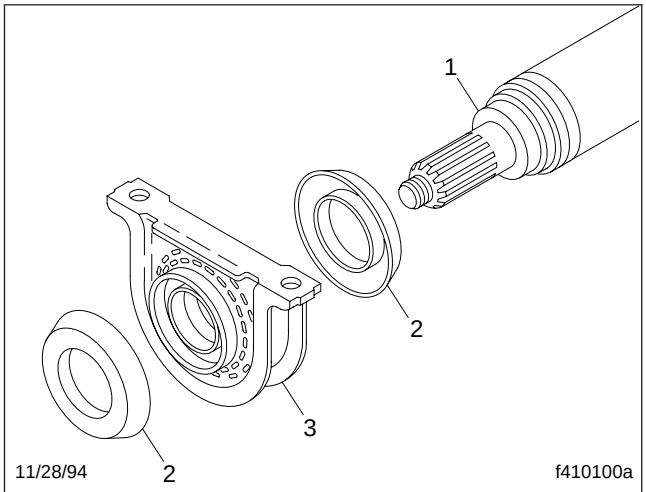


Fig. 15, Spicer SPL90 (1590) Coupling Shaft With a Splined Reverse-Slip Shaft



1. Midship Bearing Shaft
2. Slinger
3. Midship Bearing

Fig. 16, Midship Bearing and Slingers

3. Clean the slip-joint (male and female) splines, then check them for twisting and galling. See **Fig. 17**. 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.
4. Check for a loose or missing sleeve-yoke plug. See **Fig. 18**. 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. 19**.

Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly

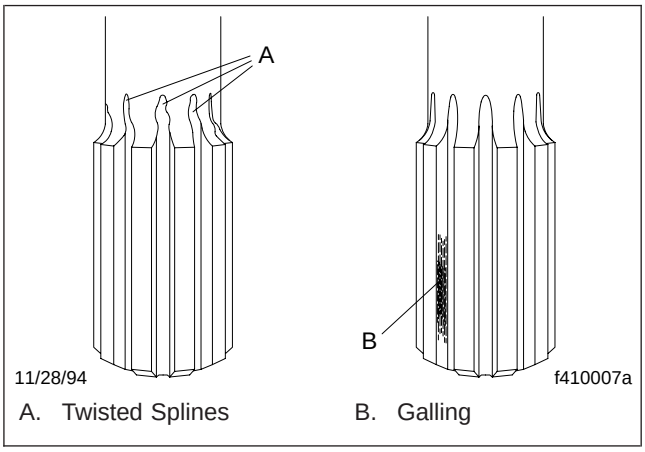


Fig. 17, Damaged Slip-Joint Splines

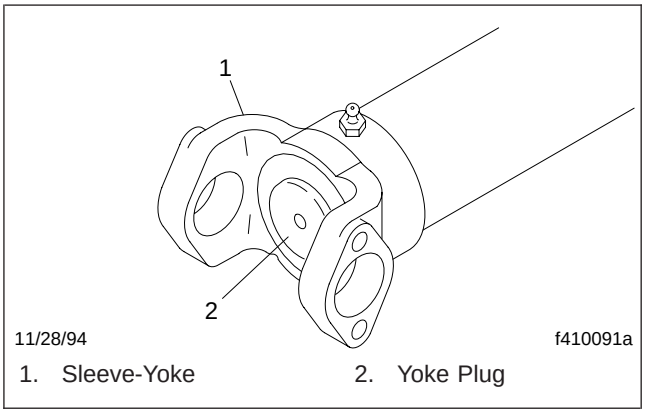


Fig. 18, Sleeve-Yoke Plug

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. 20**.
7. Using fine emery cloth, smooth and clean the entire surface of all driveshaft yoke cross-holes. See **Fig. 21**.

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.

IMPORTANT: Do not immerse the midship bearing in cleaning solvent. The solvent will wash

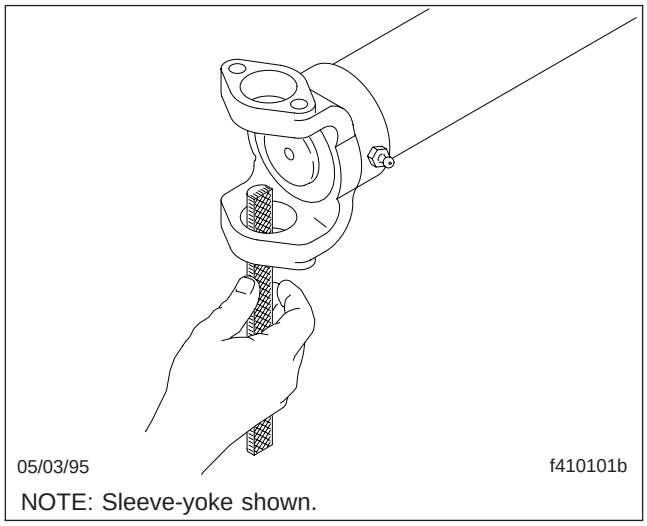


Fig. 19, Removing Burrs From a Full-Round Yoke Cross-Hole

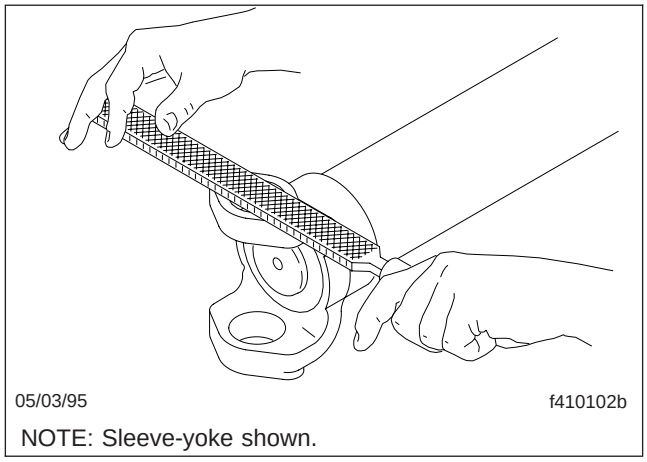
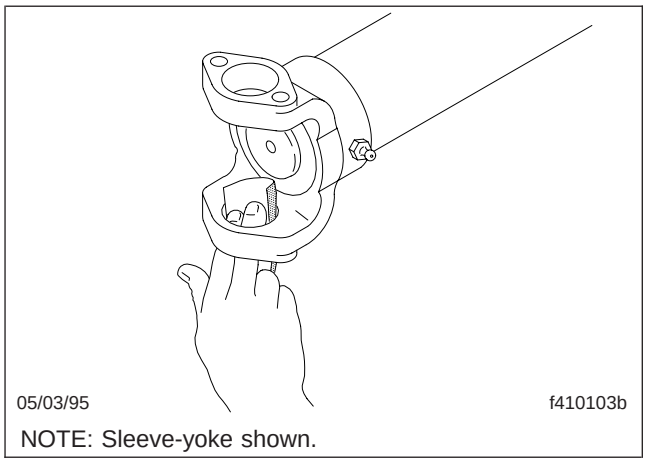


Fig. 20, Removing Burrs From the Machined Surface of a Full-Round Yoke Lug

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



NOTE: Sleeve-yoke shown.

Fig. 21, Smoothing a Full-Round Yoke Cross-Hole

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 **Specifications 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. 19** for full-round yokes, or **Fig. 22** for half-round yokes.
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. 20**.
4. Smooth and clean the entire surface of all end-yoke cross-holes, using fine emery cloth. See

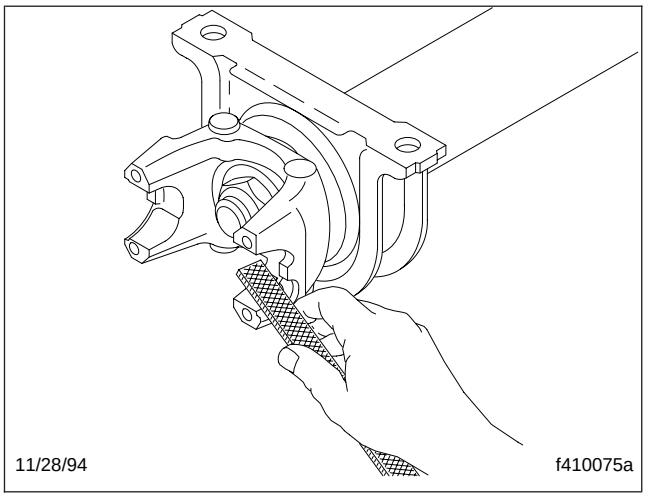
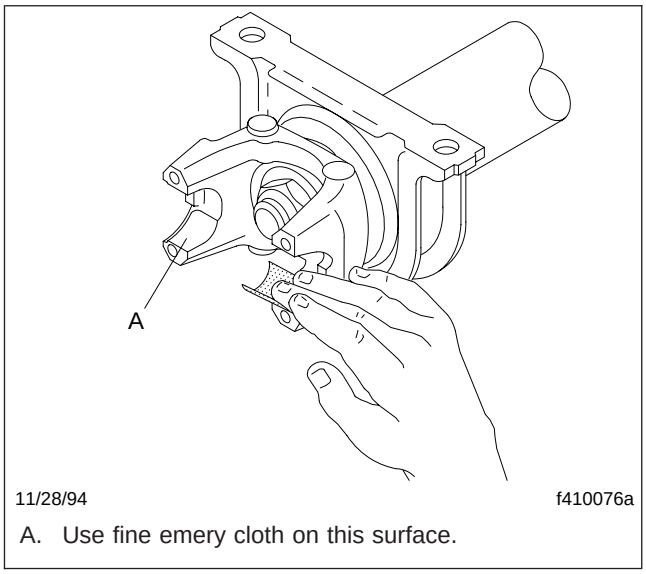


Fig. 22, Removing Burrs From a Half-Round End-Yoke Cross-Hole

Fig. 21 for full-round yokes, or **Fig. 23** for half-round yokes.



A. Use fine emery cloth on this surface.

Fig. 23, Smoothing a Half-Round End-Yoke Cross-Hole

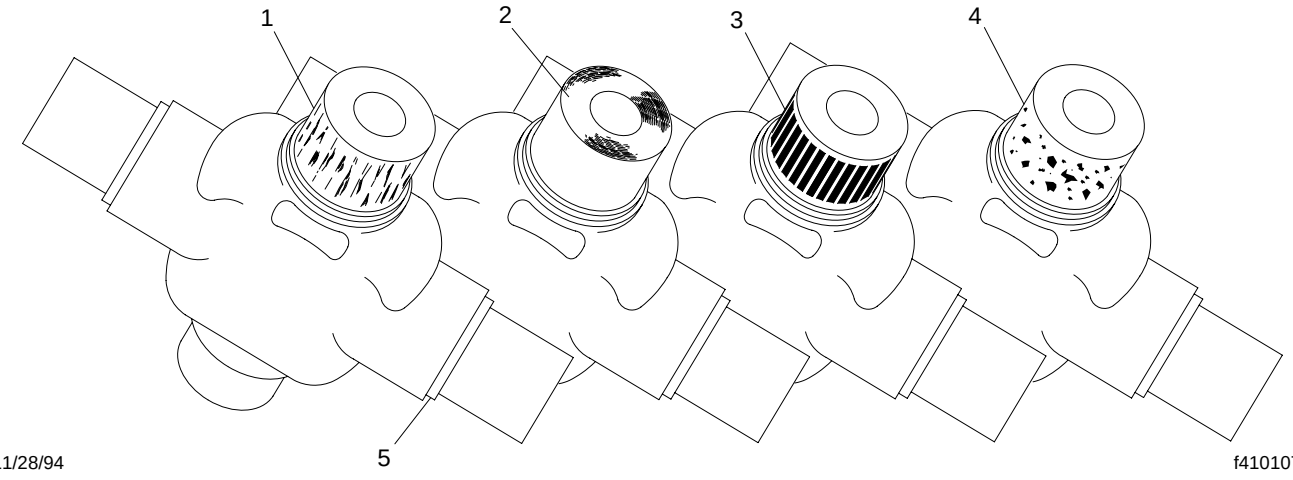
U-Joint Cleaning and Inspection

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

Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly

metal), end galling (displacement of metal), brinelling (grooves caused by bearing needles), and pitting (small craters caused by corrosion). See **Fig. 24**. If damaged, replace the U-joint assembly.

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.



1. Spalling
2. End Galling
3. Brinelling
4. Pitting
5. Slinger

Fig. 24, Damaged U-Joint Crosses

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. 25**. 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 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. 26** for a half-round-yoke U-joint bearing cup, or **Fig. 27** 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
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. 28**.
7. Using fine emery cloth, smooth and clean the outside surfaces of all bearing cups. See **Fig. 28** and **Fig. 29**.

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. 30**), 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.

Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly

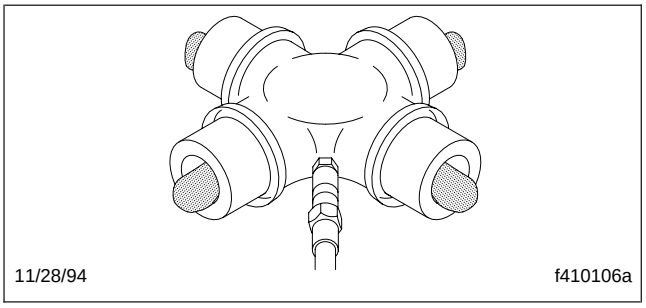
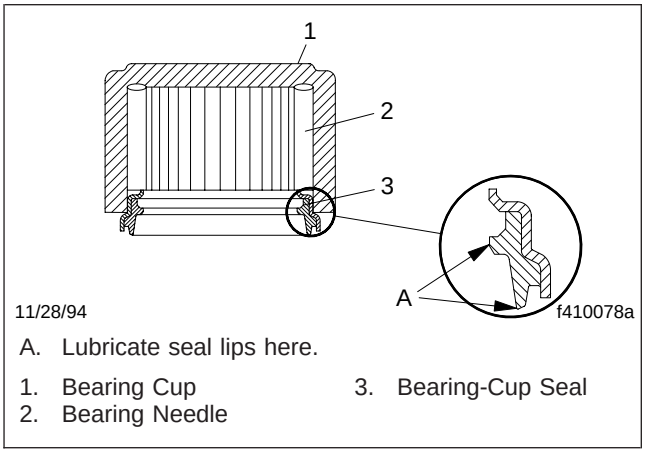


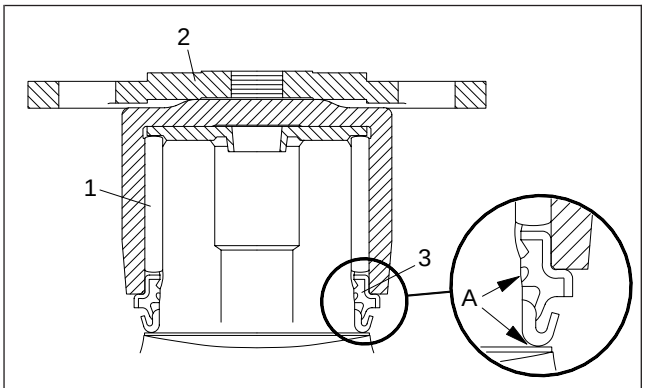
Fig. 25, Forcing Out Old Lubricant From a U-Joint Cross



A. Lubricate seal lips here.

1. Bearing Cup
2. Bearing Needle
3. Bearing-Cup Seal

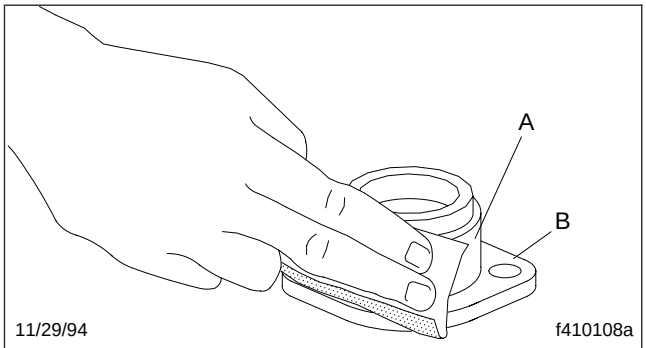
Fig. 26, Sectional View of a Half-Round End-Yoke U-Joint Bearing Cup



A. Lubricate seal lips here.

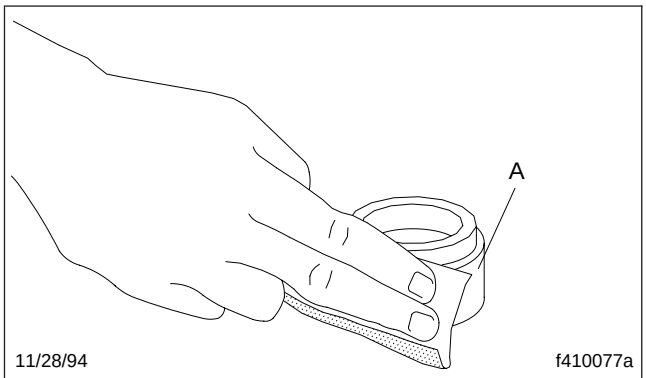
1. Bearing Needle
2. Bearing-Cup Plate
3. Bearing-Cup Seal

Fig. 27, Sectional View of a Full-Round Yoke U-Joint Bearing Cup



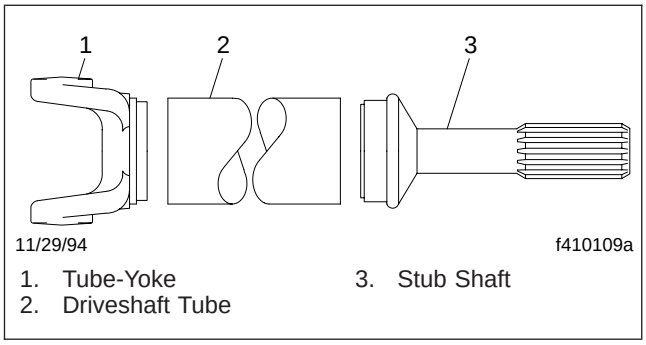
A. Use fine emery cloth on this surface.
B. Use a mill file on this surface.

Fig. 28, Smoothing a Full-Round Yoke U-Joint Bearing Cup



A. Use fine emery cloth on this surface.

Fig. 29, Smoothing a Half-Round Yoke U-Joint Bearing Cup



1. Tube-Yoke
2. Driveshaft Tube
3. Stub Shaft

Fig. 30, Driveshaft Tube, Stub Shaft, and Tube-Yoke

Runout limits for a new (rebuilt) driveshaft (**Fig. 31**) are:

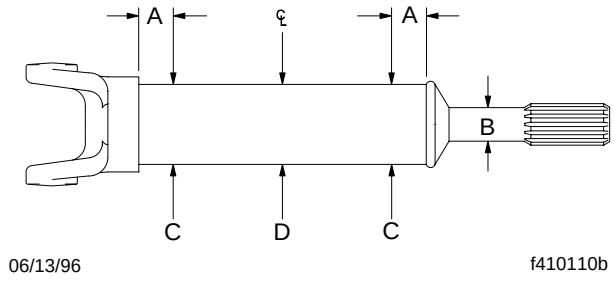
Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly

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.



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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. 31, Driveshaft Runout Specifications

Slip-Joint 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 slip-joint dust cap, and (if so equipped) steel washer and cork seal, over the splined shaft. See **Fig. 10**.
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. 8** and **Fig. 9**.

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.

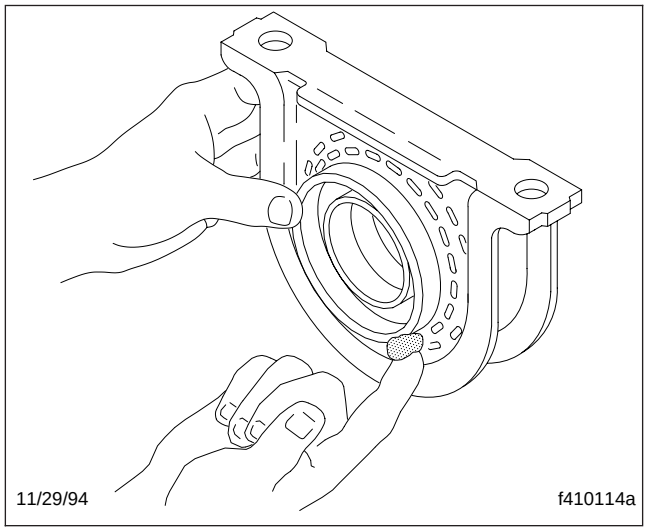
4. Using a strap wrench, tighten the slip-joint dust cap. Use only enough torque to seat the steel washer and cork seal (if so equipped) snug against the end of the sleeve-yoke; do not overtighten.

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. 32**.



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Fig. 32, Greasing a Midship Bearing

NOTE: 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.
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. 15**.

   If the coupling shaft has an end-yoke, install the end-yoke. See **Fig. 14**.

   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. 14**.

   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 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. 8** and **Fig. 9**.

   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. 14**.

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. 26** for a half-round-yoke U-joint bearing cup, or **Fig. 27** for a full-round-yoke U-joint bearing cup.

⚠ 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. 25**.

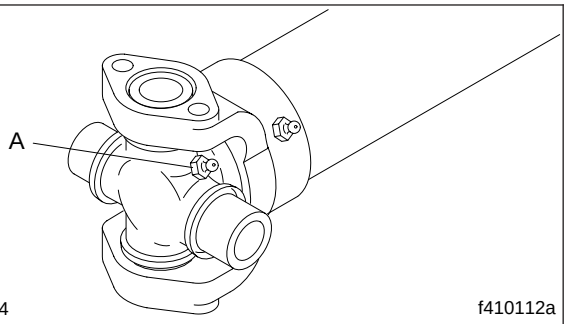
   3.3 Wipe a heavy coating of the same grease on the needles and the inside end of each bearing cup; then, using a light-weight oil, lubricate the lips of the bearing-cup seals. See **Fig. 26** for a half-round-yoke U-joint bearing cup, or **Fig. 27** for a full-round-yoke U-joint bearing cup.

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

Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly

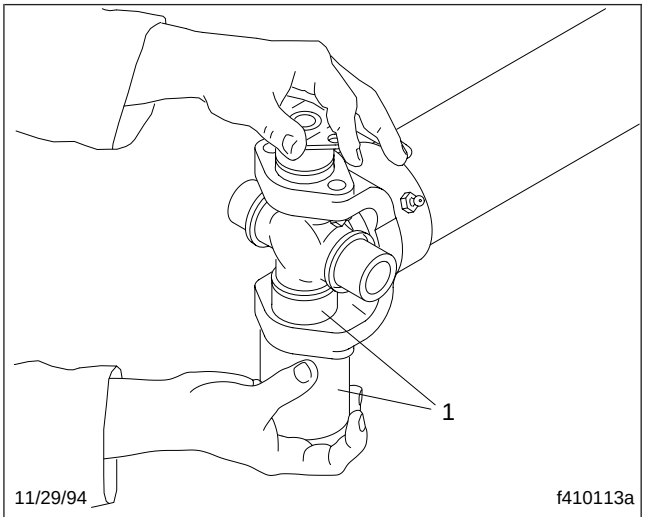
the driveshaft, and aligns with the grease fitting on the sleeve-yoke (if so equipped). See **Fig. 33**.



A. Install cross with grease fitting pointing toward driveshaft, and aligned with sleeve-yoke grease fitting.

Fig. 33, U-Joint Grease Fitting Positioning

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 **Specifications 400**), hold the trunnions 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. 34**.



NOTE: Sleeve-yoke shown.

1. Trunnion Locator

Fig. 34, 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. 35**.

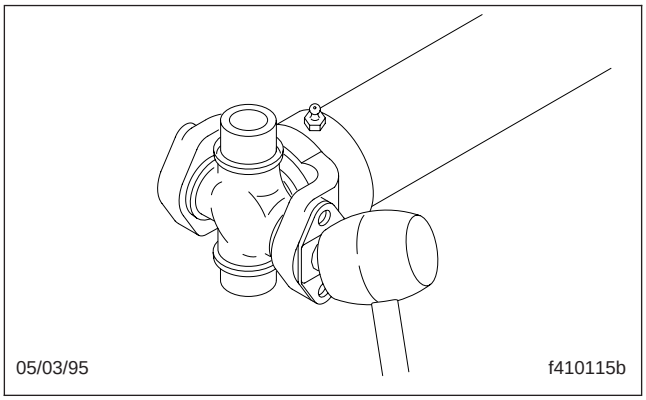


Fig. 35, Seating a U-Joint Bearing Cup In a Full-Round Yoke

4.4 Install *new* bearing-cup-plate self-locking capscrews. See **Fig. 1**. 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 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 60 lbf·in (678 N·cm), to the applicable torque value in **Specifications 400**.

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. 8** and **Fig. 9**.

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. 4**.

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. 14**.

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. 25**.

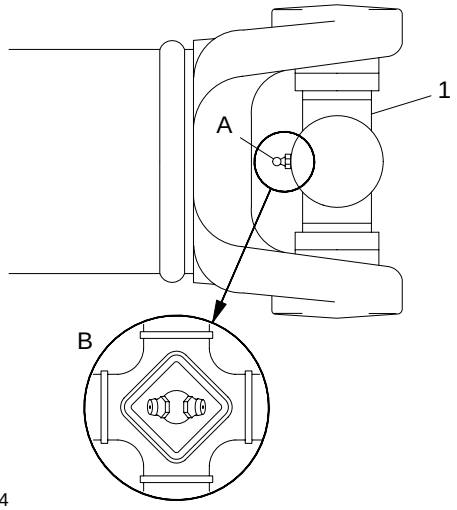
   3.2 Wipe a heavy coating of the same grease on the needles of each bearing cup, and pack each bearing cup about one-quarter full of grease. See **Fig. 26**.

⚠ 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. 36**.



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. 36, Spicer SPL90 (1590) U-Joint Grease Fitting Positioning

   4.2 Move one end of the cross until a trunnion projects through the cross-hole, beyond

Driveline Component Removal/Disassembly, Cleaning and Inspection, and Replacement or Installation/Assembly

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. 37**.

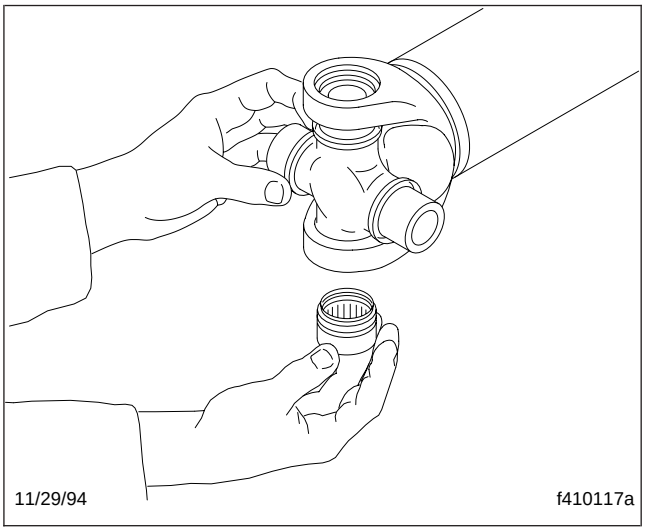


Fig. 37, Installing a Spicer SPL90 (1590) U-Joint Bearing Cup In a Full-Round Yoke

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. 7**. Press the bearing cup into the cross-hole enough to install a snap ring.

4.4 Install the snap ring. See **Fig. 6**.

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. 11**.
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 **Specifications 400**.

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.

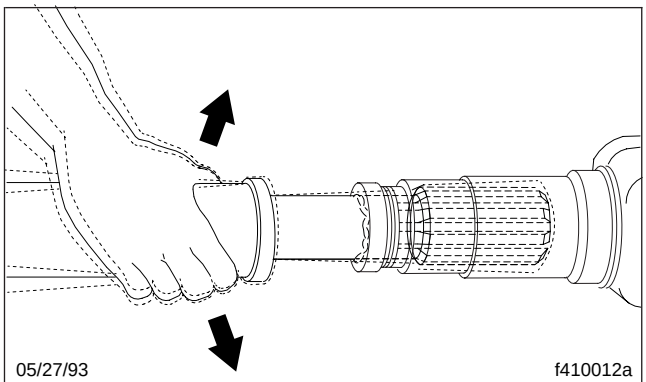
1. Check all tires for uneven wear and for out-of-roundness. Check for mismatched tires. Look for wheels and rims that are out of alignment. For instructions, see **Group 40**.
2. Check the rear suspension for loose or broken U-bolts; broken, shifted, or mismatched rear springs; or broken spring seats. 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 **Specifications 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

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 maximum tolerance of one inch-ounce per ten pounds weight per end, at 3000 rpm.

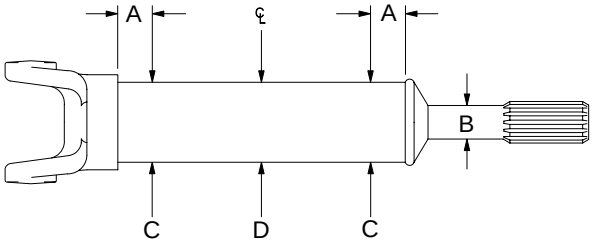
Troubleshooting

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.



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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**.

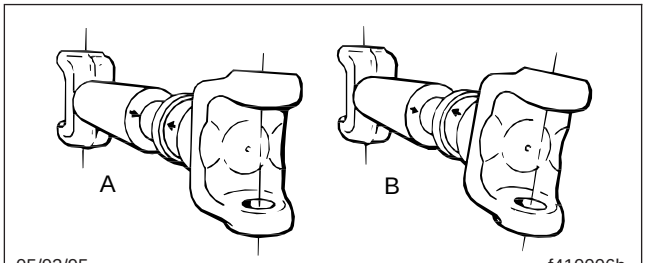
   9.1 On no. 2 and no. 3 driveshafts, if the U-joints are out of phase, check the slip-joint for alignment marks. If necessary, disassemble the slip-joint, and align the marks.

   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.

   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.



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A. In Phase B. Out of Phase

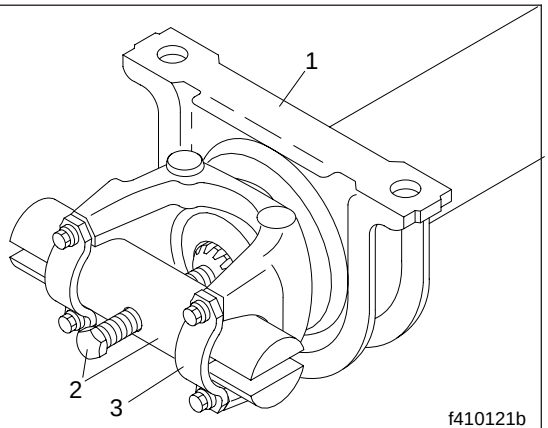
Fig. 3, U-Joint Phasing

   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 **Specifications 400**.

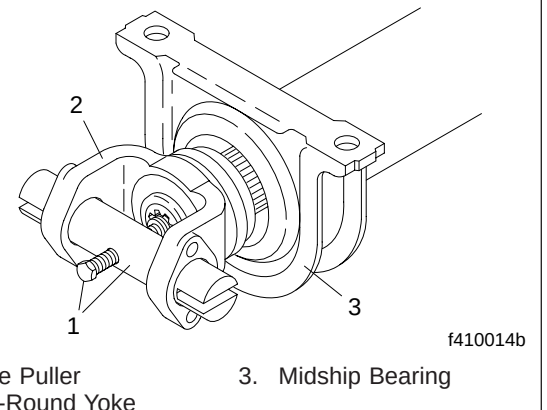
    If any yoke nut was not at its specified torque, check the yoke for wear by trying to move it up and down, and back and forth. If the yoke can be rocked on its shaft, or moved in or out on its shaft, replace the yoke and yoke nut; see **Subject 130**.

    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. 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.

Fastener Torques				
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)
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

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

Specifications

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 (chassis) diagram. See **Fig. 2** or **Fig. 3** for partial (detailed) views of **Fig. 1**.

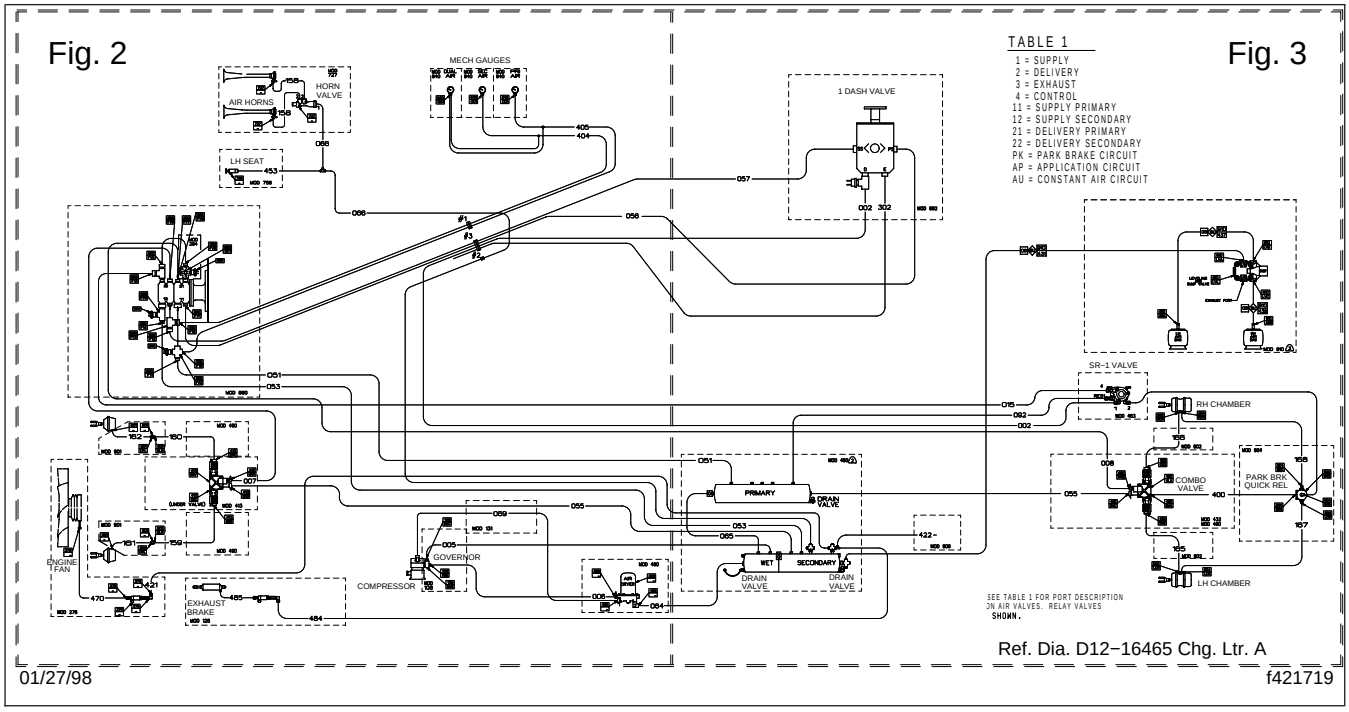


Fig. 1, Air Brake Plumbing, Cab and Chassis Diagram

Cab and Chassis Diagram

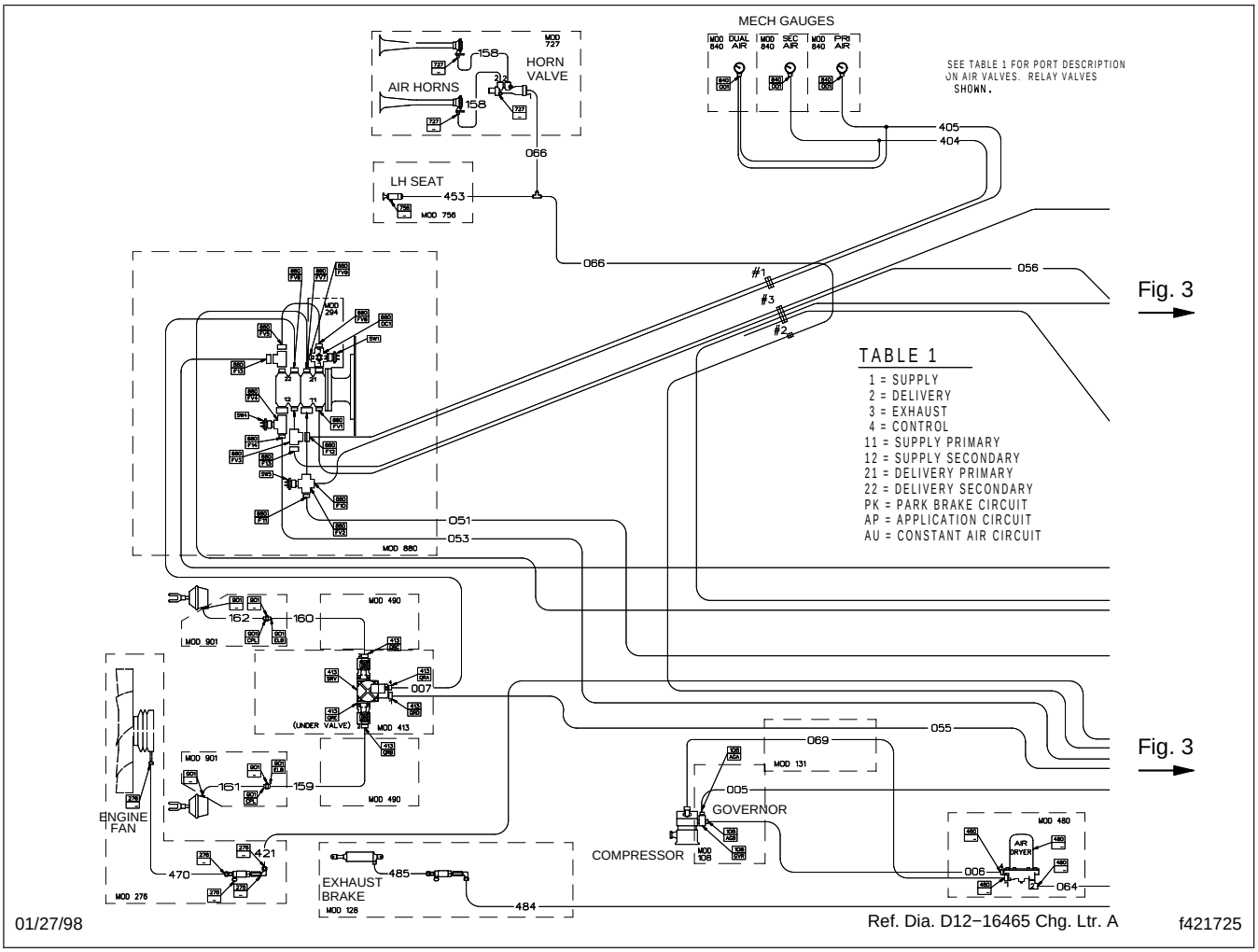


Fig. 2, Air Brake Plumbing, Cab and Chassis Diagram (detailed view)

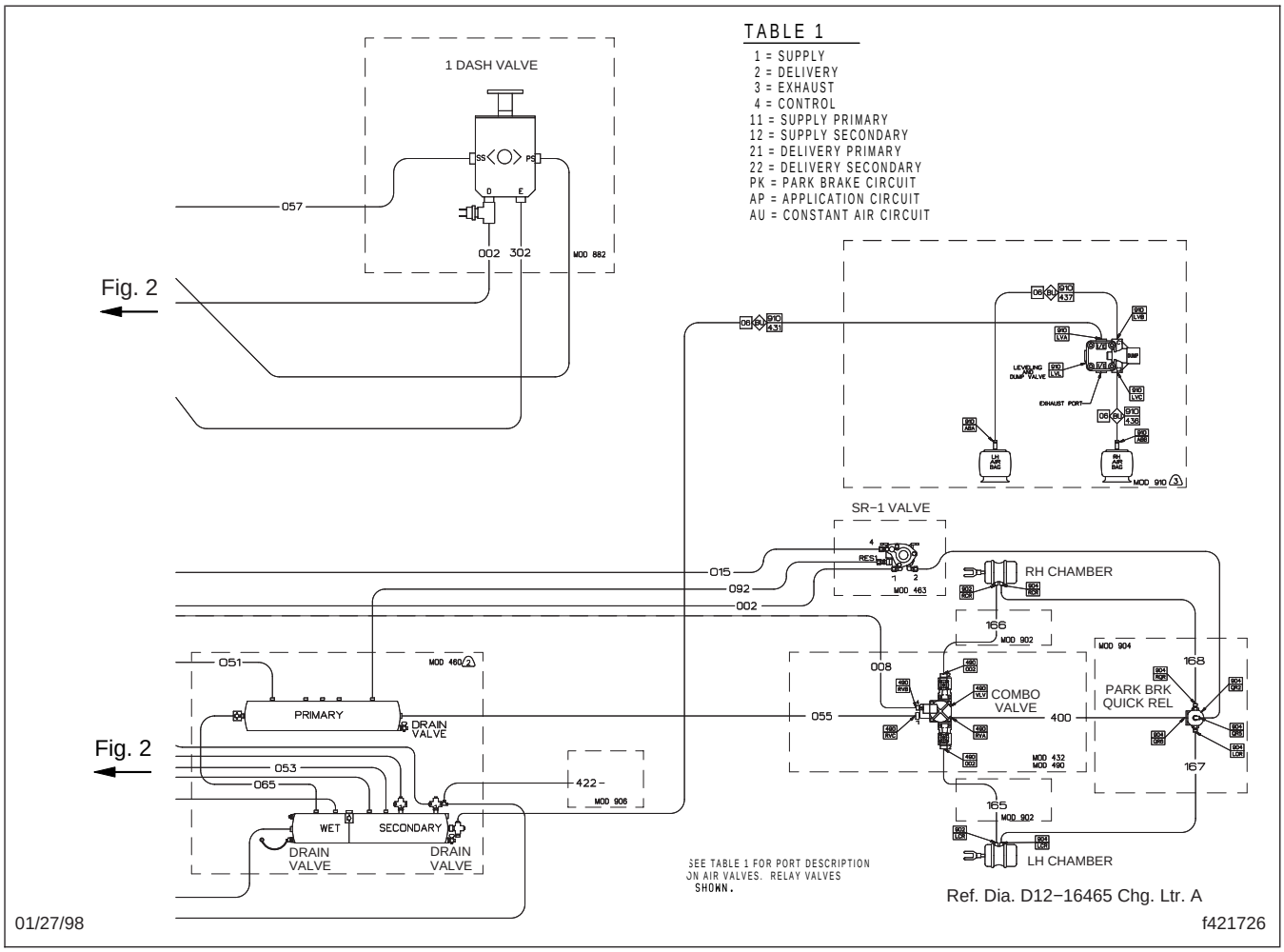


Fig. 3, Air Brake Plumbing, Cab and Chassis Diagram (detailed view)

General Description

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 group.
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 group.

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

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.

Troubleshooting Tables

Problem—Vehicle Does Not Slow Down Quickly Enough When Brakes Are Applied

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 60 psi (413 kPa) 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 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

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.

Troubleshooting

Problem—Service Brakes Release Too Slowly	
Possible Cause	**Remedy**
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.
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

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

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

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.
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

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.

Troubleshooting

Problem—Service Brakes Grab or Pull	
Possible Cause	**Remedy**
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.

Problem—Uneven Service Brakes

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 Group 33 or Group 35 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

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.

Problem—Dragging Service Brake	
Possible Cause	**Remedy**
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

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

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

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.

Troubleshooting

Problem—Air Pressure Will Not Rise to Normal	
Possible Cause	**Remedy**
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

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.	

Problem—Air Pressure Drops Quickly With the Engine Stopped and the Brakes Released

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

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.

Problem—Air Pressure Drops Quickly With the Engine Stopped and the Brakes Fully Applied	
Possible Cause	**Remedy**
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)

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

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.

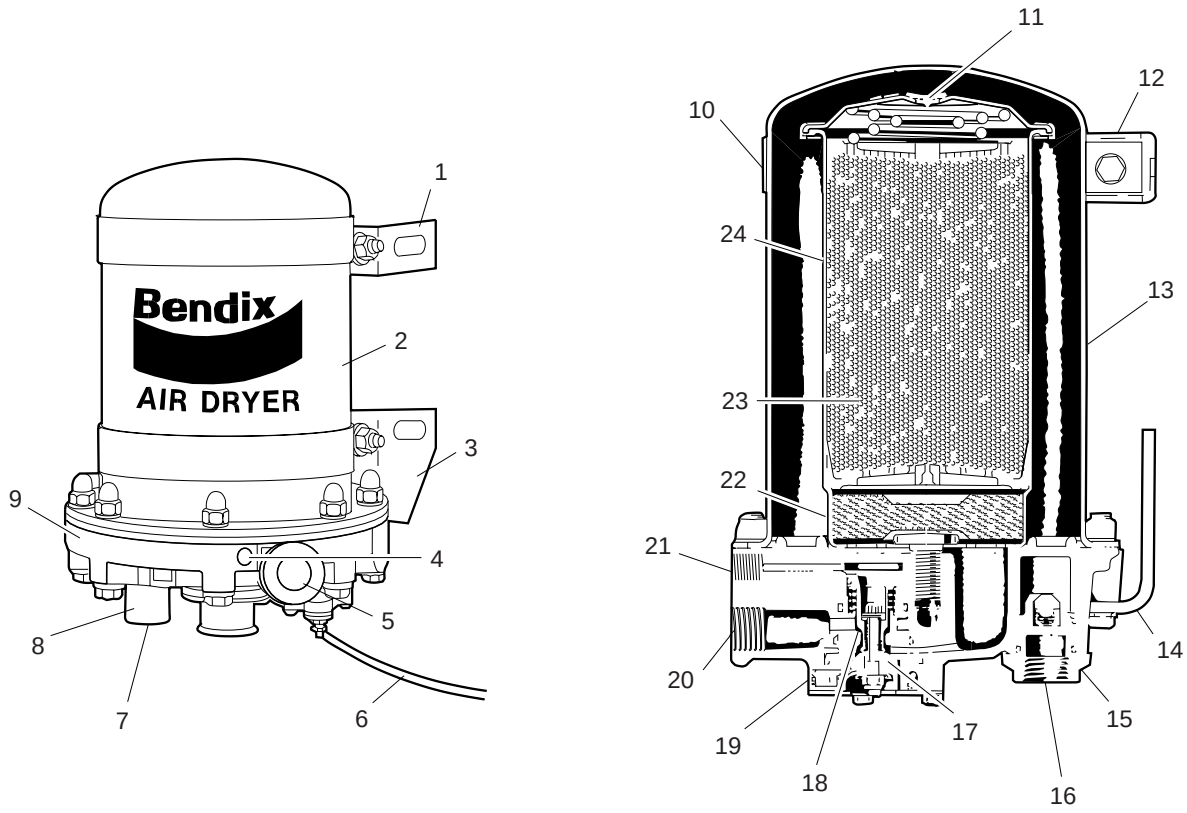
Problem—Oil or Water in the Brake System

Problem—Oil or Water in the Brake System	
Possible Cause	**Remedy**
Excessive oil is passing through the air compressor.	Rebuild or replace the compressor.
If so equipped, the air compressor air strainer is dirty.	Clean the strainer or install a new one.

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.

tions 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.



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1. Upper Bracket
2. Outer Shell
3. Lower Bracket
4. Control Port
5. Supply Port
6. Wiring Harness
7. Delivery Port
8. Check Valve Assembly
9. End Cover
10. Upper Bracket Strap
11. Check Valve
12. Upper Bracket
13. Housing
14. Lower Bracket
15. Check Valve Assembly
16. Delivery Port
17. Purge Valve
18. Turbo Cutoff Piston
19. Purge Valve Housing Assembly
20. Supply Port
21. Control Port
22. Oil Separator
23. Desiccant Bed
24. Desiccant Cartridge

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 connec-

To ease servicing, the desiccant cartridge and discharge check valve assembly are screw-in types. The purge valve housing assembly, which includes the heater and thermostat assembly, and the discharge check valve assembly, can be serviced with-

out removing the air dryer from the vehicle. The screw-in desiccant cartridge requires removal of the air dryer assembly from the vehicle.

The AD–9 has three female pipe thread air connections; each is identified in **Table 1**.

AD-9 Pipe Thread Connections	
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

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)

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)

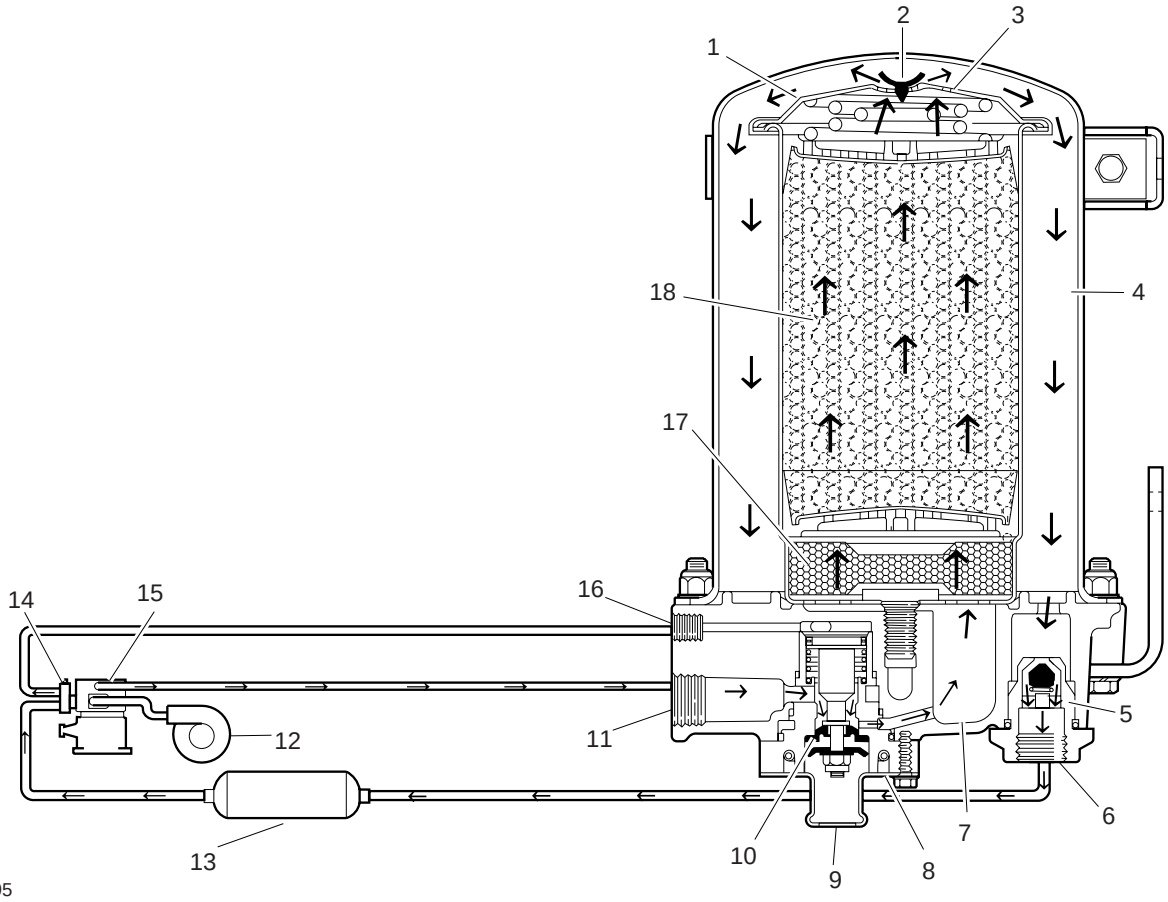
When the brake system pressure reaches the governor cutout setting, the compressor unloads (air compression stopped), and the purge cycle of the air dryer begins. When the governor unloads the compressor, it pressurizes the unloader mechanism and line connecting the governor unloader port to the AD–9 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 supply 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



1. Desiccant Cartridge
2. Check Valve
3. Orifice
4. Purge Volume
5. Check Valve Assembly
6. Delivery Port
7. Sump
8. Heater Element
9. Exhaust
10. Purge Valve
11. Supply Port
12. Engine Turbo
13. Reservoir
14. Governor
15. Compressor
16. Control Port
17. Oil Separator
18. Desiccant Bed

Fig. 2, AD-9 Charge Cycle

system pressure is reduced and the governor signals the compressor to charge.

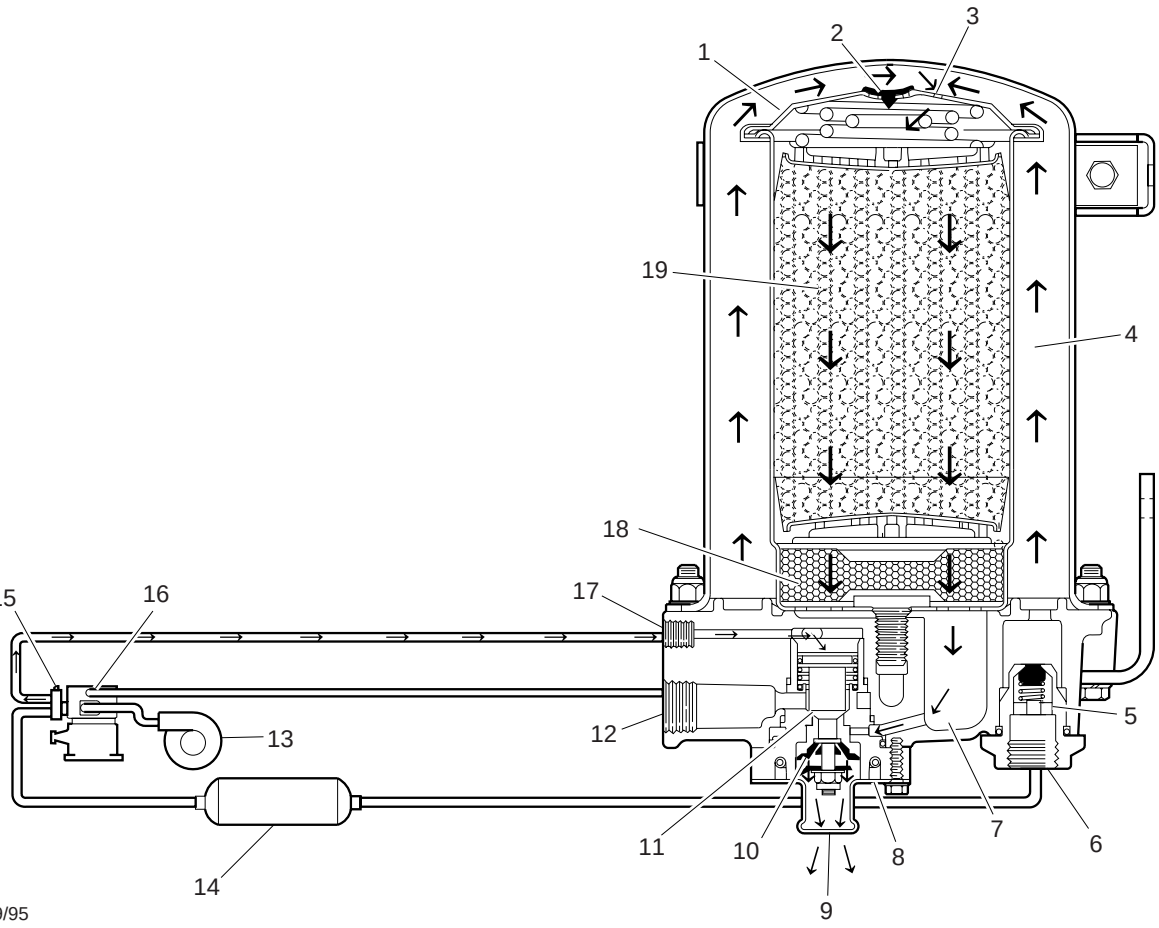
NOTE: The air dryer should be periodically checked for operation and tested for leaks. Refer to Group 42 in the vehicle maintenance manual for intervals and procedures.

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.

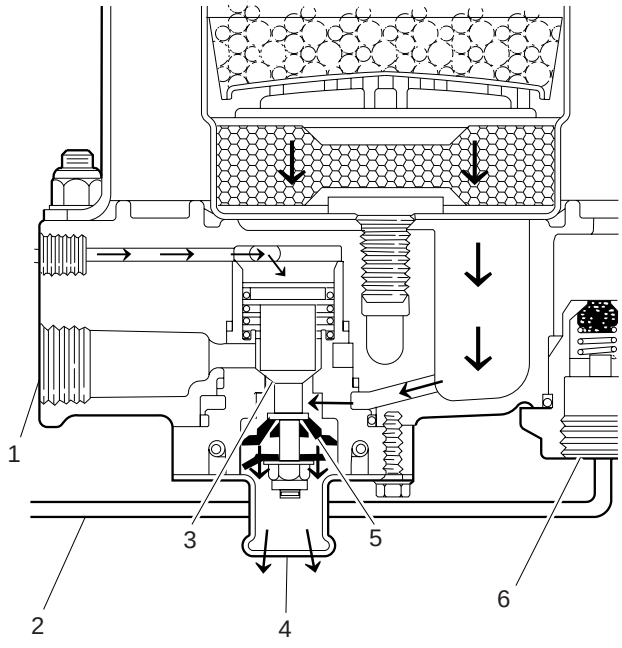
General Information



1. Desiccant Cartridge
2. Check Valve
3. Orifice
4. Purge
5. Check Valve Assembly
6. Delivery Port
7. Sump
8. Heater Element
9. Exhaust
10. Purge Valve
11. Turbo Cutoff Piston
12. Supply Port
13. Engine Turbo
14. Reservoir
15. Governor
16. Compressor
17. Control Port
18. Oil Separator
19. Desiccant Bed

Fig. 3, AD-9 Purge Cycle

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.



1. Supply Port
2. Discharge Line
3. Turbo Cutoff Piston
4. Exhaust
5. Purge Valve
6. Check Valve Assembly

Fig. 4, AD-9 Turbo Cutoff

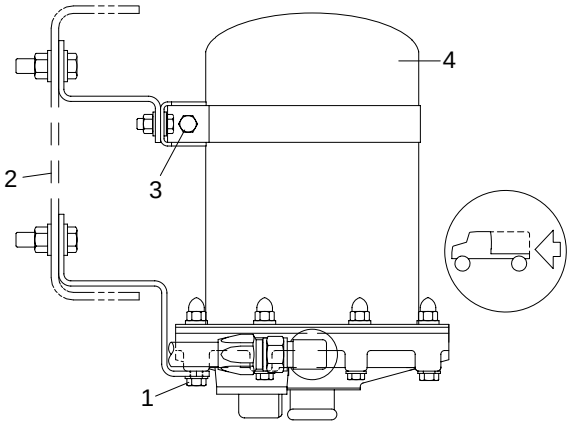
Safety Precautions

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 (See Fig. 1)



1. End Cover Fastener
2. Left Frame Rail
3. Upper Bracket Strap Capscrew
4. Air Dryer

Fig. 1, Air Dryer Mounting

⚠ WARNING

Before working on or around air brake systems and components, read the safety precautions in Safety Precautions 100. Failure to do so could result in personal injury.

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 (See Fig. 1)

⚠ WARNING

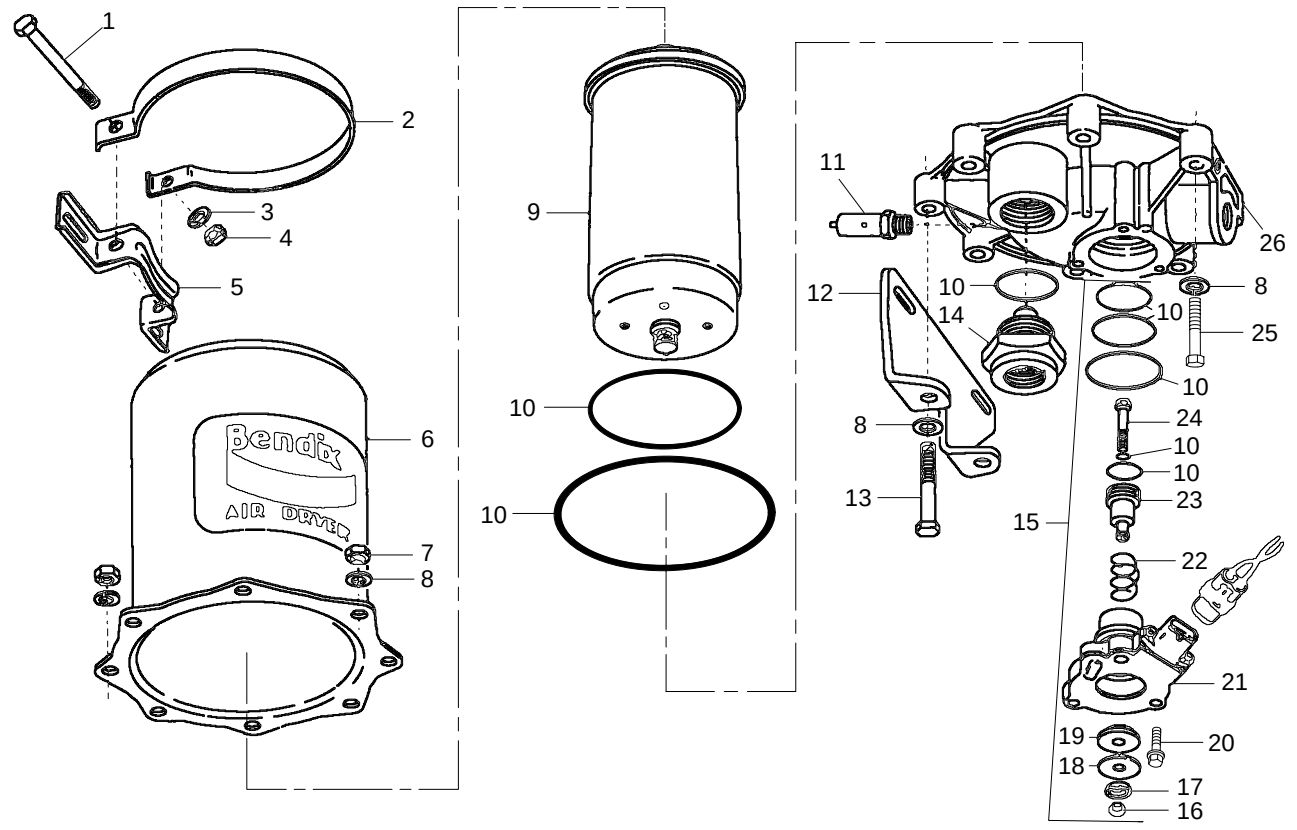
Before working on or around air brake systems and components, read the safety precautions in Safety Precautions 100. Failure to do so could result in personal injury.

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 two longest capscrews, four special washers, and two locknuts, secure the air dryer to the lower bracket. Tighten the two remaining capscrews 270 to 385 lbf·in (3060 to 4340 N·cm).
   - 1.3 Tighten the bolt and nut on the upper mounting bracket strap 80 to 120 lbf·in (900 to 1360 N·cm).
   - 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 Group 42 of the vehicle maintenance manual.

Disassembly, Cleaning and Inspection, and Assembly

As a convenience when rebuilding the air dryer, several replacement parts and maintenance kits are available that do not require full disassembly. Use the instructions provided with these parts or kits.

Disassembly (See Fig. 1)



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1. 5/16-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

Fig. 1, AD-9 (exploded view)

Disassembly, Cleaning and Inspection, and Assembly

WARNING

Before working on or around air brake systems and components, refer to Safety Precautions 100. Failure to do so could result in personal injury.

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 Subject 110.
2. Remove the check valve assembly (Ref. 14) and O-ring (Ref. 10). 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. 20) 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 (Ref. 10) from the exterior of the purge valve housing assembly.

   NOTE: O-rings (Ref. 10) 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. 21) 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. 16) 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. 24). If present, remove the diaphragm washer (Ref. 17) and diaphragm (Ref. 18), and the purge valve (Ref. 19) from the purge valve housing.
   - 4.3 Remove the Torx head bolt (Ref. 24) from the opposite end, then the purge piston (Ref. 23), the return spring (Ref. 22) and two O-rings (Ref. 10) (one on the outside diameter and the other in the inside of the purge piston).

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. 25), locknuts (Ref. 7), and twelve special washers (Ref. 8) that secure the end cover to the housing (Ref. 6). Separate the end cover and desiccant cartridge (Ref. 9) from the housing (Ref. 6).
6. Remove the end-cover-to-outer-housing O-ring (Ref. 10).
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 120 to 400 lbf·in (1360 to 4520 N·m). Make sure the drain hole (slot) is facing down.
8. Place a strap or chain wrench around the desiccant cartridge (Ref. 9) so that it is about 2 to 3 inches (5 to 8 cm) away from the end cover. Rotate the cartridge counterclockwise until it completely separates from the end cover.

NOTE: Torque of up to 50 lbf·ft (68 N·m) may be needed to do this disassembly.

9. Remove the desiccant cartridge O-ring (Ref. 10) from the end cover.

Cleaning and Inspection

WARNING

Before working on or around air brake systems and components, read the safety precautions in Safety Precautions 100. Failure to do so could result in personal injury.

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 (See Fig. 1)

WARNING

Before working on or around air brake systems and components, read the safety precautions in Safety Precautions 100. Failure to do so could result in personal injury.

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. 10) on the purge piston. Place the return spring (Ref. 22) in the purge-valve housing. Place the O-ring (Ref. 10) in the bore of the purge piston. Install the Torx head bolt (Ref. 24) in the purge piston. Insert the purge piston (Ref. 23) in the inside diameter of the spring (Ref. 22). 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. 24) from the opposite end of the purge-valve housing: the purge valve (Ref. 19) with its rubber side first, followed by the diaphragm (Ref. 18) (if present) and the diaphragm washer (Ref. 17) (if present) or the flatwasher, and finally the locknut (Ref. 16). Torque the purge valve locknut and bolt (Refs. 16 and 24) 60 to 80 lbf·in (680 to 900 N·cm).
   - 2.3 Install the three O-rings (Ref. 10) in their correct locations on the purge-valve housing.
   - 2.4 If the exhaust cover (Ref. 21) 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. 20). Start all three screws by hand, then torque 85 to 125 lbf·in (960 to 1400 N·cm).
3. Install the O-ring (Ref. 10) on the check-valve assembly (Ref. 14), then install the assembly in the end cover using a socket. Tighten 200 to 250 lbf·in (2260 to 2820 N·cm).
4. Install the desiccant cartridge in the end cover.
   - 4.1 Install the desiccant O-ring (Ref. 10) in its groove in the end cover. Using a light coat

Disassembly, Cleaning and Inspection, and Assembly

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 2 to 3 inches (5 to 8 cm) 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 50 lbf·ft (68 N·m).

5. Install the end cover housing over the desiccant cartridge.

5.1 Install the end cover outer housing O-ring (Ref. 10) on the shoulder in the end cover. Place the housing (Ref. 6) over the desiccant cartridge and align the holes.

5.2 Install the six capscrews (Ref. 25), locknuts (Ref. 7), and the twelve special washers (Ref. 8), making sure they are positioned as referenced earlier. The two longer capscrews (Ref. 13) 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 270 to 385 lbf·in (3060 to 4340 N·cm).

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.

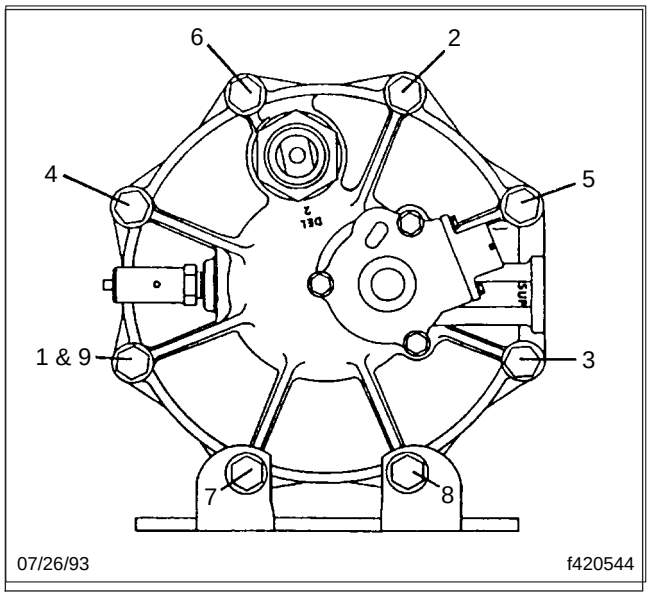


Fig. 2, End Cover to Housing Torque Pattern

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 40°F (4°C). 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 90°F (32°C) 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.

Troubleshooting Tables

Problem—Air Dryer Is Constantly Cycling or Purging

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—1 psi/min (7 kPa/min) per service reservoir • Tractor/Trailer—3 psi/min (21 kPa/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 1-inch (2.5-cm) 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 120 psi (830 kPa) at the control port. Apply a soap solution to the supply port and exhaust port (purge valve seat area). Permissible leakage is a 1-inch (2.5-cm) 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

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 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 Bendix representative for further information.

Troubleshooting

Problem—Water in the Vehicle Reservoirs	
Possible Cause	**Remedy**
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."
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

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 90 in ^{3} (1475 cm ^{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

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.

Problem—Constant Exhaust of Air at the Air Dryer Purge Valve Exhaust; Unable to Build System Pressure	
Possible Cause	**Remedy**
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.
System is leaking excessively.	Test for excessive leakage. Eliminate leaks, as needed. Allowable leakage is as follows: • Single Vehicle—1 psi/min (7 kPa/min) per service reservoir • Tractor/Trailer—3 psi/min (21 kPa/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

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.

Troubleshooting

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

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.

Problem—Pinging Noise Is Excessive During Compressor Loaded Cycle

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 90 in ^{3} (1475 cm ^{3}) reservoir between the compressor and the air dryer.

Problem—Constant Air Seepage at the Purge Valve (Non-Charging Mode)

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 1-inch (2.5-cm) 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

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.

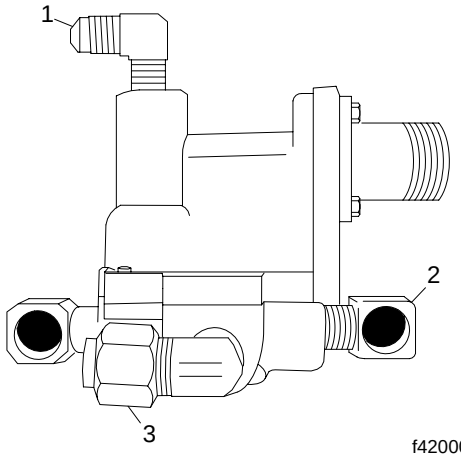
Installing Air Lines

NYLON TUBES (See Fig. 1 and Fig. 2)

When installing a nylon tube, be careful not to bend it past its minimum bend radius. For minimum bend radius values, refer to the applicable table in **Specifications 400**.

CAUTION

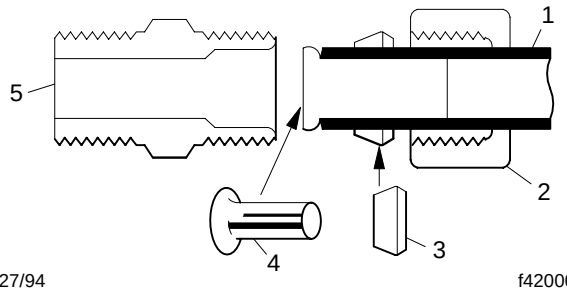
If the tubing is bent to a radius smaller than the specified minimum bend radius, it may kink and shut off normal airflow to the component.



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1. Wire Braid Hose Fitting
2. Pipe Fitting
3. Nylon Tube Fitting

Fig. 1, Tube and Hose Fittings (for reference only)

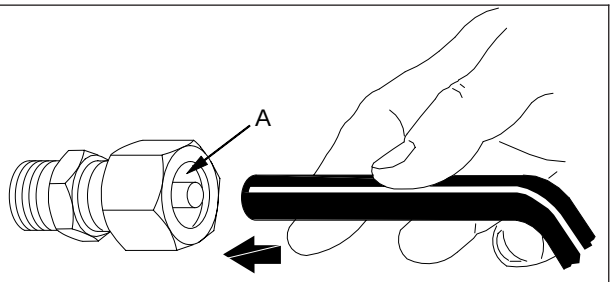


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1. Nylon Tube
2. Nut
3. Sleeve
4. Brass Insert
5. Body

Fig. 2, Nylon Tube Fitting

1. Cut the end of the tubing smooth and square.
2. Make sure the nylon tubing ends and fittings are free of grease and debris. If the tubing is crimped or otherwise damaged, replace it with new tubing.
3. Install a new sleeve in the nut.
4. Insert the squared end of the tubing in the fitting, until it bottoms in the body of the fitting. See **Fig. 3**.



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A. Tube end must bottom before tightening the nut.

Fig. 3, Installing Nylon Tubing

5. Tighten the nut finger-tight. Then, using two wrenches to prevent twisting of the tube, tighten the nut the number of turns shown in the applicable table in **Specifications 400**, or until one thread shows on the fitting body.

WIRE BRAID HOSES (See Fig. 1)

When installing a wire braid hose, be careful not to bend it past its minimum bend radius. For minimum bend radius values, refer to the applicable tables in **Specifications 400**.

CAUTION

If the hose is bent to a radius smaller than the specified minimum bend radius, it may kink and shut off normal airflow to the component.

Make sure the wire braid hose assembly is free of grease and dirt. Replace the assembly if the hose or fitting is crimped or otherwise damaged.

Install the hose and tighten the nut finger-tight. Then, using two wrenches to prevent twisting of the hose, tighten the nut until it seats solidly. Tighten the nut one-sixth turn more.

Installing Fittings

BRASS AND STEEL PIPE FITTINGS (See Fig. 1)

For brass pipe fittings, both male and female parts, tighten as follows:

1. Make sure the fittings are free of grease, dirt, and old sealant. Apply liquid Loctite® Hydraulic Sealant (brown), or an equivalent, to the threads, then tighten securely, finger-tight.

NOTE: Always apply the sealant to the external thread, so that any excess will be scraped off externally rather than internally to the joint.

2. For fittings that must be positioned, tighten one additional turn from finger-tight using a wrench. Then, continue tightening until the fitting is correctly positioned.

   For fittings that do not require positioning, tighten 1-1/2 additional turns from finger-tight.

COPPER TUBE FITTINGS

For copper tube fittings, tighten the nut finger-tight. Then, using two wrenches to prevent twisting of the tube, tighten the nut the number of turns shown in the applicable table in **Specifications 400**.

TUBE AND PIPE FITTINGS ON PLASTIC COMPONENTS

For tightening specifications, refer to the applicable table in **Specifications 400**.

Nylon Tube			
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	0.439	5/8	2.50 (64)
12	0.566	3/4	3.00 (76)

Table 1, Nylon Tube

Additional Turns from Hand-Tight (Nylon Tube)	
Tube Size (inches)	Additional Turns from Hand-Tight
1/4	3
3/8 or 1/2	4
5/8 or 3/4	3-1/2

Table 2, Additional Turns from Hand-Tight (Nylon Tube)

211 Wire Braid (Medium Pressure) Hose *			
Number	Inside Diameter inch	Outside Diameter inch	Minimum Bend Radius inches (mm)
4	3/16	0.52	3.00 (76)
5	1/4	0.58	3.38 (86)
6	5/16	0.67	4.00 (102)
8	13/32	0.77	4.63 (118)
10	1/2	0.92	5.50 (140)
12	5/8	1.08	6.50 (165)
16	7/8	1.23	7.38 (187)
20	1-1/8	1.50	9.00 (229)

* 211 hose is identified by part number and size; for example, part numbers 211-4, 211-5, and so on.

Table 3, 211 Wire Braid (Medium Pressure) Hose

213 Wire Braid (Diesel) Hose *			
Number	Inside Diameter inch	Outside Diameter inch	Minimum Bend Radius inches (mm)
4	3/16	0.49	0.75 (19)
5	1/4	0.55	1.00 (25)
6	5/16	0.62	1.25 (32)
8	13/32	0.74	1.75 (44)
10	1/2	0.83	2.25 (57)
12	5/8	0.96	2.75 (70)
16	7/8	1.21	3.50 (89)
20	1-1/8	1.49	4.50 (114)

* 213 hose is identified by two green stripes 180 degrees apart, part numbers, and size; for example, part numbers 213-4, 213-5, and so on.

Table 4, 213 Wire Braid (Diesel) Hose

Copper Tube Fittings			
Number	Outside Diameter (inches)	Additional Turns from Hand-Tight	
		Compression	Threaded Sleeve
2	1/8	1-1/4	1-1/2
3	3/16		
4	1/4		
5	5/16	1-3/4	
6	3/8	2-1/4	
8	1/2		
10	5/8		
12	3/4		
16	1		
20	1-1/4		

Table 5, Copper Tube Fittings

Tube and Pipe Fittings on Plastic Components			
Description	Port Size (inches)	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) *

Specifications

Tube and Pipe Fittings on Plastic Components			
Description	Port Size (inches)	Torque	
		lbf·in (N·cm)	lbf·ft (N·m)
Bendix MV-2/MV-3 Valve	1/4	—	10 (14)

* Tighten to the lower torque value. Then, if needed, turn the fittings to allow for the proper routing of the air lines.

Table 6, Tube and Pipe Fittings on Plastic Components

General Description

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. Refer to **Subject 110**.

If leaks occur on the surfaces of the air reservoir, replace the tank; refer to **Subject 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.

Replacement

1. Apply the parking brakes, and chock the tires.
2. Drain the air system. For instructions, refer to the vehicle driver's manual.
3. Mark all reservoir air lines, couplers, and valves for later assembly; disconnect the components. Cap the exposed ports tightly to keep out contaminants. If access is limited, remove the components 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 frame-mounted straps (**Fig. 1**), tighten the fasteners 20 to 25 lbf·ft (27 to 34 N·m).

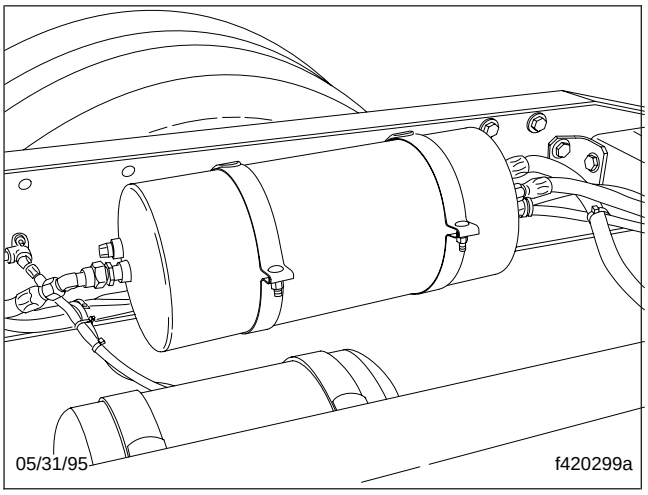
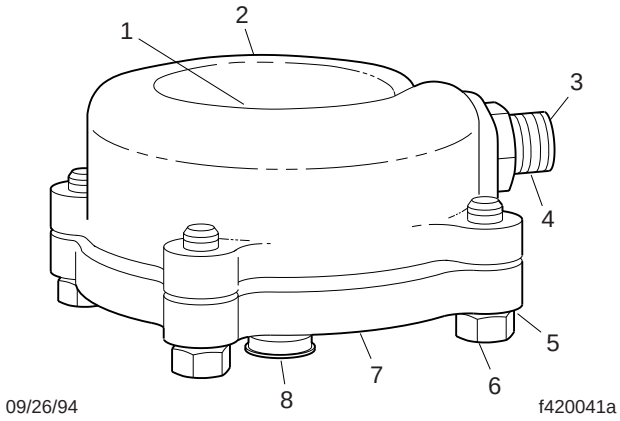


Fig. 1, Air Reservoir, Frame Rail Mounting

6. As marked earlier, connect all air lines, couplers, and valves to the new reservoir, removing the caps as each component is installed. Tighten the connections. Refer to **Section 42.04** for instructions.
7. Remove the chocks from the tires.

General Description

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.



1. Top Reservoir Port
2. Valve Body
3. Side Reservoir Port
4. Hexhead Nipple
5. Lockwasher (4 qty.)
6. Capscrew (4 qty.)
7. Valve Cover
8. Exhaust Port

Fig. 1, DV–2 Valve

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 2 psi (14 kPa), 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**.

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.

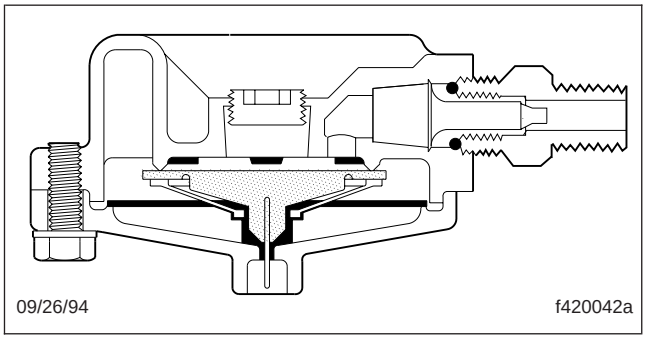


Fig. 2, Closed Inlet and Exhaust Valves

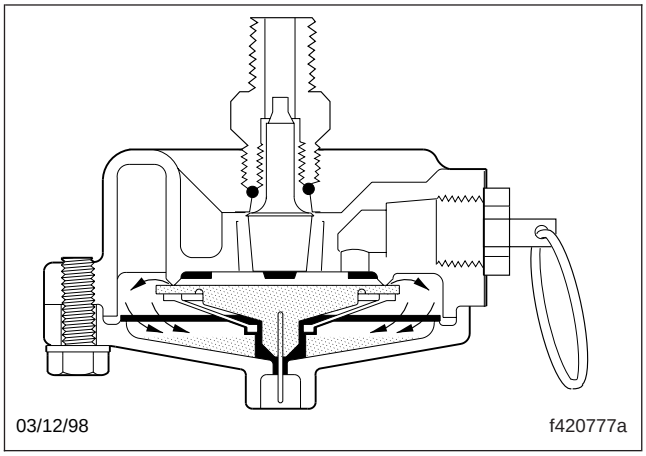


Fig. 3, Open Pressure in the Inlet Valve

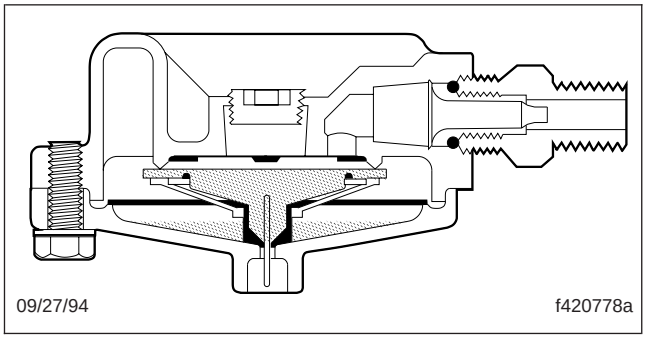


Fig. 4, Closed Inlet Valve, Following Sump Cavity Closure

General Information

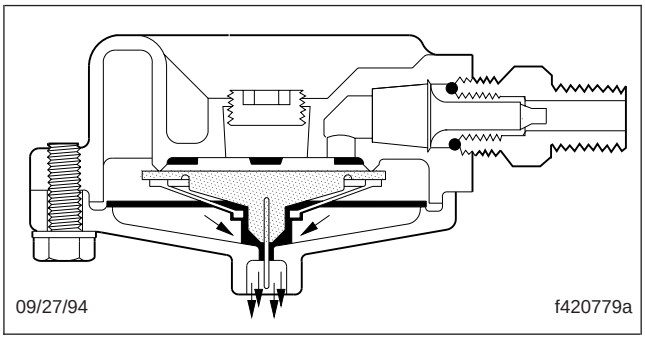


Fig. 5, Opened Exhaust Valve

Safety Precautions

When working on or around air brake systems and components, the following precautions should be observed:

1. Always chock the vehicle 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 **Subject 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 **Subject 130**.

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 **Subject 130**.

DV–2 Valve Removal and Installation

Removal

IMPORTANT: Before working on or around air brake systems and components, review **Subject 100**.

1. Chock the tires, and drain the reservoirs.
2. Remove the drain valve assembly from the end of the wet tank reservoir.

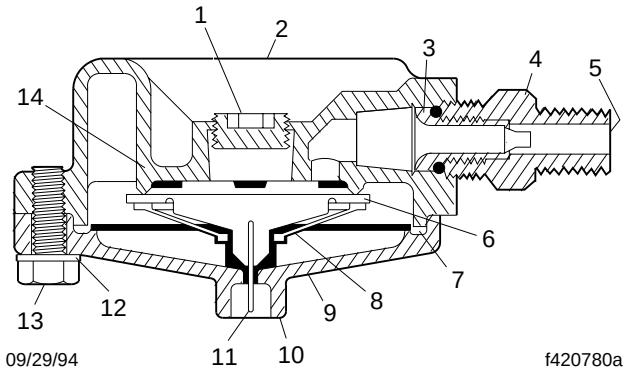
Installation

IMPORTANT: Before working on or around air brake systems and components, review **Subject 100**.

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 **Subject 110**.

DV–2 Valve Disassembly, Cleaning and Inspection, and Assembly

Disassembly (See Fig. 1)



1. Top Reservoir Port
2. Valve Body
3. Filter Retainer
4. Hexhead Nipple
5. Side Reservoir Port
6. Inlet and Exhaust Valve
7. Valve Sealing Ring
8. Valve Guide
9. Valve Cover
10. Exhaust Port
11. Wire Stem
12. Lockwasher (4qty.)
13. Capscrew (4 qty.)
14. Inlet Valve Seat

Fig. 1, DV-2 Valve, Cutaway View

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions 100**.

1. Remove the drain valve following the instructions under **Subject 120**.
2. Remove the four capscrews (Ref. 13) that hold the valve cover (Ref. 9) to the valve body (Ref. 2).
3. Remove the valve cover (Ref. 9) and sealing ring.
4. Remove the valve guide (Ref. 8) and the inlet and exhaust valve (Ref. 6) from the valve body.
5. Remove the hexhead nipple (Ref. 4) from the valve body.

Cleaning and Inspection

IMPORTANT: Before working on or around air brake systems and components, review **Safety Precautions 100**.

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

Do not reassemble the drain valve with a dirty filter; to do so could result in failure of the drain valve in service.

Assembly (See 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. 14.

IMPORTANT: Do not apply oil to the inlet and exhaust valve.

1. Install the valve sealing ring (Ref. 7) into its groove in the valve cover.
2. Install the valve guide (Ref. 8) over the inlet and exhaust valve (Ref. 6).
3. Install the valve guide, and the inlet and exhaust valve as an assembly into the valve cover. The wire stem (Ref. 11) will project through the exhaust port (Ref. 10).
4. Install the valve body on the valve cover and install the lockwashers and capscrews. Tighten the capscrews 72 to 96 lbf·in (820 to 1080 N·cm).
5. Install the hexhead nipple onto the valve body, and tighten it 48 to 72 lbf·in (540 to 820 N·cm).
6. Install the drain valve on the wet tank following the instructions under **Subject 120**.

Specifications

Torque Values	
Description	**Torque lbf·in (N·cm)**
Valve Cover Capscrews	72–96 (820–1080)
Hexhead Nipple (to valve body)	48–72 (540–820)

Table 1, Torque Values

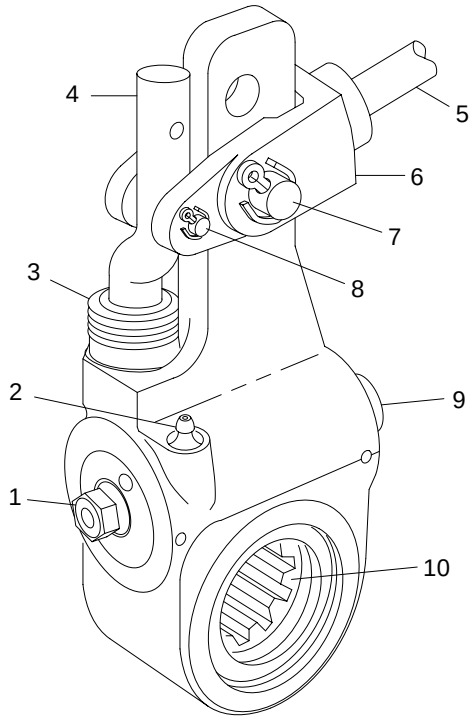
General Description (See Fig. 1)

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.



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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

Fig. 1, Gunite Automatic Slack Adjuster

[1] Formerly Kelsey-Hayes

Slack Adjuster Removal and Installation

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 (See Fig. 1)

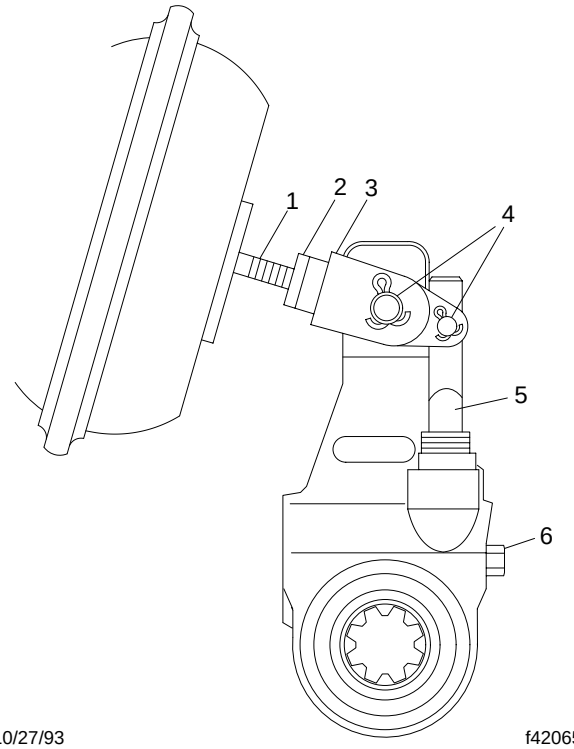
1. Park the vehicle on a level surface, and chock the tires. If you are removing a rear slack adjuster, release the parking brake, then cage the parking brake power spring. For instructions, refer to the applicable brake chamber section in this group.
2. Back off the clevis jam nut.
3. Remove the cotter 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 (See 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

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.



1. Brake Chamber Push Rod
2. Jam Nut
3. Clevis
4. Cotter Pins and Clevis Pins
5. Link
6. Adjusting Hexnut

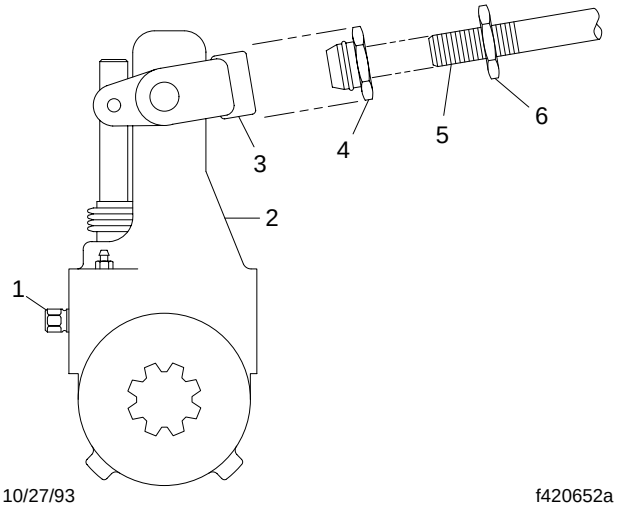
Fig. 1, Slack Adjuster Removal

⚠ 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.

Slack Adjuster Removal and Installation



1. Adjusting Hexnut
2. Slack Adjuster
3. Clevis
4. Quick-Connect Snap Nut
5. Push Rod
6. Jam Nut

Fig. 2, Slack Adjuster Installation

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 1/16 inch (1.5 mm) past the snap nut.

7.4 Tighten the jam nut.

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.

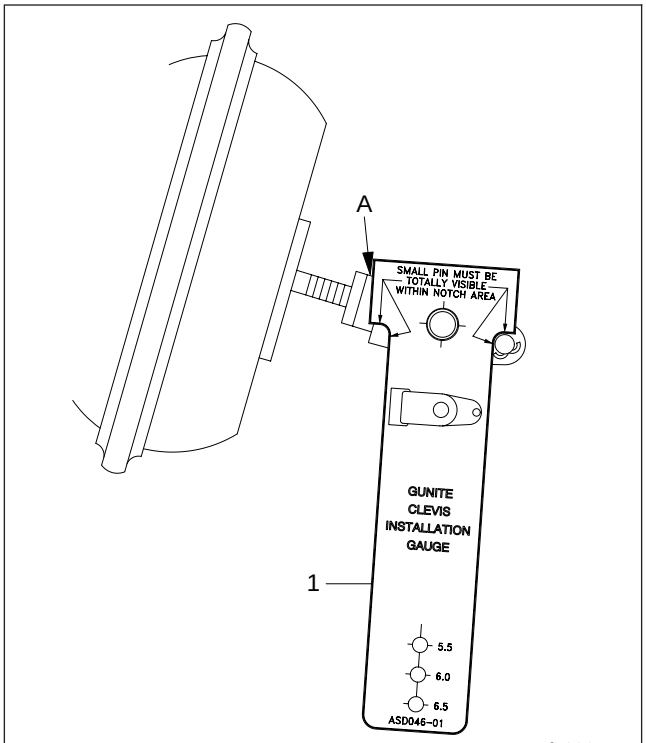
8. Set the initial free-stroke.

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 30 lbf·ft (41 N·m) 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*.



A. Turn the snap nut to position the 1/4-inch clevis pin within the notched area of the gauge.
1. Installation Gauge

Fig. 3, Adjust the Clevis

9.2 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 center of the large clevis pin. See **Fig. 4** , Ref. *B*. The difference between the measurements is the brake chamber stroke.

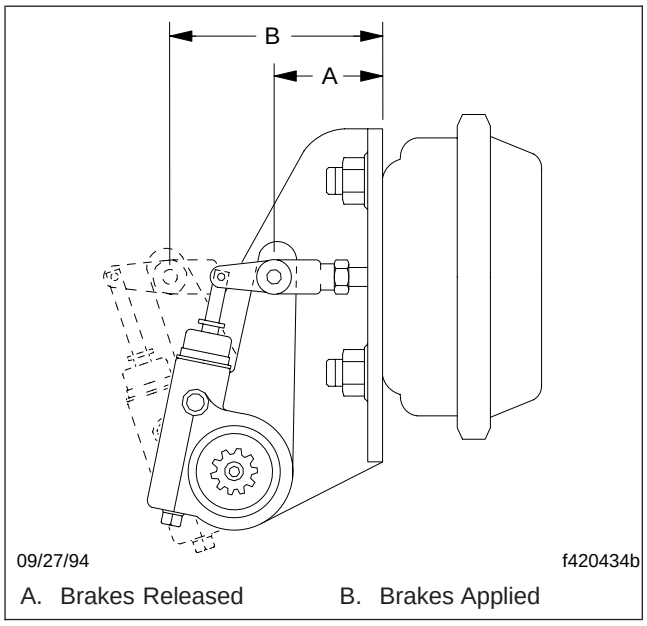


Fig. 4, Make These Measurements

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, 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 applicable brake chamber section in this group.

11. Apply the parking brakes. Remove the chocks from the tires.

Specifications

Approved Lubricants	
Lubricant Type	**Temperature**
Lubriplate Aero	Above –40°F (–40°C)
Texaco Multifak EP-2 Mobil Grease 77	Above –20°F (–29°C)

Table 1, Approved Lubricants

Maximum Adjusted Brake Chamber Strokes	
Chamber Size	**Maximum Chamber Stroke inches (mm)**
16 20 24	Less than 1-3/4 (44)
24 * 30	Less than 2 (51)

* Long stroke.

Table 2, Maximum Adjusted Brake Chamber Strokes

General Description

The Haldex (SAB) automatic slack adjuster serves two main functions:

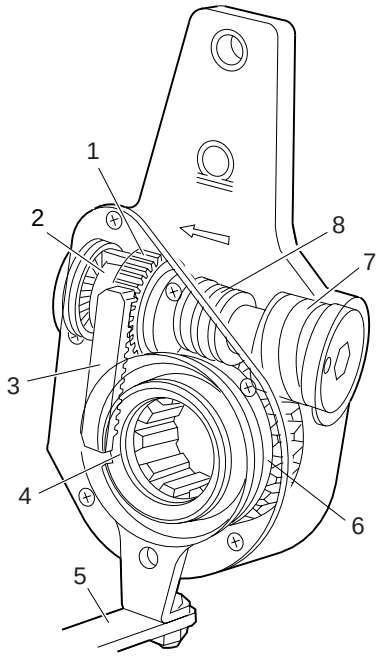
- As a lever, it converts the straight-line force of the air brake chamber push rod to torque on the brake camshaft. Rotation of the camshaft spreads the brake shoes out against the brake drum, applying the brakes.
- As an adjuster, it maintains cam brake chamber push rod stroke and lining-to-drum clearance 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.



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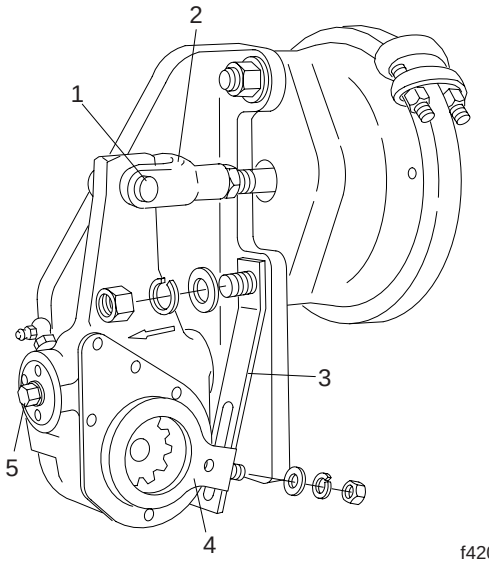
1. One-Way Clutch
2. Cone Clutch
3. Rack
4. Clearance Notch
5. Control Arm Anchor Bracket (design will vary depending on the axle)
6. Worm Wheel
7. Coil Spring
8. Worm Shaft

Fig. 1, Haldex Automatic Slack Adjuster

Slack Adjuster Removal and Installation

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. For instructions, refer to the applicable brake chamber section in this group.
2. Remove the anchor bracket fasteners and the anchor bracket (**Fig. 1**).



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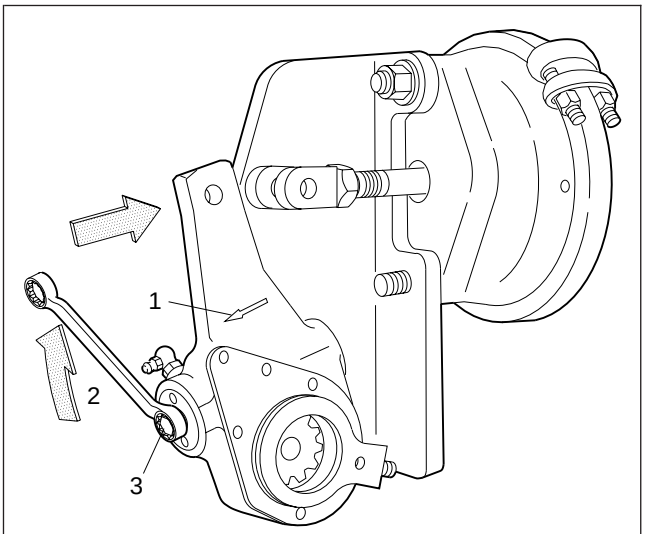
1. Clevis Pin
2. Clevis
3. Anchor Bracket
4. Control Arm
5. Adjusting Hexnut

Fig. 1, Slack Adjuster Installation

3. Remove the cotter pin from the clevis pin. Remove the clevis pin.
4. Remove the snap ring holding the slack adjuster to the camshaft.
5. Turn the adjusting hexnut counterclockwise, to move the adjuster arm out of the clevis. A ratcheting sound may occur.
6. 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.



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1. Arrow
2. Wrench
3. Adjusting Hexnut

Fig. 2, Slack Adjuster Installation

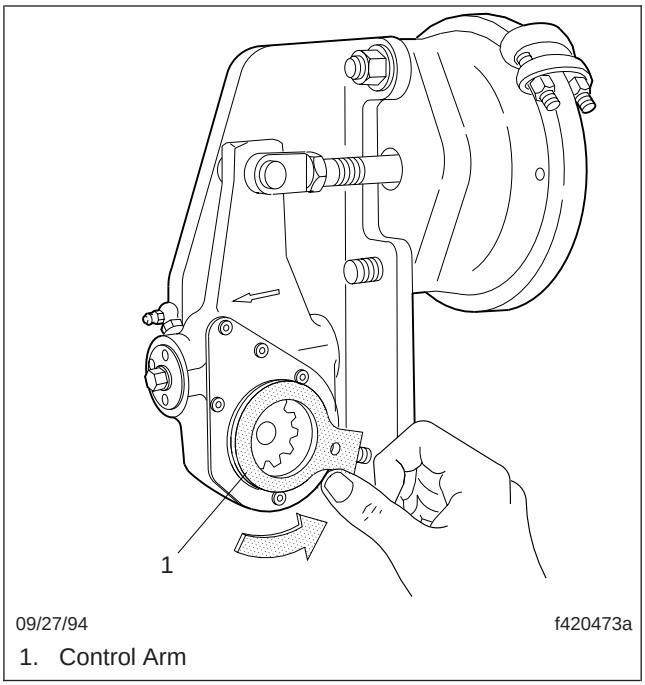
IMPORTANT: When correctly installed, the brake chamber push rod pushes in the direction of the arrow (**Fig. 2**) on the adjuster arm.

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.

Slack Adjuster Removal and Installation

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**.



1. Control Arm

Fig. 3, Rotate the Control Arm

CAUTION

Never hammer the control arm. Damage to the adjuster or camshaft spline may result.

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.

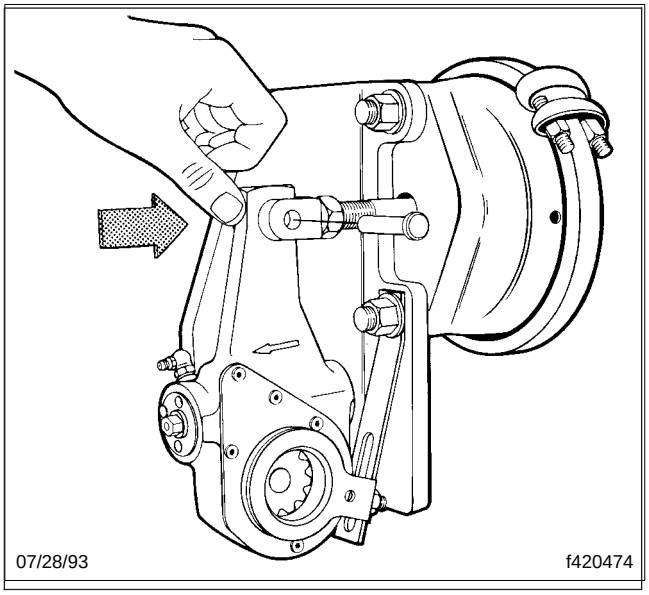


Fig. 4, Check the Installation

WARNING

Install and lock a new cotter pin. Failure to do so could allow the push rod to disengage from the slack adjuster, causing a loss of braking ability, possibly resulting in personal injury and property damage.

NOTE: Incorrect installation can cause dragging brakes.

Troubleshooting Tables

Problem—Tight or Dragging Brakes

Problem—Tight or Dragging Brakes	
Possible Cause	**Remedy**
The control arm anchor bracket is not positioned properly.	See instructions under **Subject 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 **Group 33** and **Group 35**.
The brake shoe return spring is broken.	Replace the brake shoe return spring.

Problem—Brake Chamber Push Rod Travel Is Excessive

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

Problem—Brake Chamber Push Rod Travel Is Excessive	
Possible Cause	**Remedy**
The slack adjuster clutch assembly is worn.	Replace the slack adjuster.

General Description

The Meritor 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.

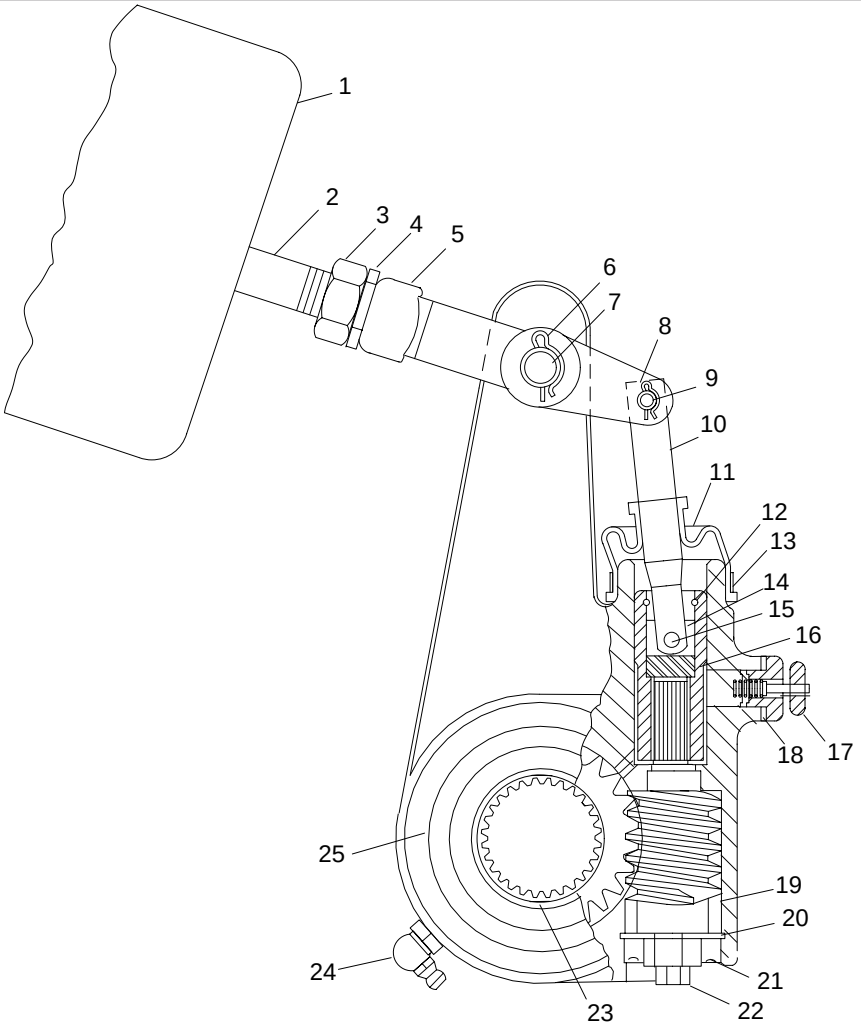
Principles of Operation (See Fig. 1)

The externally splined end of the worm fits the internal splines on the actuator. Angled serrations on the spring-held pawl 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 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 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 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 and the camshaft to automatically adjust the brake.

General Information



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1. Brake Air Chamber
2. Brake Chamber Push Rod
3. Clevis Jam Nut
4. Collar
5. Clevis
6. Cotter Pin (large)
7. Clevis 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. "Pull" Pawl Assembly
18. Gasket
19. Worm
20. Worm Retaining Snap Ring
21. Worm Grease
22. Manual (Worm) Adjusting Nut End
23. Gear
24. Grease Fitting
25. Gear Retainer/Seal

Fig. 1, Automatic Slack Adjuster (sectional view)

Slack Adjuster Removal and Installation

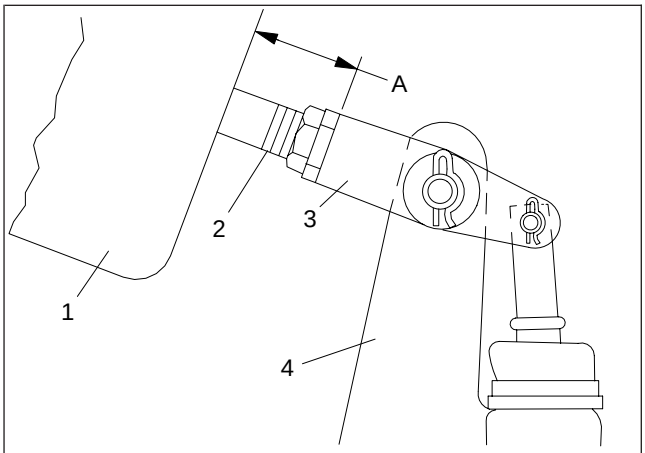
Removal

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

Manually cage each parking brake chamber power spring in the released (no application) position before continuing. Loss of brake chamber air pressure will cause sudden application of the parking brakes, which could result in personal injury or death.

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**, Ref. 17. 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

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

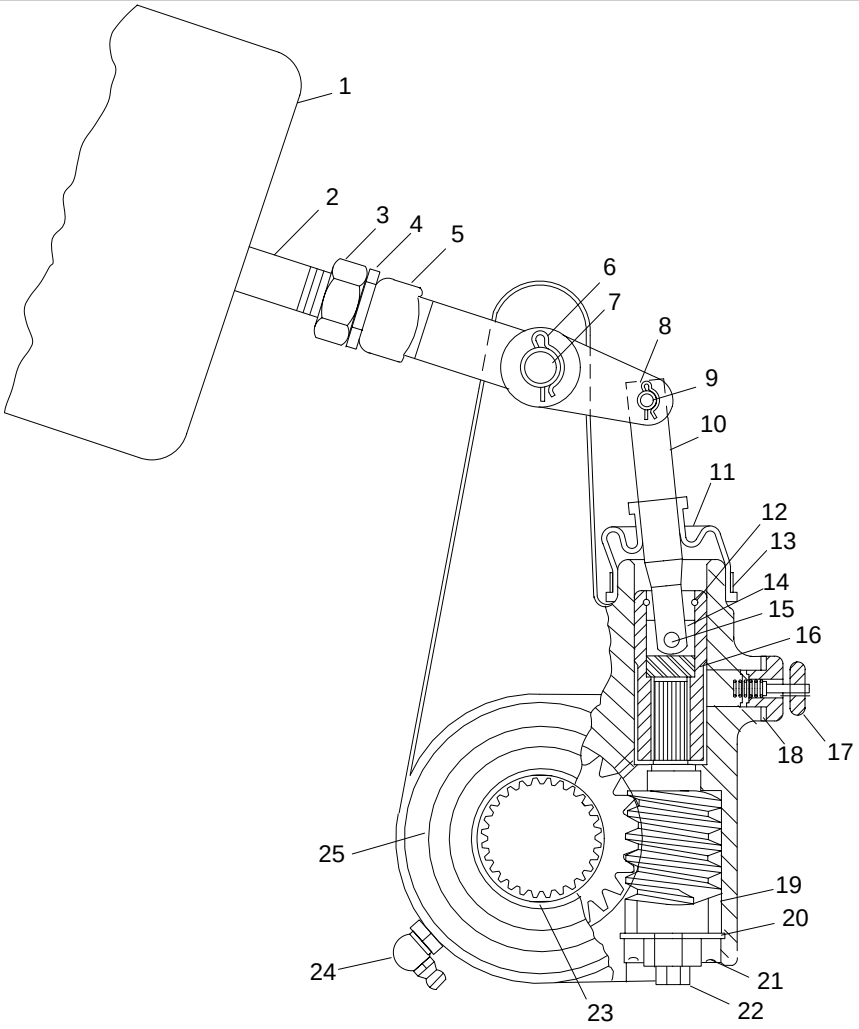
1. Inspect parts, and then prepare the slack adjuster for installation.
   - 1.1 Check the brake camshaft splines for wear or corrosion.
   - 1.2 Coat the camshaft splines and the splines of the slack adjuster gear with Meritor lubricant 0–637, Southwest SA 8249496, or an equivalent.

   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 measured during removal. Do not tighten the jam nut against the clevis.

Slack Adjuster Removal and Installation



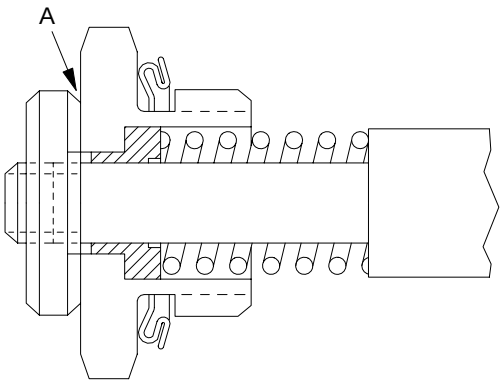
1. Brake Air Chamber
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19. Worm
20. Worm Retaining Snap Ring
21. Worm Grease
22. Manual (Worm) Adjusting Nut End
23. Gear
24. Grease Fitting
25. Gear Retainer/Seal

Fig. 2, Automatic Slack Adjuster (sectional view)

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, or 30 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



A. Insert screwdriver here.

Fig. 3, Pull-Pawl Assembly (sectional view)

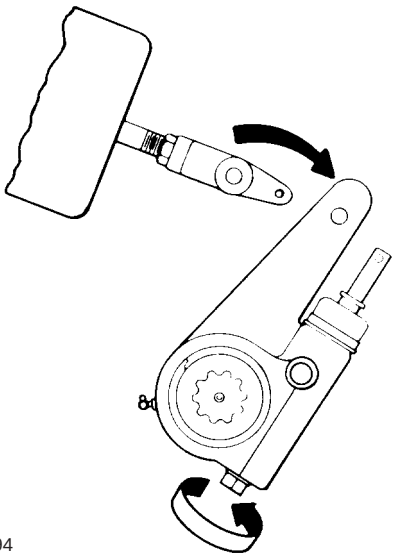
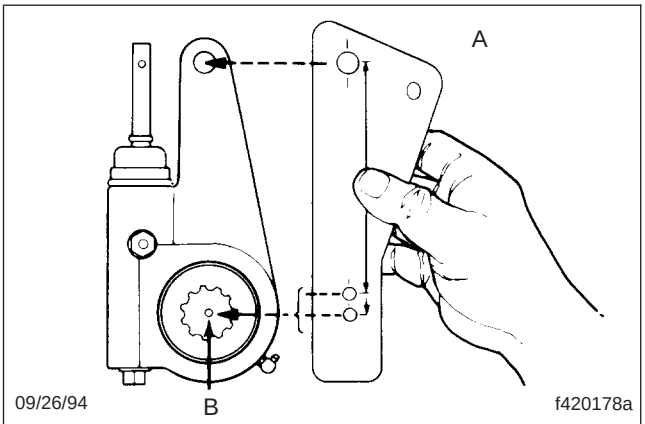


Fig. 4, Move the Slack Adjuster Away from the Clevis

was removed. Refer to the appropriate table in **Specifications 400** for the length of slack adjusters that should be used with various sizes of brake chambers.

NOTE: Depending on the type of brakes used 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 Meritor 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 group.

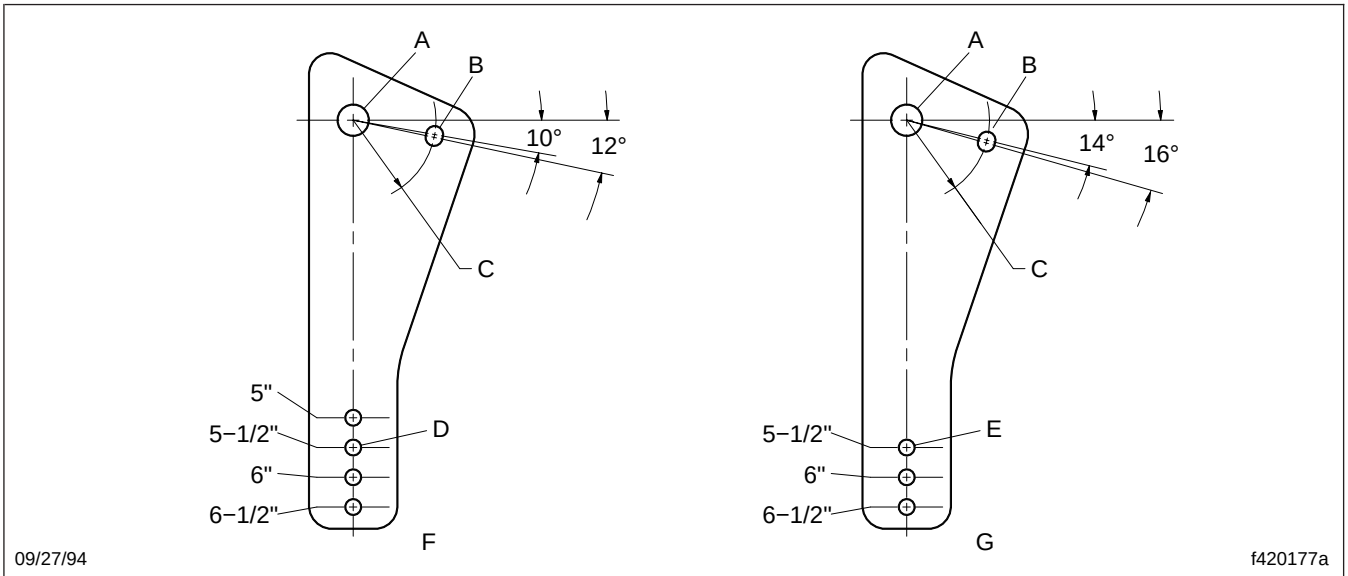
3.4 If installing a new slack adjuster, remove the pressure relief capscrew, spring, and pawl assembly from the slack adjuster housing. If equipped with a pull-pawl assembly (**Fig. 3**), carefully insert a screwdriver and raise the relief cap about 1/8 inch (3.2 mm).

CAUTION

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.

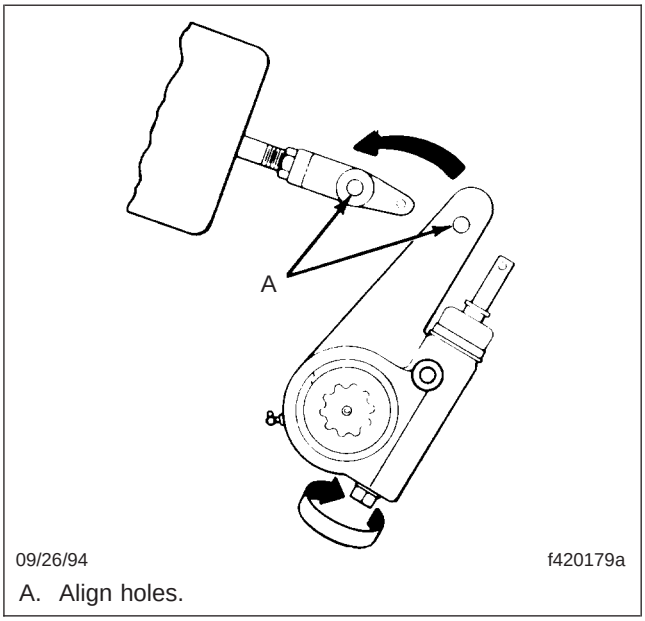
3.5 Using a wrench, turn the manual adjusting nut to align the hole in the slack adjuster housing with the large hole in the clevis. See **Fig. 7**. Insert the large clevis pin.

Slack Adjuster Removal and Installation



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

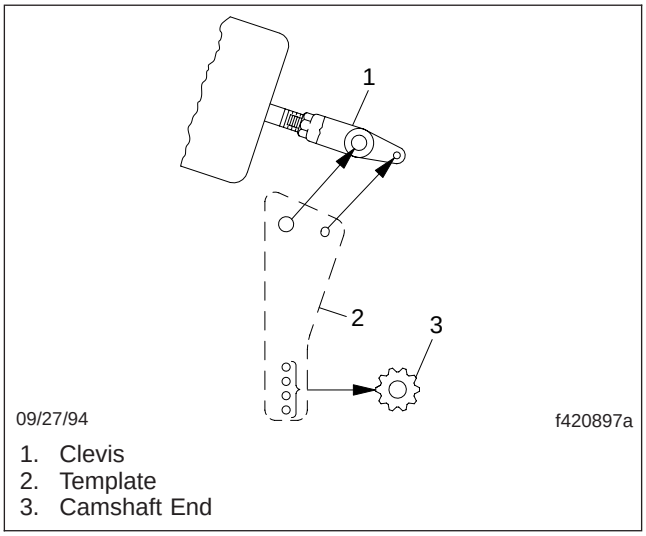
Fig. 6, Installation Template Specifications



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**.



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).

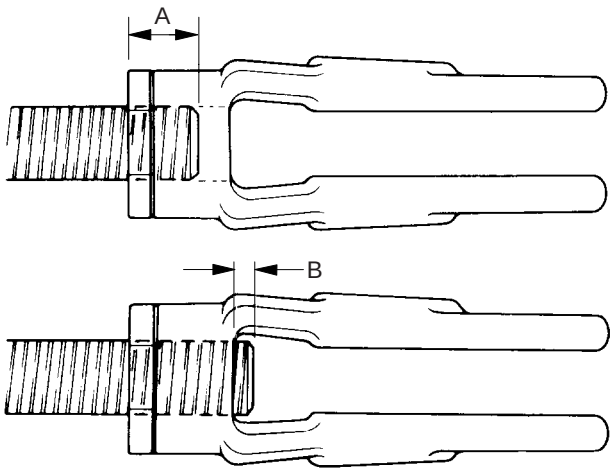
4. Set the free-stroke.

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).

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.

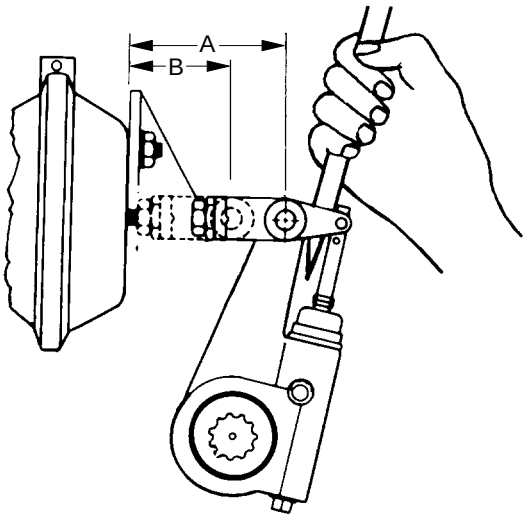
5. Measure the brake chamber stroke, and adjust as needed.

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. 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 ap-

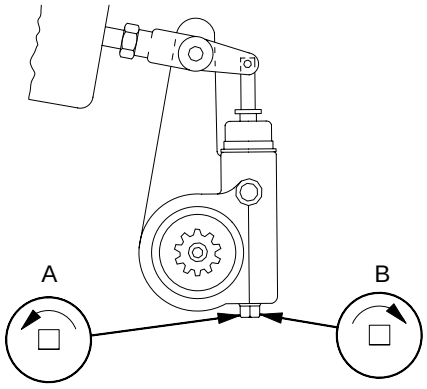
Slack Adjuster Removal and Installation



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NOTE: For a drum brake, A minus B must equal 5/8" to 3/4" (16 to 19 mm).

Fig. 10, Measuring Free-Stroke



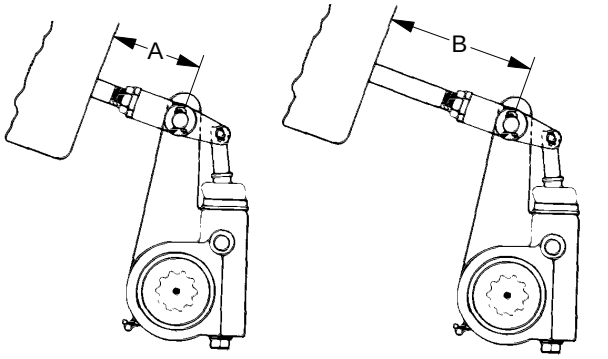
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A. Shorten stroke.
B. Lengthen stroke.

Fig. 11, Turn the Adjusting Nut

propriate table in **Specifications 400**. If needed, turn the adjusting nut to adjust the 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 group.



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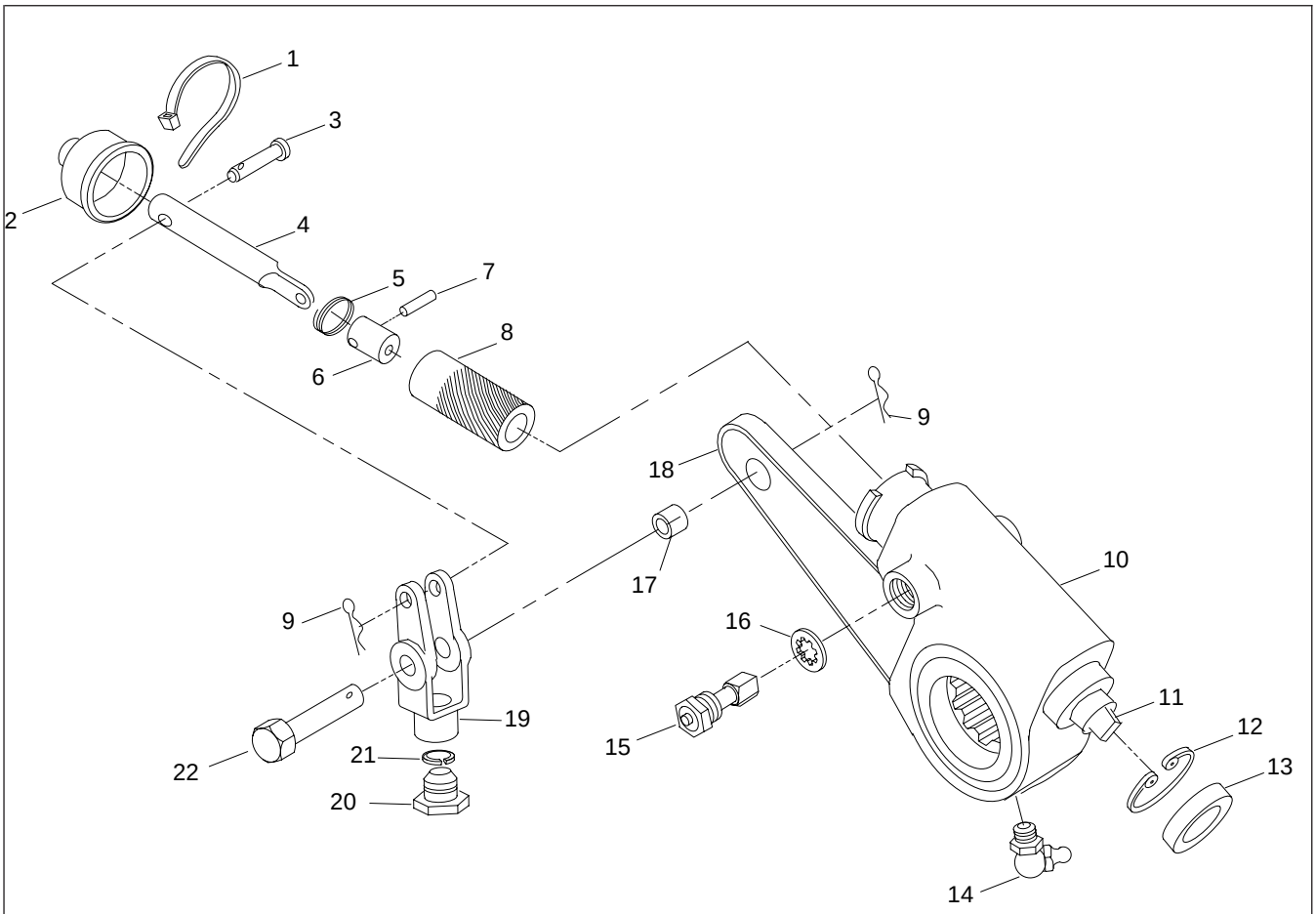
NOTE: Measure distance *A* with the brakes released; measure distance *B* with the brakes applied.

Fig. 12, Measuring Adjusted Brake Chamber Stroke

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 group.
9. Remove the chocks from the tires.

Slack Adjuster Disassembly, Cleaning and Inspection, and Assembly

Disassembly (See Fig. 1)



01/23/98 f421721

1. Boot Retaining Clip
2. Boot
3. Small Clevis Pin
4. Actuator Rod
5. Piston Retaining Ring
6. Actuator Piston
7. Roller (pin)
8. Actuator
9. Cotter Pin
10. Housing and Bushing Assembly
11. Manual Adjustment Nut
12. Worm Retaining Ring
13. Worm Grease Seal
14. Grease Fitting
15. Pull Pawl Assembly
16. Gasket
17. Large Clevis Pin Bushing
18. Slack Adjuster Housing
19. Clevis
20. Quick-Connect Collar
21. Clevis Retaining Ring
22. Large Clevis Pin

Fig. 1, Slack Adjuster Assembly (exploded view)

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.
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.

Slack Adjuster Disassembly, Cleaning and Inspection, and Assembly

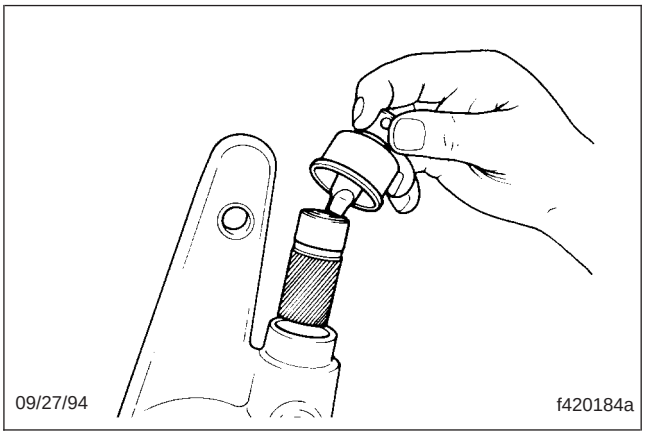
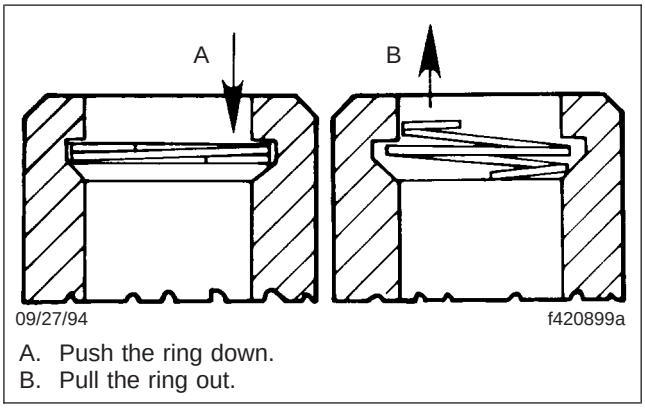


Fig. 2, Removal of the Actuator



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**.
7. Using a small screwdriver, pry the grease seal from around the worm. See **Fig. 5**.
8. Using snap ring pliers, remove the retaining ring from the worm. See **Fig. 6**.
9. Using a wrench, turn the manual adjusting nut, and wind the worm out of the bore.

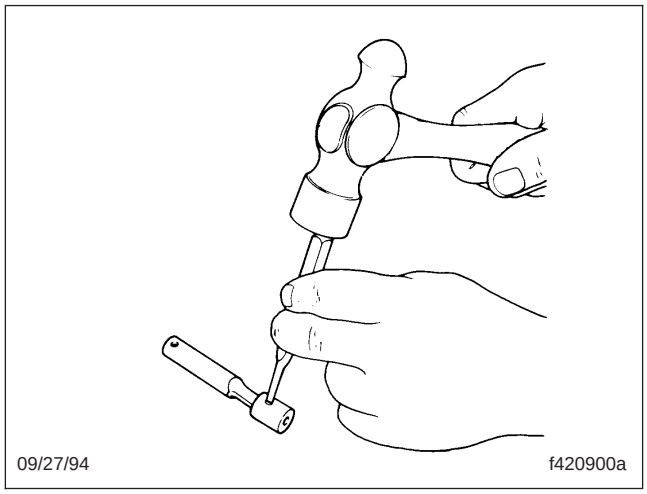


Fig. 4, Remove the Pin from the Rod and Piston

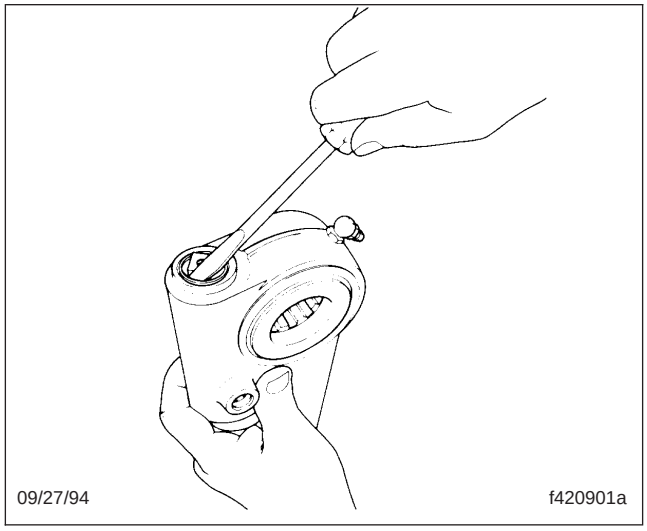


Fig. 5, Pry the Grease Seal from around the Worm

Cleaning and Inspection

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.

1. Clean the slack adjuster parts.

Slack Adjuster Disassembly, Cleaning and Inspection, and Assembly

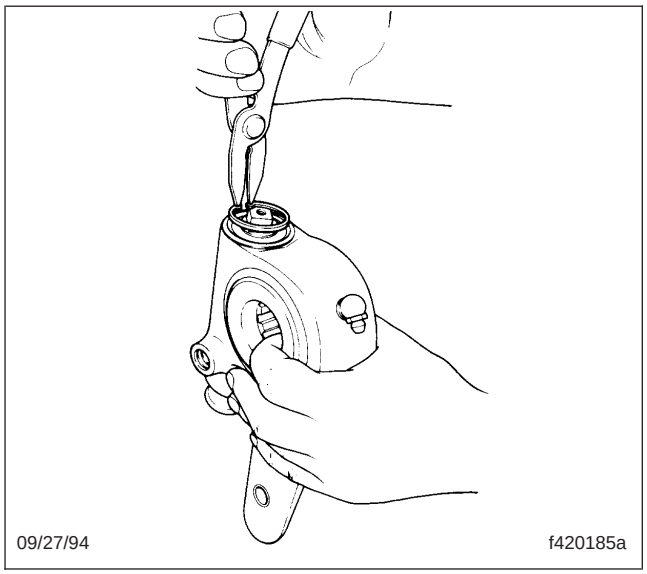


Fig. 6, Remove the Retaining Ring

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.

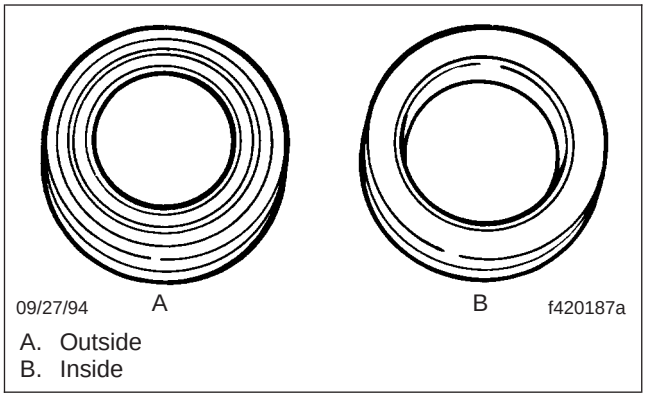
3. If storing parts for any length of time, treat them with a good rust preventative, and wrap them in special paper or other material designed to prevent corrosion.

Assembly (See Fig. 1)

1. Coat all parts and the gear bore with a grease recommended in the appropriate table in **Specifications 400**.

2. Install the retaining snap ring.

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. 7**. Using a hammer and a 1-3/16 inch seal driver, install the seal.



A. Outside
B. Inside

Fig. 7, Worm Seal

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.

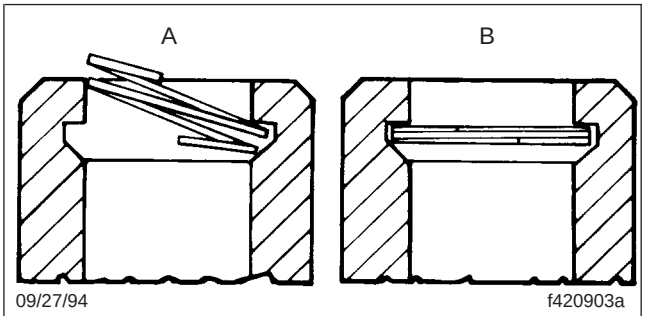
4.1 Using a small hammer and brass drift punch, install the pin that connects the piston and actuator rod.

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. 8**. 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.

Slack Adjuster Disassembly, Cleaning and Inspection, and Assembly



A. Start bottom coil.
B. Tuck ring into groove.

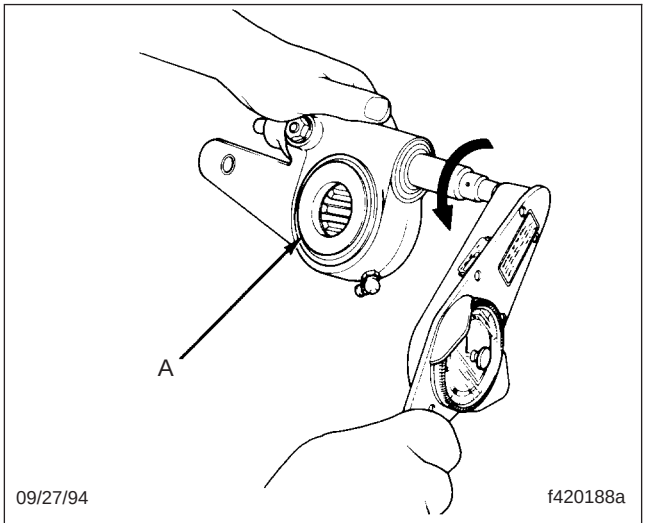
Fig. 8, Installation of the Internal Piston Retaining Ring

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. 9**. 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.
10. Install the slack adjuster. For instructions, refer to **Subject 100**.



A. Rotate the gear 360 degrees.

Fig. 9, Slack Adjuster Torque Check

Specifications

Lubricant 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 Meritor 0–616–A Meritor 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°F (–40°C) or Above
Mobil 28 Meritor 0–645	Below –40°F (–40°C)

Table 1, Lubricant Specifications

Slack Adjuster Arm Lengths	
Slack Adjuster Arm Length inches (mm)	**Chamber Size**
5 (127)	9, 12, 16, 20, 24, 30
5-1/2 (140)	9, 12, 16, 20, 24, 30
6 (152)	24, 30
6-1/2 (165)	30

Table 2, Slack Adjuster Arm Lengths

Maximum Adjusted Brake Chamber Strokes	
Chamber Size	**Maximum Chamber Stroke for Cam Brake inches (mm)**
9	Less than 1-1/2 (38)
12	Less than 1-1/2 (38)
16	Less than 1-3/4 (44)
20	Less than 1-3/4 (44)
24	Less than 1-7/8 (48)
24 *	Less than 2 (51)

Maximum Adjusted Brake Chamber Strokes	
Chamber Size	**Maximum Chamber Stroke for Cam Brake inches (mm)**
30	Less than 2 (51)

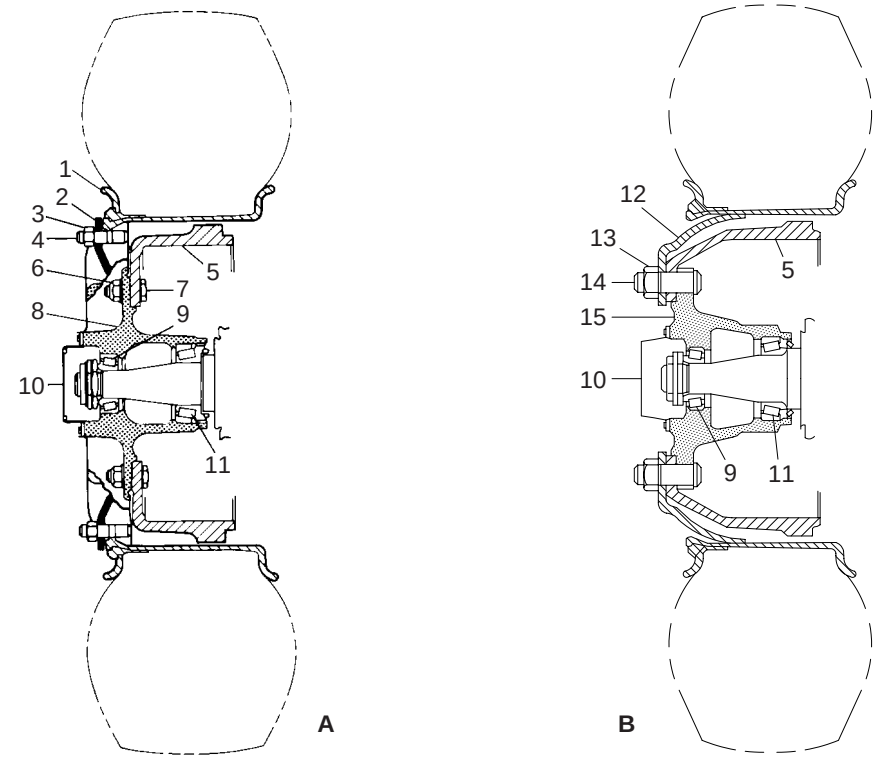
* Long stroke.

Table 3, 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.



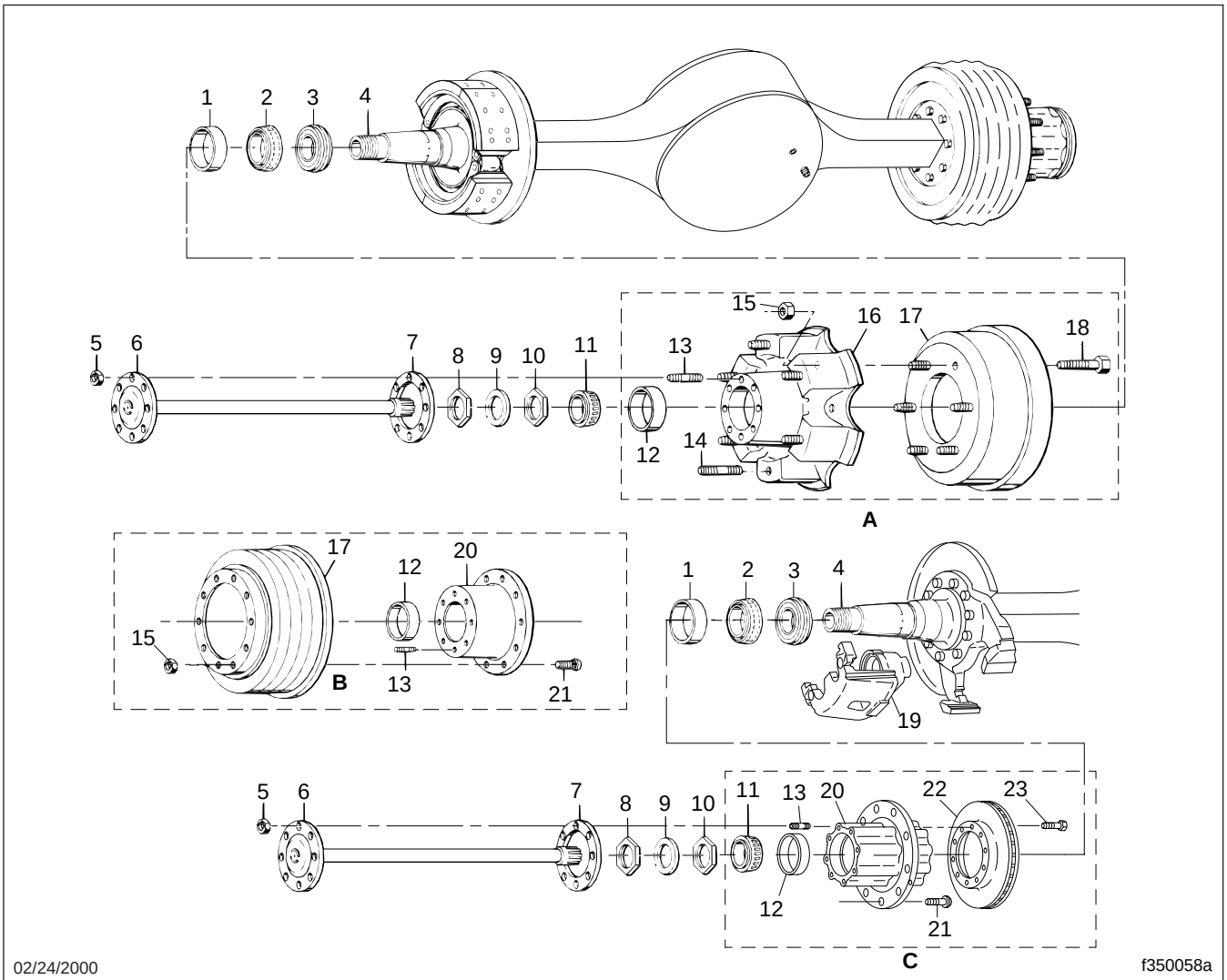
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A. Spoke Wheel Assembly
B. Disc Wheel Assembly

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

Fig. 1, Sectional View of Spoke and Disc Wheel Assemblies, Front Axle

General Information



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A. Spoke Wheel and Drum Assembly
B. Disc Wheel Hub and Drum Assembly
C. Disc Wheel Hub and Rotor Assembly

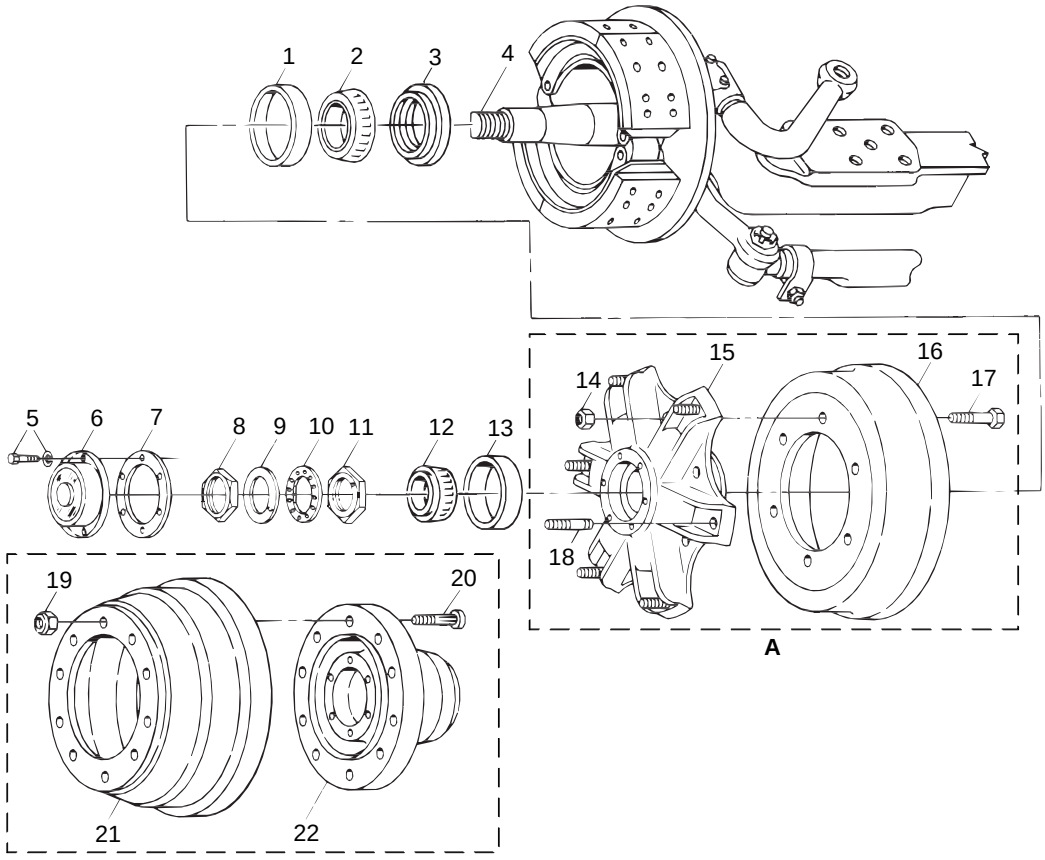
1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle
5. Drive Axle Stud Nut
6. Drive Axle Flange and Shaft
7. Gasket
8. Jam Nut
9. Inner Wheel Bearing
10. Wheel Bearing Inner Adjusting Nut
11. Outer Wheel Bearing
12. Outer Wheel Bearing Cup
13. Drive Axle Stud
14. Rim Stud
15. 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. 2, Exploded View of Spoke and Disc Wheel Assemblies, Drive Axle

Outboard-Mounted Drum Removal and Installation

Removal

When completing the following procedure, refer to **Fig. 1** and **Fig. 2**.



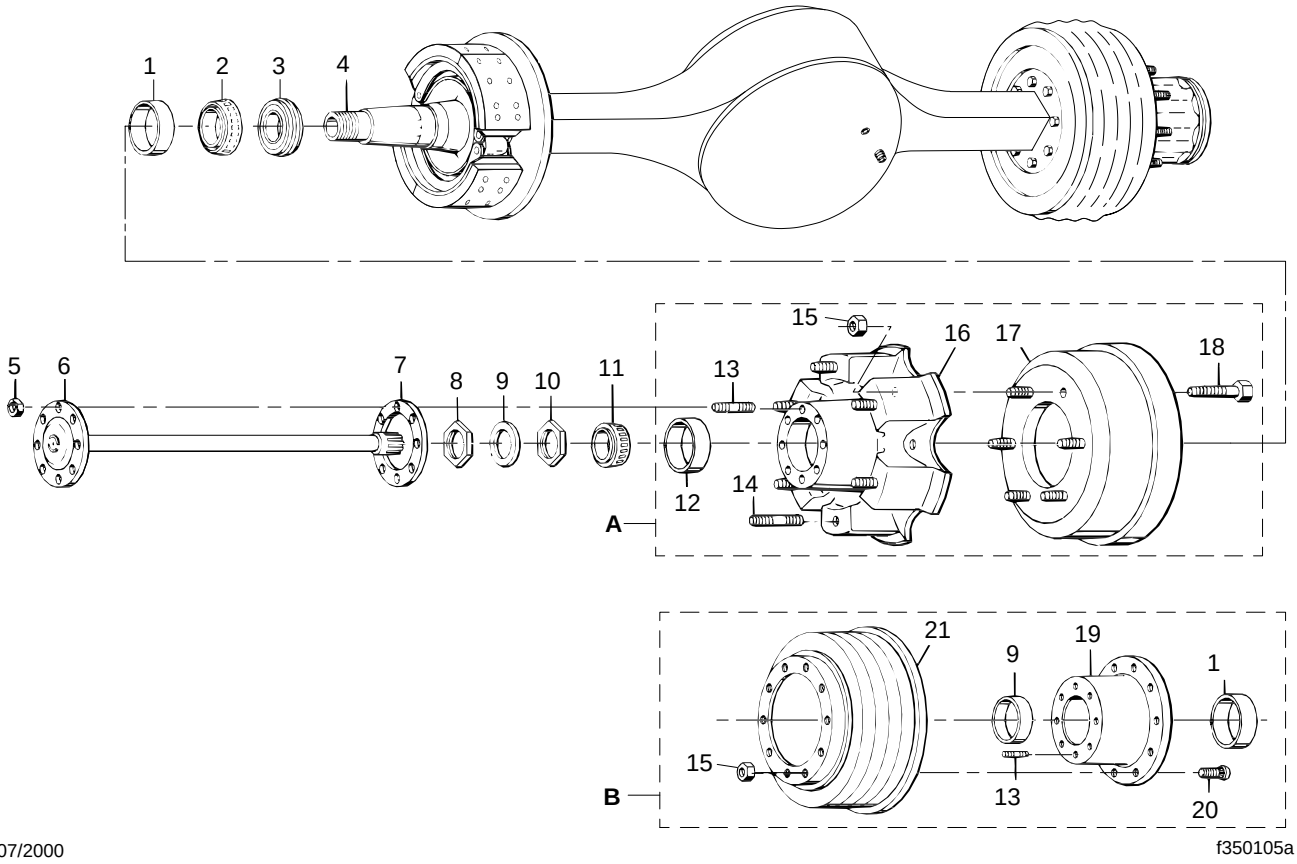
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A. Spoke Wheel and Inboard-Mounted Drum Assembly
B. Disc Wheel, Hub, and Outboard-Mounted Drum Assembly

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)

Outboard-Mounted Drum Removal and Installation



04/07/2000 f350105a

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

B. Disc Wheel, Hub, and Drum Assembly

12. Outer Wheel Bearing Cup
13. Drive Axle Stud
14. Rim Stud
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)

⚠ WARNING

When replacing brake pads, shoes, rotors, or drums, always replace components as an axle set.

- Always reline both sets of brakes on an axle at the same time.
- Always replace both rotors/drums on an axle at the same time.
- Always install the same type of linings/pads or drums/rotors on both axle ends of a single

Outboard-Mounted Drum Removal and Installation

axle, and all four axle ends of a tandem axle, at the same time. Do not mix component types.

Failure to do so could cause uneven braking and loss of vehicle control, resulting in property damage, personal injury, or death.

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.

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, refer to the applicable slack adjuster section in **Group 42** of this manual.

⚠ 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 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. Refer to **Group 40** for instructions.

5. Remove the brake drum.

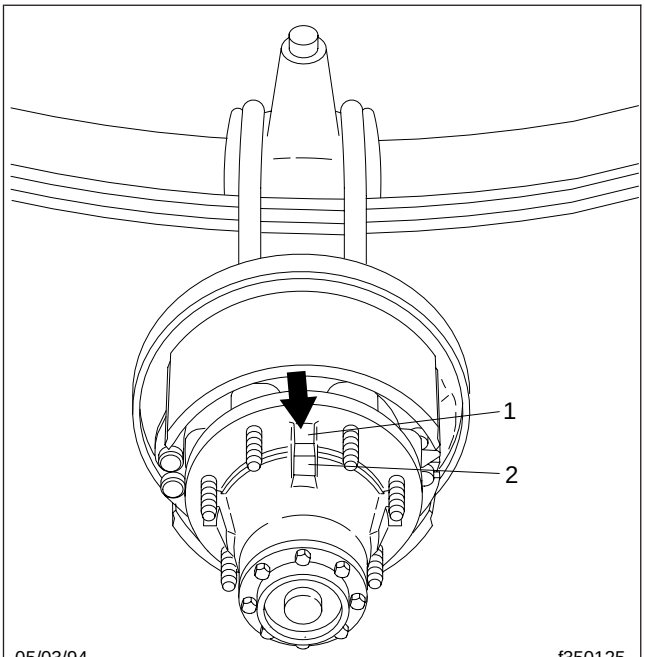
   To minimize the possibility of creating airborne brake lining dust, clean the dust from the brake drum, brake backing plate, and brake assembly, using an industrial-type vacuum cleaner equipped with a high-efficiency filter system. Then, using a rag soaked in water and wrung until nearly dry, remove any remaining dust. Don't use compressed air or dry brushing to clean the brake assembly.

6. Inspect the drum. Refer to **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**.



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)

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.

Outboard-Mounted Drum Removal and Installation

WARNING

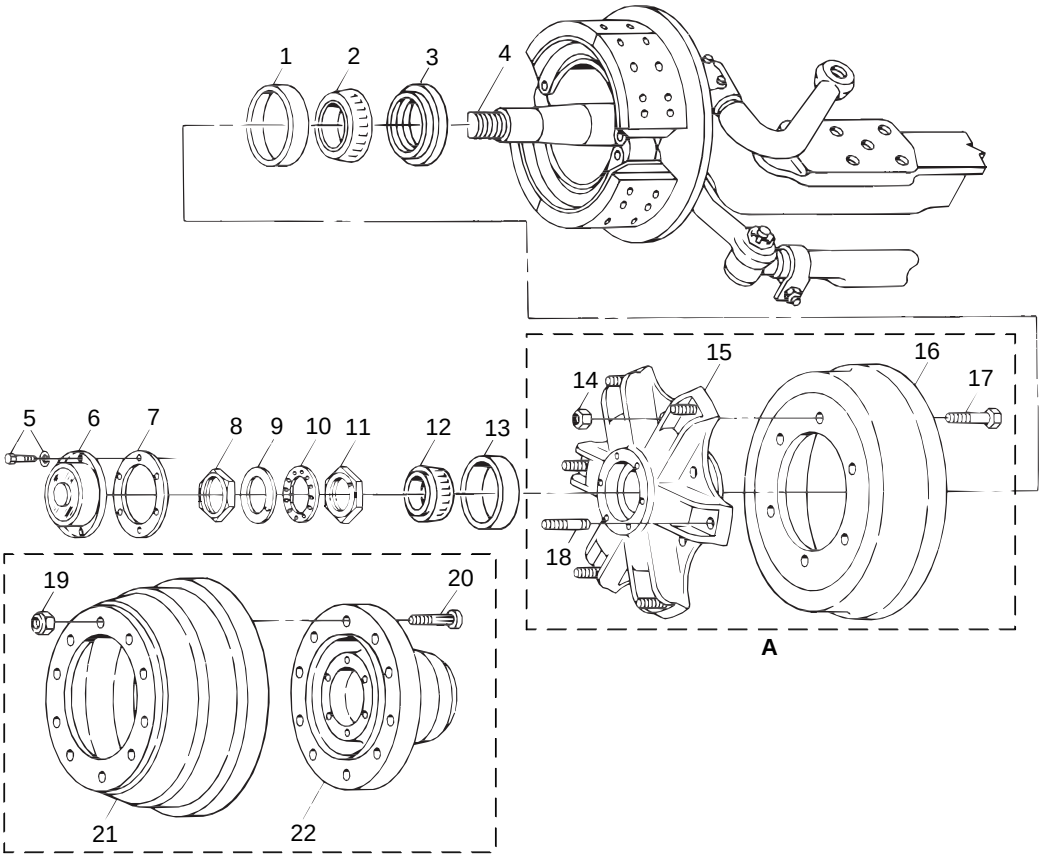
If the wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking ability, and the hub flange is probably damaged. In this case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when the conditions described above exist, could result in the loss of a wheel or loss of vehicle control, and possible personal injury.

2. Install the wheel and tire assemblies. Refer to **Group 40** for instructions.
3. Adjust the brakes at the slack adjusters. For instructions, refer to **Group 42** in the *Cargo 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

When completing the following procedure, refer to **Fig. 1** and **Fig. 2**.

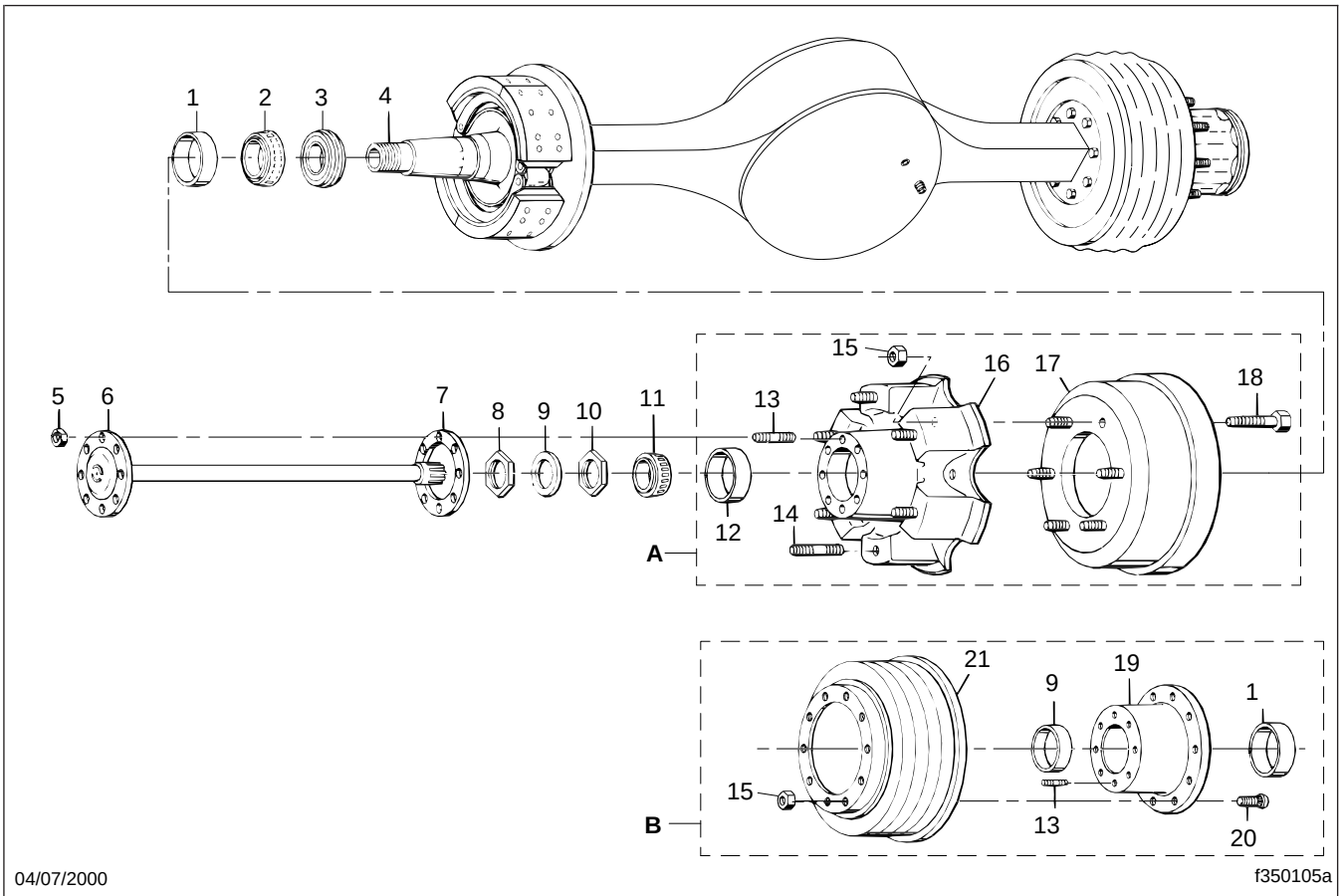


A. Spoke Wheel and Inboard-Mounted Drum Assembly
B. Disc Wheel, Hub, and Outboard-Mounted Drum Assembly

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

Inboard-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

B. Disc Wheel, Hub, and Drum Assembly

12. Outer Wheel Bearing Cup
13. Drive Axle Stud
14. Rim Stud
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)

⚠ WARNING

When replacing brake pads, shoes, rotors, or drums, always replace components as an axle set.

- Always reline both sets of brakes on an axle at the same time.
- Always replace both rotors/drums on an axle at the same time.
- Always install the same type of linings/pads or drums/rotors on both axle ends of a single

axle, and all four axle ends of a tandem axle, at the same time. Do not mix component types.

Failure to do so could cause uneven braking and loss of vehicle control, resulting in property damage, personal injury, or death.

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.
3. Back off the slack adjuster to release the brake shoes. For instructions, refer to **Group 42** in this manual.
4. Remove rim and tire assemblies. For instructions, refer to **Group 40** in this manual.
5. Remove the wheel hub. For instructions, refer to **Group 33** or **Group 35** in this manual.
6. Remove the brake drum nuts and detach the brake drum from the wheel.

⚠ 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 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 240 lbf·ft (325 N·m).
2. Install the hub and wheel bearings. For instructions, refer to **Group 33** or **Group 35** in this manual.
3. Install the wheel and tire assembly. For instructions, refer to **Group 40** in this manual.
4. Adjust the brakes at the slack adjusters. For instructions, refer to **Group 42** in the *Cargo 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. See **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

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.

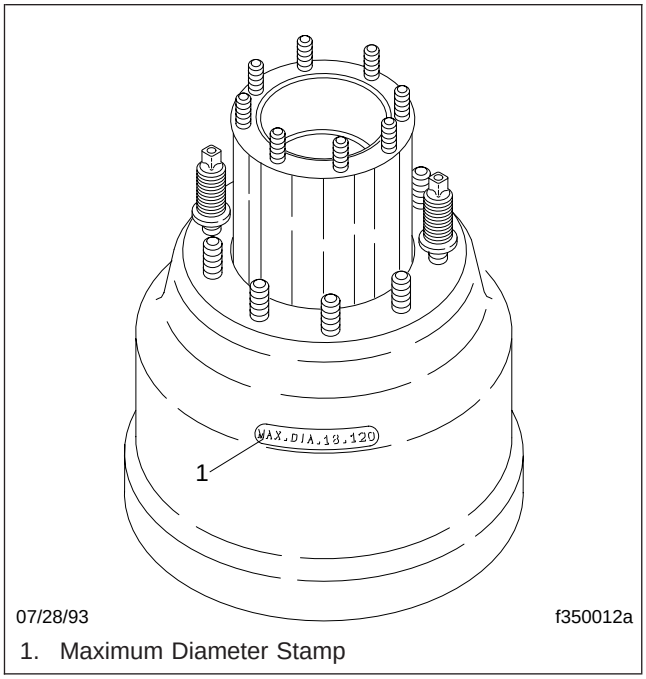
⚠ CAUTION

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. For instructions, refer to **Group 42** in this manual.

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

Fig. 1, Brake Drum

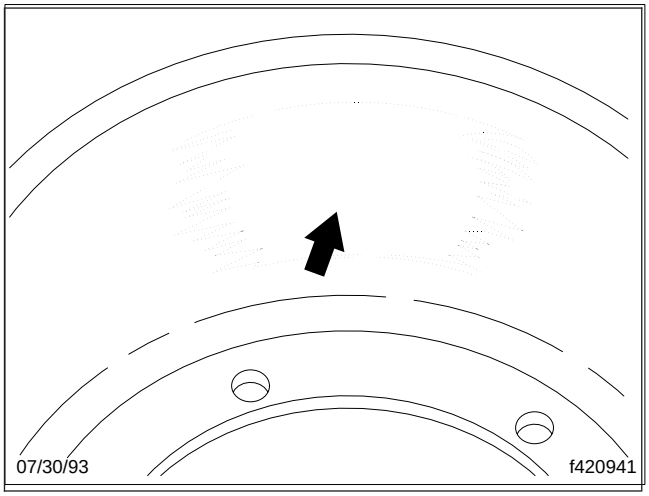


Fig. 2, Polished Drums

Inspection

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.

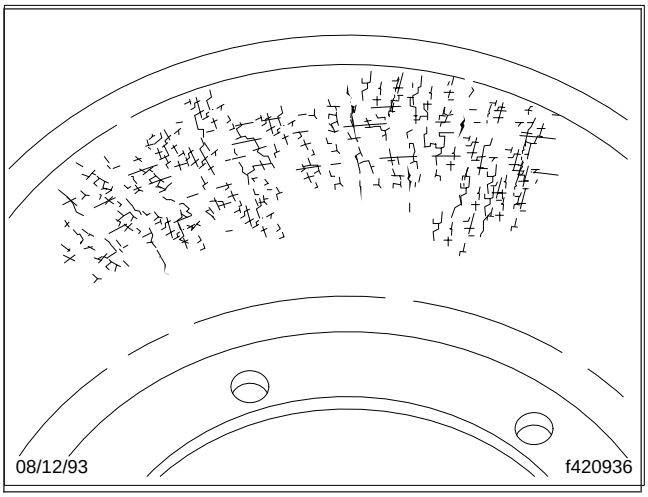


Fig. 3, Heat Checking

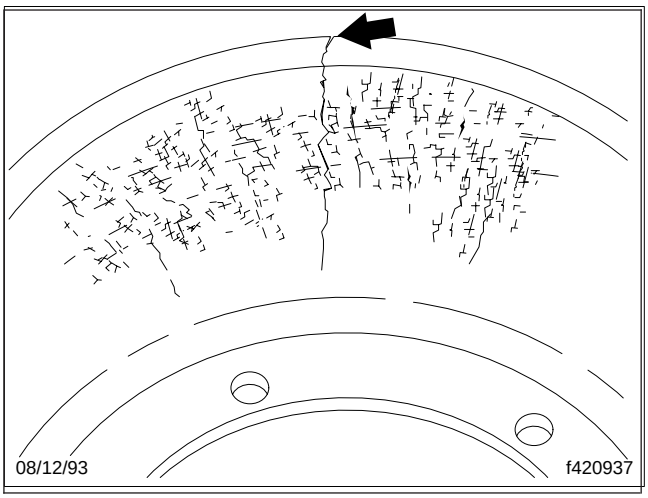


Fig. 4, Cracked Drums

NOTE: If there is normal heat checking as described above, inspect the drums at least every 12,000 miles (19 300 km) 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 6000 miles (9700 km). 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 **Group 42** in this manual.

⚠ WARNING

If the brake drums are contaminated with fluids, replace the brake linings. Failure to replace fluid contaminated brake linings could result in a partial loss of braking capacity, which could lead to personal injury or property damage.

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 0.010 inch (0.25 mm) 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 (**Fig. 6**) or for a bluish cast on the brake parts (**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 the drums. Also replace the brake shoe return springs. For instructions, refer to **Group 42** in this manual.

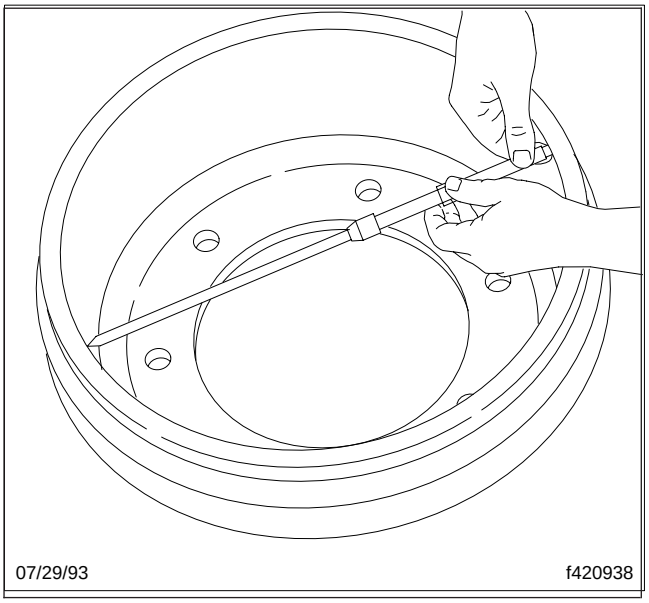


Fig. 5, Oversized Drums

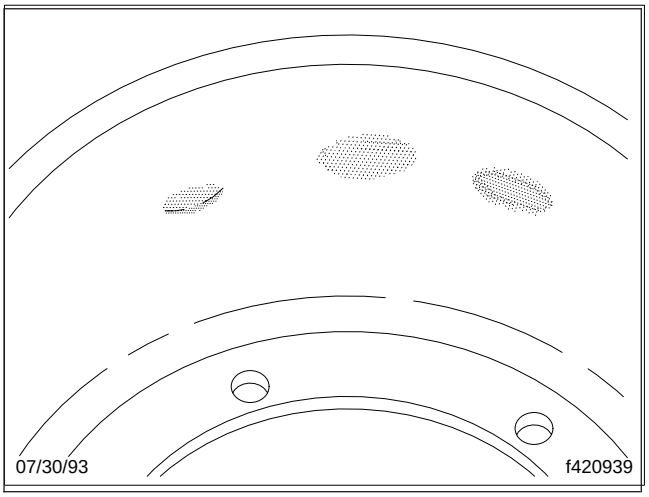


Fig. 6, Heat Spotted Drums

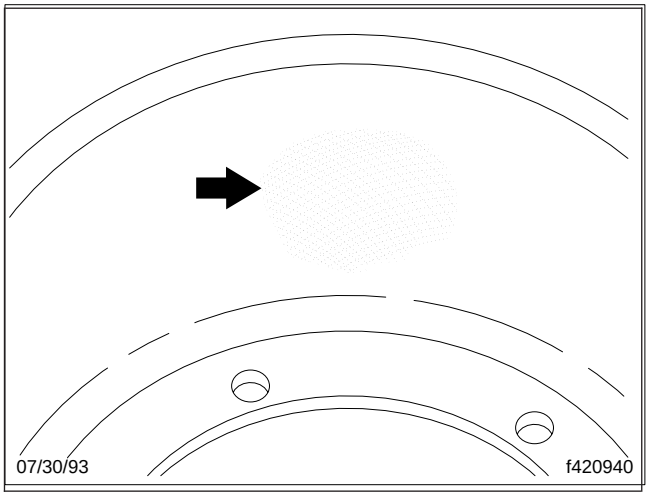


Fig. 7, Blue Drums

Specifications

Fastener Torque			
Description	**Grade**	**Size**	**Torque lbf·ft (N·m)**
Brake Drum Bolt	8	3/4–10	240 (325)

Table 1, Fastener Torque

General Information

Meritor "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.

Meritor 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.

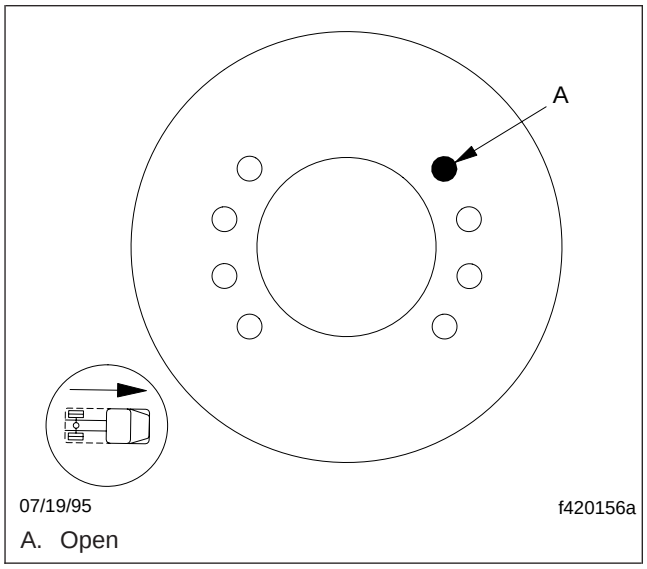


Fig. 1, Meritor Brake Spider

Meritor attaches 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. The lining edge code specifies the supplier lining designation and the corresponding Meritor designation. See **Table 1**.

Edge Codes		
Vendor Code		**Meritor 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 Meritor aftermarket lining material designation. See "Meritor Designation" in **Table 1**. The third line gives the service part number to use for replacing the shoe and lining assembly.

Refer to **Group 33** *for wheel hubs, brake drums, and wheel bearings, and to* **Group 42** *for air brake system troubleshooting.*

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 Information

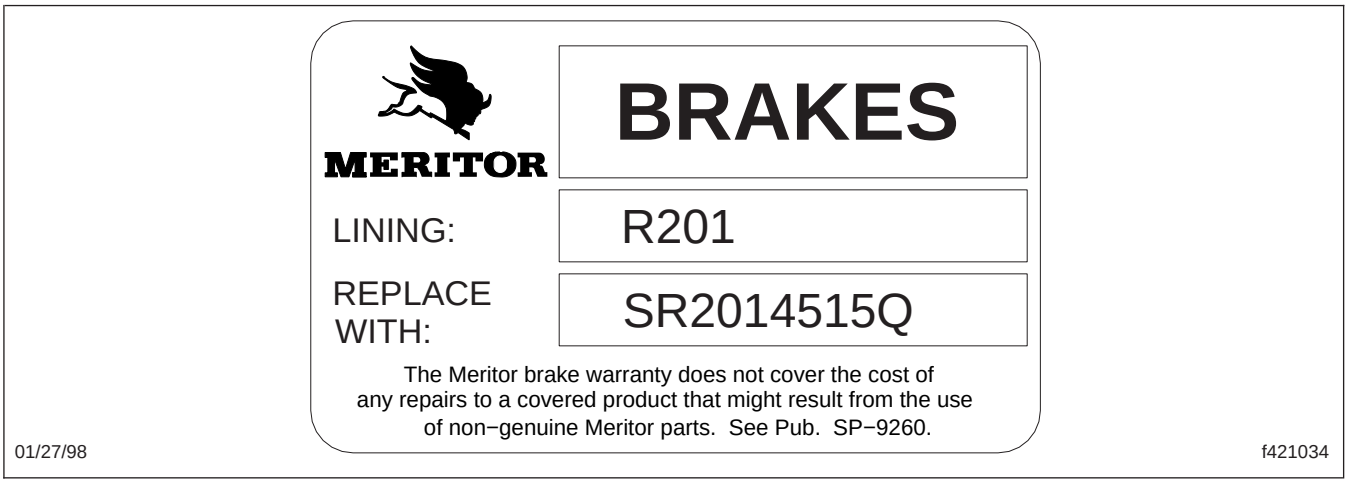


Fig. 2, Meritor Brake Shoe Label, Example

General Safety Precautions

⚠ WARNING

When replacing brake pads, shoes, rotors, or drums, always replace components as an axle set.

- Always reline both sets of brakes on an axle at the same time.
- Always replace both rotors/drums on an axle at the same time.
- Always install the same type of linings/pads or drums/rotors on both axle ends of a single axle, and all four axle ends of a tandem axle, at the same time. Do not mix component types.

Failure to do so could cause uneven braking and loss of vehicle control, resulting in property damage, personal injury, or death.

When working on or around a vehicle, observe the following precautions:

- Park the vehicle on a level surface and apply the parking brakes. Shut down the engine and chock the tires.
- If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning any work on the vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters, which may apply as air pressure drops.
- Disconnect the batteries.
- 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. Always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
- Do not remove, disassemble, assemble, or install a component until you have read and understand 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.
- Replacement hardware, tubing, hose, fittings, etc. should be the equivalent size, type, length, and strength of the original equipment.
- Make sure when replacing tubes or hoses that all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices that have stripped threads or damaged parts. Repairs requiring machining should not be attempted.
- Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

Asbestos and Non-Asbestos Safety

⚠ 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.

Because some brake linings contain asbestos, you should know the potential hazards of asbestos and the precautions to be taken. Exposure to airborne asbestos brake lining dust can cause serious and possibly fatal diseases such as asbestosis (a chronic lung disease) and cancer.

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.

Areas where brake work is done should be separate from other operations, if possible. As required by OHSA 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.

Safety Precautions

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, 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.

If grinding or other machining of the brake linings is necessary, other precautions must be taken because exposure to asbestos dust is highest during such operations. In addition to the use of an approved respirator, there must be local exhaust ventilation such that worker exposure is kept as low as possible.

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. Asbestos-containing waste, such as dirty rags, should be sealed, labeled, and disposed of as required by EPA and OSHA regulations. Respirators should be used when emptying vacuum cleaners and handling asbestos waste products.

Workers should wash before eating, drinking, or smoking, should shower after work, and should not wear work clothes home. Work clothes should be vacuumed after use and then laundered, without shaking, to prevent the release of asbestos fibers into the air.

⚠ 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 **Group 33** or **Group 35** in this manual.

⚠ CAUTION

Before you back off automatic slack adjusters, refer to Group 42 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**.

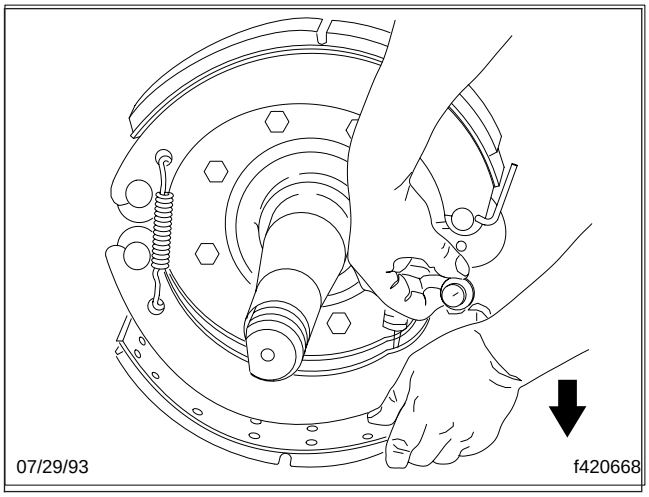


Fig. 1, Removal of Bottom Cam Roller

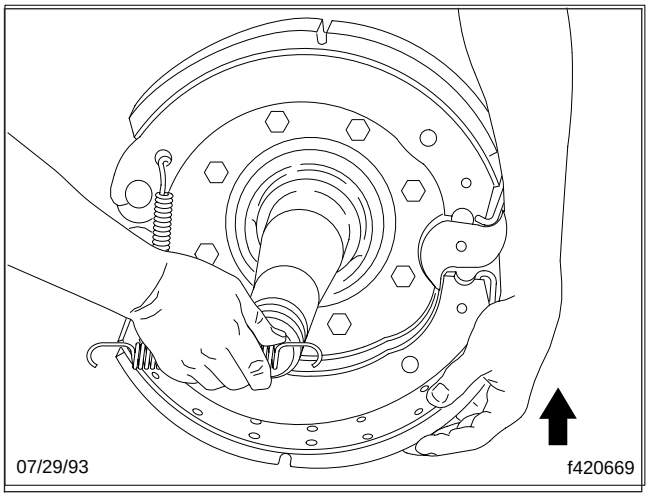


Fig. 2, Removal of Spring

   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 (Meritor 0-616, or an equivalent) on the anchor pins where they touch the brake shoes. Also, apply a multipurpose chassis grease (Meritor 0-617-A or 0-617-B, or an equivalent) on the retainer clips, spider, and shoe rollers where they touch the brake shoes.

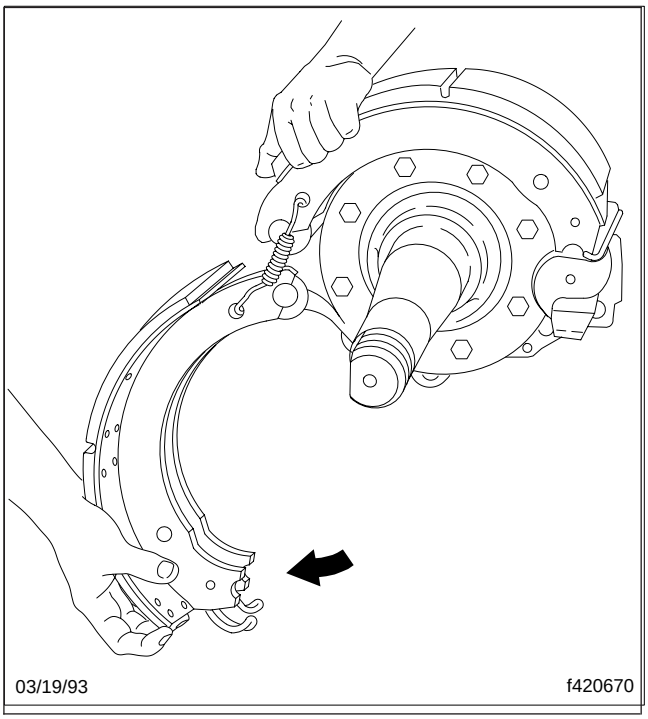


Fig. 3, Removal of Springs and Brake Shoes

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**.

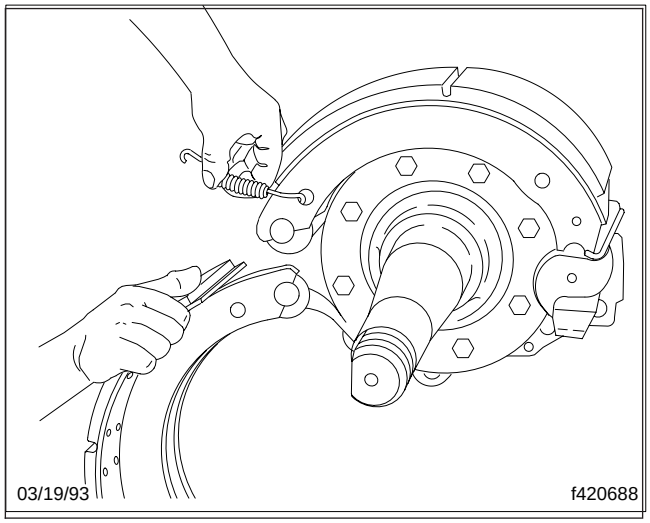


Fig. 4, Attaching Brake Shoe Retaining Springs

   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.

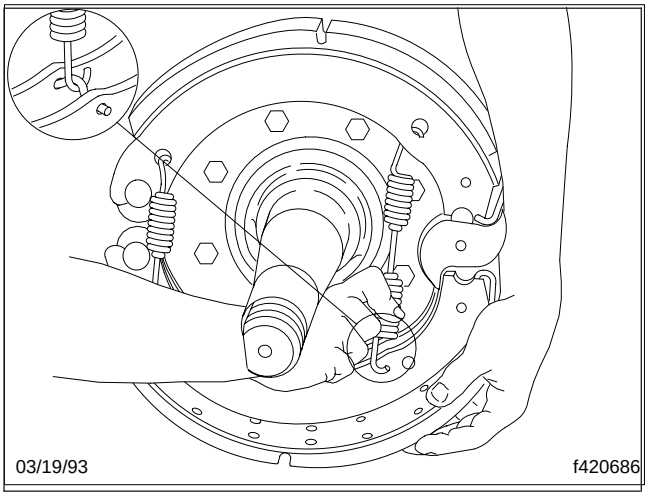
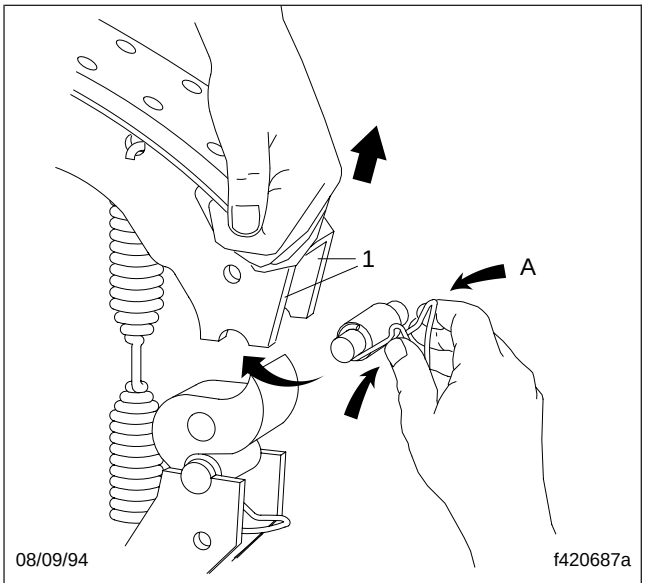


Fig. 5, Attaching Brake Shoe Return Spring



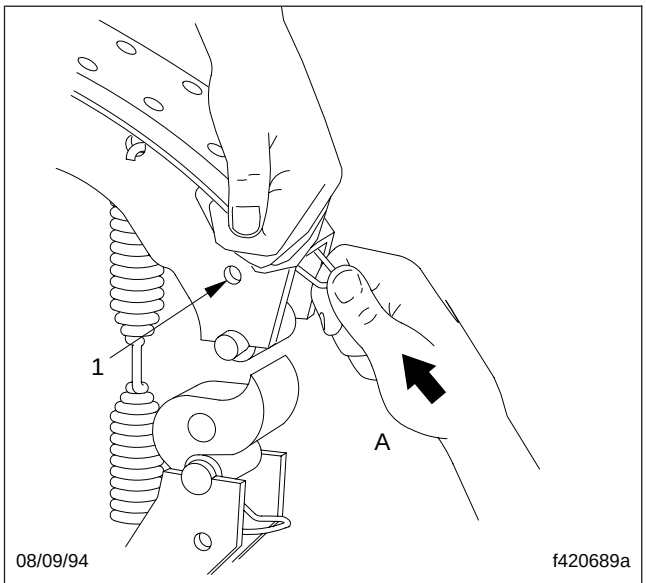
A. Squeeze.
1. Web

Fig. 6, Installing Cam Rollers and Retainers

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 **Group 33** or **Group 35** in this manual.

5. Adjust the brakes at the slack adjusters. For instructions, refer to **Subject 125**.



A. Push.
1. Web Hole

Fig. 7, Locking Retainer

6. Remove the safety stands, lower the vehicle, and remove the chocks from the tires.

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.

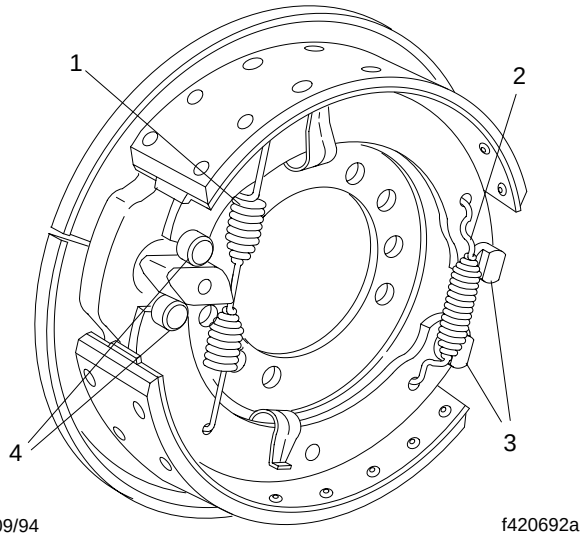
7.1 To ensure that the braking system is working correctly, make ten 40 to 20 mph (60 to 30 km/h) snubs to seat the linings.

7.2 Make ten stops from 20 mph (30 km/h) at 50 percent air pressure.

7.3 Make a full-pressure stop from 20 mph (30 km/h).

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



1. Return Spring
2. Retainer Spring
3. Anchor Pins
4. Cam Rollers

Fig. 8, Installing Retainer Spring and Shoes

⚠ 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.

     If bolts are installed, the linings should not be allowed to wear to the point where rivets or bolts may contact the brake drums.
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. 1**.

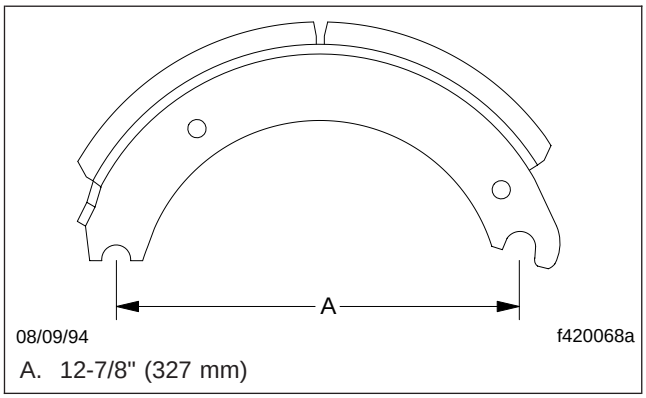


Fig. 1, Shoe Span

Adjustment

Meritor Automatic Slack Adjuster

1. Check the free-stroke.

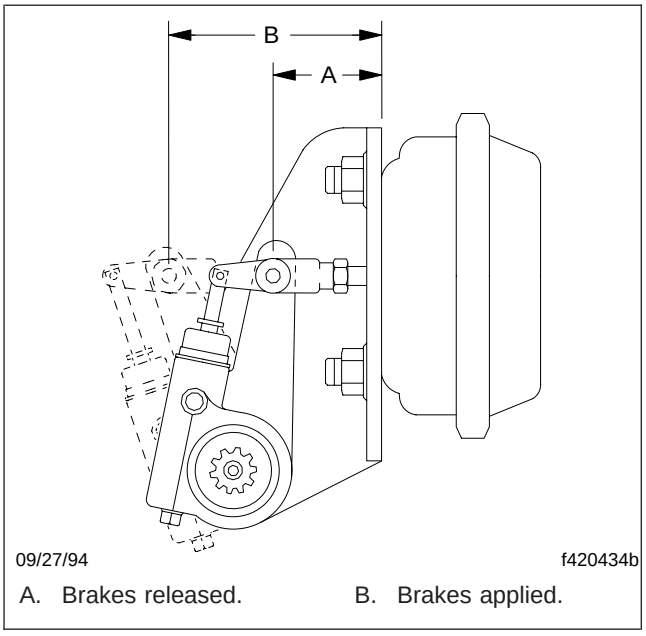
   1.1 With the brakes fully released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 1**, Ref. *A*.

   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 5/8 to 3/4 inch (16 to 19 mm);

   If the free-stroke is correct, go to the step for checking brake chamber stroke.



A. Brakes released. B. Brakes applied.

Fig. 1, Slack Adjuster and Brake Chamber

   1.5 If the free-stroke is incorrect, remove the pressure relief capscrew (**Fig. 2**), 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

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.

   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 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. 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**), 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).

Maximum Adjusted Brake Chamber Stroke	
Chamber Size	**Stroke inch (mm)**
9, 12	Less than 1-3/8 (35)
16, 20, 24	Less than 1-3/4 (44)
24 *, 30	Less than 2 (51)
36	Less than 2-1/4 (57)

* Long Stroke

Table 1, Maximum Adjusted Brake Chamber Stroke

Brake Adjustment

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.

2.4 Turn the adjusting nut 1/8 turn, as shown in **Fig. 4**. Measure the stroke again, and adjust until correct.

CAUTION

Don't make the adjusted chamber stroke too short. The free-stroke must not be less than 5/8 to 3/4 inch (16 to 19 mm). 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 15 to 20 lbf·ft (20 to 27 N·m). 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 80 psi (551 kPa) 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.

Maximum Adjusted Brake Chamber Strokes With Haldex Automatic Slack Adjusters	
Chamber Size	**Stroke inch (mm)**
16	3/4 to 1-3/4 (19 to 44)
20	1 to 1-/34 (19 to 44)
24	1 to 1-7/8 (25 to 48)
30	1-1/2 to 2 (38 to 51)

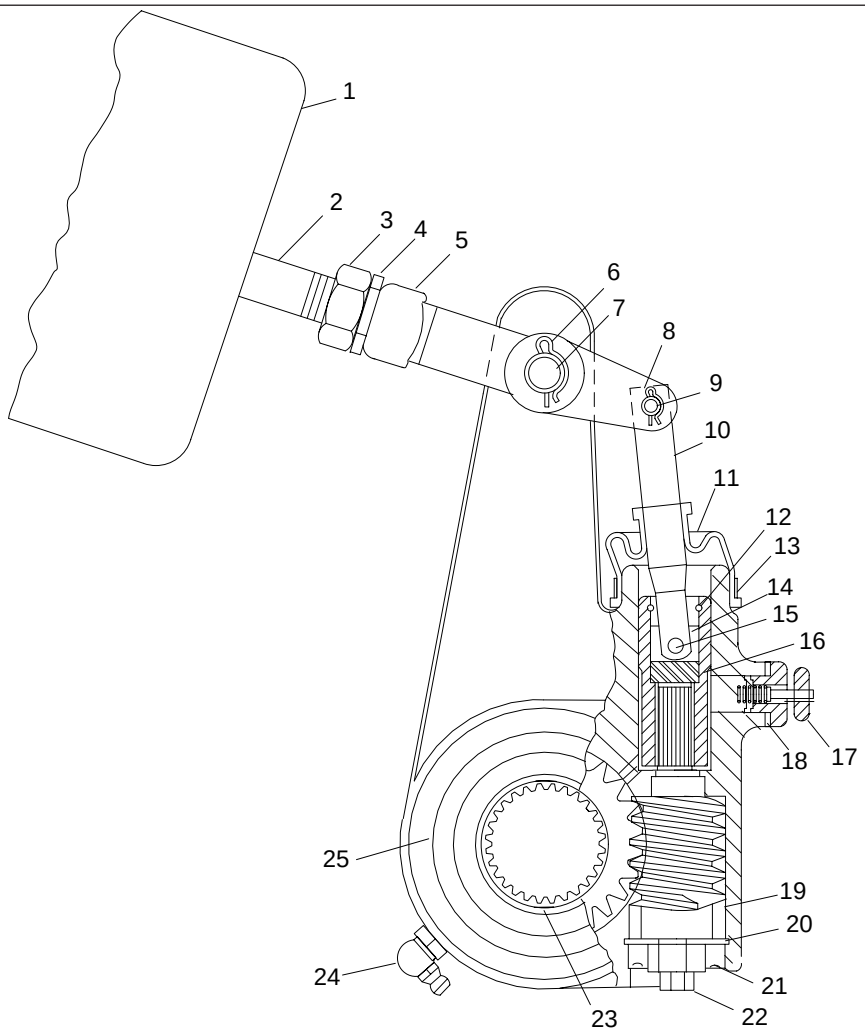
Table 2, Maximum Adjusted Brake Chamber Strokes With Haldex Automatic Slack Adjusters

Bendix Manual Slack 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 80 psi (551 kPa) 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.

   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.



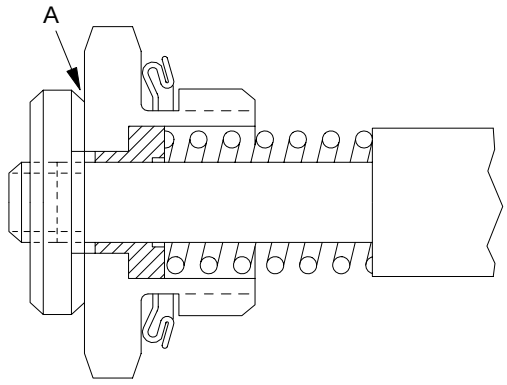
1. Brake Air Chamber
2. Push Rod
3. Jam Nut
4. Collar
5. Clevis
6. Cotter Pin (large)
7. Clevis Pin (large)
8. Cotter Pin (small)
9. Clevis Pin (small)
10. Actuator Rod
11. Boot
12. Piston Retaining Ring
13. Boot Retaining Clamp
14. Actuator Piston
15. Roller (Pin)
16. Actuator (Adjusting Sleeve)
17. Pull-Pawl Assembly (90° out of Position)
18. Gasket
19. Worm
20. Worm Retaining Ring
21. Worm grease
22. Manual Adjusting Nut
23. Gear
24. Grease Fitting
25. Gear Retainer/Seal

Fig. 2, Meritor Automatic Slack Adjuster

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.

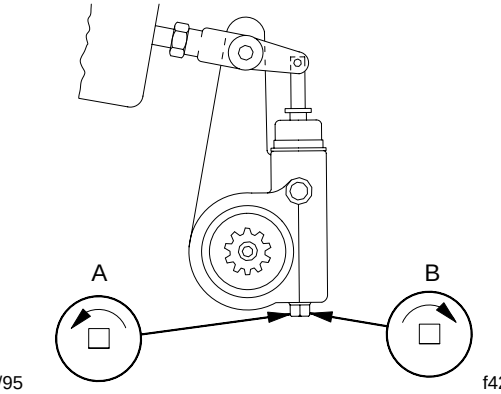
Brake Adjustment



09/27/94 f420693a

A. Insert screwdriver here.

Fig. 3, Pull-Pawl Assembly (sectional view)



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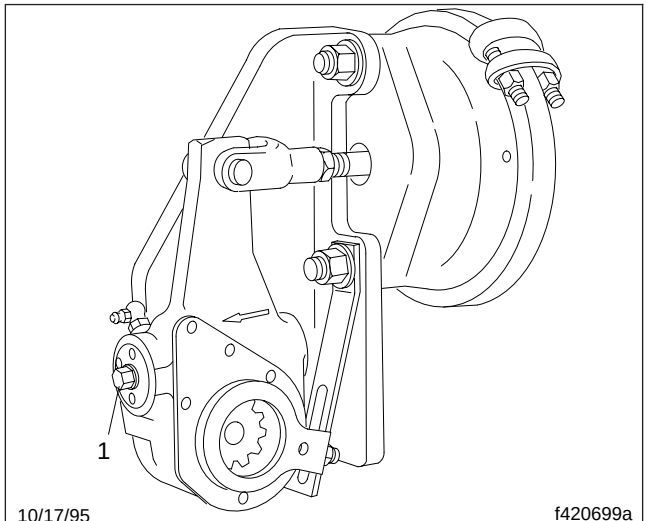
A. Shorten stroke. B. Lengthen stroke.

Fig. 4, Meritor Automatic Slack Adjuster, Adjusting Nuts

Maximum Adjusted Brake Chamber Strokes With Bendix Manual Slack Adjusters	
Chamber Size	**Stroke inch (mm)**
9, 12	Less than 1-1/2 (38)
16, 20	Less than 1-3/4 (44)
24	Less than 1-7/8 (48)
24 *, 30	Less than 2 (51)
36	Less than 2-1/4 (57)

* Long Stroke

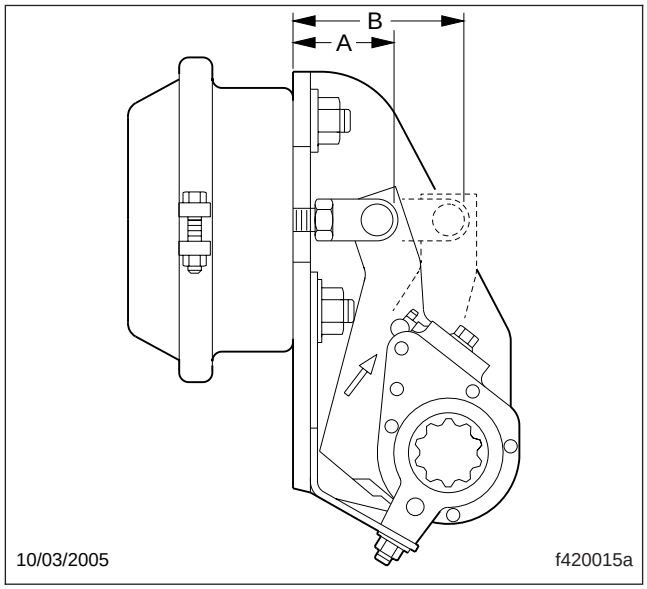
Table 3, Maximum Adjusted Brake Chamber Strokes With Bendix Manual Slack Adjusters



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1. Adjusting Hexnut

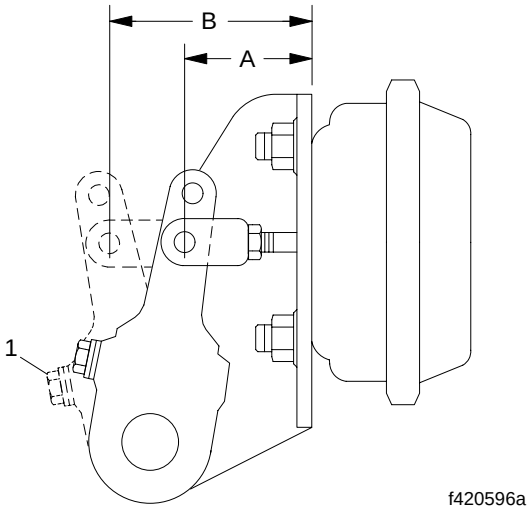
Fig. 5, Haldex Automatic Slack Adjuster



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Fig. 6, Brake Stroke Check, Haldex (SAB) Automatic Slack Adjuster

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.



A. Brakes released. B. Brakes applied.

1. Adjusting Screw Hexhead

Fig. 7, Bendix Manual Slack Adjuster

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

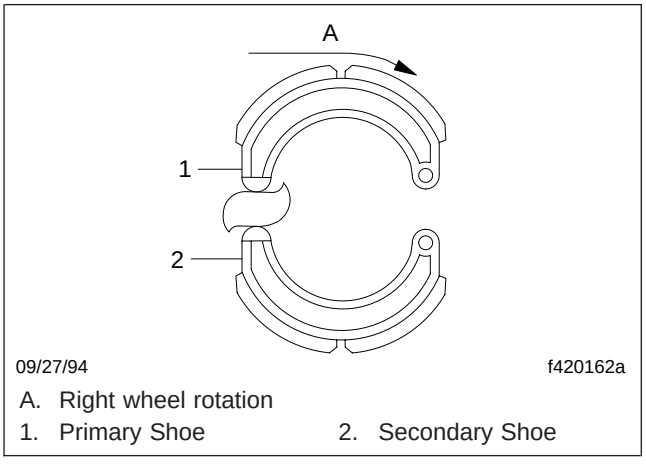
Before starting the procedure below, read the information in Safety Precautions 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.

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.

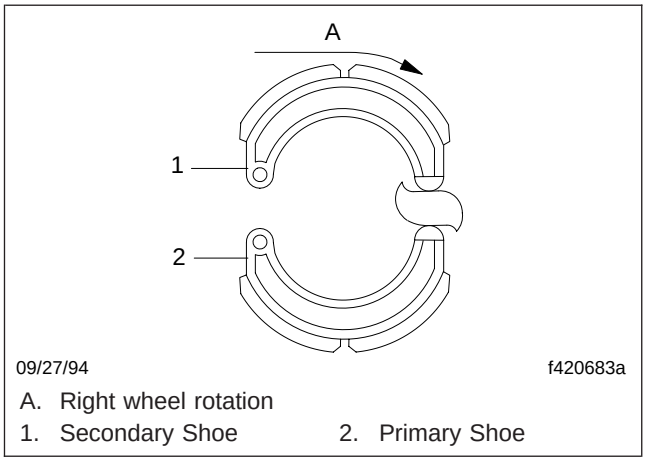
Combination linings with different friction ratings for the primary and secondary shoes are often used. When combination linings are used, install the forward blocks on the primary shoe (following the rotation of the drum, the first shoe after passing the cam or wheel cylinder is the primary shoe).

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**.



A. Right wheel rotation
1. Primary Shoe 2. Secondary Shoe

Fig. 1, Camshaft Behind Axle



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

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.

   Try to insert a 0.010-inch (0.25-mm) feeler gauge between the lining and shoe table along the

Brake Shoe Lining Replacement

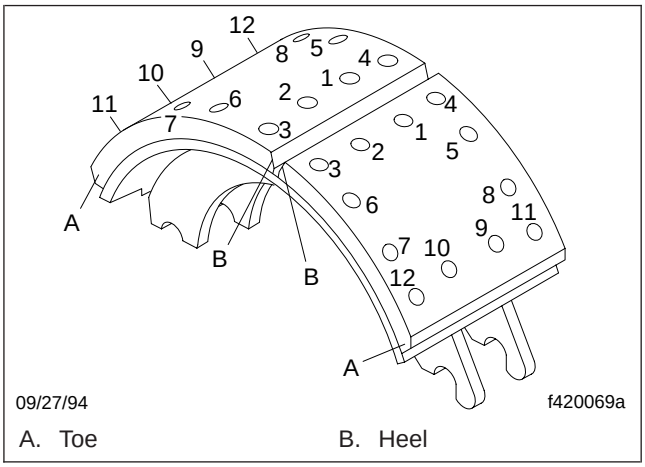


Fig. 3, Rivet or Bolt Attachment Sequence

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 0.025 inch (0.64 mm), may exist in these areas.

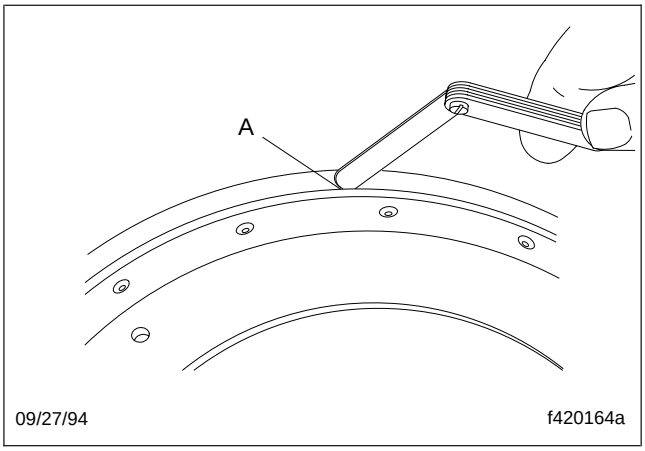


Fig. 4, Shoe Table and Lining

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 0.070 inch (1.8 mm) 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.

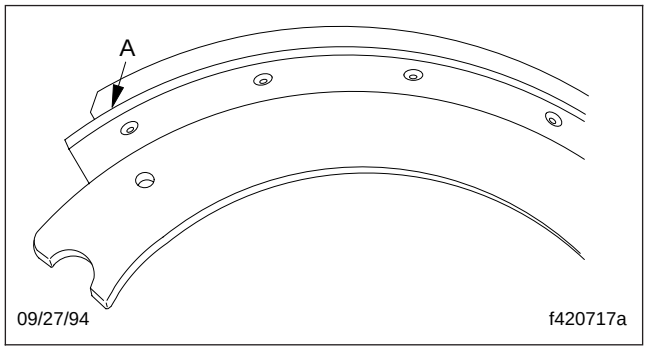


Fig. 5, Shoe Table and Lining

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 18 to 23 lbf·ft (24 to 31 N·m); on 1/4-inch brass bolts 80 to 100 lbf·in (900 to 1120 N·cm).
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 0.070 inch (1.8 mm) 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

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 0.030 inch (0.8 mm) 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

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.

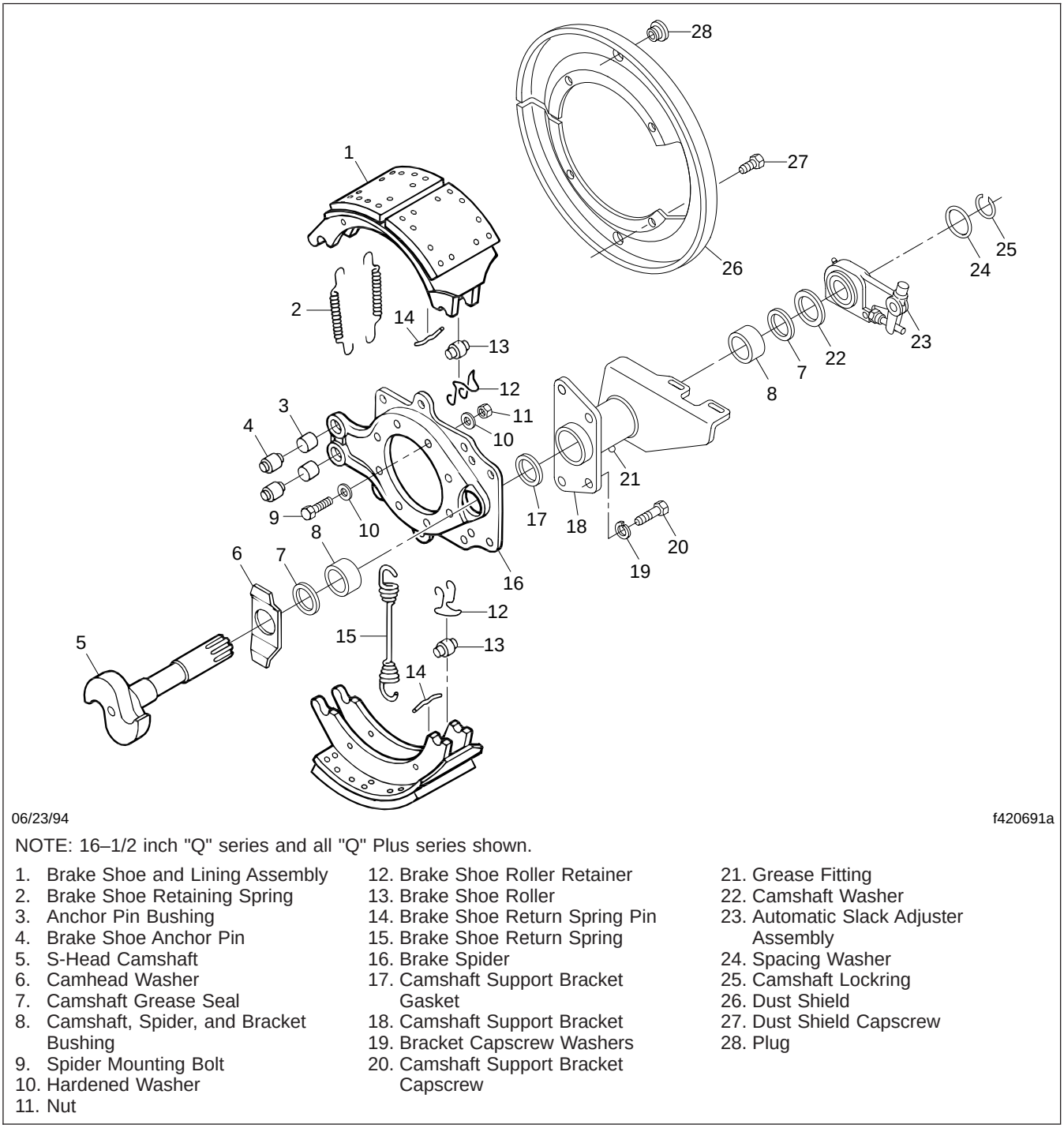
IMPORTANT: If any slack adjuster problem is found, repair or replace the unit, depending on the manufacturer's recommendations.

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



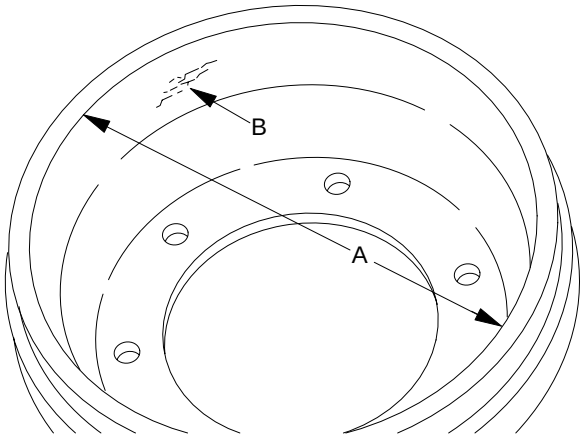
NOTE: 16–1/2 inch "Q" series and all "Q" Plus series shown.

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.

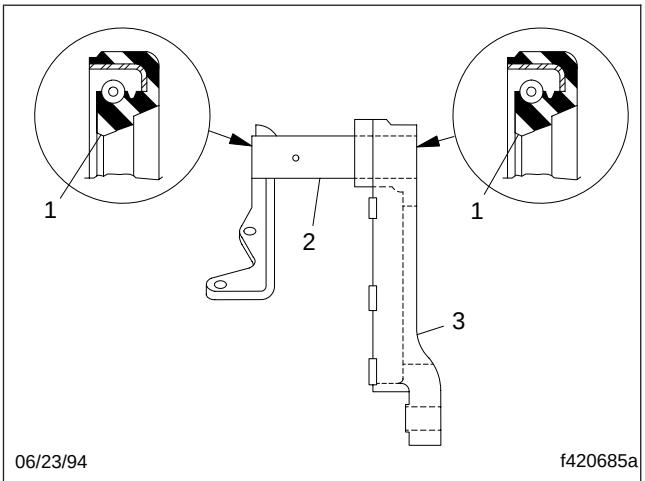


A. Check for diameter and for out-of-round.
B. Check for cracks, heat checks, glazing, and grooves.

Fig. 2, Brake Drum

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

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

A thick layer of oxidation and dirt on the outside of a brake drum acts as an insulator and may

Brake Components Disassembly and Inspection, Cleaning, and Assembly

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

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 (Meritor 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 0.060 inch (1.5 mm) 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 40 psi (276 kPa) 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**.

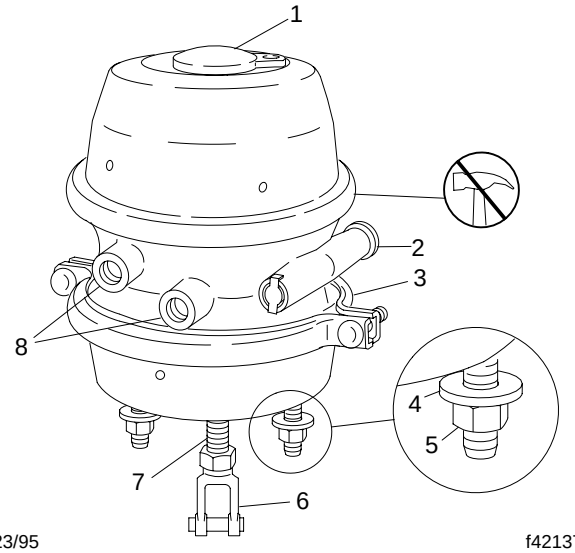
Torque Values				
Description	**Grade**	**Size**	**Torque**	
			lbf·in (N·cm)	**lbf·ft (N·m)**
Brake Shoe Lining Nuts	—	3/8	—	18–23 (24–31)
		1/4	80–100 (900–1120)	—
Dust Shield Capscrews	5	3/8–16	—	25–35 (34–47)
	8			35–50 (47–68)
Spider Mounting Bolts: Customary Thread Capscrew	8	1/2–13	—	60–80 (81–108)
Hexhead Capscrew		5/8–11		130–160 (176–217)
Flanged Hexhead Capscrew		5/8–11		160–200 (217–271)
Midland Brake Chamber Mounting-Stud Locknuts (chamber size in^2)	8		—	
12		7/16–14 stud		38–43 (52–58)
16		7/16–14 stud		38–43 (52–58)
16		1/2–13 stud		60–65 (81–88)
16		1/2–20 stud		65–70 (88–95)
20		5/8–11 stud		120–130 (162–176)
24		5 /8–11 stud		120–130 (162–176)
MGM Brake Chamber Mounting-Stud Locknuts (chamber size in^2)	8		—	
16		7/16–14 stud		35–40 (47–54)
20		5 /8–11 stud		100–115 (136–156)
24		5 /8–11 stud		100–115 (136–156)
Brake Chamber Bracket-to-Spider Capscrews	8	1/2–13	—	60–80 (81–108)
		5/8–11		105–145 (142–196)

Table 1, Torque Values

⚠ DANGER

Do not attempt to remove the factory-sealed clamp ring (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: The parking/emergency brake section is factory sealed (no clamp ring) and is a *non-serviceable* unit.



1. Dust Plug
2. Release Bolt Storage Pocket
3. Service Brake Clamp Ring
4. Hardened Flatwasher
5. Prevailing Torque Locknut
6. Clevis Assembly
7. Piston Rod
8. Air Inlet Ports

Fig. 1, Brake Chamber

General Description

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 parking brake 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.

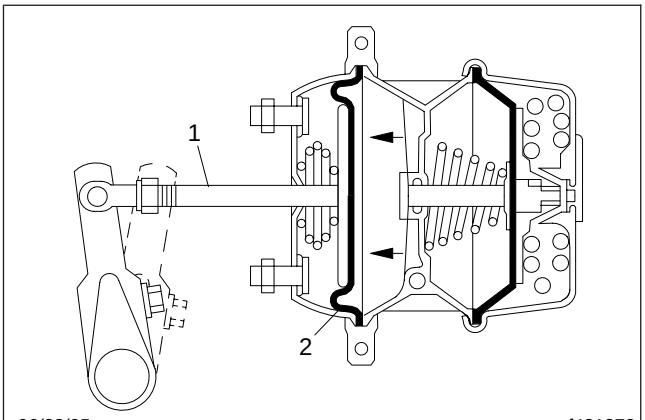
All Anchorlok brake chambers are mounted to the frame using prevailing torque locknuts and hardened flatwashers.

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 Group 42 in 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**.



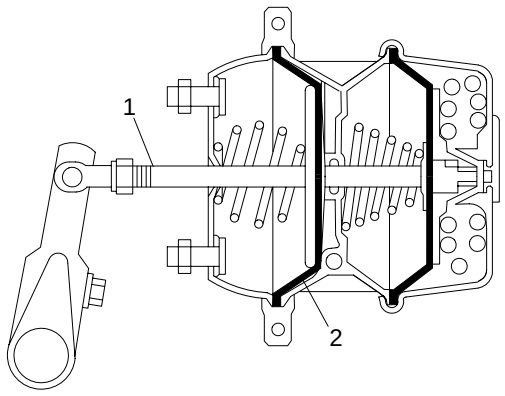
1. Piston Rod Assembly
2. Service Brake Diaphragm

Fig. 2, Service Brakes Applied

Then, when the brake pedal is released (**Fig. 3**), air is exhausted from the service brake chamber, and

General Information

the return spring allows the diaphragm, piston rod assembly, and slack adjuster to return to their normal positions, releasing the brakes.



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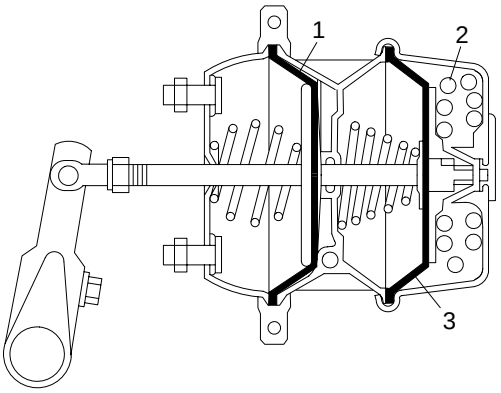
1. Piston Rod Assembly
2. Service Brake Diaphragm

Fig. 3, Service Brakes Released

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 allows the power spring to extend and apply the brakes. See **Fig. 5**.

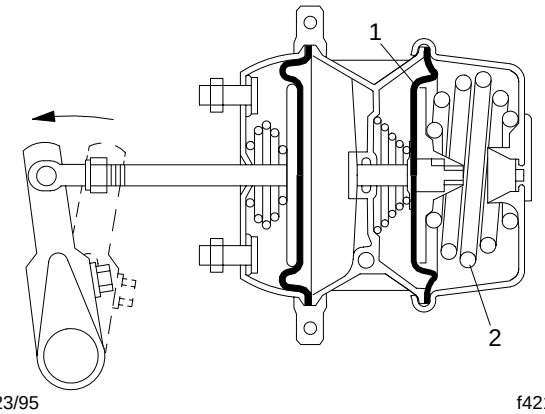
Emergency brake application begins when air pressure in the service brake reservoir drops below about 80 to 85 psi (550 to 585 kPa). Maximum parking brake force is applied when air is entirely exhausted fom the parking/emergency brake chamber.



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1. Service Brake Diaphragm
2. Power Spring
3. Parking/Emergency Brake Diaphragm

Fig. 4, Parking/Emergency Brakes Released



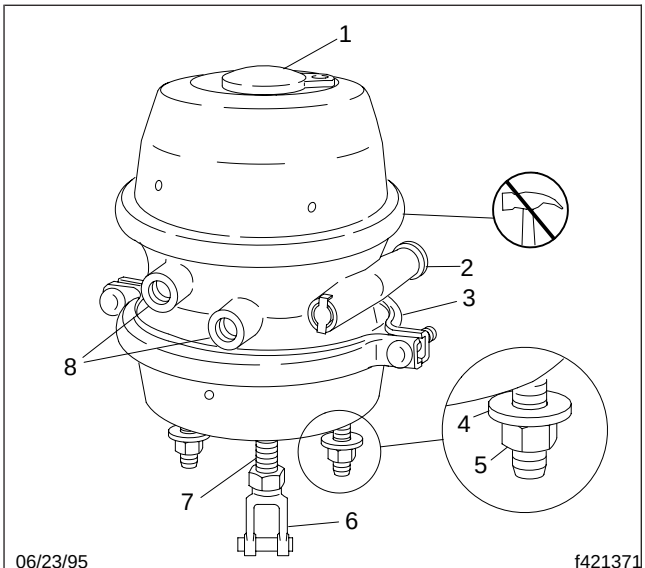
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1. Parking/Emergency Brake Diaphragm
2. Power Spring

Fig. 5, Parking/Emergency Brakes Applied

⚠ DANGER

Do not attempt to remove the factory-sealed clamp ring (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.



1. Dust Plug
2. Release Bolt Storage Pocket
3. Service Brake Clamp Ring
4. Hardened Flatwasher
5. Prevailing Torque Locknut
6. Clevis Assembly
7. Piston Rod
8. Air Inlet Ports

Fig. 1, Brake Chamber

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**.

⚠ 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.

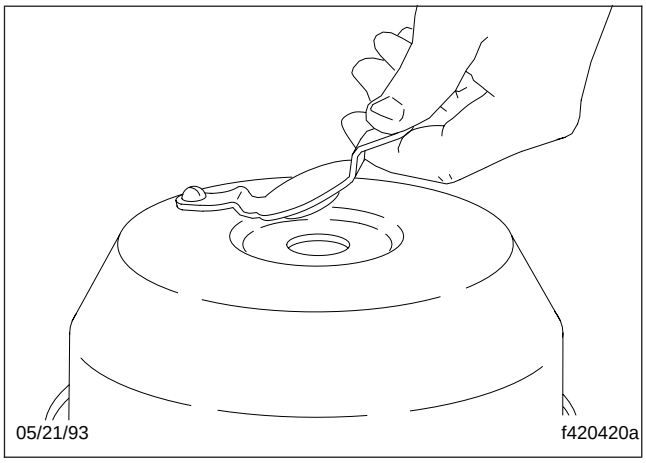


Fig. 2, Remove the Dust Plug

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).

   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 Insert the release bolt into the center-hole in the chamber head (**Fig. 4**). Continue to insert the bolt until it bottoms out into the hole in the pressure plate inside the chamber.

   IMPORTANT: If you are not absolutely sure that the formed end of the bolt has engaged

Power Spring Manual Compression and Reset

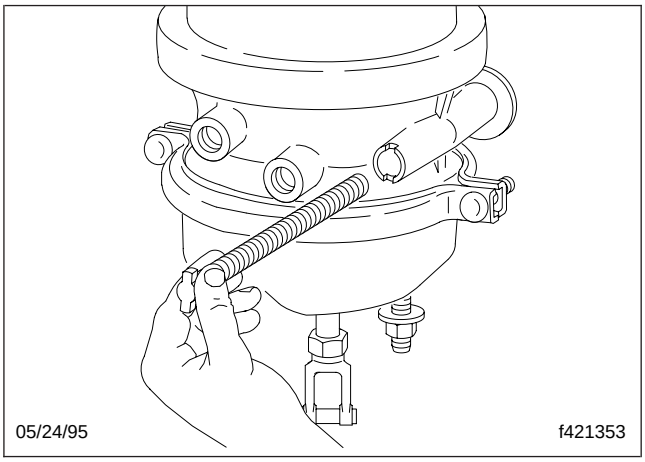


Fig. 3, Remove the Release Bolt

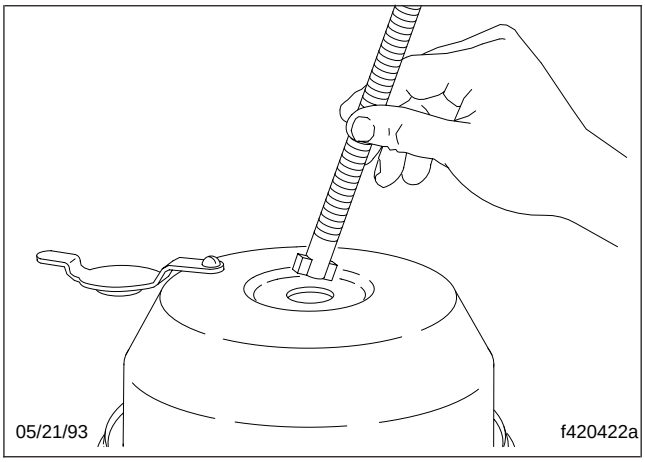


Fig. 4, Insert the Release Bolt

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**.

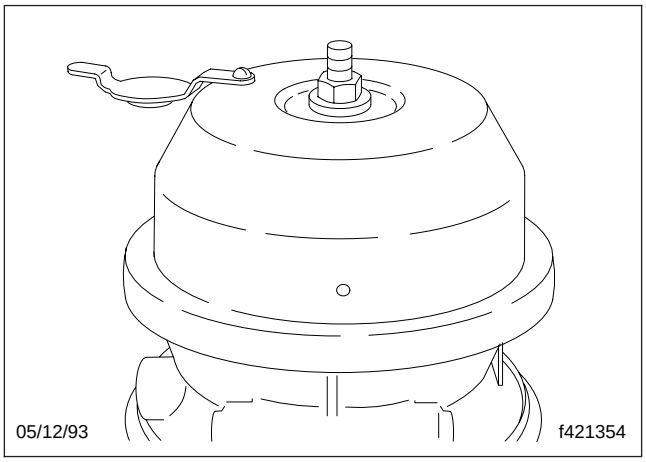


Fig. 5, Flatwasher and Release Nut Installed

⚠ 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

If equipped with S-cam brakes, don't exceed 35 lbf·ft (47 N·m) torque on the release nut; if equipped with wedge brakes, don't exceed 20 lbf·ft (27 N·m) torque on the release nut.

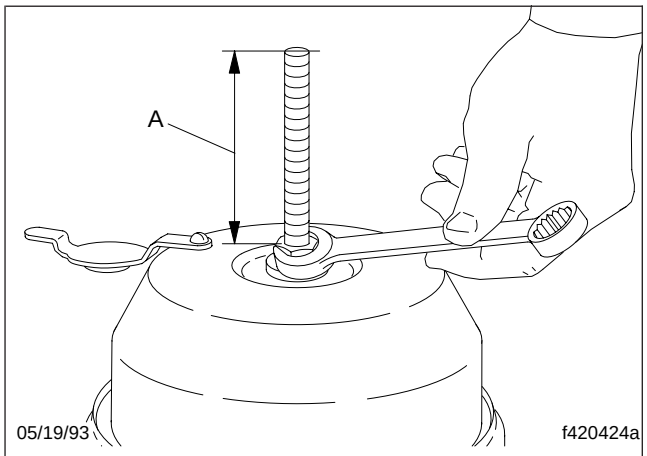
3.5 Using a hand wrench (*don't use an impact wrench*), turn the release nut clockwise until the power spring is caged (**Fig. 6**).

The bolt should extend above the nut at least 2.9 inches (74 mm) on 24-inch chambers, or 2.875 inches (73 mm) on 30-inch chambers.

IMPORTANT: Do not 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.



A. Measure this distance.

Fig. 6, Turn the Release Nut

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 to 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. Using a hand wrench, (*don't use an impact wrench*), install the release bolt, flatwasher, and release nut in the storage pocket. Tighten the nut 60 to 96 lbf·in (680 to 1080 N·cm). See **Fig. 7**.

3. Snap the dust plug in place over the center-hole in the chamber head. See **Fig. 8**.

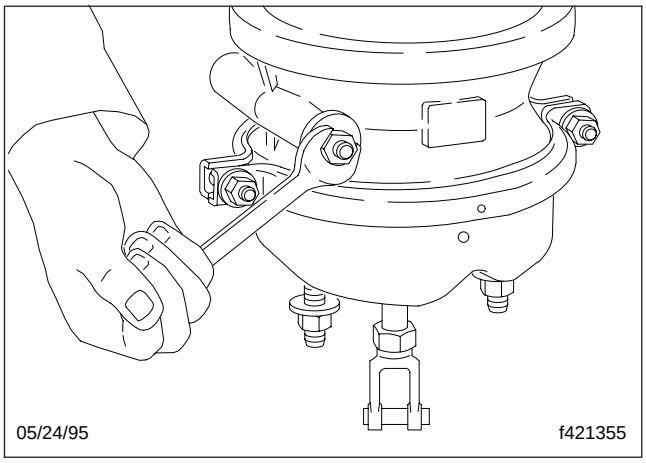


Fig. 7, Tighten the Release Nut

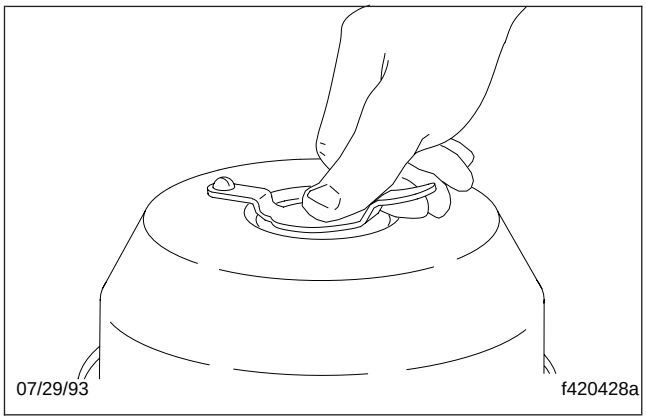


Fig. 8, Snap the Dust Plug in Place

CAUTION

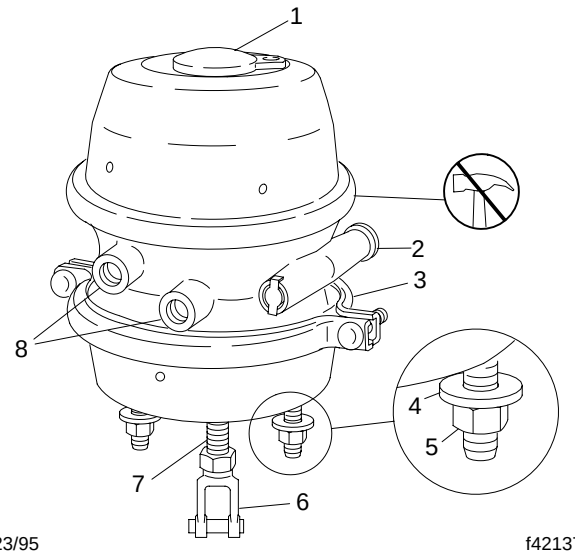
If a dust plug is missing or incorrectly installed, road dirt and debris can adversely affect the operation of the brake chamber. Once inside the chambers, dirt and debris cause the internal parts to deteriorate and shorten their lives.

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 attempt to remove the factory-sealed clamp ring (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.



1. Dust Plug
2. Release Bolt Storage Pocket
3. Service Brake Clamp Ring
4. Hardened Flatwasher
5. Prevailing Torque Locknut
6. Clevis Assembly
7. Piston Rod
8. Air Inlet Ports

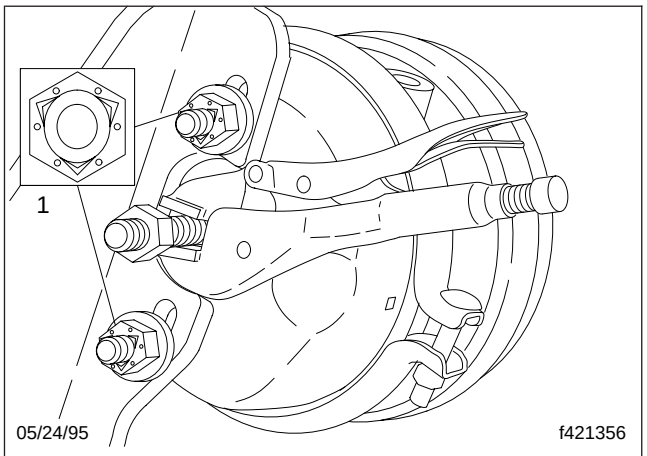
Fig. 1, Brake Chamber

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 (**Fig. 2**).



1. Prevailing Torque Locknut

Fig. 2, Lock the Piston Rod in Place

⚠ 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

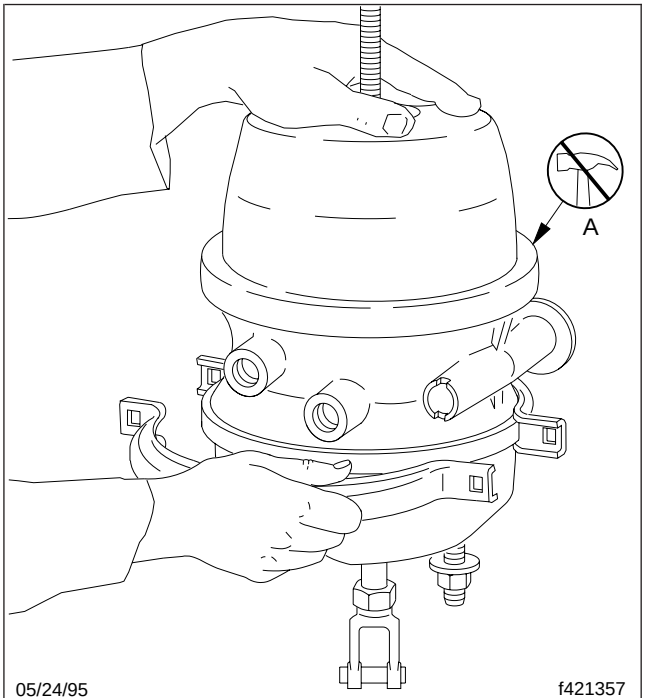
Do not attempt to remove the factory-sealed clamp ring (Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from the sudden release of the power spring.

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 the *service* brake clamp ring (*do not disassemble the parking brake section*).

Service Brake Diaphragm Replacement

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 (**Fig. 3**).



A. Do not remove the factory-sealed clamp ring.

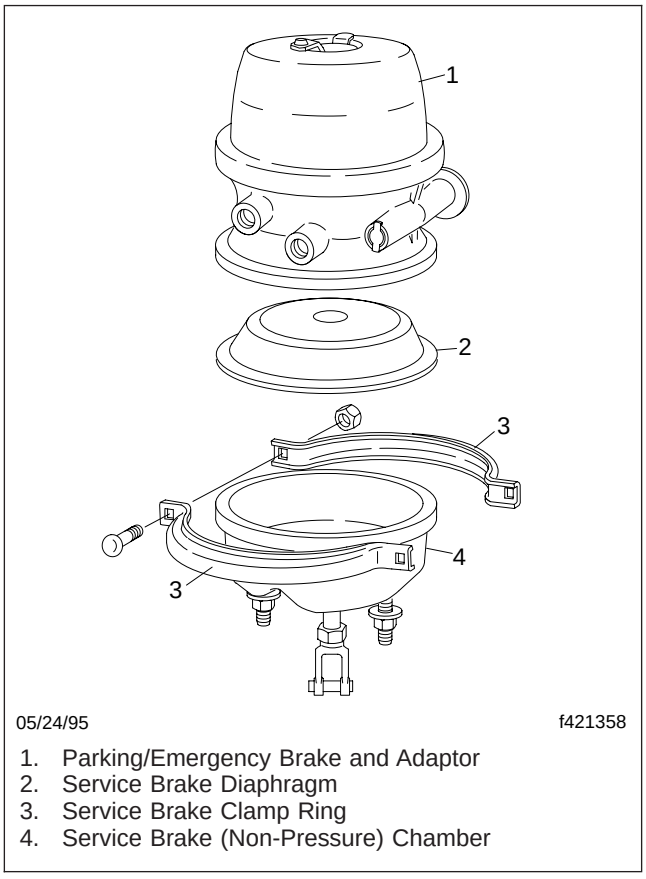
Fig. 3, Remove the Service Clamp Ring

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 (**Fig. 4**).
3. Install the (new, if needed) parking/emergency brake section.



1. Parking/Emergency Brake and Adaptor
2. Service Brake Diaphragm
3. Service Brake Clamp Ring
4. Service Brake (Non-Pressure) Chamber

Fig. 4, Brake Chamber Parts

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 18 to 25 lbf·ft (24 to 34 N·m) while

constantly rechecking the alignment of mating parts.

4.3 Lightly tap around the circumference of the service clamp ring with a rubber mallet to ensure full seating of the clamp. If re-alignment is needed, loosen the nuts again, and repeat this step.

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 25 lbf·ft (34 N·m).
6. Using the vehicle system air, charge the parking brake with full line pressure—at least 100 psi (690 kPa). 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 25 lbf·ft (34 N·m).
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 attempt to remove the factory-sealed clamp ring (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.

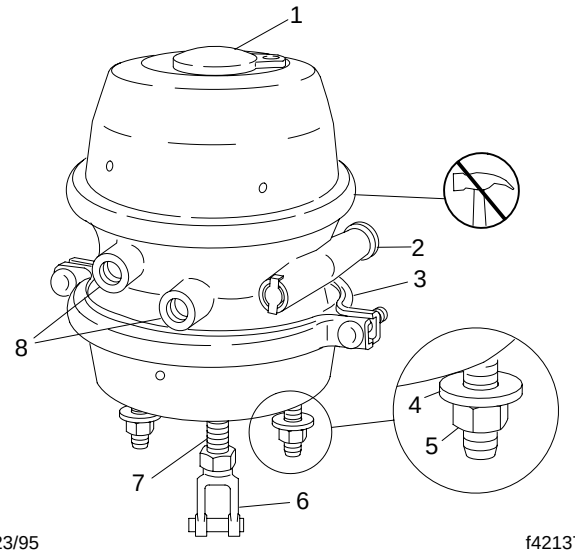
8. Test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, release all air pressure from the chamber, then retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). Anchorlok recommends 18 to 25 lbf·ft (24 to 34 N·m) torque 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 this group.

Replacement

⚠ DANGER

Don't attempt to remove the factory-sealed clamp ring (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.



1. Dust Plug
2. Release Bolt Storage Pocket
3. Service Brake Clamp Ring
4. Hardened Flatwasher
5. Prevailing Torque Locknut
6. Clevis Assembly
7. Piston Rod
8. Air Inlet Ports

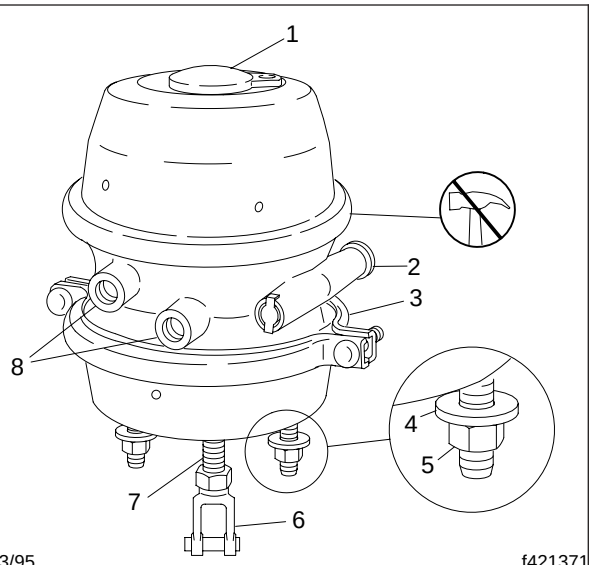
Fig. 1, Brake Chamber

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

Don't attempt to remove the factory-sealed clamp ring (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.



1. Dust Plug
2. Release Bolt Storage Pocket
3. Service Brake Clamp Ring
4. Hardened Flatwasher
5. Prevailing Torque Locknut
6. Clevis Assembly
7. Piston Rod
8. Air Inlet Ports

Fig. 1, Brake Chamber

Removal

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: 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

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

Combination Service and Parking Brake Chamber Removal and Installation

hand wrench (*don't use an impact wrench*), tighten the nuts 110 to 150 lbf·ft (149 to 203 N·m). Make sure that the hardened flatwasher is installed between the locknut and the mounting bracket.

4. Check mating and alignment with the vehicle air lines.

⚠ DANGER

Don't attempt to remove the factory-sealed clamp ring (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 18 to 25 lbf·ft (24 to 34 N·m) 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.

5. Connect the slack adjuster. Refer to the applicable slack adjuster section in this group for installation instructions.
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.
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 25 lbf·ft (34 N·m).
8. Using the vehicle system air, charge the parking brake with full line pressure, at least 100 psi (690 kPa). 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 25 lbf·ft (34 N·m).

⚠ DANGER

Do not attempt to remove the factory-sealed clamp ring (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 18 to 25 lbf·ft (24 to 34 N·m) 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 group.

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 this group.

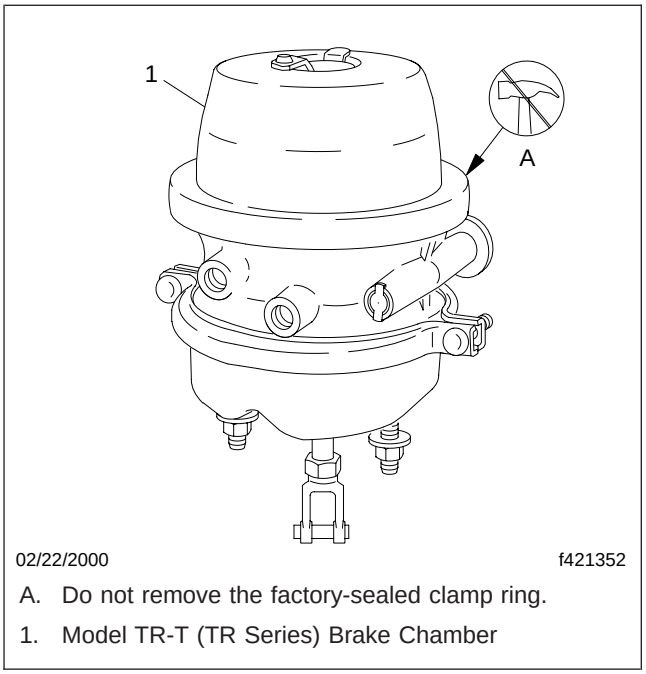
Specifications

Torque Values		
Description	**Torque**	
	lbf·ft (N·m)	**lbf·in (N·cm)**
Spring Brake Release Bolt Nut: (in storage pocket)	—	60–96 (680–1080)
(caged—on S-cam brakes)	35 (47)	—
(caged—on wedge brakes)	20 (27)	—
Service Brake Clamp Ring Nut	18–25 (24–34)	—
Brake Chamber Mounting Stud Locknut	110–150 (149–203)	—
Air Hose Fitting-to-Chamber	25 (34)	—

Table 1, Torque Values

⚠ DANGER

Do not attempt to remove the factory-sealed clamp ring (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 the factory-sealed clamp ring.

1. Model TR-T (TR Series) Brake Chamber

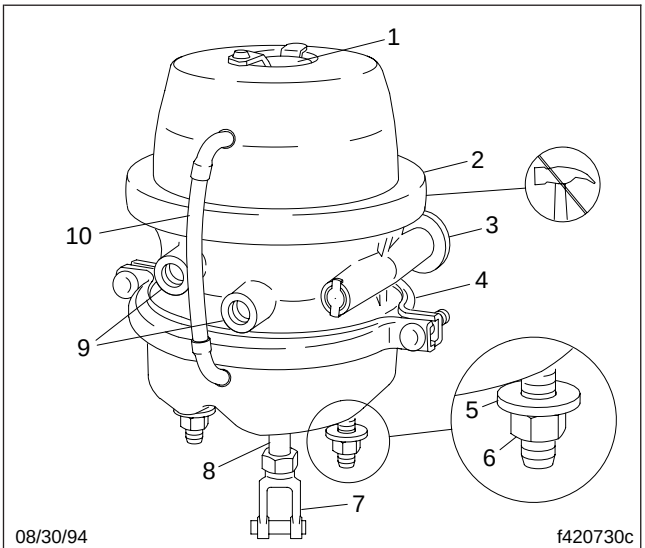
Fig. 1, Brake Chamber

IMPORTANT: On MGM "TR" Series chambers, the parking/emergency brake section is factory sealed (no clamp ring) and is a *non-serviceable* unit.

General Description

MGM "TR" Series tandem cam brake chamber consists of a service brake section and a parking/emergency spring brake section. See **Fig. 2**. 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.



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. 2, Model TR-T (TR Series) Brake Chamber

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 "TR" Series chambers may be equipped with an external breather tube that protects the parking brake chamber from contaminants. These chambers are called Model "TR-T" chambers. See **Fig. 2**.

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.

PARKING/EMERGENCY BRAKES

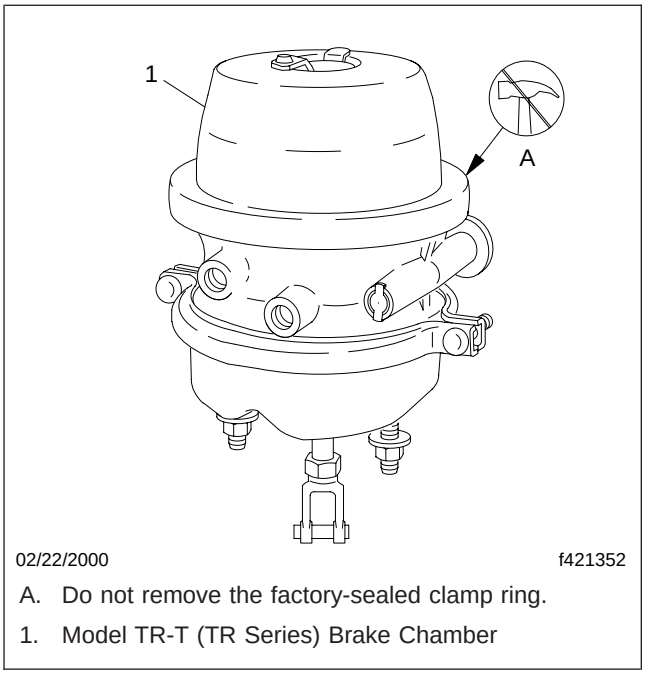
During parking brake release, compressed air enters the parking brake chamber and acts upon the diaphragm and piston, fully compressing the power spring. When the power spring is compressed, the parking brakes are released; the service brakes can then be operated at the brake pedal.

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.

Power Spring Manual Compression and Reset

⚠ DANGER

Do not attempt to remove the factory-sealed clamp ring (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 the factory-sealed clamp ring.

1. Model TR-T (TR Series) Brake Chamber

Fig. 1, Brake Chamber

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.

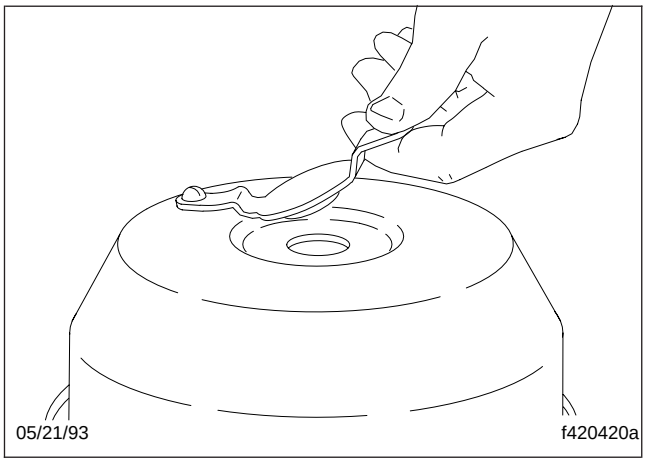


Fig. 2, Remove the End-Cover Cap

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 90 psi (620 kPa) 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 (**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

Power Spring Manual Compression and Reset

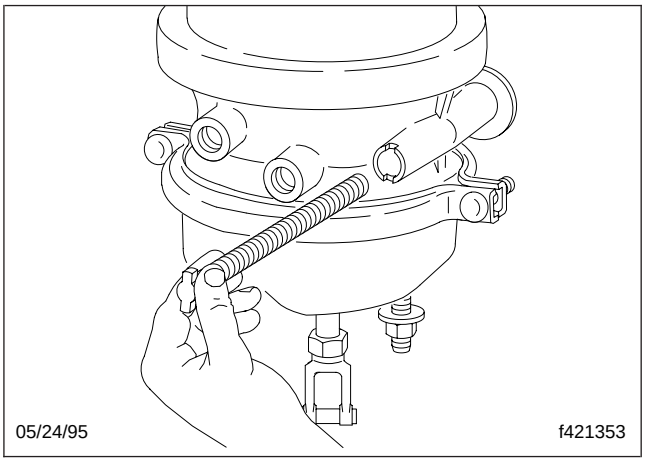


Fig. 3, Remove the Release Bolt

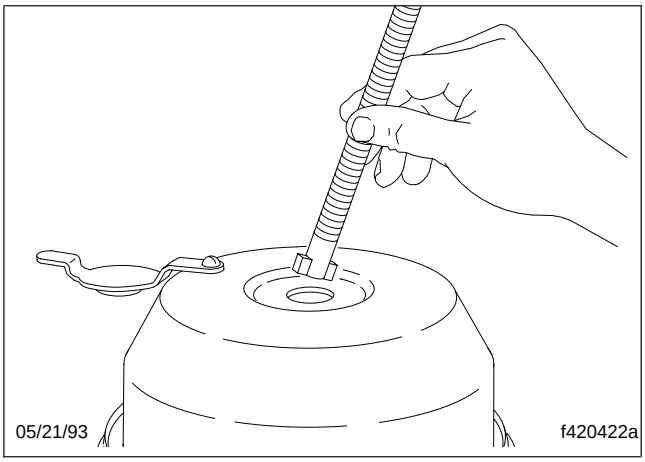


Fig. 4, Insert the Release Bolt

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 1/2-inch (13-mm) 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**.

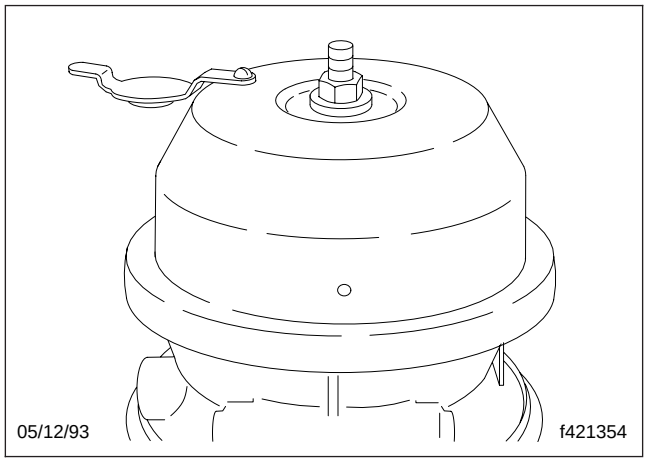
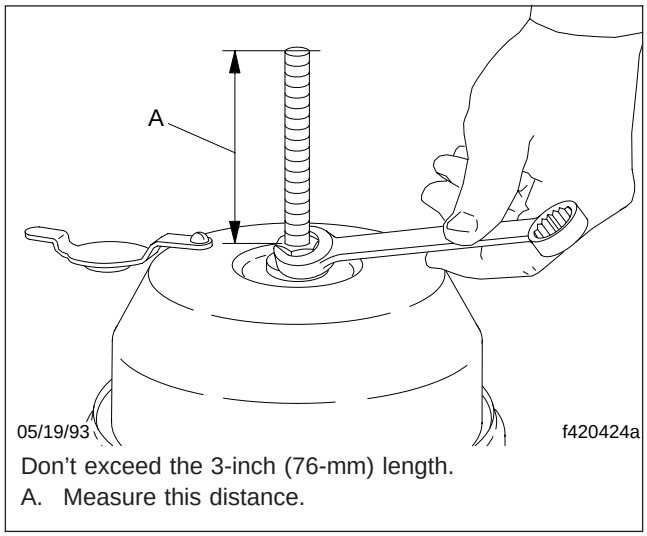


Fig. 5, Flatwasher and Release Nut Installed

⚠ CAUTION

Don't exceed 50 lbf·ft (68 N·m) 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 3 inches (76 mm) above the nut. See **Fig. 6**.



Don't exceed the 3-inch (76-mm) length.
A. Measure this distance.

Fig. 6, Turn the Release Nut

IMPORTANT: Don't exceed the 3-inch (76-mm) 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.

   1.1 Apply at least 90 psi (620 kPa) air pressure to the parking brake inlet port (set parking brake in the "release" position).

⚠ CAUTION

Don't exceed 50 lbf·ft (68 N·m) 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.

   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 10 lbf·ft (14 N·m) torque on the nut against the flatwasher (**Fig. 7**).

3. Snap the end cover cap in place over the center-hole in the chamber head. See **Fig. 8**.

⚠ 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.

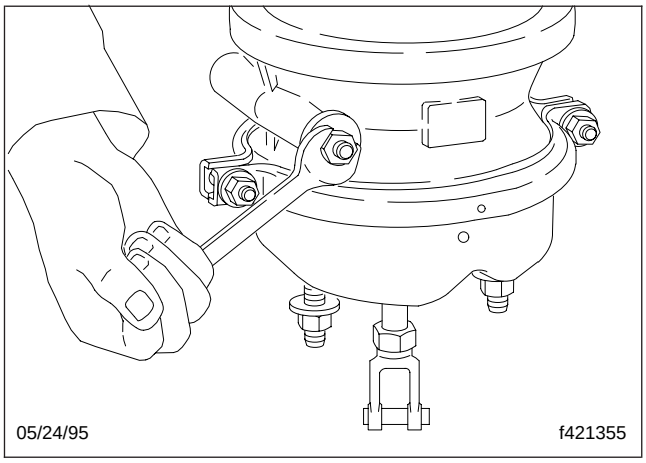


Fig. 7, Tighten the Release Nut

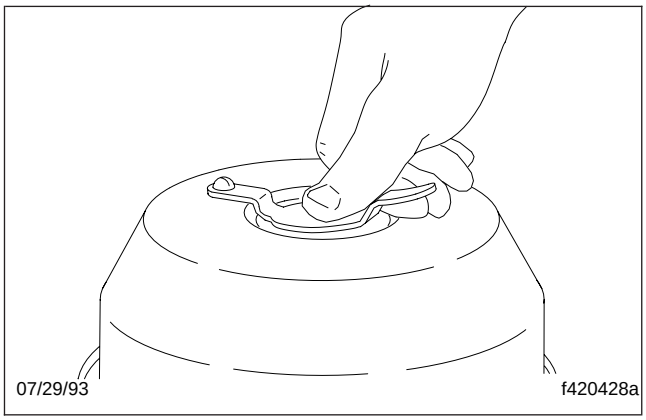


Fig. 8, Snap the End Cover Cap in Place

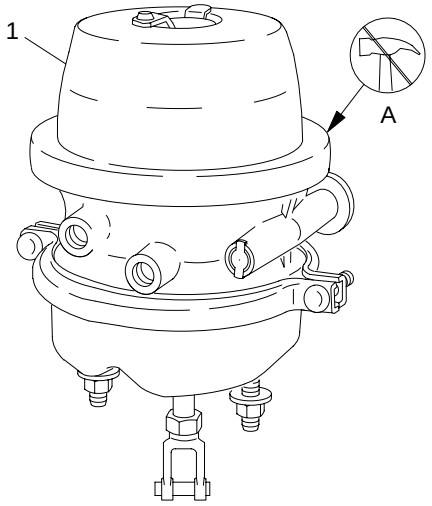
4. Check the plastic end cover cap periodically, and replace it with a new one at once if damaged or missing. For intervals, refer to the vehicle maintenance manual.

5. Remove the chocks from the tires.

Service Brake Diaphragm Replacement

DANGER

Do not attempt to remove the factory-sealed clamp ring (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.



02/22/2000 f421352

A. Do not remove the factory-sealed clamp ring.

1. Model TR-T (TR Series) Brake Chamber

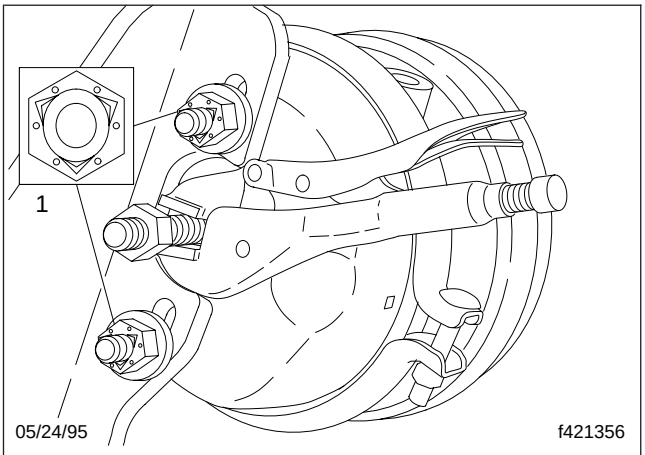
Fig. 1, Brake Chamber

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 (**Fig. 2**).



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1. Prevailing Torque Locknut

Fig. 2, Lock the Piston Rod in Place

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.

   On chambers equipped with an external breather tube, disconnect the tube and elbow from the service brake chamber.

DANGER

Do not attempt to remove the factory-sealed clamp ring (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.

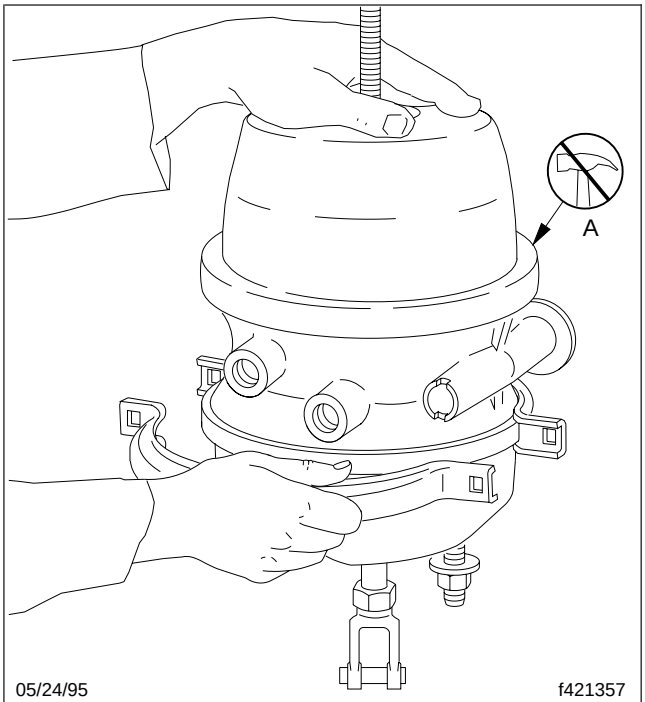
4. Remove the parking brake section from the service brake section.

   4.1 Using a hand wrench (*don't use an impact wrench*), remove the clamp nuts on the

Service Brake Diaphragm Replacement

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 (**Fig. 3**).



A. Do not remove the factory-sealed clamp ring.

Fig. 3, Remove the Service Clamp Ring

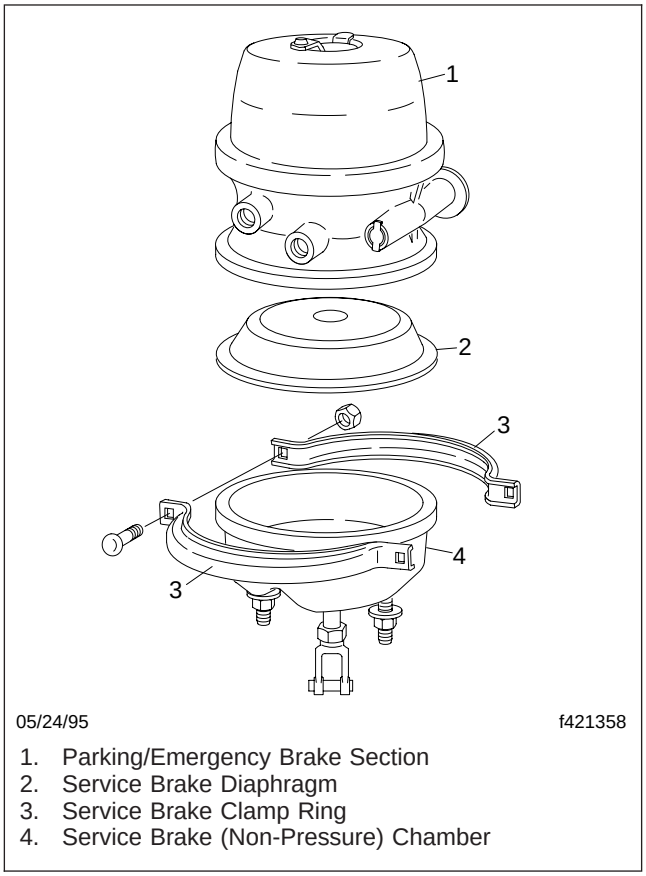
5. Remove the service brake diaphragm from the bottom of the parking brake section.

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 (**Fig. 4**).



1. Parking/Emergency Brake Section
2. Service Brake Diaphragm
3. Service Brake Clamp Ring
4. Service Brake (Non-Pressure) Chamber

Fig. 4, Brake Chamber Parts

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 60 to 120 lbf·in (680 to 1360 N·cm) 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 25 to 30 lbf·ft (34 to 41 N·m).

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 25 lbf·ft (34 N·m).

6. Using the vehicle system air, charge the parking brake with full line pressure—at least 100 psi (690 kPa). 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 25 lbf·ft (34 N·m).

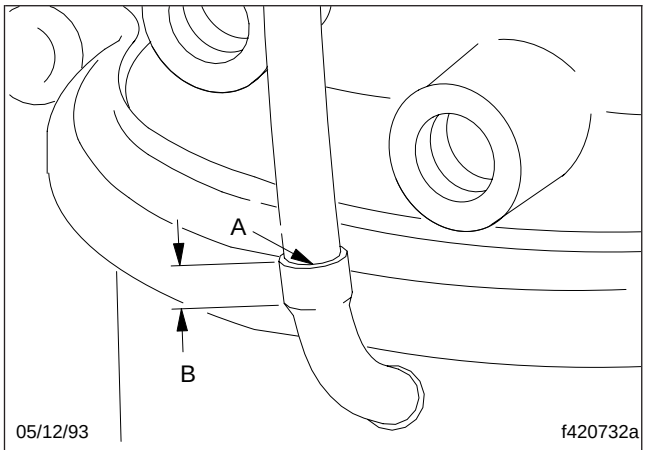
7. With the parking brake still charged with full line pressure, apply and hold the foot brake treadle valve down to charge the service brake chamber. Remove the locking-jaw pliers from the service piston rod so that the piston returns to a normal position in the chamber.

⚠ DANGER

Do not attempt to remove the factory-sealed clamp ring (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 25 to 30 lbf·ft (34 to 41 N·m) 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 1/2 inch (13 mm). 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, Install the External Breather Tube

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, refer to **Subject 100**.

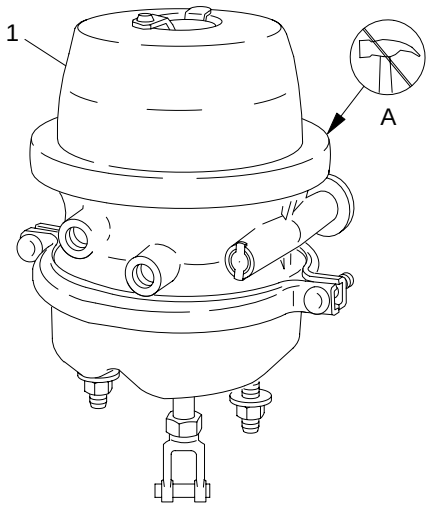
11. Adjust the brakes at the slack adjuster.

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 this group.

Replacement

⚠ DANGER

Do not attempt to remove the factory-sealed clamp ring (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.



02/22/2000 f421352

A. Do not remove the factory-sealed clamp ring.

1. Model TR-T (TR Series) Brake Chamber

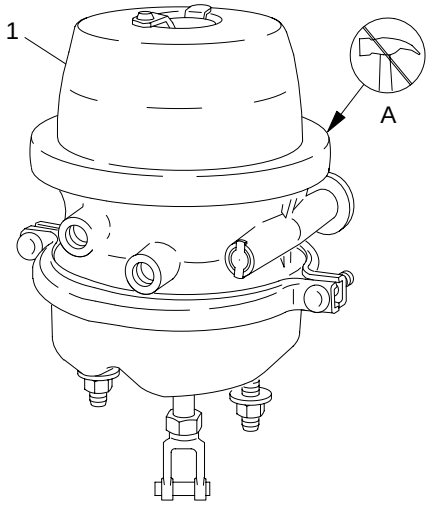
Fig. 1, Brake Chamber

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 attempt to remove the factory-sealed parking brake clamp ring (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.



02/22/2000 f421352

A. Do not remove the factory-sealed clamp ring.

1. Model TR-T (TR Series) Brake Chamber

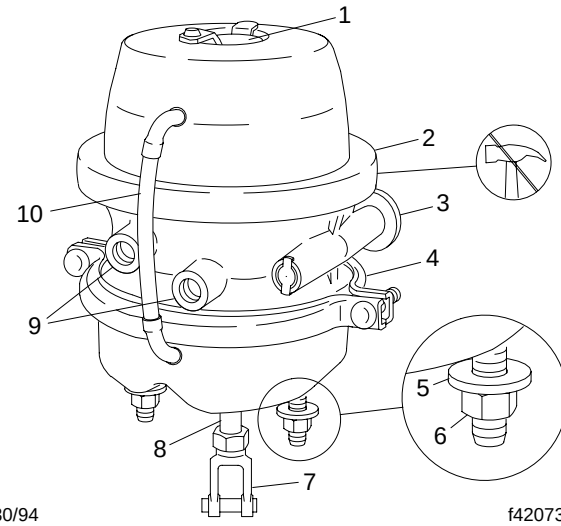
Fig. 1, Brake Chamber

Removal (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.

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.



08/30/94 f420730c

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. 2, Model TR-T (TR Series) 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 the base of the service brake chamber (**Fig. 3**):

Combination Service and Parking Brake Chamber Removal and Installation

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 (**Fig. 4**) 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 (**Fig. 4**) 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.

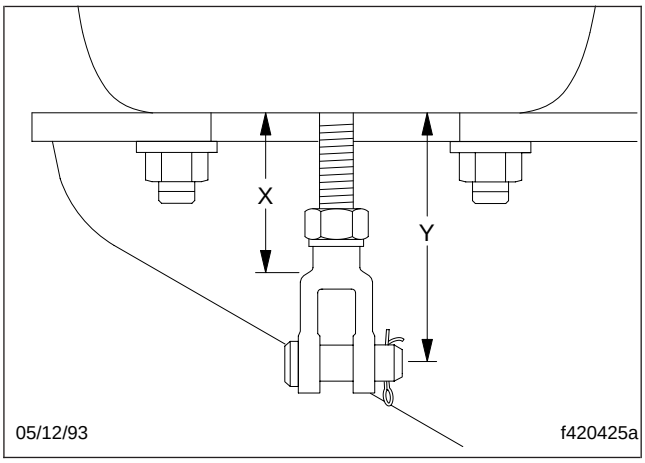


Fig. 3, Measure X and Y

Installation (See Fig. 2)

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.

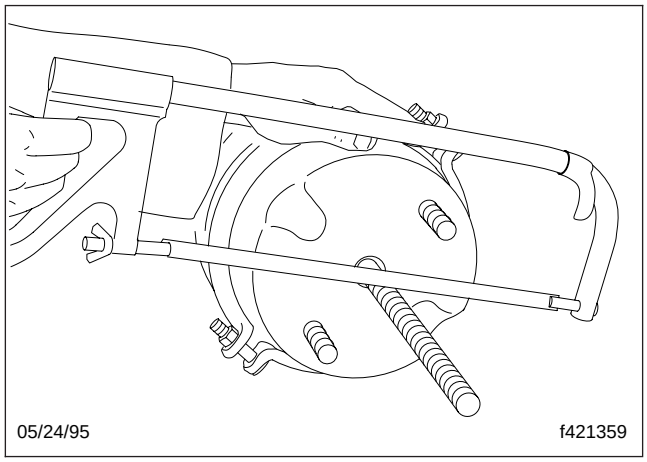


Fig. 4, Cut the Service Piston Rod

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

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 100 to 115 lbf·ft (136 to 156 N·m). Make sure the flatwasher is installed between the locknut and the mounting bracket.

Combination Service and Parking Brake Chamber Removal and Installation

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 attempt to remove the factory-sealed parking brake clamp ring (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 60 to 120 lbf·in (680 to 1360 N·cm) 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 25 to 30 lbf·ft (34 to 41 N·m).

5. Install the slack adjuster. Refer to the applicable slack adjuster section in this group for installation instructions.

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 25 lbf·ft (34 N·m).

8. Using the vehicle system air, charge the parking brake with full line pressure, at least 100 psi (690 kPa). 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 25 lbf·ft (34 N·m).

⚠ DANGER

Do not attempt to remove the factory-sealed parking brake clamp ring (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 25 to 30 lbf·ft (34 to 41 N·m) 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 group.

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

Combination Service and Parking Brake Chamber Removal and Installation

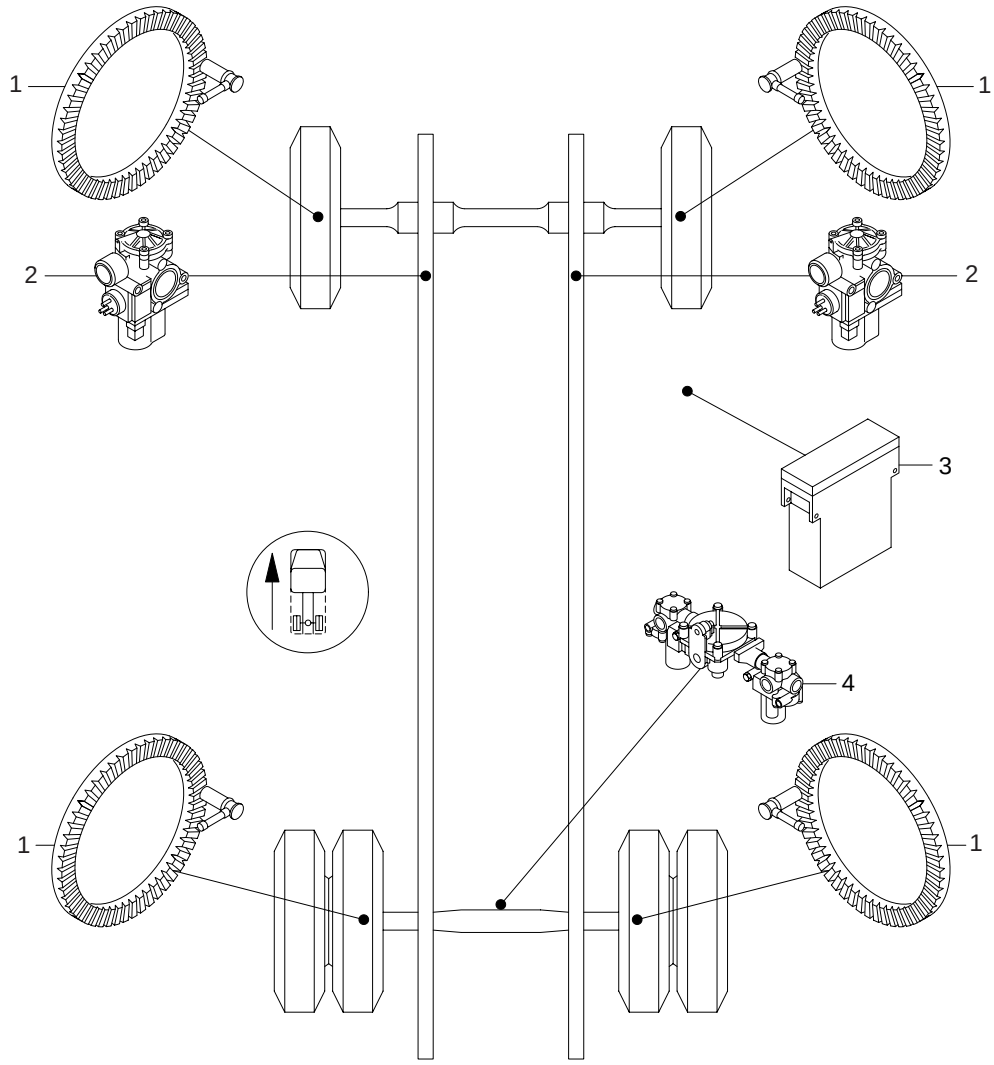
adjuster. For instructions, refer to the applicable slack adjuster section in this group.

Specifications

Torque Values	
Description	**Torque lbf·ft (N·m)**
Spring Brake Release Bolt Nut (in storage pocket)	10 (14)
Service Brake Clamp Ring Nut	25–30 (34–41)
Brake Chamber Mounting Stud Nut	100–115 (136–156)
Air Hose Fitting-to-Chamber	25 (34)

Table 1, Torque Values

General Description (See Fig. 1)



01/27/98 f421732

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 Meritor WABCO 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 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. According to programmed specifications, the control unit signals 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.

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**).

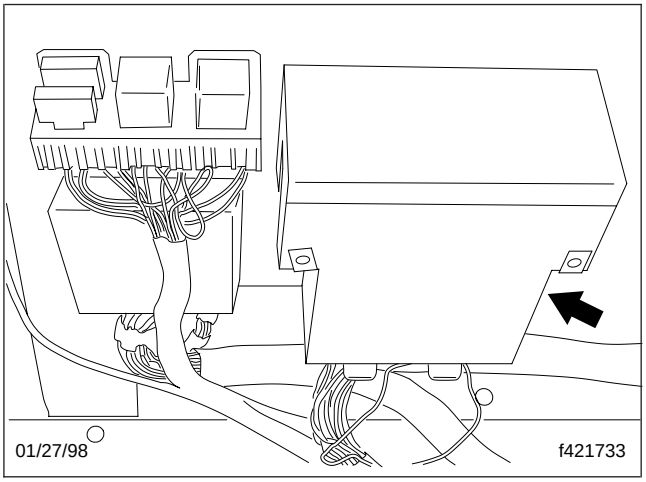


Fig. 2, Electronic Control Unit

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 interruptions in a magnetic field created by the sensor. The interruptions create electrical pulses that are sent by the sensor to the electronic control unit.

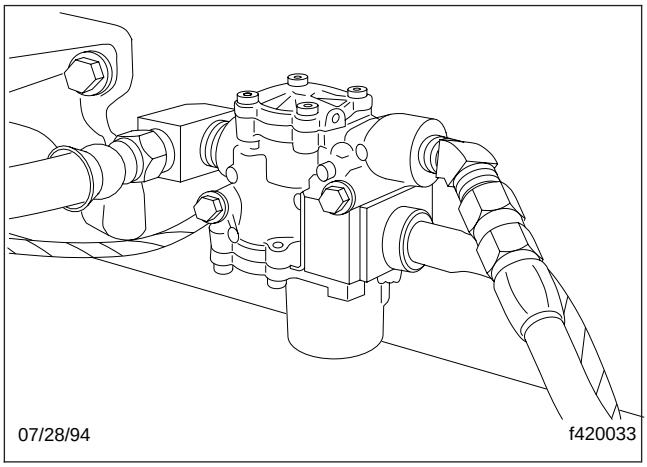


Fig. 3, Solenoid Control Valve, Front Axle Mounting shown

Electronic Control Unit (ECU)

The electronic control unit (ECU), located in a panel just behind the driver's seat, contains microcomputers to monitor the front and rear control channels. 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 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 valve (if equipped), solenoid control valves, and the electrical circuitry. After the ignition switch is turned on, the vehicle warning light comes on for about three seconds. After about three seconds, the lights go out only if all of the tractor's ABS components are working.

IMPORTANT: If the ABS warning light does not work as described above, repair the ABS system. Refer to **Troubleshooting 300** for fault diagnosis.

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 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 if a solenoid con-

trol 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.

Solenoid Control Valve

The solenoid control valves for the front axle brakes are attached on each side of the vehicle (inboard of the forward fuel tank brackets). The combination solenoid control valves (which include a relay valve) for the rear axle brakes are attached to the either the center or forward suspension crossmember near the 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.

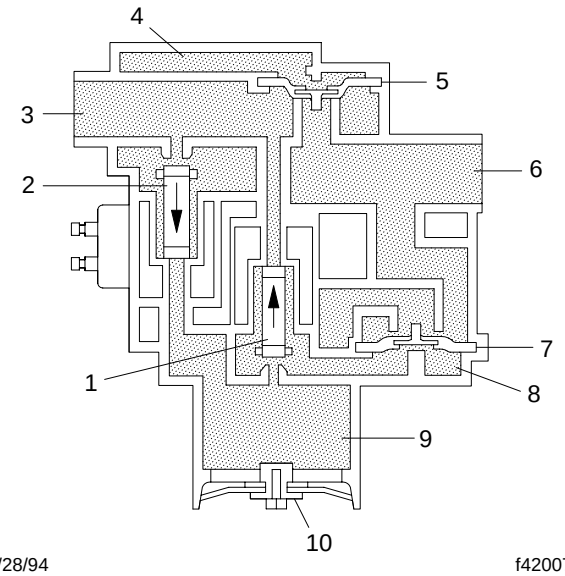
If the electronic control unit signals indicate wheel lockup, air pressure is reduced in the brake chamber. Solenoid valve 1 opens allowing compressed air to enter the inlet chamber and pilot chamber 1. See **Fig. 4**.

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. 5**), 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 escaping through the exhaust port.

If maintaining brake air pressure (**Fig. 6**), 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.

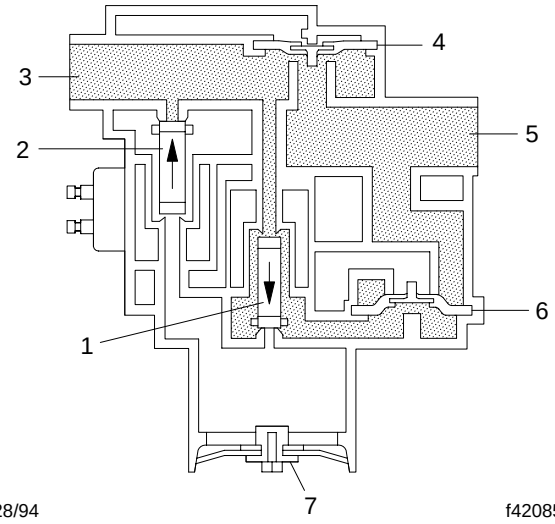


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1. Solenoid Valve No. 2
2. Solenoid Valve No. 1
3. Inlet Chamber
4. Pilot Chamber No. 1
5. Diaphragm Valve No. 1
6. Delivery Chamber
7. Diaphragm Valve No. 2
8. Pilot Chamber No. 2
9. Exhaust Chamber
10. Exhaust Port

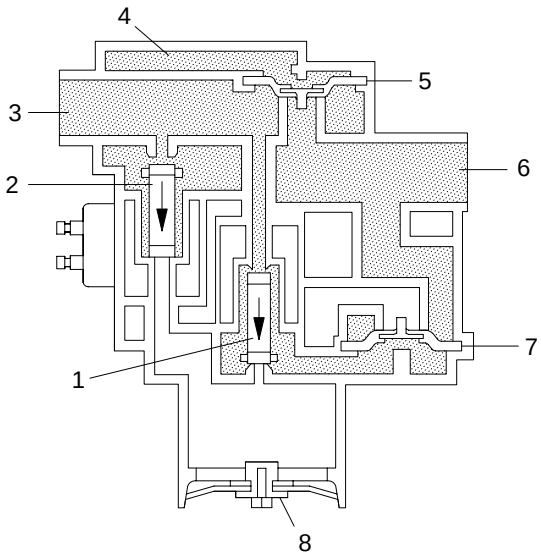
Fig. 4, Wheel Lockup Cycle

General Information



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. 5, Pressure Increase Cycle



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. 6, 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 **Group 54** (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. Twist and pull the sensor, to remove it from the steering knuckle (**Fig. 1**).

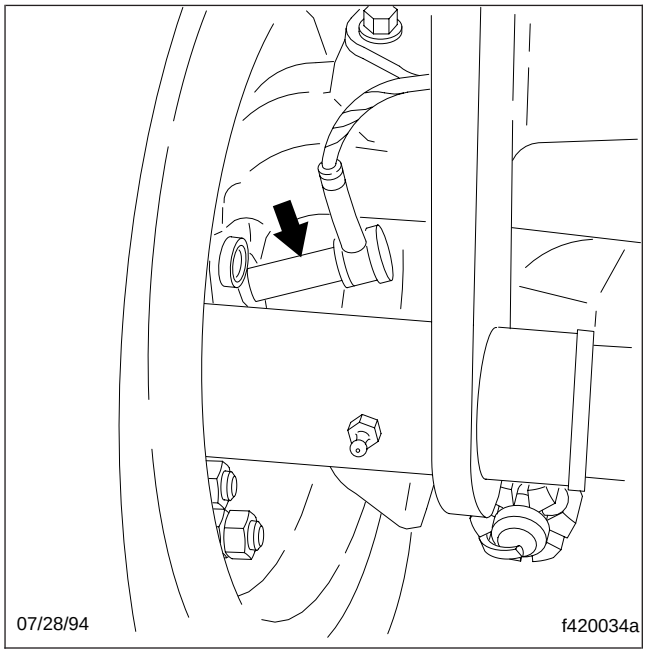


Fig. 1, Remove the Wheel Speed Sensor

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 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.

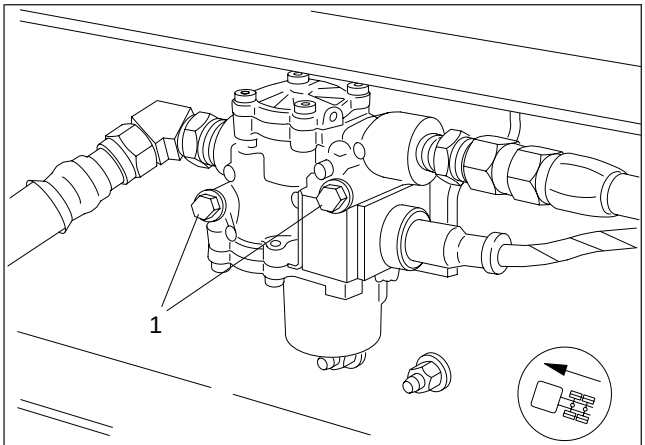
Rear Axle

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 **Group 40** in this manual.
5. Remove the brake drum. For instructions, refer to **Group 35** in 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. 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. Using your hand, push the sensor into the clamping bushing until it is stopped by the tone wheel.
14. Install the brake drum on the wheel hub. For instructions, refer to **Group 35** in this manual.

Wheel Speed Sensor Replacement

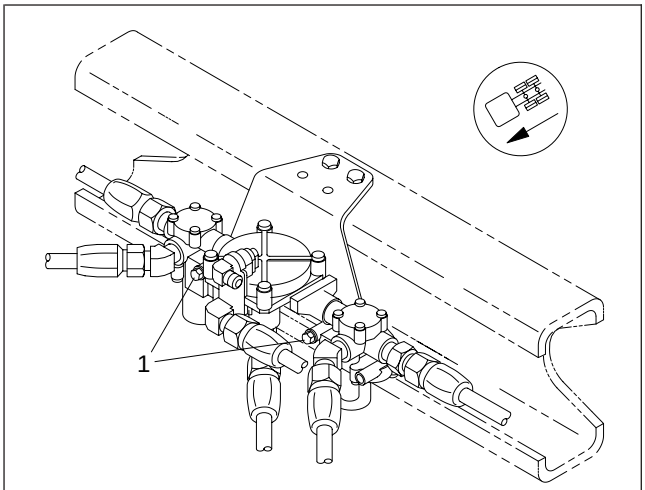
15. Adjust the rear axle brakes. For instructions, refer to the applicable brake section in this manual.
16. Install the wheel and tire assembly, and tighten the wheel nuts. Use the tightening sequence and torque values listed in **Group 40** in this manual.
17. Remove the safety stands, lower the vehicle, and remove the chocks from the front tires.

Replacement (See Fig. 1 or Fig. 2)



1. Mounting Fasteners

Fig. 1, Solenoid Control Valve Mounting (inside right-hand rail mounting shown)



1. Mounting Fasteners

Fig. 2, Combination Solenoid Control Valve Mounting (rear axle mounting shown)

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 valve, or combination solenoid control valve(s).
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 valve.

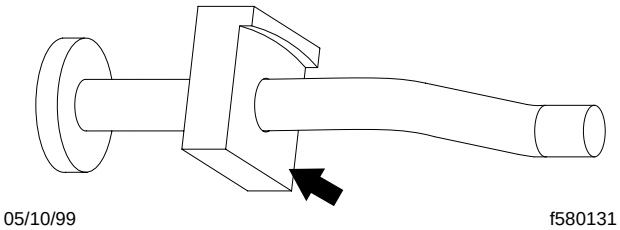
NOTE: The combination solenoid control valve can be disassembled if replacement of the relay valve, automatic traction control valve, or one of the solenoid control valves is needed. For disassembly and assembly instructions, see **Subject 130**.

7. Install the solenoid valve using the above instructions in reverse order. Tighten the mounting nuts 18 lbf·ft (24 N·m).

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**.

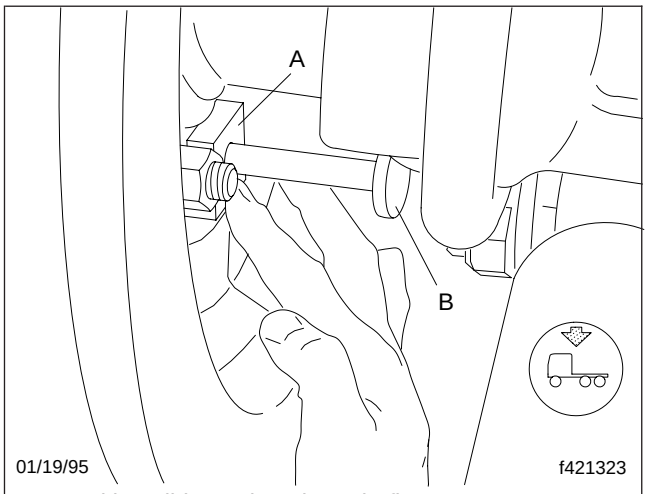
1. Park the vehicle on level ground, set the parking brake, and shut down the engine.



1. Slide

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 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.

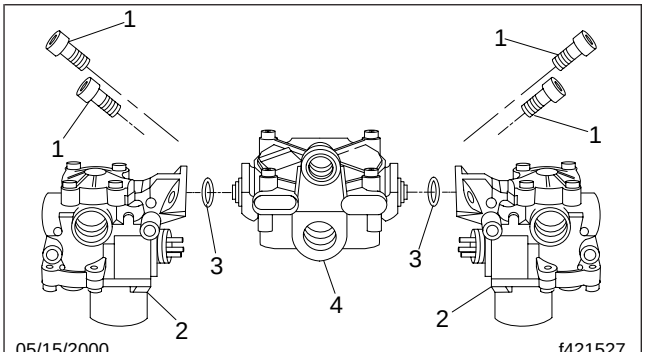


A. Position slide against the axle flange.
B. Tap here with your hand.

Fig. 2, Position the Tool

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. Use a 6 mm allen-head wrench to loosen and 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 the grease provided.
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).

Troubleshooting

This subject includes the following troubleshooting methods:

- Troubleshooting using blink codes
- Troubleshooting using fault codes

Diagnostics

This system has built-in diagnostics to ensure that all components are operating properly. Under normal conditions, the vehicle warning light comes on when the ignition is turned on. After about three seconds these lights should go out if all of the vehicle'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 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 light is still on, there is an "active" system fault that must be repaired to ensure proper system operation. If the light is not on, a "historical or intermittent" fault (indicating a loose connector or broken wire) has been recorded in the ECU memory.

Fault codes can be diagnosed by either Pro-Link 9000, or Freightliner ServiceLink. MID and SID codes are accessible only through ServiceLink.

NOTE: If troubleshooting the system with the Pro-Link 9000, use the instruction booklet that is supplied with the data cartridge.

Once a fault code has been identified, use a volt/ohmmeter to check the electrical harness at the ECU's pin connectors (there is a 15-pin and 18-pin connector at the ECU, which is located in a panel just behind the passenger's seat). Connect the ohmmeter leads to the applicable pins on each connector. See **Fig. 1**, and **Table 1**, for a description of the circuit wire numbers and their location within the pin connectors.

IMPORTANT: The ignition switch must be off when connecting or disconnecting the ECU.

If the ABS light does not operate correctly after the ignition is turned on (the light doesn't come on at all or doesn't go out after about three seconds), check all related circuit breakers in the electrical panel behind the passenger's seat, and replace if necessary. Check the wiring to the warning lamp. Refer to **Table 2**, 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).

Refer to the applicable table in this section for 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.

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.

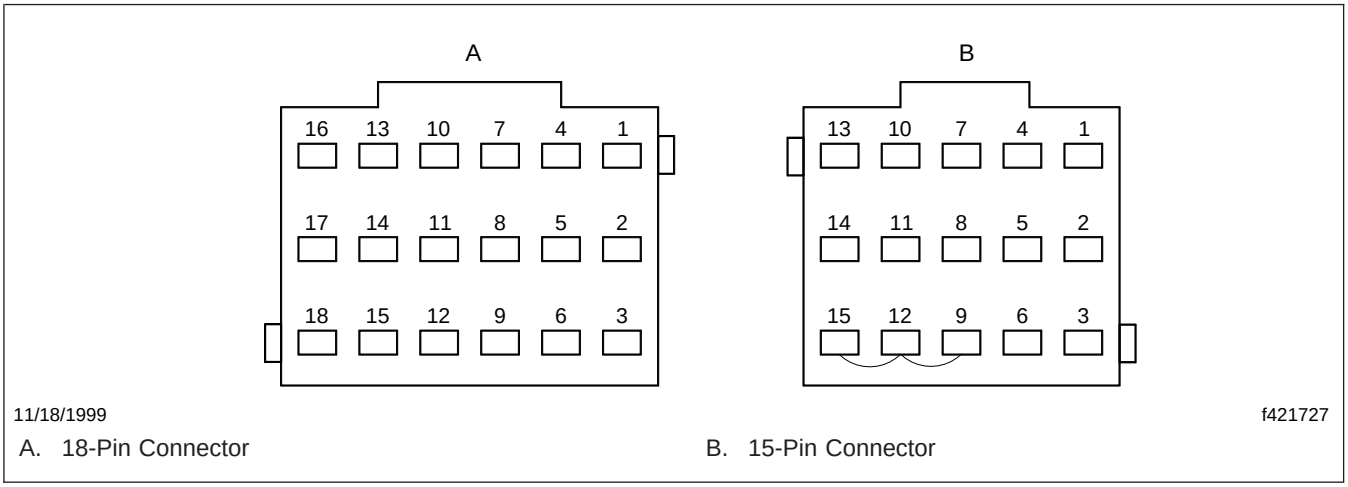
If a fault still can't be repaired, or erased from ECU memory, contact your Meritor District Service Manager, or call Meritor WABCO at 1–800–535–5560.

NOTE: An "active" fault code cannot be erased from ECU memory.

USING FAULT CODES

The first six digits of the fault code indicate the system component or area you need to troubleshoot. To find the component or area that corresponds to a fault code, see **Table 3**. After that, refer to the appropriate table for the troubleshooting procedure.

Troubleshooting



A. 18-Pin Connector

B. 15-Pin Connector

Fig. 1, ECU Pin Connectors

Circuit Wire Numbers and Descriptions			
Pin Connector	**Pin Number**	**Freightliner Wire Number**	**WABCO Circuit Description**
15-Pin	1	1922–	J1922 Data Link Negative to ECU
	3	1922+	J1922 Data Link Positive to ECU
	4	GND	ECU Ground
	7	376C	ECU Ignition Supply
	8	376A	ECU Positive 12 Volt Supply
	9	GND	ECU Control Ground
	10	1587–	J1587 Data Link Negative to ECU
	11	1587+	J1587 Data Link Positive to ECU
	14	376R	Retarder Interrupt Signal
	15	376L	Vehicle ABS Indicator Light Signal

Circuit Wire Numbers and Descriptions			
Pin Connector	**Pin Number**	**Freightliner Wire Number**	**WABCO Circuit Description**
18-Pin	1	378RFI	Right Front Solenoid Control Valve, In
	2	378LRI	Left Rear Solenoid Control Valve, In
	3	378LFI	Left Front Solenoid Control Valve, In
	4	378RFO	Right Front Solenoid Control Valve, Out
	5	378LRO	Left Rear Solenoid Control Valve, Out
	6	378LFO	Left Front Solenoid Control Valve, Out
	8	378RRI	Right Rear Solenoid Control Valve, In
	9	378RRO	Right Rear Solenoid Control Valve, Out
	10	377RF–	Right Front Sensor, Low
	11	377LR–	Left Rear Sensor, Low
	12	377LF–	Left Front Sensor, Low
	13	377RF+	Right Front Sensor, High
	14	377LR+	Left Rear Sensor, High
	15	377LF+	Left Front Sensor, High
	17	377RR–	Right Rear Sensor, Low
	18	377RR+	Right Rear Sensor, High

Table 1, Circuit Wire Numbers and Descriptions

ABS CHECK Switch and Warning Lamps Wiring Checks				
Wiring Tested	**Test These Pins**	**Volt/Ohmmeter Reading**	**Possible Cause**	**Remedy**
Vehicle Warning (ABS) Light	On the 15-pin connector, pins 9 and 15	2 to 50 ohms (depends on bulb wattage)	Wiring to the light is shorted or open; or the bulb needs replacing.	Repair the wiring, or replace the bulb.

Table 2, Warning Lamp Wiring Checks

Fault Codes and Corresponding System Components/Areas		
If the First Six Digits of the Fault Code Are:	**Troubleshoot this Component or Area:**	**See Table:**
136001	Left Front Wheel Sensor	See **Table 4**.
136002	Right Front Wheel Sensor	See **Table 5**.
136003	Left Rear Wheel Sensor	See **Table 6**.
136004	Right Rear Wheel Sensor	See **Table 7**.
136007	Left Front Solenoid Control Valve	See **Table 8**.
136008	Right Front Solenoid Control Valve	See **Table 9**.
136009	Left Rear Solenoid Control Valve	See **Table 10**.

Troubleshooting

Fault Codes and Corresponding System Components/Areas		
If the First Six Digits of the Fault Code Are:	**Troubleshoot this Component or Area:**	**See Table:**
136010	Right Rear Solenoid Control Valve	See **Table 11**.
136013	Retarder	See **Table 12**.
136014	Ground (diagonal 1)	See **Table 13**.
136023	Warning Light	See **Table 14**.
136249	SAE-J1922 Datalink	See **Table 15**.
136251	Voltage	See **Table 16**.
136253	Configuration	See **Table 17**.
136254	Miscellaneous	See **Table 18**.

Table 3, Fault Codes and Corresponding System Components/Areas

Left Front Wheel Sensor Troubleshooting					
Fault Code			**Problem**	**Diagnostic Procedure**	**Blink Code**
MID	**SID**	**FMI**			
136	001	01	Excessive air gap	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 12 and 15 of the 18-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated to 30 rpm. Check for loose wheel bearings and/or excessive hub runout.	3–2
136	001	02	Incorrect tire	Check for correct tire size. Check for correct number of teeth on the tone wheel.	5–2
136	001	03	Shorted to power	Measure the potential across pin 12 of the 18-pin connector and ground, and pin 15 and ground. If the measurement indicates a potential, the sensor is shorted to power.	4–2
136	001	04	Shorted to ground	Check the continuity between pin 12 and ground, and pin 15 and ground. If continuity exists in either pin, the sensor is shorted to ground.	4–2
136	001	05	Open circuit	Check the continuity between pins 12 and 15 of the 18-pin connector. A good resistance measurement will be between 700 and 3000 ohms.	4–2
136	001	06	Short circuit	Check the continuity between pins 12 and 15 of the 18-pin connector. A good resistance measurement will be between 700 and 3000 ohms.	4–2
136	001	07	Damaged tone wheel	Check the tone wheel for damage such as missing teeth.	6–2
136	001	08	Wheel slip	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 12 and 15 of the 18-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	3–2
136	001	09	Wires mismatched	Check for a mismatch fault of another sensor and correct the problem in the wiring harness.	5–2

Left Front Wheel Sensor Troubleshooting					
Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	001	10	Intermittent signal loss	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 12 and 15 of the 18-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	3–2
136	001	11	Erratic signal	Check the sensor wiring and connectors for intermittent contact. Check the tone wheel for damage. Verify the signal by measuring the voltage across pins 12 and 15 of the 18-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	5–2
136	001	12	Frequency too high	Check the sensor wiring and connectors for intermittent contact. Check the ECU for an improper fault.	5–2

Table 4, Left Front Wheel Sensor Troubleshooting

Right Front Wheel Sensor Troubleshooting					
Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	002	01	Excessive air gap	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 10 and 13 of the 18-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm. Check for loose wheel bearings and/or excessive hub runout.	3–1
136	002	02	Incorrect tire	Check for correct tire size. Check for correct number of teeth on the tone wheel.	5–1
136	002	03	Shorted to power	Measure the potential across pin 10 of the 18-pin connector and ground and pin 13 and ground. If the measurement indicates a potential, the sensor is shorted to power.	4–1
136	002	04	Shorted to ground	Check the continuity between pin 10 of the 18-pin connector and ground and pin 13 and ground. If continuity exists in either pin, the sensor is shorted to ground.	4–1
136	002	05	Open circuit	Check the continuity between pins 10 and 13 of the 18-pin connector. A good resistance measurement will be between 700 and 3000 ohms.	4–1
136	002	06	Short circuit	Check the continuity between pins 10 and 13 of the 18-pin connector. A good resistance measurement will be between 700 and 3000 ohms.	4–1
136	002	07	Damaged tone wheel	Check the tone wheel for damage such as missing teeth.	6–1
136	002	08	Wheel slip	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 10 and 13 of the 18-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	3–1
136	002	09	Wires mis-matched	Check for a mis-match fault of another sensor and correct the problem in the wiring harness.	5–1

Troubleshooting

Right Front Wheel Sensor Troubleshooting					
Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	002	10	Intermittent signal loss	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 10 and 13 of the 18-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	3–1
136	002	11	Erratic signal	Check the sensor wiring and connectors for intermittent contact. Check the tone wheel for damage. Verify the signal by measuring the voltage across pins 10 and 13 of the 18-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	5–1
136	002	12	Frequency too high	Check the sensor wiring and connectors for intermittent contact. Check the ECU for an improper fault.	5–1

Table 5, Right Front Wheel Sensor Troubleshooting

Left Rear Wheel Sensor Troubleshooting					
Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	003	01	Excessive air gap	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 11 and 14 of the 18-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm. Check for loose wheel bearings and/or excessive hub runout.	3–4
136	003	02	Incorrect tire	Check for correct tire size. Check for correct number of teeth on the tone wheel.	5–4
136	003	03	Shorted to power	Measure the potential across pin 11 of the 18 pin-connector and ground, and pin 14 and ground. If the measurement indicates a potential, the sensor is shorted to power.	4–4
136	003	04	Shorted to ground	Check the continuity between pin 11 of the 18 pin-connector and ground, and pin 14 and ground. If continuity exists in either pin, the sensor is shorted to ground.	4–4
136	003	05	Open circuit	Check the continuity between pins 11 and 14 of the 18-pin connector. A good resistance measurement will be between 700 and 3000 ohms.	4–4
136	003	06	Short circuit	Check the continuity between pins 11 and 14 of the 18-pin connector. A good resistance measurement will be between 700 and 3000 ohms.	4–4
136	003	07	Damaged tone wheel	Check the tone wheel for damage such as missing teeth.	6–4
136	003	08	Wheel slip	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 11 and 14 of the 18-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	3–4
136	003	09	Wires mismatched	Check for a mis-match fault of another sensor and correct the problem in the wiring harness.	5–4

Left Rear Wheel Sensor Troubleshooting					
Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	003	10	Intermittent signal loss	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 11 and 14 of the 18-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	3–4
136	003	11	Erratic signal	Check the sensor wiring and connectors for intermittent contact. Check the tone wheel for damage. Verify the signal by measuring the voltage across pins 11 and 14 of the 15-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	5–4
136	003	12	Frequency incorrect	Check the sensor wiring and connectors for intermittent contact. Check the ECU for an improper fault.	5–4

Table 6, Left Rear Wheel Sensor Troubleshooting

Right Rear Wheel Sensor Troubleshooting					
Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	004	01	Excessive air gap	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 17 and 18 of the 18-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm. Check for loose wheel bearings and/or excessive hub runout.	3–3
136	004	02	Incorrect tire	Check for correct tire size. Check for correct number of teeth on the tone wheel.	5–3
136	004	03	Shorted to power	Measure the potential across pin 17 of the 18 pin-connector and ground, and pin 18 and ground. If the measurement indicates a potential, the sensor is shorted to power.	4–3
136	004	04	Shorted to ground	Check the continuity between pin 17 and the 18 pin-connector and ground, and pin 18 and ground. If continuity exists in either pin, the sensor is shorted to ground.	4–3
136	004	05	Open circuit	Check the continuity between pins 17 and 18 of the 18-pin connector. A good resistance measurement will be between 700 and 3000 ohms.	4–3
136	004	06	Short circuit	Check the continuity between pins 17 and 18 of the 18-pin connector. A good resistance measurement will be between 700 and 3000 ohms.	4–3
136	004	07	Damaged tone wheel	Check the tone wheel for damage such as missing teeth.	6–3
136	004	08	Wheel slip	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 17 and 18 of the 18-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	3–3
136	004	09	Wires mismatched	Check for a mis-match fault of another sensor and correct the problem in the wiring harness.	5–3

Troubleshooting

Right Rear Wheel Sensor Troubleshooting					
Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	004	10	Intermittent signal loss	Adjust the sensor. Verify the adjustment by measuring the voltage across pins 17 and 18 of the 18-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	3–3
136	004	11	Erratic signal	Check the sensor wiring and connectors for intermittent contact. Check the tone wheel for damage. Verify the signal by measuring the voltage across pins 17 and 18 of the 15-pin connector. A good measurement should be above 0.2 volts AC when the tire is rotated at 30 rpm.	5–3
136	004	12	Frequency incorrect	Check the sensor wiring and connectors for intermittent contact. Check the ECU for an improper fault.	5–3

Table 7, Right Rear Wheel Sensor Troubleshooting

Left Front Solenoid Control Valve Troubleshooting					
Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	007	01	Open circuit in the inlet and/or outlet solenoid circuits	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pins 3 and 6 of the 18-pin connector and pin 4 of the 15-pin connector. A good measurement should be between 4 and 8 ohms.	2–2
136	007	03	Shorted to power	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Measure the potential across pin 3 and 6 of the 18-pin connector and pin 4 of the 15-pin connector. If the measurement indicates a potential, the valve is shorted to power.	2–2
136	007	05	Open circuit	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pin 3 and 6 of the 18-pin connector and pin 4 of the 15-pin connector. A good measurement should be between 4 and 8 ohms.	2–2
136	007	06	Shorted to ground	Check continuity between pin 3 of the 18-pin connector and ground, and pin 6 and ground. If continuity exists in either pin, the valve is shorted to ground.	2–2

Table 8, Left Front Solenoid Control Valve Troubleshooting

Right Front Solenoid Control Valve Troubleshooting					
Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	008	01	Open circuit in the inlet and/or outlet solenoid circuits	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pin 1 and 4 of the 18-pin connector and pin 4 of the 15-pin connector. A good measurement should be between 4 and 8 ohms.	2–1
136	008	03	Shorted to power	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Measure the potential across pin 1 and 4 of the 18-pin connector and pin 4 of the 15-pin connector. If the measurement indicates a potential, the valve is shorted to power.	2–1
136	008	05	Open circuit	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pin 1 and 4 of the 18-pin connector and pin 4 of the 15-pin connector. A good measurement should be between 4 and 8 ohms.	2–1
136	008	06	Shorted to ground	Check continuity between pin 1 of the 18-pin connector and ground, and pin 4 and ground. If continuity exists in either pin, the valve is shorted to ground.	2–1

Table 9, Right Front Solenoid Control Valve Troubleshooting

Left Rear Solenoid Control Valve Troubleshooting					
Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	009	01	Open circuit in the inlet and/or outlet solenoid circuits	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pin 2 and 5 of the 18-pin connector and pin 4 of the 15-pin connector. A good measurement should be between 4 and 8 ohms.	2–4
136	009	03	Shorted to power	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Measure the potential across pin 2 and 5 of the 15-pin connector and pin 4 of the 15-pin connector. If the measurement indicates a potential, the valve is shorted to power.	2–4
136	009	05	Open circuit	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pin 2 and 5 of the 18-pin connector and pin 4 of the 15-pin connector. A good measurement should be between 4 and 8 ohms.	2–4
136	009	06	Shorted to ground	Check continuity between pin 2 of the 18-pin connector and ground, and pin 5 and ground. If continuity exists in either pin, the valve is shorted to ground.	2–4

Table 10, Left Rear Solenoid Control Valve Troubleshooting

Troubleshooting

Right Rear Solenoid Control Valve Troubleshooting					
Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	010	01	Open circuit in the inlet and/or outlet solenoid circuits	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pins 8 and 9 of the 18-pin connector and pin 4 of the 15-pin connector. A good measurement should be between 4 and 8 ohms.	2–3
136	010	03	Shorted to power	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Measure the potential between pins 8 and 9 of the 18-pin connector and pin 4 of the 15-pin connector. If the measurement indicates a potential, the valve is shorted to power.	2–3
136	010	05	Open circuit	Check the solenoid control valve wiring. Check for damaged wiring in the inlet, outlet and ground circuits. Check the resistance between pins 8 and 9 of the 18-pin connector and pin 4 of the 15-pin connector. A good measurement should be between 4 and 8 ohms.	2–3
136	010	06	Shorted to ground	Check continuity between pin 8 of the 18-pin connector and ground, and pin 9 and ground. If continuity exists in either pin, the valve is shorted to ground.	2–3

Table 11, Right Rear Solenoid Control Valve Troubleshooting

Retarder Troubleshooting					
Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	013	03	Shorted to power	Measure the potential between pin 14 on the 15-pin connector and ground. If the measurement indicates a potential, the relay circuit is shorted to power.	7–3
136	013	05	Open circuit	Check continuity of the retarder relay circuit. Replace the wire if continuity does not exist.	7–3
136	013	06	Shorted to ground	Check continuity between pin 14 on the 15-pin connector and ground. If continuity exists, the retarder relay circuit is shorted to ground.	7–3

Table 12, Retarder Troubleshooting

Ground (diagonal 1) Troubleshooting					
Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	014	04	Voltage, diagonal 1, low voltage/open circuit	Check 10A circuit breaker. Check pin 8 in the 15-pin connector for power contact. Check the continuity of the circuit. If continuity does not exist, replace the wire.	8–1
136	014	07	Valve relay, diagonal 1	If fault detection repeats, replace ECU. An internal relay does not open the ECU power supply.	8–3

Table 13, Ground (diagonal 1) Troubleshooting

Warning Light Troubleshooting					
Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	023	05	Warning Light	Check the bulb and continuity of the warning light circuit. Was the blink code switch activated longer than 16 seconds? If so, cycle the ignition off and on to verify the fault.	7–4

Table 14, Warning Light Troubleshooting

J1922 Datalink Troubleshooting					
Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	249	05	The J1922 datalink has an open circuit	Check the J1922 datalink connections. Check continuity of the datalink wires.	7–1
136	249	06	The J1922 datalink is shorted to ground	Check continuity between pin 1 of the 15-pin connector and ground, and pin 3 and ground. If continuity exists, the J1922 datalink is shorted to ground.	7–1
136	249	10	The J1922 bus is not free	Check other J1922 ECUs for incorrect communication.	7–1

Table 15, J1922 Datalink Troubleshooting

Overvoltage Troubleshooting					
Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	251	03	Overvoltage	Check the alternator output and the battery potential. Supply voltage is too high for more than 5 seconds.	8–2

Table 16, Overvoltage Troubleshooting

Configuration Troubleshooting					
Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	253	02	EEPROM, wheel parameter incorrect	Check parameter setting.	8–4
136	253	12	EEPROM, checksum	Check the parameter setting. Diagnostic device disconnected during active diagnosis.	8–4

Table 17, Configuration Troubleshooting

Miscellaneous ABS Troubleshooting					
Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	254	02	Internal error	Cycle the ignition off and on. If the fault detection repeats, replace the ABS electronic control unit.	8–3

Troubleshooting

Miscellaneous ABS Troubleshooting					
Fault Code			Problem	Diagnostic Procedure	Blink Code
MID	SID	FMI			
136	254	05	ABS ECU, no loads	No modulators connected. Fault not memorized.	8–4
136	254	08	Excessive slip/ dynotester	Check the wheel sensor air gaps. One axle was much faster than the other.	7–1
136	254	09	Solenoid Control Valve, activation time	Modulator valve was activated for too long.	2–1
136	254	12	Internal error	Cycle the ignition off and on. If the fault detection repeats, replace the ABS electronic control unit.	8–3

Table 18, Miscellaneous ABS Troubleshooting

See **Fig. 1** for a full view of the wiring diagram for the ABS valves and sensors. See **Fig. 2**, and **Fig. 3** for partial (detailed) views of the wiring diagram.

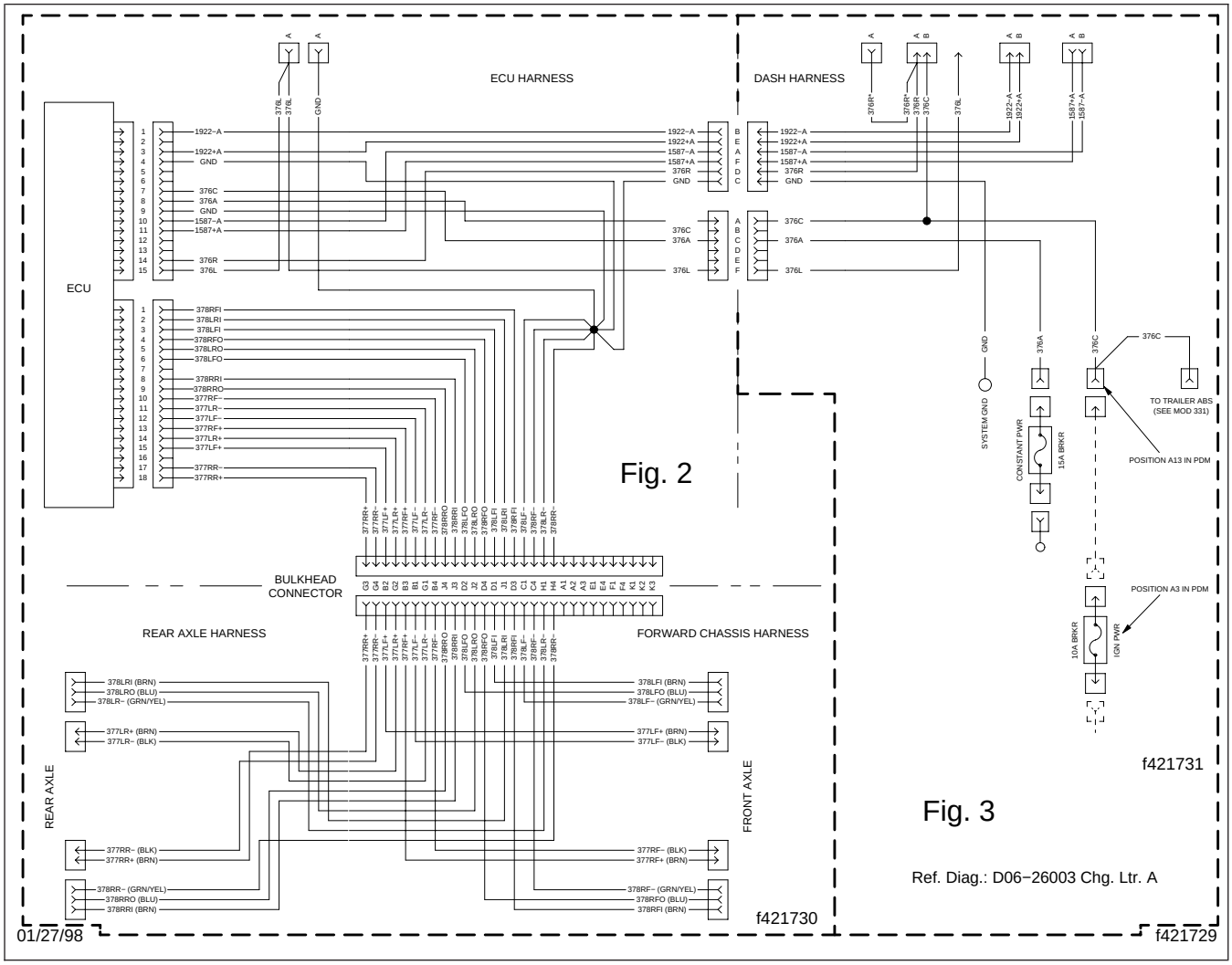


Fig. 1, Wiring Diagram for ABS Valves and Sensors

Specifications

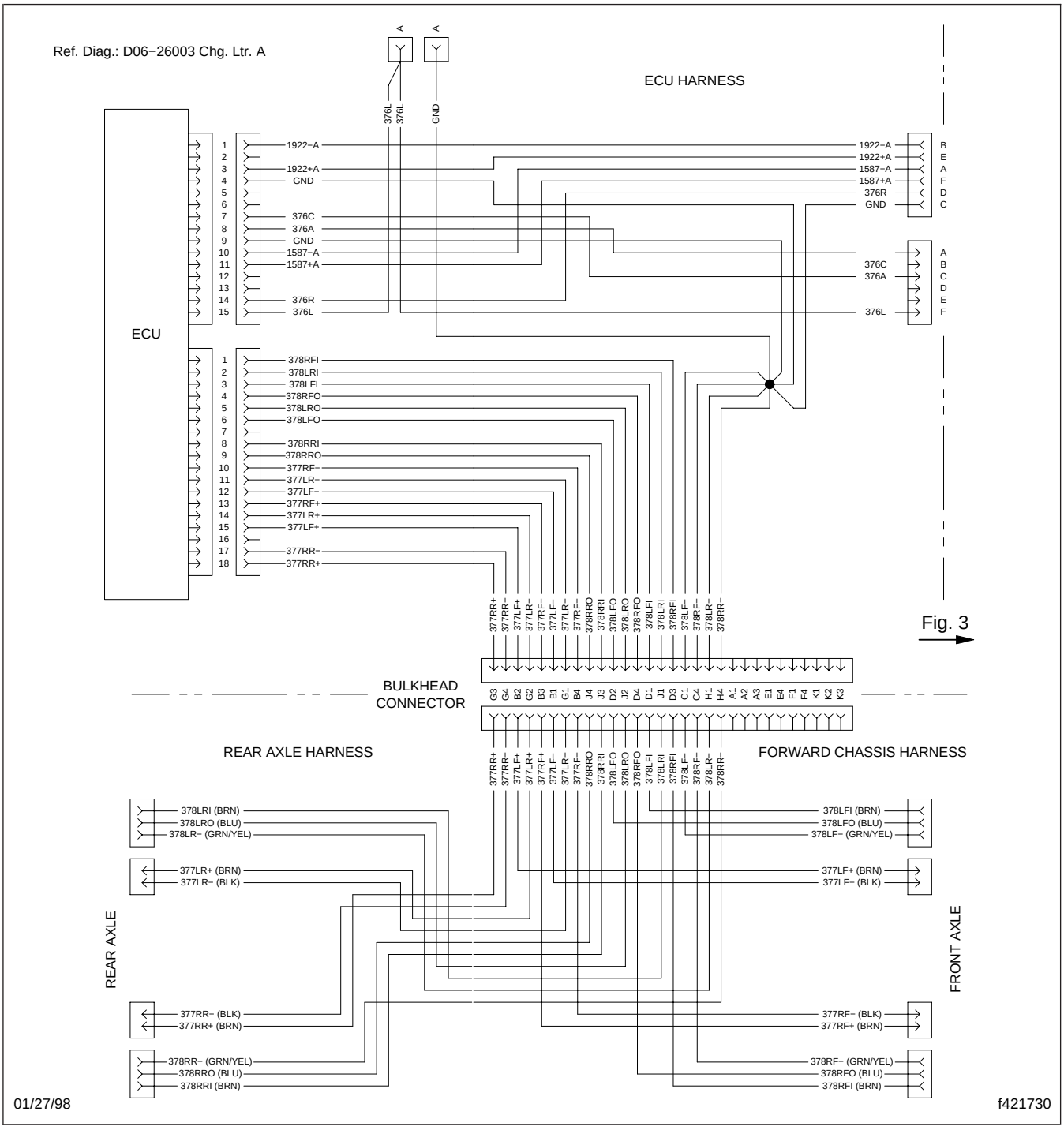


Fig. 2, Partial View Showing ABS Valves and Sensors

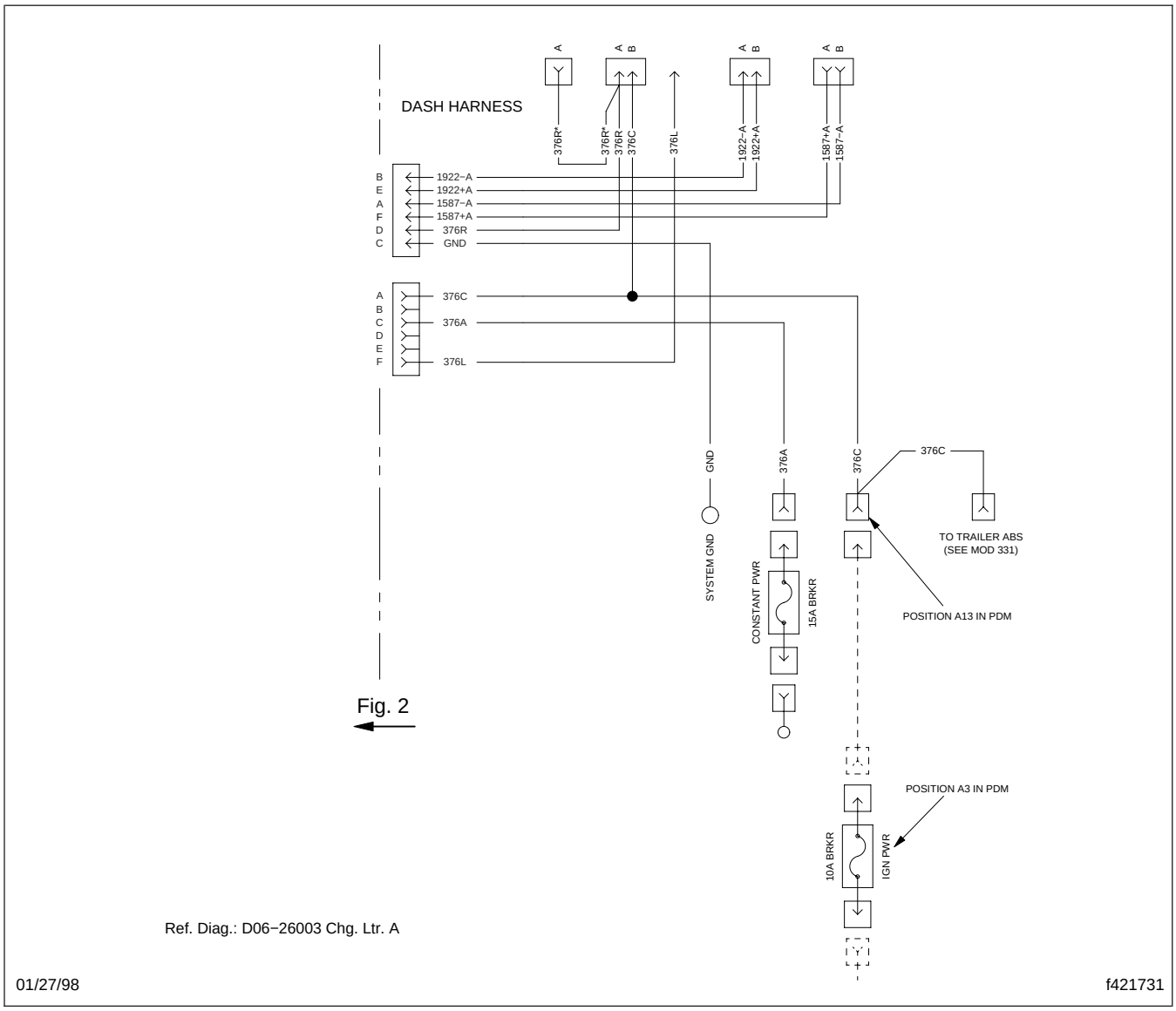


Fig. 3, Partial View Showing ABS Valves and Sensors

General Information

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.

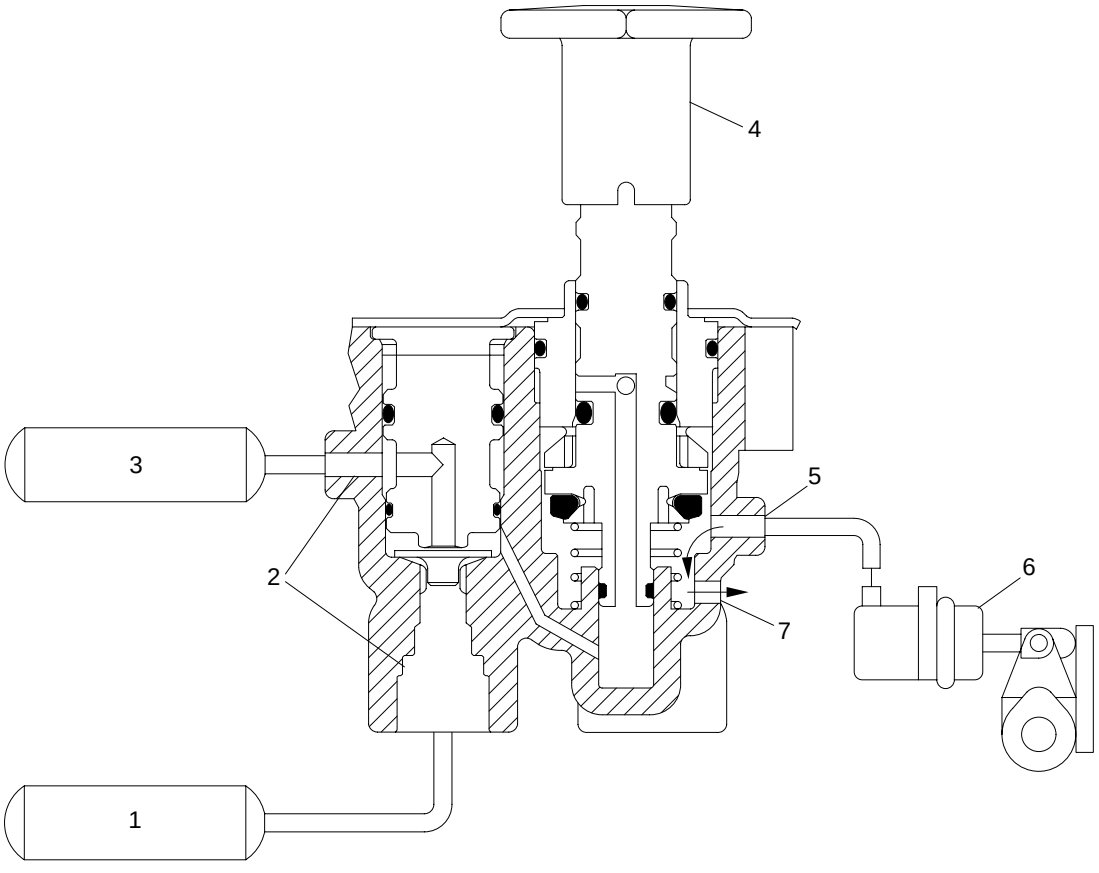
Parking Brake Hand Valve Tests

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

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 counterclockwise and remove it from the valve stem.
3. Remove the dash panel.
4. 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.

5. Remove the four screws that attach the valve to the dash bracket. Remove the valve.

Installation

1. Position the valve assembly in the dash 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

1. Remove the valve assembly from the dash, following the instructions in **Subject 120.**
2. Pull the plunger stem and remove the plunger and guide spool from the body.
3. Remove and discard the plunger spring.
4. 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.
5. Remove and discard the check valve seat O-rings.
6. Turn the body upside down and gently tap it on a flat surface to remove the check valve. Discard the check valve.
7. Remove the guide spool from the plunger. Remove and discard the O-ring.
8. Remove and discard the O-rings from the plunger. Also, remove and discard the exhaust seal.

Assembly

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 valve in the dash, Tighten the screws to 35 lbf·in (400 N·cm). Follow the instructions in **Subject 120** for installation and **Subject 110** for leak testing.

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.

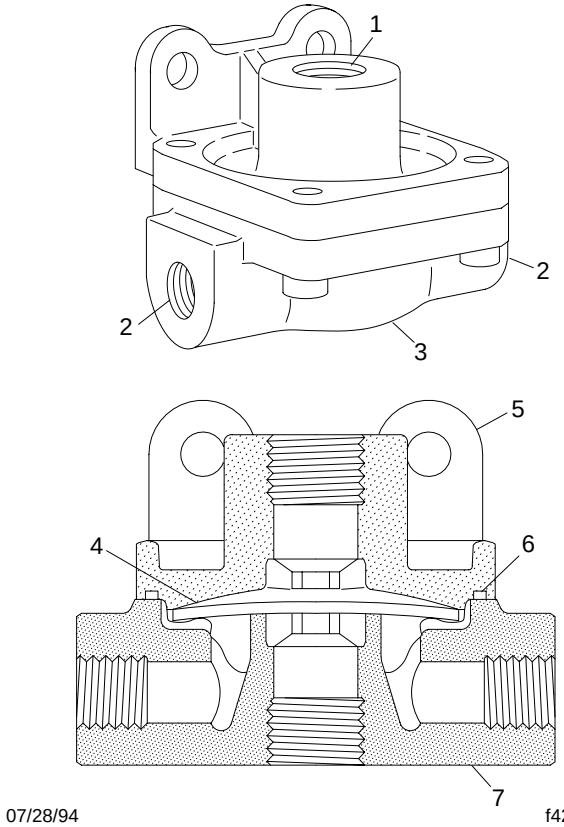
When the parking brake chambers are equipped with a QR–1 valve, it is located on the rear suspension crossmember.

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 (See 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.



1. Brake Valve Port
2. Brake Chamber Port
3. Exhaust Port
4. Diaphram
5. Cover
6. O-Ring
7. Body

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.

Bendix QR–1 Valve Operating and Leakage Tests

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 1-inch (2.5-cm) 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.

Bendix QR–1 Valve Removal and Installation

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. Perform the operation and leakage tests under **Subject 110**.

Bendix QR–1 Valve Disassembly, Cleaning and Inspection, and Assembly

Disassembly

1. Remove the quick release valve from the vehicle. For instructions, see **Subject 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

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 30 to 60 lbf·in (340 to 680 N·cm) evenly and securely.
3. Install the quick release valve. For instructions, see **Subject 120**.

General Information

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.

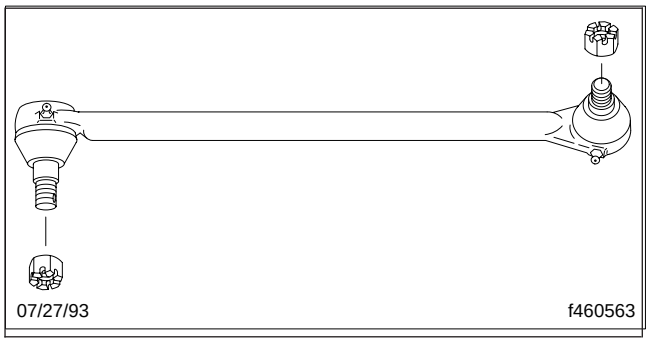


Fig. 1, Nonadjustable Drag Link

Drag Link Removal and Installation

Removal

1. Before removing the drag link, check for wear of the ball studs if ball stud wear or looseness is suspected. 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. Tilt the cab.
5. Remove the drag link from the vehicle.
   - 5.1 At both ends of the drag link, remove the cotter pins and loosen the nuts on the socket ball studs. Be sure the nuts are loosened far enough to allow use of a ball stud removal tool.
   - 5.2 Using a ball stud removal tool, loosen the drag link from the pitman arm and the axle steering arm. See **Fig. 1.**
   - 5.3 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.
   - 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:
     - 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.

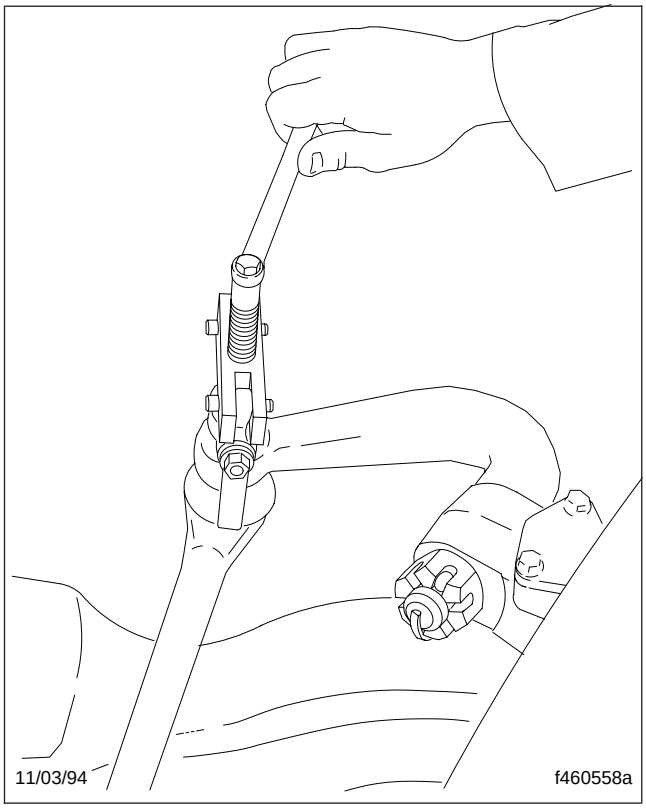


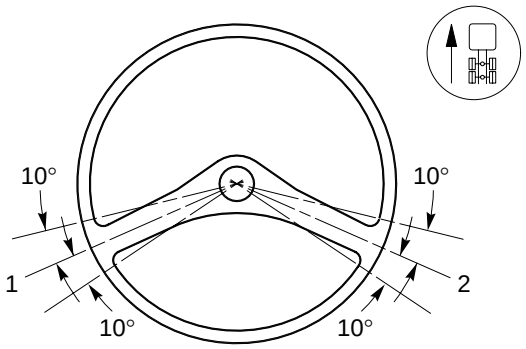
Fig. 1, Removing Ball Stud from Axle Steering Arm

⚠ 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.

Drag Link Removal and Installation

3. Wipe the dirt from the grease fittings. Apply chassis grease until the old grease is forced out.
4. Lower the cab.
5. 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. 2**. 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. 2, Aligning the Steering Wheel

Drag Link Ball Stud Testing, On-Vehicle

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:

- 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)**
3/4–16	90–170 (122–230)
7/8–14	160–300 (217–407)

Table 1, Torque Values

General Description

The TRW TAS55 and TAS65 integral power steering gears use pressurized hydraulic fluid to help the driver turn the front wheels. Both models mount on the left frame rail and all operate in the same way.

The difference between the two gears is size. The TAS55 is for front axle capacities up to 12,000 pounds (5448 kg) and the TAS65 is for front axle capacities up to 14,300 pounds (6500 kg).

Both 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 TAS55 needs 2.6 gpm (9.8 L/min) and the TAS65 needs 3.0 gpm (11.4 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**. 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. 2**.

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.

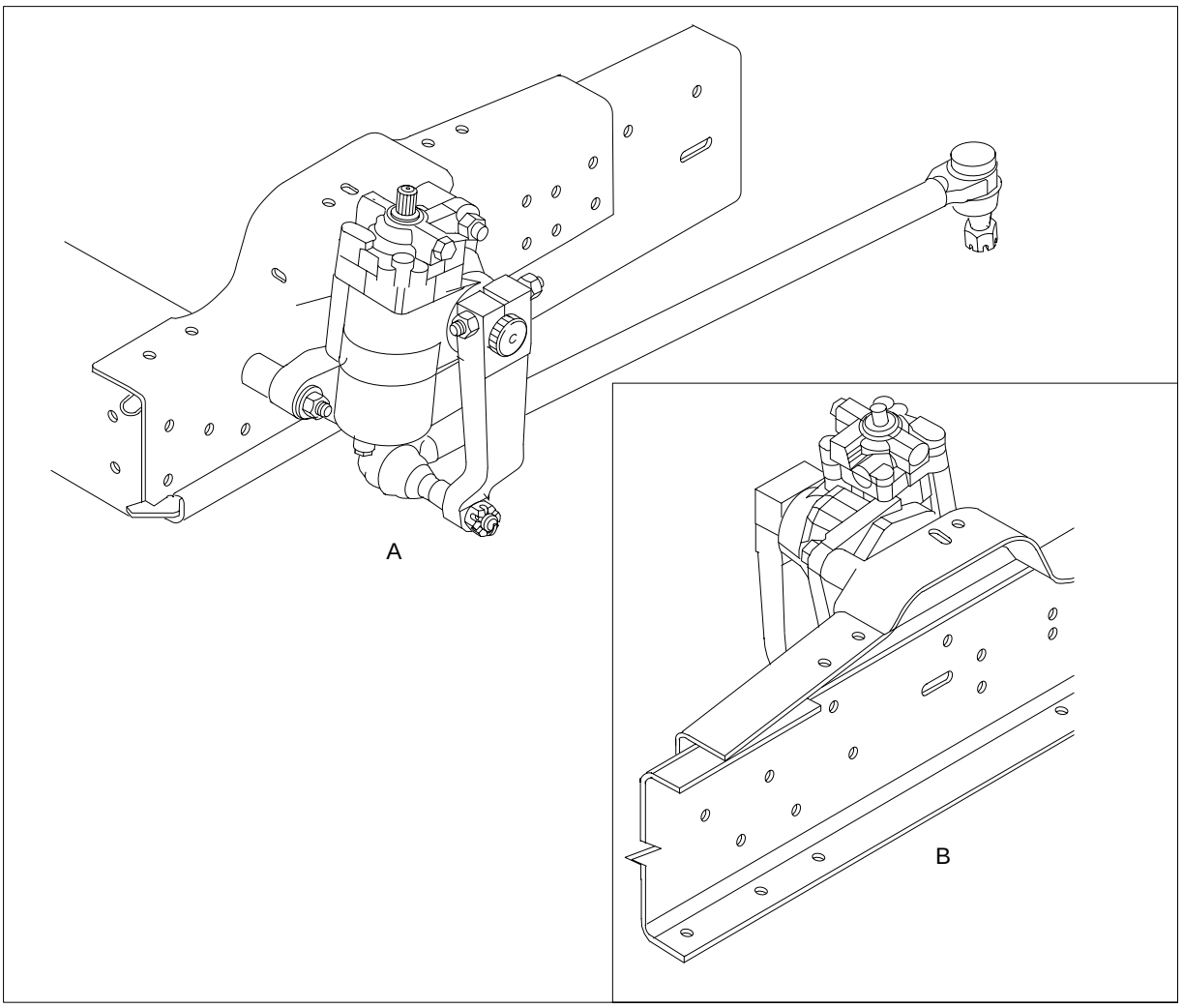
The torsion bar controls the hydraulic fluid. As the driver turns the steering wheel to turn the input shaft, and the front wheels resist turning and hold the rack piston and worm shaft in place, the torsion bar connecting the input shaft and worm shaft twists slightly. That twisting aligns holes in 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.

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 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 dampen the shock before it can move up the worm shaft to the steering driveline and the steering wheel.

General Information

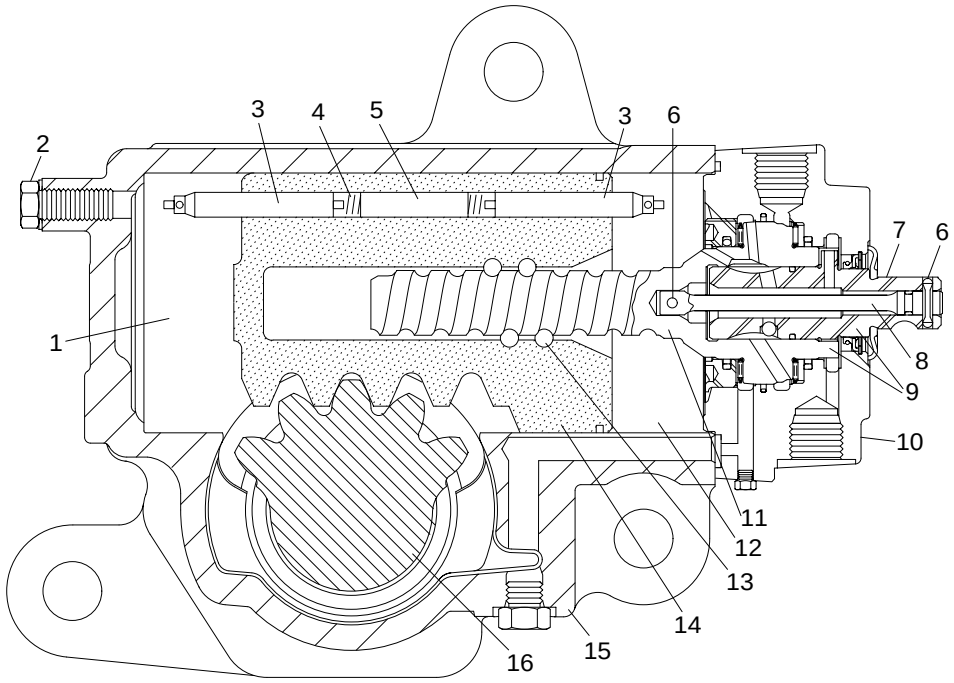


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A. Side view of steering gear.

B. Reverse view of steering gear.

Fig. 1, TRW TAS55/65 Power Steering Gear



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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. 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**.

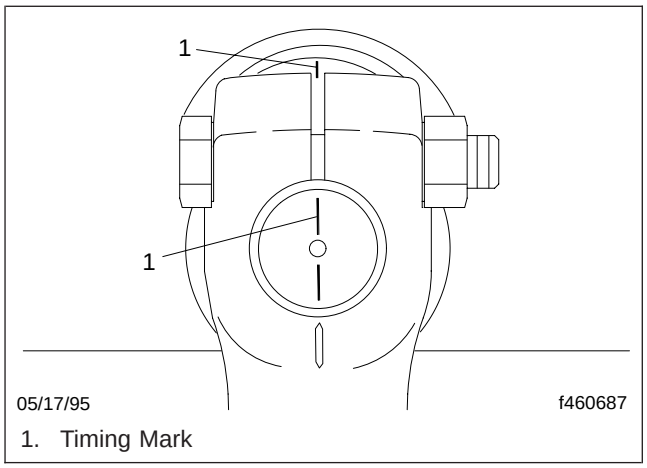


Fig. 1, Position the Sector Shaft

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. Finger-tip force is adequate to detect lash (free play) of a loose sector shaft. There should be no movement of the input shaft or sector shaft. Loosen the sector shaft adjusting screw jam nut. See **Fig. 2**. 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).

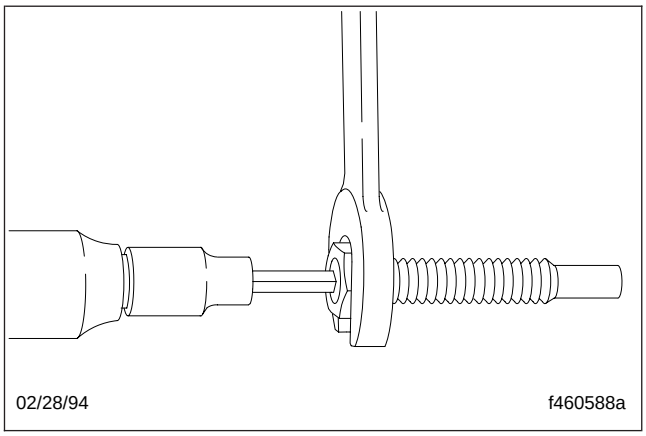


Fig. 2, Loosen Screw in the Poppet Adjusting Screw

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 elsewhere in this group.

Poppet Valves Adjustment

TAS55 and TAS65 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 **decreased** 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 automati-

In-Vehicle Adjustments

cally 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**.

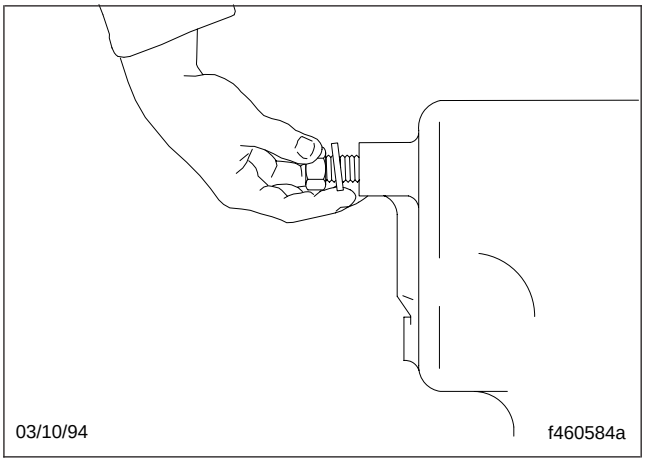


Fig. 3, Remove the Poppet Fixed Stopscrew and Washer

NOTE: With the wheels straight ahead and the timing marks on the sector shaft and gear housing aligned as shown in **Fig. 1**, the steering gear is centered.

   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. 4**. Tighten the nut 33 to 37 lbf·ft (45 to 50 N·m).

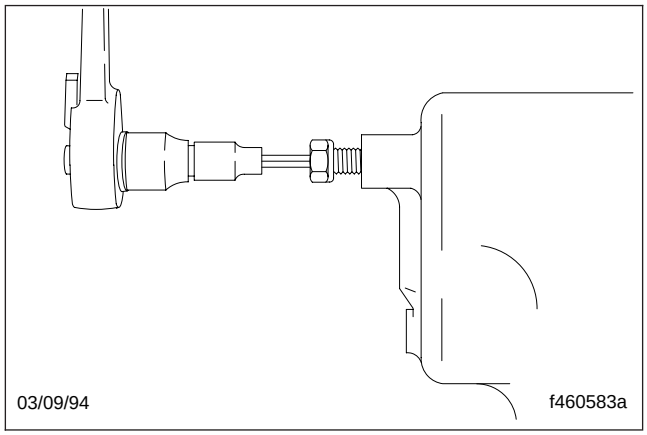


Fig. 4, Turn the Adjusting Screw

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.

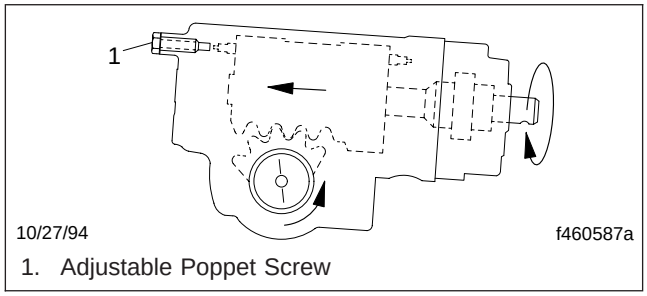
4. Adjust the poppets manually.

   4.1 Check the fluid level and fill the power steering reservoir with Dexron II type ATF if required.

   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. 5**.



1. Adjustable Poppet Screw

Fig. 5, Preparing the Poppet for Setting

   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. 6**. Tighten the sealing nut 33 to 37 lbf·ft (45 to 50 N·m).

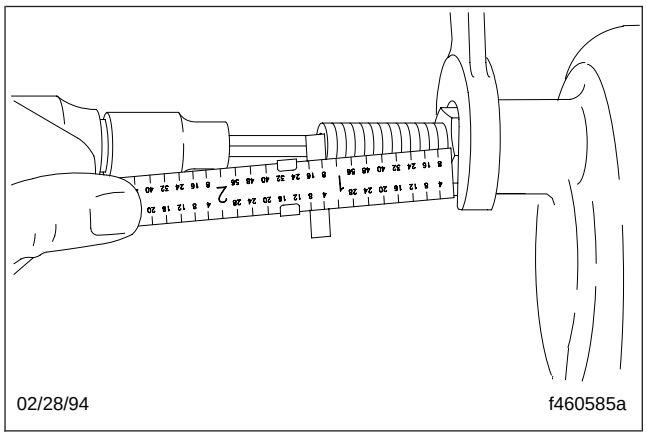


Fig. 6, Back Out the Adjusting Screw and Measure

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 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. 7**. 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. 6** and **Fig. 7**.

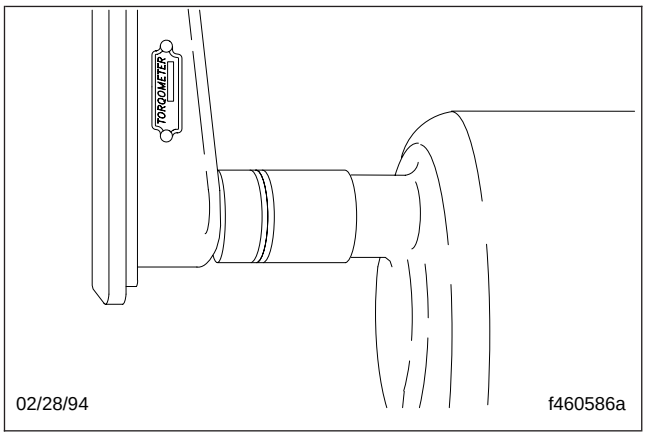


Fig. 7, Tightening the Sealing Nut

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 **Section 46.04, Subject 300** to identify the problem.

1. Verify correct axle stop adjustment. For instructions, see **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, chock the tires, and tilt the cab.
3. Remove the left 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. Plug 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 nut.
   - 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 the pinch bolt nut and pinch bolt from the steering driveline lower end yoke.
   - 7.2 Discard the nut. Mark the driveline and gear splines for later assembly.

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.

   - 7.3 Remove the lower end yoke from the input shaft.
8. Clean the entire assembly before removing the gear.

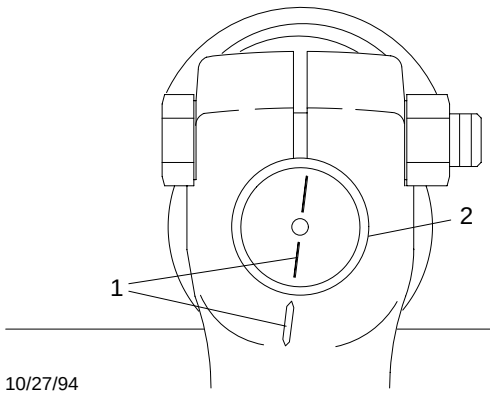
IMPORTANT: The TAS55 weights 60 pounds (27 kg) dry and the TAS65 weights 80 pounds (36 kg) dry. Use care when removing, lifting, and carrying the steering gear to avoid injury.

9. Remove the fasteners that attach the steering gear to the frame rail. Remove the steering gear.

Installation

IMPORTANT: The TAS55 weights 60 pounds (27 kg) dry and the TAS65 weights 80 pounds (36 kg) dry. Use care when removing, lifting, and carrying the steering gear to avoid injury.

1. Install the steering gear and fasteners. Torque the 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. 1**.



1. Timing Marks
2. Steering Gear Sector Shaft

Fig. 1, Position the Pitman Arm on the Steering Gear

Steering Gear Removal and 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.

3.2 Install the pitman arm pinch bolt, washer, and a new nut. Torque the nut to the specification in **Table 1**.

Torque Specifications		
Description	**Size**	**Torque lbf·ft (N·m)**
Pinch Bolt Locknut	5/8–14	120–140 (163–190)
	3/4–16	215–245 (292–332)

Table 1, Torque Specifications

3.3 Apply white torque seal OGP F900WHITE to the exposed threads and 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.

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 yoke pinch bolt and a new pinch bolt nut. Tighten the nut 55 to 65 lbf·ft (75 to 88 N·m).

4.4 Apply white torque seal OGP F900WHITE to the exposed pinch bolt threads and 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 Dexron II type ATF 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.

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. Refer to **Subject 140** and perform the checks as instructed.

8. 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 pointing within ±10 degrees of the 4 o'clock and 8 o'clock positions. If not, remove the steer-

ing wheel and install it in the correct position. For instructions, see the applicable section in this group.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

Disassembly

⚠ WARNING

All steering mechanisms are safety items. Because of this, follow the instructions in this subject to the letter. Failure to do so may result in the loss of steering, which could cause an accident resulting in personal injury or property damage.

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 SPX Kent-Moore or an affiliated dealer.

IMPORTANT: When the sector shaft is disconnected from the vehicle steering linkage, don't 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 view 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 Using one layer of masking tape, tape the splines and the bolt groove of the sector shaft. See **Fig. 5**.
   - 4.3 Using a 3/4-inch socket, remove the jam nut from the sector shaft adjusting screw.
   - 4.4 Put a container under the side cover to catch any drainage, then remove the special bolts from the side cover.

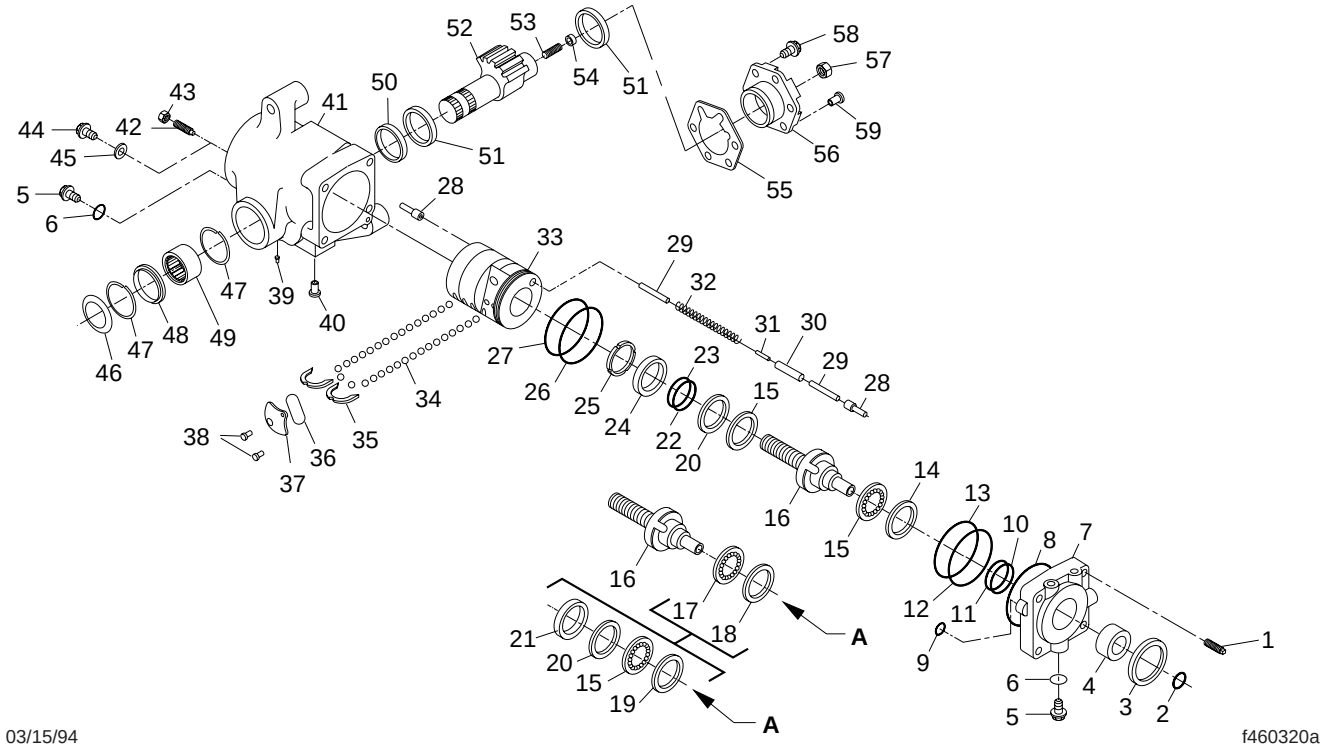
   IMPORTANT: These special bolts are equipped with either an integral ring or washer on the underside of the head. See **Fig. 6**. If replacing one or more bolts, use bolts of the same special type and length as those that were removed. Do not use a substitute and do not mix different types of bolts.

   - 4.5 Remove the side cover and the sector shaft assembly as a unit from the steering gear housing. 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.
   - 5.2 Remove the sector shaft from the side cover.
   - 5.3 Remove the side-cover seal as follows.

   IMPORTANT: Be careful when you are removing the side-cover seal, or you may damage the side-cover bore, the DU bushing.

   - 5.4 Screw a 1/2–20 x 3 bolt into the hole in the side cover where the sector shaft adjusting screw was.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments



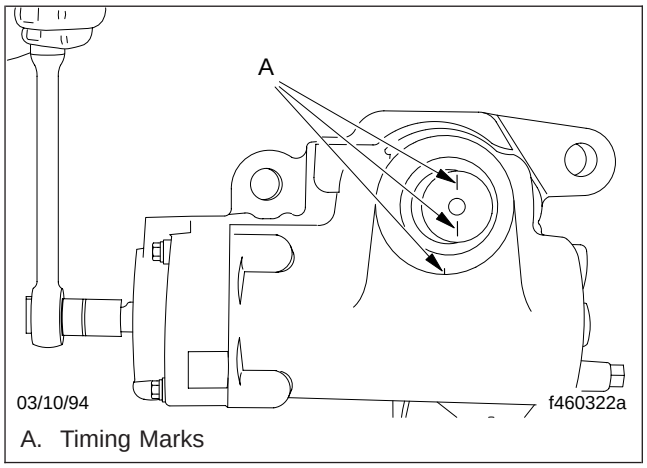
NOTE: The side cover for TAS55 and TAS65 steering gears contains a bushing.

A. Alternate Construction

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. Seal Ring, Large
9. Seal Ring, Small
10. O-Ring
11. Seal Ring
12. O-Ring, Valve Housing
13. Seal Ring
14. Thrustwasher, Thick
15. Roller Thrust Bearing
16. Input-Shaft/Valve/Worm Assembly
17. Ball Bearing Assembly (valve/worm)
18. Ball Bearing Race
19. Thrustwasher, Thick
20. Thrustwasher, Thin
21. Spacer Sleeve
22. Seal Ring
23. O-Ring
24. Bearing Adjuster
25. Adjuster Locknut
26. Seal Ring, Rack Piston
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. Seal, Ball Return Guide Cap
37. Ball Return Guide Cap
38. Torx Screws
39. Grease Fitting
40. Plug, Auto-Bleed
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. Seal, Output
52. Sector Shaft
53. Adjusting Screw, Shaft
54. Retainer, Adjusting Screw
55. Gasket, Side Cover
56. Side Cover and Bushing/Bearing Assembly
57. Jam Nut
58. Special Bolts, Side Cover
59. Vent Plug, Side Cover

Fig. 1, TRW Steering Gear

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments



A. Timing Marks

Fig. 2, Line Up the Timing Marks

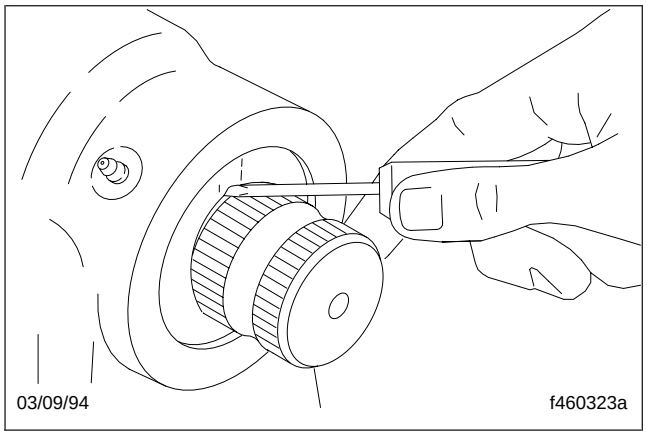


Fig. 3, Remove the Water Seal

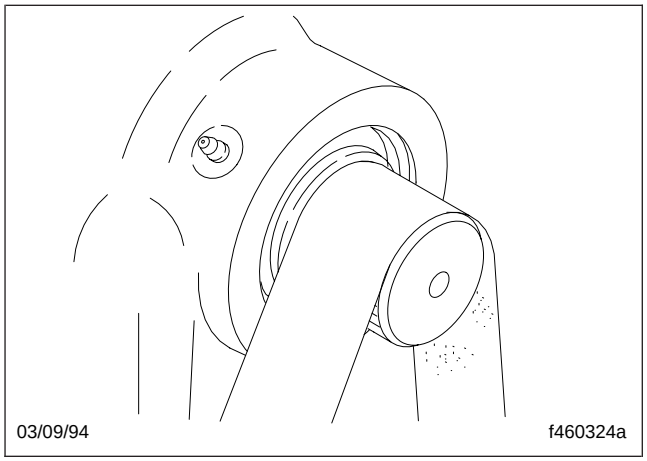


Fig. 4, Remove Dirt, Paint, or Corrosion

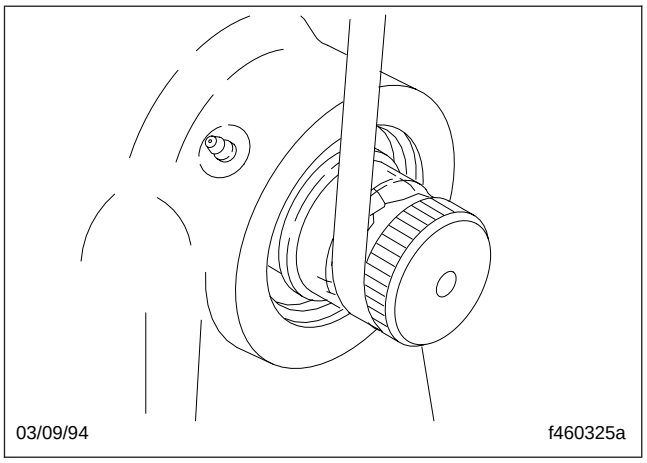
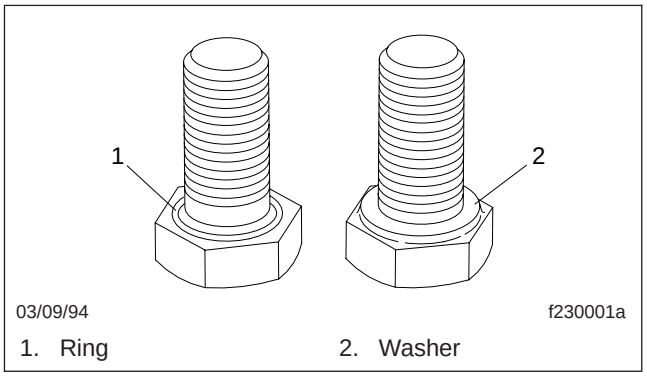


Fig. 5, Tape the Splines



1. Ring
2. Washer

Fig. 6, Integral Ring and Washer

Make sure the bolt is in far enough so that it will support a rolling head (lady-foot) type pry bar. See **Fig. 7**.

5.5 With the pry bar supported by the bolt end, pry up the side-cover seal and remove 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.

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. 8**.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

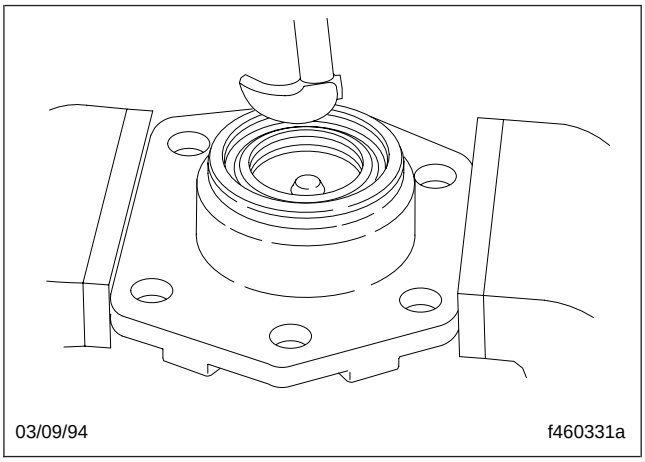


Fig. 7, Check the Bolt for Support

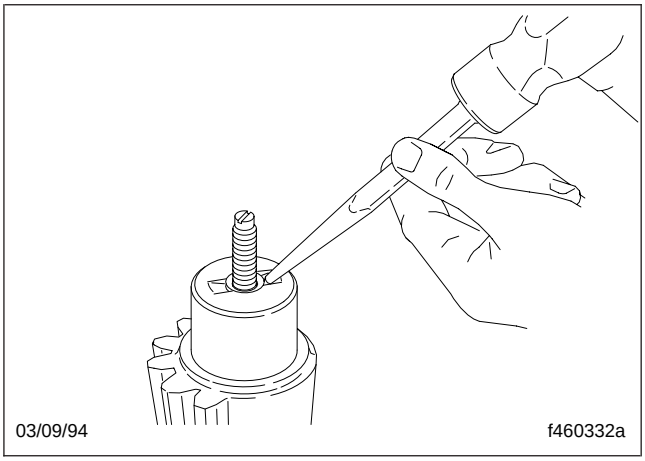


Fig. 8, Unstake the Adjusting-Screw Retainer

6.2 Unscrew the retainer and remove it from the sector shaft.

6.3 Remove the adjusting screw. Discard the retainer.

7. Remove the relief valve components if equipped: relief valve cap, 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. 9**.

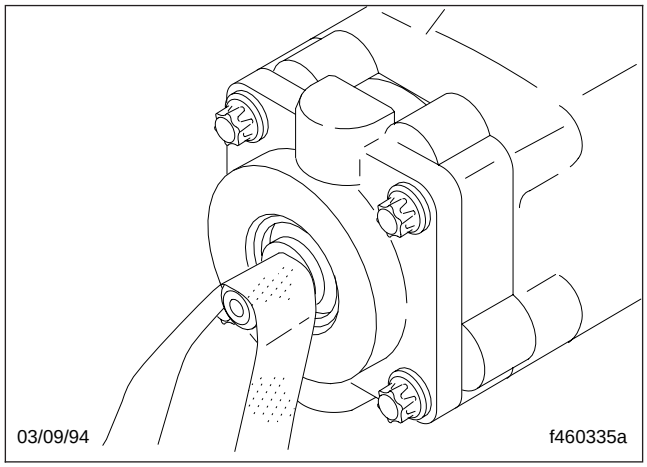


Fig. 9, Remove the Dirt-and-Water Seal

8.2 Using an E–16 Torx® socket wrench, remove the four valve housing bolts.

8.3 Remove the valve housing from the main gear housing together with the worm shaft and rack piston assembly. Set the assembly on a clean bench.

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. 10**.

9.2 Remove the cap and its seal. Discard the two screws and the seal.

9.3 Remove the ball return guide halves from the rack piston by carefully prying up on them with a screwdriver. See **Fig. 11**.

9.4 Remove the 31 (TAS55) or 32 (TAS65) steel balls from the rack piston by turning the worm shaft until all of them are out.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

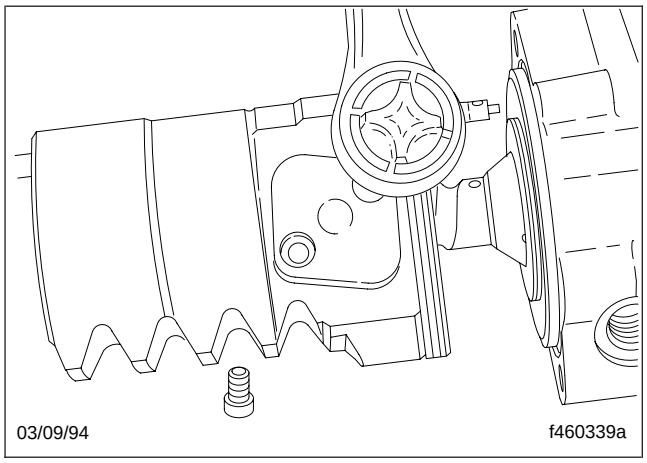


Fig. 10, Remove the Two Sealing Screws

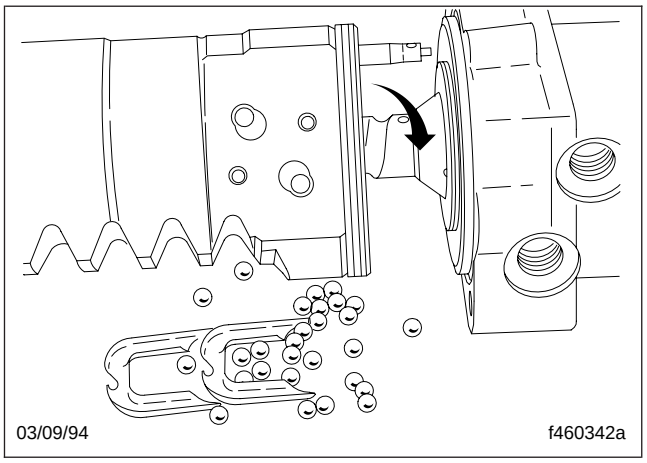


Fig. 12, Remove the Steel Balls

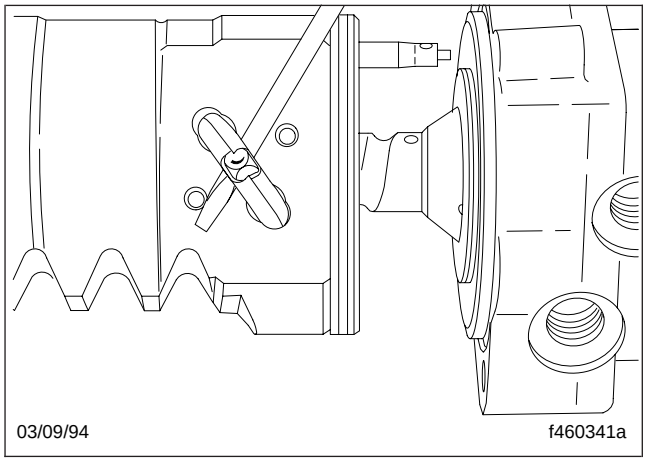


Fig. 11, Remove the Ball Return Guide Halves

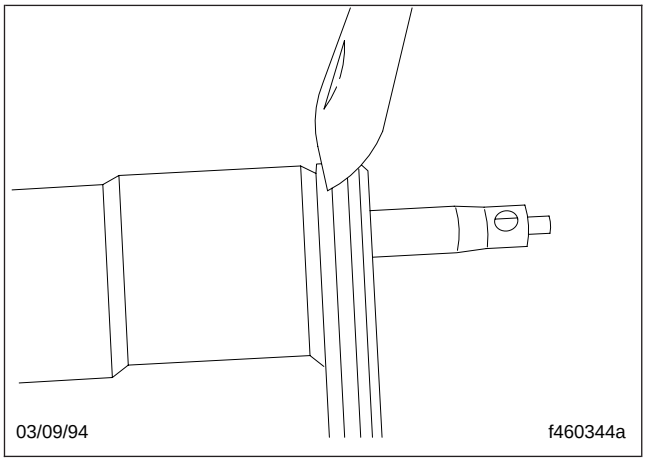


Fig. 13, Cut the Teflon Seal Ring

See **Fig. 12**. Do not lose any of these balls, or you will have to replace the entire set.

⚠ WARNING

Never mix different sets of steel balls. To do so may cause a loss of steering control, which could cause an accident resulting in serious injury or property damage.

10. Remove the worm shaft and valve housing assembly from the rack piston.
11. Cut and remove the Teflon seal ring and the O-ring from the rack piston. See **Fig. 13**.
12. If replacing poppet assemblies, remove the poppet valve assemblies.

⚠ CAUTION

The poppet valve assemblies are installed with Loctite®. Be careful when removing them and use only special tool J36452 or J38713 (preferred). Failure to do so may damage the rack piston, which would require replacing the rack piston, steel ball kit, and 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.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

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. 14**. Hit the end of the tool firmly four or five times with a 16 oz. hammer to loosen the Loctite. See **Fig. 15**.

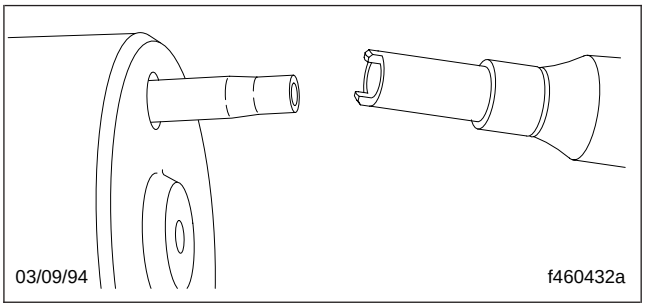


Fig. 14, Slide the Special Tool Over the Poppet Adjuster Seat

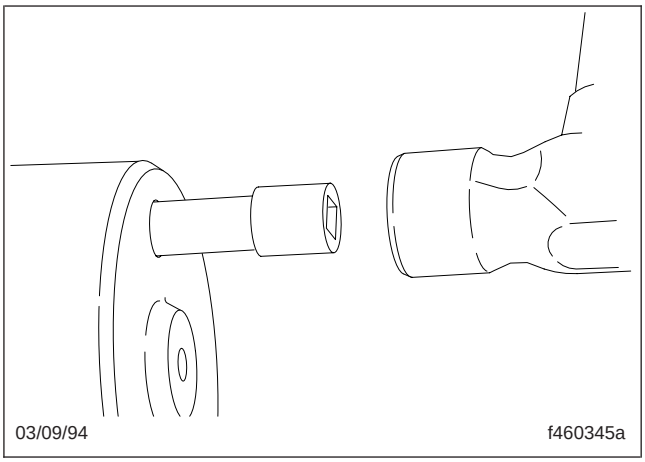
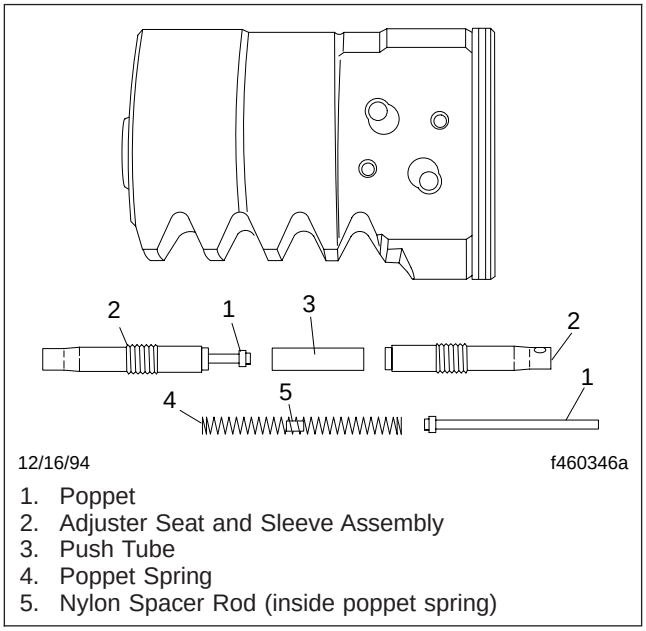


Fig. 15, Hit the End of the Tool with a Hammer

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, the spring, spacer rod, and push tube. See **Fig. 16**.

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. Poppet Spring
5. Nylon Spacer Rod (inside poppet spring)

Fig. 16, 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. 17**.

13.2 Unstake the adjuster locknut using a punch. See **Fig. 17**.

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. 18**.

NOTE: The bearing adjuster has either two slots or two drill points on its face. Special tool J37070 can be used for removing and installing either style of bearing adjuster. See **Fig. 18**.

13.4 Remove and discard the seal ring and the O-ring from the bearing adjuster. See **Fig. 19**.

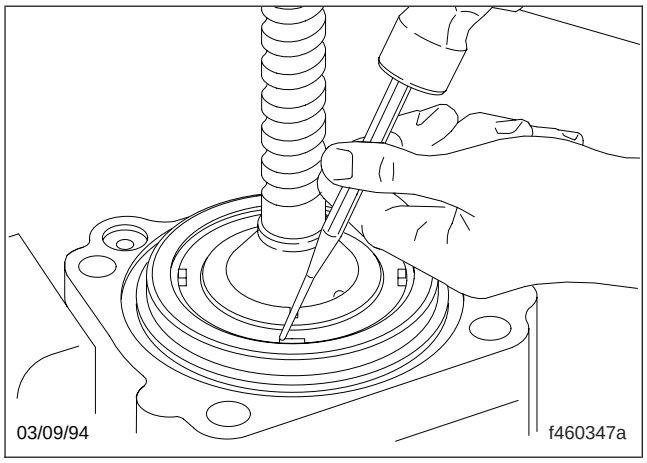


Fig. 17, Unstake the Adjuster Locknut

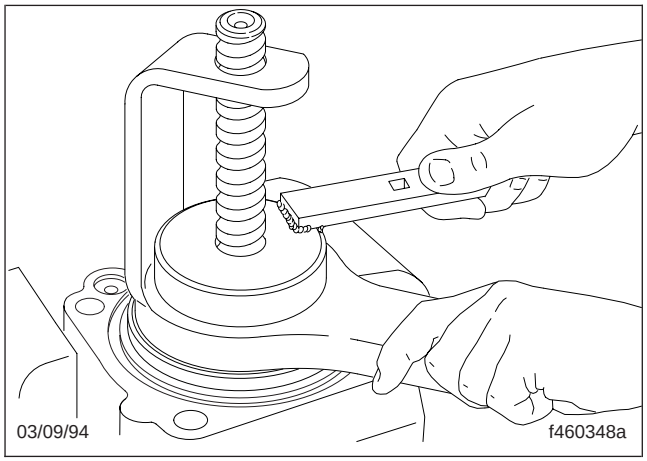


Fig. 18, Unscrew the Adjuster Locknut and Bearing Adjuster

13.5 Remove the thin washer, thrust bearing, input shaft, rotary valve, and worm shaft assembly from the valve housing. See **Fig. 20**.

IMPORTANT: Do not disassemble the input shaft or worm shaft assembly any further. These are not serviceable.

13.6 Remove the roller thrust bearing assembly and the thick thrustwasher from the valve housing. See **Fig. 21**.

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. 22**.

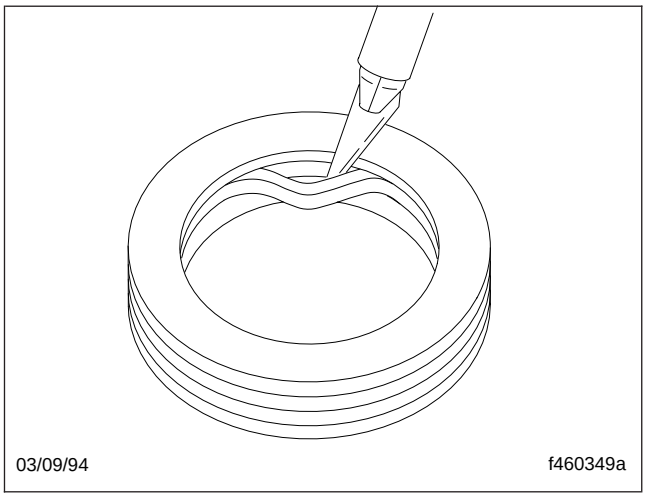


Fig. 19, Remove the Seal Ring and O-Ring

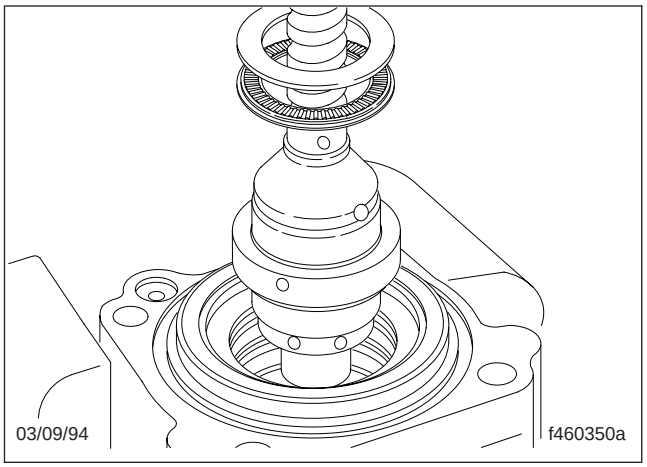


Fig. 20, Remove the Thin Washer, Thrust Bearing, Input Shaft, Rotary Valve, and Worm Shaft Assembly

CAUTION

In the next substep, be careful when removing the retaining ring and seal from the valve housing or you may damage the seal bore. If this happens, you will have to replace the gear housing.

13.8 Turn the valve housing over and remove the retaining ring. See **Fig. 23**.

13.9 Using a 1-1/8 inch socket, tap out the seal from the valve housing. See **Fig. 24**. Discard the seal.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

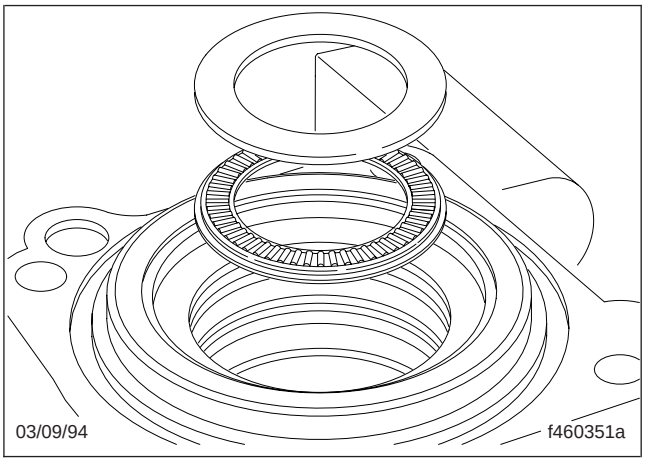


Fig. 21, Remove the Roller Thrust Bearing and Thick Thrustwasher

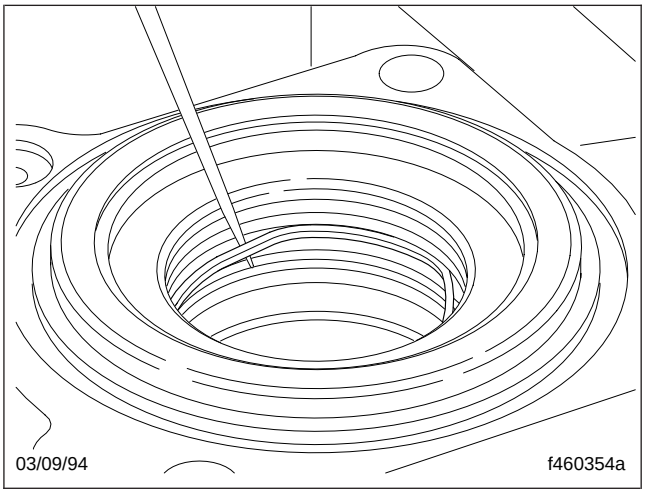


Fig. 22, Remove and Discard the Seal Rings and O-Rings from the Valve Housing

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. 25**.

14.1 If the poppet fixed stopscrew needs replacement, remove it.

14.2 If the adjusting screw and sealing nut need replacing, remove them.

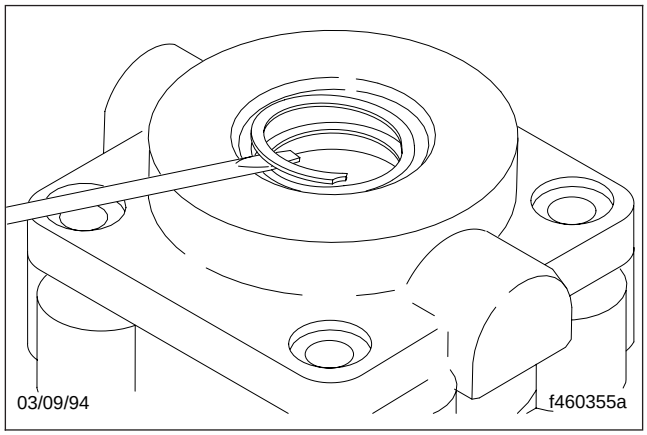


Fig. 23, Remove the Retaining Ring

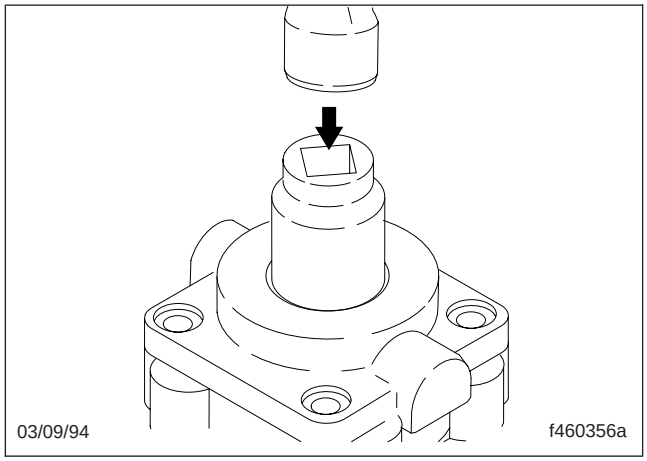
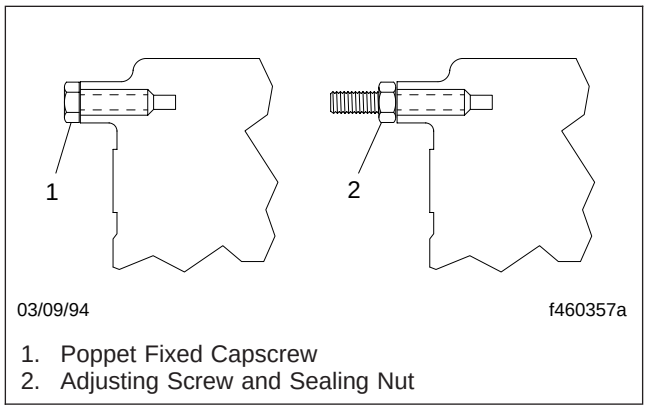


Fig. 24, Tap Out the Seal from the Valve Housing



1. Poppet Fixed Capscrew
2. Adjusting Screw and Sealing Nut

Fig. 25, Gear Equipped with a Poppet Fixed Stopscrew and Adjusting Screw and Sealing Nut

14.3 Remove the retaining ring from the output end of the housing trunnion. See **Fig. 26**.

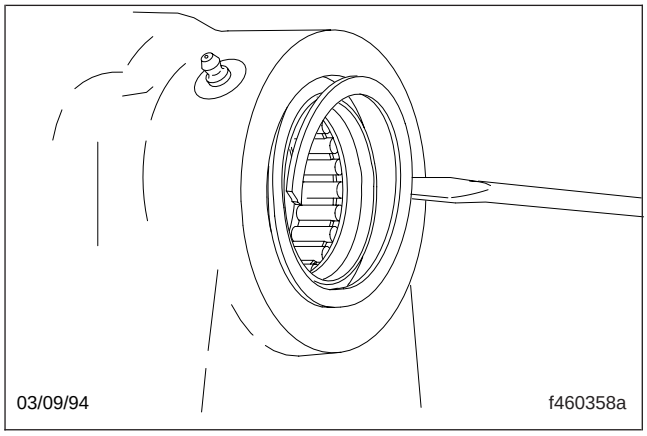


Fig. 26, Remove the Retaining Ring

14.4 Remove and discard the dirt seal. See **Fig. 27**.

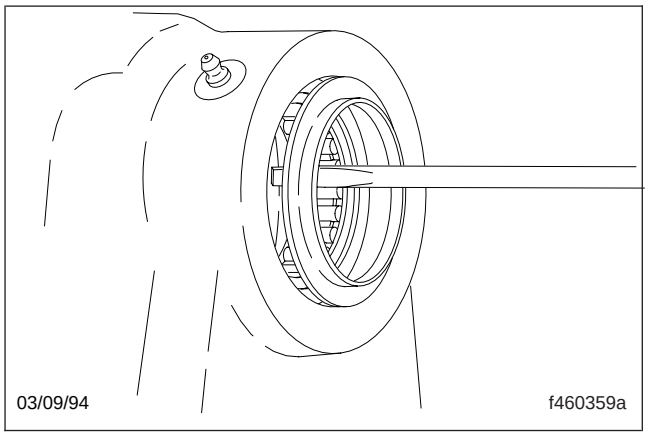


Fig. 27, Remove the Dirt Seal

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. 28**. 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 J37071. 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. 29**.

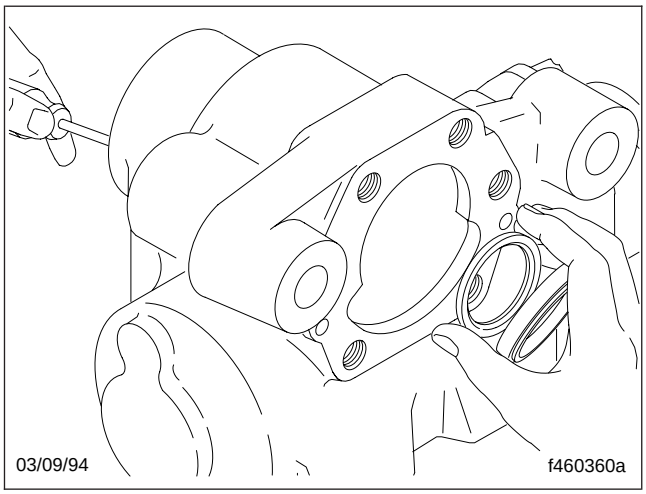


Fig. 28, Push the Seal and the Spacer Washer

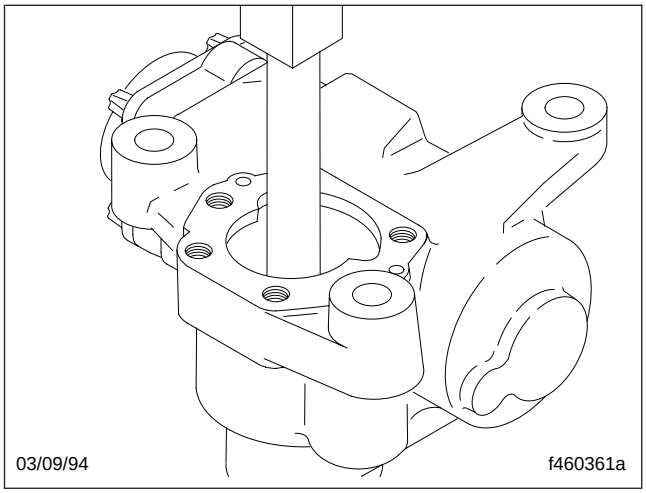


Fig. 29, Press Out the Roller Bearings

CAUTION

Be sure the retaining ring is not damaged when the roller bearing is pressed out.

14.7 If replacing the retaining ring, remove it through the trunnion end, opposite the end where the side cover was attached. See **Fig. 30**. Be careful not to damage the pressure seal bore area.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

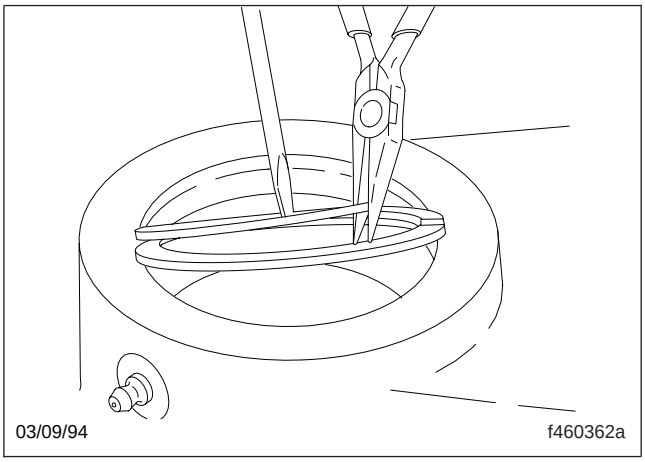


Fig. 30, Remove the Retaining Ring

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. 31**. 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.

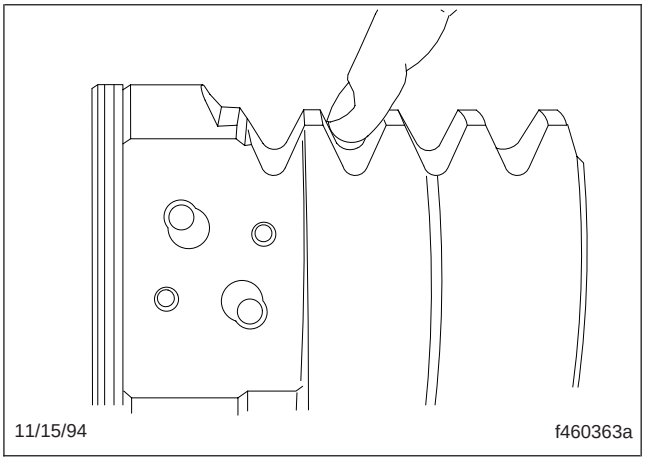


Fig. 31, Inspect the Rack Piston Teeth

2. Inspect the rack piston internal ball-track grooves for brinelling (dents) or spalling (flaking). See **Fig. 32**. If either condition exists, replace rack piston, the valve/worm shaft assembly, and the set of 31 (TAS55) or 32 (TAS65) steel balls.

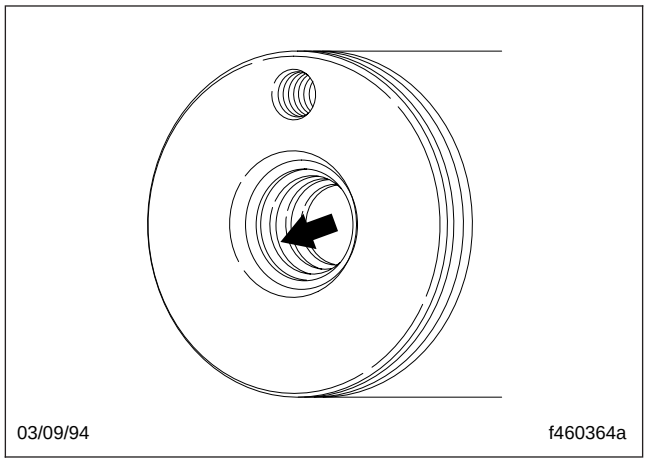


Fig. 32, Inspect the Rack Piston Internal Ball-Track Grooves

3. Inspect the worm shaft ball-track grooves for brinelling or spalling. See **Fig. 33**. 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. 34**.

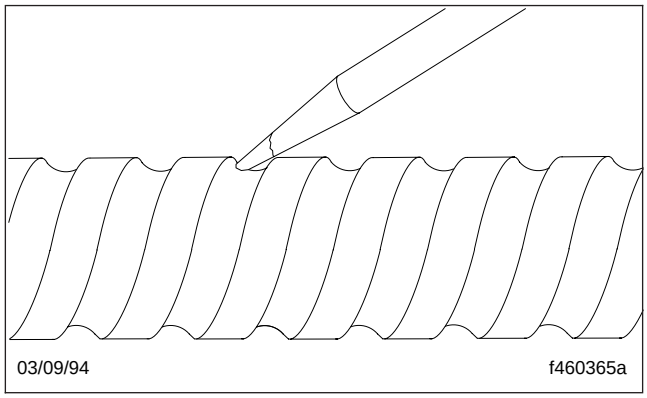
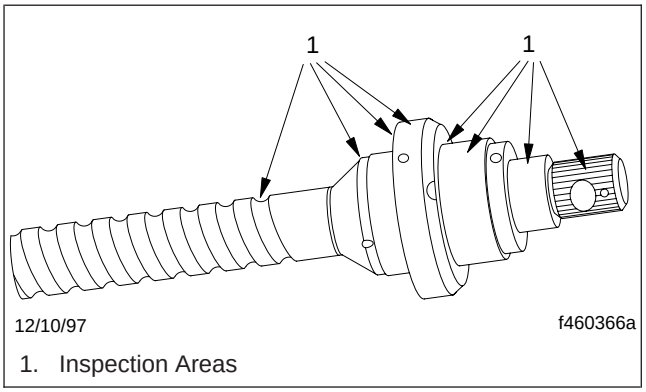


Fig. 33, Inspect the Worm Shaft Ball-Track Grooves

4. Inspect the housing cylinder bore. 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



1. Inspection Areas

Fig. 34, Inspect the Upper Shaft Seal Area

leakage and it is determined that the scoring is the cause of internal leakage greater than 1 gpm (3.8 L/min). For troubleshooting procedures, see **Section 46.04, Subject 300**.

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. Replace the gear housing if these nicks cannot be easily removed with a fine-toothed flat file, without changing the dimensional characteristics.
6. Inspect the housing roller bearing for brinelling or spalling. See **Fig. 35**. If either condition exists, replace the housing bearing.

   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. 36**.
7. Inspect the sector shaft bearing sealing areas for brinelling or spalling. See **Fig. 37**. Run your fingernail across these areas to detect steps. Also inspect for cracks. If any of these conditions exist, replace the sector shaft.
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.

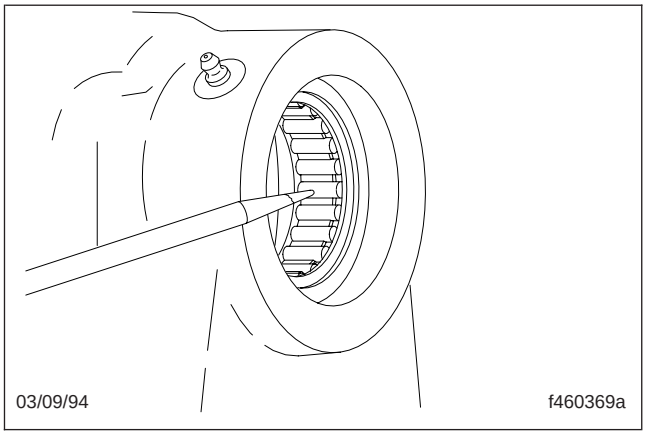


Fig. 35, Inspect the Housing Roller Bearing

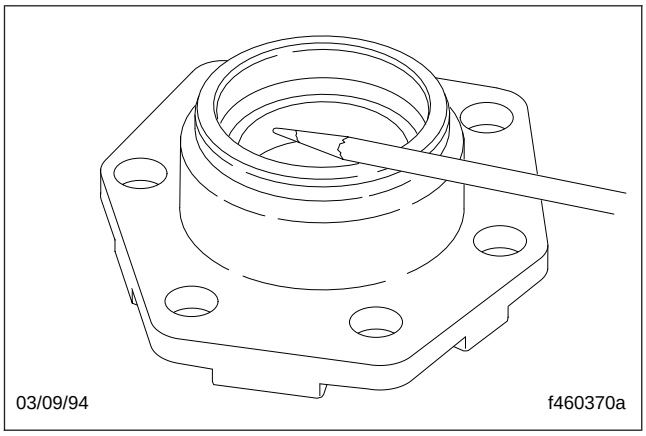
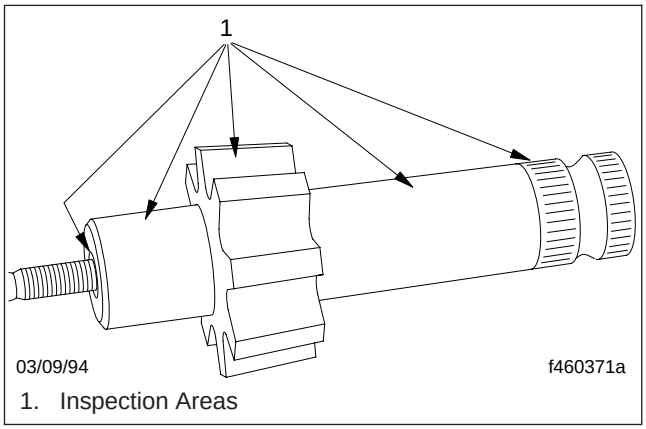


Fig. 36, Inspect the Side Cover Bushing



1. Inspection Areas

Fig. 37, Inspect the Sector Shaft Bearing Sealing Areas

9. Inspect the thrust bearing rollers for any deterioration. Inspect the thrustwashers for brinelling,

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

spalling, or cracks. See **Fig. 38**. Replace any part if these conditions are detected.

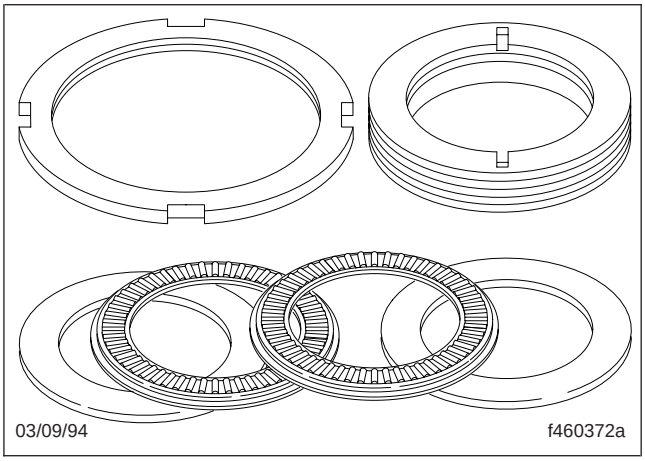


Fig. 38, Inspect the Thrust Bearing Rollers and Thrustwashers

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 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. 39**.
   - 1.2 Install the retaining ring in the groove closest to the side-cover end of the bore. See **Fig. 39**. 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.

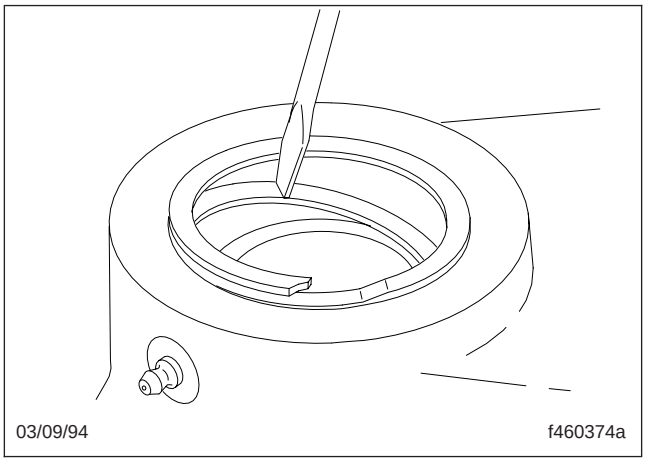


Fig. 39, Put the Gear Housing on its Side

CAUTION

When using special tool J37071 to install the roller bearing, be sure to use the installation side of the tool, or you may damage the new roller bearing.

- 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. 40**.

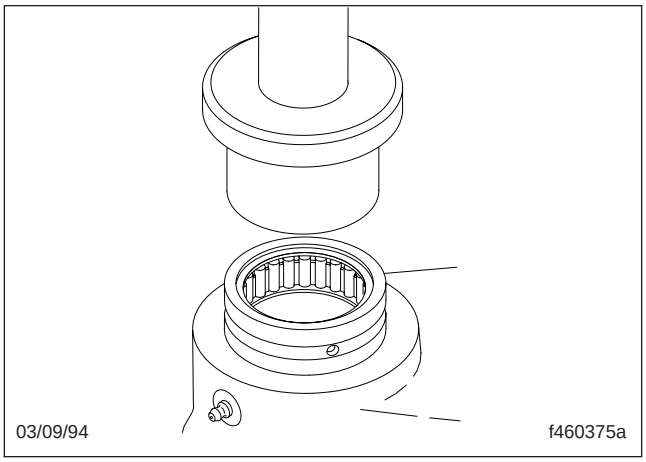


Fig. 40, Press the Roller Bearing into the Housing

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. 41**.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

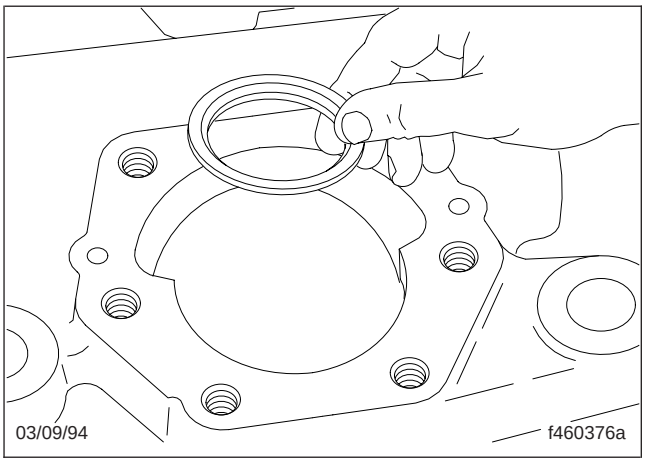


Fig. 41, Put the Gear Housing on its Side (with the side-cover end of the bore facing up)

2.2 Install the washer in the bore, with the small diameter end of it facing the roller bearing retaining ring. See **Fig. 41**.

2.3 Put the new seal on special tool J37071 so that the lip of the seal with the garter spring is toward the shoulder of the tool. See **Fig. 42**.

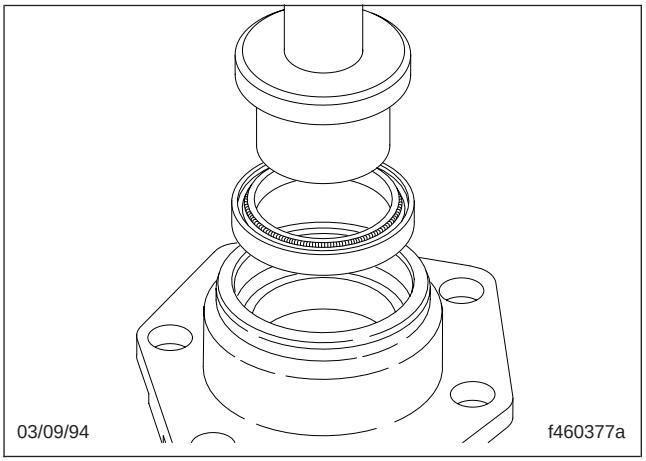


Fig. 42, Put the New Seal on Special Tool J37071

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 pounds (45 to 363 kg).

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. 43**.

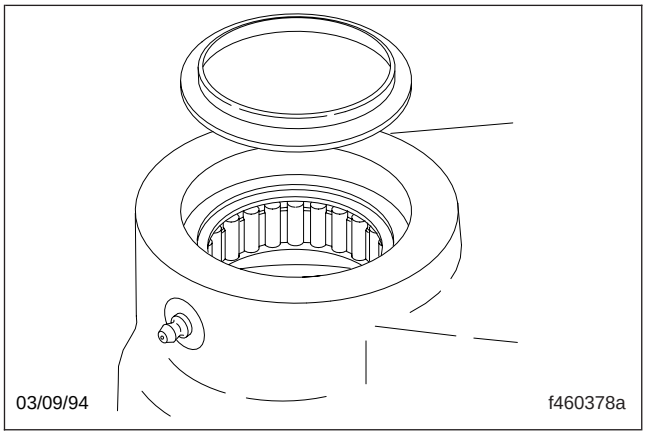


Fig. 43, Install the New Dirt Seal

2.6 Install the second retaining ring, seating it firmly into the groove in the bore. See **Fig. 44**.

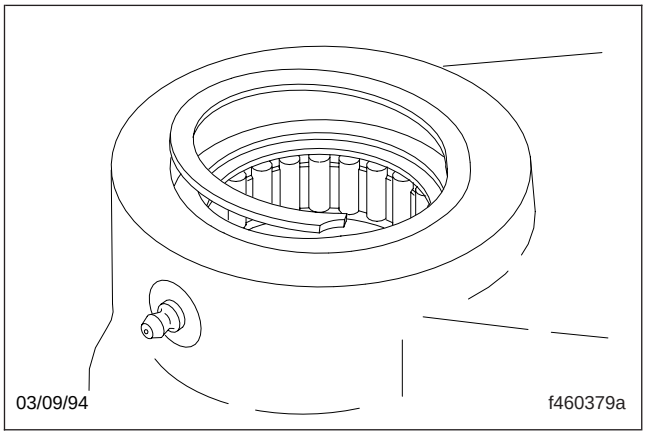


Fig. 44, Install the Second Retaining Ring

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. 45**.

3. Assemble the valve housing.

⚠ CAUTION

In the next step, when putting the valve housing in a vise, be careful not to clamp against the threaded port hole or the relief-valve hole sealing

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

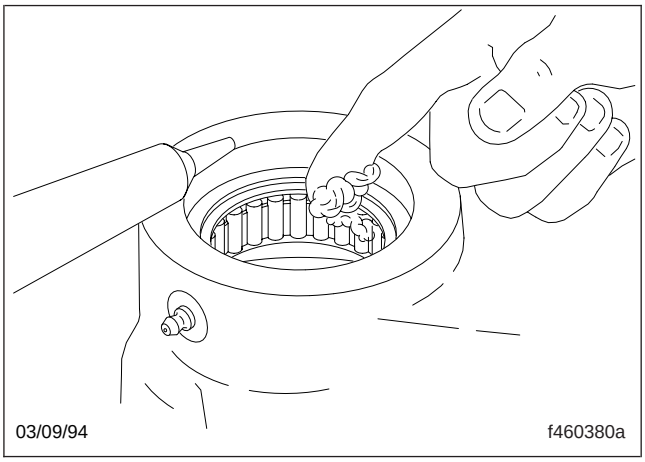


Fig. 45, Pack the Area between the Dirt Seal and the Pressure Seal with Grease

faces. To do so may damage these surfaces, which would require the replacement of 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. 46**.

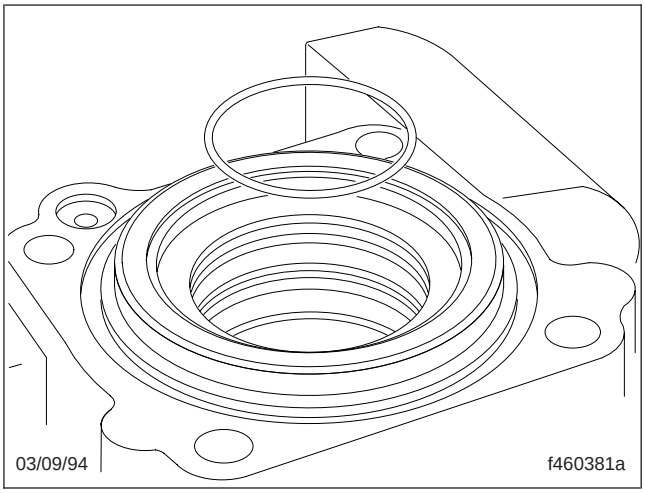


Fig. 46, Lubricate and Install a New O-Ring

3.3 Lubricate a new large diameter O-ring and a new seal ring, then install them in the valve housing. See **Fig. 46** and **Fig. 47**.

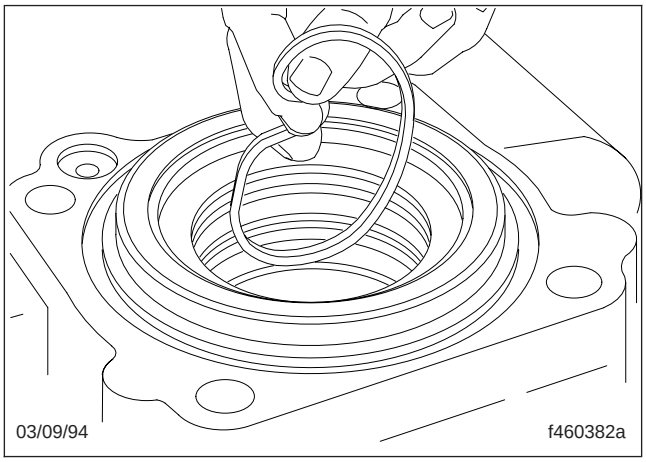


Fig. 47, Lubricate and Install a New Large Diameter O-Ring and a New Seal Ring

3.4 Install the roller thrust bearing and the thick thrustwasher on the input shaft thrust face. See **Fig. 48**.

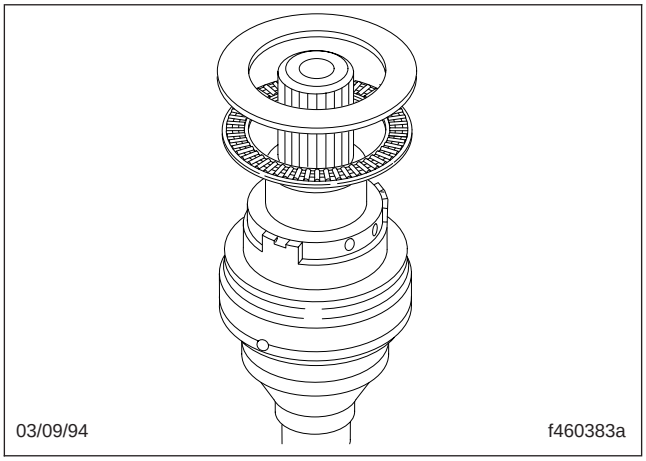


Fig. 48, Install the Roller Thrust Bearing and the Thick Thrustwasher

3.5 Install a new seal ring on the input shaft and against the thick thrustwasher.

3.6 Lubricate, then install the input-shaft/valve/worm assembly in the valve housing, seating it firmly. See **Fig. 49**.

3.7 Lubricate, then install a second thrust bearing and thin washer over the worm shaft. See **Fig. 50**.

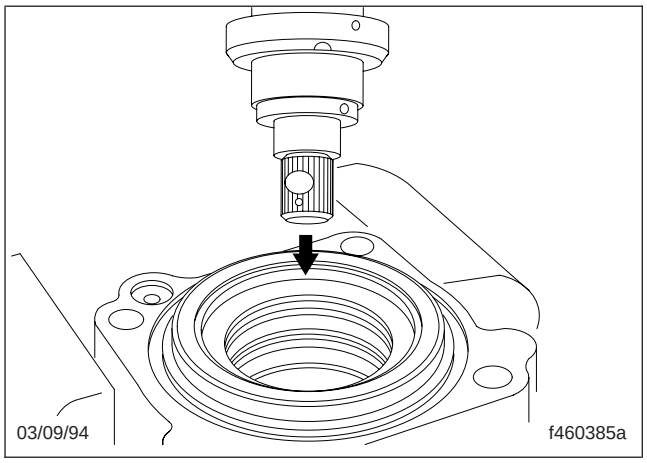


Fig. 49, Lubricate, then Install the Input-Shaft/Valve/ Worm Assembly

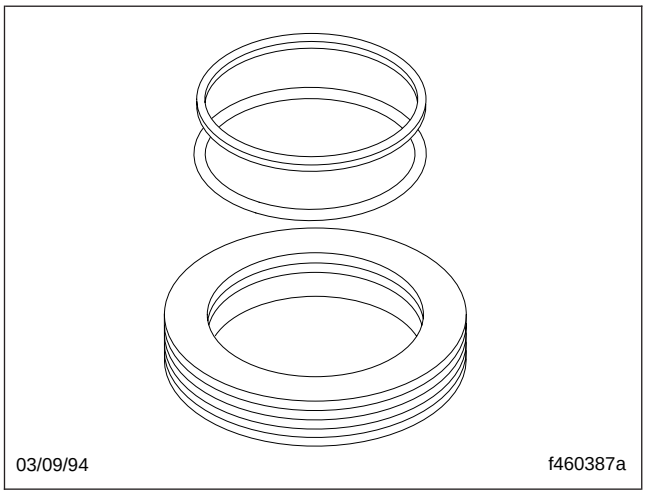


Fig. 51, Lubricate the New O-Ring and Seal Ring

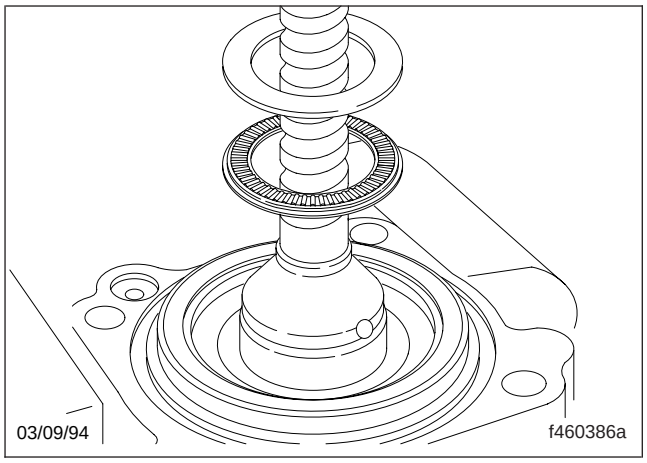


Fig. 50, Lubricate, then Install a Second Thrust Bearing and Thin Washer

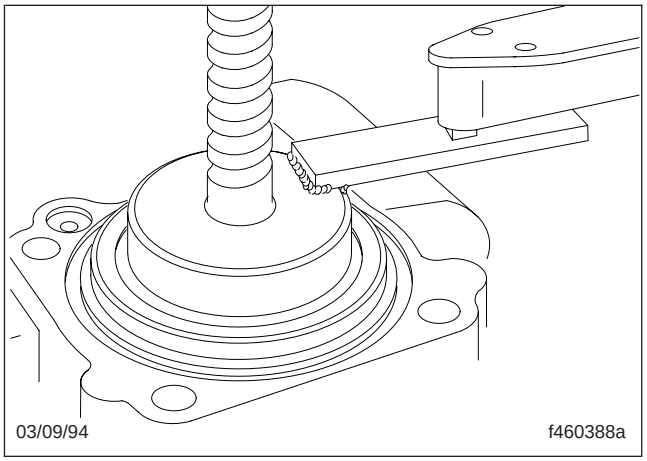


Fig. 52, Install the Bearing Adjuster over the Worm Shaft

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. 51**.

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. 52**.

3.11 Turn the valve housing over in the vise so that the worm shaft is facing down.

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. 53**.

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

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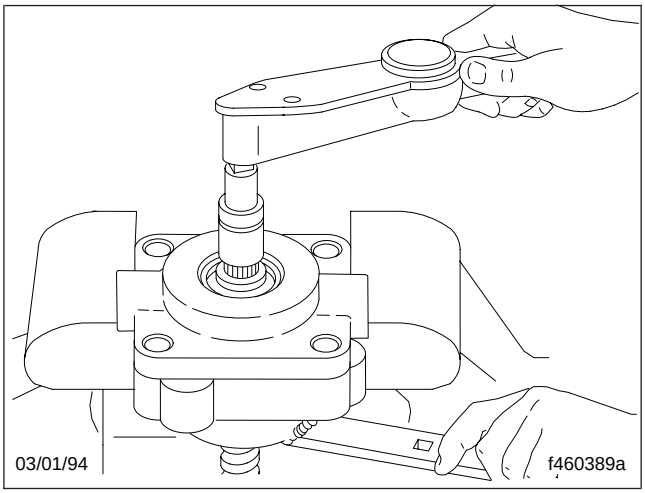


Fig. 53, Check the Torque

and J37464, tighten the locknut 101 to 122 lbf·ft (137 to 165 N·m) while holding the bearing adjuster. See **Fig. 54**.

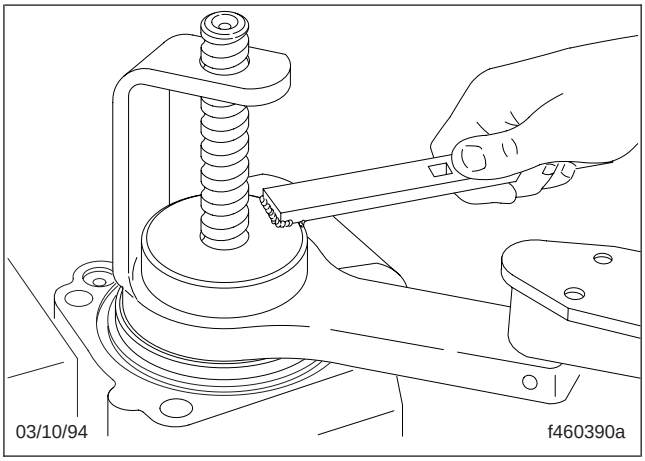


Fig. 54, Install the Locknut on the Bearing Adjuster

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. 55**.

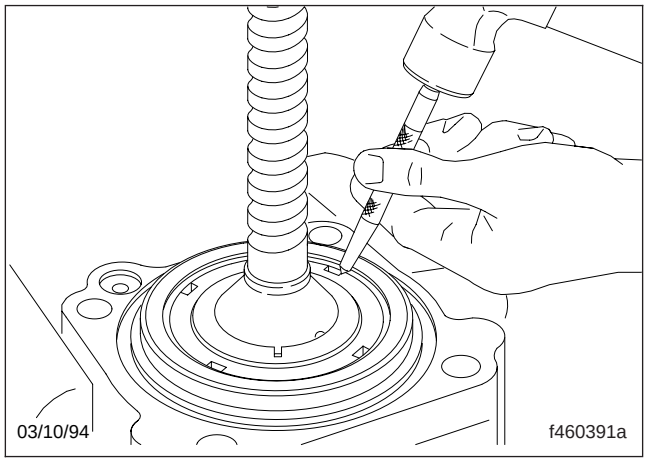


Fig. 55, Stake the Locknut to the Valve Housing and the Bearing Adjuster

3.17 Stake the locknut to the bearing adjuster at two places 180 degrees apart. See **Fig. 55**. Do not use a spot that was staked before.

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. 56**.

4. Reset the automatic poppet valves.

IMPORTANT: Make sure the poppet adjuster seat and sleeve assemblies and the 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. 57**.

4.2 Press the adjuster seat into the adjuster sleeve with a force of 500 to 2500 pounds

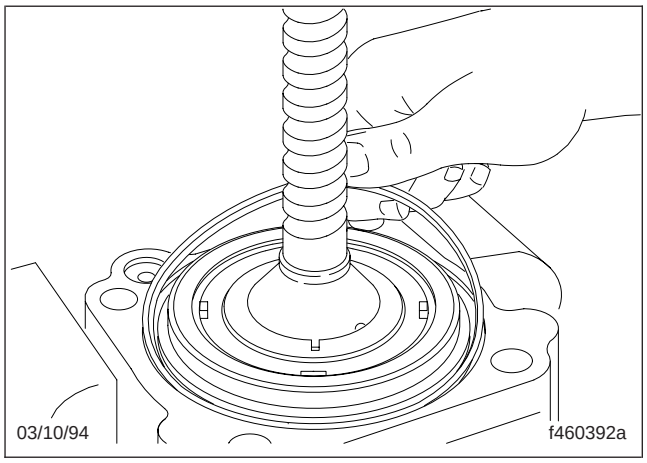


Fig. 56, Install the New Grease Seal Rings

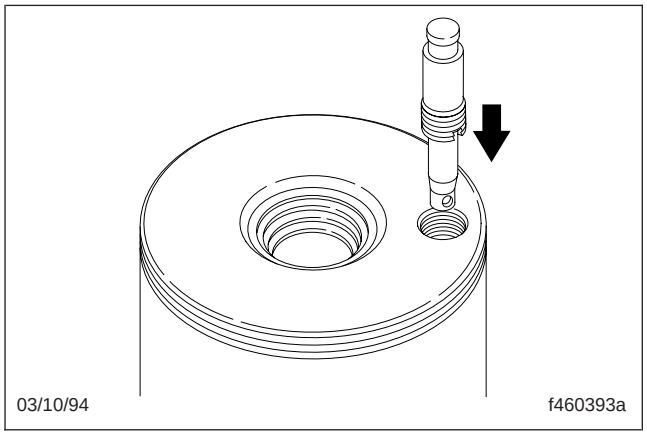


Fig. 57, Screw the Poppet Adjuster Seat and Sleeve Assembly into the Rack Piston

(227 to 1134 kg) until the shoulder on the seat bottoms on the sleeve. See **Fig. 58** and **Fig. 59**.

4.3 Remove the adjuster seat and sleeve assembly from the rack piston.

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. 60**. Do not stretch them more than necessary when installing them.

6. Install the automatic poppets.

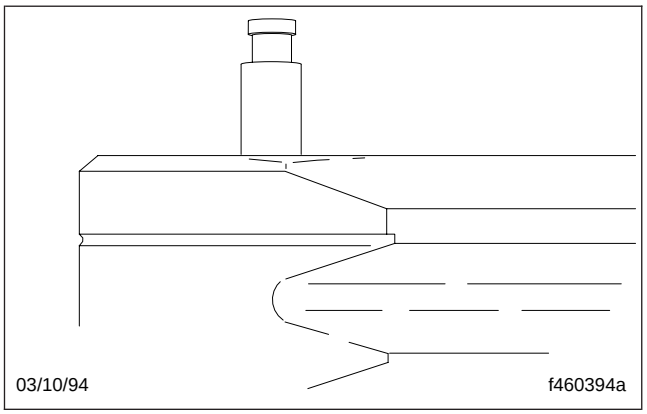


Fig. 58, Adjuster Seat/Adjuster Sleeve in the Rack Piston

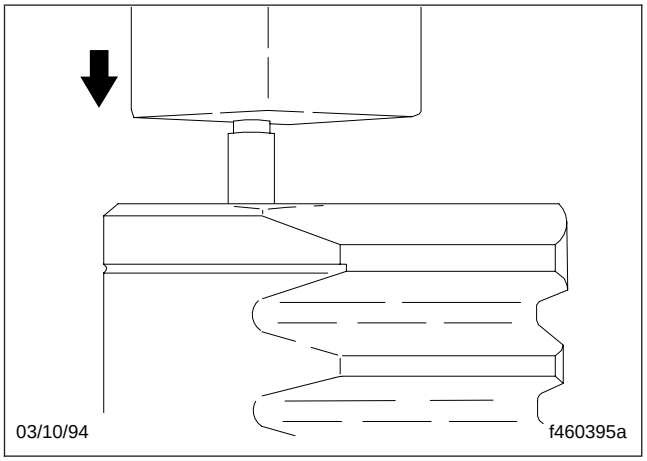


Fig. 59, Press the Adjuster Seat Into the Adjuster Sleeve

⚠ CAUTION

When doing the next step, be careful not to get any Loctite or Locquic on the adjuster seat itself. If this happens, the automatic poppets will not adjust correctly.

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 min-

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

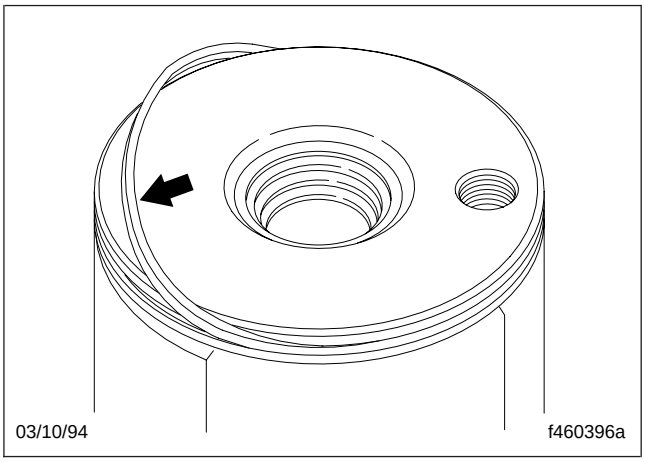


Fig. 60, Install a new Backup O-Ring and new Teflon Seal Ring

utes, then apply Loctite RC680 to the same threads. See **Fig. 61**.

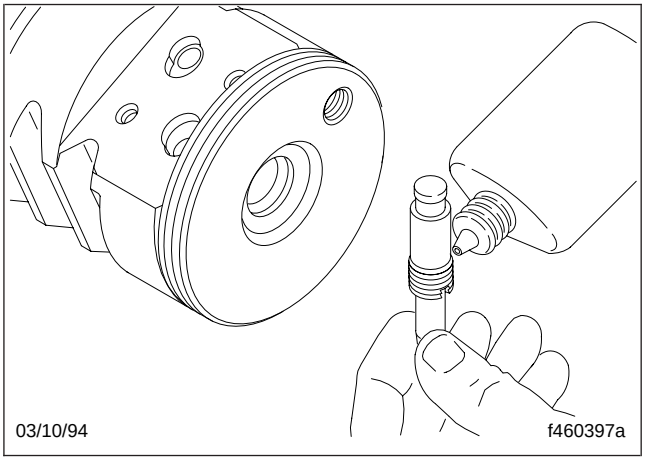


Fig. 61, Apply Locquic Primer T

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. 62**.

⚠ WARNING

Wear eye protection while assembling the poppets. The poppets are spring-loaded and could be ejected, which could result in serious eye injury.

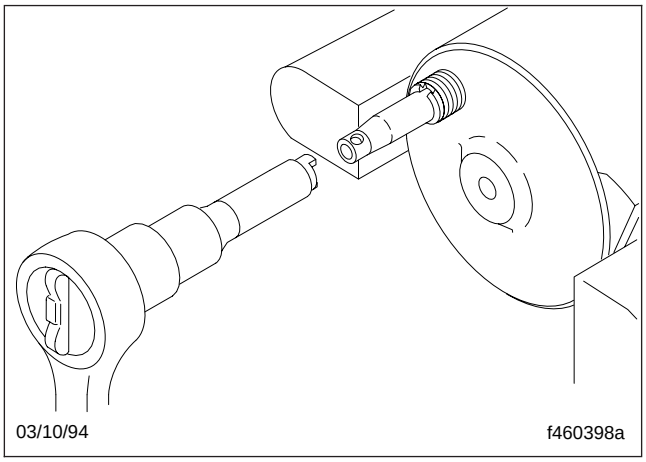


Fig. 62, Install a Poppet Adjuster Seat and Sleeve Assembly

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. 63**.

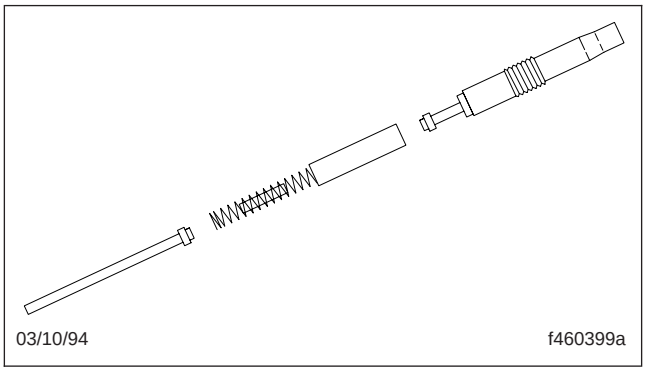


Fig. 63, Install the Poppet Assembly Parts

6.4 Using special tool J36452 or J38713 (preferred), tighten both poppet adjuster seat and sleeve assemblies 10 lbf·ft (14 N·m). See **Fig. 64**.

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.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

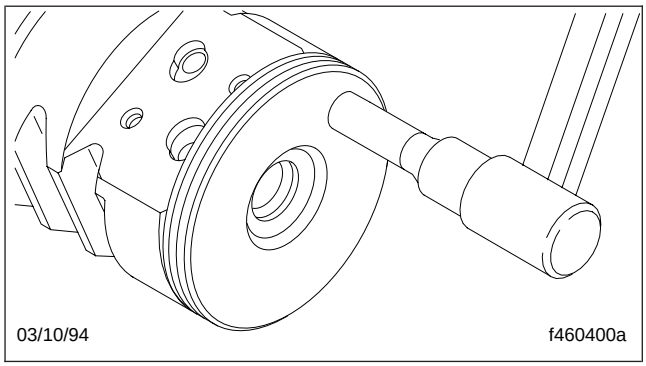


Fig. 64, Tighten both Poppet Adjuster Seat and Sleeve Assemblies

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. 65**.

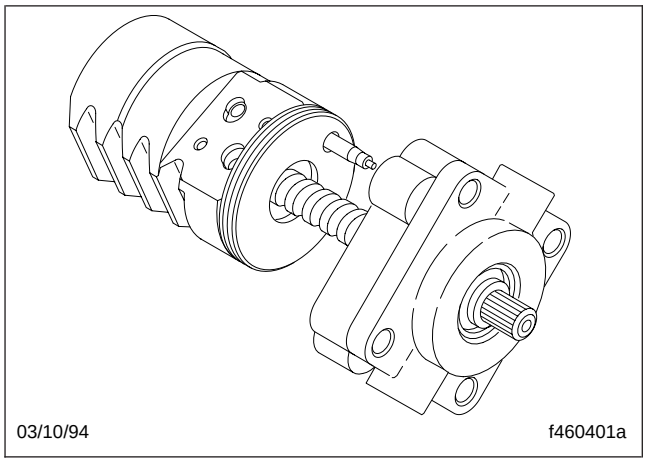


Fig. 65, Insert the Worm Shaft and Input Shaft Assembly

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.

⚠ WARNING

In the next step, do not seat the ball return guides with a hammer. This could damage them and cause steering gear lockup or loss of steering, resulting in an accident causing personal injury or property damage.

8. Install the steel balls.

8.1 Install new ball return guide halves in the rack piston. See **Fig. 66**. Make sure they are correctly seated.

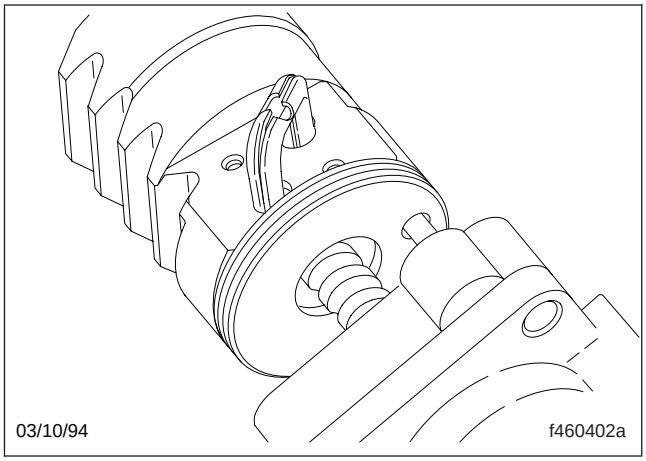


Fig. 66, Install New Ball Return Guide Halves

⚠ CAUTION

If you are installing a new rack piston or a new input-shaft/valve/worm assembly, do not install the existing steel balls. Use a new set of steel balls or damage to the steering gear may result.

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 plated. Make sure the correct new ball return guide halves are installed by comparing them with the old ones and then discarding the old ones.

8.2 Insert the 31 (TAS55) or 32 (TAS65) steel balls in the ball return guide hole as shown in **Fig. 67**. As the balls are dropped into the guide, turn the worm shaft so that the balls are pulled down into its grooves.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

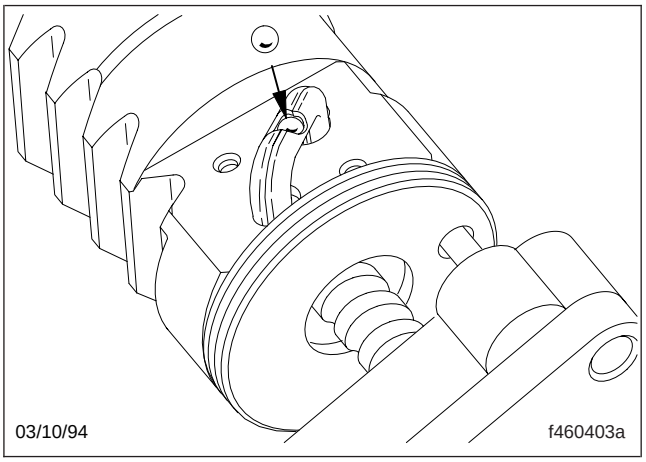


Fig. 67, Insert the Steel Balls

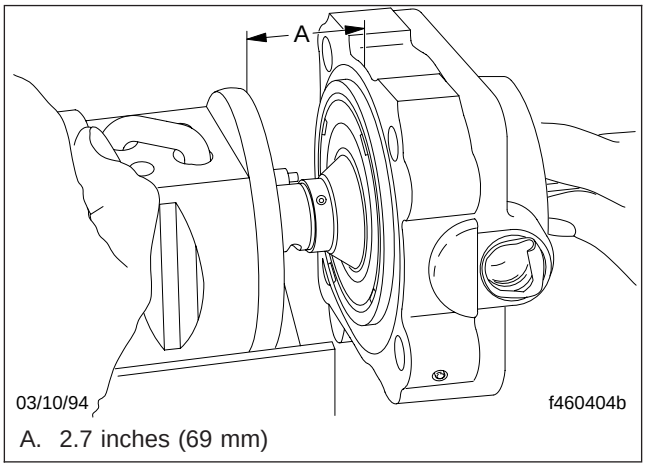


Fig. 68, Check the Valve Housing Pilot Face

⚠ WARNING

Make sure the ball return guide halves stay down and in place while you are inserting the steel balls or turning the input shaft. Failure to hold the ball guide halves down may result in a ball being trapped outside the closed ball-track loop. A trapped ball could cause a steering lockup, which could result in an accident and personal injury or property damage.

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.

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. 68**. 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. 69**.

8.5 Using a 5/32-inch Allen socket and two new 5/32-inch Allen 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).

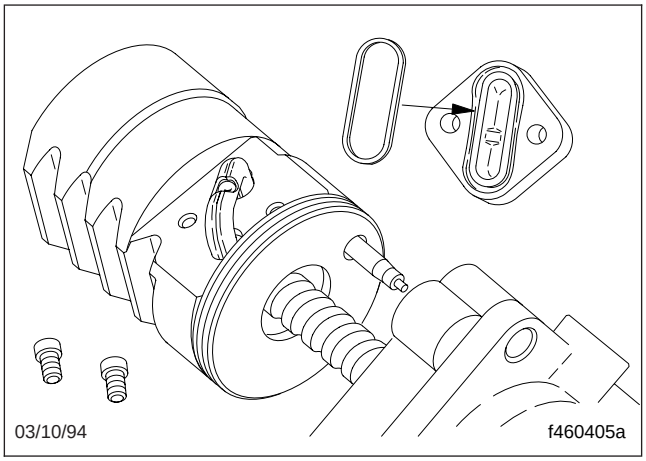


Fig. 69, Install the Seal

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 inches (69 mm) from the input end (upper end) of the rack piston. See **Fig. 68**.

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. 70**. Tighten it 38 to 42 lbf·ft (52 to 57 N·m).

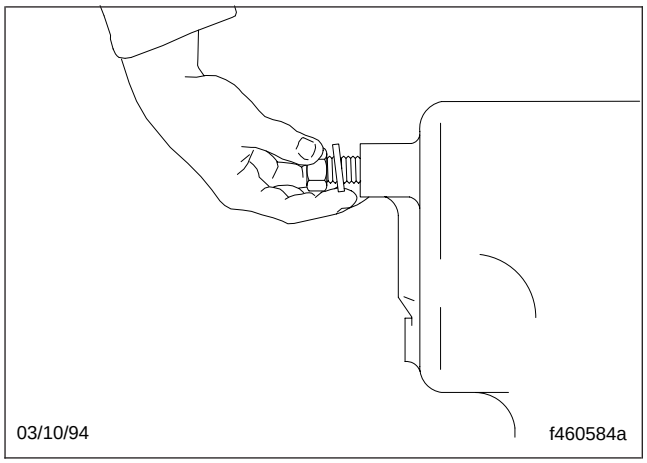
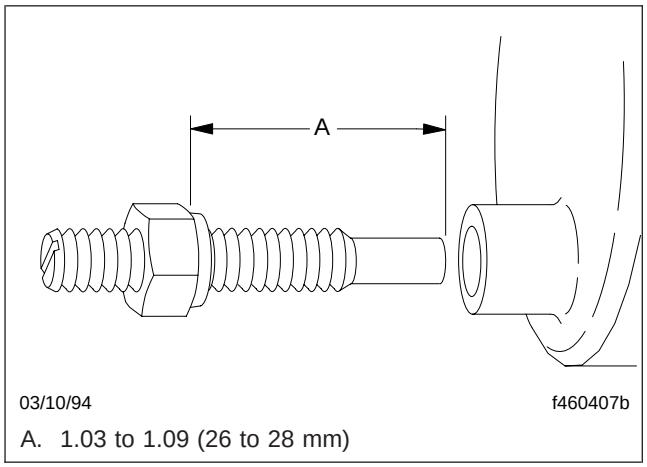


Fig. 70, Install a new Poppet Stopscrew

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 to 1.09 inches (26 to 28 mm) protrudes from the bottom of the jam nut. See **Fig. 71**.



A. 1.03 to 1.09 (26 to 28 mm)

Fig. 71, Check the Distance from the Bottom of the Jam Nut

    10.2 Install the assembly into the gear housing. Tighten the jam nut 45 to 33 to 37 lbf·ft (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 3/8 to 1/2 inch (10 to 13 mm) between the valve housing and the upper poppet adjuster seat and sleeve assembly.

⚠ CAUTION

When installing the rack piston in the steering gear housing, be careful not to damage the seal ring on the rack piston as this could seriously affect the operation of the steering gear.

Do not let the poppet adjuster seat and sleeve assemblies on the rack piston bottom out when installing the rack piston in the gear housing.

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. 72**. Be sure the valve housing cylinder feed hole lines up with the gear housing feed hole.

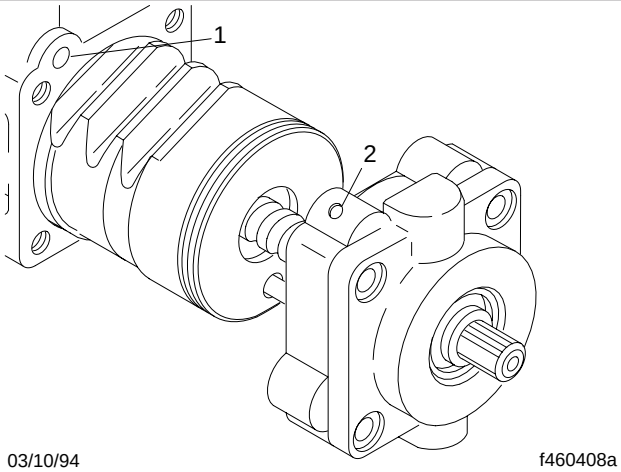
    11.3 Using an E–16 Torx socket wrench, install and tighten the four valve housing bolts 75 to 85 lbf·ft (102 to 115 N·m). See **Fig. 73**.

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. 74**.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments



1. Gear Housing Feed Hole
2. Valve Housing Cylinder Feed-Hole Boss

Fig. 72, Install the Piston with the Rack Teeth toward the Sector Shaft Hole

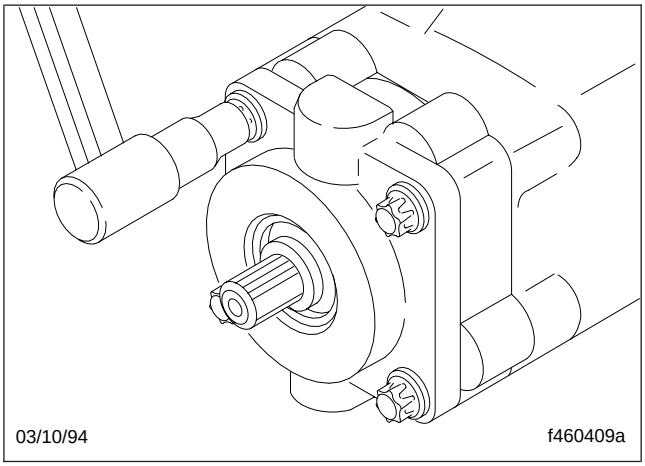


Fig. 73, Install the Valve Housing Bolts

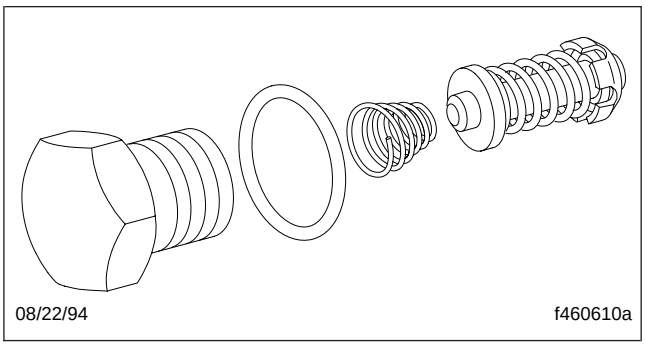


Fig. 74, Install the Tapered Spring

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. 75**.

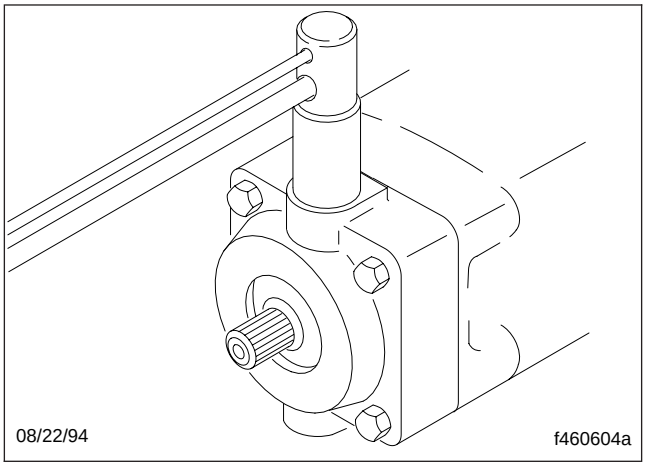


Fig. 75, Turn the Relief Valve Cap into the Valve Housing

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).

⚠ WARNING

Be careful when staking the sector shaft screw retainer. If the retainer is broken or cracked, the sector shaft could come loose, resulting in loss of manual and power steering control. This could cause an accident resulting in personal injury or property damage. Replace a broken or cracked sector shaft screw retainer.

    13.3 Stake the sector shaft screw retainer to the slots in the sector shaft. See **Fig. 76**.

Check the adjusting screw again for free movement and end play.

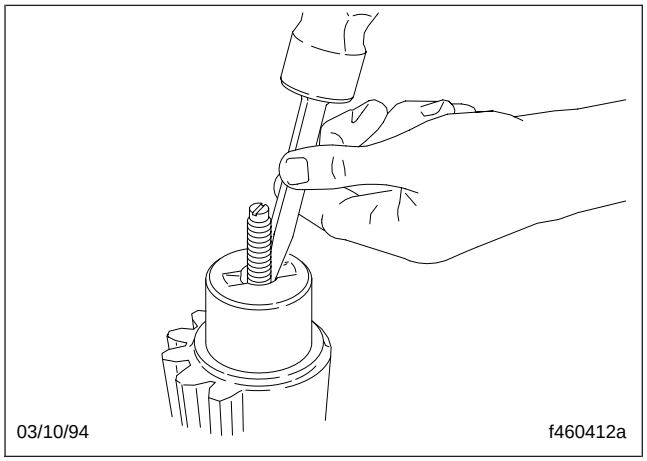


Fig. 76, Stake the Sector Shaft Screw Retainer

14. Install the sector shaft/side cover components.

14.1 Lightly oil the side-cover DU bushing. Do not grease it. See **Fig. 77**.

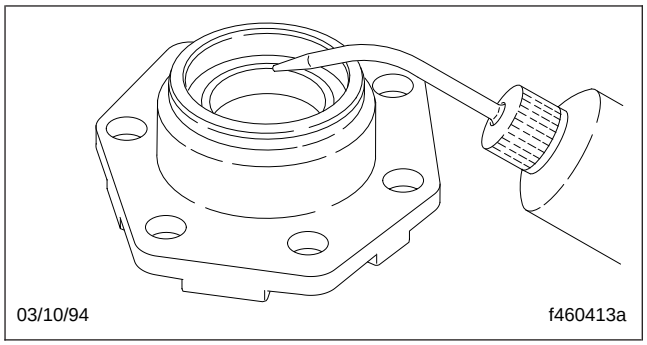


Fig. 77, Applying Oil to the DU Bushing

14.2 Put a new seal on special tool J37071 so that the garter spring is against the shoulder of the tool. See **Fig. 78**. Press the new seal into the side cover with a force of 100 to 800 pounds (45 to 363 kg). Make sure the seal is seated against the bottom of the counterbore.

14.3 Lightly oil 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. 79**. Then rotate

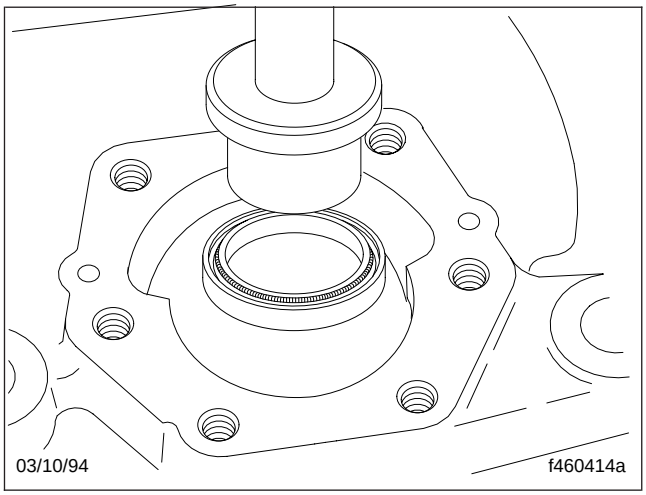


Fig. 78, Press in the New Seal

the adjusting screw clockwise one turn so that the side cover rotates freely on the sector shaft.

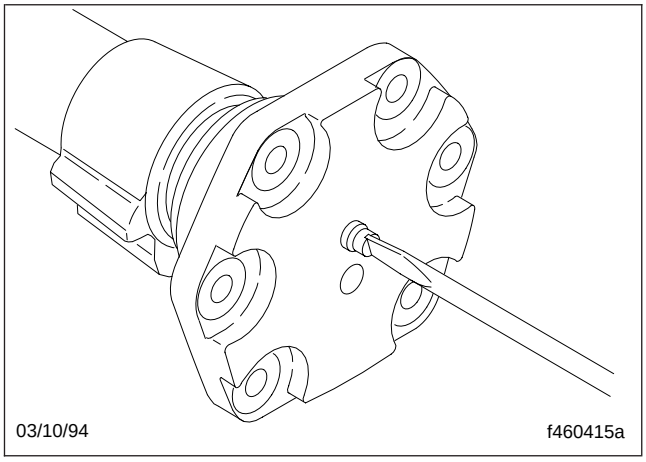


Fig. 79, Install the Sector Shaft Adjusting Screw

14.4 Install the sector shaft adjusting screw jam nut onto the sector shaft adjusting screw a few threads. See **Fig. 80**. 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. 81**.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

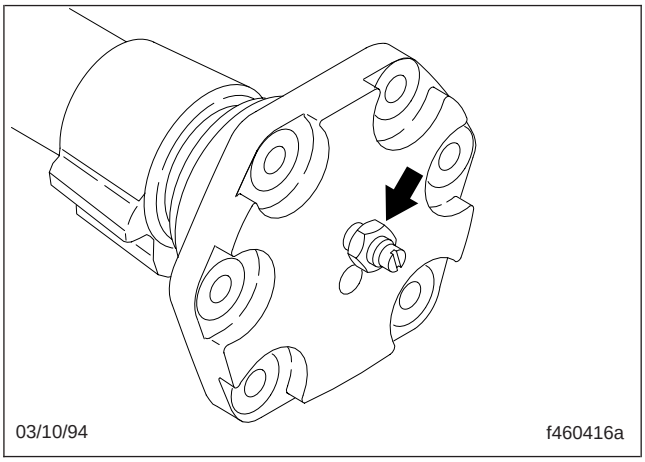


Fig. 80, Loosely Install the Sector Shaft Adjusting Screw Jam Nut

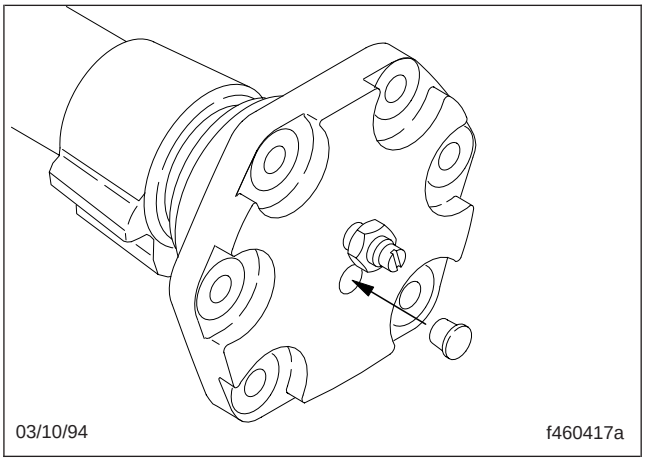


Fig. 81, Press in a New Rubber Plug

⚠ WARNING

Do not weld or plug this hole permanently. This is a safety vent which functions only if the side cover output shaft seal does not work. If the seal does not work and the plug cannot vent, the steering gear can lock up or otherwise malfunction. This could result in a loss of steering control, which could cause personal injury or property damage.

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. 82**. Apply enough grease to hold the gasket in place.

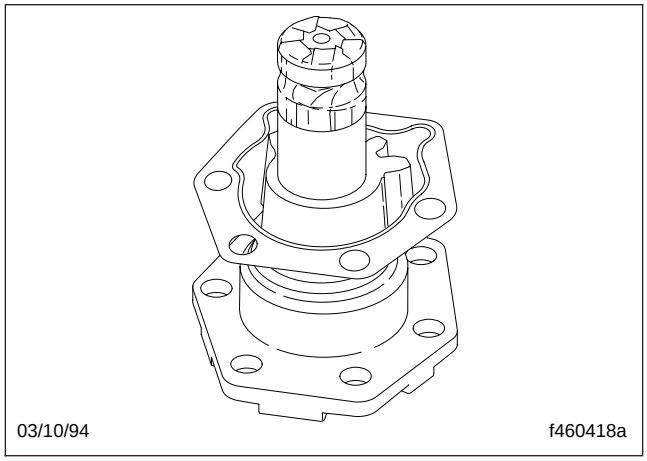


Fig. 82, Install the Side Cover Gasket

    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. 83** (it is the third space between the second and the third tooth) is in the center of the sector shaft opening. See **Fig. 84**. This will center the rack piston in the opening.

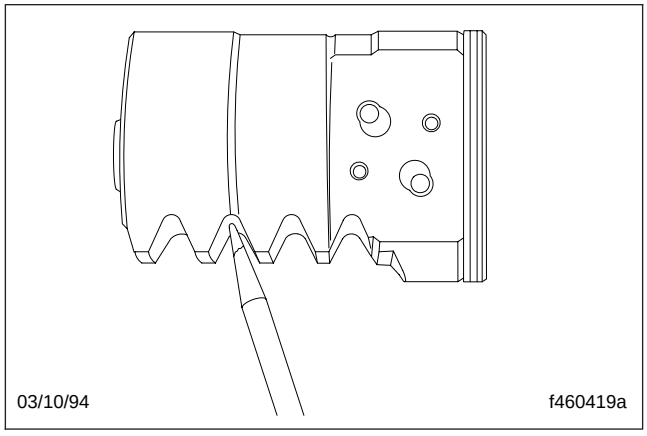


Fig. 83, Check the Tooth Space

    15.3 Remove all tape from the sector shaft splines. Retape the splines and the bolt groove with one layer of masking tape.

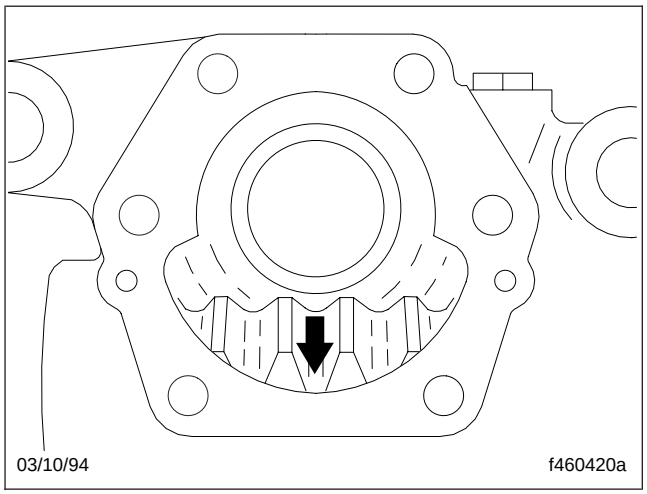


Fig. 84, Check the Tooth Position

CAUTION

If the splines on the sector shaft are not taped correctly, the spline will damage the housing seal during assembly, causing the seal to leak.

15.4 Install the sector shaft and side cover as an assembly in the gear housing. See **Fig. 85**. Make sure the center tooth of the sector engages the center space (between the second and third teeth) of the rack piston.

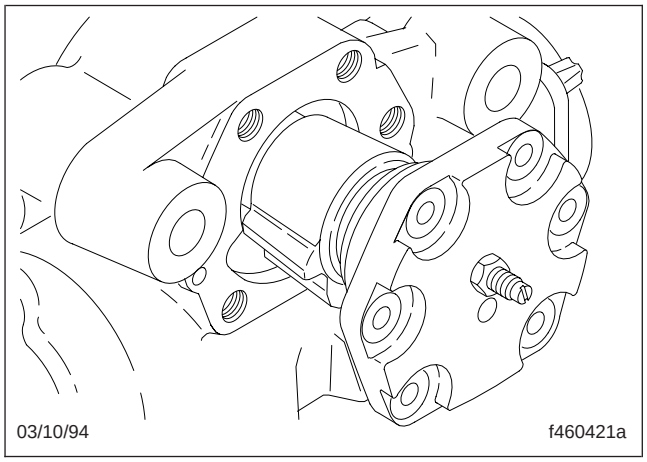


Fig. 85, Install the Sector Shaft and Side Cover

15.5 Install the special side cover bolts in the side cover. Using the torque pattern shown in **Fig. 86** or **Fig. 87**, torque the bolts 230 lbf·ft (312 N·m) for dry bolts and 170 lbf·ft (230 N·m) for lubricated bolts. See **Fig. 88**.

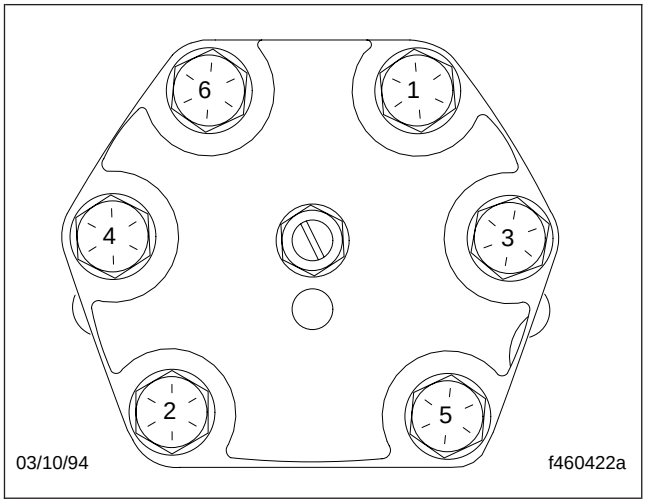


Fig. 86, Six-Bolt Tightening Sequence

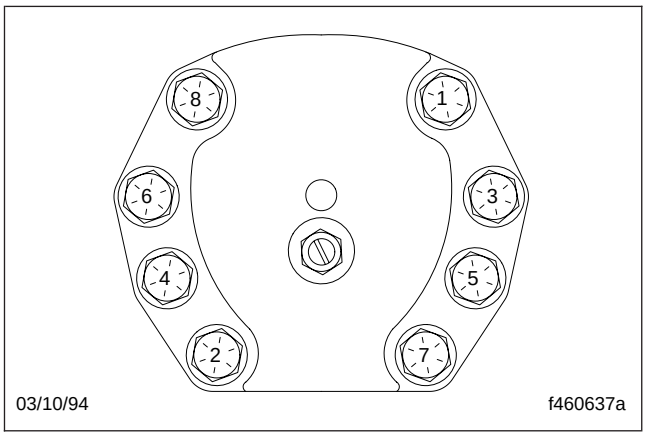


Fig. 87, Eight-Bolt Tightening Sequence

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. 89**.

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

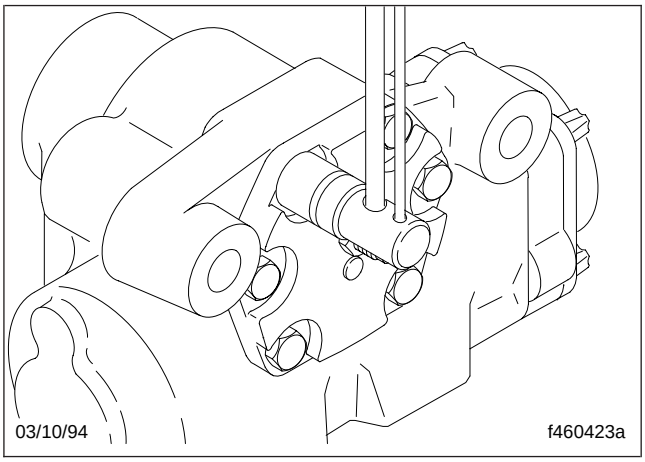


Fig. 88, Install the Special Side Cover Bolts

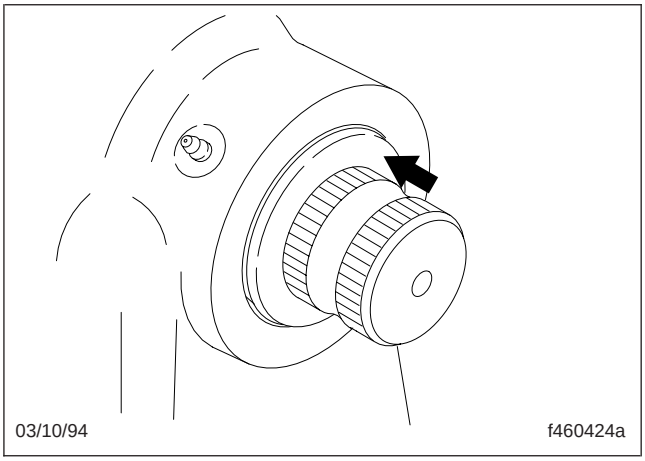
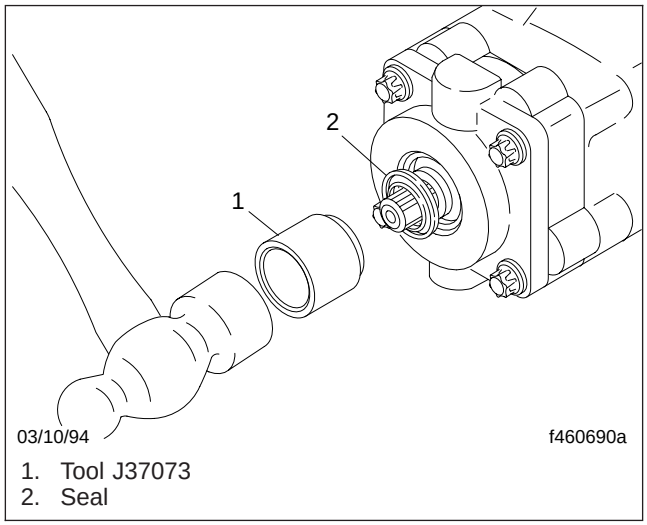


Fig. 89, Install a New Trunnion Dirt Seal

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. 90**. Remove any seal material that may have sheared off in the retaining groove.

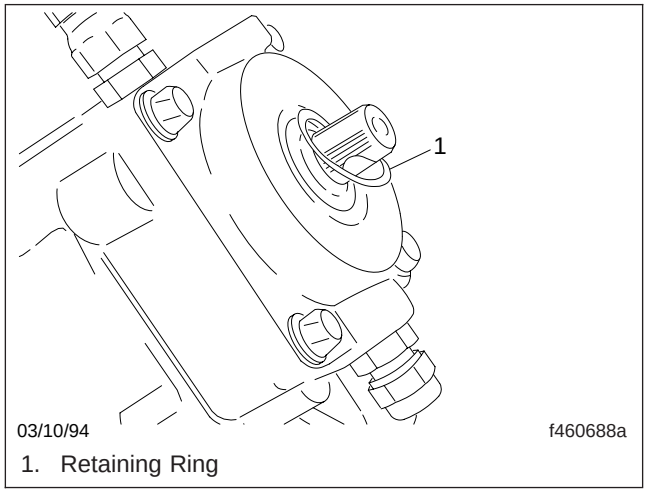
17.2 Install a new retaining ring into its groove in the valve housing. See **Fig. 91**.

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 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. 92**.



1. Tool J37073
2. Seal

Fig. 90, Tap the Seal Into the Valve Housing Bore



1. Retaining Ring

Fig. 91, Install a New Retaining Ring

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. 93**. 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).

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

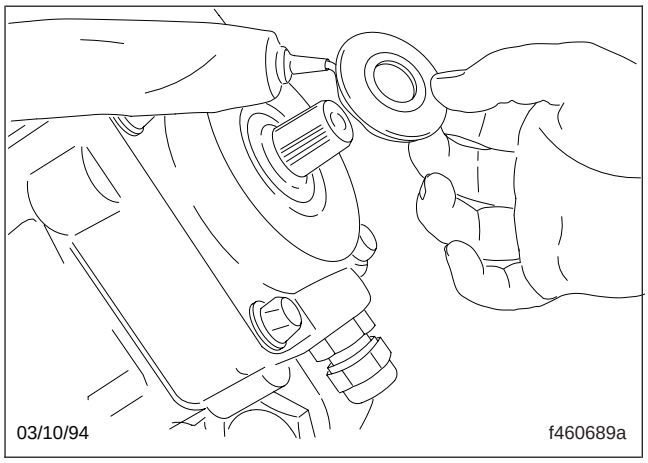


Fig. 92, Install the Dirt-and-Water Seal

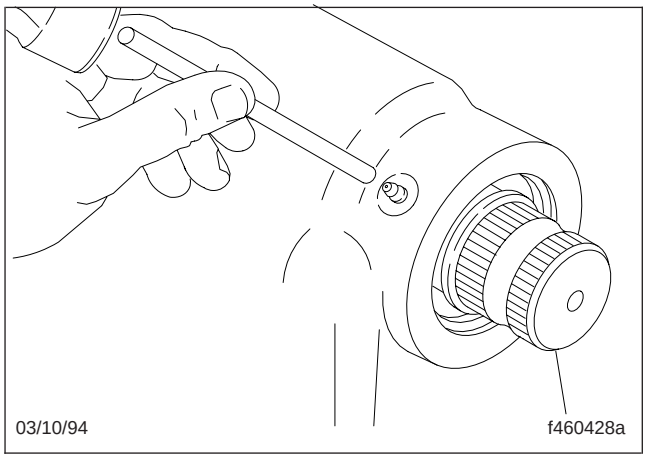


Fig. 93, Install a New Grease Fitting

Final Adjustments

Before installing the steering gear on the vehicle, make these adjustments.

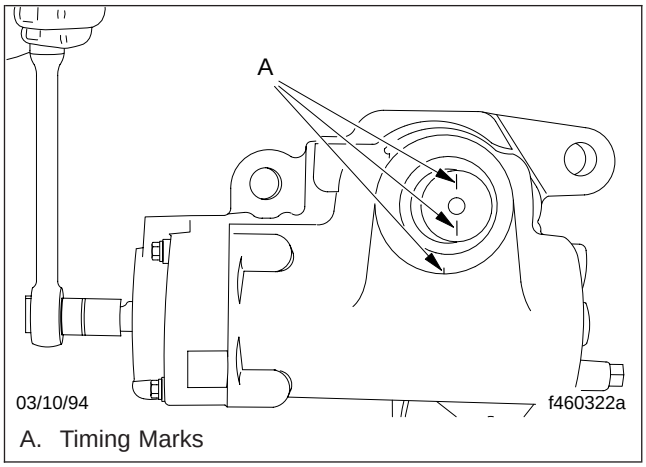
NOTE: Worm shaft preload adjustment was done when the input shaft was installed in the valve housing during the assembly procedure.

1. Adjust the sector shaft preload.

⚠ CAUTION

When the steering gear is not connected to the steering system, do not turn the input shaft more than 1-1/2 turns from the center position or the automatic poppets could become inoperative when the steering gear is installed on the vehicle. This would require either disassembling the gear to position the poppet seat and sleeve assemblies for automatic adjustment, or using the special poppet adjusting screw kit 021407-X1 for manual poppet adjustment.

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. 94**. Use a 12-point, 11/16-inch 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.



A. Timing Marks

Fig. 94, Check the Timing Marks

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. 95**. Use a 12-point socket and an inch-pound torque wrench to turn the input shaft.

Steering Gear Disassembly, Inspection, Assembly, and Final Adjustments

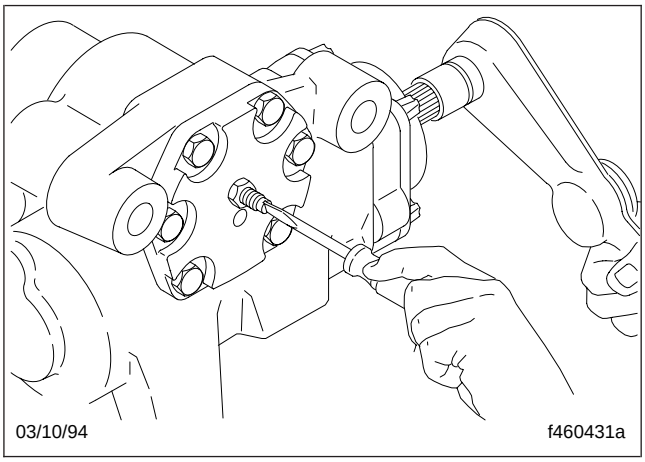


Fig. 95, Adjust the Sector Shaft Adjusting Screw

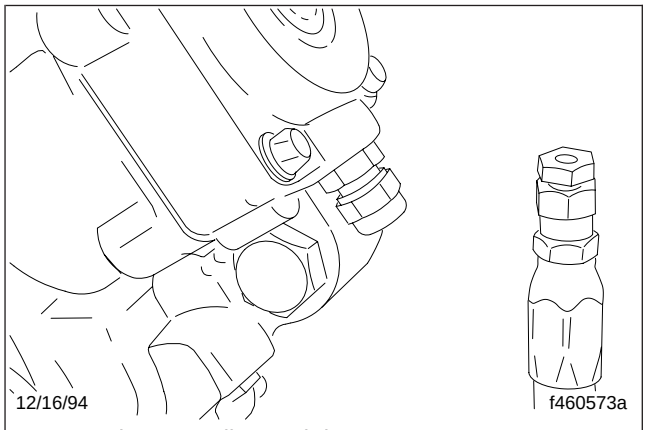
1.3 Back out the sector shaft adjusting screw one-half turn. Note the torque needed to turn the input shaft through 180 degrees each side of center.

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.

Replacement

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 as follows.

   2.1 Remove the pinch bolt nut and pinch bolt from the steering driveline lower end yoke. Discard the nut.

CAUTION

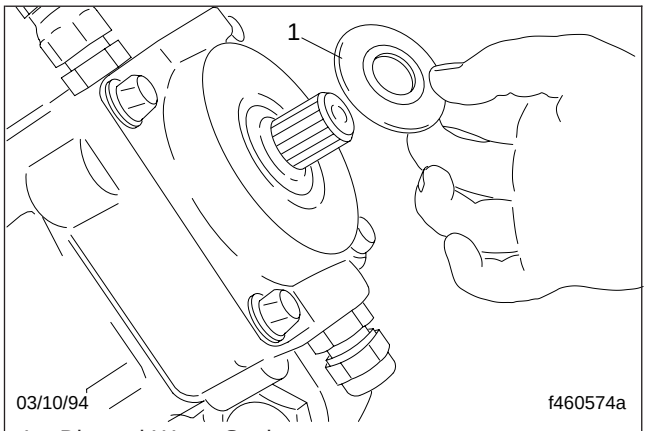
Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.

   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**.

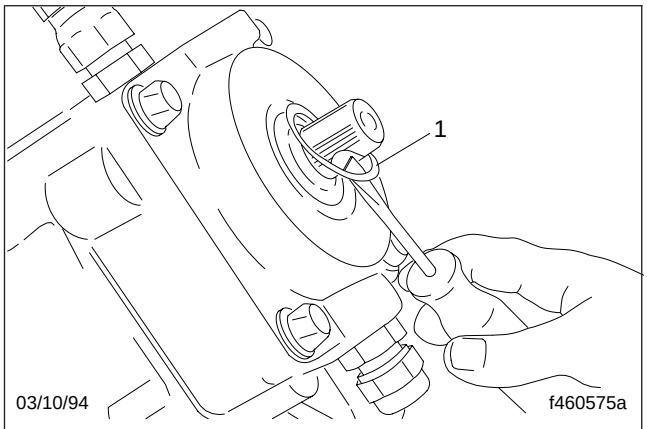
4. Wipe out the grease and then remove the spiral retaining ring. See **Fig. 3**. Use a screwdriver inserted into the notch formed in the end of the ring.

5. Slip the input yoke back onto the input shaft with the pinch bolt installed, but not tightened. See **Fig. 4**.



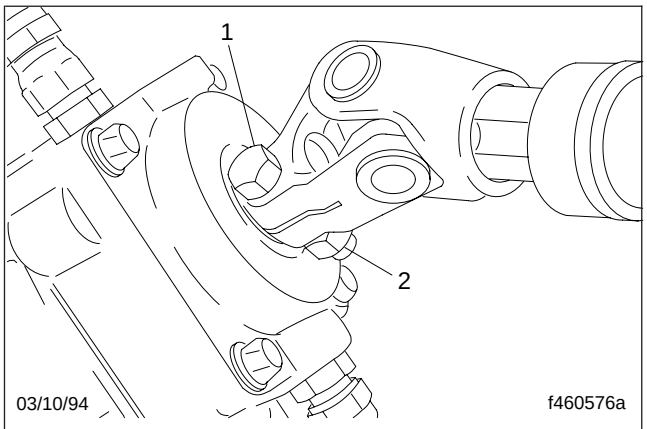
1. Dirt-and-Water Seal

Fig. 2, Remove the Dirt-and-Water Seal



1. Retaining Ring

Fig. 3, Remove the Retaining Ring

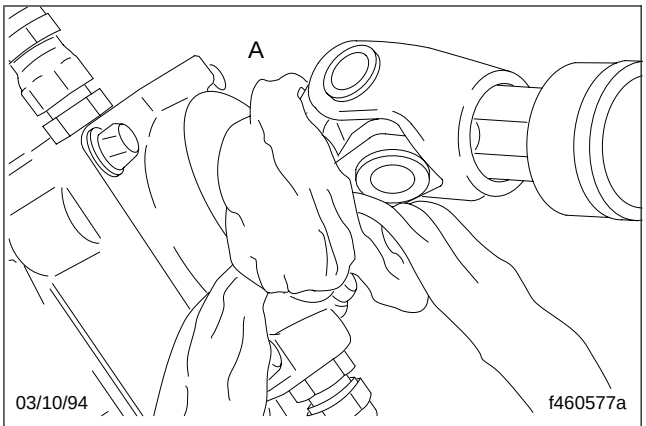


1. Pinch Bolt 2. Pinch Bolt Nut

Fig. 4, Install the Pinch Bolt

Input Shaft Seal Replacement

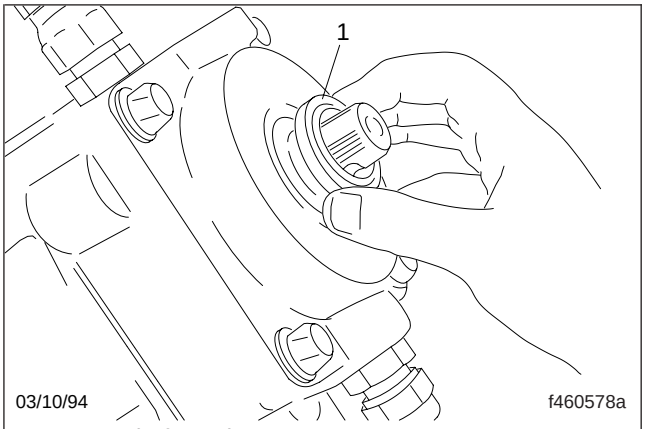
6. Tie or wrap a shop towel around the input shaft area and place a drip pan under the vehicle to catch the oil. See **Fig. 5**.



A. Cover the Input Shaft Area

Fig. 5, Shop Towel Covering the Input Shaft

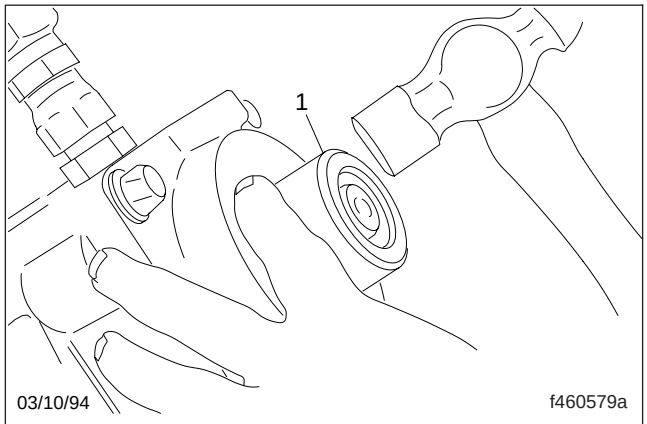
7. Add Dexron II type ATF as necessary to the fill line on the dipstick.
8. With the vehicle in neutral, momentarily turn the starter; quickly turn off the engine if it starts.
9. Remove the shop towel, pinch bolt, and input yoke.
10. Remove the seal. See **Fig. 6**.



1. Input Shaft Seal

Fig. 6, Install the Input Shaft Seal

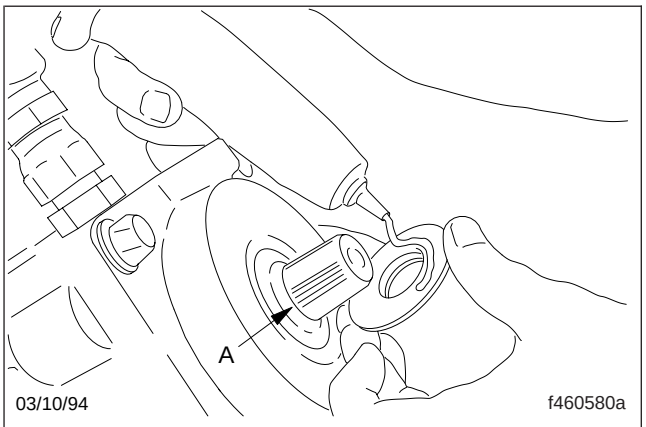
11. Check the seal area of the valve housing for any seal fragments. Remove any that are found.
12. Check the seal for heat damage. If the seal is stiff, brittle, and not pliable like the new seal, it is probably heat damaged. See the troubleshooting procedures in **Section 46.04, Subject 300** to determine and fix the cause of excessive heat in the vehicle.
13. 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

14. Insert the new retaining ring into the groove.
15. 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.
16. Connect the steering driveline to the steering gear input shaft.
    - 16.1 Clean the input shaft and the inside of the driveline yoke.
    - 16.2 Apply a thin film of grease to the yoke splines. Use lithium-based grease, NLGI grade 2.



A. Seat the seal here.

Fig. 8, Install the Dirt-and-Water Seal

16.3 Slide the yoke on the input shaft and install the new 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 55 to 65 lbf·ft (75 to 88 N·m).

16.4 Apply white torque seal OGP F900WHITE to the exposed pinch bolt threads and the locknut.

17. Connect the return line to the steering gear return port.

18. 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.

18.1 Fill the power steering reservoir with Dexron II type ATF 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.

18.2 Start the engine and let it idle for two minutes. Shut down the engine, and check the fluid level in the reservoir.

18.3 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, the following items must be checked.

⚠ WARNING

Failure to check the following items 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. 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 right turns. 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 necessary. Bleed the air from the system.
2. With the engine turned off and warm, check the power steering reservoir fluid level using the instructions in the steering section in the vehicle maintenance manual.
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 the above, reset the axle stops.
4. Check that the poppet plungers are set correctly. If needed, adjust them. For instructions refer to **Subject 100**
5. If there are still problems with the power steering system, see **Section 46.04, Subject 300** and perform the troubleshooting procedures. Otherwise, go to the next step.
6. Test drive the vehicle, or take a ride with the driver. Check the steering wheel spoke position. If during straight-ahead driving on a level road the steering wheel spokes are not within ±10 degrees of the 4 o'clock and 8 o'clock positions, remove the steering wheel and reposition it.

Specifications

Refer to **Fig. 1** for a plumbing diagram of the steering system.

Steering Gear Torque Values			
Description	**Bolt or Nut Size**	**Grade**	**Torque: lbf·ft (N·m)**
Valve Housing Bolt: TAS55/65	1/2–13	—	75–85 (102–115)
Auxiliary Port Plug	—	—	25–35 (34–47)
Poppet Adjuster Sleeve and Seat Assembly: TAS55/65	—	—	10 (14)
Ball Return Guide Bolt	—	—	14–22 (19–30)
Sector Shaft Adjusting Screw Jam Nut	—	—	40–55 (54–75)
Side Cover Bolt	9/16–18	—	118 (160)
	5/8–18	—	170 (230)
Relief Valve Cap	—	—	25–35 (34–47)
Drag Link Castle Nut	5/8–18	C	60–115 (81–156)
	3/4–16	C	90–170 (122–230)
	7/8–14	C	160–300 (217–407)
Steering Driveline Lower End Yoke Pinch Bolt Nut	7/16–20	C	55–65 (75–88)
Pitman Arm Pinch Bolt Nut	5/8–18	C	120–140 (163–190)
	3/4–16		215–245 (292–332)
Steering Gear Mount Hexbolt Nut*	7/8–14	C	377–477 (511–647)

* Torque values are for a plain capscrew with a phosphate and oil coated locknut with a hardened washer.

Table 1, Steering Gear Torque Values

SPX Kent-Moore, 28635 Mound Road, Warren, MI 48092, 800-328-6657	
Kent-Moore Part Number (TAS55/65)	**Tool**
J37070	Adjuster Tool
J37464	Adjuster Locknut Tool
J37071	Bearing and Seal Tool
J37073	Input Seal Installer
J38713	Poppet Adjuster Seat Tool, Heavy-Duty (preferred)
J36452	Poppet Adjuster Seat Tool
J37130	Relief Valve Plug
J8092	Tool Handle

Table 2, SPX Kent-Moore, 28635 Mound Road, Warren, MI 48092, 800-328-6657

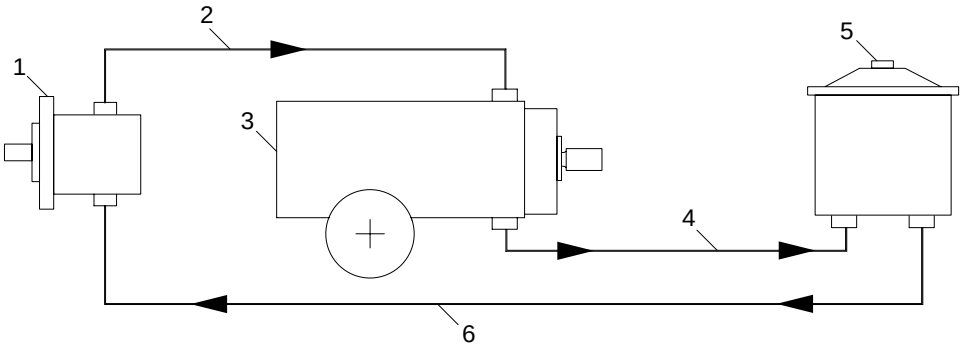
Specifications

⚠ WARNING

Fill only with approved clean automatic transmission 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 Fluid	
Fluid Type	**Recommended Fluid**
Automatic Transmission Fluid	Dexron II

Table 3, Approved Power Steering Fluid



1. Steering Pump
2. Pressure Line
3. Steering Gear
4. Return Line
5. Reservoir
6. Supply Line

Fig. 1, Steering System With Air Brakes

General Description

The steering wheel is splined to the steering shaft and retained by a self-locking nut. The steering shaft passes through the steering column tube (secured to the dash panel) and is supported in the tube by two ball bearings. The lower end of the shaft passes through a shroud which is secured to the cab floor. A plastic dust seal is sandwiched between the shroud and the cab floor.

The male splined steering shaft is allowed to slide into a female splined universal slip-yoke attached to the steering gear input shaft. The shaft is allowed to slide to compensate for cab articulation and tilting of the vehicle cab. See **Fig. 1**.

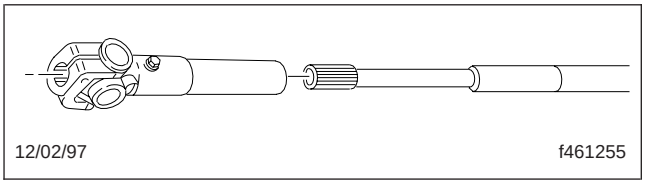
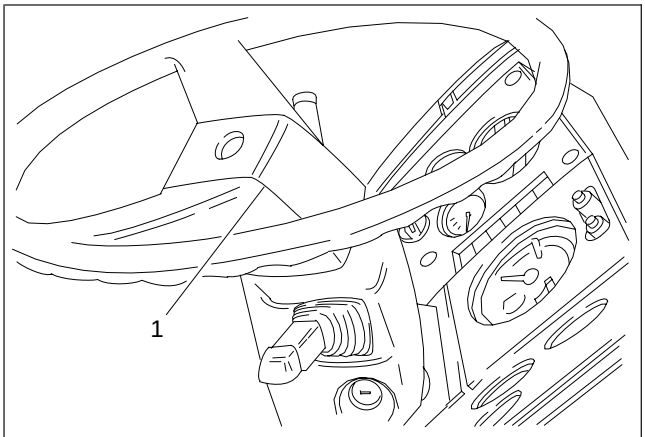


Fig. 1, Slip Yoke and Steering Shaft

Removal

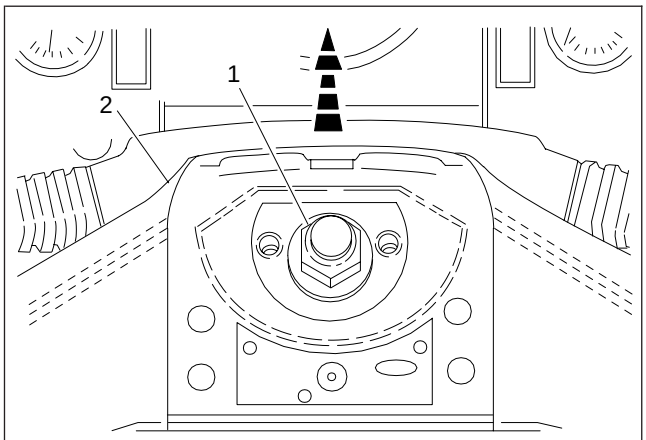
1. Be sure the vehicle wheels are in the straight-ahead position. Disconnect the battery.
2. Carefully pull up on the steering wheel emblem cover. Lift toward the instrument panel. See **Fig. 1**.



1. Steering Wheel Emblem Cover

Fig. 1, Steering Wheel

3. Mark steering column in line with steering wheel for proper positioning during assembly.
4. Remove the steering wheel locknut. See **Fig. 2**. Use a puller to remove the steering wheel.



1. Steering Wheel Locknut
2. Steering Wheel

Fig. 2, Removing Steering Wheel

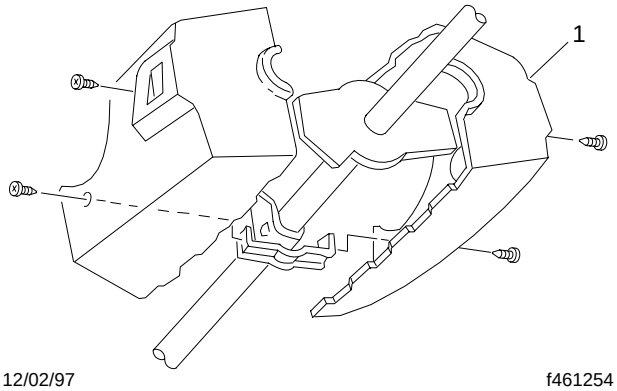
Installation

1. Install the steering wheel in the original position.
2. Install the steering wheel locknut and tighten it 55 to 63 lb·ft (75 to 85 N·m).
3. Install the steering wheel emblem cover.
4. Connect the battery.
5. Test the steering wheel for proper operation.

Steering Column Shroud Removal and Installation

Removal

1. The two halves of the steering column shroud are held in position by four retaining screws—two each side. See **Fig. 1**. Remove the retaining screws located near the switch handle openings.



1. Steering Column Shroud

Fig. 1, Steering Column Shroud Installation

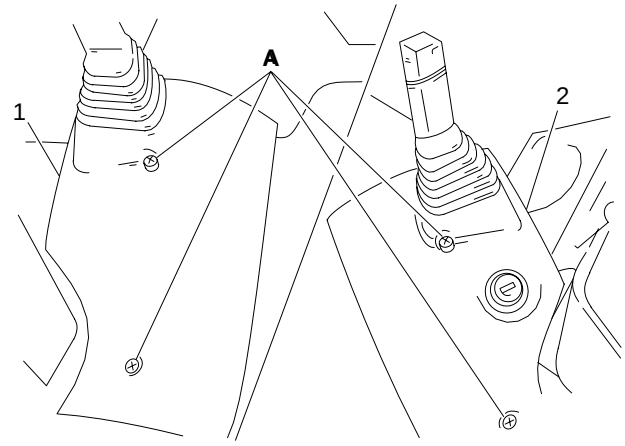
2. Remove the retaining screws located near the bottom of each half of the shroud.

Installation

1. Position the shroud halves and install the attaching screws.
2. Tighten the retaining screws to 9 to 11.5 lbf·in (100 to 120 N·cm).

Removal

1. Make sure front wheels are in straight-ahead position. Disconnect the battery.
2. Tilt the vehicle cab. Remove the pinch bolt and nut securing the steering shaft universal joint to the steering gear input shaft and disconnect joint. Lower the vehicle cab.
3. Remove the steering wheel.
4. Remove the screws securing the two-piece steering column shroud. See **Fig. 1**. Remove the shroud.

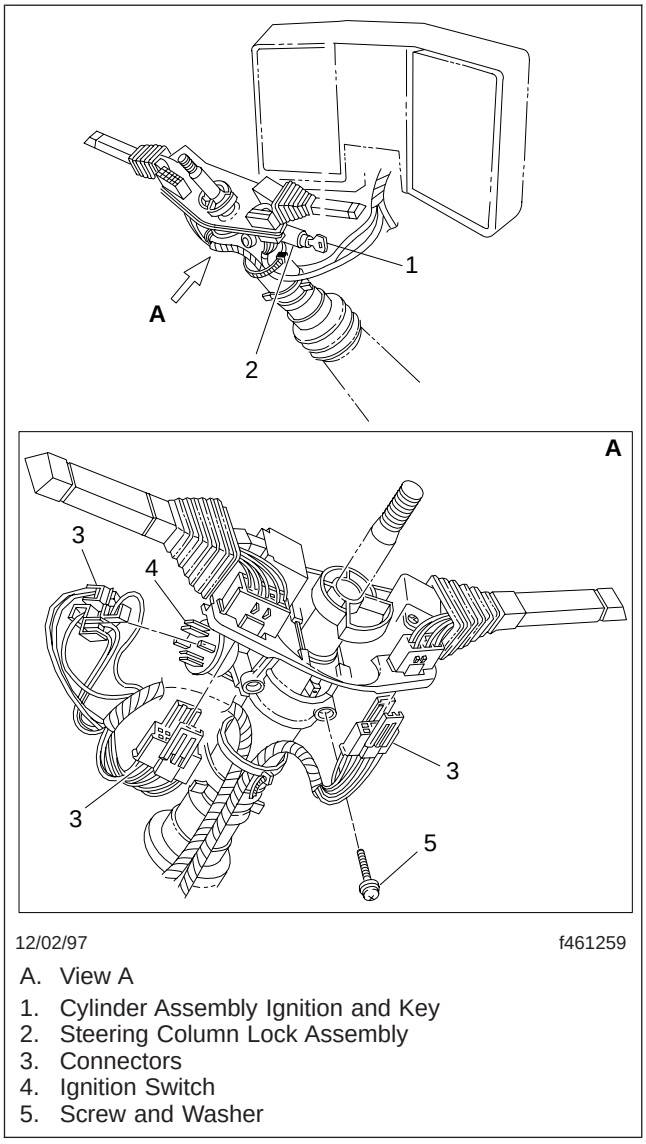


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A. Remove these screws.
1. Left Shroud Half
2. Right Shroud Half

Fig. 1, Shroud Fasteners

5. Make sure the steering column lock is in the unlocked position.
6. Disconnect the direction indicator, windshield wiper, and ignition switch multi-plugs. See **Fig. 2**.
7. Remove the two shear-head bolts from the switch assemblies and separate the assemblies from the steering column tube.
8. Remove the bolts and washers securing the steering column bracket to the pedal box. Carefully lift the steering shaft assembly until the universal joint is clear of the lower shroud. See **Fig. 3**. Remove the assembly from the vehicle.



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A. View A
1. Cylinder Assembly Ignition and Key
2. Steering Column Lock Assembly
3. Connectors
4. Ignition Switch
5. Screw and Washer

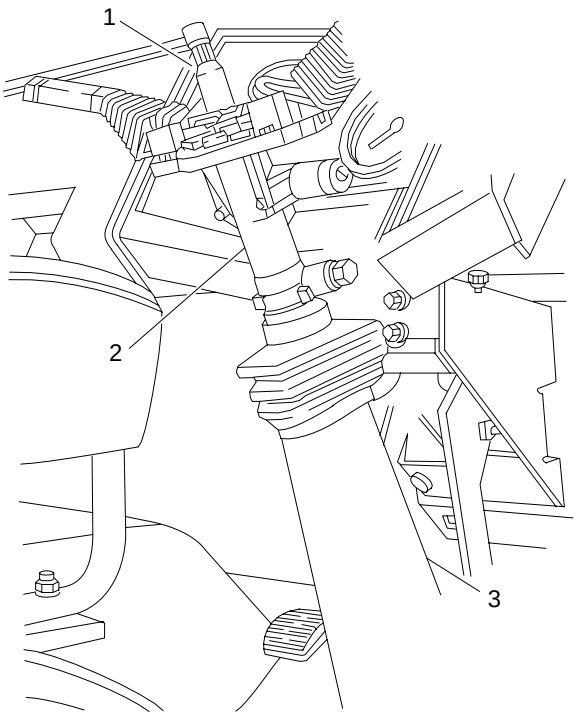
Fig. 2, Multi-Plug Connections

Installation

NOTE: Vehicles fitted with shear bolts must have shear bolts fitted in the lower two positions.

1. Position the steering shaft assembly in the vehicle and carefully guide the universal joint assembly through the lower shroud. Position the

Steering Column Removal and Installation



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1. Steering Shaft
2. Steering Column Tube
3. Lower Shroud

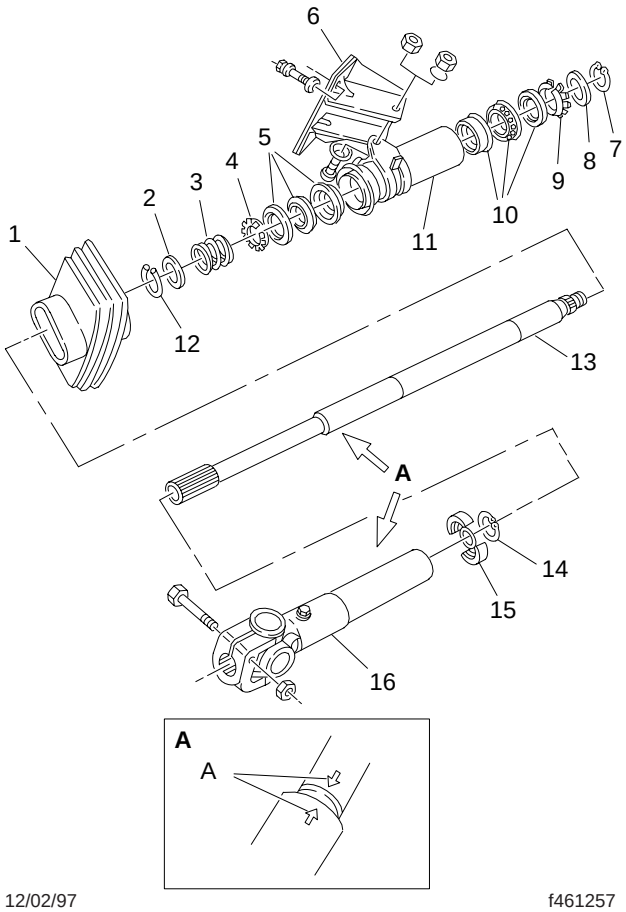
Fig. 3, Steering Column Components

steering column bracket against the pedal box. Secure it with bolts and washers. Tighten it securely.

2. Fit two halves of the switch casting to the steering column tube, and install two new shear-head bolts. Tighten the bolts until the heads shear. Reconnect the direction indicator, windshield wiper, and ignition switch multi-plugs.
3. Position the two-piece steering column shroud and secure it with screws.
4. Install the steering wheel in straight-ahead position. Install new retaining nut, and tighten it 55 to 63 lbf·ft (75 to 85 N·m). Install the steering wheel emblem cover.
5. Tilt the cab. Install the sliding universal joint into the steering gear input shaft. Install the bolt nut and flatwashers. Tighten it 31 to 42 lbf·ft (42 to 57 N·m).
6. Lower the vehicle cab.
7. Reconnect the battery and install the battery cover.
8. Check operation of all steering column-mounted electrical equipment.

Steering Column Disassembly and Assembly

Disassembly (See Fig. 1)



A. Alignment Marks

1. Boot
2. Washer
3. Spring
4. Tolerance Ring
5. Lower Bearing Assy
6. Support Bracket
7. Circlip
8. Washer
9. Tolerance Ring
10. Upper Bearing Assy
11. Column Tube
12. Circlip
13. Steering Shaft
14. Circlip
15. Split Bushing
16. Slip Yoke

Fig. 1, Steering Column, Exploded

1. Remove tube-to-steering column support bracket nut and bolt. Separate the assembly.
2. Remove circlip from upper end of sliding universal joint assembly. Remove universal joint assembly from steering shaft. Separate the two halves of the bushing and remove O-ring and rubber boot.

   The spring loading on the assembly is between 221 to 308 lbf·ft (983 to 1370 N·m).
3. Place the support shaft and column tube assembly in a vise with pads on vise jaws to prevent damage. Push column tube toward the lower end of shaft to release load on the upper circlip. Remove circlip without releasing the tolerance ring from upper bearing.
4. Remove steering shaft from lower end of column tube. The lock ring will help to remove the lower bearing assembly.
5. Remove upper bearing assembly using a long, soft drift to push the bearing from the column tube. Take care not to damage the bearing seals.
6. Remove the lower circlip washer, spring, tolerance ring, and bearing assembly, if they are still on the shaft.
7. Inspect shaft splines for damage or wear, replace if necessary. Separate bearing assemblies. Do not intermix parts. Inspect bearings for wear. Replace as necessary if pitting or galling is present. Check spring for wear or damage.

Assembly

1. Clean bearing assemblies in approved solvent, taking care not to intermix bearing components. Lubricate the bearings with the grease specified in Group 46 of the vehicle maintenance manual.
2. Install lower bearing assembly tolerance ring, spring, and washer. Install lower circlip in groove on shaft.
3. Slide the column tube over the top of the shaft until lower bearing is seated in belled end of the column tube.
4. Place shaft in vise and install upper bearing, tolerance ring, washer and circlip over the upper end of the shaft.
5. Push column tube downward to allow installation of upper bearing, tolerance ring, washer and circlip.
6. Install rubber boot.
7. Lubricate the shaft splines with the grease specified in Group 46 of the vehicle maintenance manual. Install the O-ring and lower circlip.

Steering Column Disassembly and Assembly

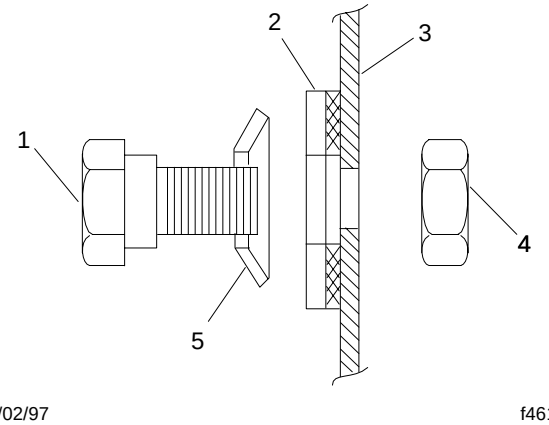
8. Install shaft into universal joint making sure the arrows on shaft and joint are in alignment.
9. Lubricate O-ring and shaft with grease. Install the two halves of split bushing around O-ring and slide the bushing into the end of the sliding joint.

NOTE: Take care not to over lubricate or a hydraulic lock could develop, preventing the sliding joint from working properly.

10. Reinstall grease fitting if removed. Compress the sliding joint by hand and apply two or three strokes of grease.

NOTE: Before tightening to specified torque, check that the mounting bracket pivots on column tube bracket.

11. Install steering column support bracket over the steering column tube bracket. Install dished washers to each shouldered bolt. See **Fig. 2**. Slide the bolts through the column tube bracket into the support bracket. Install nuts (or special shear nuts) for vehicles with steering column lock. Tighten 15 to 24 lbf·ft (21 to 32 N·m). Make sure bolts locate correctly in column tube bracket.



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1. Shouldered Bolt
2. Column Tube Bracket
3. Support Bracket
4. Locknut
5. Dished Washer

Fig. 2, Column Tube Bracket to Support Bracket Fitting Installation

Specifications

Torque Specifications		
Description	**lbf·ft (N·m)**	**lbf·in (N·cm)**
Steering Wheel to Steering Shaft Nut	55–63 (75–85)	–
U-Joint to Steering Gear Nut and Bolt	31–42 (42–57)	–
Column Tube Retaining Bracket Bolt	15–24 (21–32)	–
Steering Column Shroud Screws	–	9.0–11.5 (100–120)

Table 1, Torque Specifications

General Description

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 and 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.

Steering Pump Removal and Installation

Removal

1. Apply the parking brake, chock the tires, then tilt the cab.
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 lockwashers that attach the pump to the compressor mounted to the engine accessory drive mounting flange. Hold the pump as you remove the second mounting bolt.
   - 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 compressor.
   - 2.2 Install the lockwashers and capscrews, and tighten them 35 lbf·ft (46 N·m).
3. Connect the inlet hose (from the power steering reservoir) to the inlet port. Tighten it 26 lbf·ft (35 N·m).
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. Lower the cab, then remove the chocks.

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 personal injury.

See **Fig. 1** for an exploded view of the steering pump.

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. See **Fig. 2**. Remove the spring if it did not come out with the end plug. See **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

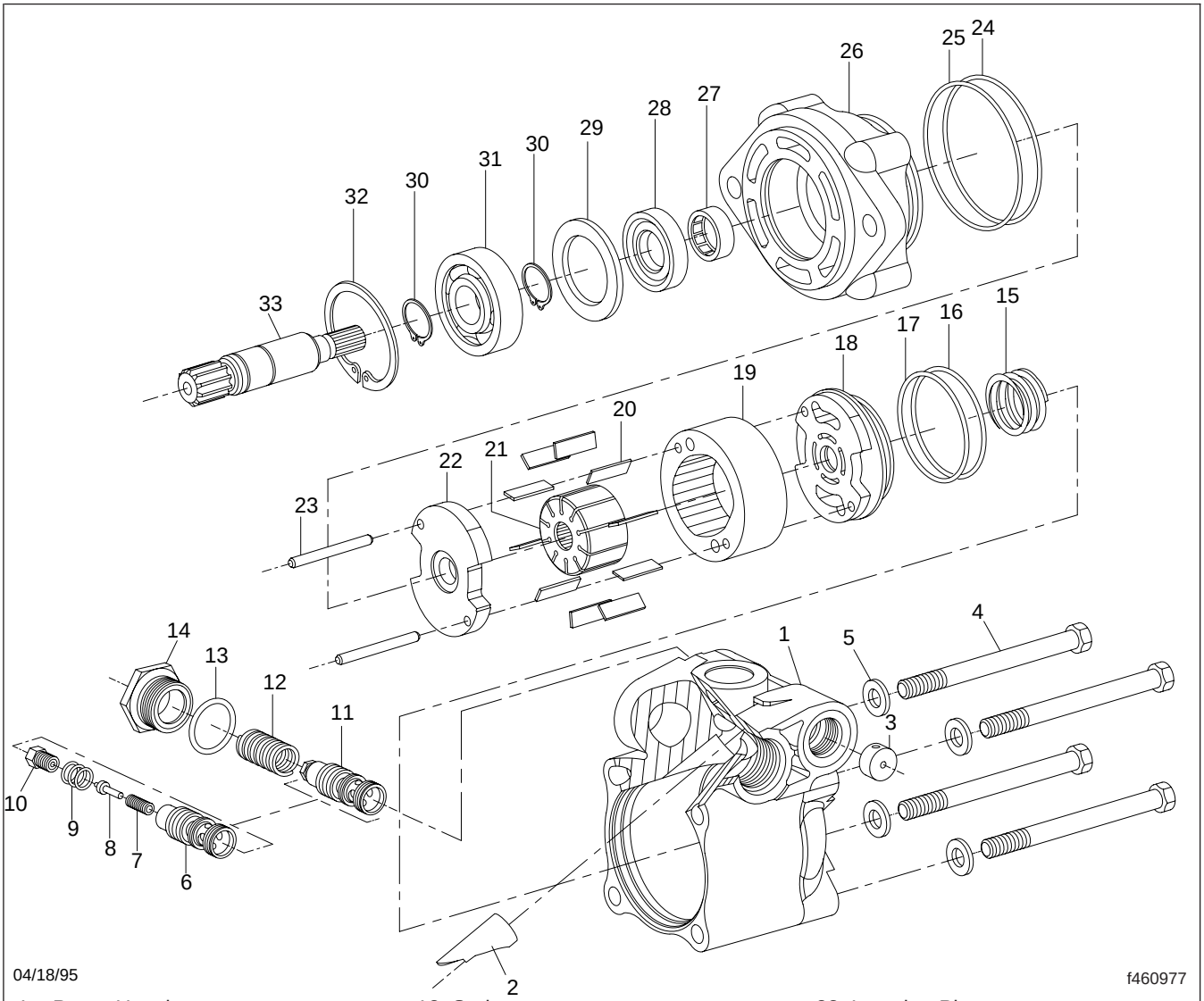
1. Clean all the parts using a solvent that is compatible with the power steering fluid. Then use filtered compressed air to dry all the parts.

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.

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 (2)
31. Ball Bearing
32. Large Retaining Ring
33. Input Shaft

Fig. 1, Steering Pump

4.1 Place the cover in a press with the flange side down. Using an 11/16-inch socket, press the needle bearing out of the cover. See **Fig. 20**.

Steering Pump Disassembly, Inspection, and Assembly

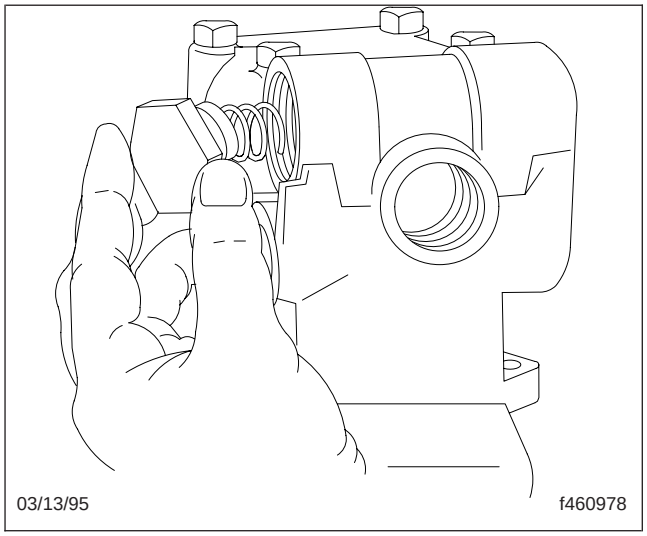


Fig. 2, Removing the End Plug

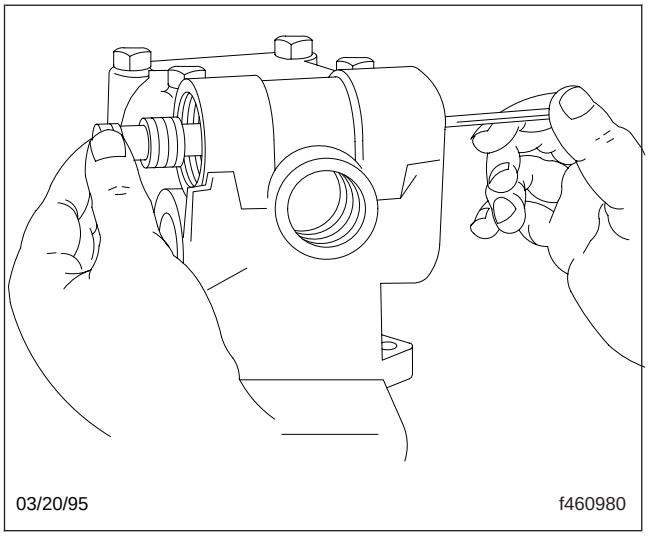


Fig. 4, Removing the Control Valve Assembly

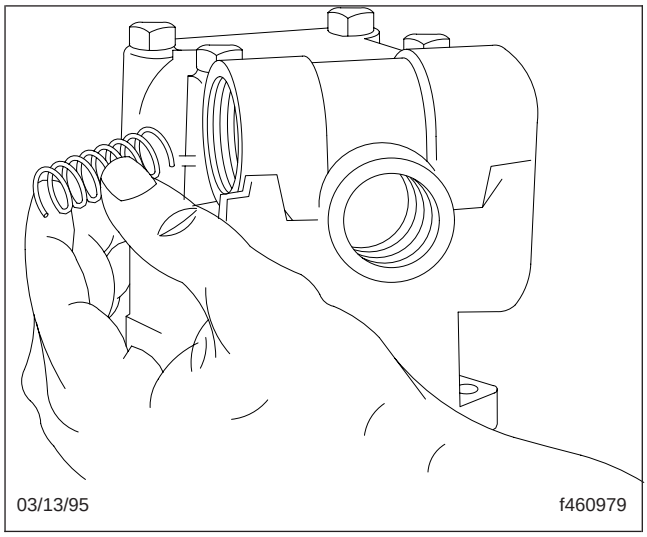


Fig. 3, Removing the Spring

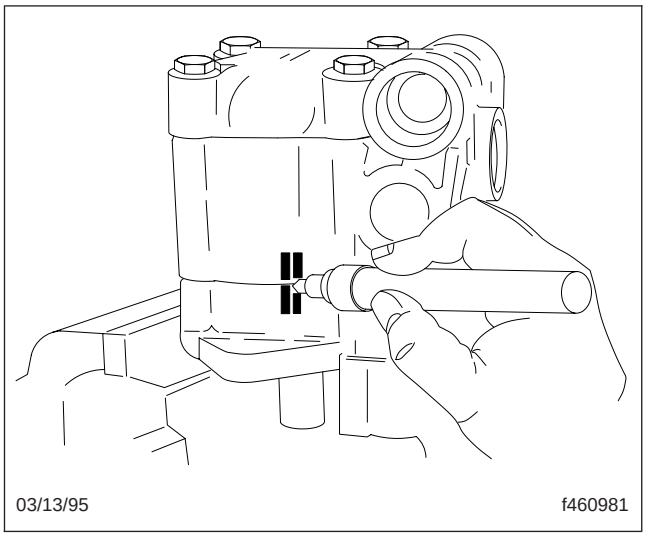


Fig. 5, Marking the Housing and the Cover

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

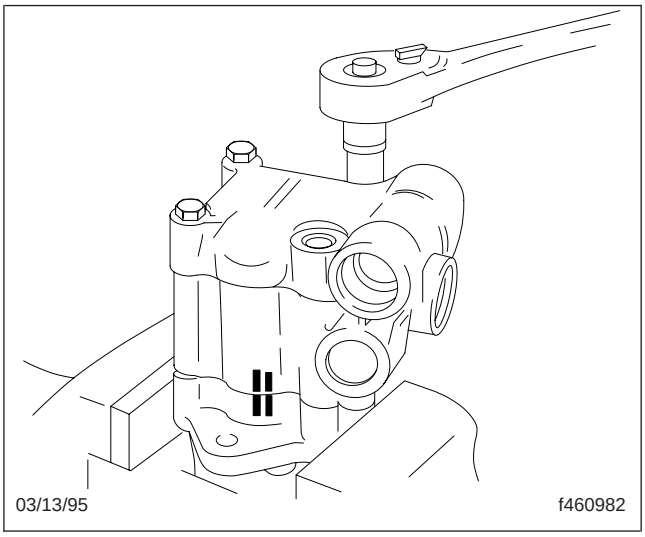


Fig. 6, Removing the Screws and Washers

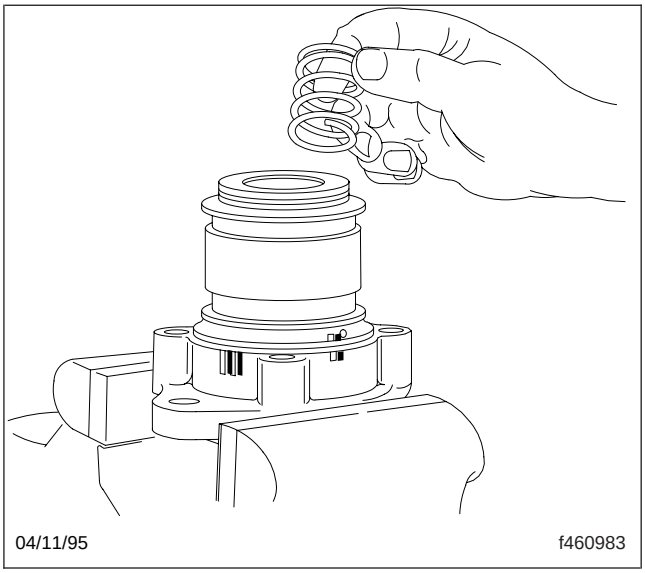


Fig. 7, Removing the Spring

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.

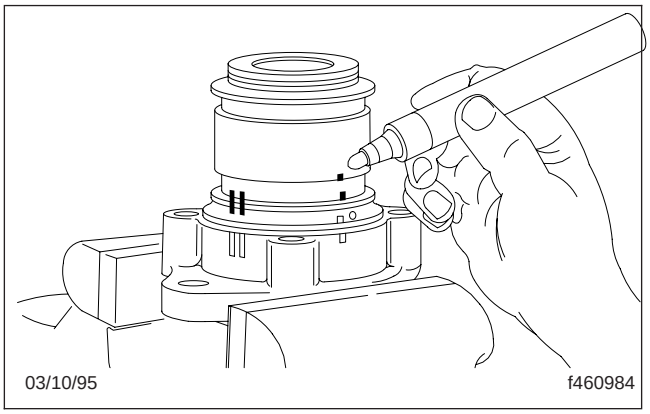


Fig. 8, Marking the Top Plate and the Bottom Plate

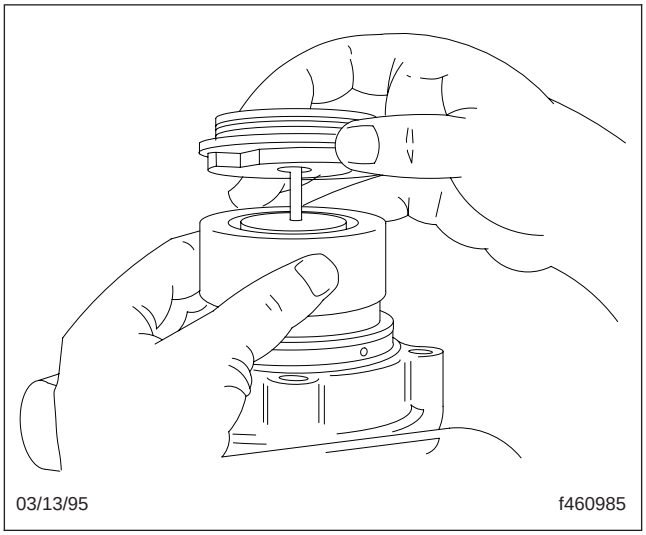


Fig. 9, Removing the Top Plate

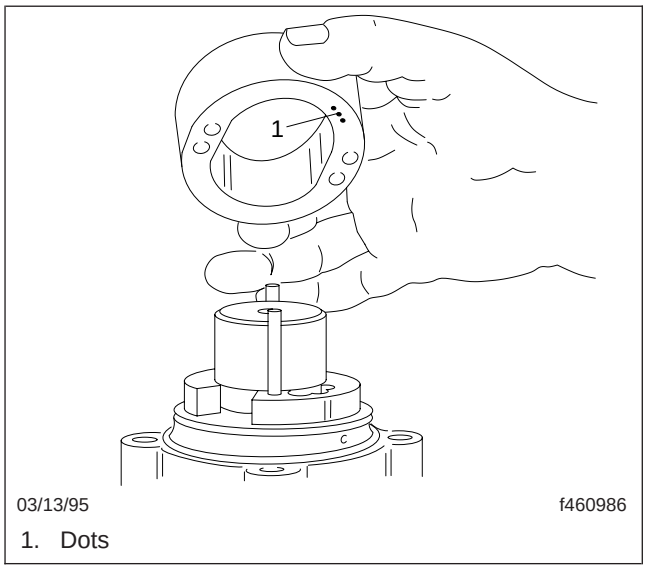
9. Check the input shaft for damaged splines and abnormal wear grooves around the seal area. See **Fig. 23**. Replace the input shaft if there are grooves that can be detected with your fingernail.

   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, Checking whether the Dots are Up or Down

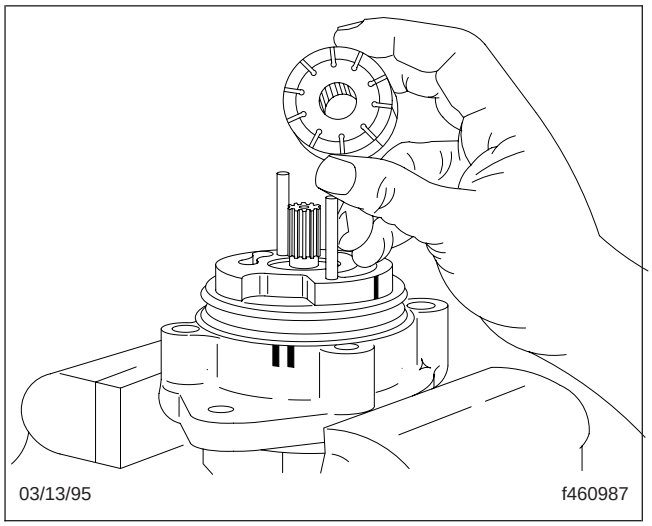


Fig. 11, Removing the Rotor and Vanes

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.

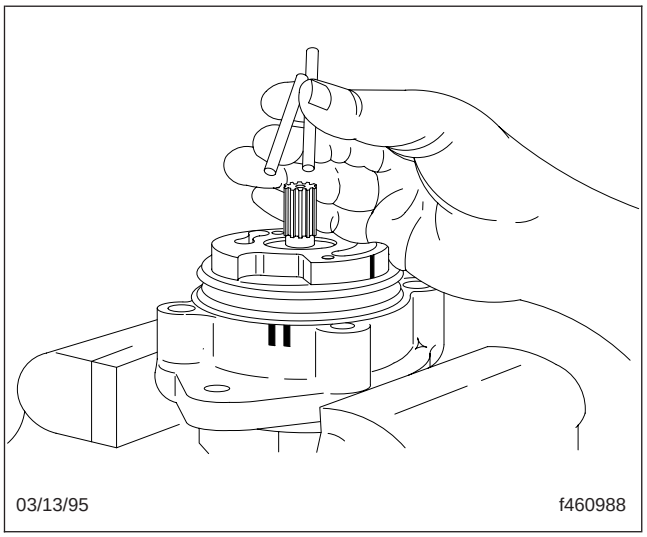


Fig. 12, Removing the Locating Pins

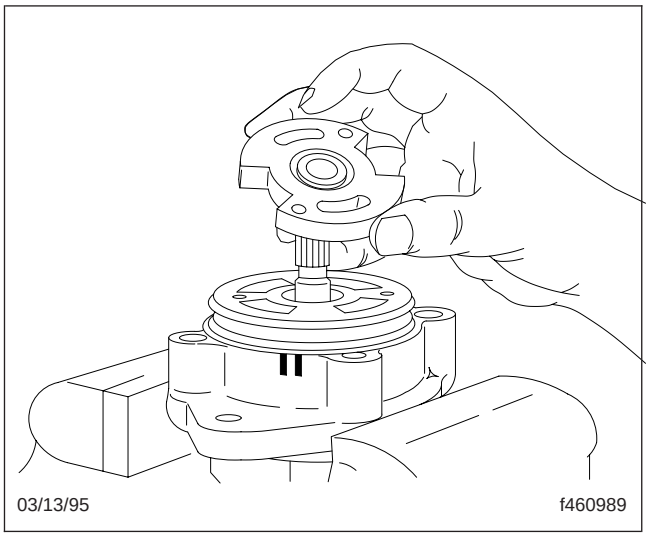


Fig. 13, Removing the Bottom Plate

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

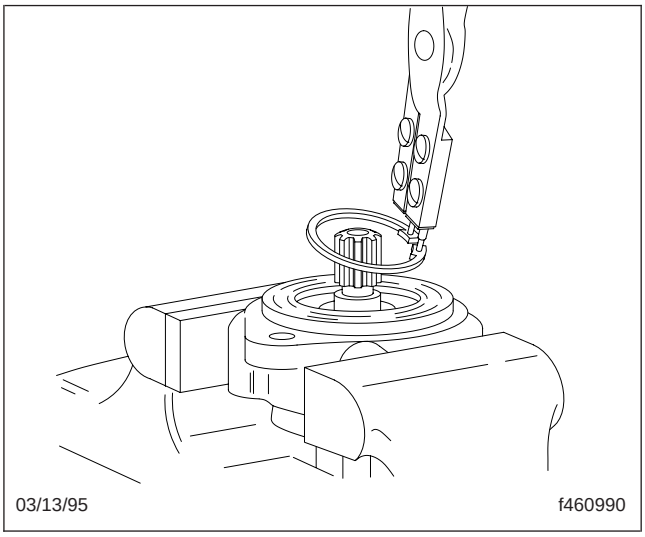


Fig. 14, Removing the Large Retaining Ring

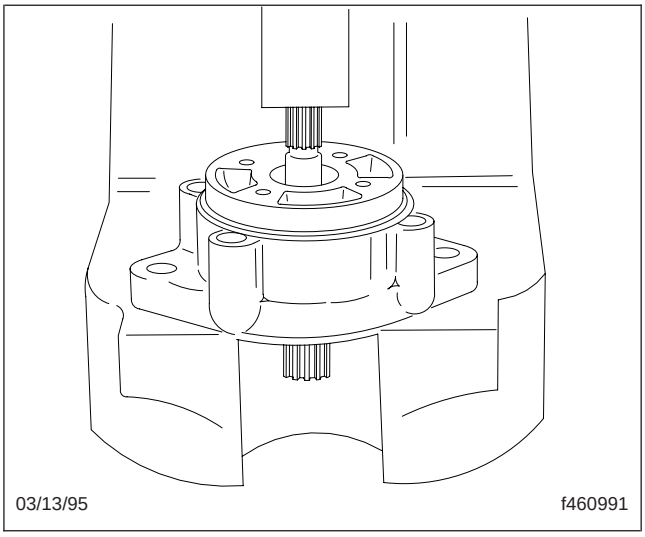


Fig. 15, Pressing out the Input Shaft and Ball Bearing Assembly

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.

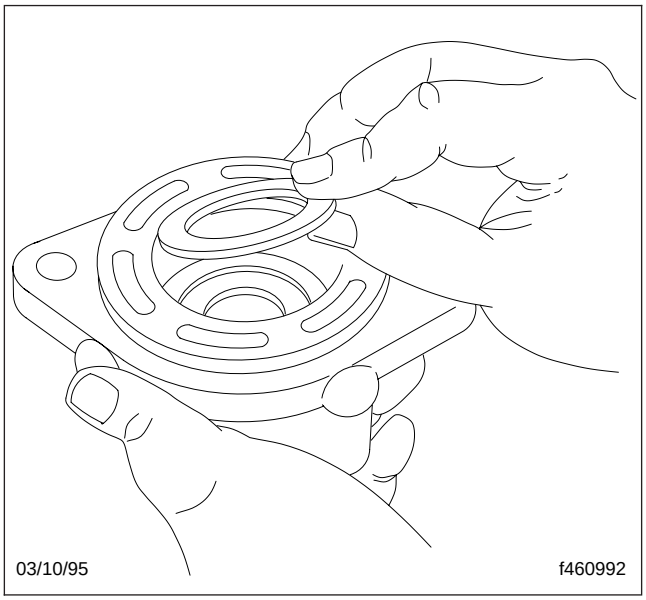


Fig. 16, Removing the Spacer

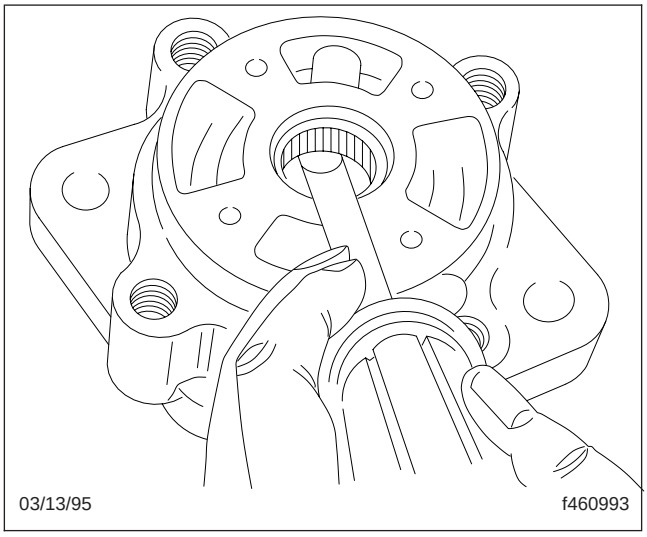


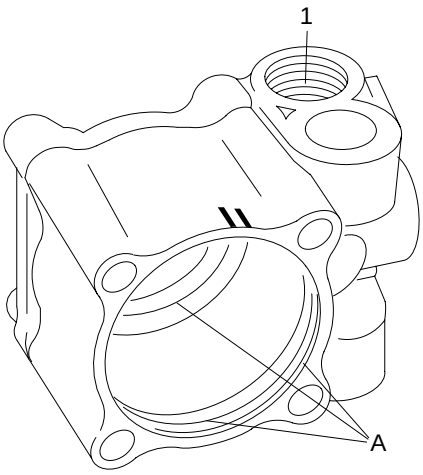
Fig. 17, Removing the Shaft Seal

⚠ CAUTION

Do not allow the splines to contact the shaft seal. The splines could damage the shaft seal.

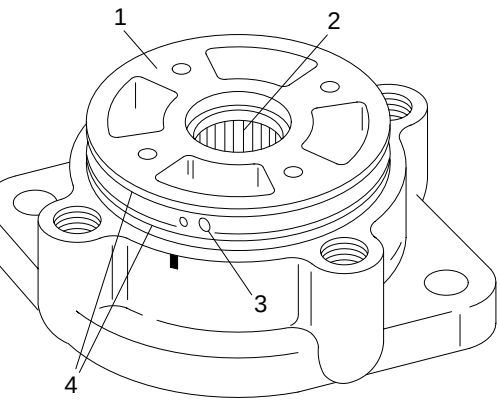
4. Insert the input shaft (small splined end first) into the cover. Do not allow the splines to contact the shaft seal. Insert the shaft into the seal by hand until the ball bearing contacts the cover.

Steering Pump Disassembly, Inspection, and Assembly



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.

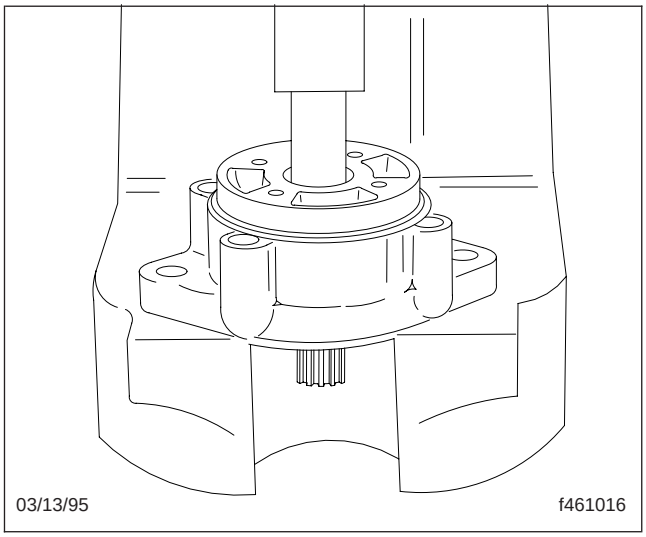


Fig. 20, Pressing the Needle Bearing out of the Cover

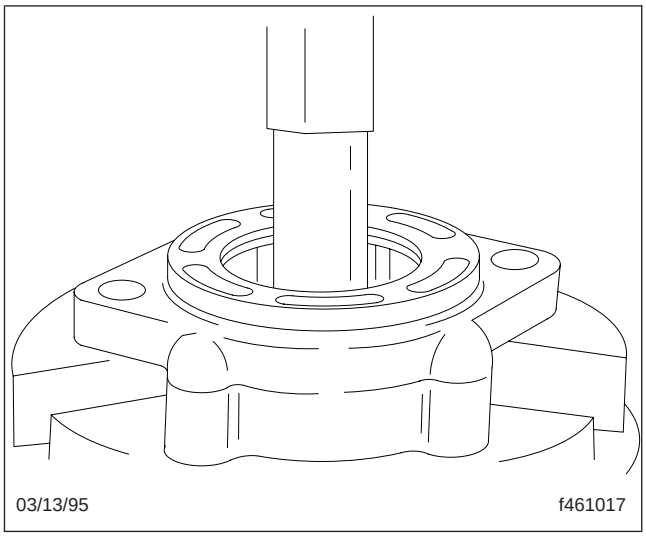


Fig. 21, Pressing a New Needle Bearing into the Cover

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.

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

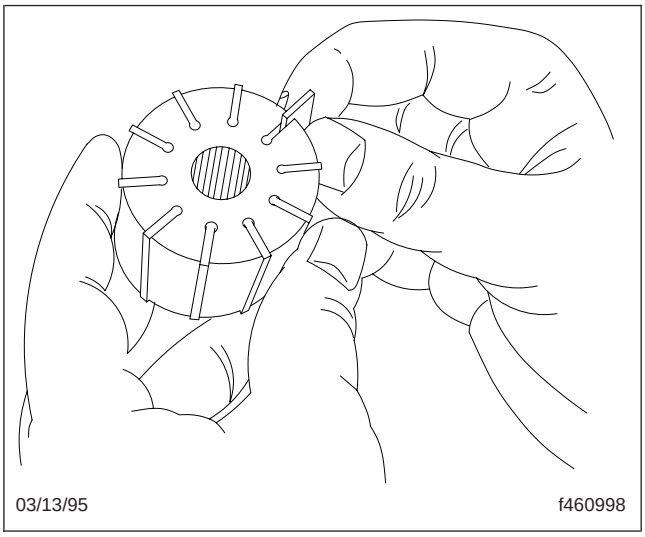


Fig. 22, Checking the Vanes

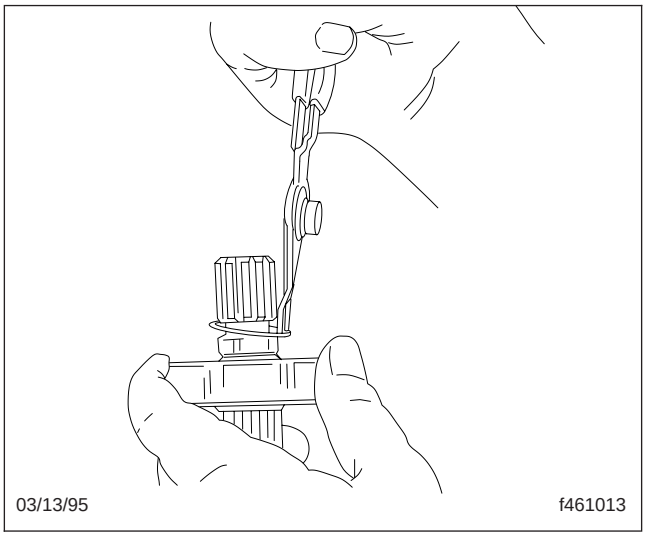
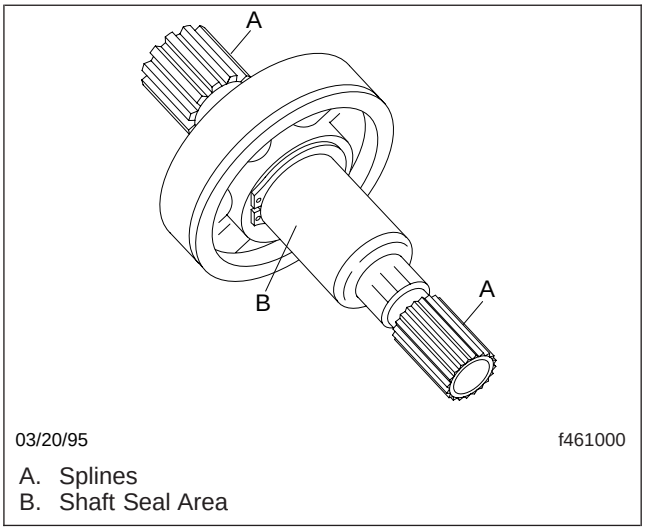


Fig. 24, Removing the Retaining Ring



A. Splines
B. Shaft Seal Area

Fig. 23, Check the Input Shaft

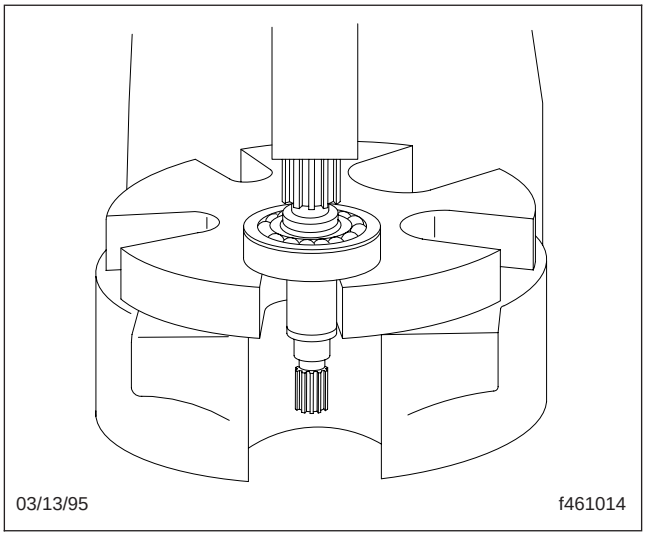


Fig. 25, Pressing the Input Shaft

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**.
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.

Steering Pump Disassembly, Inspection, and Assembly

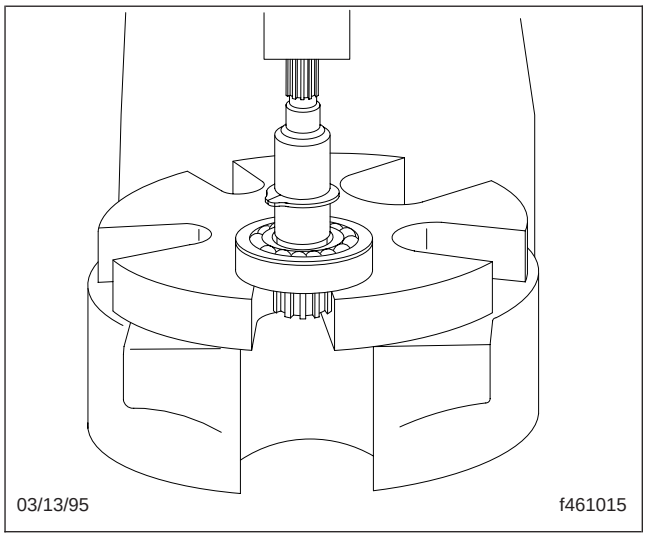


Fig. 26, Pressing the New Input Shaft

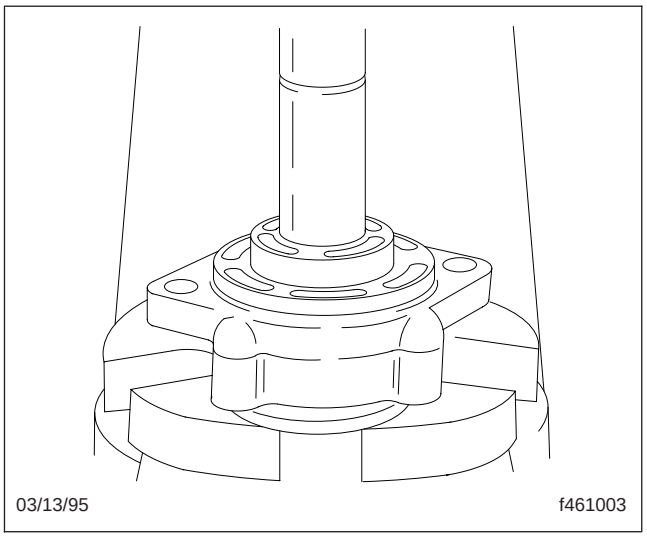


Fig. 28, Pressing the Shaft and Bearing into the Cover

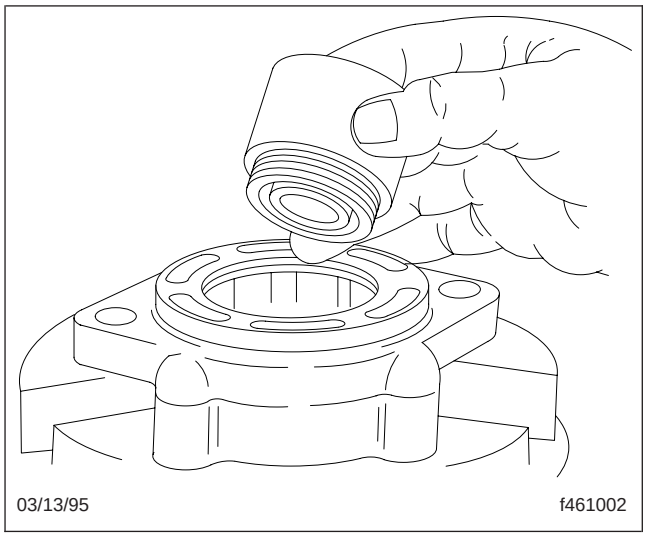
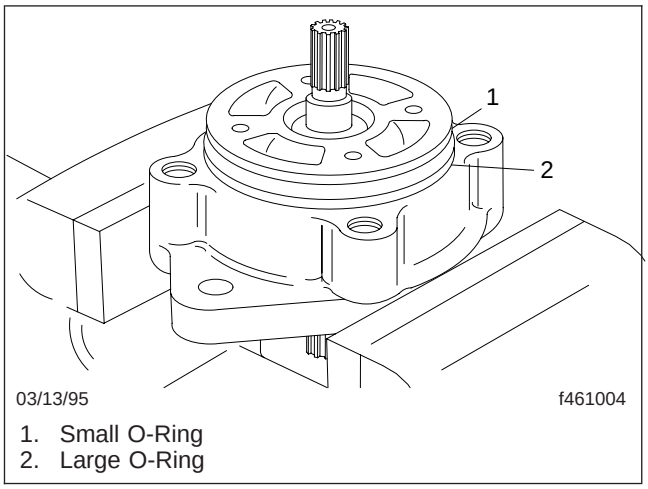


Fig. 27, Installing the Seal in the Cover



1. Small O-Ring
2. Large O-Ring

Fig. 29, Installing the O-Rings

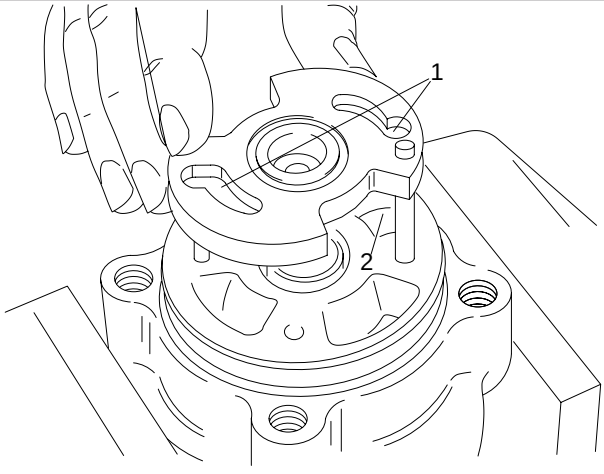
12. Install the backup O-ring on the top plate. Seat the O-ring at the bottom of the groove.
13. Install a new O-ring (without allowing it to roll) on the top plate. Seat the O-ring at the top of the groove.
14. Grease both the O-ring and the backup O-ring. See **Fig. 34**.

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, Installing the Bottom Plate

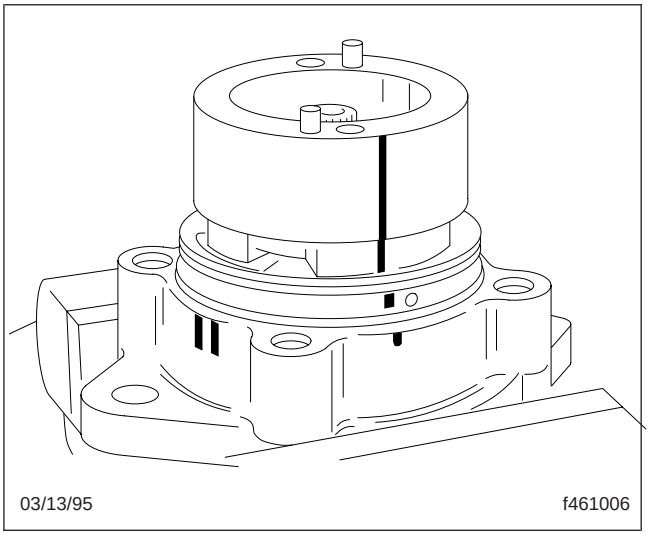
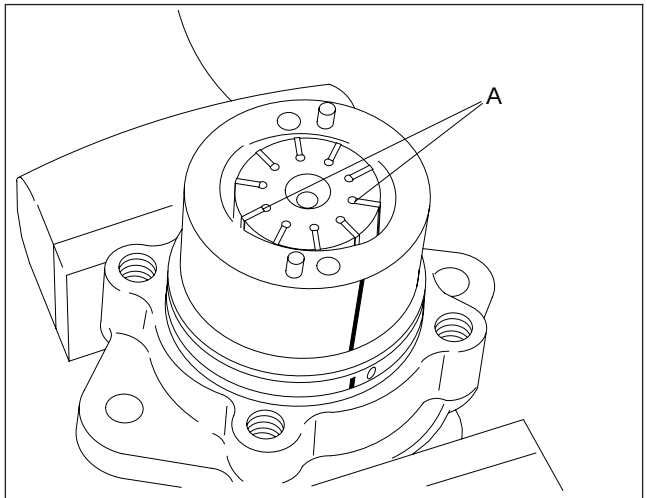


Fig. 31, Installing the Cam Ring

⚠ CAUTION

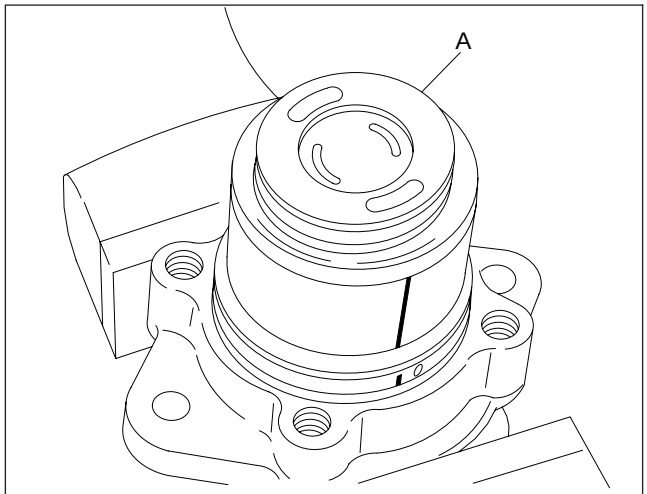
Evenly thread the mounting bolts into the cover. If not evenly threaded into the cover, damage could occur to the seals, top plate, or housing.

18. Install the mounting bolts and washers. Evenly thread all four bolts into the cover. Alternately tighten the bolts 30 lbf·ft (41 N·m).



A. Squared edge of vane pointing toward the center of the rotor.

Fig. 32, Installing the Rotor and the Vanes



A. Top plate installed with pin holes down.

Fig. 33, Installing the Top Plate

19. Screw the relief valve seat assembly into the control valve spool assembly. Tighten the assembly 87 lbf·in (982 N·cm).

NOTE: Placing the spool assembly in a collet will assist the tightening procedure.

Steering Pump Disassembly, Inspection, and Assembly

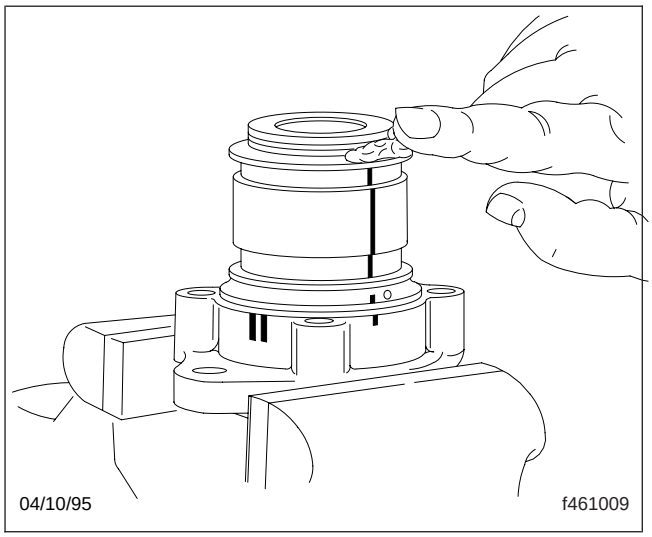


Fig. 34, Greasing the O-Rings

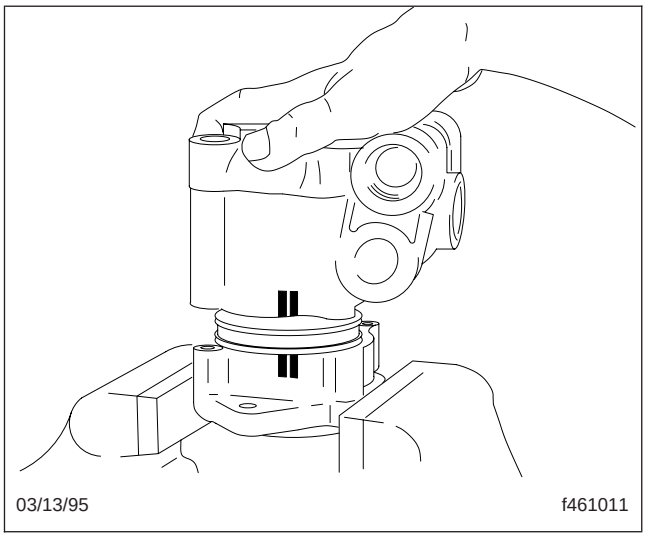


Fig. 36, Installing the Housing

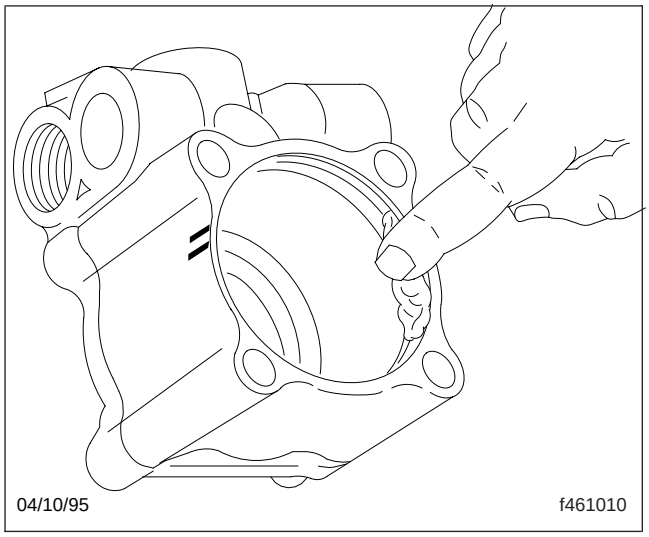


Fig. 35, Greasing the Sealing Areas

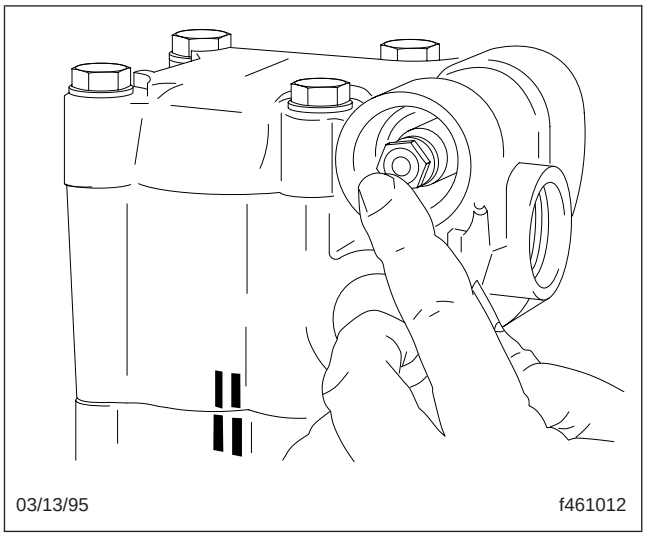


Fig. 37, Installing the Valve Spool Assembly

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 30 lbf·ft (41 N·m).
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

Torque Specifications	
Description	**Torque: lbf·ft (N·m)**
Pump Mounting Bolts	35 (47)
Pump Housing-to-Cover Assembly Bolts	30 (41)
Pump End Plug	30 (41)
Pump Inlet Connection	26 (35)

Table 1, Torque Specifications

Approved Power Steering Fluid	
Steering Gear and Lubricant Type	**Recommended Lubricant**
Ross or Sheppard Power Steering Gears With Automatic Transmission Fluid Installed*	Dexron III®
Ross or Sheppard Power Steering Gears With Heavy-Duty Engine Oil Installed*	Union 10W–40 Texaco 10W–40 Chevron 10W–40 Mobil Super 10W–40 Union 15W–40 Unocal 15W–40 Shell Rotella T30W

* Do not mix engine oil with automatic transmission fluid (ATF). Use the same lubricant for parts as is used in the power steering system.

Table 2, Approved Power Steering Fluid

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 *Cargo Driver's Manual*; some of these inspections and procedures can be found in the *Cargo 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 fifth wheel lubrication and condition.

   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)

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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.

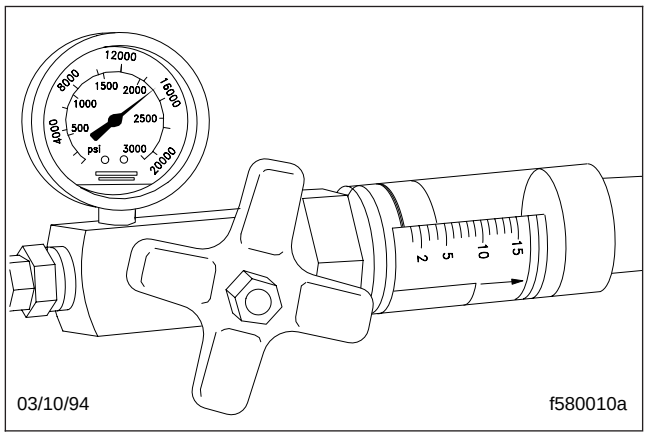


Fig. 3, Power Steering System Analyzer

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.

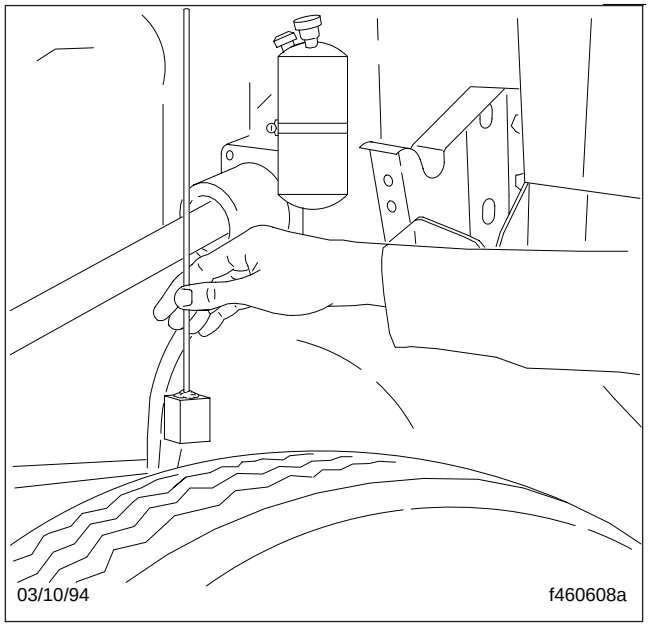


Fig. 4, Position the Steel Spacer

- 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

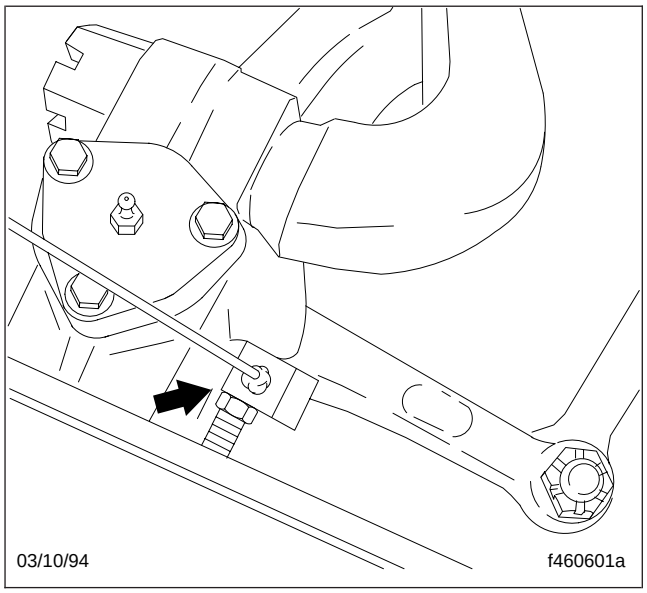


Fig. 5, Steel Spacer Contacting the Axle Stop

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 level is correct and air is removed from the system by running the engine at idle and checking the fluid level.

Troubleshooting Procedures

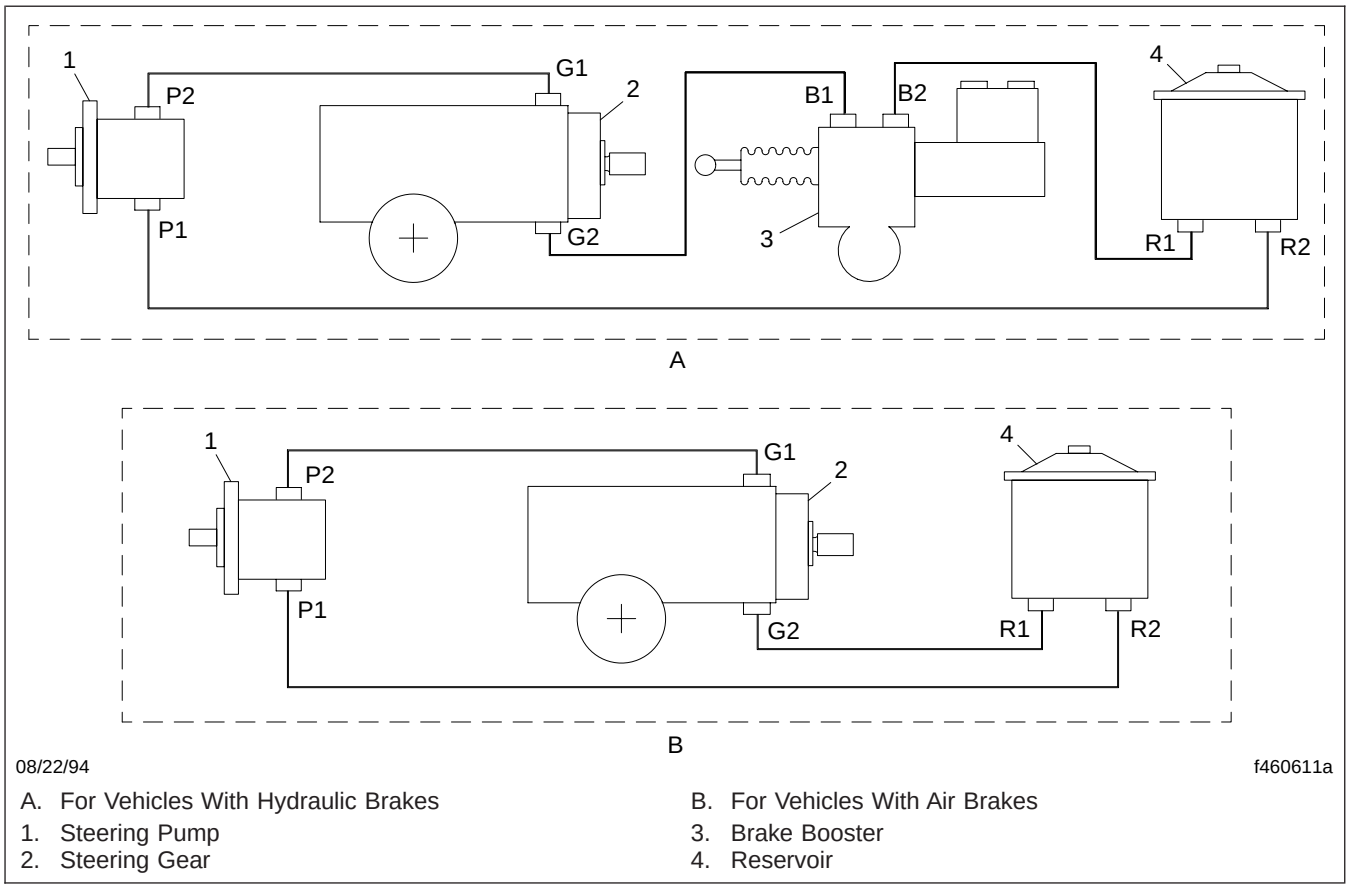
- Install the low-pressure gauge between the pump outlet and the pump-to-gear hose. Record this value as P2.
- Install the low-pressure gauge between the pump-to-gear hose and the steering gear inlet port. Record this value as G1.
- Install the low-pressure gauge between the steering gear outlet port 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



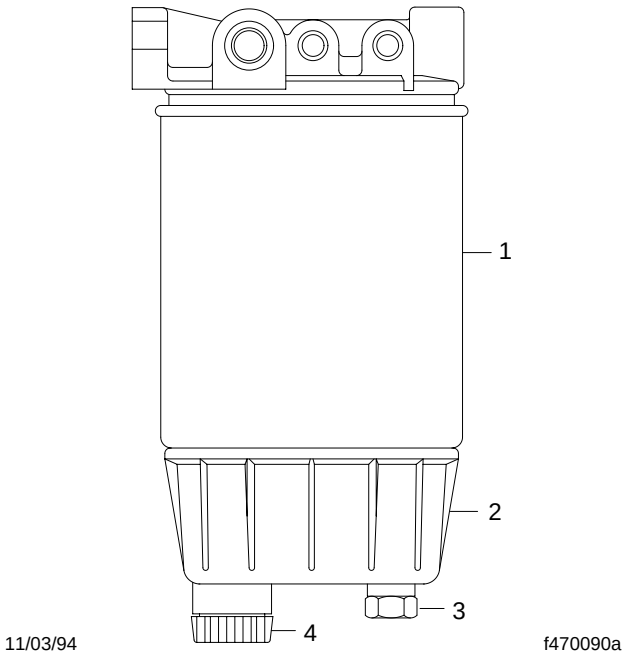
A. For Vehicles With Hydraulic Brakes
1. Steering Pump
2. Steering Gear

B. For Vehicles With Air Brakes
3. Brake Booster
4. Reservoir

Fig. 6, Plumbing Diagrams

General Description

The 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

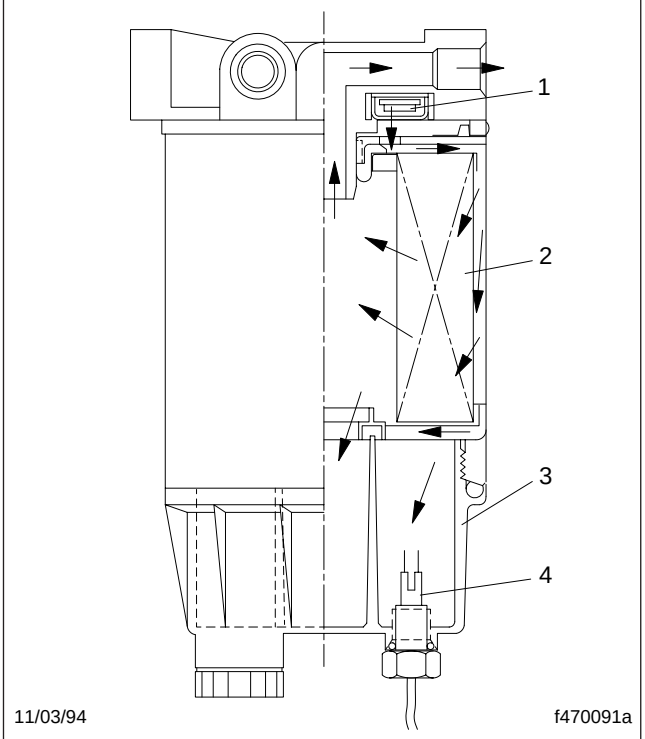
Fig. 1, Fuel/Water Separator

The separator is mounted on the left 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 which 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.

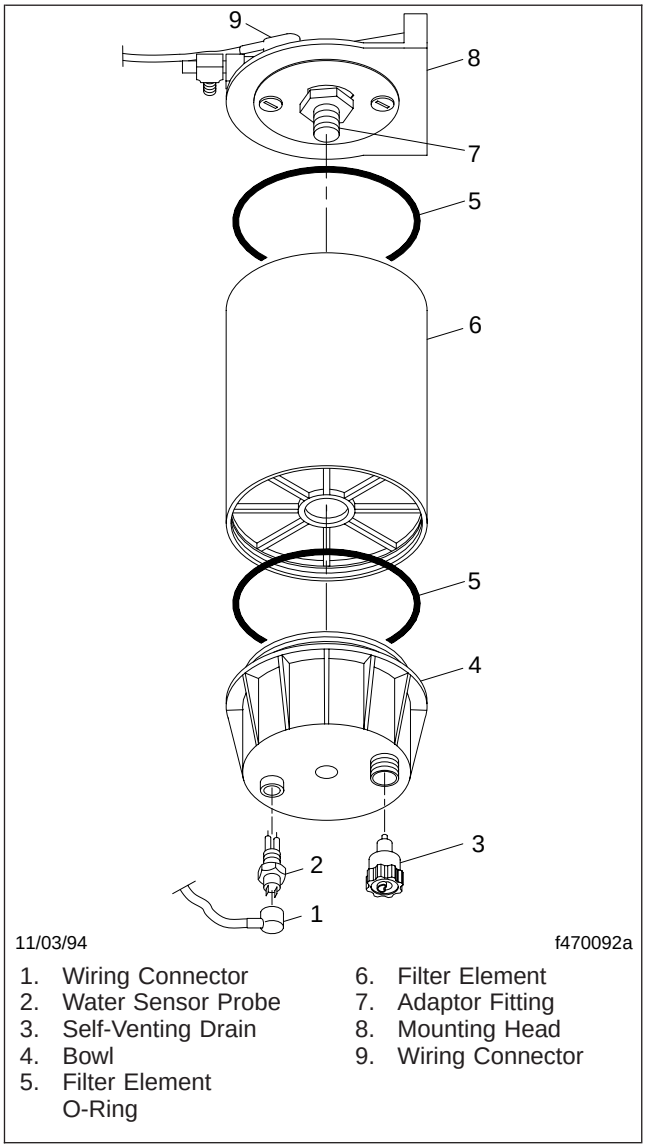


1. Heater Element
2. Filter Element
3. Collection Bowl
4. Water Sensor Probe

Fig. 2, Fuel Flow Through the Separator

Replacement (See Fig. 1)

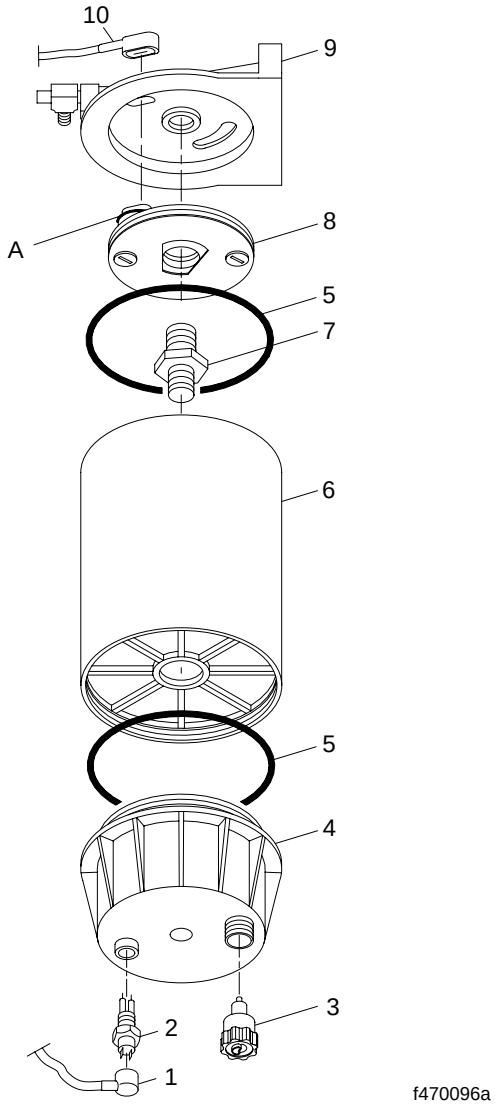
1. Apply the parking brakes, chock the tires, and tilt the cab.
2. Drain the fuel/water separator.
   - 2.1 Place a suitable container under the separator.
   - 2.2 Turn the drain (Ref. 3) counterclockwise to remove it.
3. Disconnect the wiring connector (Ref. 1) from the water sensor probe (Ref. 2).
4. Remove the bowl (Ref. 4) from the element (Ref. 6).
5. Remove the element from the adaptor fitting (Ref. 7) and the mounting head (Ref. 8).
6. Install the bowl (Ref. 4) on the bottom of the new filter element.
7. Install the drain (Ref. 3) 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. Return the cab to the operating position, 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

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

1. Apply the parking brakes, chock the tires, and tilt the cab.
2. Drain the fuel/water separator.
   - 2.1 Place a suitable container under the separator.
   - 2.2 Turn the drain (Ref. 3) counterclockwise to remove it.
3. Disconnect the wiring connector (Ref. 1) from the water sensor probe (Ref. 2).
4. Remove the bowl (Ref. 4) from the element (Ref. 6).
5. Remove the element from the adaptor fitting (Ref. 7) and the mounting head (Ref. 9).
6. Remove the brass adaptor fitting (Ref. 7) from the mounting head.
7. Disconnect the wiring connector (Ref. 10) from the heater element (Ref. 8).
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 adaptor fitting threads, and install the adaptor on the mounting head. Tighten the adaptor 30 lbf·ft (40 N·m).
11. Connect the wiring connector (Ref. 10) to the element.
12. Install the bowl (Ref. 4) on the bottom of the replacement filter element.
13. Screw the drain (Ref. 3) 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 (Ref. 7). Tighten the element 72 lbf·in (820 N·cm).
17. Connect the wiring connector to the water sensor probe.
18. Start the engine and check for leaks. Repair any leaks.

Heater Element Replacement

19. Return the cab to the operating position, and remove the chocks from the tires.

Replacement

1. Apply the parking brakes, chock the tires, and tilt the cab.
2. Drain the fuel/water separator.
   - 2.1 Disconnect the fuel lines from the separator, and mark the lines for reassembly.
   - 2.2 Place a suitable container under the separator.
   - 2.3 Turn the drain counterclockwise to remove it.
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.
13. Start the engine and check for leaks. Repair any leaks.
14. Return the cab to the operating position, and remove the chocks from the tires.

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

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.

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 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.

Standard equipment includes a fuel level gauge sender in the primary tank, with an electric fuel level gauge mounted in the cab instrument panel.

Fuel Tank Removal and Installation

Removal (See Fig. 1 or Fig. 2)

If there is any damage to the fuel tank, replace it.

IMPORTANT: Fuel tanks made after January 1, 1973, are subject to U.S. Federal Motor Carrier Safety Regulation 393.67. This law calls for certain standards relating to strength, leakage, and venting. These standards are achieved through the use of specific materials and construction methods. *These standards also apply to replacement fuel tanks.*

1. Park the vehicle on level ground. Apply the parking brakes and chock the tires.

⚠ WARNING

Do not expose the fuel to, or work with the fuel system near, open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.

NOTE: Dual suction/dual return fuel systems are not equipped with shut-off valves.

2. 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.

3. 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.

4. If removing a single or primary tank, disconnect the wires from the fuel level gauge sender. See **Fig. 3.**

5. Remove the tank straps and isolators. See **Fig. 4**.

   5.1 Remove the nuts and washers from the tank strap T-bolts at the outboard end of the tank brackets.

   5.2 Remove the cotter pins and clevis pins from the inboard end of the tank straps. Remove the tank straps and isolators.

6. Using a fork lift, remove the fuel tank.

7. 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.

8. 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.

   8.1 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.

   8.2 Inspect the vent line, then transfer it to the new fuel tank.

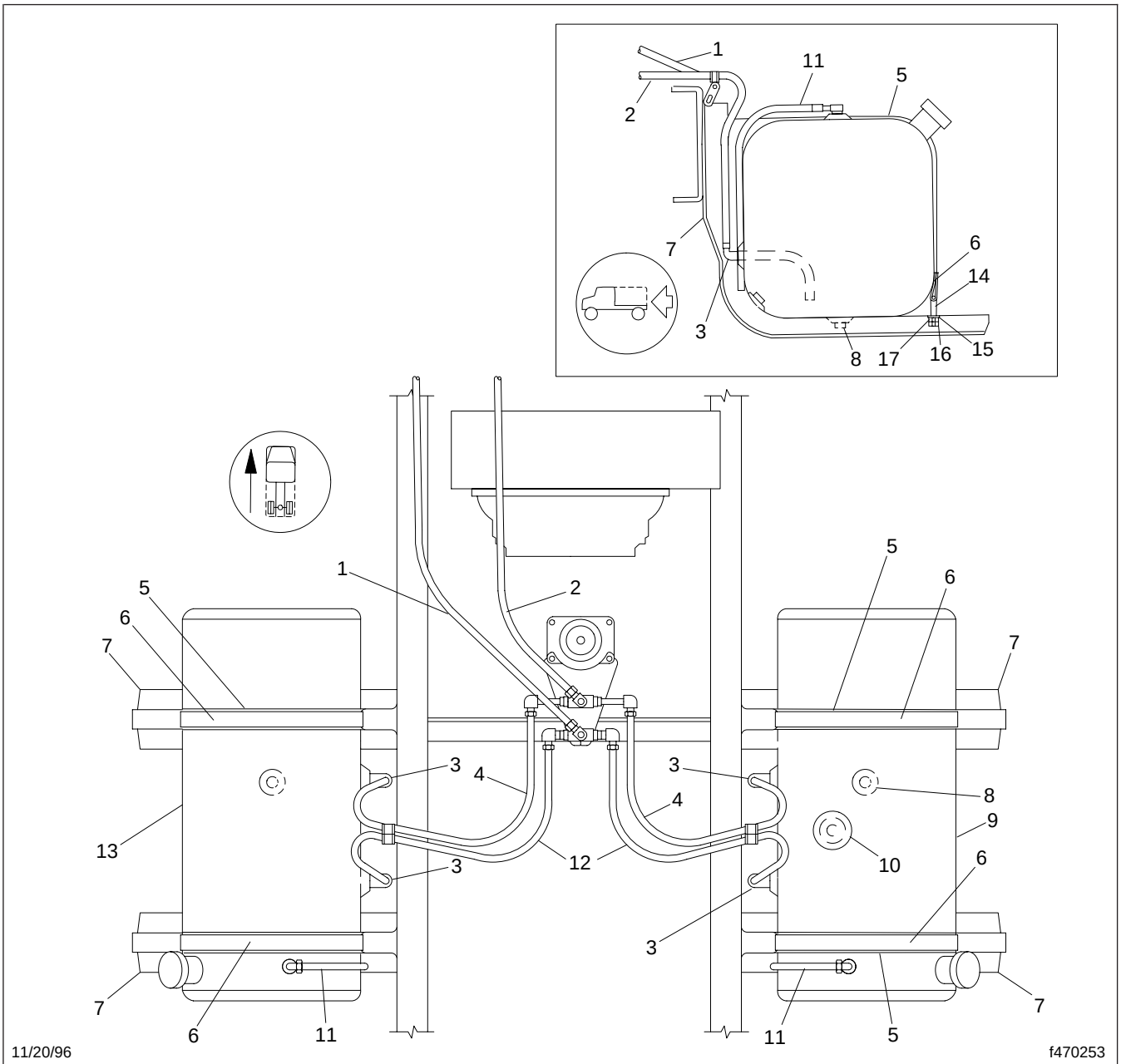
   8.3 If a single or primary fuel tank is being replaced, transfer the fuel level gauge sender and gasket to the new fuel tank. Install the machine screws until contact is made with the sender unit. Use a star pattern (see **Fig. 5**) to distribute the torque evenly around the sender unit.

Installation (See Fig. 6)

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.

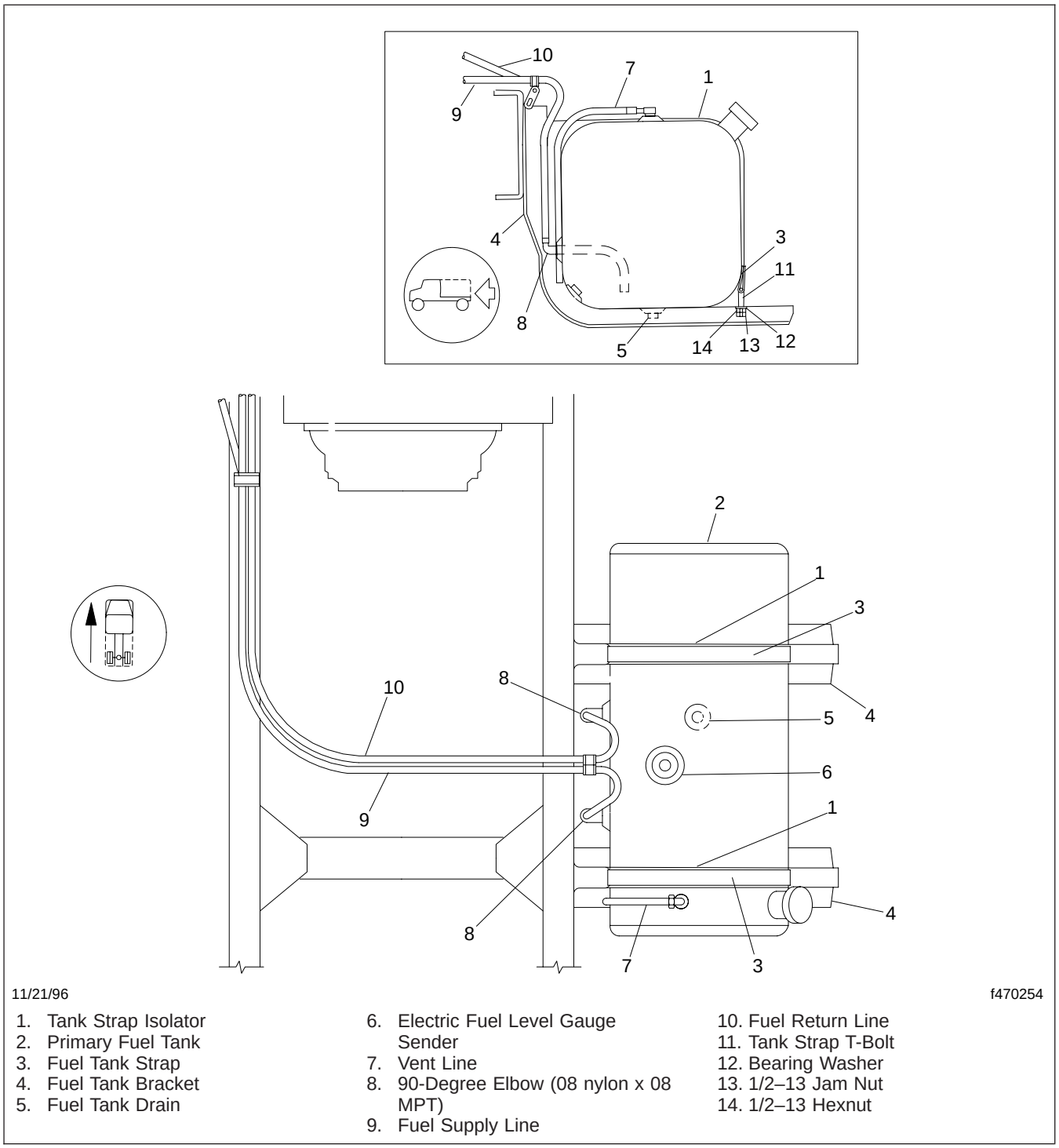
   Move the tank fore or aft until the distance from the front of the tank to the centerline of the for-

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

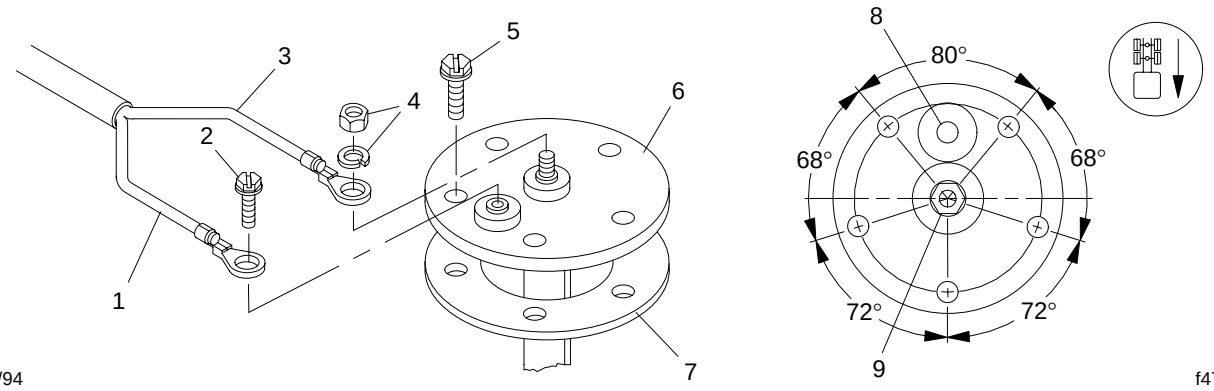
Fig. 1, Fuel Tank Installation with Dual Suction/Dual Return Fuel System (typical)



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
14. 1/2–13 Hexnut

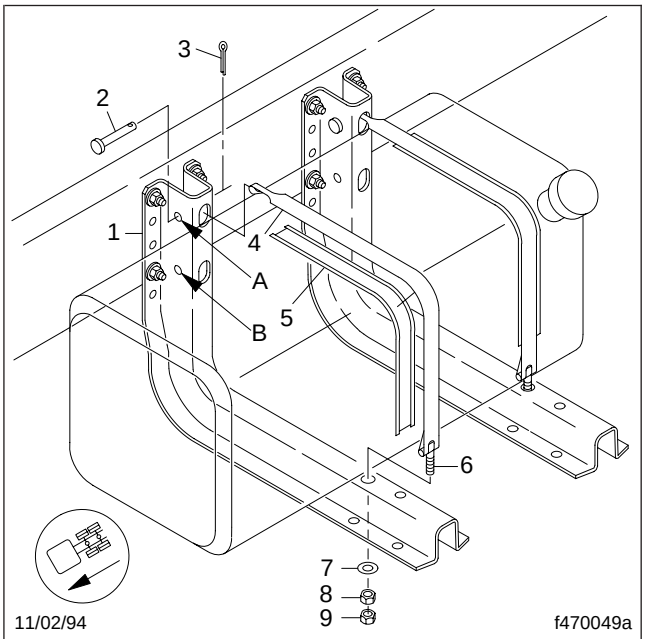
Fig. 2, Fuel Tank Installation with Single Suction/Single Return Fuel System (typical)

Fuel Tank Removal and Installation



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)

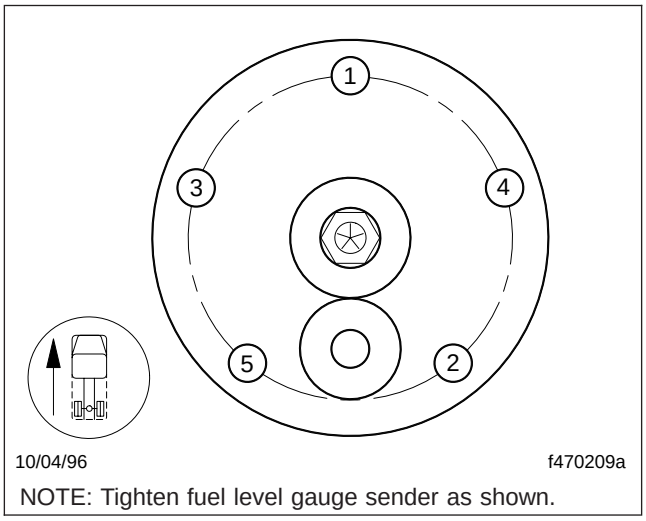
Fig. 3, Fuel Level Gauge Sender Installation



A. Use for 45-gallon short tank (shown) or 75-gallon tank.
B. Use for 45-gallon long 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. 4, Fuel Tank Brackets and Straps



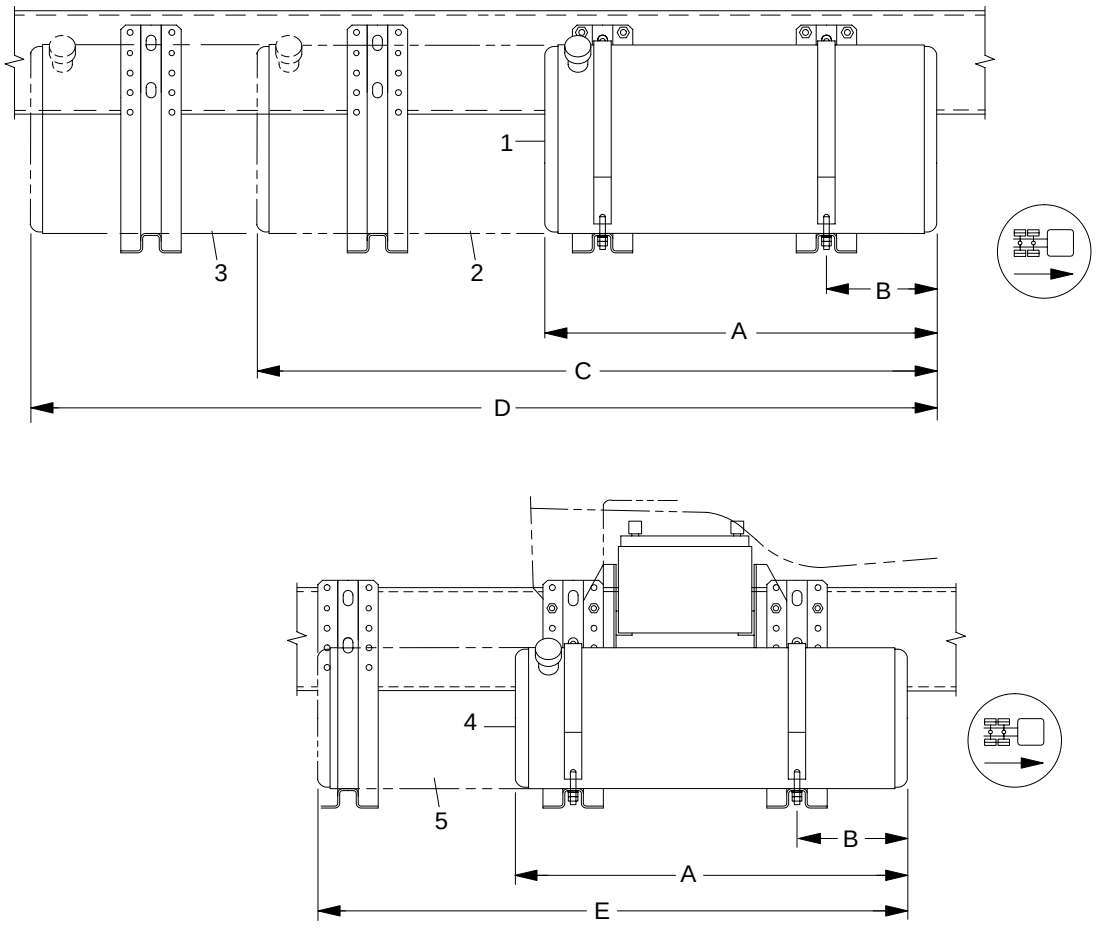
NOTE: Tighten fuel level gauge sender as shown.

Fig. 5, Electric Fuel Level Gauge Sender Tightening Sequence

ward tank bracket (Ref. B) is 10-13/16 ± 3/16 inches (275 ± 5 mm).

2. Install the isolators and tank straps. See **Fig. 4**.

   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.



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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. 6, Fuel Tank Positioning

⚠ CAUTION

Do not overtighten the fuel tank straps. To do so could damage the fuel tanks.

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 140** for general guidelines. Coat all tapered pipe plug and fitting threads with Loctite 592, or

Fuel Tank Removal and Installation

an equivalent sealer. Install pipe plugs in any remaining open threaded holes.

5. Add clean fuel to the fuel tank.
6. On a single suction/single return fuel system with dual fuel tanks, open the fuel shutoff valve.
7. Prime the engine fuel pump; see **Subject 150**.
8. Remove the tire chocks.

Replacement

1. Apply the vehicle parking brakes and chock the tires.
2. Remove the fuel tank strap and isolator.
   - 2.1 Remove the nuts and washer from the tank strap T-bolt at the outboard end of the tank bracket.
   - 2.2 Remove the cotter pin and clevis pin from the tank strap eye at the inboard end of the tank bracket.
3. Inspect the isolator and clevis pin for wear or damage; replace if needed.

⚠ 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.

4. Install the isolator and the new tank strap on the tank.
   - 4.1 Install the clevis pin through the inboard end of the tank bracket and tank strap. Install and lock a new cotter pin in the clevis pin.

⚠ CAUTION

Fuel tanks can be damaged by direct isolator pressure on the tank weld seam, and by overtightening the fuel tank bands. Be sure the weld seam aligns with relief in the isolators and that the bands are tightened to specification.

   - 4.2 Install a bearing washer and two nuts on the tank strap T-bolt. Tighten the first nut 15 lbf·ft (20 N·m).
   - 4.3 While holding the first nut stationary with a wrench, tighten the jam nut 30 lbf·ft (41 N·m).
5. Remove the tire chocks.

Replacement

1. Remove the fuel tank; refer to **Subject 100**.
2. If the fuel tank bracket has a compression brace attached, remove the locknut, washers, spacer, 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.
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 68 lbf·ft (92 N·m).
6. If a compression brace was attached to the bracket, install the capscrew, hardened washers, spacer, compression brace, and locknut. Tighten the locknut 68 lbf·ft (92 N·m).
7. Install the fuel tank; refer to **Subject 100**.

Replacement

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, and capscrews that attach the compression brace to the fuel tank brackets. Remove the compression brace.
4. Position the new compression brace. Install the capscrews, bearing washers, spacers, and locknuts, in the indicated mounting holes.
5. Tighten the locknuts 68 lbf·ft (92 N·m).
6. Install the clamps and fasteners that attach the fuel crossover line to the compression brace. Tighten the fasteners snugly.
7. Remove the chocks.

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.

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

Never fill fuel tanks to more than 95 percent of their liquid capacity. This could make them more likely to rupture from impact, possibly causing fire and resulting in serious personal injury or death by burning.

⚠ CAUTION

Don't crank the engine for more than 30 seconds at a time during any of the following procedures; wait two minutes after each try to allow the starter to cool. Failure to do so could cause starter damage.

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 5 psi (35 kPa) 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.

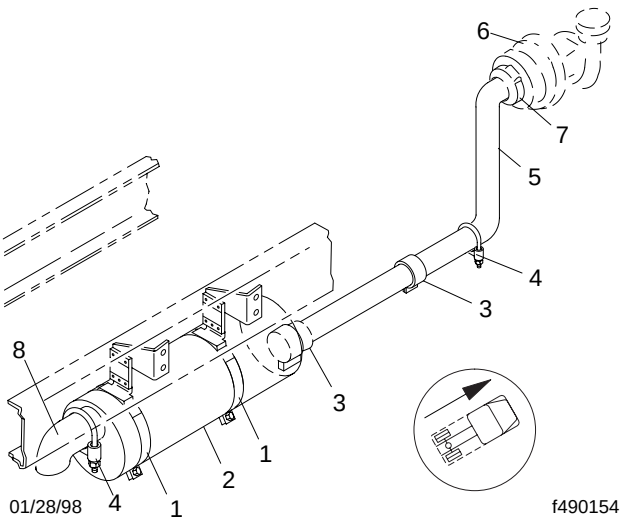
Specifications

Fastener Torques			
Description	**Size**	**Grade**	**Torque: lbf·ft (N·m)**
Cab-Access Step Bracket-to-Fuel Tank Bracket Locknut	3/8–16	C	28 (38)
Cab-Access Step Bracket-to-Fuel Tank Weldnut Capscrew	3/8–16	5	26 (35)
Cab-Access Step-to-Step Bracket Locknut	1/4–20	B	7 (10)
Chassis-Access Step Clamp Capscrew	3/8–16	5	26 (35)
Fuel Tank Strap T-Bolt:			
Hexnut	1/2–13	B	15 (20)
Jam Nut	1/2–13	B	30 (41)
Fuel Tank Bracket Mounting Locknut	1/2–13	C	68 (92)
Compression Brace Mounting Locknut	1/2–13	C	68 (92)

Table 1, Fastener Torques

General Information (See Fig. 1)

The exhaust system routes hot exhaust gas away from the cab, and reduces engine exhaust noise. Vehicles have a horizontally mounted muffler on either the left or right side of the vehicle, and have a horizontal outlet.



1. Muffler Mounting Band
2. Muffler
3. Wide-Band Exhaust Clamp
4. Saddle Clamp
5. Engine Outlet Exhaust Pipe
6. Turbocharger
7. V-Clamp
8. Tail Pipe

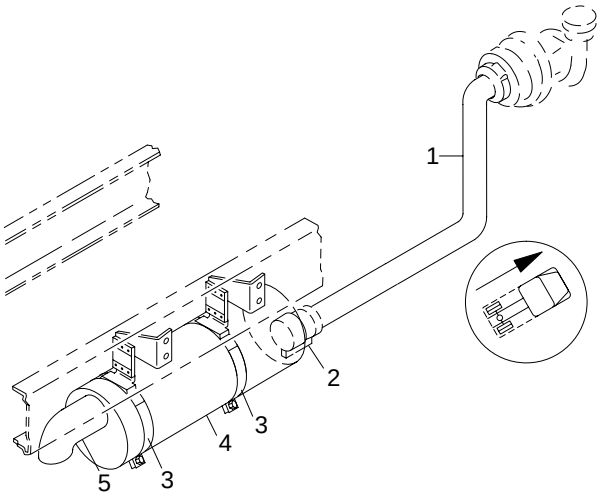
Fig. 1, Exhaust Mounting

System components include the engine outlet exhaust pipe, muffler, muffler mounting components, saddle clamps, and wide-band exhaust clamps.

The exhaust installation consists of an engine exhaust pipe, sometimes called the turbo pipe, mounted to the rear of the turbocharger and secured with a V-clamp. A wide-band clamp holds the exhaust pipe to the muffler.

A horizontal muffler hangs from brackets mounted inside the frame rail web. 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.

Replacement (See Fig. 1)



1. Muffler Mounting Band
2. Muffler
3. Wide-Band Exhaust Clamp
4. Muffler Inlet Exhaust Pipe
5. Saddle Clamp
6. Tail Pipe

Fig. 1, Exhaust System

1. Remove the muffler.
   - 1.1 Remove and discard the wide-band exhaust clamp from the muffler inlet connection.
   - 1.2 Remove the bolts and locknuts on the front and rear muffler mounting bands. Remove the mounting bands. Remove the muffler.
   - 1.3 Remove the saddle clamp on the tail pipe, and remove the tail pipe.
2. Install the new muffler.
   - 2.1 Slide the inlet tube on the new muffler 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.
   - 2.3 Coat the lap joint area with chassis grease, so the clamp will slide freely without scratching the surface of the pipe.
   - 2.4 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.
   - 2.5 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.
   - 2.6 Attach the tail pipe to the muffler and install the saddle clamp. Tighten the saddle clamp U-bolt 24 lbf·ft (33 N·m).
   - 2.7 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.
   - 2.8 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. 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.
3. 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 50 to 60 lbf·ft (68 to 81 N·m).
4. Run the engine, and check for exhaust leakage at the exhaust clamp joint. Replace the wide-band exhaust clamp if it leaks.

Specifications

Fastener Torques		
Description	**Size**	**Torque lbf·ft (N·m)**
Wide-Band Exhaust Clamp	—	50–60 (68–81)
Saddle Clamp U-Bolt	3/8–16	24 (33)

Table 1, Fastener Torques

General Information

To clean vehicle exhaust and reduce exhaust noise, a combined catalytic converter and muffler in the same housing is used.

Exhaust pipes route the exhaust from the engine to the catalytic converter. The converter consists of three sections: a muffler section, the catalytic converter, another muffler section.

Inside the converter (**Fig. 1**), a series of baffles dampens the noise of the exhaust by breaking the sound waves into shorter lengths. The exhaust is channeled through 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.

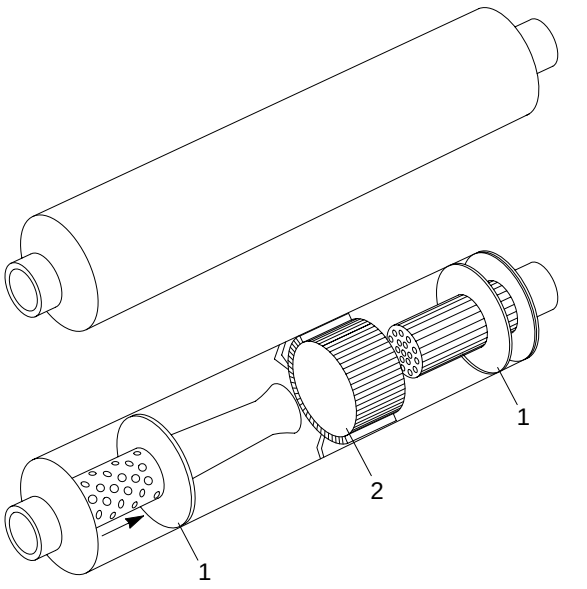


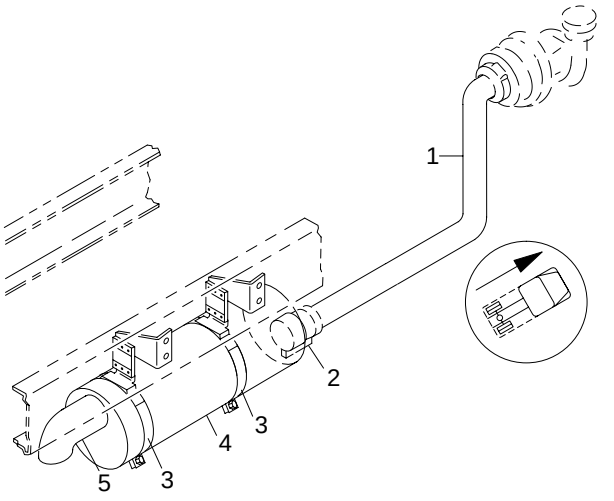
Fig. 1, Typical Catalytic Converter Muffler

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 20 lbs (9 kg), while a converter muffler the same size will weigh 33 lbs (15 kg). 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.

All catalytic muffler installations are certified to be in compliance with 1994 EPA standards. Use parts specified by PartsPro® when replacing any of the exhaust system components.

Catalytic Converter Muffler Replacement

Replacement (See Fig. 1)



1. Muffler Mounting Band
2. Muffler
3. Wide-Band Exhaust Clamp
4. Muffler Inlet Exhaust Pipe
5. Saddle Clamp
6. Tail Pipe

Fig. 1, Exhaust System

1. Remove the muffler.
   - 1.1 Remove and discard the wide-band exhaust clamp from the muffler inlet connection.
   - 1.2 Remove the bolts and locknuts on the front and rear muffler mounting bands. Remove the mounting bands. Remove the muffler.
   - 1.3 Remove the saddle clamp, and remove the tail pipe.
2. Install the new muffler.
   - 2.1 Slide the inlet tube on the new muffler 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.
   - 2.3 Coat the lap joint area with chassis grease, so the clamp will slide freely without scratching the surface of the pipe.
   - 2.4 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.
   - 2.5 Install the fasteners in the clamp. Starting from the larger end of the clamp, alternately tighten each 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.
   - 2.6 Attach the tail pipe to the muffler and install the saddle clamp. Tighten the saddle clamp U-bolt 24 lbf·ft (33 N·m).
   - 2.7 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.
   - 2.8 Run the engine, and check for exhaust leakage at the exhaust clamp joints. Replace the wide-band exhaust clamps if they leak.

Specifications

Fastener Torques		
Description	**Size**	**Torque lbf·ft (N·m)**
Wide-Band Exhaust Clamp	—	50–60 (68–81)
Saddle Clamp U-Bolt	3/8–16	24 (33)

Table 1, Fastener Torques

General Description

The instrument cluster consists of three dash panels. See **Fig. 1**. The right and left panels are attached at the top with quick-release fasteners. At the bottom, they are retained with tabs so that the panel can be tilted forward to allow access behind the panel.

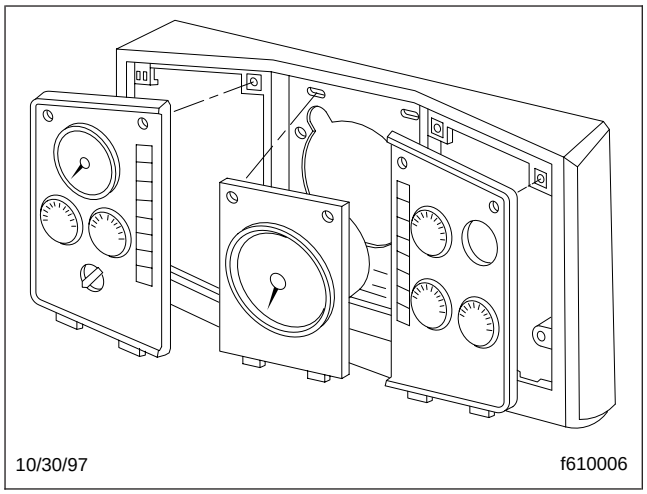
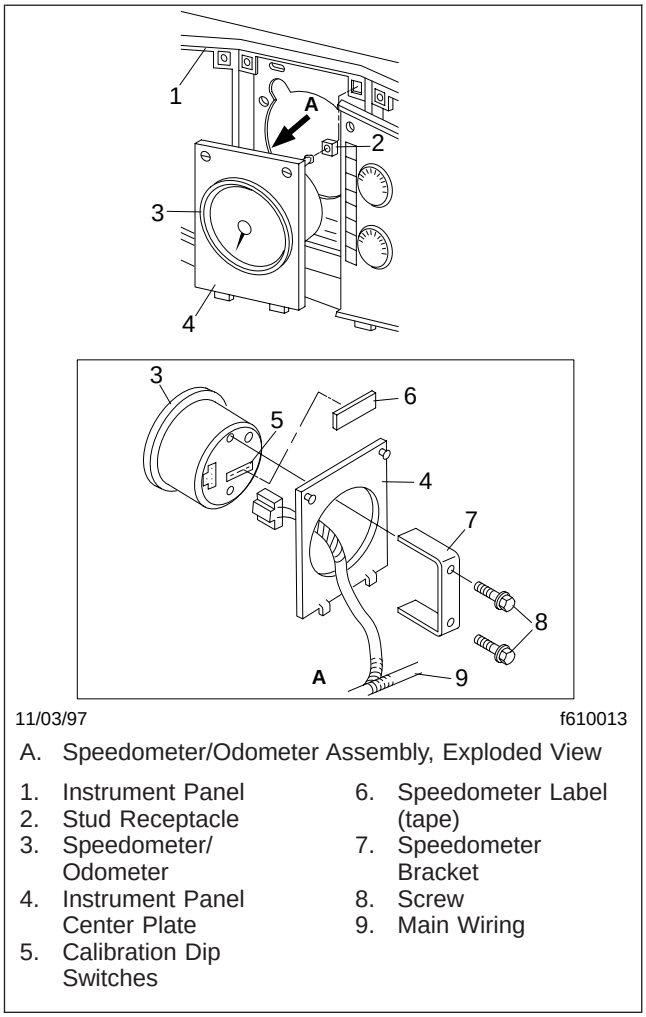


Fig. 1, Instrument Cluster (IC)

The center panel includes a speedometer and an odometer. See **Fig. 2**. The left panel contains a tachometer, an engine coolant temperature gauge, an oil pressure gauge, a set of warning lights, and a rotating switch knob for the front lights, taillights, and headlights. See **Fig. 3**. The right panel contains a fuel level gauge, an air pressure gauge, a voltmeter, and other warning lights. See **Fig. 4**.



A. Speedometer/Odometer Assembly, Exploded View

1. Instrument Panel
2. Stud Receptacle
3. Speedometer/ Odometer
4. Instrument Panel Center Plate
5. Calibration Dip Switches
6. Speedometer Label (tape)
7. Speedometer Bracket
8. Screw
9. Main Wiring

Fig. 2, Center Instrument Panel

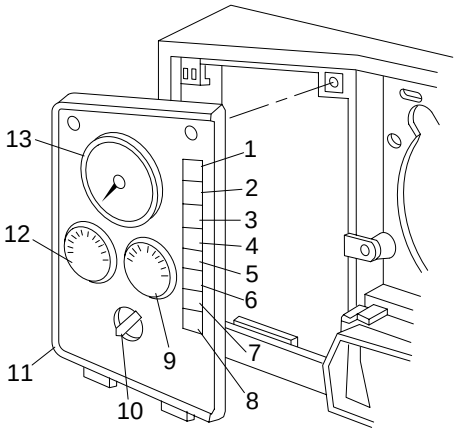
WARNING

Do not drive the vehicle when the low air pressure buzzer is sounding, or the low air pressure light is lit. These warnings indicate that there is not enough air pressure for the brake system to operate properly, which may lead to a loss of vehicle control resulting in personal injury or property damage.

The conditions monitored are low engine oil pressure, high engine coolant temperature, low coolant level, exhaust brake activation, air conditioning compressor temperature, high automatic transmission temperature (or DO NOT shift), antilock brake operation, low air pressure, parking brake, differential lockout activation, daytime running lights and cab lock.

These lights will turn on and remain on if any of these conditions exist, until the condition is corrected or the key is turned to the OFF position.

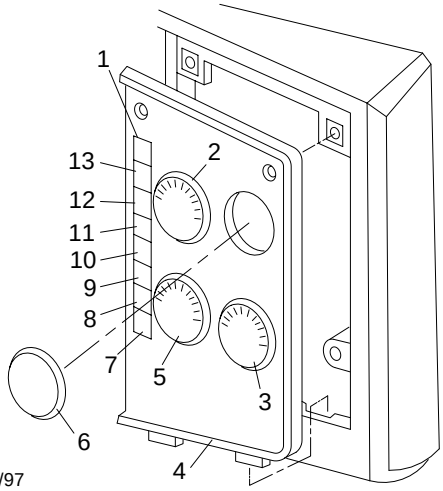
The low engine oil pressure, high engine coolant temperature, and low coolant level warning lights are accompanied by a warning chime and, in vehicles equipped with the engine shutdown system option, automatic engine shutdown.



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1. Turn Indicator (LH)
2. Low Oil Pressure Warning
3. High Coolant Temperature Warning Indicator
4. Low Coolant Level Warning Indicator
5. Wait to Start Indicator
6. Exhaust Brake Indicator
7. Blank
8. Transmission Temperature Warning Indicator
9. Oil Pressure Gauge
10. Headlight Switch
11. Panel (LH)
12. Coolant Temperature Gauge
13. Tachometer

Fig. 3, Left Instrument Panel



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1. Turn Indicator (RH)
2. Air Pressure Gauge
3. Voltmeter
4. Panel (RH)
5. Fuel Level Gauge
6. Instrument Cluster Opening Cover
7. Cab Lock Warning Indicator
8. Daytime Running Lights Indicator
9. Differential Lockout Indicator
10. Parking Brake Indicator
11. Brake Low Air Pressure Warning Indicator
12. ABS Indicator
13. High Beam Indicator

Fig. 4, Right Instrument Panel

Dash Instruments

FUEL LEVEL INDICATION SYSTEM

The fuel level indication system is an electromagnetic system and consists of a fuel indicator gauge mounted in the instrument cluster (**Fig. 4**, Ref. 5) and a fuel level sensor located in the fuel tank. The system operates directly from battery voltage and indicates fuel level condition based on the variable resistance of the fuel level sensor.

The magnetic gauge movement consists of three primary coils, one of which is wound at a 90-degree angle to the other two. The coils form a magnetic field which varies in direction according to the variable resistance of the sending panel which is connected between two of them. A primary magnet, to which a shaft and pointer are attached, rotates to align to this primary field, resulting in pointer position.

NOTE: There is no adjustment, calibration, or maintenance required for this gauge.

The fuel level sensor consists of a variable screened resistor made up of a ceramic substrate. It is controlled by the action of an attached float in the fuel tank. When the fuel level is low, resistance in the fuel level sensor is high. When the fuel level is high, the resistance in the fuel level sensor is low. As the float moves from empty to full, the resistance will gradually and continuously decrease.

COOLANT TEMPERATURE INDICATION SYSTEM

The engine coolant temperature indication system is a magnetic gauge system (**Fig. 3**, Ref. 12). It consists of a magnetic engine coolant temperature gauge mounted in the instrument cluster and an engine coolant temperature sender panel.

The magnetic gauge movement consists of two primary coils, one of which is wound at a 90-degree

angle to the other. The coils form a magnetic field which varies in direction according to the variable resistance of the sender panel which is connected between them. A primary magnet, to which a shaft and pointer are attached, rotates to align to this primary field, resulting in pointer position.

NOTE: There is no adjustment, calibration or maintenance required for the gauge.

The high coolant temperature warning light (**Fig. 3**, Ref. 3) will come on to indicate a high engine temperature. If the light comes on, operate the engine at a low rpm (approximately 1000 rpm) for five minutes, then low idle for 30 to 60 seconds. Stop the engine and let it cool. This procedure allows a hot engine to cool gradually. Check the coolant level, following the instructions about care in removing the filler cap. If the engine coolant is low, add coolant gradually, with the engine running.

OIL PRESSURE INDICATION SYSTEM

A red indicator light (**Fig. 3**, Ref. 2) comes on and a buzzer sounds when the oil pressure is below a specified value. The light should come on when the key is first turned to the RUN position. The indicator light should go out after the engine is started, indicating that the oil pressure has reached a normal operating value.

The light is connected between the oil pressure switch panel (mounted on the engine) and the coil terminal of the ignition switch.

The direct reading engine oil pressure indicating system consists of an oil pressure gauge (**Fig. 3**, Ref. 9) mounted in the instrument cluster and a pressure tube connected to the engine. As the engine oil pressure increases, a Bourdon tube in the gauge deflects, causing the pointer to move.

CHARGE INDICATION SYSTEM

The voltmeter (**Fig. 4**, Ref. 3) is a gauge which measures the voltage potential at the battery to indicate the battery state of charge. The voltmeter is not adjustable and must be replaced if inoperative.

Voltage applied across the terminals of the battery voltage gauge causes a gauge movement response proportional to the input. This positions the gauge pointer to indicate the appropriate voltage.

NOTE: There is no adjustment calibration or maintenance required for this gauge.

AIR PRESSURE GAUGE

The air pressure gauge (**Fig. 4**, Ref. 2) shows the amount of air pressure in the brake system (green/primary and red/secondary) in pounds per square inch (psi). When the pressure is too low for normal brake operation, less than 60 psi (414 kPa), and when the key is turned to the RUN position, a warning buzzer sounds and the warning light comes on. All vehicles have a dual-pointer air pressure gauge to indicate the pressure in each of the two brake circuits.

SPEEDOMETER

The speedometer indicates the speed at which the vehicle is traveling. See **Fig. 2**.

ODOMETER

The odometer indicates the total distance the vehicle has been driven. See **Fig. 2**.

NOTE: The mileage on replacement speedometer/odometers cannot be reset. If a replacement speedometer/odometer is installed, a label recording the vehicle's mileage and date at the time of the speedometer/odometer replacement must be attached to the driver's door jamb.

PROGRAMMABLE SPEEDOMETER/ODOMETER PANEL

The programmable electric speedometer/odometer is standard on all Cargo vehicles. The instrument features an analog air-core meter movement for speed indication and a digital stepper motor to drive the odometer.

The instrument panel receives electrical pulses from a vehicle speed sensor (VSS). The sensor detects the teeth of a 16-tooth interrupter mounted in most transmissions or signal generator mounted in the rear of some automatic transmissions. These electrical pulses are converted to an analog speedometer/odometer display. The speedometer is designed so

that the pointer will not return to zero with the key off. This should never be interpreted as a damaged panel.

Only a single external adjustment is necessary to calibrate both the speedometer and odometer. There is a 10-position DIP switch for this calibration.

TRIP ODOMETER

The trip odometer registers distance driven and can be reset to zero by depressing the button.

TACHOMETER

The electric tachometer (**Fig. 3**, Ref. 13) features an analog air core meter movement indicating engine speed in revolutions per minute (rpm). The tachometer has few moving mechanical parts.

The tachometer receives electrical pulses from a vehicle speed sensor (VSS). The VSS is mounted in the flywheel housing. It reads engine rpm. The electrical pulses are converted to an analog tachometer display.

NOTE: The tachometer pointer will not return to zero with the key off. This should never be interpreted as an inoperative condition.

There is only one electrical adjustment. An eight-position DIP switch is necessary for engine calibration.

Warning Indicators

ANTILOCK BRAKES

The antilock brake system uses one amber ABS warning light (**Fig. 4**, Ref. 12) to alert the driver of malfunctions in the system.

The amber ABS warning light will come on for numerous reasons. It warns the driver that the ABS has been disabled. Normal power-assisted braking remains but the wheels can lock during a panic stop while the indicator is on. To correct the problem, refer to **Group 42** for diagnosis and testing of the system.

LOW OIL PRESSURE

The low oil pressure light (**Fig. 3**, Ref. 2) will come on to indicate low engine oil pressure. If the light comes on while the engine is running, there is a loss of pressure. If this occurs, stop your vehicle as soon as possible, turn off the engine and check the oil level. Add oil if necessary.

LOW COOLANT

All vehicles equipped with diesel engines have a low coolant warning system with a red indicator light (**Fig. 3**, Ref. 4). If this light comes on, correct the low coolant condition immediately. Refer to **Group 20** for instructions.

HIGH BEAM

The high beam indicator light (**Fig. 4**, Ref. 13) will come on when the headlights are operating on high beam. To change your headlights from low to high beam or high to low beam pull the turn signal lever away from the instrument panel.

TURN SIGNALS

The left-hand/right-hand turn indicator will flash when the turn signal lever is pushed up for a right turn (**Fig. 4**, Ref. 1) and down for a left turn (**Fig. 3**, Ref. 1).

COOLANT TEMPERATURE

The coolant temperature light (**Fig. 3**, Ref. 3) will come on to indicate a high engine coolant temperature. If the light comes on, operate the engine at 1000 rpm for five minutes, then low idle for 30 to 60 seconds. Stop the engine and let it cool. This procedure allows a hot engine to cool gradually.

Check the coolant level. Refer to **Group 20** for instructions. If the engine coolant is low, add coolant gradually, with the engine running.

TRANSMISSION TEMPERATURE

The transmission temperature light (**Fig. 3**, Ref. 8) comes on to indicate maximum transmission-to-cooler oil temperature of 300°F (149°C). Should the light come on, stop the vehicle and shift the transmission to neutral. Accelerate the engine to 1200 to 1500 rpm to allow the transmission to return to normal, 160 to 220°F (71 to 104°C), before resuming operation. Check transmission oil level and fill as needed.

WAIT TO START

When the wait to start indicator is illuminated (**Fig. 3**, Ref. 5), it indicates that the air intake (inlet manifold) heater is in operation.

EXHAUST BRAKE

The exhaust brake light (**Fig. 3**, Ref. 6) will illuminate when the engine exhaust brake is in the ON position.

LOW AIR

All vehicles are equipped with a low air pressure warning light (**Fig. 4**, Ref. 11). The air brake systems are split or dual systems. If there is a loss of air pressure to either system, to a level below 60 psi (414 kPa), the red warning light will illuminate and the buzzer will sound. The remaining brake system is capable of stopping the vehicle. However, the stopping distance will be greater.

DIFFERENTIAL LOCKOUT

The differential lockout indicator light (**Fig. 4**, Ref. 9) will come on when the differential lockout control and/or wheel to wheel lock is in the LOCK position. This light indicates that the lockout mechanism in the tandem rear axle is engaged to provide extra traction, or if the single axle wheel lock is engaged.

CAB LOCK

The cab lock indicator (**Fig. 4**, Ref. 7) will illuminate to warn you that the cab is not locked securely.

PARKING BRAKE

Whenever the parking brake is applied with the key in the RUN position, the parking brake warning light (**Fig. 4**, Ref. 10) will illuminate to warn you to release the parking brake before driving the vehicle.

DAYTIME RUNNING LIGHTS

If the daytime running lights indicator is on (**Fig. 4** Ref. 8), it indicates that the headlights are illuminated at reduced intensity for daytime driving.

Instrument Cluster Removal and Installation

Removal

1. Disconnect the battery ground cable.
2. Loosen the quick-release fasteners securing the left instrument cluster to the instrument panel.
3. Tilt the top of the cluster back and lift the cluster out of the instrument panel.
4. Disconnect the electrical wiring and the oil pressure tube and remove the cluster.
5. Loosen the quick-release fasteners securing the right instrument cluster to the instrument panel.
6. Tilt the top of the cluster back and lift the cluster out of the instrument panel.
7. Disconnect the electrical wiring and the air pressure tubes and remove the cluster.
8. Loosen the quick-release fasteners securing the center instrument cluster to the instrument panel.
9. Tilt the top of the cluster back and lift the cluster out of the instrument panel.
10. Disconnect the speedometer electrical connector and remove the cluster.

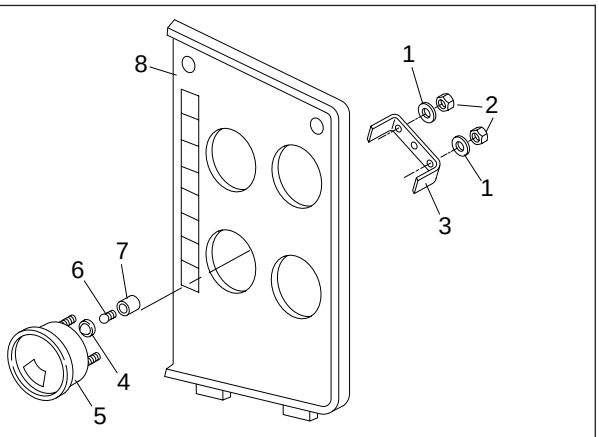
Installation

1. Connect the speedometer electrical connector in to the center instrument panel, and position the cluster in the panel.
2. Tilt the cluster down and secure it in the panel housing.
3. Tighten the quick release fasteners securing the center instrument cluster to the instrument panel.
4. Connect the electrical wiring and the air pressure tubes in to the right instrument panel, and position the cluster in to the panel.
5. Tilt the cluster down and secure it in the panel housing.
6. Tighten the quick release fasteners securing the right instrument cluster to the instrument panel.
7. Connect the electrical wiring and the oil pressure tube to the left instrument panel, and position the cluster in the instrument panel.
8. Tilt the cluster down and secure it in the panel housing.
9. Tighten the quick release fasteners securing the left instrument cluster to the instrument panel.
10. Connect the battery ground cable.

Fuel Gauge Removal and Installation

Removal

1. Disconnect the battery ground cable.
2. Turn the one-quarter turn fasteners and remove the right-hand instrument cluster. See **Fig. 1**.



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1. Washer
2. Nut
3. Mounting Support
4. Lens
5. Fuel Gauge
6. Bulb
7. Socket
8. Right-Hand Instrument Panel Plate Assembly

Fig. 1, Fuel Gauge Assembly (exploded view)

3. Disconnect the electrical connectors from the rear of the gauge assembly. Mark them for later replacement.
4. Remove the lamp and socket assembly.
5. Remove the two retaining nuts, the washers and the mounting support, then pull the fuel gauge through the front of the instrument panel.

Installation

1. Position the fuel gauge in the instrument panel. Install the mounting support, the two washers, and the retaining nuts.
2. Install the lamp and the socket assembly including the lens.
3. Connect the three terminal electrical connector wires to the rear of the fuel gauge.
4. Install the instrument cluster and tighten the one-quarter turn fasteners.
5. Connect the battery ground cable and check the operation of the fuel gauge.

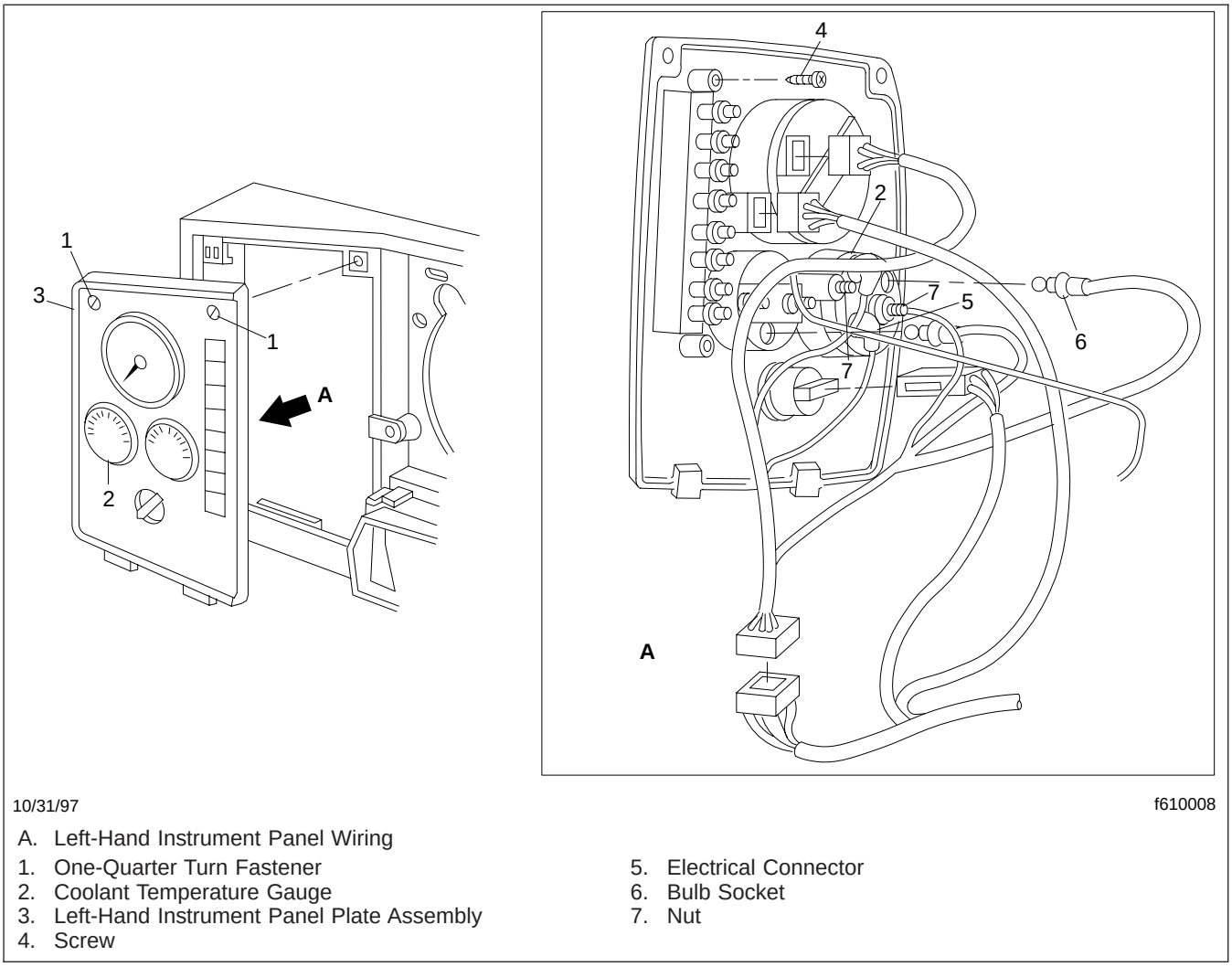
Temperature Gauge Removal and Installation

Removal (See Fig. 1)

1. Disconnect the battery ground cable.
2. Turn the one-quarter turn fasteners and remove the left instrument cluster.
3. Disconnect the electrical connectors from the rear of the gauge assembly. Mark them for later replacement.
4. Remove the lamp and socket assembly.
5. Remove the two retaining nuts and the washers, then pull the temperature gauge through the front of the instrument panel.

Installation

1. Position the temperature gauge in the instrument panel. Install the two washers and the retaining nuts.
2. Install the lamp and socket assembly including the lens.
3. Connect the three wires to the rear of the temperature gauge.
4. Install the instrument cluster. Turn the one-quarter turn fasteners.
5. Connect the battery ground cable.



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A. Left-Hand Instrument Panel Wiring
1. One-Quarter Turn Fastener
2. Coolant Temperature Gauge
3. Left-Hand Instrument Panel Plate Assembly
4. Screw
5. Electrical Connector
6. Bulb Socket
7. Nut

Fig. 1, Temperature Gauge, Left Instrument Cluster

Temperature Gauge Removal and Installation

6. Check the operation of the temperature gauge.

Oil Pressure Gauge Removal and Installation

Removal

1. Disconnect the battery ground cable.
2. Turn the one-quarter turn fasteners and remove the instrument cluster.
3. Remove the oil pressure tube from the back of the gauge.
4. Disconnect the illumination bulb and socket assembly. See **Fig. 1**.

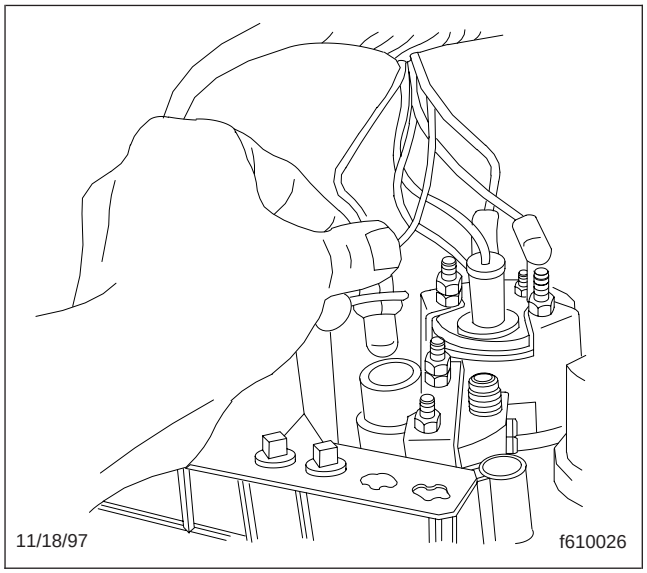


Fig. 1, Illumination Bulb and Socket Assembly

5. Remove the attaching nuts and clamp used to secure the oil pressure gauge. See **Fig. 2**.
6. Remove the gauge. See **Fig. 3**.

Installation

1. Position the oil pressure gauge in the cluster and install the clamp. See **Fig. 4**.
2. Secure the clamp to the gauge with the two attaching nuts.
3. Connect the oil pressure tube to the back of the gauge.
4. Install the illumination bulb and the socket assembly.
5. Install the instrument cluster assembly and secure by turning the one-quarter turn fasteners.

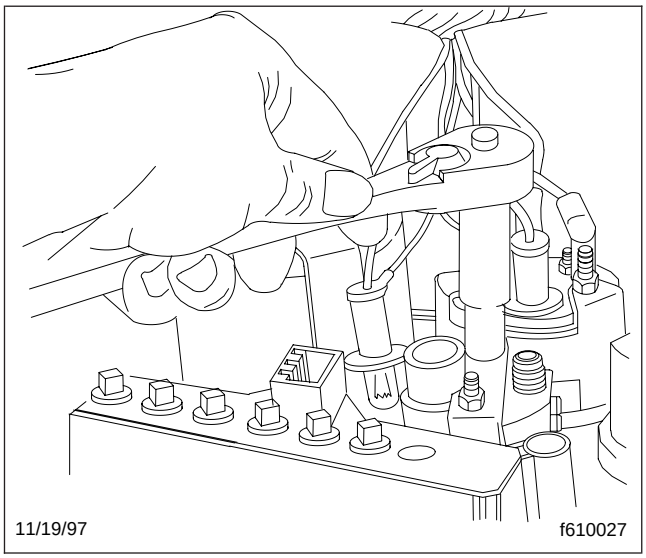


Fig. 2, Remove the Attaching Nuts and Clamp

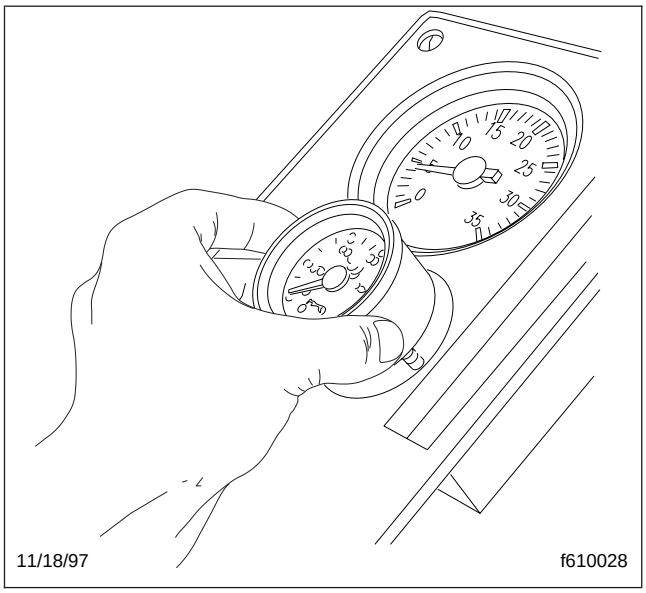
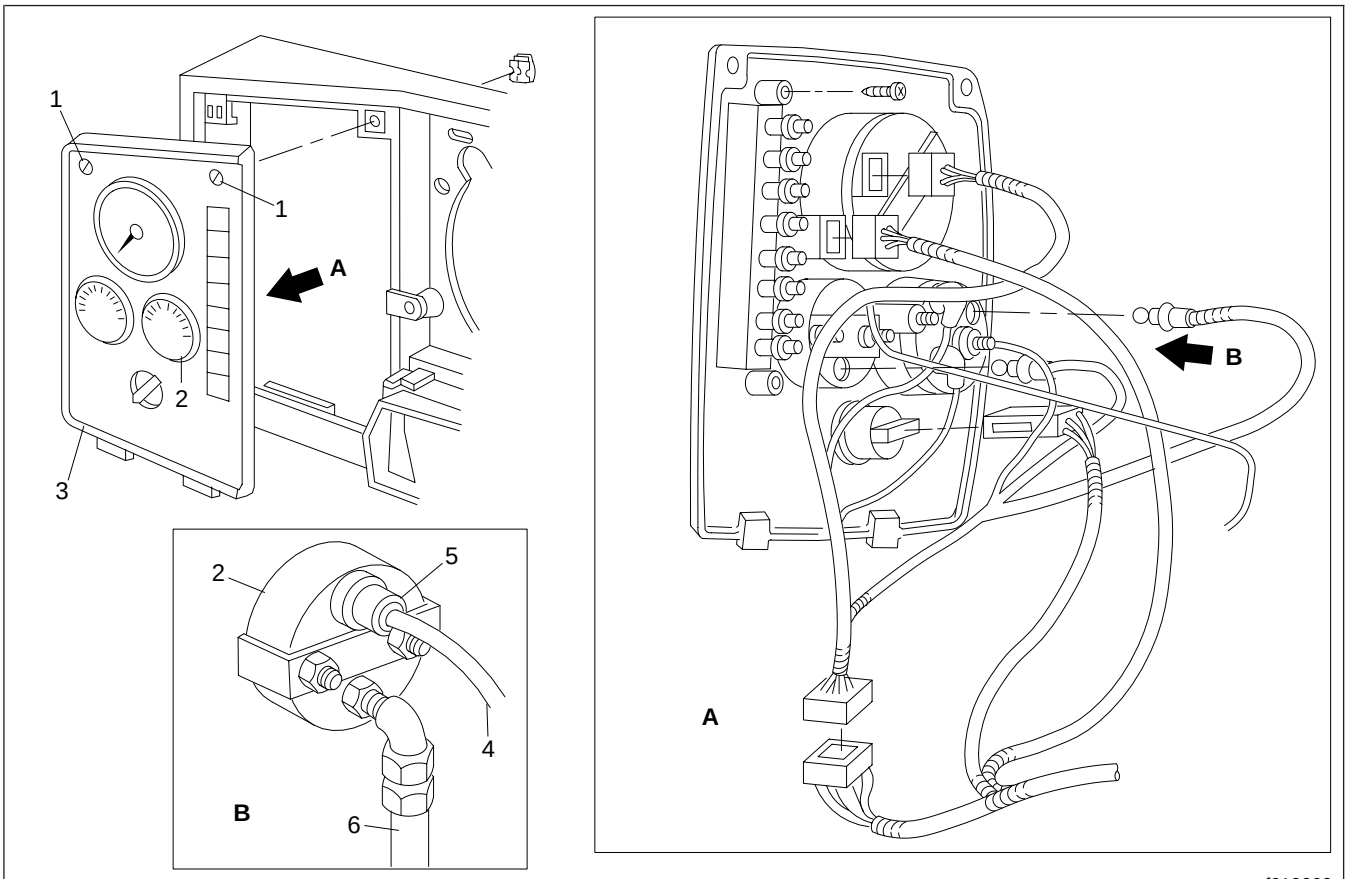


Fig. 3, Gauge Removal

6. Connect the battery ground cable.
7. Check the operation of the gauge.

Oil Pressure Gauge Removal and Installation



A. Left-Hand Instrument Panel Wiring
B. Oil Pressure Gauge Assembly

1. One-Quarter Turn Fasteners
2. Oil Pressure Gauge
3. Left-Hand Instrument Panel Plate Assembly
4. Wire Assembly
5. Bulb Socket
6. Oil Pressure Tube

Fig. 4, Oil Pressure Gauge, Left Instrument Cluster

Battery Voltage Gauge Removal and Installation

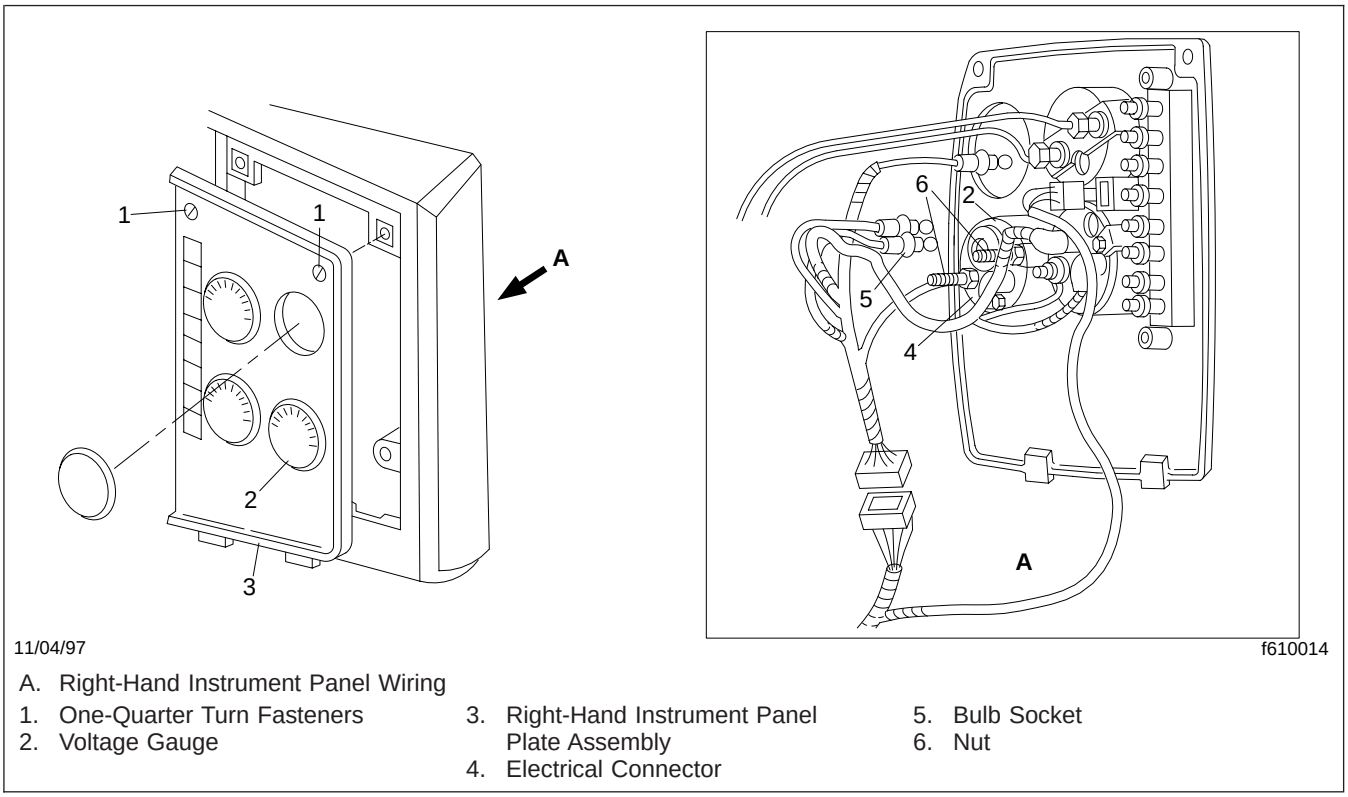
Removal

1. Disconnect the battery ground cable.
2. Turn the one-quarter turn fasteners and remove the right instrument panel assembly. See **Fig. 1**.
3. Remove the nuts securing the voltmeter to the clamp.
4. Disconnect the two wires at the gauge terminals.
5. Remove the illumination bulb and socket.
6. Remove the gauge from the instrument panel.

Installation

1. Position the gauge to the instrument panel and install the clamp.
2. Install the illumination bulb and socket.
3. Connect the two electrical wires at the gauge terminals and secure the clamp to the voltmeter with two attaching nuts.
4. Install the instrument panel assembly and tighten the fasteners.
5. Connect the battery ground cable.
6. Check the operation of the gauge.

Battery Voltage Gauge Removal and Installation



A. Right-Hand Instrument Panel Wiring
1. One-Quarter Turn Fasteners
2. Voltage Gauge
3. Right-Hand Instrument Panel Plate Assembly
4. Electrical Connector
5. Bulb Socket
6. Nut

Fig. 1, Battery Voltage Gauge, Right Instrument Panel

Speedometer/Odometer Removal and Installation

Removal

1. Disconnect the battery ground cable.
2. Remove the speedometer/odometer instrument panel by turning the one-quarter turn fasteners and pulling the top of the panel out. See **Fig. 1**.

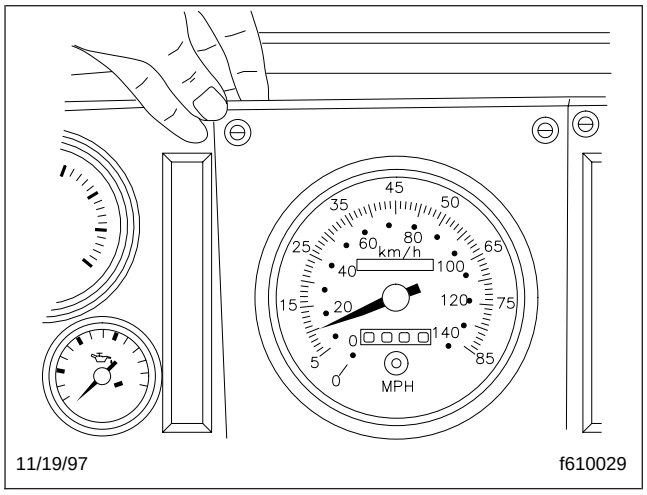
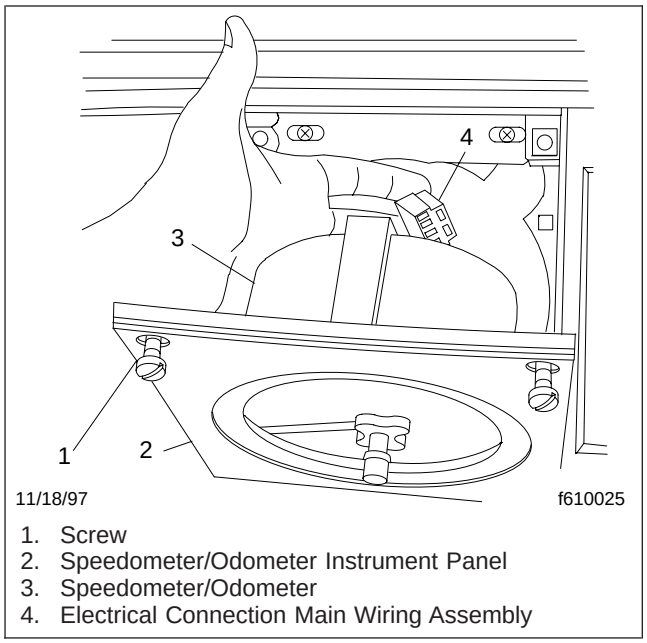


Fig. 1, Speedometer/Odometer Instrument Panel

3. Disconnect the electrical connection from the speedometer/odometer. See **Fig. 2**.



1. Screw
2. Speedometer/Odometer Instrument Panel
3. Speedometer/Odometer
4. Electrical Connection Main Wiring Assembly

Fig. 2, Speedometer/Odometer Main Wiring Assembly

4. Remove the speedometer from the cluster.

Installation

1. Position the speedometer in the cluster.
2. Connect the electrical connection to the speedometer/odometer.
3. Install the speedometer/odometer instrument panel and replace the one-quarter turn fasteners.
4. Connect the battery ground cable.

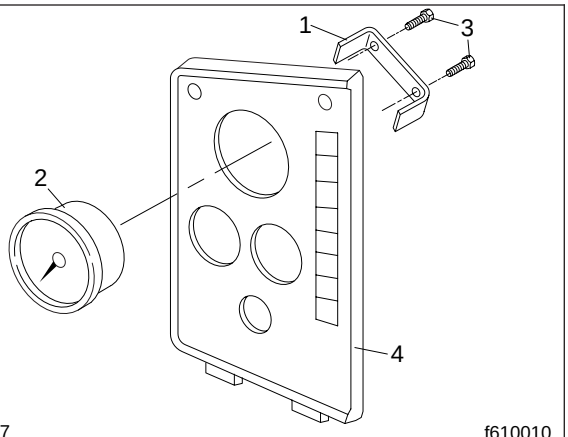
Tachometer Removal and Installation

Removal

1. Disconnect the battery ground cable. See **Fig. 1**.
2. Turn the one-quarter turn fasteners and remove the left hand instrument cluster.
3. Disconnect the tachometer electrical connector from the back of the tachometer.
4. Remove the mounting screws and the mounting support.
5. Remove the tachometer from the instrument cluster assembly.

Installation

1. Position the tachometer in the instrument cluster assembly.
2. Install the mounting screws and the mounting support.
3. Connect the tachometer electrical connector to the back of the tachometer.
4. Install the left hand instrument cluster, and turn the one-quarter turn fasteners.
5. Connect the battery ground cable.



1. Mounting Support
2. Tachometer
3. Screw
4. Plate Assembly

Fig. 1, Tachometer

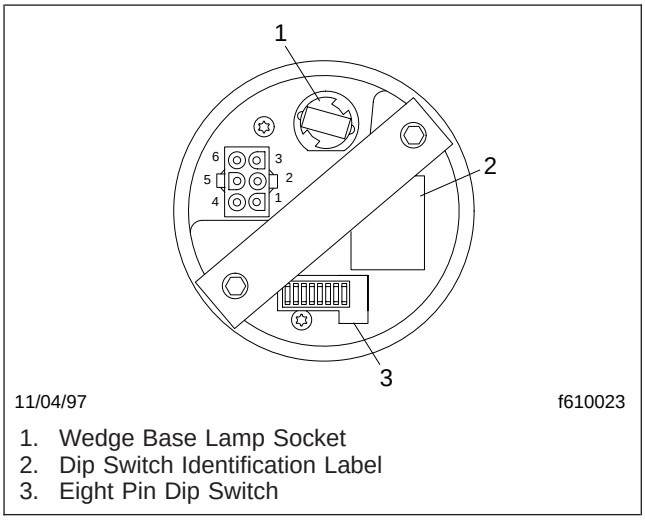
Adjustments

TACHOMETER CALIBRATION

(See Fig. 1)

The tachometer is calibrated according to engine type, specifically, the number of flywheel teeth. The tachometer can be calibrated by setting eight dip switches on back of the tachometer. The switches have the numbers 1 through 8 embossed on the switch. To calibrate the tachometer, the switches are set so each switch is either in the ON or OFF position, depending on the engine type. A switch is set to the ON position when the switch is depressed towards the number on top of the switch. A switch is set to the OFF position when the switch is depressed at the bottom of the switch, away from the switch number.

NOTE: Settings are shown on the tachometer case label.



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1. Wedge Base Lamp Socket
2. Dip Switch Identification Label
3. Eight Pin Dip Switch

Fig. 1, Tachometer Calibration

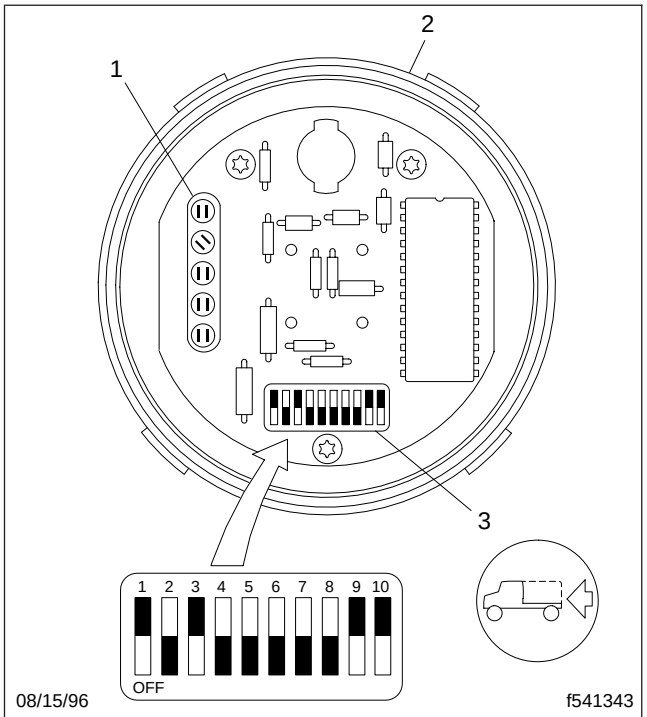
SPEEDOMETER HEAD CALIBRATION

Always calibrate a new speedometer head before installing it.

IMPORTANT: Use this procedure only for calibrating speedometers on mechanical engines, like the Cummins "B." The speedometer calibration setting on these engines is always the same: ON, OFF, ON, OFF, OFF, OFF, OFF, OFF, ON, ON. See **Fig. 2**.

1. Determine the pulses per mile (PPM).

   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.



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When the lower half of the switch is depressed, the switch is OFF. When the upper half of the switch is depressed, the switch is ON.

1. Connector
2. Speedometer Head
3. DIP Switch Panel

Fig. 2, DIP Switch Location

   1.2 Find the rear axle ratio (RAR) on the vehicle specification decal, or on the identification plate attached to the axle housing.

   1.3 Determine the number of teeth (T) on the tone wheel.

NOTE: The number of tone wheel teeth is normally 16.

Tachometer/Speedometer Calibration

1.4 Now, calculate the pulses per mile (PPM) using this formula:

PPM = Rev/mi x RAR x T

Explanation of abbreviations:

- Rev/mi = Tire revolutions per mile
- RAR = rear axle ratio
- T = number of tone wheel teeth

2. Determine the calibration settings for the speedometer.

2.1 Divide the PPM by 120 and round it off to the nearest whole number.

2.2 Find this value in the "PPM/120" column of the applicable table in **Specifications 400**.

2.3 Read across to find the corresponding calibration settings for each of the ten DIP switches.

Example: For a vehicles with a rear axle ratio of 4.11 and tires having 456 revolutions per mile, the calculations would be as follows:

456 x 4.11 x 16 = 29886.56 PPM

29886.56 ÷ 120 = 249.888 (rounded off, this becomes 250)

Look up "250" in the PPM/120 column in **Specifications 400**. Read off the settings: ON, OFF, ON, OFF, OFF, OFF, OFF, OFF, ON, ON.

3. Remove the speedometer head from the dash. For detailed instructions, see **Section 150**.

4. Set each of the ten DIP switches to the correct calibration settings. See **Fig. 2**.

4.1 Note the correct setting for each switch, either ON or OFF.

4.2 Using a tool that will not break off, depress the upper part of the rocker to set it to ON; depress the lower part to set it to OFF.

5. Install the speedometer head. For detailed instructions, see **Subject 150**.

Table 1: Symptom Chart		
Problem	**Possible Cause**	**Remedy**
Gauge Inoperative	If only one gauge inoperative.	Check fuse.
	Poor sending unit ground.	Ensure good ground.
	Worn or damaged fuel level sensor.	Replace sending unit.
	Worn or damaged gauge.	Replace gauge.
Gauge Inoperative	Worn or damaged fuel level sensor or poor ground.	Disconnect wire from sending unit. Connect sending unit lead through a 137-ohm resistor to ground. Gauge should read high. If it does, check sending unit ground. If OK, Replace sending unit.
	Open circuit in wiring.	Service as required.
	Worn or damaged gauge.	Service gauge.
High Coolant Temperature Warning Lamp Does Not Go Out (engine running)	Worn or damaged sending unit.	Perform electrical continuity check of wiring from switch. If wiring check is good, service as necessary.
	Engine cooling system.	Check engine cooling system.
	Short circuit.	Check circuit to ignition prove-out terminal. Service as required.
	Worn or damaged prove-out relay.	Check continuity of relay prove-out circuit. Service if necessary.
High Coolant Temperature Warning Lamp Does Not Light with Engine Cranking	Open circuit from ignition switch coil terminal to cluster circuit.	Turn key to run. Alternator and oil warning lamps should light. If not, service circuit wiring.
	Bulb burned out.	Replace bulb.
	Open circuit in wiring.	Perform electrical continuity check of wiring from switch. If wiring check is good, service as necessary.
	Worn or damaged prove-out relay.	Check continuity to relay and ignition switch. Replace units if necessary.

Troubleshooting

Table 1: Symptom Chart		
Problem	**Possible Cause**	**Remedy**
Brake Low Air Pressure Warning Buzzer Does Not Work	Worn or damaged low air pressure switch or poor ground.	Turn key to run. Disconnect wire to low air pressure switch and Connect to ground. Buzzer should work. If buzzer sounds, Check switch ground. If ground OK, replace switch.
	Open circuit between ignition switch coil connection to low air pressure warning buzzer.	Check for power at buzzer. If no power, service circuit as required.
	Worn or damaged low air pressure warning buzzer.	Replace buzzer.
Power Divider Differential Lockout Warning Lamp Will Not Light	Open circuit to differential lock out switch.	Check for power to switch. If no power, service open in circuit.
	Worn or damaged differential lock out switch.	Check continuity of switch. Replace if necessary.
	Open circuit between switch and bulb.	Check for power to warning bulb. If no power, service circuit.
	Bulb burned out.	Replace bulb.
Gauge Shows Full or Partial Tank When Tank Is Empty	Wrong fuel level sensor installed.	Check part number. Install correct fuel level sensor.
	Fuel level sensor arm is bent or obstructed.	Check fuel level sensor mounting angle. Bend fuel level sensor arm gently to correct position.
	Improper fuel level sensor calibration.	Test for correct resistance values and replace as needed.
		See **Table 2**.

Table 1: Symptom Chart		
Problem	**Possible Cause**	**Remedy**
Gauge Reads Full at All Fuel Levels	Short circuit the in wiring.	Check and service wiring and/or connectors as necessary.
	Fuel level sensor arm movement obstructed.	Check for correct part number and correct angle. Bend fuel level sensor arm gently away from obstruction or remove obstruction if possible.
		See **Table 2**.
Gauge Reading Fluctuates (Erratic) NOTE: Some needle movement toward empty during braking, accelerating or cornering is normal	Loose connection or damaged wiring.	Tighten all connections and terminations. Check and service wiring for shorts or opens.
	Wear spot on fuel level sensor variable resistor.	Check fuel level sensor for smooth electrical resistance change as arm is moved through full range. If resistance readings hesitate or jump, replace fuel level sensor.
	Leaking fuel level sensor float.	Replace float.
		See **Table 2**.

Troubleshooting

Table 1: Symptom Chart		
Problem	**Possible Cause**	**Remedy**
Fuel Gauge Shows Empty at All Levels of Fill	Loose or dirty wiring connections or short to ground in wiring.	Check wiring connectors and fuel level sensor terminals. Service, clean or tighten as needed.
	Leaking fuel level sensor float.	Replace float.
	Missing fuel level sensor float.	Install float. Make sure float is securely retained on fuel level sensor arm.
	Open circuit in fuel level sensor.	Test for correct resistance values and replace if needed.
	Fuel level sensor arm movement obstructed.	Reinstall fuel level sensor properly. Bend arm to correct position if needed.
	Short circuit in the wiring.	Check and service wiring and/or fuel level sensor as necessary.
		See **Table 2**.
Fuel Gauge Will Not Read Full When Tank Is Full	Wrong fuel level sensor installed.	Check part number. Install correct part.
	Fuel level sensor arm movement obstructed.	Reinstall fuel level sensor to correct operation. Bend fuel level sensor arm slightly away from obstruction or remove obstruction.
	Leaking float.	Install new float.
	Fuel level sensor or gauge calibration.	Test for correct resistance value and replace if needed.
		See **Table 2**.
Coolant Temperature Reads Inaccurately	Worn or damaged sending unit. Damaged gauge. Poor ground.	See **Table 3**.
Oil Pressure Reads Inaccurately	Plugged or kinked oil pressure line. Damaged gauge.	See **Table 4**.
Charge Indication Reads Inaccurately	Poor ground. Damaged gauge. Loose connections.	See **Table 5**.

Table 1: Symptom Chart		
Problem	**Possible Cause**	**Remedy**
Speedometer/Odometer Reads Inaccurately	Worn or damaged sending unit. Damaged gauge. Improperly calibrated gauge. Loose connections.	See **Table 6**.
Speedometer/Odometer Inoperative	Blown fuse. Worn or damaged sending unit. Damaged gauge.	See **Table 7**.
Tachometer Not Reflecting Engine Speed	Worn or damaged sending unit. Blown fuse. Damaged gauge.	See **Table 8**.
Antilock Warning Never/Always On	Blown fuse. Damaged indicator bulb. Worn or damaged sensor.	Refer to **Group 42** in this manual.

Table 1, Symptom Chart

Table 2: Fuel Level Reads Inaccurately		
Test Step	**Result**	**Action to Take**
Step 1, Verify Power At Fuse 11 (10A) Output Key to run. Using a Digital Volt-Ohmmeter, verify system voltage at the load side of fuse 11 (10A). Is the voltage greater than 10 volts?	Yes	Go to Step 3.
	No	Go to Step 2.
Step 2, Verify Power at Fuse 11 (10A) Input Using a Digital Volt-Ohmmeter, verify system voltage at the feed side of fuse 11 (10A). Is the voltage greater than 10 volts?	Yes	Replace the fuse. Retest the system.
	No	Service Circuit 16 (R/GN) for open. Retest system.
Step 3, Verify Power at Fuel Gauge Have fuel gauge connector(s) remain intact. Partially remove the fuel gauge from the instrument panel. Using a Digital Volt-Ohmmeter, measure the voltage on Circuit 640 (R/Y) at the fuel gauge connector to ground. Is the voltage greater than 10 volts?	Yes	Go to Step 4
	No	Service Circuit 640 (R/Y) for open. Retest system.
Step 4, Verify Ground Circuitry at Fuel Gauge **CAUTION: Before checking the continuity of any circuit, make sure there is no voltage present in the circuit prior to switching the test equipment to the resistance function, to avoid damage to equipment. Refer to the test equipment user's manual for additional information.** Using a Digital Volt-Ohmmeter, check the continuity of Circuit 57 (BK) at the fuel gauge connector to ground. Is the resistance less than 1 ohm?	Yes	Go to Step 5.
	No	Service Circuit 57 (BK) for open. Retest system.

Troubleshooting

Table 2: Fuel Level Reads Inaccurately		
Test Step	**Result**	**Action to Take**
Step 5, Check Fuel Gauge (EMPTY) Key off. Disconnect the fuel level sensor. Connect one lead of an Instrument Gauge System Tester to the fuel level sensor Circuit 286 (O) at fuel level sensor connector C412 and the other lead to ground. Set the tester to 240 ohms. Key to run. Wait one minute. Wait one minute. Does the fuel gauge read E (empty)?	Yes	Go to Step 7
	No	Go to Step 6.
Step 6, Recheck Fuel Gauge (EMPTY) Key off. Then key to run. Tap on the fuel gauge. Wait one minute. Read the fuel gauge. Does the fuel gauge read E (empty)?	Yes	Replace fuel gauge. Refer to Fuel Gauge in the Removal and Installation portion of this section. Retest system.
	No	Go to Step 7.
Step 7, Check the fuel level sensor circuit 286 (O)	Yes	Go to Step 8.
Key off. Disconnect the fuel gauge and the fuel level sensor. Measure the resistance of Circuit 286 (O) between the fuel gauge and the fuel level sensor. Is the resistance less than 5 ohms?	No	Service circuit 286 (O) for open between the fuel gauge and the fuel level sensor. Retest system.
Step 8, Check circuit 286 (O) for short to ground Leave fuel gauge and fuel level sensor disconnected. Measure the resistance of Circuit 286 (O) to chassis ground. Is the resistance less than 5 ohms?	Yes	Service Circuit 286 (O) for short to chassis ground. Retest system.
	No	Go to Step 9
Step 9, Check Fuel Level Sensor Ground Circuit 57 (BK)	Yes	Go to Step 10.
Measure the resistance of Circuit 57 (BK) at the fuel level sensor connector C412 to ground at battery. Is the resistance less than 1 ohm?	No	Service Circuit 57 (BK) for open between the fuel level sensor and ground.
Step 10, Check fuel gauge (FULL)	Yes	Go to Step 11.
Disconnect the fuel level sensor. Connect one lead of a Instrument Gauge System Tester to Circuit 286 (O) at the fuel level sensor connector C412 and the other lead to ground. Set the tester to 30 ohms. Key to run. Wait one minute. Read the fuel gauge. Does the fuel gauge read F (full)?	No	Replace fuel gauge. Refer to Fuel Gauge in the Removal and Installation portion of this section. Retest system.
Step 11, Fuel Tank Inspection Inspect fuel tank for distortion or damage. Is the fuel tank damaged?	Yes	Replace fuel tank. Refer to **Group 47** for instructions. Retest system.
	No	Go to Step 12.
Step 12, Test Box Check - Empty Stop	Yes	Go to Step 13.
Connect one lead of a a Digital Volt-Ohmmeter to the fuel level sensor signal lead, Circuit 286 (O) and the other lead to fuel level sensor ground, Circuit 57 (BK). Put the float rod against the empty stop (closest to fuel filter). Is the resistance 235-245 ohms?	No	Replace fuel level sensor. Refer to **Group 47** for instructions. Retest system.

Table 2: Fuel Level Reads Inaccurately		
Test Step	**Result**	**Action to Take**
Step 13, Test Box Check - Full Stop	Yes	Go to Step 14.
Connect one lead of a Digital Volt-Ohmmeter to the fuel level sensor signal lead, Circuit 286 (O) and the other lead to fuel level sensor ground, Circuit 57 (BK). Leave the float rod against the full stop. Is the resistance 30-35 ohms?	No	Replace fuel level sensor. Refer to **Group 47** for instructions. Retest system.
Step 14, Test Box Check - Float Rod Travel	Yes	Go to Step 15.
Connect one lead of a Digital Volt-Ohmmeter to the fuel level sensor signal lead, Circuit 286 (O) and the other lead to fuel level sensor ground, Circuit 57 (BK). Move float rod slowly from FULL to EMPTY stop position. Does ohmmeter reading increase slowly?	No	Replace fuel level sensor. Refer to **Group 47** for instructions. Retest system.
Step 15, Harness Connector Check - Empty Stop	Yes	Go to Step 16.
Reattach all fuel indication connectors. Move float rod to empty stop position. Wait 60 seconds. Read fuel gauge. Does gauge read empty?	No	Service harness connector for open. Retest system.
Step 16, Harness Connector Check - Full Stop	Yes	Replace fuel level sensor. Refer to **Group 47** for instructions. Retest system.
Move float rod to full stop position. Wait 60 seconds. Read fuel gauge. Does gauge read full?	No	Service harness connector for open. Retest system.

Table 2, Fuel Level Reads Inaccurately

Table 3: Coolant Temperature Reads Inaccurately		
Test Step	**Result**	**Action to Take**
Step 1, Check Other Gauges	Yes	Go to Step 2.
Check power to gauges. With key to run, observe other gauges and warning lamps for proper operation. If necessary, use voltmeter or test lamp to verify voltage at B+ terminal, Circuit 640 (R/Y), of gauge connector. Do other gauges and warning lamps operate correctly; voltage present at coolant temperature gauge?	No	Service Circuit 640 (R/Y), Fuse 11 (10A), Circuit 16 (R/GN), ignition switch, Circuit 37 (BK/Y), or fuse link A (14-gauge) for open. Retest system.
Step 2, Test Box Check, Cold	Yes	Go to Step 3.
Insert an Instrument Gauge System Tester in sensor circuit. Disconnect connector at sensor and connect tester between Circuit 39 (R/W) on gauge side of connector and chassis ground. Set tester to 74 ohms. Does gauge read C?	No	Go to Step 4.
Step 3, Test Box Check, Hot	Yes	Go to Step 4.
Set tester to 9.7 ohms. Does gauge read H?	No	Replace sensor. Retest system.

Troubleshooting

Table 3: Coolant Temperature Reads Inaccurately		
Test Step	**Result**	**Action to Take**
Step 4, Check Sensor Wiring	Yes	Replace gauge.
Check sensor circuit wiring for shorts or open with ohmmeter. Is wiring OK?	No	Service wiring.

Table 3, Coolant Temperature Reads Inaccurately

Table 4: Oil Pressure Reads Inaccurately		
Test Step	**Result**	**Action to Take**
Step 1, Check Oil Pressure Line	Yes	Replace gauge.
Verify that oil pressure line is not plugged, broken or kinked. Is line OK?	No	Replace oil pressure line.

Table 4, Oil Pressure Reads Inaccurately

Table 5: Charge Indication Reads Inaccurately		
Test Step	**Result**	**Action to Take**
Step 1, Check Voltage Gauge Operation Key to run (with engine stopped). Turn the headlamps on, and the heater blower/fan on HIGH. Does gauge pointer move toward lower voltage readings?	Yes	CHECK harness connections for corrosion or poor connection.
	No	Go to Step 2.
Step 2, Verify Power at Fuse 11 (10A) Output Using a Digital Volt-Ohmmeter, verify system voltage at load side, Circuit 640 (R/Y) of warning indicator Fuse 11 (10A). Is system voltage present at load side of Fuse 11 (10A)?	Yes	Go to Step 4.
	No	Go to Step 3.
Step 3, Verify Power at Fuse 11 (10A) Input Using a Digital Volt-Ohmmeter, verify system voltage at feed side, Circuit 16 (R/GN) of warning indicator Fuse 11 (10A). Is system voltage present at feed side of Fuse 11 (10A)?	Yes	Replace fuse. Retest system.
	No	Service Circuit 16 (R/GN), ignition switch, Circuit 37 (BK/Y), or fuse link A for open. Retest system.
Step 4, Verify Power at Voltage Gauge Partially remove voltage gauge from instrument panel. Using a Digital Volt-Ohmmeter, verify system voltage at voltage gauge terminal. Is voltage present at voltage gauge terminal?	Yes	Go to Step 5.
	No	Service Circuit 640 (R/Y) for open. Retest system.
Step 5, Verify Ground Circuitry at Voltage Gauge **CAUTION: Before checking the continuity of any circuit, make sure there is no voltage present in the circuit prior to switching the test equipment to the resistance function to avoid damage to equipment. Refer to the test equipment user's manual for additional information.** Using a Digital Volt-Ohmmeter, check continuity of voltage gauge ground Circuit 57 (BK). Is continuity present?	Yes	Replace gauge.
	No	Service Circuit 57 (BK) for open. Retest system.

Table 5, Charge Indication Reads Inaccurately

Table 6: Speedometer/Odometer Reads Inaccurately		
Test Step	**Result**	**Action to Take**
Step 1, Check Wiring Check for loose wiring connections at rear of transmission and at instrument panel. Are all wiring connections good?	Yes	Go to Step 2.
	No	Secure loose connections.
Step 2, Make Resistance Checks Remove instrument and make resistance and voltage checks at the 14401 wiring harness connector as follows: 1. Check the black ground wire pin to chassis ground, should read 1 ohm or less. 2. Check the pin resistance between the two sensor signal pins, should read 3500 ohms or less. 3. Reconnect battery. Key to run. Check for +12 volts at the positive pin — red wire with green stripe. Key off. Are resistance and voltage readings correct?	Yes	Go to Step 3.
	No	Condition is not in speedometer or sensor. Service wiring.
Step 3, Check VSS Sensor or Signal Generator Disconnect VSS sensor connection at rear of transmission. Connect voltmeter such as a Digital Volt-Ohmmeter, and 22 k ohm resistor across sensor output pins. Connect a jumper wire between sensor ground and chassis ground as shown in the test setup. Drive vehicle. Monitor voltmeter for VSS or signal generator output. Does voltage exceed normal operating range by 0.5-35.5 V RMS?	Yes	Go to Step 4.
	No	Condition is not in speedometer. Inspect VSS sensor for metal filings on the pole face. Remove metal filings from sensor. Verify that sensor air gap is between 0.010 inch and 0.080 inch (0.254 and 2.032 mm). If gap is OK, replace sensor.
Step 4, Check Speedometer Head Verify DIP switch setting, which is a function of rear axle ratio, tire size, manufacture, and tread type. Refer to Speedometer Calibration in **Subject 170** for instructions. Are DIP switch settings correct?	Yes	Replace speedometer. Record mileage on label supplied with replacement speedometer. Set dip switches and PLACE tape over switch opening. **CAUTION: To prevent damaging the speedometer, never use a screwdriver to set dip switches.**
	No	Set dip switches and replace tape over switch opening. **CAUTION: To prevent damaging the speedometer, never use a screwdriver to set dip switches.**

Table 6, Speedometer/Odometer Reads Inaccurately

Troubleshooting

Table 7: Speedometer/Odometer Inoperative		
Test Step	**Result**	**Action to Take**
Step 1, Check Fuse 11 (10A) and Fuse Link A	Yes	Go to **Table 6**, Step 1.
Check Fuse 11 (10A) and fuse link A. Are Fuse 11 (10A) and fuse link A OK?	No	Replace Fuse 11 (10A) and fuse link A. If speedometer remains inoperative, check for short circuit.

Table 7, Speedometer/Odometer Inoperative

Table 8: Tachometer Not Reflecting Engine Speed		
Test Step	**Result**	**Action to Take**
Step 1, Check Fuse	Yes	Go to Step 2.
Check Fuse. Is the fuse OK?	No	Replace fuse. If fuse blows again, check for short in circuit.
Step 2, Check Wiring	Yes	Go to Step 3.
Check for loose wiring connections in engine compartment and for loose wiring connections at the rear of the instrument, or damaged wiring. Is wiring OK?	No	Secure loose connections or service damaged wiring.
Step 3, Make Resistance Checks	Yes	Go to Step 4.
Remove instrument and make resistance and voltage checks at 14401 main wiring harness connector as follows: Disconnect battery. Check black ground wire pin to chassis ground — should read 1 ohm or less. Check resistance between the sensor signal (+) and the signal (-) pins — should read 1600 ohms or less. Reconnect battery cable. Key to run. Check for 12V at the positive pin (red wire with yellow stripe). Do resistances check OK?	No	Condition is not in tachometer or sensor. Service wiring.
Step 4, Check Tachometer Signal Generator	Yes	Go to Step 5.
Disconnect tachometer signal generator connector C119 at flywheel housing. Connect voltmeter and 22 k ohm resistor across sensor output pins. Ground negative voltmeter lead to chassis ground. Run engine. Monitor voltmeter output. Voltage should be between 0.5 V RMS to 35.5 V RMS over normal vehicle operating range. Is tachometer signal generator OK?	No	Condition is not in tachometer. Check tachometer signal generator air gap. If tachometer signal generator air gap is between 0.010 and 0.080 inch (0.254 and 2.032 mm), replace sensor.
Step 5, Check Tachometer	Yes	Replace tachometer.
Verify calibration switch setting, which is a function of engine type. Is switch setting correct?	No	Set dip switches at the rear of the tachometer. Refer to **Subject 170** for instructions.

Table 8, Tachometer Not Reflecting Engine Speed

Specifications

Coolant Temperature Indicator Sensor Specifications	
Item	**Specification**
Insulator Color Code	Black
Thread Pitch	3/8 x 18 NPTF
Sensor Resistance (engine cold)	74 Ohms
Sensor Resistance (engine hot)	9.7 Ohms

Table 1, Coolant Temperature Indicator Sensor Specifications

Torque Specifications				
Description	**lbf·ft**	**N·m**	**lbf·in**	**N·cm**
Coolant Temperature Indicator Sensor	8–10	11–14	—	—
Oil Pressure Gauge Switch	15–20	20–27	—	—
Oil Pressure Gauge Lines - 1/8-inch Pipe Line	10–15	14–20	—	—
Oil Pressure Gauge Lines - All Others	15–20	20–27	—	—
Oil Pressure Tube	—	—	62–115	700—1300

Table 2, Torque Specifications

Ametek Speedometer Calibration Settings, 58 to 92										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
58	ON	OFF	ON	OFF	OFF	OFF	ON	ON	ON	ON
59	OFF	OFF	ON	OFF	OFF	OFF	ON	ON	ON	ON
60	ON	ON	OFF	OFF	OFF	OFF	ON	ON	ON	ON
61	OFF	ON	OFF	OFF	OFF	OFF	ON	ON	ON	ON
62	ON	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	ON
63	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	ON
64	ON	ON	ON	ON	ON	ON	OFF	ON	ON	ON
65	OFF	ON	ON	ON	ON	ON	OFF	ON	ON	ON
66	ON	OFF	ON	ON	ON	ON	OFF	ON	ON	ON
67	OFF	OFF	ON	ON	ON	ON	OFF	ON	ON	ON
68	ON	ON	OFF	ON	ON	ON	OFF	ON	ON	ON
69	OFF	ON	OFF	ON	ON	ON	OFF	ON	ON	ON
70	ON	OFF	OFF	ON	ON	ON	OFF	ON	ON	ON
71	OFF	OFF	OFF	ON	ON	ON	OFF	ON	ON	ON
72	ON	ON	ON	OFF	ON	ON	OFF	ON	ON	ON
73	OFF	ON	ON	OFF	ON	ON	OFF	ON	ON	ON
74	ON	OFF	ON	OFF	ON	ON	OFF	ON	ON	ON
75	OFF	OFF	ON	OFF	ON	ON	OFF	ON	ON	ON

Specifications

Ametek Speedometer Calibration Settings, 58 to 92										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
76	ON	ON	OFF	OFF	ON	ON	OFF	ON	ON	ON
77	OFF	ON	OFF	OFF	ON	ON	OFF	ON	ON	ON
78	ON	OFF	OFF	OFF	ON	ON	OFF	ON	ON	ON
79	OFF	OFF	OFF	OFF	ON	ON	OFF	ON	ON	ON
80	ON	ON	ON	ON	OFF	ON	OFF	ON	ON	ON
81	OFF	ON	ON	ON	OFF	ON	OFF	ON	ON	ON
82	ON	OFF	ON	ON	OFF	ON	OFF	ON	ON	ON
83	OFF	OFF	ON	ON	OFF	ON	OFF	ON	ON	ON
84	ON	ON	OFF	ON	OFF	ON	OFF	ON	ON	ON
85	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	ON	ON
86	ON	OFF	OFF	ON	OFF	ON	OFF	ON	ON	ON
87	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	ON	ON
88	ON	ON	ON	OFF	OFF	ON	OFF	ON	ON	ON
89	OFF	ON	ON	OFF	OFF	ON	OFF	ON	ON	ON
90	ON	OFF	ON	OFF	OFF	ON	OFF	ON	ON	ON
91	OFF	OFF	ON	OFF	OFF	ON	OFF	ON	ON	ON
92	ON	ON	OFF	OFF	OFF	ON	OFF	ON	ON	ON

Table 3, Ametek Speedometer Calibration Settings, 58 to 92

Ametek Speedometer Calibration Settings, 93 to 125										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
93	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	ON	ON
94	ON	OFF	OFF	OFF	OFF	ON	OFF	ON	ON	ON
95	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON	ON	ON
96	ON	ON	ON	ON	ON	OFF	OFF	ON	ON	ON
97	OFF	ON	ON	ON	ON	OFF	OFF	ON	ON	ON
98	ON	OFF	ON	ON	ON	OFF	OFF	ON	ON	ON
99	OFF	OFF	ON	ON	ON	OFF	OFF	ON	ON	ON
100	ON	ON	OFF	ON	ON	OFF	OFF	ON	ON	ON
101	OFF	ON	OFF	ON	ON	OFF	OFF	ON	ON	ON
102	ON	OFF	OFF	ON	ON	OFF	OFF	ON	ON	ON
103	OFF	OFF	OFF	ON	ON	OFF	OFF	ON	ON	ON
104	ON	ON	ON	OFF	ON	OFF	OFF	ON	ON	ON
105	OFF	ON	ON	OFF	ON	OFF	OFF	ON	ON	ON
106	ON	OFF	ON	OFF	ON	OFF	OFF	ON	ON	ON
107	OFF	OFF	ON	OFF	ON	OFF	OFF	ON	ON	ON

Ametek Speedometer Calibration Settings, 93 to 125										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
108	ON	ON	OFF	OFF	ON	OFF	OFF	ON	ON	ON
109	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	ON	ON
110	ON	OFF	OFF	OFF	ON	OFF	OFF	ON	ON	ON
111	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	ON	ON
112	ON	ON	ON	ON	OFF	OFF	OFF	ON	ON	ON
113	OFF	ON	ON	ON	OFF	OFF	OFF	ON	ON	ON
114	ON	OFF	ON	ON	OFF	OFF	OFF	ON	ON	ON
115	OFF	OFF	ON	ON	OFF	OFF	OFF	ON	ON	ON
116	ON	ON	OFF	ON	OFF	OFF	OFF	ON	ON	ON
117	OFF	ON	OFF	ON	OFF	OFF	OFF	ON	ON	ON
118	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	ON	ON
119	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	ON	ON
120	ON	ON	ON	OFF	OFF	OFF	OFF	ON	ON	ON
121	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	ON	ON
122	ON	OFF	ON	OFF	OFF	OFF	OFF	ON	ON	ON
123	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON	ON	ON
124	ON	ON	OFF	OFF	OFF	OFF	OFF	ON	ON	ON
125	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON	ON	ON

Table 4, Ametek Speedometer Calibration Settings, 93 to 125

Ametek Speedometer Calibration Settings, 126 to 158										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
126	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	ON
127	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	ON
128	ON	ON	ON	ON	ON	ON	ON	OFF	ON	ON
129	OFF	ON	ON	ON	ON	ON	ON	OFF	ON	ON
130	ON	OFF	ON	ON	ON	ON	ON	OFF	ON	ON
131	OFF	OFF	ON	ON	ON	ON	ON	OFF	ON	ON
132	ON	ON	OFF	ON	ON	ON	ON	OFF	ON	ON
133	OFF	ON	OFF	ON	ON	ON	ON	OFF	ON	ON
134	ON	OFF	OFF	ON	ON	ON	ON	OFF	ON	ON
135	OFF	OFF	OFF	ON	ON	ON	ON	OFF	ON	ON
136	ON	ON	ON	OFF	ON	ON	ON	OFF	ON	ON
137	OFF	ON	ON	OFF	ON	ON	ON	OFF	ON	ON
138	ON	OFF	ON	OFF	ON	ON	ON	OFF	ON	ON
139	OFF	OFF	ON	OFF	ON	ON	ON	OFF	ON	ON

Specifications

Ametek Speedometer Calibration Settings, 126 to 158										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
140	ON	ON	OFF	OFF	ON	ON	ON	OFF	ON	ON
141	OFF	ON	OFF	OFF	ON	ON	ON	OFF	ON	ON
142	ON	OFF	OFF	OFF	ON	ON	ON	OFF	ON	ON
143	OFF	OFF	OFF	OFF	ON	ON	ON	OFF	ON	ON
144	ON	ON	ON	ON	OFF	ON	ON	OFF	ON	ON
145	OFF	ON	ON	ON	OFF	ON	ON	OFF	ON	ON
146	ON	OFF	ON	ON	OFF	ON	ON	OFF	ON	ON
147	OFF	OFF	ON	ON	OFF	ON	ON	OFF	ON	ON
148	ON	ON	OFF	ON	OFF	ON	ON	OFF	ON	ON
149	OFF	ON	OFF	ON	OFF	ON	ON	OFF	ON	ON
150	ON	OFF	OFF	ON	OFF	ON	ON	OFF	ON	ON
151	OFF	OFF	OFF	ON	OFF	ON	ON	OFF	ON	ON
152	ON	ON	ON	OFF	OFF	ON	ON	OFF	ON	ON
153	OFF	ON	ON	OFF	OFF	ON	ON	OFF	ON	ON
154	ON	OFF	ON	OFF	OFF	ON	ON	OFF	ON	ON
155	OFF	OFF	ON	OFF	OFF	ON	ON	OFF	ON	ON
156	ON	ON	OFF	OFF	OFF	ON	ON	OFF	ON	ON
157	OFF	ON	OFF	OFF	OFF	ON	ON	OFF	ON	ON
158	ON	OFF	OFF	OFF	OFF	ON	ON	OFF	ON	ON

Table 5, Ametek Speedometer Calibration Settings, 126 to 158

Ametek Speedometer Calibration Settings, 159 to 191										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
159	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF	ON	ON
160	ON	ON	ON	ON	ON	OFF	ON	OFF	ON	ON
161	OFF	ON	ON	ON	ON	OFF	ON	OFF	ON	ON
162	ON	OFF	ON	ON	ON	OFF	ON	OFF	ON	ON
163	OFF	OFF	ON	ON	ON	OFF	ON	OFF	ON	ON
164	ON	ON	OFF	ON	ON	OFF	ON	OFF	ON	ON
165	OFF	ON	OFF	ON	ON	OFF	ON	OFF	ON	ON
166	ON	OFF	OFF	ON	ON	OFF	ON	OFF	ON	ON
167	OFF	OFF	OFF	ON	ON	OFF	ON	OFF	ON	ON
168	ON	ON	ON	OFF	ON	OFF	ON	OFF	ON	ON
169	OFF	ON	ON	OFF	ON	OFF	ON	OFF	ON	ON
170	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	ON
171	OFF	OFF	ON	OFF	ON	OFF	ON	OFF	ON	ON

Ametek Speedometer Calibration Settings, 159 to 191										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
172	ON	ON	OFF	OFF	ON	OFF	ON	OFF	ON	ON
173	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	ON	ON
174	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	ON
175	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	ON
176	ON	ON	ON	ON	OFF	OFF	ON	OFF	ON	ON
177	OFF	ON	ON	ON	OFF	OFF	ON	OFF	ON	ON
178	ON	OFF	ON	ON	OFF	OFF	ON	OFF	ON	ON
179	OFF	OFF	ON	ON	OFF	OFF	ON	OFF	ON	ON
180	ON	ON	OFF	ON	OFF	OFF	ON	OFF	ON	ON
181	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	ON	ON
182	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	ON	ON
183	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF	ON	ON
184	ON	ON	ON	OFF	OFF	OFF	ON	OFF	ON	ON
185	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	ON	ON
186	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	ON
187	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	ON
188	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	ON	ON
189	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF	ON	ON
190	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON	ON
191	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON	ON

Table 6, Ametek Speedometer Calibration Settings, 159 to 191

Ametek Speedometer Calibration Settings, 192 to 224										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
192	ON	ON	ON	ON	ON	ON	OFF	OFF	ON	ON
193	OFF	ON	ON	ON	ON	ON	OFF	OFF	ON	ON
194	ON	OFF	ON	ON	ON	ON	OFF	OFF	ON	ON
195	OFF	OFF	ON	ON	ON	ON	OFF	OFF	ON	ON
196	ON	ON	OFF	ON	ON	ON	OFF	OFF	ON	ON
197	OFF	ON	OFF	ON	ON	ON	OFF	OFF	ON	ON
198	ON	OFF	OFF	ON	ON	ON	OFF	OFF	ON	ON
199	OFF	OFF	OFF	ON	ON	ON	OFF	OFF	ON	ON
200	ON	ON	ON	OFF	ON	ON	OFF	OFF	ON	ON
201	OFF	ON	ON	OFF	ON	ON	OFF	OFF	ON	ON
202	ON	OFF	ON	OFF	ON	ON	OFF	OFF	ON	ON
203	OFF	OFF	ON	OFF	ON	ON	OFF	OFF	ON	ON

Specifications

Ametek Speedometer Calibration Settings, 192 to 224										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
204	ON	ON	OFF	OFF	ON	ON	OFF	OFF	ON	ON
205	OFF	ON	OFF	OFF	ON	ON	OFF	OFF	ON	ON
206	ON	OFF	OFF	OFF	ON	ON	OFF	OFF	ON	ON
207	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF	ON	ON
208	ON	ON	ON	ON	OFF	ON	OFF	OFF	ON	ON
209	OFF	ON	ON	ON	OFF	ON	OFF	OFF	ON	ON
210	ON	OFF	ON	ON	OFF	ON	OFF	OFF	ON	ON
211	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	ON	ON
212	ON	ON	OFF	ON	OFF	ON	OFF	OFF	ON	ON
213	OFF	ON	OFF	ON	OFF	ON	OFF	OFF	ON	ON
214	ON	OFF	OFF	ON	OFF	ON	OFF	OFF	ON	ON
215	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	ON	ON
216	ON	ON	ON	OFF	OFF	ON	OFF	OFF	ON	ON
217	OFF	ON	ON	OFF	OFF	ON	OFF	OFF	ON	ON
218	ON	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	ON
219	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	ON
220	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	ON	ON
221	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	ON	ON
222	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	ON
223	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	ON
224	ON	ON	ON	ON	ON	OFF	OFF	OFF	ON	ON

Table 7, Ametek Speedometer Calibration Settings, 192 to 224

Ametek Speedometer Calibration Settings, 225 to 257										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
225	OFF	ON	ON	ON	ON	OFF	OFF	OFF	ON	ON
226	ON	OFF	ON	ON	ON	OFF	OFF	OFF	ON	ON
227	OFF	OFF	ON	ON	ON	OFF	OFF	OFF	ON	ON
228	ON	ON	OFF	ON	ON	OFF	OFF	OFF	ON	ON
229	OFF	ON	OFF	ON	ON	OFF	OFF	OFF	ON	ON
230	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	ON	ON
231	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF	ON	ON
232	ON	ON	ON	OFF	ON	OFF	OFF	OFF	ON	ON
233	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	ON	ON
234	ON	OFF	ON	OFF	ON	OFF	OFF	OFF	ON	ON
235	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	ON	ON

Ametek Speedometer Calibration Settings, 225 to 257										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
236	ON	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	ON
237	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	ON
238	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	ON
239	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	ON
240	ON	ON	ON	ON	OFF	OFF	OFF	OFF	ON	ON
241	OFF	ON	ON	ON	OFF	OFF	OFF	OFF	ON	ON
242	ON	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	ON
243	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	ON
244	ON	ON	OFF	ON	OFF	OFF	OFF	OFF	ON	ON
245	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	ON	ON
246	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON	ON
247	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON	ON
248	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	ON	ON
249	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	ON	ON
250	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON	ON
251	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON	ON
252	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON
253	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON
254	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON
255	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON
256	ON	ON	ON	ON	ON	ON	ON	ON	OFF	ON
257	OFF	ON	ON	ON	ON	ON	ON	ON	OFF	ON

Table 8, Ametek Speedometer Calibration Settings, 225 to 257

Ametek Speedometer Calibration Settings, 258 to 290										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
258	ON	OFF	ON	ON	ON	ON	ON	ON	OFF	ON
259	OFF	OFF	ON	ON	ON	ON	ON	ON	OFF	ON
260	ON	ON	OFF	ON	ON	ON	ON	ON	OFF	ON
261	OFF	ON	OFF	ON	ON	ON	ON	ON	OFF	ON
262	ON	OFF	OFF	ON	ON	ON	ON	ON	OFF	ON
263	OFF	OFF	OFF	ON	ON	ON	ON	ON	OFF	ON
264	ON	ON	ON	OFF	ON	ON	ON	ON	OFF	ON
265	OFF	ON	ON	OFF	ON	ON	ON	ON	OFF	ON
266	ON	OFF	ON	OFF	ON	ON	ON	ON	OFF	ON
267	OFF	OFF	ON	OFF	ON	ON	ON	ON	OFF	ON

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Ametek Speedometer Calibration Settings, 258 to 290										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
268	ON	ON	OFF	OFF	ON	ON	ON	ON	OFF	ON
269	OFF	ON	OFF	OFF	ON	ON	ON	ON	OFF	ON
270	ON	OFF	OFF	OFF	ON	ON	ON	ON	OFF	ON
271	OFF	OFF	OFF	OFF	ON	ON	ON	ON	OFF	ON
272	ON	ON	ON	ON	OFF	ON	ON	ON	OFF	ON
273	OFF	ON	ON	ON	OFF	ON	ON	ON	OFF	ON
274	ON	OFF	ON	ON	OFF	ON	ON	ON	OFF	ON
275	OFF	OFF	ON	ON	OFF	ON	ON	ON	OFF	ON
276	ON	ON	OFF	ON	OFF	ON	ON	ON	OFF	ON
277	OFF	ON	OFF	ON	OFF	ON	ON	ON	OFF	ON
278	ON	OFF	OFF	ON	OFF	ON	ON	ON	OFF	ON
279	OFF	OFF	OFF	ON	OFF	ON	ON	ON	OFF	ON
280	ON	ON	ON	OFF	OFF	ON	ON	ON	OFF	ON
281	OFF	ON	ON	OFF	OFF	ON	ON	ON	OFF	ON
282	ON	OFF	ON	OFF	OFF	ON	ON	ON	OFF	ON
283	OFF	OFF	ON	OFF	OFF	ON	ON	ON	OFF	ON
284	ON	ON	OFF	OFF	OFF	ON	ON	ON	OFF	ON
285	OFF	ON	OFF	OFF	OFF	ON	ON	ON	OFF	ON
286	ON	OFF	OFF	OFF	OFF	ON	ON	ON	OFF	ON
287	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	OFF	ON
288	ON	ON	ON	ON	ON	OFF	ON	ON	OFF	ON
289	OFF	ON	ON	ON	ON	OFF	ON	ON	OFF	ON
290	ON	OFF	ON	ON	ON	OFF	ON	ON	OFF	ON

Table 9, Ametek Speedometer Calibration Settings, 258 to 290

Ametek Speedometer Calibration Settings, 291 to 323										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
291	OFF	OFF	ON	ON	ON	OFF	ON	ON	OFF	ON
292	ON	ON	OFF	ON	ON	OFF	ON	ON	OFF	ON
293	OFF	ON	OFF	ON	ON	OFF	ON	ON	OFF	ON
294	ON	OFF	OFF	ON	ON	OFF	ON	ON	OFF	ON
295	OFF	OFF	OFF	ON	ON	OFF	ON	ON	OFF	ON
296	ON	ON	ON	OFF	ON	OFF	ON	ON	OFF	ON
297	OFF	ON	ON	OFF	ON	OFF	ON	ON	OFF	ON
298	ON	OFF	ON	OFF	ON	OFF	ON	ON	OFF	ON
299	OFF	OFF	ON	OFF	ON	OFF	ON	ON	OFF	ON

Ametek Speedometer Calibration Settings, 291 to 323										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
300	ON	ON	OFF	OFF	ON	OFF	ON	ON	OFF	ON
301	OFF	ON	OFF	OFF	ON	OFF	ON	ON	OFF	ON
302	ON	OFF	OFF	OFF	ON	OFF	ON	ON	OFF	ON
303	OFF	OFF	OFF	OFF	ON	OFF	ON	ON	OFF	ON
304	ON	ON	ON	ON	OFF	OFF	ON	ON	OFF	ON
305	OFF	ON	ON	ON	OFF	OFF	ON	ON	OFF	ON
306	ON	OFF	ON	ON	OFF	OFF	ON	ON	OFF	ON
307	OFF	OFF	ON	ON	OFF	OFF	ON	ON	OFF	ON
308	ON	ON	OFF	ON	OFF	OFF	ON	ON	OFF	ON
309	OFF	ON	OFF	ON	OFF	OFF	ON	ON	OFF	ON
310	ON	OFF	OFF	ON	OFF	OFF	ON	ON	OFF	ON
311	OFF	OFF	OFF	ON	OFF	OFF	ON	ON	OFF	ON
312	ON	ON	ON	OFF	OFF	OFF	ON	ON	OFF	ON
313	OFF	ON	ON	OFF	OFF	OFF	ON	ON	OFF	ON
314	ON	OFF	ON	OFF	OFF	OFF	ON	ON	OFF	ON
315	OFF	OFF	ON	OFF	OFF	OFF	ON	ON	OFF	ON
316	ON	ON	OFF	OFF	OFF	OFF	ON	ON	OFF	ON
317	OFF	ON	OFF	OFF	OFF	OFF	ON	ON	OFF	ON
318	ON	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF	ON
319	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF	ON
320	ON	ON	ON	ON	ON	ON	OFF	ON	OFF	ON
321	OFF	ON	ON	ON	ON	ON	OFF	ON	OFF	ON
322	ON	OFF	ON	ON	ON	ON	OFF	ON	OFF	ON
323	OFF	OFF	ON	ON	ON	ON	OFF	ON	OFF	ON

Table 10, Ametek Speedometer Calibration Settings, 291 to 323

Ametek Speedometer Calibration Settings, 324 to 356										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
324	ON	ON	OFF	ON	ON	ON	OFF	ON	OFF	ON
325	OFF	ON	OFF	ON	ON	ON	OFF	ON	OFF	ON
326	ON	OFF	OFF	ON	ON	ON	OFF	ON	OFF	ON
327	OFF	OFF	OFF	ON	ON	ON	OFF	ON	OFF	ON
328	ON	ON	ON	OFF	ON	ON	OFF	ON	OFF	ON
329	OFF	ON	ON	OFF	ON	ON	OFF	ON	OFF	ON
330	ON	OFF	ON	OFF	ON	ON	OFF	ON	OFF	ON
331	OFF	OFF	ON	OFF	ON	ON	OFF	ON	OFF	ON

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Ametek Speedometer Calibration Settings, 324 to 356										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
332	ON	ON	OFF	OFF	ON	ON	OFF	ON	OFF	ON
333	OFF	ON	OFF	OFF	ON	ON	OFF	ON	OFF	ON
334	ON	OFF	OFF	OFF	ON	ON	OFF	ON	OFF	ON
335	OFF	OFF	OFF	OFF	ON	ON	OFF	ON	OFF	ON
336	ON	ON	ON	ON	OFF	ON	OFF	ON	OFF	ON
337	OFF	ON	ON	ON	OFF	ON	OFF	ON	OFF	ON
338	ON	OFF	ON	ON	OFF	ON	OFF	ON	OFF	ON
339	OFF	OFF	ON	ON	OFF	ON	OFF	ON	OFF	ON
340	ON	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON
341	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON
342	ON	OFF	OFF	ON	OFF	ON	OFF	ON	OFF	ON
343	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	OFF	ON
344	ON	ON	ON	OFF	OFF	ON	OFF	ON	OFF	ON
345	OFF	ON	ON	OFF	OFF	ON	OFF	ON	OFF	ON
346	ON	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	ON
347	OFF	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	ON
348	ON	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	ON
349	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	ON
350	ON	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	ON
351	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	ON
352	ON	ON	ON	ON	ON	OFF	OFF	ON	OFF	ON
353	OFF	ON	ON	ON	ON	OFF	OFF	ON	OFF	ON
354	ON	OFF	ON	ON	ON	OFF	OFF	ON	OFF	ON
355	OFF	OFF	ON	ON	ON	OFF	OFF	ON	OFF	ON
356	ON	ON	OFF	ON	ON	OFF	OFF	ON	OFF	ON

Table 11, Ametek Speedometer Calibration Settings, 324 to 356

Ametek Speedometer Calibration Settings, 357 to 389										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
357	OFF	ON	OFF	ON	ON	OFF	OFF	ON	OFF	ON
358	ON	OFF	OFF	ON	ON	OFF	OFF	ON	OFF	ON
359	OFF	OFF	OFF	ON	ON	OFF	OFF	ON	OFF	ON
360	ON	ON	ON	OFF	ON	OFF	OFF	ON	OFF	ON
361	OFF	ON	ON	OFF	ON	OFF	OFF	ON	OFF	ON
362	ON	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	ON
363	OFF	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	ON

Ametek Speedometer Calibration Settings, 357 to 389										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
364	ON	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	ON
365	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	ON
366	ON	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF	ON
367	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF	ON
368	ON	ON	ON	ON	OFF	OFF	OFF	ON	OFF	ON
369	OFF	ON	ON	ON	OFF	OFF	OFF	ON	OFF	ON
370	ON	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	ON
371	OFF	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	ON
372	ON	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	ON
373	OFF	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	ON
374	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	ON
375	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	ON
376	ON	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	ON
377	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	ON
378	ON	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF	ON
379	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF	ON
380	ON	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON
381	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON
382	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON
383	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON
384	ON	ON	ON	ON	ON	ON	ON	OFF	OFF	ON
385	OFF	ON	ON	ON	ON	ON	ON	OFF	OFF	ON
386	ON	OFF	ON	ON	ON	ON	ON	OFF	OFF	ON
387	OFF	OFF	ON	ON	ON	ON	ON	OFF	OFF	ON
388	ON	ON	OFF	ON	ON	ON	ON	OFF	OFF	ON
389	OFF	ON	OFF	ON	ON	ON	ON	OFF	OFF	ON

Table 12, Ametek Speedometer Calibration Settings, 357 to 389

Ametek Speedometer Calibration Settings, 390 to 422										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
390	ON	OFF	OFF	ON	ON	ON	ON	OFF	OFF	ON
391	OFF	OFF	OFF	ON	ON	ON	ON	OFF	OFF	ON
392	ON	ON	ON	OFF	ON	ON	ON	OFF	OFF	ON
393	OFF	ON	ON	OFF	ON	ON	ON	OFF	OFF	ON
394	ON	OFF	ON	OFF	ON	ON	ON	OFF	OFF	ON
395	OFF	OFF	ON	OFF	ON	ON	ON	OFF	OFF	ON

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Ametek Speedometer Calibration Settings, 390 to 422										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
396	ON	ON	OFF	OFF	ON	ON	ON	OFF	OFF	ON
397	OFF	ON	OFF	OFF	ON	ON	ON	OFF	OFF	ON
398	ON	OFF	OFF	OFF	ON	ON	ON	OFF	OFF	ON
399	OFF	OFF	OFF	OFF	ON	ON	ON	OFF	OFF	ON
400	ON	ON	ON	ON	OFF	ON	ON	OFF	OFF	ON
401	OFF	ON	ON	ON	OFF	ON	ON	OFF	OFF	ON
402	ON	OFF	ON	ON	OFF	ON	ON	OFF	OFF	ON
403	OFF	OFF	ON	ON	OFF	ON	ON	OFF	OFF	ON
404	ON	ON	OFF	ON	OFF	ON	ON	OFF	OFF	ON
405	OFF	ON	OFF	ON	OFF	ON	ON	OFF	OFF	ON
406	ON	OFF	OFF	ON	OFF	ON	ON	OFF	OFF	ON
407	OFF	OFF	OFF	ON	OFF	ON	ON	OFF	OFF	ON
408	ON	ON	ON	OFF	OFF	ON	ON	OFF	OFF	ON
409	OFF	ON	ON	OFF	OFF	ON	ON	OFF	OFF	ON
410	ON	OFF	ON	OFF	OFF	ON	ON	OFF	OFF	ON
411	OFF	OFF	ON	OFF	OFF	ON	ON	OFF	OFF	ON
412	ON	ON	OFF	OFF	OFF	ON	ON	OFF	OFF	ON
413	OFF	ON	OFF	OFF	OFF	ON	ON	OFF	OFF	ON
414	ON	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF	ON
415	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF	ON
416	ON	ON	ON	ON	ON	OFF	ON	OFF	OFF	ON
417	OFF	ON	ON	ON	ON	OFF	ON	OFF	OFF	ON
418	ON	OFF	ON	ON	ON	OFF	ON	OFF	OFF	ON
419	OFF	OFF	ON	ON	ON	OFF	ON	OFF	OFF	ON
420	ON	ON	OFF	ON	ON	OFF	ON	OFF	OFF	ON
421	OFF	ON	OFF	ON	ON	OFF	ON	OFF	OFF	ON
422	ON	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	ON

Table 13, Ametek Speedometer Calibration Settings, 390 to 422

Ametek Speedometer Calibration Settings, 423 to 455										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
423	OFF	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	ON
424	ON	ON	ON	OFF	ON	OFF	ON	OFF	OFF	ON
425	OFF	ON	ON	OFF	ON	OFF	ON	OFF	OFF	ON
426	ON	OFF	ON	OFF	ON	OFF	ON	OFF	OFF	ON
427	OFF	OFF	ON	OFF	ON	OFF	ON	OFF	OFF	ON

Ametek Speedometer Calibration Settings, 423 to 455										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
428	ON	ON	OFF	OFF	ON	OFF	ON	OFF	OFF	ON
429	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	OFF	ON
430	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	ON
431	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	ON
432	ON	ON	ON	ON	OFF	OFF	ON	OFF	OFF	ON
433	OFF	ON	ON	ON	OFF	OFF	ON	OFF	OFF	ON
434	ON	OFF	ON	ON	OFF	OFF	ON	OFF	OFF	ON
435	OFF	OFF	ON	ON	OFF	OFF	ON	OFF	OFF	ON
436	ON	ON	OFF	ON	OFF	OFF	ON	OFF	OFF	ON
437	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	OFF	ON
438	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	ON
439	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	ON
440	ON	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	ON
441	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	ON
442	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	ON
443	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	ON
444	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON
445	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON
446	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON
447	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON
448	ON	ON	ON	ON	ON	ON	OFF	OFF	OFF	ON
449	OFF	ON	ON	ON	ON	ON	OFF	OFF	OFF	ON
450	ON	OFF	ON	ON	ON	ON	OFF	OFF	OFF	ON
451	OFF	OFF	ON	ON	ON	ON	OFF	OFF	OFF	ON
452	ON	ON	OFF	ON	ON	ON	OFF	OFF	OFF	ON
453	OFF	ON	OFF	ON	ON	ON	OFF	OFF	OFF	ON
454	ON	OFF	OFF	ON	ON	ON	OFF	OFF	OFF	ON
455	OFF	OFF	OFF	ON	ON	ON	OFF	OFF	OFF	ON

Table 14, Ametek Speedometer Calibration Settings, 423 to 455

Ametek Speedometer Calibration Settings, 456 to 488										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
456	ON	ON	ON	OFF	ON	ON	OFF	OFF	OFF	ON
457	OFF	ON	ON	OFF	ON	ON	OFF	OFF	OFF	ON
458	ON	OFF	ON	OFF	ON	ON	OFF	OFF	OFF	ON
459	OFF	OFF	ON	OFF	ON	ON	OFF	OFF	OFF	ON

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Ametek Speedometer Calibration Settings, 456 to 488										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
460	ON	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	ON
461	OFF	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	ON
462	ON	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF	ON
463	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF	ON
464	ON	ON	ON	ON	OFF	ON	OFF	OFF	OFF	ON
465	OFF	ON	ON	ON	OFF	ON	OFF	OFF	OFF	ON
466	ON	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	ON
467	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	ON
468	ON	ON	OFF	ON	OFF	ON	OFF	OFF	OFF	ON
469	OFF	ON	OFF	ON	OFF	ON	OFF	OFF	OFF	ON
470	ON	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	ON
471	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	ON
472	ON	ON	ON	OFF	OFF	ON	OFF	OFF	OFF	ON
473	OFF	ON	ON	OFF	OFF	ON	OFF	OFF	OFF	ON
474	ON	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	ON
475	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	ON
476	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON
477	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON
478	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON
479	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON
480	ON	ON	ON	ON	ON	OFF	OFF	OFF	OFF	ON
481	OFF	ON	ON	ON	ON	OFF	OFF	OFF	OFF	ON
482	ON	OFF	ON	ON	ON	OFF	OFF	OFF	OFF	ON
483	OFF	OFF	ON	ON	ON	OFF	OFF	OFF	OFF	ON
484	ON	ON	OFF	ON	ON	OFF	OFF	OFF	OFF	ON
485	OFF	ON	OFF	ON	ON	OFF	OFF	OFF	OFF	ON
486	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	ON
487	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	ON
488	ON	ON	ON	OFF	ON	OFF	OFF	OFF	OFF	ON

Table 15, Ametek Speedometer Calibration Settings, 456 to 488

Ametek Speedometer Calibration Settings, 489 to 521										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
489	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	OFF	ON
490	ON	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	ON
491	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	ON

Ametek Speedometer Calibration Settings, 489 to 521										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
492	ON	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON
493	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON
494	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON
495	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON
496	ON	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	ON
497	OFF	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	ON
498	ON	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	ON
499	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	ON
500	ON	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON
501	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON
502	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON
503	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON
504	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON
505	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON
506	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON
507	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON
508	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON
509	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON
510	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON
511	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON
512	ON	ON	ON	ON	ON	ON	ON	ON	ON	OFF
513	OFF	ON	ON	ON	ON	ON	ON	ON	ON	OFF
514	ON	OFF	ON	ON	ON	ON	ON	ON	ON	OFF
515	OFF	OFF	ON	ON	ON	ON	ON	ON	ON	OFF
516	ON	ON	OFF	ON	ON	ON	ON	ON	ON	OFF
517	OFF	ON	OFF	ON	ON	ON	ON	ON	ON	OFF
518	ON	OFF	OFF	ON	ON	ON	ON	ON	ON	OFF
519	OFF	OFF	OFF	ON	ON	ON	ON	ON	ON	OFF
520	ON	ON	ON	OFF	ON	ON	ON	ON	ON	OFF
521	OFF	ON	ON	OFF	ON	ON	ON	ON	ON	OFF

Table 16, Ametek Speedometer Calibration Settings, 489 to 521

Ametek Speedometer Calibration Settings, 522 to 554										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
522	ON	OFF	ON	OFF	ON	ON	ON	ON	ON	OFF
523	OFF	OFF	ON	OFF	ON	ON	ON	ON	ON	OFF

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Ametek Speedometer Calibration Settings, 522 to 554										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
524	ON	ON	OFF	OFF	ON	ON	ON	ON	ON	OFF
525	OFF	ON	OFF	OFF	ON	ON	ON	ON	ON	OFF
526	ON	OFF	OFF	OFF	ON	ON	ON	ON	ON	OFF
527	OFF	OFF	OFF	OFF	ON	ON	ON	ON	ON	OFF
528	ON	ON	ON	ON	OFF	ON	ON	ON	ON	OFF
529	OFF	ON	ON	ON	OFF	ON	ON	ON	ON	OFF
530	ON	OFF	ON	ON	OFF	ON	ON	ON	ON	OFF
531	OFF	OFF	ON	ON	OFF	ON	ON	ON	ON	OFF
532	ON	ON	OFF	ON	OFF	ON	ON	ON	ON	OFF
533	OFF	ON	OFF	ON	OFF	ON	ON	ON	ON	OFF
534	ON	OFF	OFF	ON	OFF	ON	ON	ON	ON	OFF
535	OFF	OFF	OFF	ON	OFF	ON	ON	ON	ON	OFF
536	ON	ON	ON	OFF	OFF	ON	ON	ON	ON	OFF
537	OFF	ON	ON	OFF	OFF	ON	ON	ON	ON	OFF
538	ON	OFF	ON	OFF	OFF	ON	ON	ON	ON	OFF
539	OFF	OFF	ON	OFF	OFF	ON	ON	ON	ON	OFF
540	ON	ON	OFF	OFF	OFF	ON	ON	ON	ON	OFF
541	OFF	ON	OFF	OFF	OFF	ON	ON	ON	ON	OFF
542	ON	OFF	OFF	OFF	OFF	ON	ON	ON	ON	OFF
543	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	ON	OFF
544	ON	ON	ON	ON	ON	OFF	ON	ON	ON	OFF
545	OFF	ON	ON	ON	ON	OFF	ON	ON	ON	OFF
546	ON	OFF	ON	ON	ON	OFF	ON	ON	ON	OFF
547	OFF	OFF	ON	ON	ON	OFF	ON	ON	ON	OFF
548	ON	ON	OFF	ON	ON	OFF	ON	ON	ON	OFF
549	OFF	ON	OFF	ON	ON	OFF	ON	ON	ON	OFF
550	ON	OFF	OFF	ON	ON	OFF	ON	ON	ON	OFF
551	OFF	OFF	OFF	ON	ON	OFF	ON	ON	ON	OFF
552	ON	ON	ON	OFF	ON	OFF	ON	ON	ON	OFF
553	OFF	ON	ON	OFF	ON	OFF	ON	ON	ON	OFF
554	ON	OFF	ON	OFF	ON	OFF	ON	ON	ON	OFF

Table 17, Ametek Speedometer Calibration Settings, 522 to 554

Ametek Speedometer Calibration Settings, 555 to 587										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
555	OFF	OFF	ON	OFF	ON	OFF	ON	ON	ON	OFF

Ametek Speedometer Calibration Settings, 555 to 587										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
556	ON	ON	OFF	OFF	ON	OFF	ON	ON	ON	OFF
557	OFF	ON	OFF	OFF	ON	OFF	ON	ON	ON	OFF
558	ON	OFF	OFF	OFF	ON	OFF	ON	ON	ON	OFF
559	OFF	OFF	OFF	OFF	ON	OFF	ON	ON	ON	OFF
560	ON	ON	ON	ON	OFF	OFF	ON	ON	ON	OFF
561	OFF	ON	ON	ON	OFF	OFF	ON	ON	ON	OFF
562	ON	OFF	ON	ON	OFF	OFF	ON	ON	ON	OFF
563	OFF	OFF	ON	ON	OFF	OFF	ON	ON	ON	OFF
564	ON	ON	OFF	ON	OFF	OFF	ON	ON	ON	OFF
565	OFF	ON	OFF	ON	OFF	OFF	ON	ON	ON	OFF
566	ON	OFF	OFF	ON	OFF	OFF	ON	ON	ON	OFF
567	OFF	OFF	OFF	ON	OFF	OFF	ON	ON	ON	OFF
568	ON	ON	ON	OFF	OFF	OFF	ON	ON	ON	OFF
569	OFF	ON	ON	OFF	OFF	OFF	ON	ON	ON	OFF
570	ON	OFF	ON	OFF	OFF	OFF	ON	ON	ON	OFF
571	OFF	OFF	ON	OFF	OFF	OFF	ON	ON	ON	OFF
572	ON	ON	OFF	OFF	OFF	OFF	ON	ON	ON	OFF
573	OFF	ON	OFF	OFF	OFF	OFF	ON	ON	ON	OFF
574	ON	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	OFF
575	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	OFF
576	ON	ON	ON	ON	ON	ON	OFF	ON	ON	OFF
577	OFF	ON	ON	ON	ON	ON	OFF	ON	ON	OFF
578	ON	OFF	ON	ON	ON	ON	OFF	ON	ON	OFF
579	OFF	OFF	ON	ON	ON	ON	OFF	ON	ON	OFF
580	ON	ON	OFF	ON	ON	ON	OFF	ON	ON	OFF
581	OFF	ON	OFF	ON	ON	ON	OFF	ON	ON	OFF
582	ON	OFF	OFF	ON	ON	ON	OFF	ON	ON	OFF
583	OFF	OFF	OFF	ON	ON	ON	OFF	ON	ON	OFF
584	ON	ON	ON	OFF	ON	ON	OFF	ON	ON	OFF
585	OFF	ON	ON	OFF	ON	ON	OFF	ON	ON	OFF
586	ON	OFF	ON	OFF	ON	ON	OFF	ON	ON	OFF
587	OFF	OFF	ON	OFF	ON	ON	OFF	ON	ON	OFF

Table 18, Ametek Speedometer Calibration Settings, 555 to 587

Specifications

Ametek Speedometer Calibration Settings, 588 to 620										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
588	ON	ON	OFF	OFF	ON	ON	OFF	ON	ON	OFF
589	OFF	ON	OFF	OFF	ON	ON	OFF	ON	ON	OFF
590	ON	OFF	OFF	OFF	ON	ON	OFF	ON	ON	OFF
591	OFF	OFF	OFF	OFF	ON	ON	OFF	ON	ON	OFF
592	ON	ON	ON	ON	OFF	ON	OFF	ON	ON	OFF
593	OFF	ON	ON	ON	OFF	ON	OFF	ON	ON	OFF
594	ON	OFF	ON	ON	OFF	ON	OFF	ON	ON	OFF
595	OFF	OFF	ON	ON	OFF	ON	OFF	ON	ON	OFF
596	ON	ON	OFF	ON	OFF	ON	OFF	ON	ON	OFF
597	OFF	ON	OFF	ON	OFF	ON	OFF	ON	ON	OFF
598	ON	OFF	OFF	ON	OFF	ON	OFF	ON	ON	OFF
599	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	ON	OFF
600	ON	ON	ON	OFF	OFF	ON	OFF	ON	ON	OFF
601	OFF	ON	ON	OFF	OFF	ON	OFF	ON	ON	OFF
602	ON	OFF	ON	OFF	OFF	ON	OFF	ON	ON	OFF
603	OFF	OFF	ON	OFF	OFF	ON	OFF	ON	ON	OFF
604	ON	ON	OFF	OFF	OFF	ON	OFF	ON	ON	OFF
605	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	ON	OFF
606	ON	OFF	OFF	OFF	OFF	ON	OFF	ON	ON	OFF
607	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON	ON	OFF
608	ON	ON	ON	ON	ON	OFF	OFF	ON	ON	OFF
609	OFF	ON	ON	ON	ON	OFF	OFF	ON	ON	OFF
610	ON	OFF	ON	ON	ON	OFF	OFF	ON	ON	OFF
611	OFF	OFF	ON	ON	ON	OFF	OFF	ON	ON	OFF
612	ON	ON	OFF	ON	ON	OFF	OFF	ON	ON	OFF
613	OFF	ON	OFF	ON	ON	OFF	OFF	ON	ON	OFF
614	ON	OFF	OFF	ON	ON	OFF	OFF	ON	ON	OFF
615	OFF	OFF	OFF	ON	ON	OFF	OFF	ON	ON	OFF
616	ON	ON	ON	OFF	ON	OFF	OFF	ON	ON	OFF
617	OFF	ON	ON	OFF	ON	OFF	OFF	ON	ON	OFF
618	ON	OFF	ON	OFF	ON	OFF	OFF	ON	ON	OFF
619	OFF	OFF	ON	OFF	ON	OFF	OFF	ON	ON	OFF
620	ON	ON	OFF	OFF	ON	OFF	OFF	ON	ON	OFF

Table 19, Ametek Speedometer Calibration Settings, 588 to 620

Ametek Speedometer Calibration Settings, 621 to 653										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
621	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	ON	OFF
622	ON	OFF	OFF	OFF	ON	OFF	OFF	ON	ON	OFF
623	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	ON	OFF
624	ON	ON	ON	ON	OFF	OFF	OFF	ON	ON	OFF
625	OFF	ON	ON	ON	OFF	OFF	OFF	ON	ON	OFF
626	ON	OFF	ON	ON	OFF	OFF	OFF	ON	ON	OFF
627	OFF	OFF	ON	ON	OFF	OFF	OFF	ON	ON	OFF
628	ON	ON	OFF	ON	OFF	OFF	OFF	ON	ON	OFF
629	OFF	ON	OFF	ON	OFF	OFF	OFF	ON	ON	OFF
630	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	ON	OFF
631	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	ON	OFF
632	ON	ON	ON	OFF	OFF	OFF	OFF	ON	ON	OFF
633	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	ON	OFF
634	ON	OFF	ON	OFF	OFF	OFF	OFF	ON	ON	OFF
635	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON	ON	OFF
636	ON	ON	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF
637	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF
638	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF
639	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF
640	ON	ON	ON	ON	ON	ON	ON	OFF	ON	OFF
641	OFF	ON	ON	ON	ON	ON	ON	OFF	ON	OFF
642	ON	OFF	ON	ON	ON	ON	ON	OFF	ON	OFF
643	OFF	OFF	ON	ON	ON	ON	ON	OFF	ON	OFF
644	ON	ON	OFF	ON	ON	ON	ON	OFF	ON	OFF
645	OFF	ON	OFF	ON	ON	ON	ON	OFF	ON	OFF
646	ON	OFF	OFF	ON	ON	ON	ON	OFF	ON	OFF
647	OFF	OFF	OFF	ON	ON	ON	ON	OFF	ON	OFF
648	ON	ON	ON	OFF	ON	ON	ON	OFF	ON	OFF
649	OFF	ON	ON	OFF	ON	ON	ON	OFF	ON	OFF
650	ON	OFF	ON	OFF	ON	ON	ON	OFF	ON	OFF
651	OFF	OFF	ON	OFF	ON	ON	ON	OFF	ON	OFF
652	ON	ON	OFF	OFF	ON	ON	ON	OFF	ON	OFF
653	OFF	ON	OFF	OFF	ON	ON	ON	OFF	ON	OFF

Table 20, Ametek Speedometer Calibration Settings, 621 to 653

Specifications

Ametek Speedometer Calibration Settings, 654 to 686										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
654	ON	OFF	OFF	OFF	ON	ON	ON	OFF	ON	OFF
655	OFF	OFF	OFF	OFF	ON	ON	ON	OFF	ON	OFF
656	ON	ON	ON	ON	OFF	ON	ON	OFF	ON	OFF
657	OFF	ON	ON	ON	OFF	ON	ON	OFF	ON	OFF
658	ON	OFF	ON	ON	OFF	ON	ON	OFF	ON	OFF
659	OFF	OFF	ON	ON	OFF	ON	ON	OFF	ON	OFF
660	ON	ON	OFF	ON	OFF	ON	ON	OFF	ON	OFF
661	OFF	ON	OFF	ON	OFF	ON	ON	OFF	ON	OFF
662	ON	OFF	OFF	ON	OFF	ON	ON	OFF	ON	OFF
663	OFF	OFF	OFF	ON	OFF	ON	ON	OFF	ON	OFF
664	ON	ON	ON	OFF	OFF	ON	ON	OFF	ON	OFF
665	OFF	ON	ON	OFF	OFF	ON	ON	OFF	ON	OFF
666	ON	OFF	ON	OFF	OFF	ON	ON	OFF	ON	OFF
667	OFF	OFF	ON	OFF	OFF	ON	ON	OFF	ON	OFF
668	ON	ON	OFF	OFF	OFF	ON	ON	OFF	ON	OFF
669	OFF	ON	OFF	OFF	OFF	ON	ON	OFF	ON	OFF
670	ON	OFF	OFF	OFF	OFF	ON	ON	OFF	ON	OFF
671	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF	ON	OFF
672	ON	ON	ON	ON	ON	OFF	ON	OFF	ON	OFF
673	OFF	ON	ON	ON	ON	OFF	ON	OFF	ON	OFF
674	ON	OFF	ON	ON	ON	OFF	ON	OFF	ON	OFF
675	OFF	OFF	ON	ON	ON	OFF	ON	OFF	ON	OFF
676	ON	ON	OFF	ON	ON	OFF	ON	OFF	ON	OFF
677	OFF	ON	OFF	ON	ON	OFF	ON	OFF	ON	OFF
678	ON	OFF	OFF	ON	ON	OFF	ON	OFF	ON	OFF
679	OFF	OFF	OFF	ON	ON	OFF	ON	OFF	ON	OFF
680	ON	ON	ON	OFF	ON	OFF	ON	OFF	ON	OFF
681	OFF	ON	ON	OFF	ON	OFF	ON	OFF	ON	OFF
682	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF
683	OFF	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF
684	ON	ON	OFF	OFF	ON	OFF	ON	OFF	ON	OFF
685	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	ON	OFF
686	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	OFF

Table 21, Ametek Speedometer Calibration Settings, 654 to 686

Ametek Speedometer Calibration Settings, 687 to 719										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
687	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	OFF
688	ON	ON	ON	ON	OFF	OFF	ON	OFF	ON	OFF
689	OFF	ON	ON	ON	OFF	OFF	ON	OFF	ON	OFF
690	ON	OFF	ON	ON	OFF	OFF	ON	OFF	ON	OFF
691	OFF	OFF	ON	ON	OFF	OFF	ON	OFF	ON	OFF
692	ON	ON	OFF	ON	OFF	OFF	ON	OFF	ON	OFF
693	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	ON	OFF
694	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	ON	OFF
695	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF	ON	OFF
696	ON	ON	ON	OFF	OFF	OFF	ON	OFF	ON	OFF
697	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	ON	OFF
698	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	OFF
699	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	OFF
700	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF
701	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF
702	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF
703	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF
704	ON	ON	ON	ON	ON	ON	OFF	OFF	ON	OFF
705	OFF	ON	ON	ON	ON	ON	OFF	OFF	ON	OFF
706	ON	OFF	ON	ON	ON	ON	OFF	OFF	ON	OFF
707	OFF	OFF	ON	ON	ON	ON	OFF	OFF	ON	OFF
708	ON	ON	OFF	ON	ON	ON	OFF	OFF	ON	OFF
709	OFF	ON	OFF	ON	ON	ON	OFF	OFF	ON	OFF
710	ON	OFF	OFF	ON	ON	ON	OFF	OFF	ON	OFF
711	OFF	OFF	OFF	ON	ON	ON	OFF	OFF	ON	OFF
712	ON	ON	ON	OFF	ON	ON	OFF	OFF	ON	OFF
713	OFF	ON	ON	OFF	ON	ON	OFF	OFF	ON	OFF
714	ON	OFF	ON	OFF	ON	ON	OFF	OFF	ON	OFF
715	OFF	OFF	ON	OFF	ON	ON	OFF	OFF	ON	OFF
716	ON	ON	OFF	OFF	ON	ON	OFF	OFF	ON	OFF
717	OFF	ON	OFF	OFF	ON	ON	OFF	OFF	ON	OFF
718	ON	OFF	OFF	OFF	ON	ON	OFF	OFF	ON	OFF
719	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF	ON	OFF

Table 22, Ametek Speedometer Calibration Settings, 687 to 719

Specifications

Ametek Speedometer Calibration Settings, 720 to 752										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
720	ON	ON	ON	ON	OFF	ON	OFF	OFF	ON	OFF
721	OFF	ON	ON	ON	OFF	ON	OFF	OFF	ON	OFF
722	ON	OFF	ON	ON	OFF	ON	OFF	OFF	ON	OFF
723	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	ON	OFF
724	ON	ON	OFF	ON	OFF	ON	OFF	OFF	ON	OFF
725	OFF	ON	OFF	ON	OFF	ON	OFF	OFF	ON	OFF
726	ON	OFF	OFF	ON	OFF	ON	OFF	OFF	ON	OFF
727	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	ON	OFF
728	ON	ON	ON	OFF	OFF	ON	OFF	OFF	ON	OFF
729	OFF	ON	ON	OFF	OFF	ON	OFF	OFF	ON	OFF
730	ON	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	OFF
731	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	OFF
732	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF
733	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF
734	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF
735	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF
736	ON	ON	ON	ON	ON	OFF	OFF	OFF	ON	OFF
737	OFF	ON	ON	ON	ON	OFF	OFF	OFF	ON	OFF
738	ON	OFF	ON	ON	ON	OFF	OFF	OFF	ON	OFF
739	OFF	OFF	ON	ON	ON	OFF	OFF	OFF	ON	OFF
740	ON	ON	OFF	ON	ON	OFF	OFF	OFF	ON	OFF
741	OFF	ON	OFF	ON	ON	OFF	OFF	OFF	ON	OFF
742	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	ON	OFF
743	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF	ON	OFF
744	ON	ON	ON	OFF	ON	OFF	OFF	OFF	ON	OFF
745	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	ON	OFF
746	ON	OFF	ON	OFF	ON	OFF	OFF	OFF	ON	OFF
747	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	ON	OFF
748	ON	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF
749	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF
750	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF
751	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF
752	ON	ON	ON	ON	OFF	OFF	OFF	OFF	ON	OFF

Table 23, Ametek Speedometer Calibration Settings, 720 to 752

Ametek Speedometer Calibration Settings, 753 to 785										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
753	OFF	ON	ON	ON	OFF	OFF	OFF	OFF	ON	OFF
754	ON	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	OFF
755	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	OFF
756	ON	ON	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF
757	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF
758	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF
759	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF
760	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF
761	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF
762	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF
763	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF
764	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF
765	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF
766	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF
767	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF
768	ON	ON	ON	ON	ON	ON	ON	ON	OFF	OFF
769	OFF	ON	ON	ON	ON	ON	ON	ON	OFF	OFF
770	ON	OFF	ON	ON	ON	ON	ON	ON	OFF	OFF
771	OFF	OFF	ON	ON	ON	ON	ON	ON	OFF	OFF
772	ON	ON	OFF	ON	ON	ON	ON	ON	OFF	OFF
773	OFF	ON	OFF	ON	ON	ON	ON	ON	OFF	OFF
774	ON	OFF	OFF	ON	ON	ON	ON	ON	OFF	OFF
775	OFF	OFF	OFF	ON	ON	ON	ON	ON	OFF	OFF
776	ON	ON	ON	OFF	ON	ON	ON	ON	OFF	OFF
777	OFF	ON	ON	OFF	ON	ON	ON	ON	OFF	OFF
778	ON	OFF	ON	OFF	ON	ON	ON	ON	OFF	OFF
779	OFF	OFF	ON	OFF	ON	ON	ON	ON	OFF	OFF
780	ON	ON	OFF	OFF	ON	ON	ON	ON	OFF	OFF
781	OFF	ON	OFF	OFF	ON	ON	ON	ON	OFF	OFF
782	ON	OFF	OFF	OFF	ON	ON	ON	ON	OFF	OFF
783	OFF	OFF	OFF	OFF	ON	ON	ON	ON	OFF	OFF
784	ON	ON	ON	ON	OFF	ON	ON	ON	OFF	OFF
785	OFF	ON	ON	ON	OFF	ON	ON	ON	OFF	OFF

Table 24, Ametek Speedometer Calibration Settings, 753 to 785

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Ametek Speedometer Calibration Settings, 786 to 818										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
786	ON	OFF	ON	ON	OFF	ON	ON	ON	OFF	OFF
787	OFF	OFF	ON	ON	OFF	ON	ON	ON	OFF	OFF
788	ON	ON	OFF	ON	OFF	ON	ON	ON	OFF	OFF
789	OFF	ON	OFF	ON	OFF	ON	ON	ON	OFF	OFF
790	ON	OFF	OFF	ON	OFF	ON	ON	ON	OFF	OFF
791	OFF	OFF	OFF	ON	OFF	ON	ON	ON	OFF	OFF
792	ON	ON	ON	OFF	OFF	ON	ON	ON	OFF	OFF
793	OFF	ON	ON	OFF	OFF	ON	ON	ON	OFF	OFF
794	ON	OFF	ON	OFF	OFF	ON	ON	ON	OFF	OFF
795	OFF	OFF	ON	OFF	OFF	ON	ON	ON	OFF	OFF
796	ON	ON	OFF	OFF	OFF	ON	ON	ON	OFF	OFF
797	OFF	ON	OFF	OFF	OFF	ON	ON	ON	OFF	OFF
798	ON	OFF	OFF	OFF	OFF	ON	ON	ON	OFF	OFF
799	OFF	OFF	OFF	OFF	OFF	ON	ON	ON	OFF	OFF
800	ON	ON	ON	ON	ON	OFF	ON	ON	OFF	OFF
801	OFF	ON	ON	ON	ON	OFF	ON	ON	OFF	OFF
802	ON	OFF	ON	ON	ON	OFF	ON	ON	OFF	OFF
803	OFF	OFF	ON	ON	ON	OFF	ON	ON	OFF	OFF
804	ON	ON	OFF	ON	ON	OFF	ON	ON	OFF	OFF
805	OFF	ON	OFF	ON	ON	OFF	ON	ON	OFF	OFF
806	ON	OFF	OFF	ON	ON	OFF	ON	ON	OFF	OFF
807	OFF	OFF	OFF	ON	ON	OFF	ON	ON	OFF	OFF
808	ON	ON	ON	OFF	ON	OFF	ON	ON	OFF	OFF
809	OFF	ON	ON	OFF	ON	OFF	ON	ON	OFF	OFF
810	ON	OFF	ON	OFF	ON	OFF	ON	ON	OFF	OFF
811	OFF	OFF	ON	OFF	ON	OFF	ON	ON	OFF	OFF
812	ON	ON	OFF	OFF	ON	OFF	ON	ON	OFF	OFF
813	OFF	ON	OFF	OFF	ON	OFF	ON	ON	OFF	OFF
814	ON	OFF	OFF	OFF	ON	OFF	ON	ON	OFF	OFF
815	OFF	OFF	OFF	OFF	ON	OFF	ON	ON	OFF	OFF
816	ON	ON	ON	ON	OFF	OFF	ON	ON	OFF	OFF
817	OFF	ON	ON	ON	OFF	OFF	ON	ON	OFF	OFF
818	ON	OFF	ON	ON	OFF	OFF	ON	ON	OFF	OFF

Table 25, Ametek Speedometer Calibration Settings, 786 to 818

Ametek Speedometer Calibration Settings, 819 to 851										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
819	OFF	OFF	ON	ON	OFF	OFF	ON	ON	OFF	OFF
820	ON	ON	OFF	ON	OFF	OFF	ON	ON	OFF	OFF
821	OFF	ON	OFF	ON	OFF	OFF	ON	ON	OFF	OFF
822	ON	OFF	OFF	ON	OFF	OFF	ON	ON	OFF	OFF
823	OFF	OFF	OFF	ON	OFF	OFF	ON	ON	OFF	OFF
824	ON	ON	ON	OFF	OFF	OFF	ON	ON	OFF	OFF
825	OFF	ON	ON	OFF	OFF	OFF	ON	ON	OFF	OFF
826	ON	OFF	ON	OFF	OFF	OFF	ON	ON	OFF	OFF
827	OFF	OFF	ON	OFF	OFF	OFF	ON	ON	OFF	OFF
828	ON	ON	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF
829	OFF	ON	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF
830	ON	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF
831	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF
832	ON	ON	ON	ON	ON	ON	OFF	ON	OFF	OFF
833	OFF	ON	ON	ON	ON	ON	OFF	ON	OFF	OFF
834	ON	OFF	ON	ON	ON	ON	OFF	ON	OFF	OFF
835	OFF	OFF	ON	ON	ON	ON	OFF	ON	OFF	OFF
836	ON	ON	OFF	ON	ON	ON	OFF	ON	OFF	OFF
837	OFF	ON	OFF	ON	ON	ON	OFF	ON	OFF	OFF
838	ON	OFF	OFF	ON	ON	ON	OFF	ON	OFF	OFF
839	OFF	OFF	OFF	ON	ON	ON	OFF	ON	OFF	OFF
840	ON	ON	ON	OFF	ON	ON	OFF	ON	OFF	OFF
841	OFF	ON	ON	OFF	ON	ON	OFF	ON	OFF	OFF
842	ON	OFF	ON	OFF	ON	ON	OFF	ON	OFF	OFF
843	OFF	OFF	ON	OFF	ON	ON	OFF	ON	OFF	OFF
844	ON	ON	OFF	OFF	ON	ON	OFF	ON	OFF	OFF
845	OFF	ON	OFF	OFF	ON	ON	OFF	ON	OFF	OFF
846	ON	OFF	OFF	OFF	ON	ON	OFF	ON	OFF	OFF
847	OFF	OFF	OFF	OFF	ON	ON	OFF	ON	OFF	OFF
848	ON	ON	ON	ON	OFF	ON	OFF	ON	OFF	OFF
849	OFF	ON	ON	ON	OFF	ON	OFF	ON	OFF	OFF
850	ON	OFF	ON	ON	OFF	ON	OFF	ON	OFF	OFF
851	OFF	OFF	ON	ON	OFF	ON	OFF	ON	OFF	OFF

Table 26, Ametek Speedometer Calibration Settings, 819 to 851

Specifications

Ametek Speedometer Calibration Settings, 852 to 884										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
852	ON	ON	OFF	ON	OFF	ON	OFF	ON	OFF	OFF
853	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	OFF
854	ON	OFF	OFF	ON	OFF	ON	OFF	ON	OFF	OFF
855	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	OFF	OFF
856	ON	ON	ON	OFF	OFF	ON	OFF	ON	OFF	OFF
857	OFF	ON	ON	OFF	OFF	ON	OFF	ON	OFF	OFF
858	ON	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	OFF
859	OFF	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	OFF
860	ON	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF
861	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF
862	ON	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF
863	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF
864	ON	ON	ON	ON	ON	OFF	OFF	ON	OFF	OFF
865	OFF	ON	ON	ON	ON	OFF	OFF	ON	OFF	OFF
866	ON	OFF	ON	ON	ON	OFF	OFF	ON	OFF	OFF
867	OFF	OFF	ON	ON	ON	OFF	OFF	ON	OFF	OFF
868	ON	ON	OFF	ON	ON	OFF	OFF	ON	OFF	OFF
869	OFF	ON	OFF	ON	ON	OFF	OFF	ON	OFF	OFF
870	ON	OFF	OFF	ON	ON	OFF	OFF	ON	OFF	OFF
871	OFF	OFF	OFF	ON	ON	OFF	OFF	ON	OFF	OFF
872	ON	ON	ON	OFF	ON	OFF	OFF	ON	OFF	OFF
873	OFF	ON	ON	OFF	ON	OFF	OFF	ON	OFF	OFF
874	ON	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	OFF
875	OFF	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	OFF
876	ON	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF
877	OFF	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF
878	ON	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF
879	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF
880	ON	ON	ON	ON	OFF	OFF	OFF	ON	OFF	OFF
881	OFF	ON	ON	ON	OFF	OFF	OFF	ON	OFF	OFF
882	ON	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	OFF
883	OFF	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	OFF
884	ON	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF

Table 27, Ametek Speedometer Calibration Settings, 852 to 884

Ametek Speedometer Calibration Settings, 885 to 917										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
885	OFF	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF
886	ON	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF
887	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF
888	ON	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF
889	OFF	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF
890	ON	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF
891	OFF	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF
892	ON	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF
893	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF
894	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF
895	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF
896	ON	ON	ON	ON	ON	ON	ON	OFF	OFF	OFF
897	OFF	ON	ON	ON	ON	ON	ON	OFF	OFF	OFF
898	ON	OFF	ON	ON	ON	ON	ON	OFF	OFF	OFF
899	OFF	OFF	ON	ON	ON	ON	ON	OFF	OFF	OFF
900	ON	ON	OFF	ON	ON	ON	ON	OFF	OFF	OFF
901	OFF	ON	OFF	ON	ON	ON	ON	OFF	OFF	OFF
902	ON	OFF	OFF	ON	ON	ON	ON	OFF	OFF	OFF
903	OFF	OFF	OFF	ON	ON	ON	ON	OFF	OFF	OFF
904	ON	ON	ON	OFF	ON	ON	ON	OFF	OFF	OFF
905	OFF	ON	ON	OFF	ON	ON	ON	OFF	OFF	OFF
906	ON	OFF	ON	OFF	ON	ON	ON	OFF	OFF	OFF
907	OFF	OFF	ON	OFF	ON	ON	ON	OFF	OFF	OFF
908	ON	ON	OFF	OFF	ON	ON	ON	OFF	OFF	OFF
909	OFF	ON	OFF	OFF	ON	ON	ON	OFF	OFF	OFF
910	ON	OFF	OFF	OFF	ON	ON	ON	OFF	OFF	OFF
911	OFF	OFF	OFF	OFF	ON	ON	ON	OFF	OFF	OFF
912	ON	ON	ON	ON	OFF	ON	ON	OFF	OFF	OFF
913	OFF	ON	ON	ON	OFF	ON	ON	OFF	OFF	OFF
914	ON	OFF	ON	ON	OFF	ON	ON	OFF	OFF	OFF
915	OFF	OFF	ON	ON	OFF	ON	ON	OFF	OFF	OFF
916	ON	ON	OFF	ON	OFF	ON	ON	OFF	OFF	OFF
917	OFF	ON	OFF	ON	OFF	ON	ON	OFF	OFF	OFF

Table 28, Ametek Speedometer Calibration Settings, 885 to 917

Specifications

Ametek Speedometer Calibration Settings, 918 to 950										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
918	ON	OFF	OFF	ON	OFF	ON	ON	OFF	OFF	OFF
919	OFF	OFF	OFF	ON	OFF	ON	ON	OFF	OFF	OFF
920	ON	ON	ON	OFF	OFF	ON	ON	OFF	OFF	OFF
921	OFF	ON	ON	OFF	OFF	ON	ON	OFF	OFF	OFF
922	ON	OFF	ON	OFF	OFF	ON	ON	OFF	OFF	OFF
923	OFF	OFF	ON	OFF	OFF	ON	ON	OFF	OFF	OFF
924	ON	ON	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF
925	OFF	ON	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF
926	ON	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF
927	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF
928	ON	ON	ON	ON	ON	OFF	ON	OFF	OFF	OFF
929	OFF	ON	ON	ON	ON	OFF	ON	OFF	OFF	OFF
930	ON	OFF	ON	ON	ON	OFF	ON	OFF	OFF	OFF
931	OFF	OFF	ON	ON	ON	OFF	ON	OFF	OFF	OFF
932	ON	ON	OFF	ON	ON	OFF	ON	OFF	OFF	OFF
933	OFF	ON	OFF	ON	ON	OFF	ON	OFF	OFF	OFF
934	ON	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	OFF
935	OFF	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	OFF
936	ON	ON	ON	OFF	ON	OFF	ON	OFF	OFF	OFF
937	OFF	ON	ON	OFF	ON	OFF	ON	OFF	OFF	OFF
938	ON	OFF	ON	OFF	ON	OFF	ON	OFF	OFF	OFF
939	OFF	OFF	ON	OFF	ON	OFF	ON	OFF	OFF	OFF
940	ON	ON	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF
941	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF
942	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF
943	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF
944	ON	ON	ON	ON	OFF	OFF	ON	OFF	OFF	OFF
945	OFF	ON	ON	ON	OFF	OFF	ON	OFF	OFF	OFF
946	ON	OFF	ON	ON	OFF	OFF	ON	OFF	OFF	OFF
947	OFF	OFF	ON	ON	OFF	OFF	ON	OFF	OFF	OFF
948	ON	ON	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF
949	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF
950	ON	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF

Table 29, Ametek Speedometer Calibration Settings, 918 to 950

Ametek Speedometer Calibration Settings, 951 to 983										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
951	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF
952	ON	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF
953	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF
954	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF
955	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF
956	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF
957	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF
958	OFF	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF
959	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF
960	ON	ON	ON	ON	ON	ON	OFF	OFF	OFF	OFF
961	OFF	ON	ON	ON	ON	ON	OFF	OFF	OFF	OFF
962	ON	OFF	ON	ON	ON	ON	OFF	OFF	OFF	OFF
963	OFF	OFF	ON	ON	ON	ON	OFF	OFF	OFF	OFF
964	ON	ON	OFF	ON	ON	ON	OFF	OFF	OFF	OFF
965	OFF	ON	OFF	ON	ON	ON	OFF	OFF	OFF	OFF
966	ON	OFF	OFF	ON	ON	ON	OFF	OFF	OFF	OFF
967	OFF	OFF	OFF	ON	ON	ON	OFF	OFF	OFF	OFF
968	ON	ON	ON	OFF	ON	ON	OFF	OFF	OFF	OFF
969	OFF	ON	ON	OFF	ON	ON	OFF	OFF	OFF	OFF
970	ON	OFF	ON	OFF	ON	ON	OFF	OFF	OFF	OFF
971	OFF	OFF	ON	OFF	ON	ON	OFF	OFF	OFF	OFF
972	ON	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF
973	OFF	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF
974	ON	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF
975	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF
976	ON	ON	ON	ON	OFF	ON	OFF	OFF	OFF	OFF
977	OFF	ON	ON	ON	OFF	ON	OFF	OFF	OFF	OFF
978	ON	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	OFF
979	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	OFF
980	ON	ON	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF
981	OFF	ON	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF
982	ON	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF
983	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF

Table 30, Ametek Speedometer Calibration Settings, 951 to 983

Specifications

Ametek Speedometer Calibration Settings, 984 to 1016										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
984	ON	ON	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF
985	OFF	ON	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF
986	ON	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF
987	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF
988	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF
989	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF
990	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF
991	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF
992	ON	ON	ON	ON	ON	OFF	OFF	OFF	OFF	OFF
993	OFF	ON	ON	ON	ON	OFF	OFF	OFF	OFF	OFF
994	ON	OFF	ON	ON	ON	OFF	OFF	OFF	OFF	OFF
995	OFF	OFF	ON	ON	ON	OFF	OFF	OFF	OFF	OFF
996	ON	ON	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF
997	OFF	ON	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF
998	ON	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF
999	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF
1000	ON	ON	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF
1001	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF
1002	ON	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF
1003	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF
1004	ON	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF
1005	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF
1006	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF
1007	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF
1008	ON	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF
1009	OFF	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF
1010	ON	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF
1011	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF
1012	ON	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF
1013	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF
1014	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF
1015	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF
1016	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF

Table 31, Ametek Speedometer Calibration Settings, 984 to 1016

Ametek Speedometer Calibration Settings, 1017 to 1023										
PPM/120	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
1017	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF
1018	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF
1019	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF
1020	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
1021	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
1022	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
1023	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF

Table 32, Ametek Speedometer Calibration Settings, 1017 to 1023

General Description

HEADLAMPS

Two rectangular halogen headlamps are used. Each of these sealed beams has two filaments, one for high beam and one for low beam. Headlamps are controlled by the headlamp switch on the instrument panel. High beam/low beam selection is located on the turn signal stalk on the steering column.

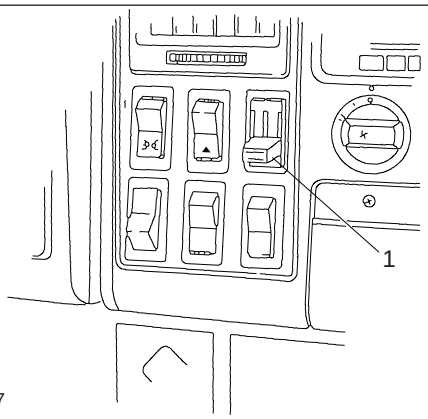
HEADLAMP SWITCH

The headlamp switch is a combination, three-position switch that controls the circuits to the headlamps and exterior lamps (except stoplamps and turn signal/hazard warning lamps and backup lamps). Circuits are connected to the switch by a molded connector.

The headlamp switch is powered through a fuse link at the fuse box. The fuse link is powered directly with battery voltage. Headlamp circuits on the output side of the headlamp switch feed the headlamp dimmer switch, which feeds the headlamps, and the exterior lighting relay, which feeds the fuse panel that distributes power to the exterior lamps.

PANEL DIM SWITCH

The instrument cluster illumination can be dimmed using the panel dim switch. See **Fig. 1**.



1. Panel Dim Switch

Fig. 1, Switch Location

STOPLIGHT SWITCH

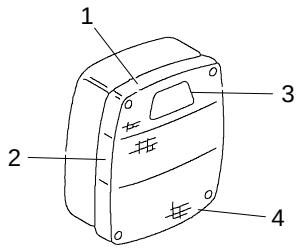
The stoplight switch is located at the left, lower rear of the cab on vehicles equipped with the tractor package, and at the left, lower front of the cab on trucks. The switch is threaded into a pressure port of the air pressure manifold.

LAMPS—PARKING, TAIL/MARKER

Parking

The parking lamp system includes all external lamps except the stoplamps, turn signal lamps, backup lamps and headlamps. The parking lamps are actuated when the headlamp switch is in the second or third position.

Tail (See Fig. 2)



1. Reflector
2. Turn Signal Lamp
3. Backup Lamp
4. Tail Lamp/Stoplamp

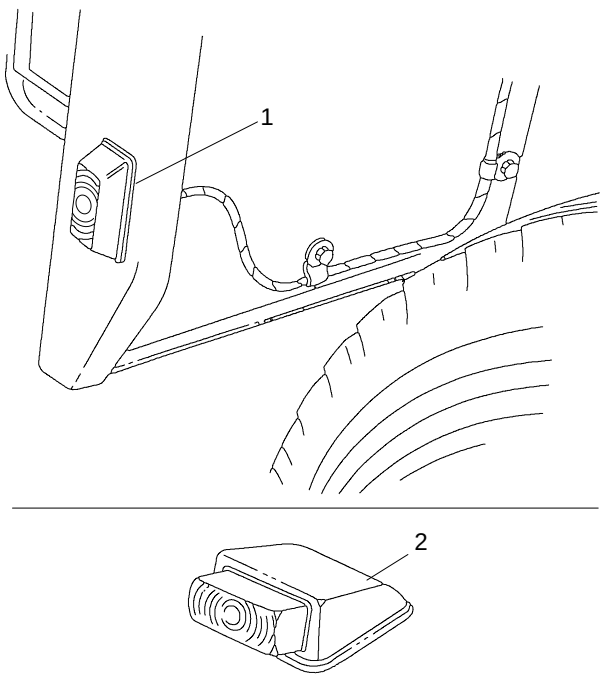
Fig. 2, Tail Lamp/Stoplamp Assembly

The rear stoplamps are operated by two air pressure switches fitted on the output side of the control valve. When the foot brake is applied, the control valve is actuated and air pressure in each of the dual lines activates the air pressure switches. The air pressure switches are wired in parallel circuit.

Marker (See Fig. 3)

The marker lamps are operated by placing the three-position headlamp switch in either the second or third (headlamps ON) position. The marker lamps can be turned off momentarily (blinked) by pressing the marker lamp blink switch.

General Information



1. Side Marker Lamp
2. Cab Roof Marker Lamp

Fig. 3, Marker Lamps

LICENSE LAMPS

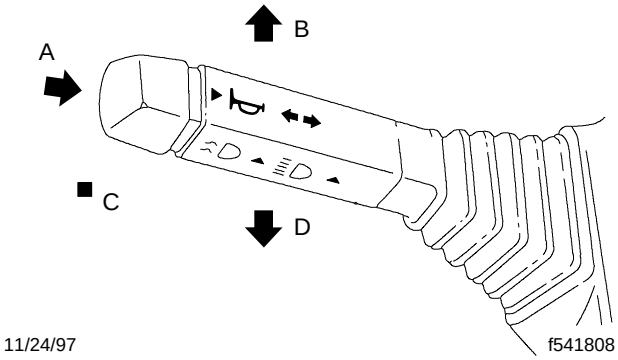
The stop/tail/backup lamp is illuminated when the headlamp switch is in the PARK or HEAD position. A clear shield at the bottom of the left lamp allows illumination of the license plate.

BACKUP LAMPS

The backup lamps are actuated by a lock cylinder on the transmission. When the ignition switch lock cylinder is in the RUN or START position and the transmission is placed in REVERSE, a switch on the transmission is actuated and illuminates the backup lamps. The backup lamp is contained in the center of the rear lamp assembly.

TURN SIGNALS

The left switch on the steering column controls the high-low beam selection of the headlamps (pull switch arm toward driver and release). See **Fig. 4**. This switch also controls the horn (push end of knob toward steering column) and turn signal (lift upward or press downward for direction). An instrument panel lamp indicates high-beam operation when lamps are on, and corresponding signal lamps of the panel flash to signal a turn.



A. Press for horn.
B. Right Turn Position
C. Off
D. Left Turn Position

Fig. 4, Turn Signal Switch

ROOF MARKER LAMPS

The five lamps mounted on the roof of the vehicle are on whenever the headlamp switch is in the PARK or HEADLAMP position.

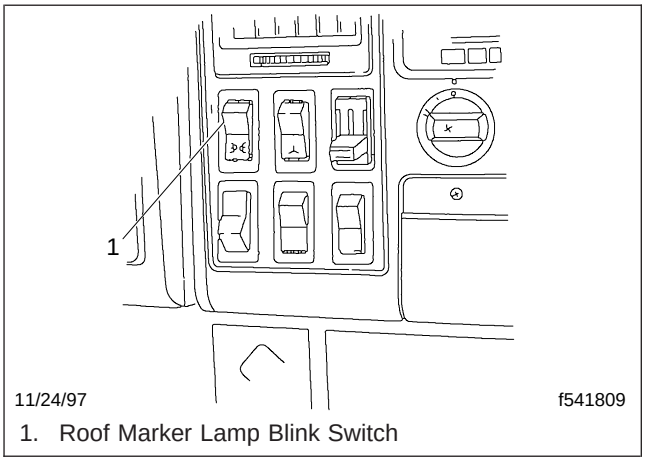
The circuit includes a blink switch. The rocker-type switch is located in the left switch bank. When the switch is pressed the roof marker lamps are turned off. When released, the switch returns to the ON position. See **Fig. 5**.

HAZARD WARNING FLASHER SWITCH

The hazard warning flasher switch is located in the center portion of the instrument panel, on the right side of the steering column. The front and rear turn signal lamps flash intermittently when the hazard warning flasher switch is actuated. See **Fig. 6**.

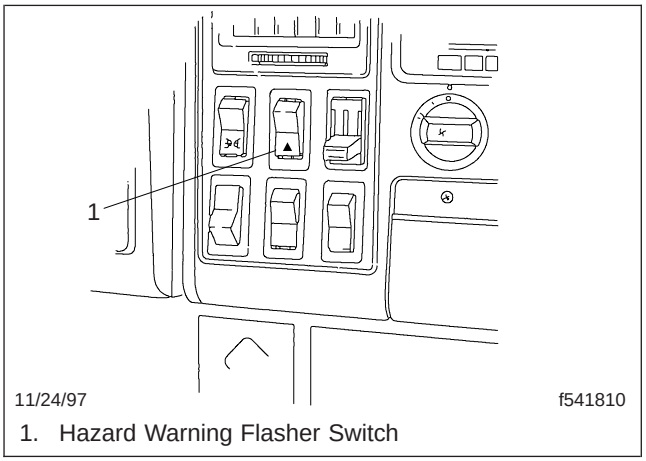
INDICATOR FLASHER

Cargo vehicles use a combination turn signal/hazard warning flasher located in the upper left of the fuse panel.



1. Roof Marker Lamp Blink Switch

Fig. 5, Blink Switch Location



1. Hazard Warning Flasher Switch

Fig. 6, Hazard Warning Flasher Switch Location

Headlamps Inspection and Verification

Common point diagnosis should be used to isolate a problem in a multi-load circuit (a circuit with more than one operating component) without making any tests. If one system functions properly but another does not, the problem is in the part of the circuit unique to the inoperative system.

If more than one circuit does not operate, check for blown fuses.

Before performing any lighting system tests, make sure the battery is in a fully charged condition and all battery cable connections are clean and tight.

A visual inspection is an important part of the lighting system test. Check for wires with frayed or damaged insulation, loose connections and improper wiring harness routing.

1. Visually inspect the components of the headlamp system.
2. Shake the wiring harness. Look for obvious signs of shorts, opens or damage.
3. If the fault is not visually evident, verify condition and refer to the symptom chart in **Subject 300**.
4. Correct any problems found by the visual inspection before performing further tests of the lighting system. For example, a loose ground strap between the engine and body dash panel can cause an intermittent operation of the lamps and gauges. Inspect and tighten (if necessary) the ground strap retaining screws at the back of the engine and the body dash panel.

Turn Signal Lamps/Hazard Warning Lamps Inspection and Verification

1. Visually inspect the components of the turn signal lamp/hazard warning flasher lamp system.
2. Shake the wiring harness. Look for obvious signs of shorts, opens or damage.
3. If the fault is not visually evident, verify condition and refer to the symptom chart in **Subject 300**.

Parking/Cornering Lamps Inspection and Verification

1. Visually inspect the components of the parking/cornering lamp system.
2. Shake the wiring harness. Look for obvious signs of shorts, open or damage.
3. If the fault is not visually evident, verify condition and refer to the symptom chart in **Subject 300**.

Roof Marker Lamps Inspection and Verification

1. Visually inspect the components of the marker lamp system.
2. Shake the wiring harness. Look for obvious signs of shorts, opens or damage.
3. If the fault is not visually evident, verify condition and refer to the symptom chart in **Subject 300**.

Headlamp Switch Removal and Installation

Removal

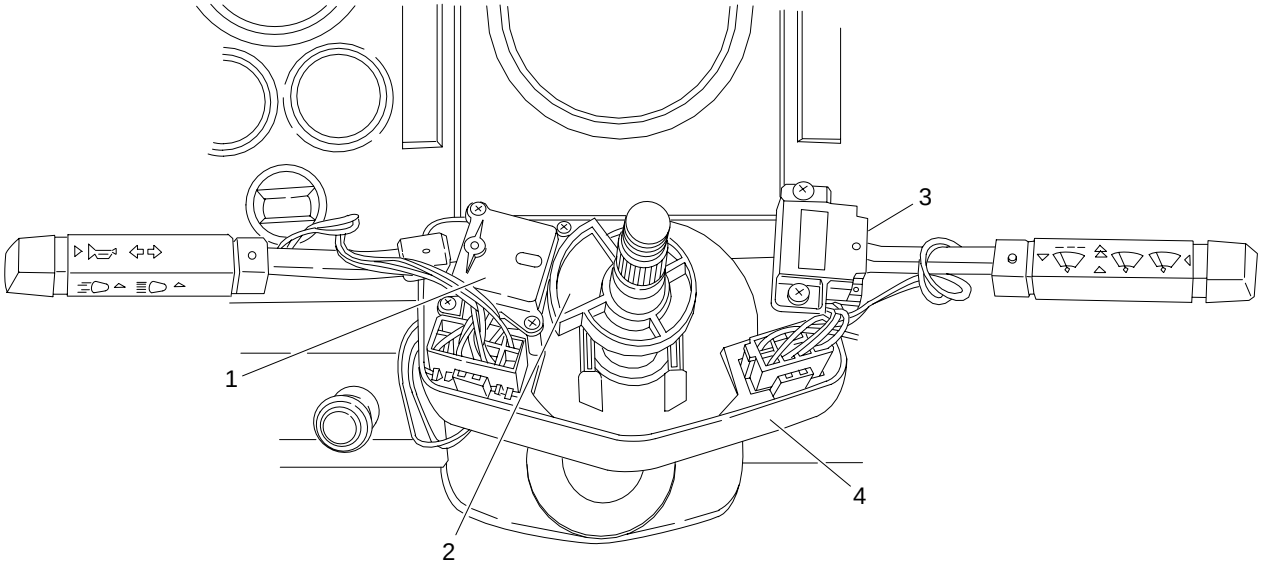
1. Disconnect the battery ground cable.
2. Turn lock screws and open left instrument cluster.
3. Disconnect plug on back of light switch.
4. Squeeze tabs on light switch and pull switch out the front of instrument cluster panel.

Installation

1. Push light switch into instrument cluster panel.
2. Plug in connector to light switch.
3. Close instrument cluster panel and latch lock screws.
4. Connect battery ground cable and check headlamp switch operation.

Turn Signal/High Beam Switch Removal and Installation

Removal (See Fig. 1)



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1. Turn Signal/High and Low Beam Headlamp Switch
2. Cancelling Cam
3. Windshield Wash/Wipe Switch
4. Switch Mounting Plate

Fig. 1, Dimmer Switch

1. Position vehicle so that wheels are in a straight-ahead position.
2. Make sure dimmer switch is in low beam position and turn signal position is neutral. Do not change these switch positions during switch removal.
3. Apply parking brake and disconnect battery ground cable.

NOTE: Scribe an arrow on the steering shaft, and a small mark on the steering wheel that coincides with the first mark. This is done to ensure correct positioning of the steering wheel when installing.

4. Remove steering wheel center cap.
5. Remove steering wheel retaining nut and remove steering wheel.

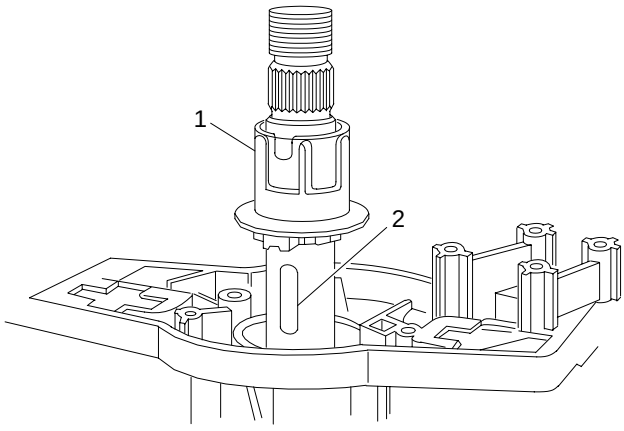
NOTE: One screw must be removed from the underside of the mounting.

6. Remove steering column securing screws. Separate shrouds, and remove.
7. Remove multi-plug connector and securing screws.
8. Remove self-cancelling collar and switch as a single unit by carefully lifting them both from steering shaft.

Installation

1. Install self-cancelling collar/switch as a single unit. Make sure self-cancelling collar is aligned properly with steering shaft recess. See **Fig. 2**.
2. Align switch and install securing screws.
3. Connect multi-plug connector. Make sure that the wiring is not twisted and does not restrict switch operation.
4. Hold each steering column shroud in place and install securing screws.
5. Align mark on steering wheel with mark on the steering shaft and position wheel onto shaft.

Turn Signal/High Beam Switch Removal and Installation



1. Collar
2. Recess

Fig. 2, Collar Alignment

6. Install steering wheel retaining nut and install steering wheel center cap.
7. Connect battery ground cable and release the parking brake. Check dimmer switch operation.

Headlamp Bulb Replacement

Removal

1. Hold grille in place and release eight quick-release grille fasteners.
2. Hold lamp in place and remove four retaining screws that secure retaining ring to adjustment ring. Do not disturb adjusting screw settings.
3. Pull headlamp bulb forward and disconnect wiring assembly plug from bulb.

Installation

1. Hold headlamp in position and install headlamp retaining ring.
2. Connect wiring assembly plug to bulb.
3. Place grille into position and secure eight quick-release grille fasteners.
4. Adjust headlamps, if necessary. See **Subject 200**.

Front Parking Lamps Removal and Installation

Removal

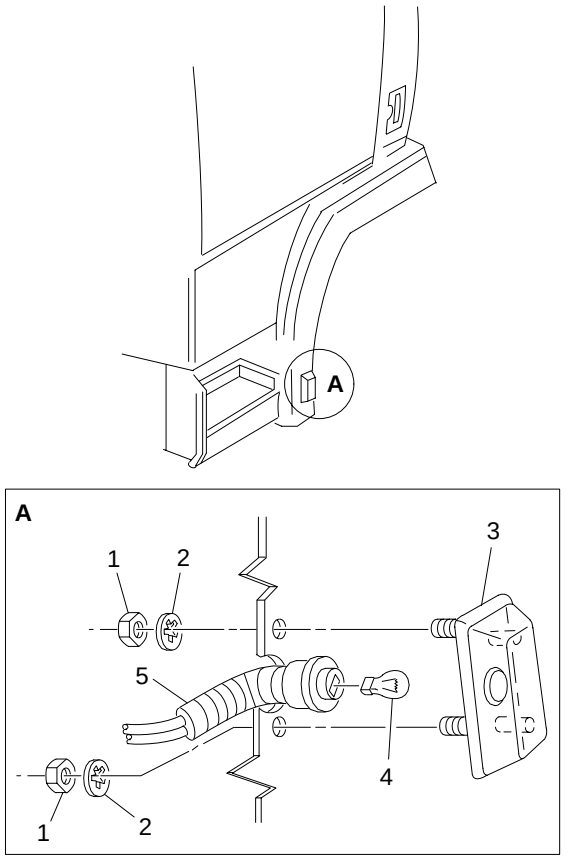
1. Open the hood and release the eight quick-release grille fasteners on the front grille. Remove the grille.
2. Hold in place and remove the retaining screws and washers securing the turn signal/parking lamp lens assembly.
3. Pull the lens assembly forward, and turn the bulb and socket assembly counterclockwise. Remove it from the top of the lens assembly.
4. If necessary, remove the expander nuts from the headlamp mount panel assembly and replace the nuts.

Installation

1. Push the lens assembly backward, and turn the bulb and socket assembly clockwise. Install it from the top of lens assembly.
2. Hold in place and install the retaining screws and washers securing the turn signal/parking lamp lens assembly.
3. Install the grille, and fasten the eight quick-release grille fasteners. Close the hood.

Turn Signal/Side Marker Lamps Removal and Installation

Removal (See Fig. 1)



A. View A
1. Hex Attaching Nut
2. Lockwasher
3. Lamp Assembly
4. Bulb
5. Rubber Boot

Fig. 1, Side Marker Lamp Assembly

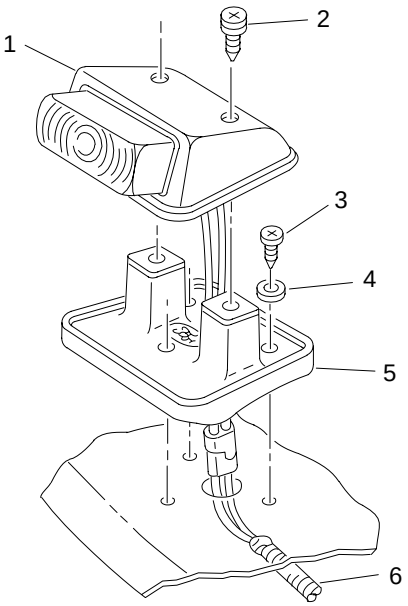
1. Remove retaining nuts and lockwasher (from inside of fender well) securing lamp assembly.
2. Remove socket/bulb assembly rubber boot from back of lamp assembly.
3. Remove bulb holder from socket/bulb assembly. Remove bulb from bulb holder.

Installation

1. Install the bulb in the bulb holder. Install the bulb holder in the socket/bulb assembly.
2. Install the socket/bulb assembly rubber boot on the back of the lamp assembly.
3. Install the retaining nuts and lockwasher (from inside of fender well) securing lamp assembly.

Roof Marker Lamps Removal and Installation

Removal (See Fig. 1)



1. Marker Lamp Assembly
2. Screw
3. Screw
4. Washer
5. Marker Lamp Socket Plate
6. Wiring Assembly

Fig. 1, Roof Marker Lamp Assembly

1. Pry roof marker lamp assembly from marker lamp plate and place out of way.
2. Remove three screw and washer assemblies retaining marker lamp plate to cab roof.
3. Pull harness through routing hole in cab roof until the harness connector emerges.
4. Fasten harness side of wiring harness to cab roof with tape.
5. Disconnect marker lamp assembly from harness.

Installation

1. Connect marker lamp assembly from harness.
2. Push harness through routing hole in cab roof.
3. Install three screw and washer assemblies retaining marker lamp plate to cab roof.
4. Install the roof marker lamp assembly on the marker lamp plate.

Adjustment

Before making any headlamp adjustments, perform the following preparatory steps:

1. Remove ice or mud from underhood assembly fender area (or wheel housing).
2. Make sure all tires are inflated to recommended pressures.
3. Check springs for sag or broken leaves.
4. Take into consideration incorrect wheel alignment or improper tracking of the rear axle.
5. Make sure there is no load in vehicle other than fuel tank one-half full.
6. Clean lenses and aiming pads.
7. Check for bulb burn-out and proper beam switching.
8. Make sure light output is well toward normal new lamp value.
9. Park vehicle on a level floor, perpendicular to aiming surface, at a distance of 25 ft (7.62 m) from the flat white aiming screen.
10. Aim the head lamps.

ADJUSTMENT PROCEDURE

The high beam is automatically adjusted when the low beam is adjusted.

Always bring each beam into final position by turning adjusting screws clockwise so that headlamp will be held against the tension springs when the operation is completed.

When setup requirements are satisfied, perform the following steps for headlamp adjustment.

1. Right headlamp: Cover left headlamp and turn headlamps on, in low beam position.
2. Horizontal adjustment: Turn adjustment screw (B) at left of sealed beam retainer ring:
    - *Clockwise* moves the beam to the right.
    - *Counterclockwise* moves the beam to the left.
3. Vertical adjustment: Turn adjustment screw (A) at top of sealed beam retainer ring:
    - *Clockwise* moves the beam upward.
    - *Counterclosckwise* moves the beam downward.
4. Turn off headlamps, allow lamps to cool, and remove left headlamp cover.
5. Left headlamps: Cover the right headlamp and turn headlamps on, in low beam position.
6. Horizontal adjustment: Turn adjustment screw (C) at right of sealed beam retainer ring:
    - *Clockwise* moves the beam to the left.
    - *Counterclockwise* moves the beam to the right.
7. Vertical adjustment: Turn adjustment screw (A) at top of the sealed beam retainer ring:
    - *Clockwise* moves the beam upward.
    - *Counterclockwise* moves the beam downward.
8. Turn off headlamps, allow lamps to cool, and remove right headlamp cover.

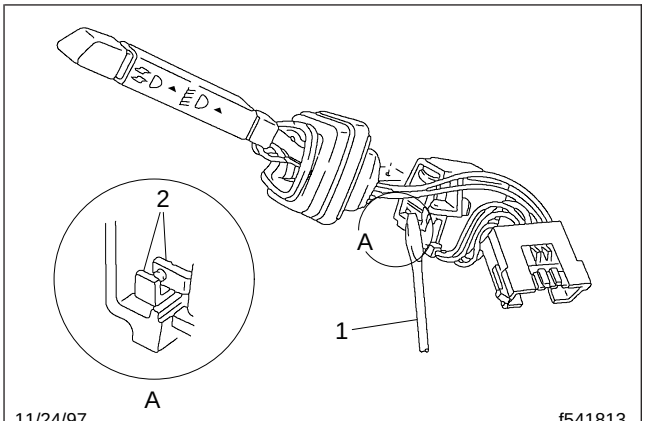
Headlamp Dimmer Switch Adjustment

Adjustment

The headlamp dimmer switch, mounted to the steering column, may cause an erratic of continual ON condition for the headlamps.

The following procedure is used to adjust the dimmer switch/flash-to-pass, in order to prevent an occasional short circuit condition between the contact points.

1. Disconnect battery ground cables.
2. Push back rubber boot on turn signal lever.
3. Locate dimmer switch contact points on the lower forward section.
4. Insert a screwdriver between the contact points and pry the front tab slightly outward and away from the other. See **Fig. 1**.



A. View A
1. Screwdriver
2. Contact Points

Fig. 1, Dimmer Switch Adjustment

5. Push rubber boot on turn signal lever back to steering column.
6. Connect ground cables to batteries and check dimmer switch operation.

Troubleshooting

Headlamp Symptom Chart		
Condition	**Possible Source**	**Action**
One Headlamp Does Not Work	Loose wiring connections.	Secure connections to headlamp and ground.
	Headlamp burned out.	Replace sealed beam.
	Corroded socket.	Service or replace as required.
Headlamps Inoperative	Wiring connections. Fusible link. Worn or damaged dimmer switch. Worn or damaged headlamp switch. Open circuit in wiring.	See **Table 2**.
Flash-to-Pass Does Not Work	Battery feed to switch. Switch.	See **Table 3**.
Headlamps On Continuously	Dimmer switch.	See **Subject 210**.

Table 1, Headlamp Symptom Chart

Test A: Headlamps Inoperative		
Test Step	**Result**	**Action to Take**
Step A1, Fusible Link Check for open at fusible link C. Is fusible link open?	Yes	Replace fusible link. Check Circuit 37 (BK/Y) for cause of overload and/or short to ground. Restore vehicle. Retest system.
	No	Go to Step A2.
Step A2, Battery Feed to Headlamp Switch	Yes	Go to Step A3.
Remove headlamp switch. Check for battery voltage at headlamp switch connector C227 battery feed Circuit 37 (BK/Y). Is battery voltage present?	No	Service open in Circuit 37 (BK/Y). Restore vehicle. Retest system.
Step A3, Headlamp Switch Continuity	Yes	Go to Step A4.
Connect headlamp switch to wiring harness connector C227. Headlamp switch in HEADLAMP position. Check for battery voltage at harness connector C227 output, Circuit 15 (R/Y). Is battery voltage present?	No	Replace headlamp switch. Restore vehicle. Retest system.
Step A4, Battery Feed to Circuit Breaker	Yes	Go to Step A5.
Remove circuit breaker 9. Switch in HEADLAMP position. Check for battery voltage at feed side of circuit breaker 9. Is battery voltage present at feed terminal 15 (R/Y)?	No	Service open in Circuit 15 (R/Y) between headlamp switch and circuit breaker. Restore vehicle. Retest system.

Troubleshooting

Test A: Headlamps Inoperative		
Test Step	**Result**	**Action to Take**
Step A5, Circuit Breaker Continuity Remove circuit breaker 9. Check for continuity across circuit breaker terminals. Is continuity present?	Yes	Go to step A6.
	No	Replace circuit breaker. Restore vehicle. Retest system.
Step A6, Battery Feed to Multi-Function Switch Switch in HEADLAMP position. Check for battery voltage at multi-function switch harness connector C225, Pin 4, Circuit 15 (R/Y). Is battery voltage present?	Yes	Replace multi-function switch. Restore vehicle. Retest system.
	No	Service open in Circuit 15 (R/Y) between circuit breaker and multi-function switch. Restore vehicle. Retest system.

Table 2, Test A: Headlamps Inoperative

Test B: Flash-to-Pass Inoperative		
Test Step	**Result**	**Action to Take**
Step B1, Battery Feed to Multi-Function Switch Check for battery voltage at multi-function switch harness connector C225, Pin 8, Circuit 37 (BK/Y). Is battery voltage present?	Yes	Replace multi-function switch. Restore vehicle. Retest system.
	No	Service open in Circuit 37 (BK/Y) between multi-function switch and splice. Restore vehicle. Retest system.

Table 3, Test B: Flash-to-Pass Inoperative

Turn Signal Lamps/Hazard Flasher Lamps Symptom Chart		
Condition	**Possible Source**	**Action**
Turn Signal/Hazard Warning Lamps Inoperative	Fuse burned out. Flasher unit. Wiring.	See **Table 5**.
All Turn Signal Lamps Inoperative	Fuse burned out. Worn or damaged turn signal flasher. Loose wiring connections. Open circuit in wiring or poor ground. Damaged multi-function switch.	See **Table 6**.
Hazard Lamps Inoperative, but Turn Signals OK	Switch. Wiring.	See **Table 7**.

Turn Signal Lamps/Hazard Flasher Lamps Symptom Chart		
Condition	**Possible Source**	**Action**
Turn Signal Lamps Light but Do Not Flash	Worn or damaged turn signal flasher.	Substitute a known good flasher. Replace if required.
	Poor ground.	Service ground.
One Turn Signal Lamp Does Not Light	Bulb burned out.	Replace bulb.
	Open circuit in wiring or poor ground.	Service as required.
Hazard Flasher Lamps Do Not Flash	Worn or damaged turn signal/hazard flasher.	Substitute a known good flasher. Replace flasher. Replace flasher if found damaged. If flasher appears melted, check for external short circuit.
	Fuse burned out.	Replace fuse.
	Open circuit in wiring.	Service as required.
	Worn or damaged hazard switch.	Service or replace hazard switch.

Table 4, Turn Signal Lamps/Hazard Flasher Lamps Symptom Chart

Test C: Turn Signal Lamps/Hazard Flasher Lamps Inoperative		
Test Step	**Result**	**Action to Take**
Step C1, Circuit Protection Is fuse blown?	Yes	Replace the fuse. If fuse blows again, check entire circuit for short to ground.
	No	Go to Step C2.
Step C2, Flasher Substitute	Yes	Condition corrected.
Substitute a known good flasher. Do turn signal/hazard lamps operate?	No	Go to Step C3.
Step C3, Fuse to Flasher Circuit	Yes	Go to Step C4.
Remove the flasher an check for battery voltage at connector C224, Circuit 383 (R/W). Is battery voltage present?	No	Service open in Circuit 383 (R/W) between fuse and flasher. Restore vehicle. Retest system.
Step C4, Flasher Output Terminal	Yes	Return to symptom chart.
With the flasher installed, check fro battery voltage at connector C224, Circuit 44 (BL). Is battery voltage present?	No	Service open at wiring terminal (Circuit 44). Restore vehicle. Retest system.

Table 5, Test C: Turn Signal Lamps/Hazard Flasher Lamps Inoperative

Troubleshooting

Test D: All Turn Signal Lamps Inoperative		
Test Step	**Result**	**Action to Take**
Step D1, Check Fuse and Flasher Circuit	Yes	Go to Step D6.
Turn on hazard switch. Do lamps flash?	No	Go to Step D2.
Step D2, Circuit Protection Check for blown Fuse 3. Is fuse blown?	Yes	Replace fuse. If fuse blows again, check entire circuit for short to ground.
	No	Go to Step D3.
Step D3, Flasher Substitute	Yes	Condition corrected.
Substitute a known good flasher. Do turn signals operate?	No	Go to Step D4.
Step D4, Fuse to Flasher Circuit	Yes	Go to Step D5.
Remove flasher and check for battery voltage at connector C224, Circuit 383 (R/W). Is battery voltage present?	No	Service open in Circuit 383 (R/W) between fuse and flasher. Restore vehicle. Retest system.
Step D5, Flasher Output Terminal With flasher installed, check for battery voltage at connector C224, Circuit 44 (BL). Is battery voltage present?	Yes	Return to symptom chart.
	No	Service open at flasher wiring terminal (Circuit 44). Restore vehicle. Retest system.
Step D6, Flasher to Turn Signal Switch Circuit At multi-function switch check for battery voltage at connector C225, Pin 3, Circuit 44 (BL). Is battery voltage present?	Yes	Replace multi-function switch. Restore vehicle. Retest system.
	No	Service open in Circuit 383 (R/W) between fuse and flasher. Restore vehicle. Retest system.

Table 6, Test D: All Turn Signal Lamps Inoperative

Test E: Hazard Flasher Inoperative		
Test Step	**Result**	**Action to Take**
Step E1, Hazard Switch Continuity	Yes	Go to Step E2.
Remove the hazard switch. With switch in ON position, check for continuity across switch terminals. Is continuity present?	No	Replace hazard switch. Restore vehicle. Retest system.

Test E: Hazard Flasher Inoperative		
Test Step	**Result**	**Action to Take**
Step E2, Battery Feed to Hazard Lamp Switch Check for battery voltage at harness connector C226, Circuit 44 (BL). Is battery voltage present?	Yes	Replace hazard switch. Restore vehicle. Retest system.
	No	Service open in Circuit 44 between switch and flasher. Restore vehicle. Retest system.

Table 7, Test E: Hazard Flasher Inoperative

Parking and Cornering Lamps Symptom Chart		
Condition	**Possible Source**	**Action**
Parking and Cornering Lamps Inoperative	Fuse. Exterior lamp relay. Circuit.	See **Table 9**.
One Parking or Cornering Lamp Inoperative	Bulb. Bulb feed circuit. Bulb ground circuit.	See **Table 9**.
Parking and Cornering Lamps On Continuously	Exterior lamp relay.	See **Table 10**.

Table 8, Parking and Cornering Lamps Symptom Chart

Test F: Parking and Cornering Lamps Inoperative		
Test Step	**Result**	**Action to Take**
Step F1, Circuit Protection Check for blown fuse 27. Is fuse blown?	Yes	Replace fuse. If fuse blows again, check entire circuit for short to ground.
	No	Go to Step F2.
Step F2, Exterior Lamp Relay Check Place finger on exterior lamp relay and actuate headlamp switch to Park position. Did the relay "click"?	Yes	Go to Step F5.
	No	Go to Step F3.
Step F3, Exterior Lamp Relay—Coil Feed Remove the exterior lamp relay. Check for battery voltage at wiring harness connector C229 for relay terminal, Circuit 288 (W/BK). Is battery voltage present?	Yes	Go to Step F4.
	No	Service open in Circuit 288 (W/BK) between headlamp switch and relay. Restore vehicle. Retest system.

Troubleshooting

Test F: Parking and Cornering Lamps Inoperative		
Test Step	**Result**	**Action to Take**
Step F4, Exterior Lamp Relay—Coil Ground Key in OFF position. Check for continuity between harness connector C229 for relay terminal, Circuit 57 (BK) and clean chassis ground. Is continuity present?	Yes	Replace exterior lamp relay. Restore vehicle. Retest system.
	No	Service open in relay ground Circuit 57 (BK). Restore vehicle. Retest system.
Step F5, Exterior Lamp Relay—Contact Feed Circuit Remove exterior lamp relay. Check for battery voltage at wiring harness connector C229 for relay terminal, Circuit 37 (BK/Y). Is battery voltage present?	Yes	Go to Step F6.
	No	Service open in Circuit 37 (BK/Y) between fuse link (B) and exterior lamp relay. If fusible link is open, check Circuit 37 (BK/Y) for overload and short to ground. Restore vehicle. Retest system.
Step F6, Exterior Lamp Relay—Functional Check Connect relay coil feed terminal to 12 V battery supply. Connect relay coil ground terminal to clean chassis ground. Check for continuity across relay pull-in terminals. Is continuity present?	Yes	Service open in Circuit 285 (BR) between wiring harness connector for relay terminal and fuse (No. 27). Restore vehicle. Retest system.
	No	Replace relay. Restore vehicle. Retest system.

Table 9, Test F: Parking and Cornering Lamps Inoperative

Test G: One Parking or Tail Lamp Inoperative		
Test Step	**Result**	**Action to Take**
Step G1, Check Bulb Remove bulb and check for broken filament. Also check for damaged or corroded socket. Is bulb burned out, and is socket serviceable?	Yes	Go to Step G2.
	No	Replace bulb or socket as required. Restore vehicle. Retest system.
Step G2, Battery Feed to Bulb Check for battery voltage at bulb feed terminal connector C127, C125, C124, C126, C310, C311, C312, C313, C314, C403, or C404. Is battery voltage present?	Yes	Go Step G3.
	No	Service open in Circuit 285 (BR). Restore vehicle. Retest system.
Step G3, Bulb Ground Key in Off position. Check for continuity between ground terminal connector C127, C125, C124, C126, C310, C311, C312, C313, C314, C403, or C404 and clean chassis ground. Is continuity present?	Yes	See **Table 8**.
	No	Service open in ground circuit. Restore vehicle. Retest system.

Table 10, Test G: One Parking or Tail Lamp Inoperative

Test H: Parking and Tail Lamps on Continuously		
Test Step	**Result**	**Action to Take**
Step H1, Relay Check Remove the exterior lamp relay. Connect relay coil feed terminal to 12 V battery supply. Connect relay coil ground terminal to clean chassis ground. Check for continuity across pull-in terminals. Is continuity present?	Yes	Replace relay. Restore vehicle. Retest system.
	No	Go to Step H2.
Step H2, Exterior Lamp Relay—Coil Feed Make sure headlamp switch is off. Check for battery voltage at wiring harness connector C229 for relay terminal, Circuit 288 (W/BK). Is battery voltage present?	Yes	Replace headlamp switch. Restore vehicle. Retest system.
	No	Check for short to battery voltage in Circuit 285 (BR). Restore vehicle. Retest system.

Table 11, Test H: Parking and Tail Lamps on Continuously

Roof Marker Lamps Symptom Chart		
Condition	**Possible Source**	**Action**
Roof Marker Lamps Inoperative	Fuse. Blink switch. Feed Circuit to lamps. Lamp ground circuit.	See **Table 13**.
One Roof Marker Lamp Inoperative	Bulb. Feed circuit to switch. Bulb ground circuit.	See **Table 14**.

Table 12, Roof Marker Lamps Symptom Chart

Test I: Roof Marker Lamps Inoperative		
Test Step	**Result**	**Action to Take**
Step I1, Circuit Protection Check for blown Fuse 28. Is fuse blown?	Yes	Replace fuse. If fuse blows again, check entire circuit for short to ground.
	No	Go to Step I2.
Step I2, Blink Switch Battery Feed	Yes	Go to Step I3.
Remove blink switch. Check for battery voltage at harness wiring connector C228, Circuit 19 (BL/R). Is battery voltage present?	No	Service open in Circuit 19 (BL/R). Restore vehicle. Retest system.
Step I3, Blink Switch Continuity	Yes	Go to Step I4.
Headlamp switch in Off position. Check for continuity across blink switch. Is continuity present?	No	Replace blink switch. Restore vehicle. Retest system.

Troubleshooting

Test I: Roof Marker Lamps Inoperative		
Test Step	**Result**	**Action to Take**
Step I4, Battery Feed to Roof Lamps	Yes	Go to Step I5.
Remove one roof lamp bulb. Check for battery voltage at lamp feed wire Connector C310, C311, C312, C313, or C314, Circuit 984 (BR). Is battery voltage present?	No	Service open in Circuit 984 (BR) to splice. Restore vehicle. Retest system.
Step I5, Roof Lamp Ground Circuit	Yes	See **Table 12**.
Key in Off position. Check for continuity between lamp ground wire connector C310, C311, C312, C313, or C314 and clean chassis ground. Is continuity present?	No	Service open in ground Circuit 57 (BK). Restore vehicle. Retest system.

Table 13, Test I: Roof Marker Lamps Inoperative

Test J: One Roof Marker Lamp Inoperative		
Test Step	**Result**	**Action to Take**
Step J1, Roof Lamp Bulb	Yes	Go to Step J2.
Remove bulb an check for broken filament. Also check for damaged or corroded bulb socket. Are bulb and socket OK?	No	Replace bulb or socket as required. Restore vehicle. Retest system.
Step J2, Battery Feed to Bulb	Yes	Go to Step J3.
Check for battery voltage between bulb connector C310, C311, C312, C313, or C314 and splice. Is battery voltage present?	No	Service open in Circuit 984 (BR) between lamp and splice. Restore vehicle. Retest system.
Step J3, Bulb Ground Circuit	Yes	See **Table 12**.
Key in Off position. Check for continuity between lamp ground wire connector C310, C311, C312, C313, or C314 and clean chassis ground. Is continuity present?	No	Service open in Circuit 57 (BK) between lamp and splice or splice and ground. Restore vehicle. Retest system.

Table 14, Test J: One Roof Marker Lamp Inoperative

Courtesy Lamps Inspection and Verification (See Table 1)

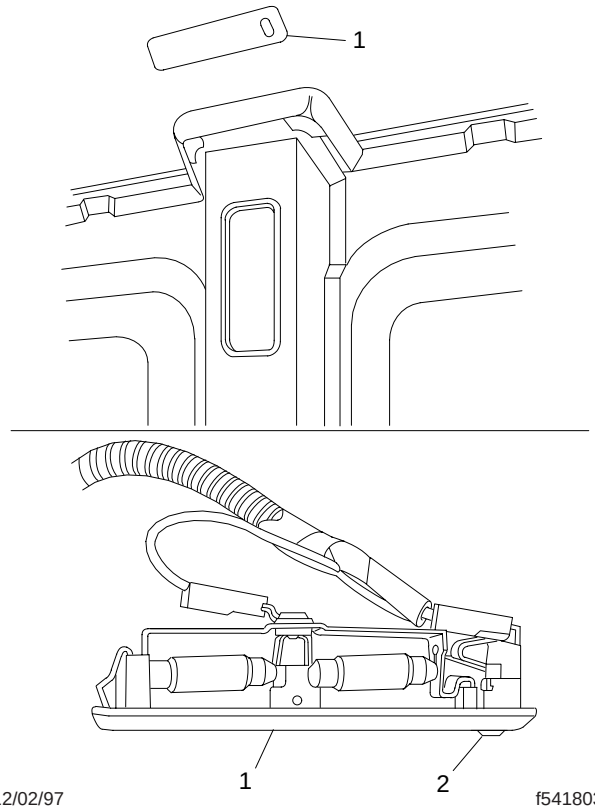
Electrical
Open fuse—instrument panel fuse panel 2 (10A)
Loose connectors
Corroded connectors
Burned-out bulbs

Table 1, Visual Inspection Chart

1. Verify the vehicle owner's original concern by operating the dome lamp to duplicate the concern.
2. Inspect to determine if one of the electrical concerns in **Table 1** apply.
3. If the concern(s) remains after the inspection, determine the symptom(s) and proceed to **Subject 300**.

Dome Lamps Removal and Installation

Removal (See Fig. 1 and Fig. 2)



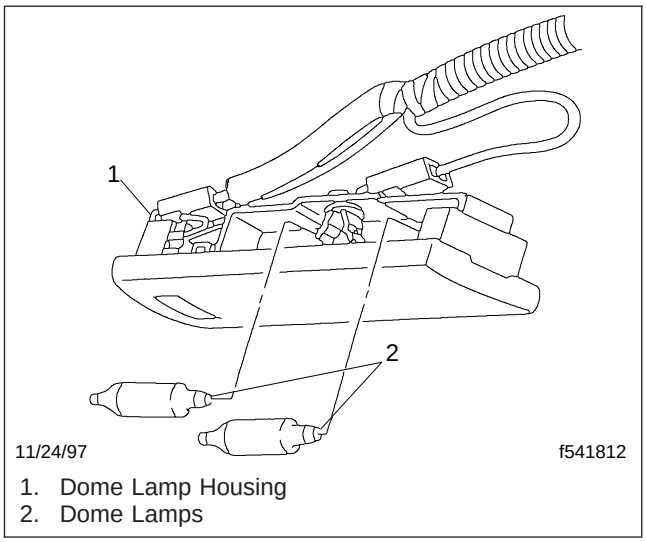
1. Dome Lamp Assembly
2. Dome Lamp Selector Switch

Fig. 1, Dome Lamp Assembly Removal

1. To replace the bulbs, carefully remove the dome lamp assembly from the headliner of the cab by pressing the driver side end of the assembly while pulling down on the lamp housing. Bulbs are exposed at the side of the assembly and are easily removed when cool.
2. To replace the dome lamp housing, remove three leads, two from the end and one from the top of the housing, and replace the unit.

Installation

1. Connect the two leads, one to the end and one to the top of the housing.
2. Install the unit by pressing it into place.



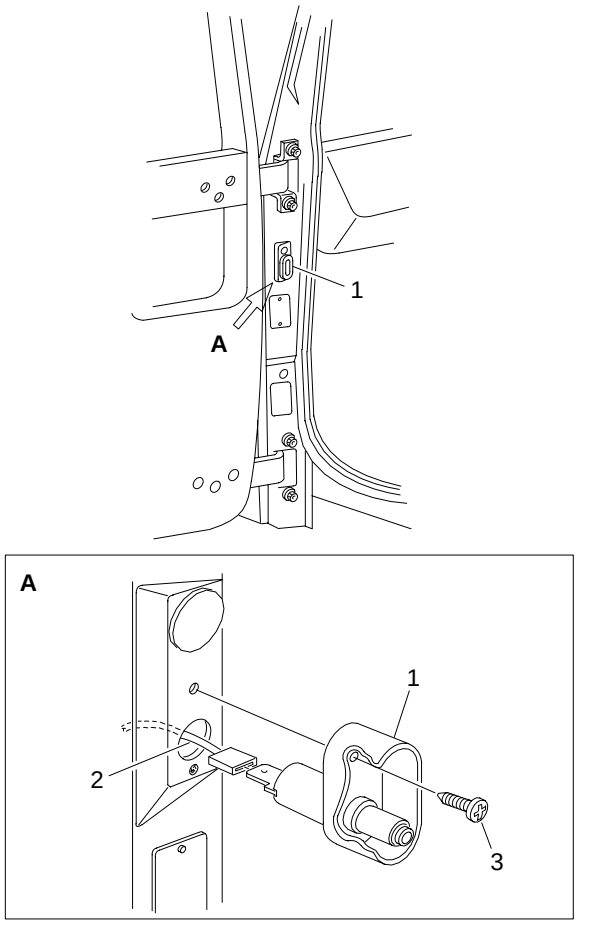
1. Dome Lamp Housing
2. Dome Lamps

Fig. 2, Dome Lamp Assembly Bulb Removal and Wire Disconnection

Dome Lamp Door Pillar Switch Replacement

Removal and installation

See **Fig. 1** for removal and Installation.



A. View A
1. Switch Assembly Door Opening
2. Wiring Assembly
3. Screw

Fig. 1, Door Switch Assembly Installation

Troubleshooting

Dome Lamps Symptom Chart		
Condition	**Possible Source**	**Action**
Dome Lamp Does Not Turn On When One Door Is Opened, OK When All Doors Are Opened	Circuit. Door jamb switch.	See **Table 2**.
Dome Lamp Does Not Turn On When All Doors Are Opened	Fuse. Circuit. Bulbs.	See **Table 3**.
Dome Lamp Does Not Turn On When Door Is Opened	Blown fuse.	Replace fuse. If fuse blows again, check for short circuit.
	Bulbs burned out.	Replace bulbs.
	Open circuit in wiring.	See **Table 4**.
	Worn or damaged door jamb switch.	Replace door jamb switch.
Dome Lamp Stays On	Worn or damaged door jamb switch.	Replace switch.
	Worn or damaged dome lamp switch.	Replace switch.

Table 1, Dome Lamps Symptom Chart

Test A: Dome Lamp Inoperative When One Door Is Opened		
Test Step	**Result**	**Action to Take**
Step A1, Check Switch Ground At door jamb switch that does not turn on lamp, press switch button and check for continuity between switch and clean chassis ground. Is continuity present?	Yes	Go to Step A2.
	No	Replace door jamb switch. Restore vehicle. Retest system.
Step A2, With faulty door jamb switch closed, check for continuity between lamp assembly, ground wire and clean chassis ground. Is continuity present?	Yes	Replace lamp assembly. Restore vehicle. Retest system.
	No	Repair open in ground circuit wiring. Restore vehicle. Retest system.

Table 2, Test A: Dome Lamp Inoperative When One Door Is Opened

Test B: Dome Lamp Inoperative When All Doors Are Opened		
Test Step	**Result**	**Action to Take**
Step B1, Check Operation of Fuse 2 Circuit Check operation of the radio illumination that shares the same fuse. Does illumination function correctly?	Yes	Go to Step B2.
	No	Go to Step B4.

Troubleshooting

Test B: Dome Lamp Inoperative When All Doors Are Opened		
Test Step	**Result**	**Action to Take**
Step B2, Check for Power to Bulbs Check for power to bulbs. Is power present at socket?	Yes	Go to Step B3.
	No	Service open in circuit between bulbs and common point with other circuits. Restore vehicle. Retest system.
Step B3, Check Continuity Check continuity of bulbs. Is continuity present?	Yes	Service bulb circuit ground. Go to Step B4.
	No	Replace bulbs. Restore vehicle. Retest system.
Step B4, Check Fuse Check dome lamp fuse. Is dome lamp fuse good?	Yes	Go to Step B5.
	No	Replace fuse. If fuse blows again, check for shorted circuit(s).
Step B5, Check for Fuse Power Check for power to fuse. Is there power to fuse?	Yes	Service open circuit between fuse and common point in dome lamp power circuit(s).
	No	Service power feed circuit.

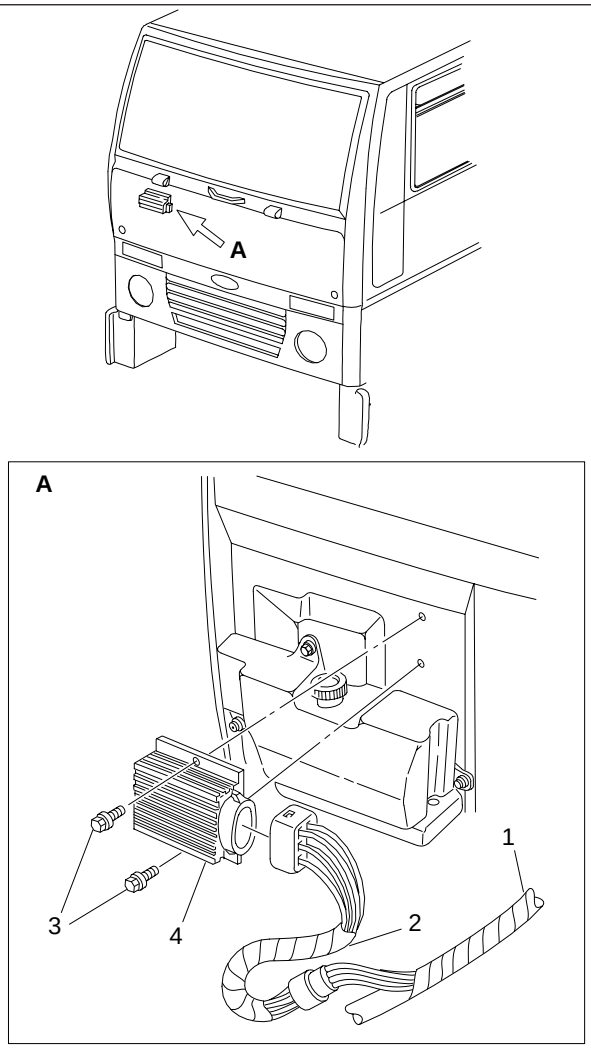
Table 3, Test B: Dome Lamp Inoperative When All Doors Are Opened

Test C: Dome Lamp Inoperative-Switch On, Door Open		
Test Step	**Result**	**Action to Take**
Step C1, Check Fuse Turn on radio. Does radio work?	Yes	Go to Step C2.
	No	Check fuse. If OK, go to Step C5.
Step C2, Check Bulbs Remove bulbs and check for broken filament. Are bulbs OK?	Yes	Go to Step C3.
	No	Replace bulbs. Restore vehicle. Retest system.
Step C3, Switch Voltage Supply Check for voltage at dome lamp feed wire. Is battery voltage present?	Yes	Go to Step C4.
	No	Service open in wiring from fuse to switch. Restore vehicle. Retest system.
Step C4, Ground Circuit Check for continuity between switch ground wires and clean chassis ground. Door jamb switches should be closed. Is continuity present?	Yes	Replace switch. Restore vehicle. Retest system.
	No	Service opens in ground circuits. Restore vehicle. Retest system.

Test C: Dome Lamp Inoperative-Switch On, Door Open		
Test Step	**Result**	**Action to Take**
Step C5, Fuse Voltage Supply Check for voltage at suppy side of fuse. Is battery voltage present?	Yes	Check fuse and fuse block terminal. Restore vehicle. Retest system.
	No	Service open in fuse feed circuit. Restore vehicle. Retest system.

Table 4, Test C: Dome Lamp Inoperative-Switch On, Door Open

General Description (See Fig. 1)



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A. View A
1. Wiring Assembly
2. Wiring Assembly
3. Screw
4. Control Assembly

Fig. 1, Control Module Location

CANADIAN DAYTIME RUNNING LAMP (DRL) SYSTEM

The Canadian daytime running lamp (DRL) system is designed to turn the high beam headlamps on, with a reduced light output, and without illuminating the high beam indicator lamp in the instrument panel when the following conditions are met:

- The ignition switch lock cylinder is in the RUN position;
- The parking brake is fully released;
- The headlamp switch is in the OFF or PARK position.

The daytime running lamps (DRL) control module is grounded through the low beam input when the DRL system is active.

NOTE: When the DRL system is active, the pulsed voltage on the high beam circuit cannot be measured accurately. If the low beam headlamps or the high beam headlamps are inoperative, see **Section 54.01**.

U.S. DAYTIME RUNNING LAMP SYSTEM

The U.S. daytime running lamp (DRL) system is designed to turn the low beam headlamps on, at a reduced light intensity, when the following conditions are met:

- The ignition switch lock cylinder is in the RUN position;
- The parking brake is fully released;
- The headlamp switch is in the OFF or PARK position.

The daytime running lamps (DRL) control module is grounded through the high beam input when the DRL system is active.

NOTE: When the DRL system is active, the pulsed voltage on the low beam circuit cannot be measured accurately. If the low beam headlamps or the high beam headlamps are inoperative, see **Section 54.01**.

Daytime Running Lamp (DRL) System Inspection and Verification

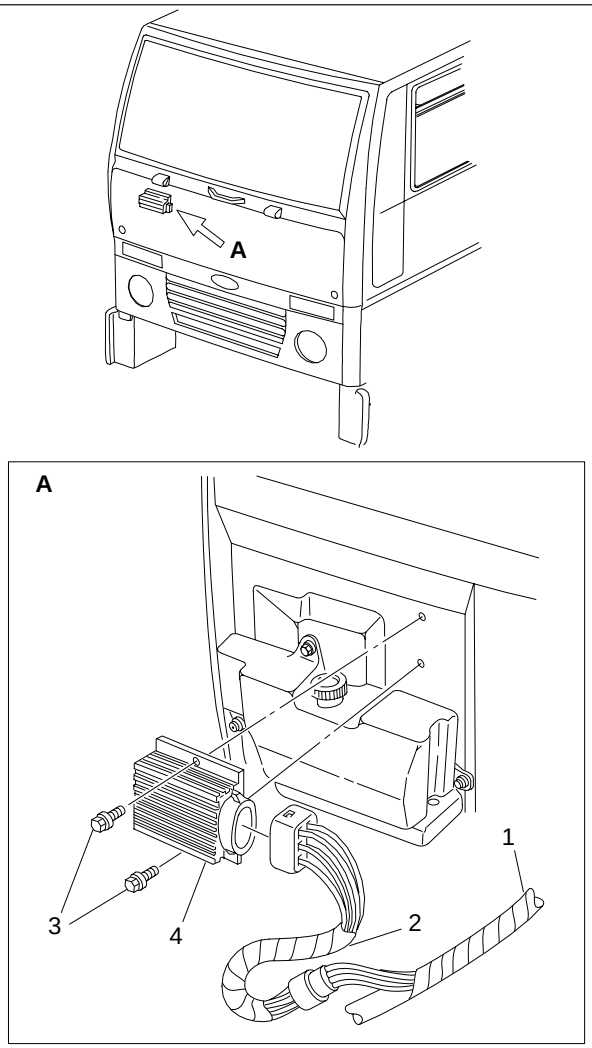
Inspection and Verification

Before performing any lighting systems tests, check that the battery is fully charged, battery connections are clean and tight, and burned out fuses and bulbs have been replaced. The DRL system also requires the parking brake switch light to function correctly.

1. Verify the vehicle owner's original concern by operating the daytime running lamps to duplicate the concern.
2. Inspect to determine if one of the following electrical concerns applies:
   - Open fuse junction panel fuses
   - Corroded connectors
   - Loose connectors
3. If the concern(s) remains after the inspection, determine the symptoms and proceed to **Subject 300**.

Daytime Running Lamp (DRL) Control Module Removal and Installation

Removal (See Fig. 1)



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A. View A
1. Wiring Assembly
2. Wiring Assembly
3. Screw
4. Control Assembly

Fig. 1, Control Module Location

1. Disconnect daytime running lamps (DRL) control module connector.
2. Remove the two screws to release daytime running lamps (DRL) control module.

Installation (See Fig. 1)

1. Install the two screws to secure daytime running lamps (DRL) control module.
2. Connect daytime running lamps (DRL) control module connector.

Troubleshooting

Daytime Running Lamps Symptom Chart		
Condition	**Possible Source**	**Action**
• DRL Malfunction or DRL Inoperative.	• Daytime running lamps (DRL) control module. • Parking brake signal lamp switch. • Wiring.	• See **Table 2**.

Table 1, Daytime Running Lamps Symptom Chart

Test A: A DRL Malfunction or DRL Inoperative		
Test Step	**Result**	**Action to Take**
Step A1, Check High (low U.S.) Beam Operation. Key in Run. Parking brake fully released. Headlamp switch Off or in Park position. Are the high beams (low beams U.S.) off?	Yes	Go to Step A3.
	No	Go to Step A2.
Step A2, Check High (low U.S.) Beam Intensity. Key in Run. Parking brake fully released. Headlamp switch Off or in the Park position. Are the high beams (low beams U.S.) on at reduced intensity?	Yes	System is functioning properly. No service required.
	No	Replace daytime running lamps control module. Restore vehicle. Retest system.
Step A3, Check Daytime Running Lamps Control Module Installation. Key Off. Headlamp switch Off. Check installation of daytime running lamps control module and harness connector C223. Is daytime running lamps control module installed and connector fully seated?	Yes	Go to Step A4.
	No	Reinstall daytime running lamps control module. Restore vehicle. Retest system.
Step A4, Check Daytime Running Lamps Control Module Power. Key Off. Remove daytime running lamps control module. Check fuse junction panel fuses 1, 9 and 17 for an open. Replace fuse(s) if opened. Key in Run. Parking brake fully released. Headlamp switch Off or in the Park position. Multi-function switch in LO beam (HI beam U.S.) position. Is battery voltage present at daytime running lamps control module connector C223, Pins 3 and 7, Circuits 640 (R/Y) and 565 (BL)?	Yes	Go to Step A5.
	No	Service Circuit 565 (BL) or Circuit 640 (R/Y) for an open circuit. Restore vehicle. Retest system.
Step A5, Check Daytime Running Lamps Control Module Pin 8. With daytime running lamps control module connector C223 removed, actuate key to Run. Headlamp switch in the Head position. Multi-function switch in the HI beam (LO beams U.S.) position. Check for battery voltage at daytime running lamps control module connector C223, Pin 8, Circuit 13 (R/BK) (U.S.) or connector C223, Pin 8, Circuit 12 (GN/BK) (Canadian). Is battery voltage present?	Yes	Go to Step A6.
	No	Service open on Circuit 12 (GN/BK) (Canadian) or Circuit 13 (R/BK) (U.S.) between headlamps and daytime running lamps control module connector C223. Restore vehicle. Retest system.

Troubleshooting

Test A: A DRL Malfunction or DRL Inoperative		
Test Step	**Result**	**Action to Take**
Step A6, Check Module Ground.	Yes	Go to Step A7.
With daytime running lamps control module removed, actuate key to Run. Headlamp switch in the Head position. Multi-function switch in the HI beam (LO beam U.S.) position. Check resistance between a known ground and daytime running lamps control module connector C223, Pin 6, Circuit 12 (GN/BK) (U.S.) or connector C223, Pin 6, Circuit 13 (R/BK) (Canadian). Is resistance 1.5 ohms or less?	No	Service open on Circuit 13 (R/BK) (Canadian) or Circuit 12 (GN/BK) (U.S.) between headlamps and daytime running lamps control module connector C223. Restore vehicle. Retest system.
Step A7, Check Daytime Running Lamps Control Module Pin 6.	Yes	Go to Step A8.
With daytime running lamps control module removed, actuate key to Run. Headlamp switch in the Head position. Multi-function switch in the LO beam (HI beam U.S.) position. Check for battery voltage at the daytime running lamps control module connector C223, Pin 6, Circuit 12 (GN/BK) (U.S.) or connector C223, Pin 6, Circuit 13 (R/BK) (Canadian). Is battery voltage present?	No	Service open on Circuit 13 (R/BK) (Canadian) or Circuit 12 (GN/BK) (U.S.) between headlamps and daytime running lamps control module connector C223. Restore vehicle. Retest system.
Step A8, Check High Beam Indicator (Canadian).	Yes	Go to Step A9.
With daytime running lamps control module removed, actuate key to Run. Headlamp switch in the Head position. Multi-function switch in the HI beam position. Jumper Pin 8 to Pin 1 of the daytime running lamps control module connector C223. Did high beam indicator illuminate?	No	Replace illumination bulb or service Circuits 34 (GN/BK) or 57 (BK) for an open. Restore vehicle. Retest system.
Step A9, Check Parking Brake Signal Lamps Switch.	Yes	Go to Step A10.
With daytime running lamps control module removed, actuate all accessories to the Off position. Check continuity of the parking brake signal lamp switch between the daytime running lamps control module connector C223, Pin 4, Circuit 162 (GN/R) and a known good ground. Apply and release parking brake. Is resistance less than 1.5 ohms with parking brake applied and infinite with the parking brake released?	No	Service ground connection at parking brake signal lamp switch or service Circuit 34 (GN/R) for an open or a short or replace parking brake signal lamp switch. Restore vehicle. Retest system.
Step A10, Recheck Daytime Running Lamps Control Module.	Yes	System is functioning properly. No service required.
Reinstall daytime running lamps control module. Key in Run. Parking brake fully released. Headlamp switch Off or in the Park position. Are the high beams (low beams U.S.) on at reduced intensity?	No	Replace daytime running lamps control module. Restore vehicle. Retest system.

Table 2, Test A: A DRL Malfunction or DRL Inoperative

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.

Only good care can ensure long battery life. Proper testing will indicate the battery condition. For more information, see **Subject 140**.

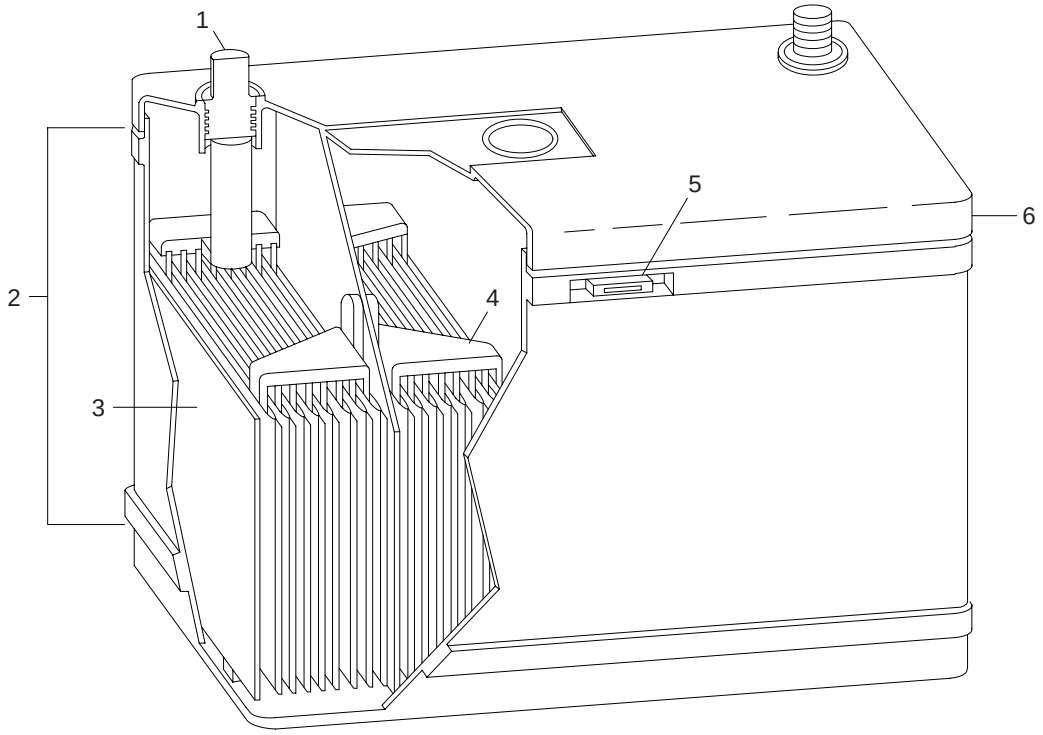
GEL CELLS (ISOLATED BATTERY SYSTEM)

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.

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 cell, particularly when used in deep-cycle applications.

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

- It is non-spillable, and can be operated in virtually any position (upside-down installation is not recommended).

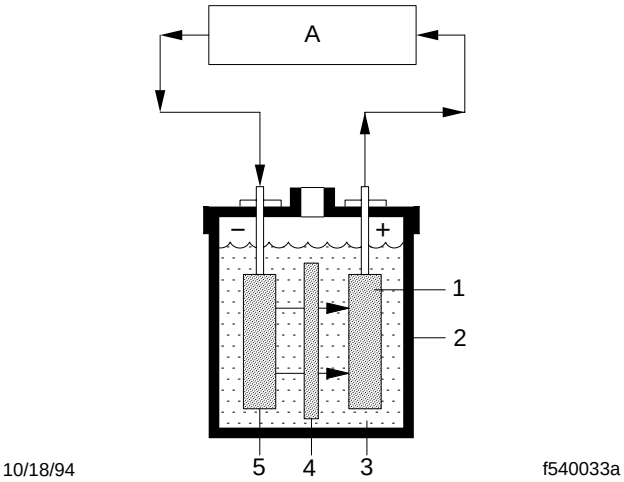
At 14 volts, a gel cell has a very high charge acceptance rate. Because a truck charging system operates at approximately 14 volts, under normal conditions a gel cell should never need to be recharged with an external charger.

⚠ 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.

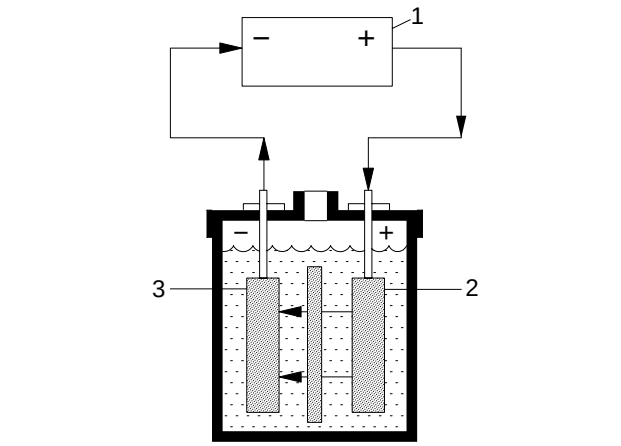
A gel cell is a "recombinant" battery. The oxygen that is normally produced at the positive plate (in all lead-acid batteries) recombines (in a gel cell) with the hydrogen given off at the negative plate. The recombination of hydrogen and oxygen produces water (H_2O), which replenishes the moisture in 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

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

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.

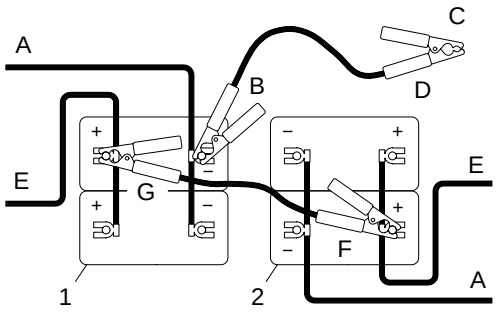
⚠ WARNING

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.



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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

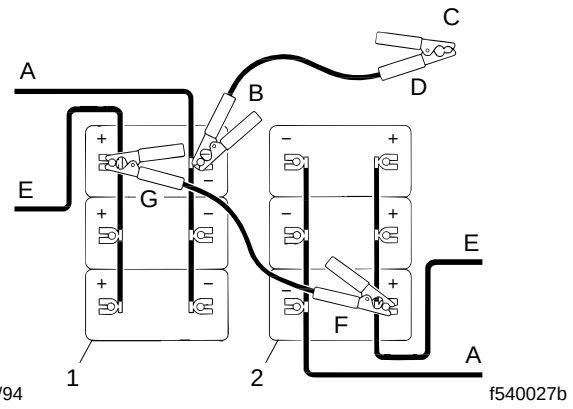
3. For your third connection, attach one end of the other jumper cable to the negative terminal of the booster battery. For the fourth connection, attach the opposite end of that cable to a ground at least 12 inches (300 mm) from the battery of the vehicle being started. See Fig. 1 and Fig. 2. The vehicle 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, read the instructions in Subject 120. 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, Midtronics PowerSensor Micro740 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.

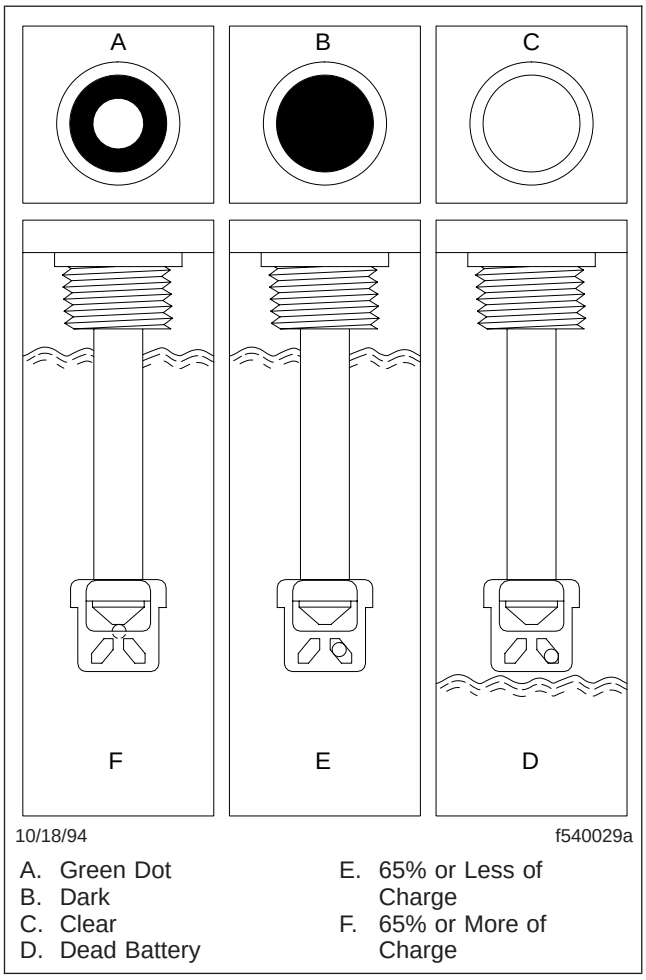


Fig. 1, Built-In Hydrometer or Charge Indicator (on optional batteries only)

Midtronics PowerSensor Micro740 Test

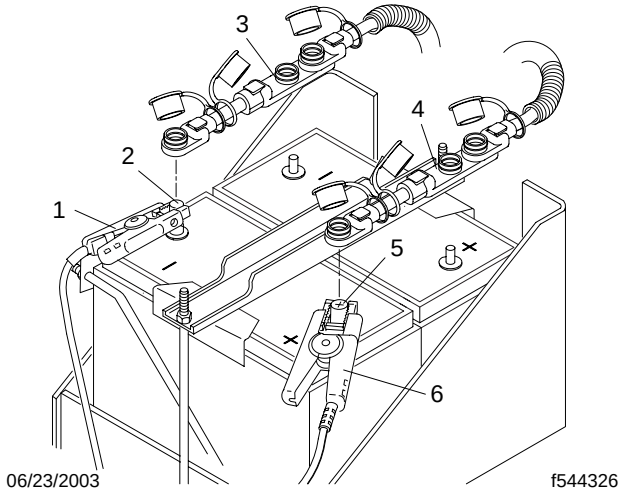
NOTE: This test must be used by all U.S and Canadian dealers for battery warranty claims.

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 Adaptor
3. Negative-Terminal Battery Jumper
4. Positive-Terminal Jumper
5. Positive-Terminal 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. See **Subject 150**.
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. See **Subject 150**.
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

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. See **Subject 150**.
Poor connection at battery terminal.	Connect the battery cables and retest.

Test Message—NON 12-VOLT BATTERY DETECTED

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

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

Test Message—REVERSE CONNECTION	
Possible Cause	**Remedy**
The clamps are connected in reverse polarity. IE: Red to negative(-), and black to positive (+).	Disconnect the clamps and reclamp to proper polarity.

Test Message—UNSTABLE BATTERY

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. See **Subject 150**.

Test Message—CHECK CONNECTION

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. Before beginning the load test, make sure the battery to be tested is fully charged. See **Subject 150** for conventional battery and gel cell charging instructions.

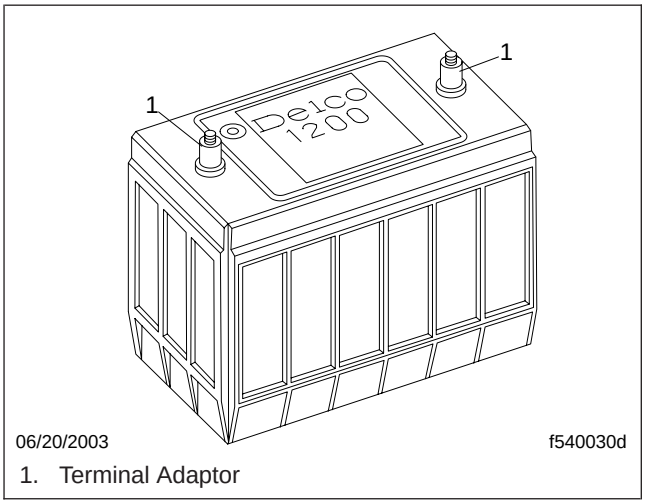
⚠ WARNING

Before charging a battery, read the instructions in Subject 150. 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. Test each battery separately, either installed or removed. Disconnect the battery ground cable first.

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 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 Table 1, **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.

⚠ WARNING

Before charging a battery, read the instructions in Subject 120. 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.

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.

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

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.

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.

⚠ WARNING

Always turn the charger off before disconnecting it. Touching a charger lead when the circuit is live could create a spark and cause an explosion, resulting in personal injury.

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.

   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.

Battery Charging

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.

CAUTION

Use a reliable, automatic, temperature-sensing, voltage-regulated charger to charge gel cells. Any other type of charger will damage the gel cell.

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).

CAUTION

To prevent damage, do not open a sealed gel cell or charge it in excess of 14.1 volts (2.35 volts per cell).

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.

WARNING

Always turn the charger off before disconnecting it. Touching a charger lead when the circuit is live could create a spark and cause an explosion, resulting in personal injury.

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.

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.

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-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.

Battery Removal, Cleaning and Inspection, and Installation

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.
The isolator relay is not operating correctly (optional battery isolator system only).	Replace the isolator relay with an exact replacement continuous duty relay.

Troubleshooting

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

Approved Electrical Lubricants	
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

Standard Battery Specifications	
Reserve Capacity	Cold Cranking Amps (CCA)
180 minutes	750

Table 4, Standard Battery Specifications

General Information

At the rear of the vehicle are the taillights, stoplights with turn signals, and backup lights.

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 interrrupter operates only with the headlights ON; it will not operate when only the parking lights are on.

Stoplight and Taillight Replacement

1. Remove the screws attaching the lens to the light housing. See **Fig. 1**.
2. Remove the lamp by pressing in on the bulb and turning it counterclockwise to release it from the socket. See **Fig. 2**.
3. To provide corrosion protection, coat the base of the new bulb with dielectric grease. For approved electrical lubricants, refer to 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.

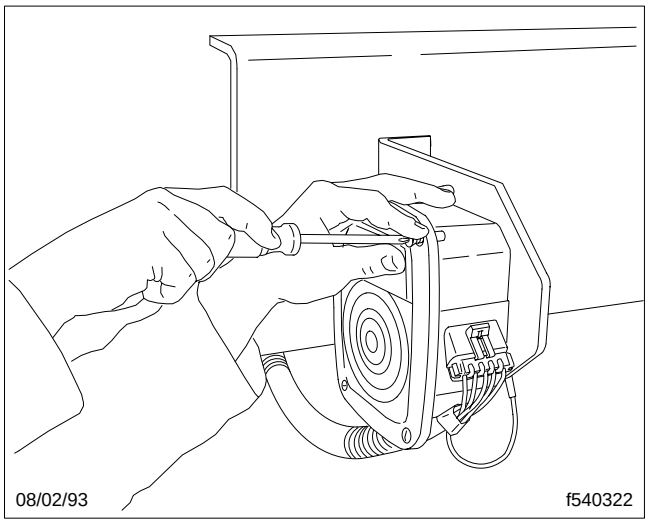


Fig. 1, Lens Removal

5. Install the lens on the housing. Fasten it in place with the attaching screws. Do not over tighten the screw or you will crack the lens.

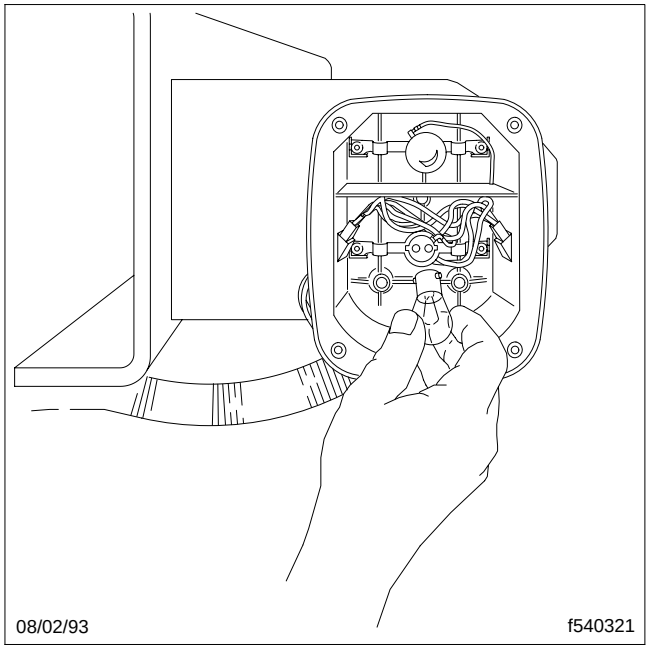


Fig. 2, Bulb Removal

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

Bulb Replacement	
Description	**Part Number**
Clearance and Identification Light	WEE 193
Tail/Brake/Rear Turn Signal Light	WEE 1157
Backup Light	WEE 1156

Table 2, Bulb Replacement

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 by 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. See **Table 1**.

Wiring Damage	
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
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.

Table 1, Wiring Damage

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

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.

IMPORTANT: If the damaged wire is 12 gauge or larger, don't replace a section of it; replace the entire 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, and then dry the area. Replace any damaged connectors.
3. Spray any exposed connectors (such as ground terminals) with dielectric red enamel. See **Table 2**.

Protectant Material	Approved Brands
Spray-On Application	MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC

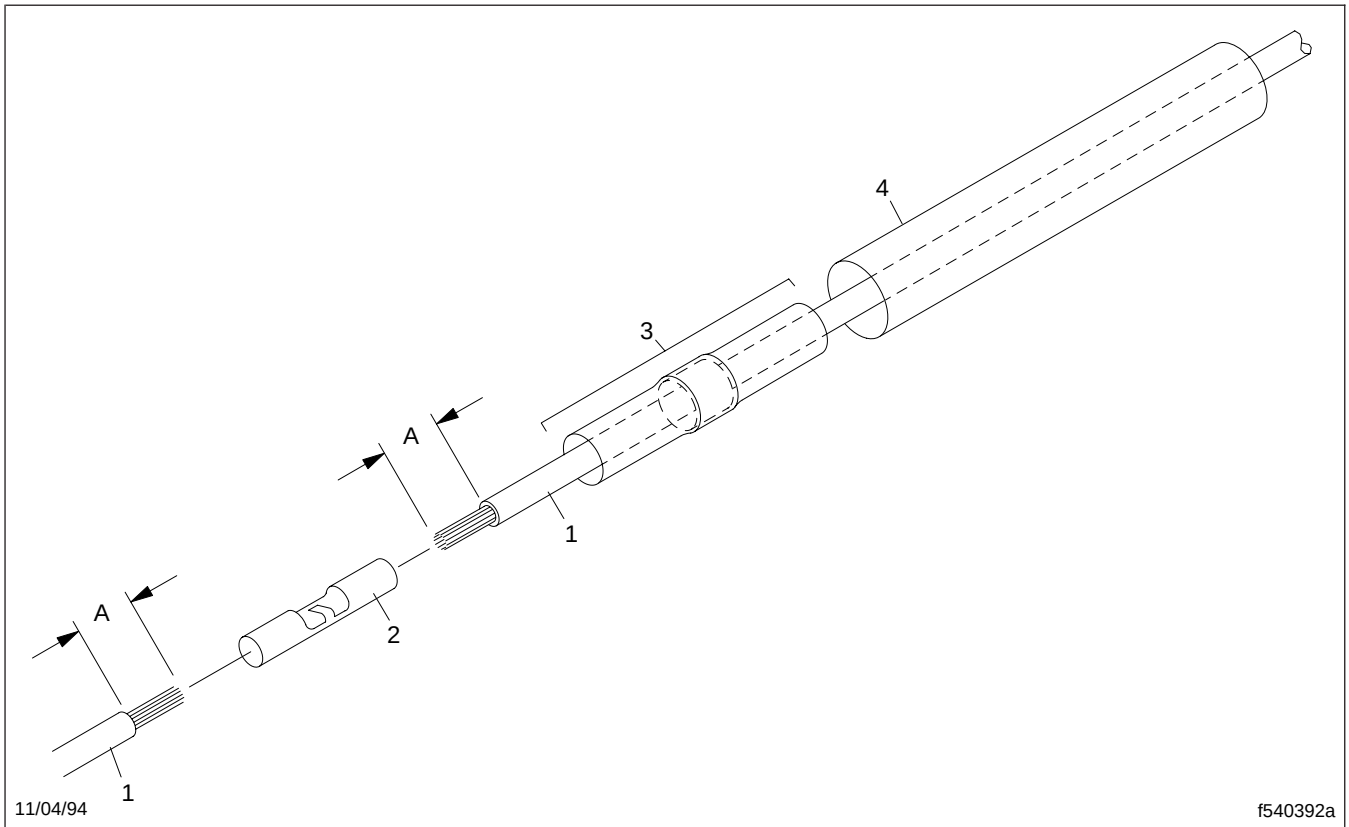
Protectant Material	Approved Brands
Brush-On Application	Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201

Table 2, Approved Dielectric Red Enamel

REPAIRING BROKEN WIRE

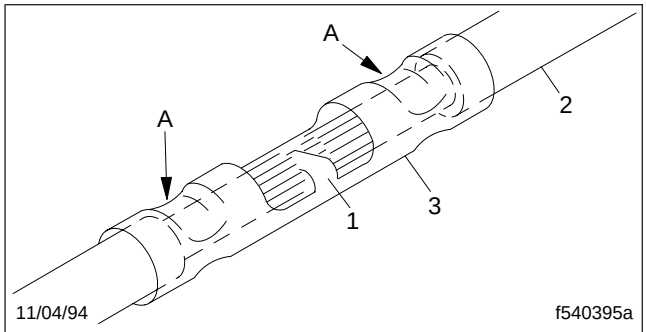
IMPORTANT: The following procedure is the only approved method of repairing broken wires on Freightliner vehicles. This procedure (solder splicing) is done using solder repair kit ESYES66 404, and is for 14- or 16-gauge wire. Don't repair wire that is 12 gauge or larger; replace it.

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 the two sub-steps above for 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. Slide the shrink tubing over the splice; then apply 250°F (121°C) heat to it until completely shrunk against the wire insulation. Some of the sealant material should be bubbling out from the ends of the shrink tube.



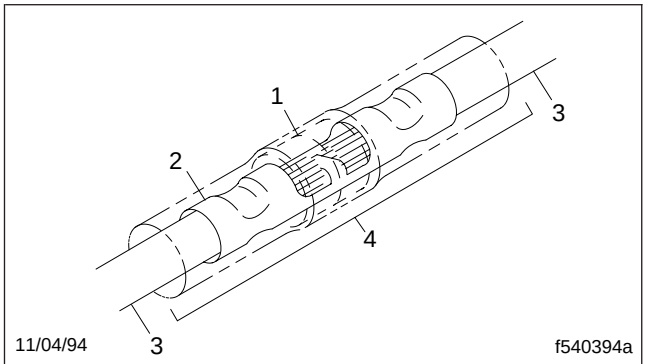
A. 3/8 to 1/2 Inch (10 to 13 mm)
1. Wire End
2. Crimp Splice
3. Solder Sleeve
4. Shrink Tube

Fig. 1, Exterior Wire Repair



A. Center crimping tool here.
1. Wire Stop
2. Wire
3. Crimp Splice (shown crimped)

Fig. 2, Centering the Crimping Tool



1. Solder
2. Crimp Splice (shown crimped)
3. Wire
4. Solder Sleeve

Fig. 3, Wire Ready for Soldering

Basic Wiring Diagrams

See **Fig. 1** for a schematic of the cab wiring, showing the front lighting (left-hand side) and the ABS module. For a detailed (partial) view of the basic cab wiring diagram showing the front lighting (left-hand side) and the ABS module, see **Fig. 2**. For a detailed (partial) view of the basic cab wiring diagram showing only the front lighting (left-hand side), see **Fig. 3**.

See **Fig. 4** for a schematic of the cab electrical center and power distribution wiring. For a detailed (partial) view of the cab electrical center and power distribution wiring, see **Fig. 5**. For a detailed (partial) view of the basic cab wiring diagram showing only the front lighting (left-hand side), see **Fig. 6**.

See **Fig. 7** for a schematic of the main cab wiring harness. For detailed (partial) views of the main cab wiring harness, see **Fig. 8** and **Fig. 9**.

See **Fig. 10** for a schematic of the cab wiring, showing dash gauges. For detailed (partial) views of the cab wiring, showing dash gauges, see **Fig. 11** and **Fig. 12**.

See **Fig. 13** for a schematic of the front lighting (right-hand side). For detailed (partial) views of the front lighting (right-hand side), see **Fig. 14** and **Fig. 15**.

See **Fig. 16** for a schematic of the engine wiring harness. For detailed (partial) views of the engine wiring harness, see **Fig. 17** and **Fig. 18**.

See **Fig. 19** for a schematic of the chassis wiring harness. For detailed (partial) views of the chassis wiring harness, see **Fig. 20** and **Fig. 21**.

Specifications

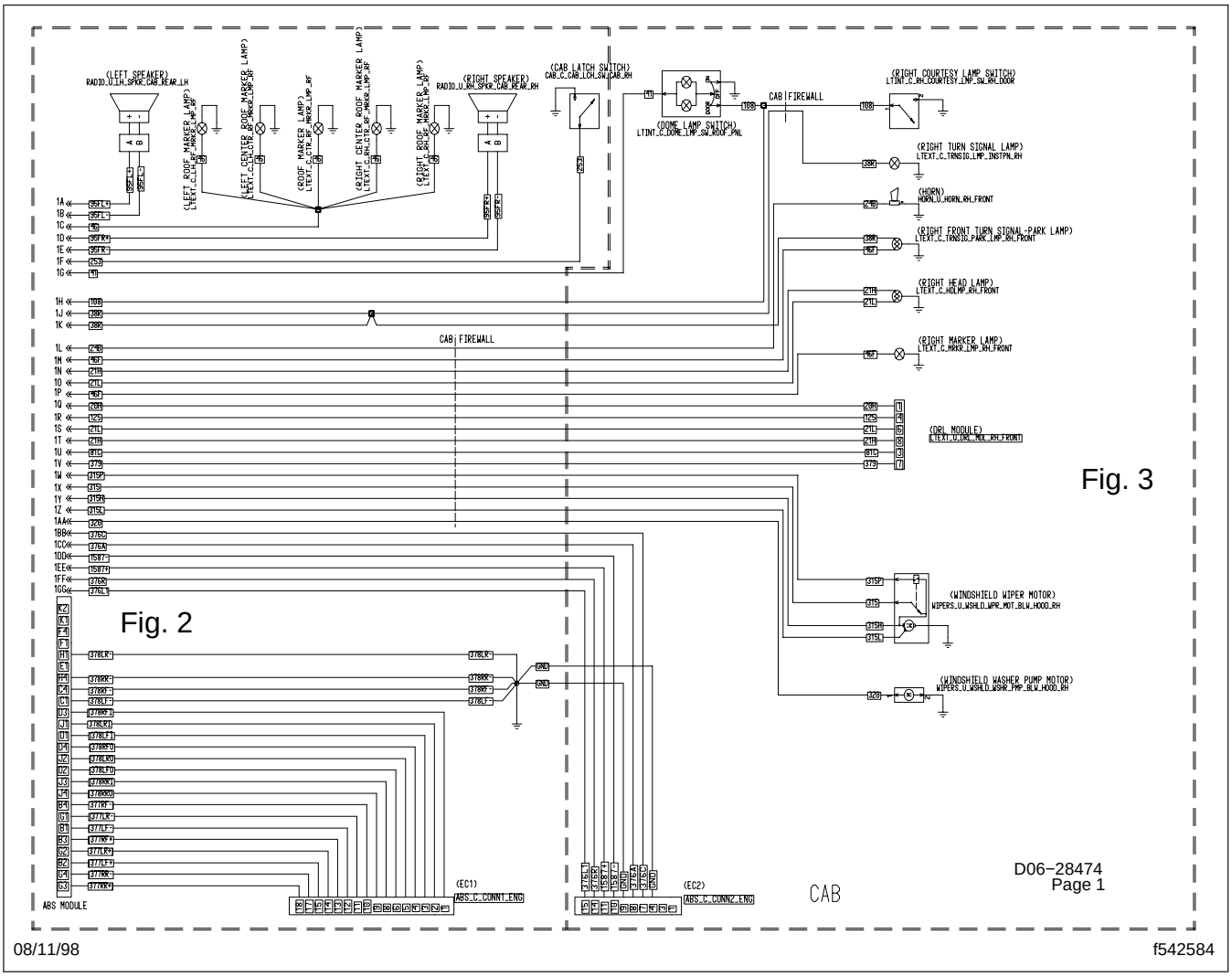


Fig. 1, Front Lighting Schematic, Left-Hand Side, Showing ABS Module

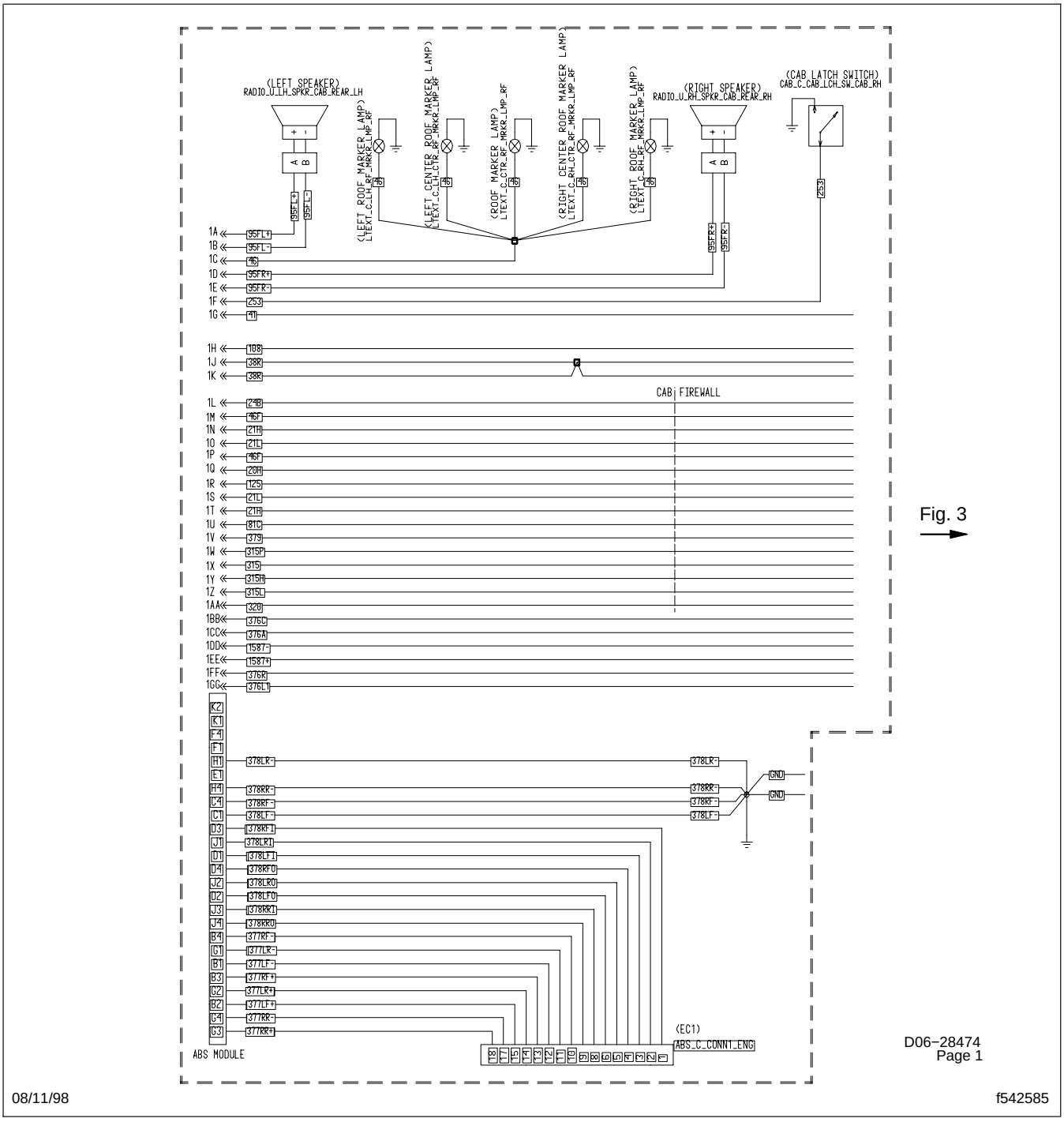


Fig. 2, Front Lighting Schematic, Left-Hand Side, Showing ABS Module (partial view)

Specifications

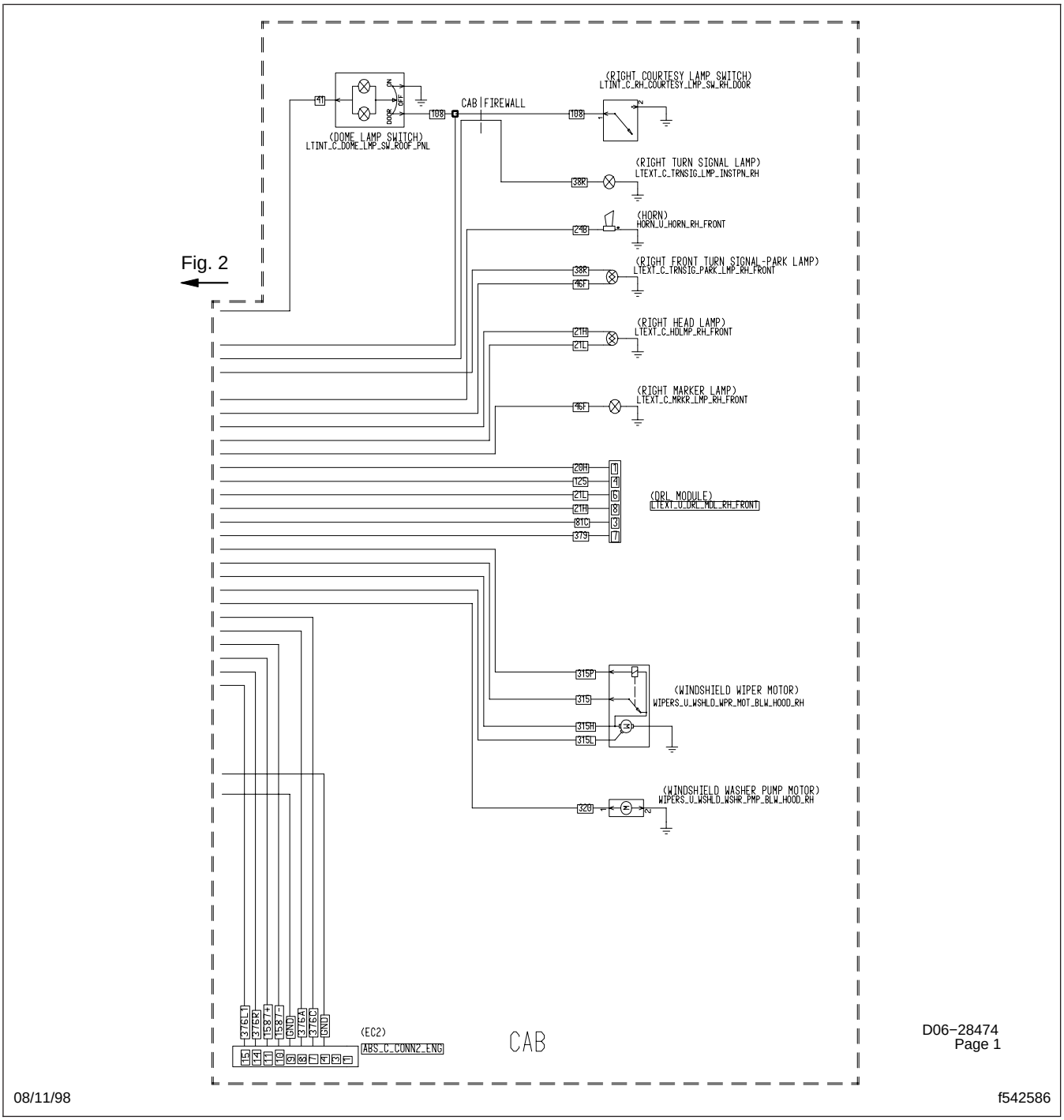


Fig. 3, Front Lighting Schematic, Left-Hand Side (partial view)

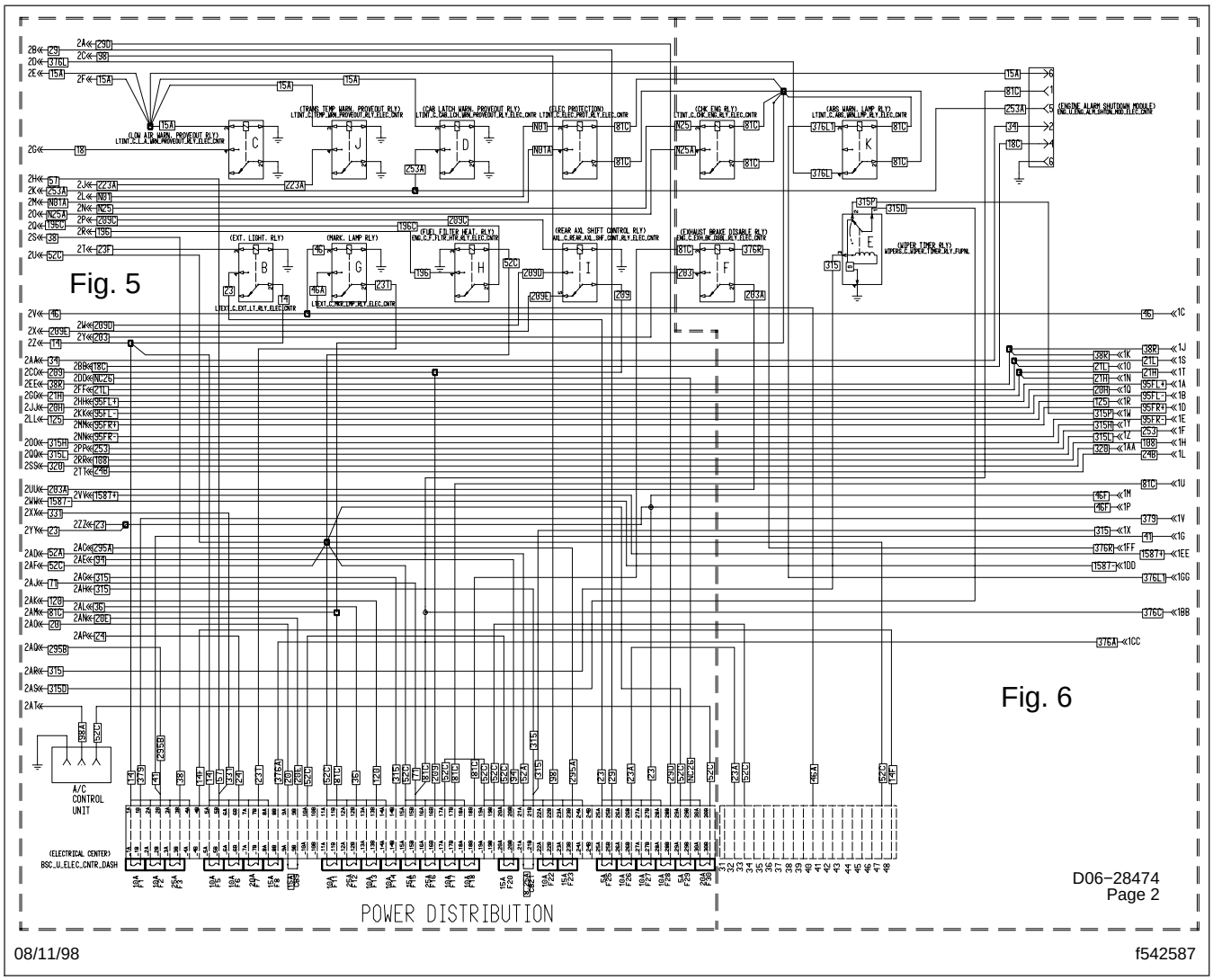


Fig. 4, Power Distribution Schematic

Specifications

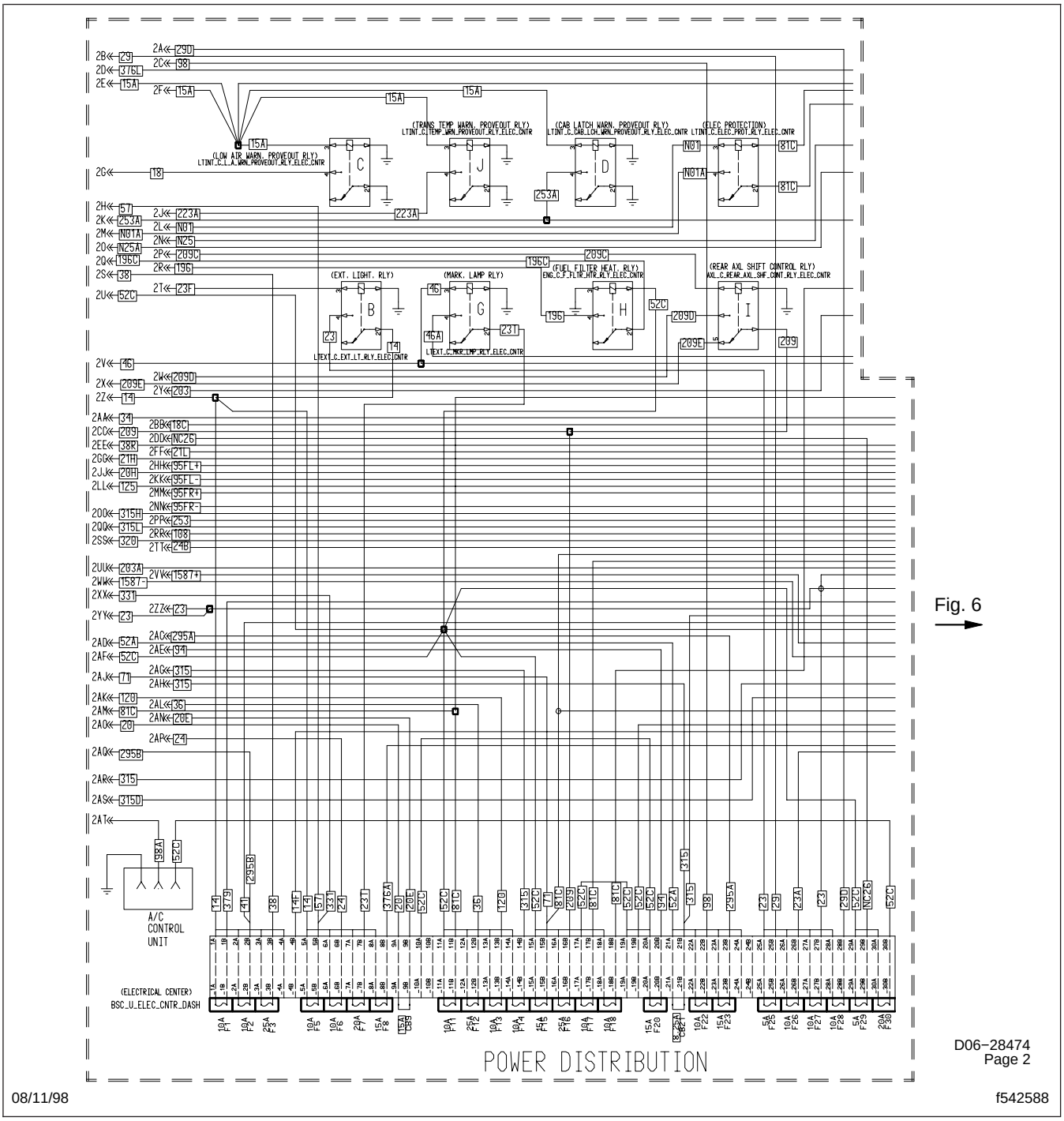


Fig. 5, Power Distribution Schematic (partial view)

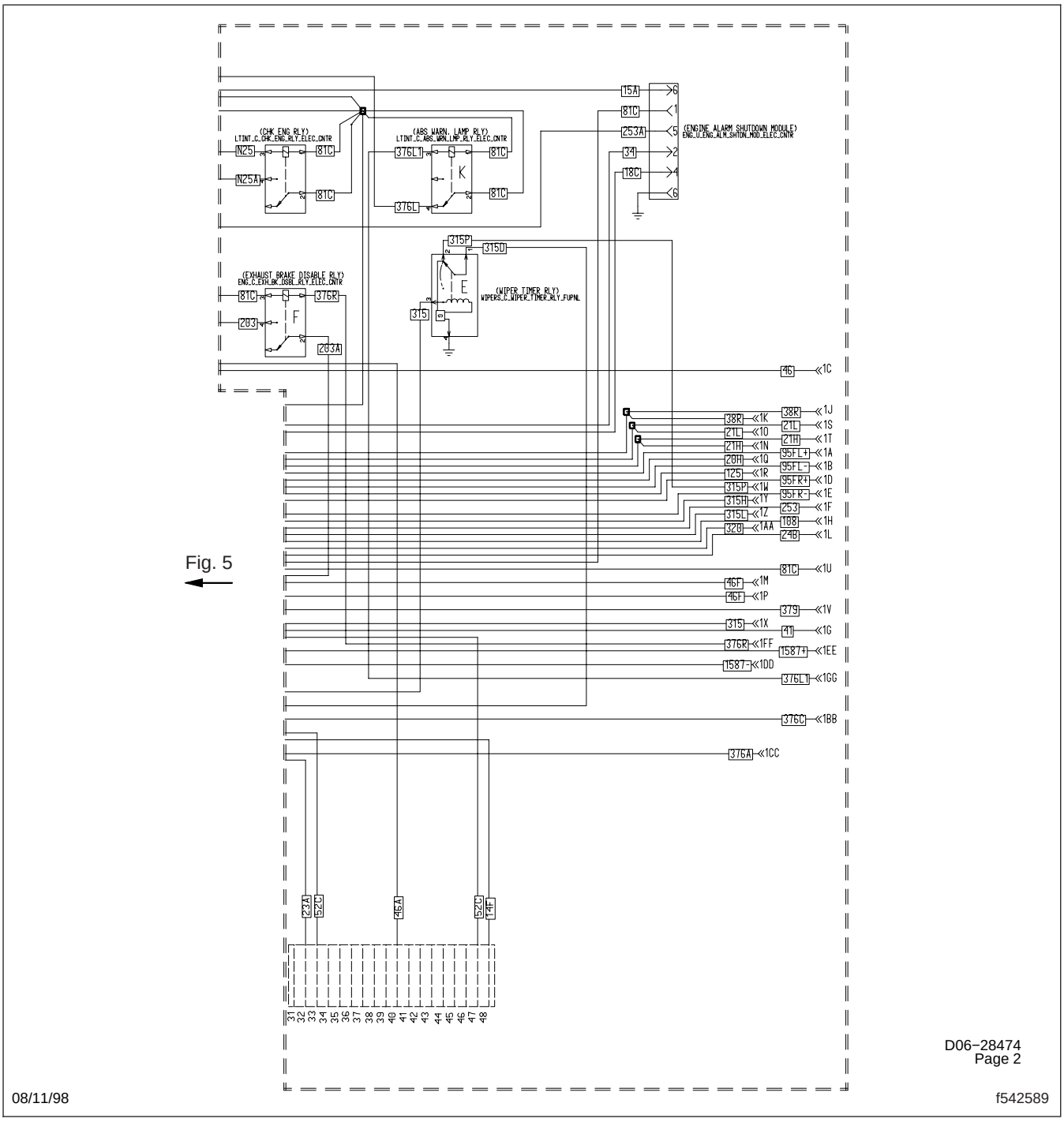


Fig. 5

Fig. 6, Power Distribution Schematic (partial view)

Specifications

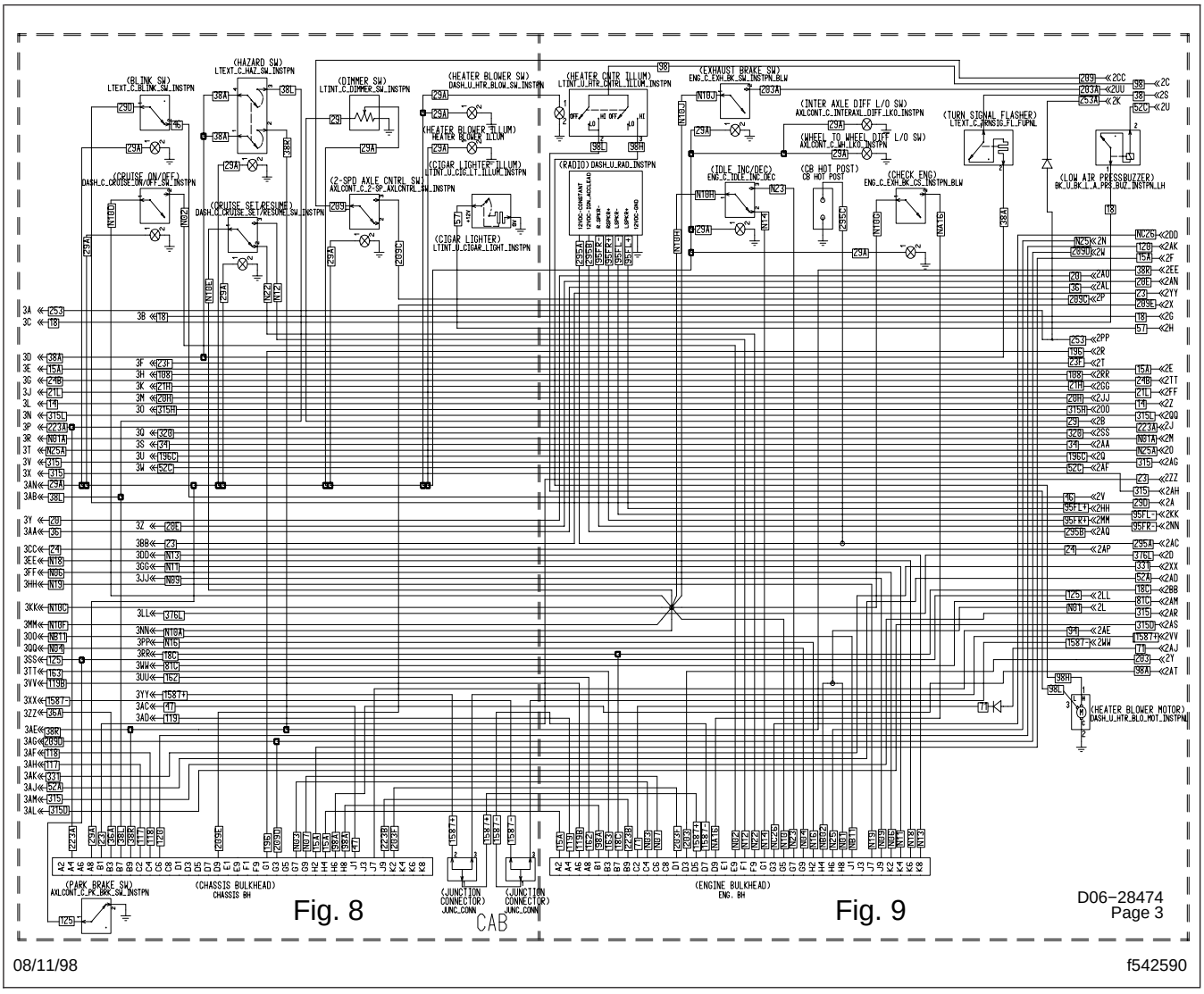


Fig. 7, Main Cab Harness Schematic

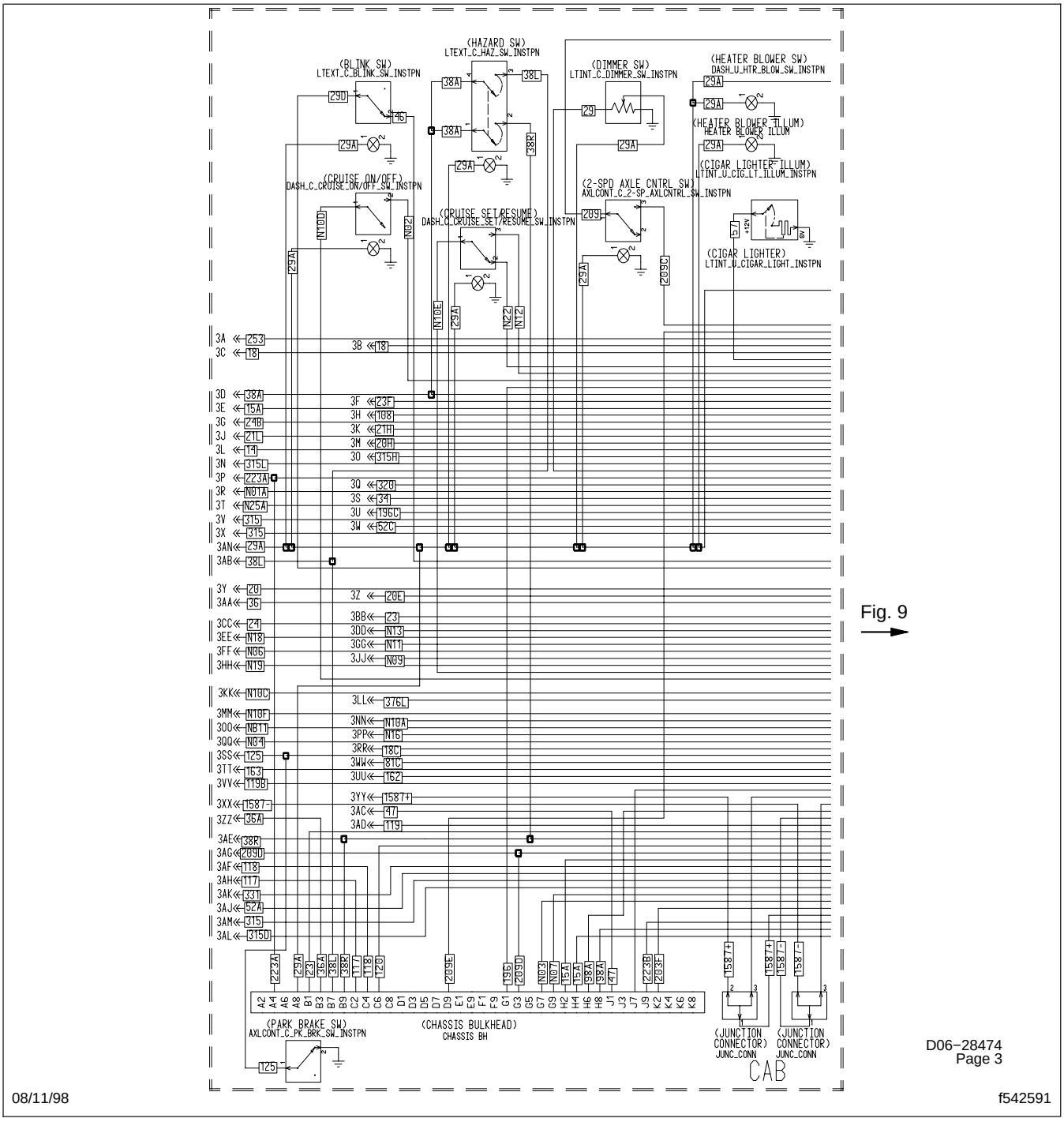


Fig. 9

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Fig. 8, Main Cab Harness Schematic (partial view)

Specifications

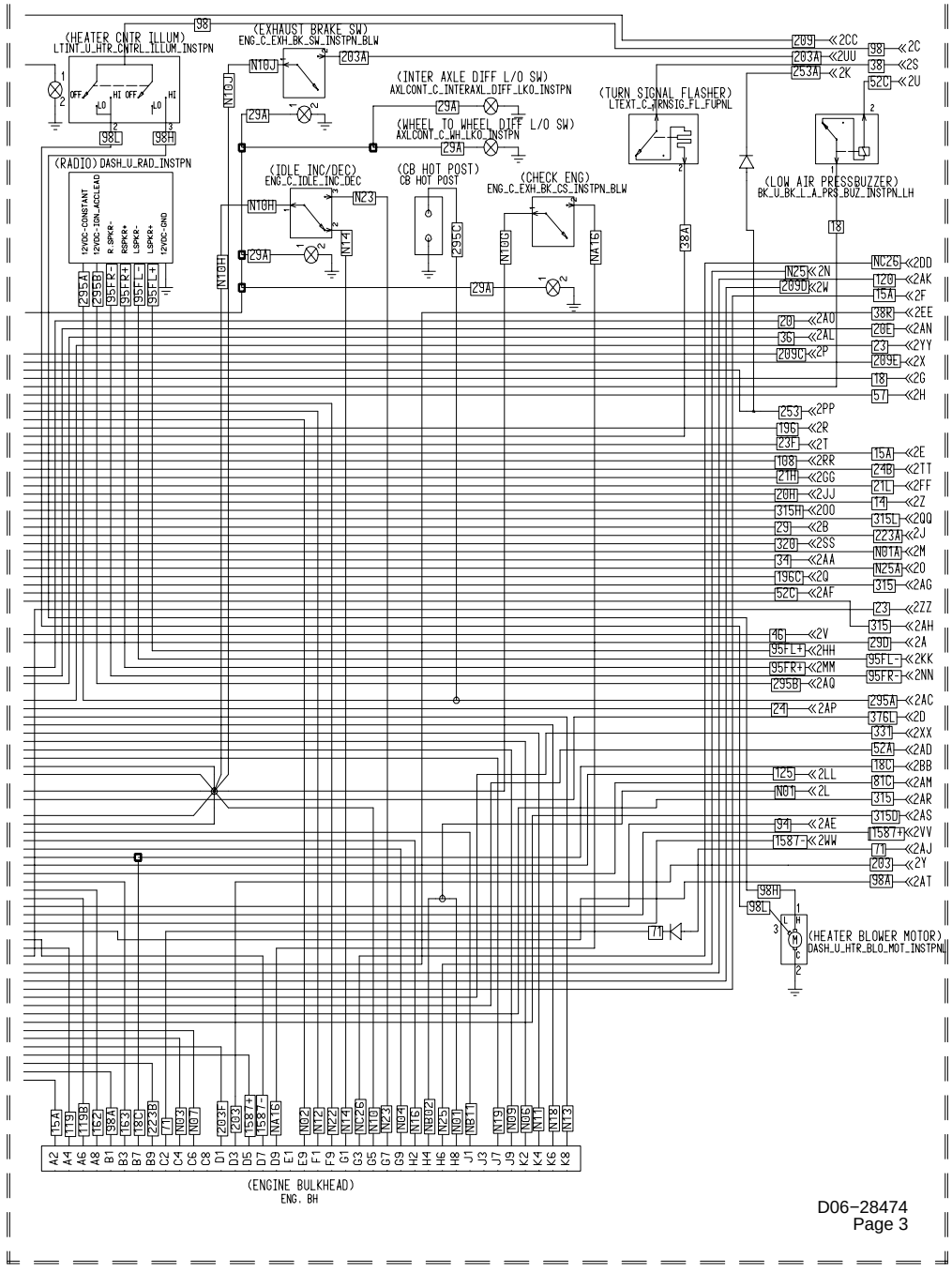


Fig. 8

Fig. 9, Main Cab Harness Schematic (partial view)

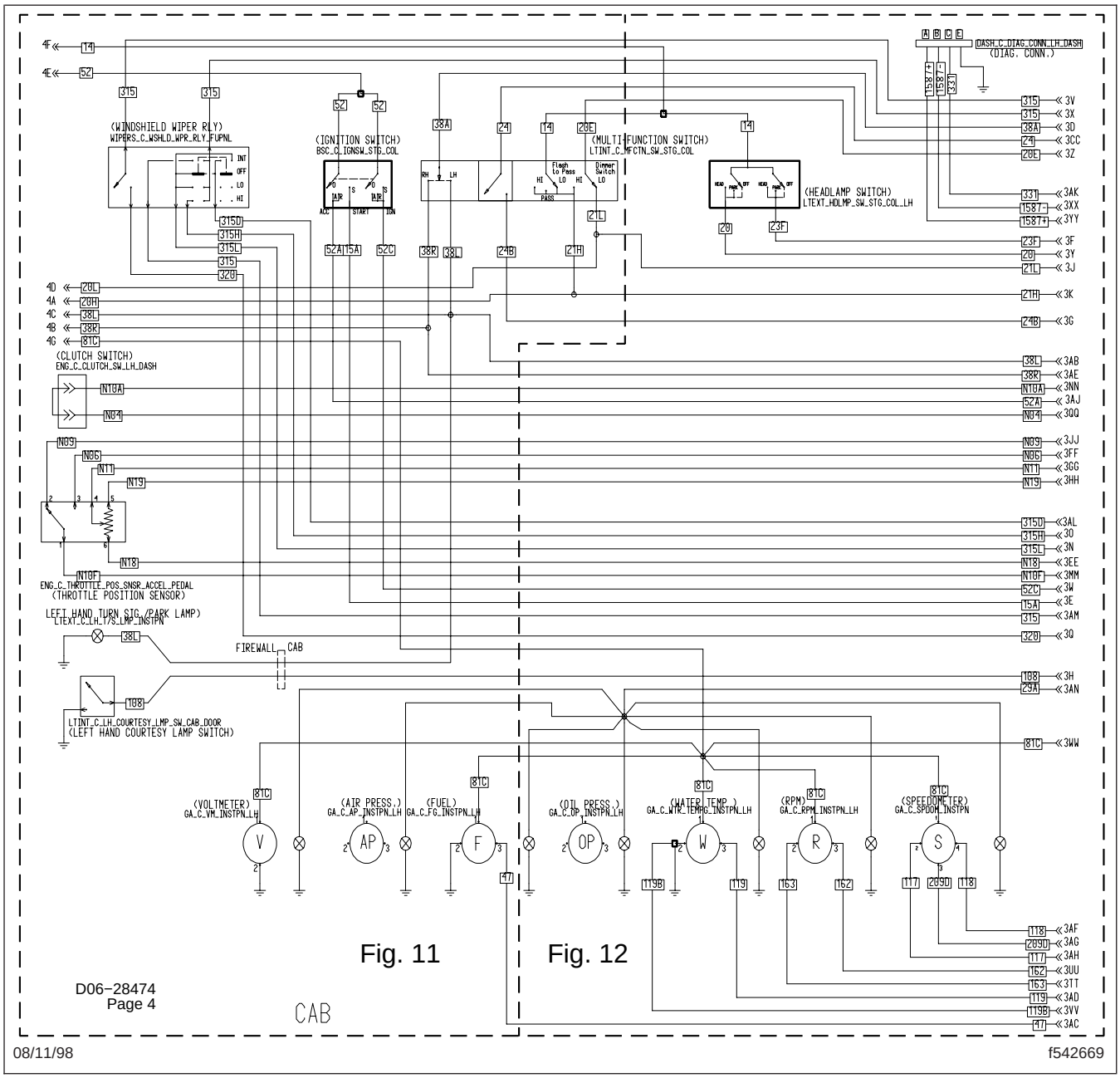


Fig. 10, Cab Wiring Schematic, Showing Dash Gauges

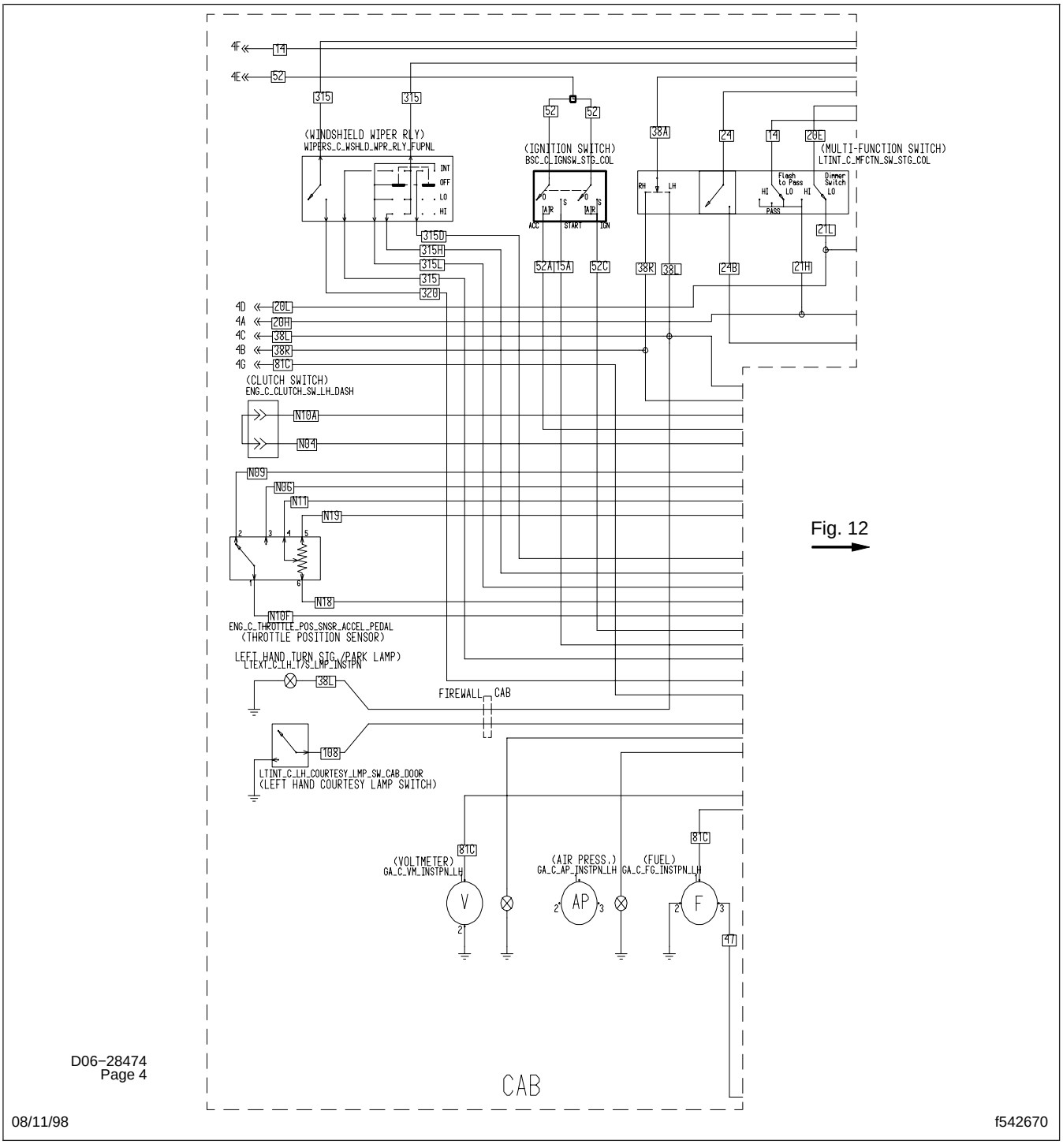


Fig. 12

Fig. 11, Cab Wiring Schematic, Showing Dash Gauges (partial view)

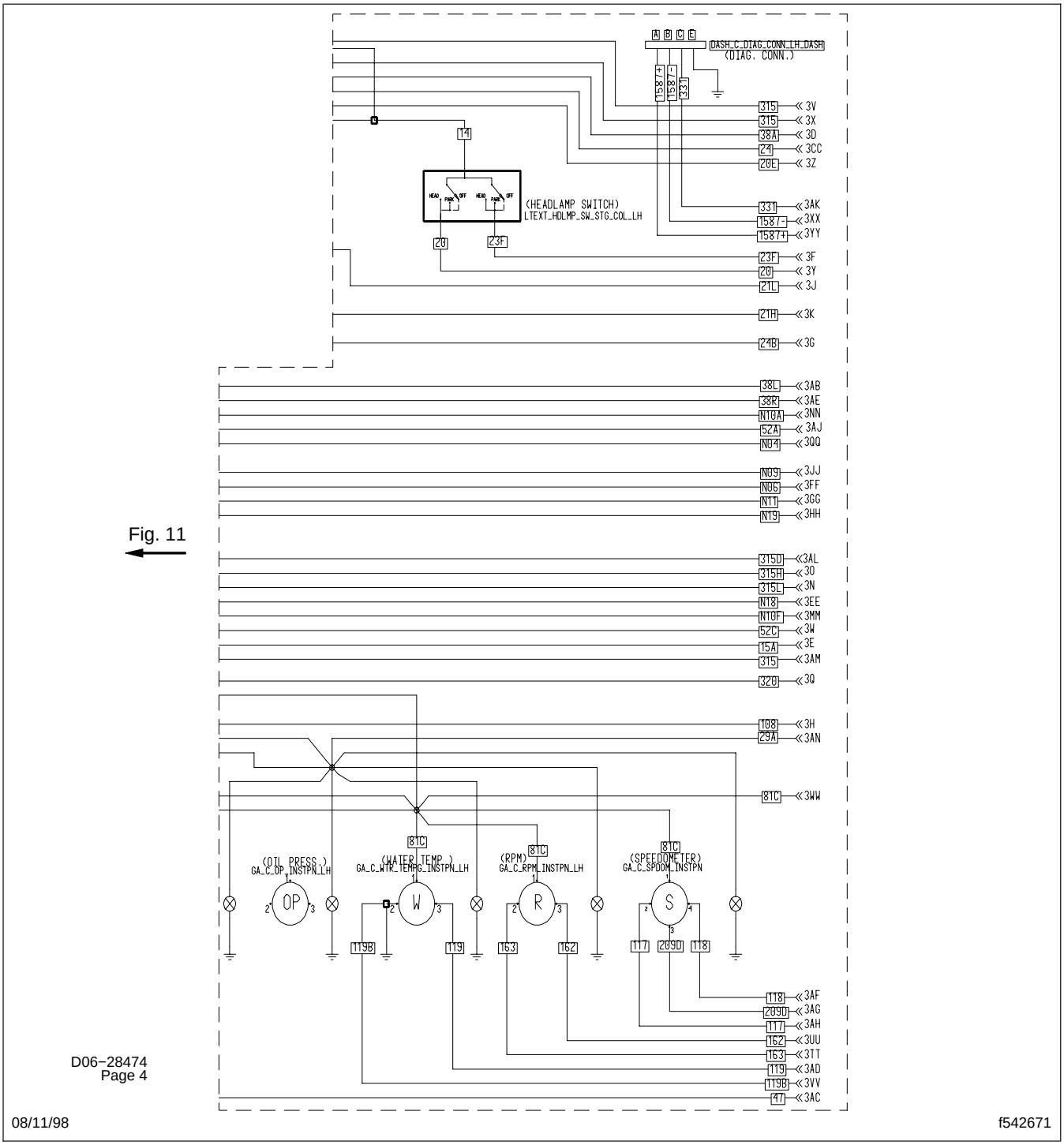


Fig. 11

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Fig. 12, Cab Wiring Schematic, Showing Dash Gauges (partial view)

Specifications

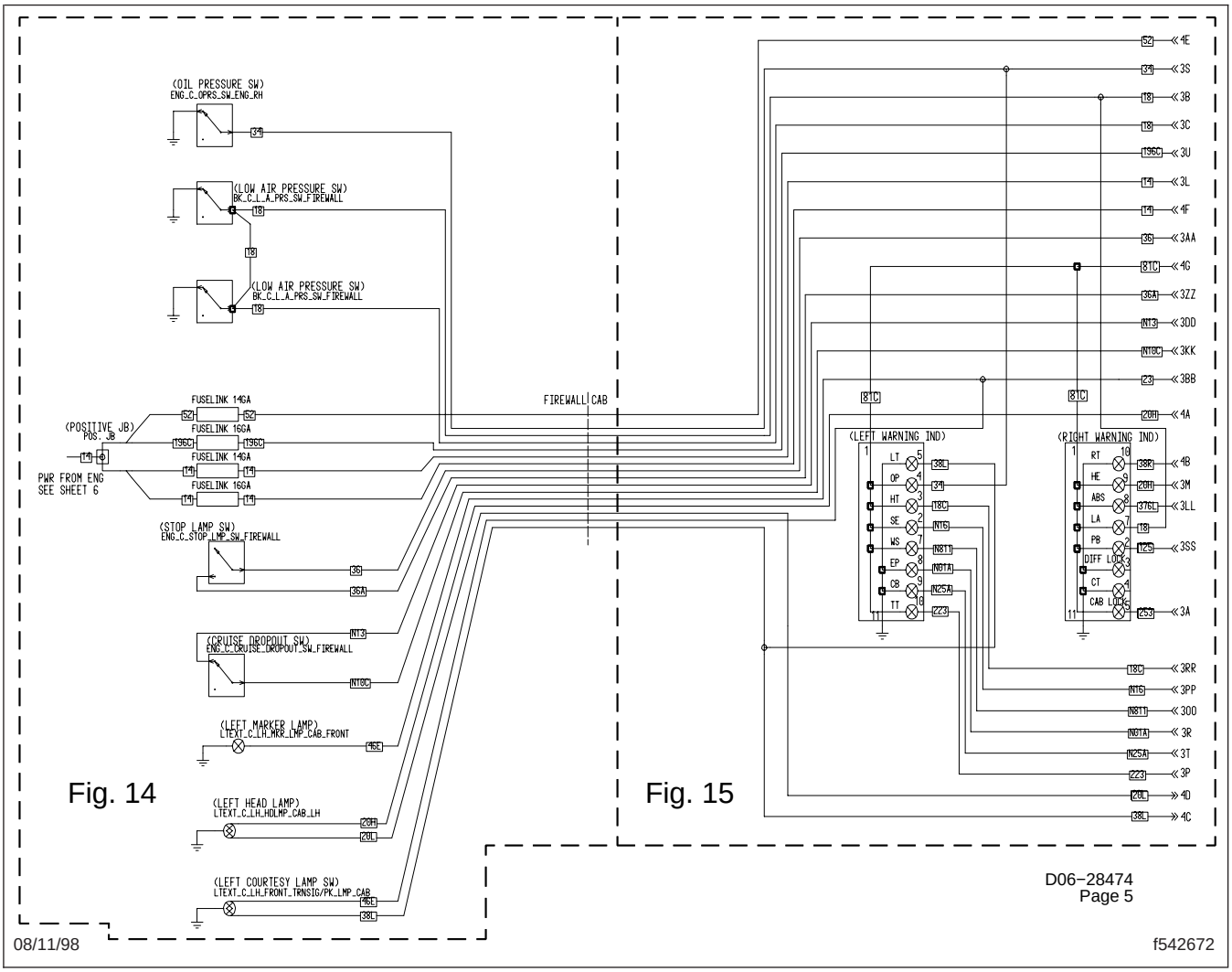


Fig. 13, Front Lighting Schematic, Right-Hand Side

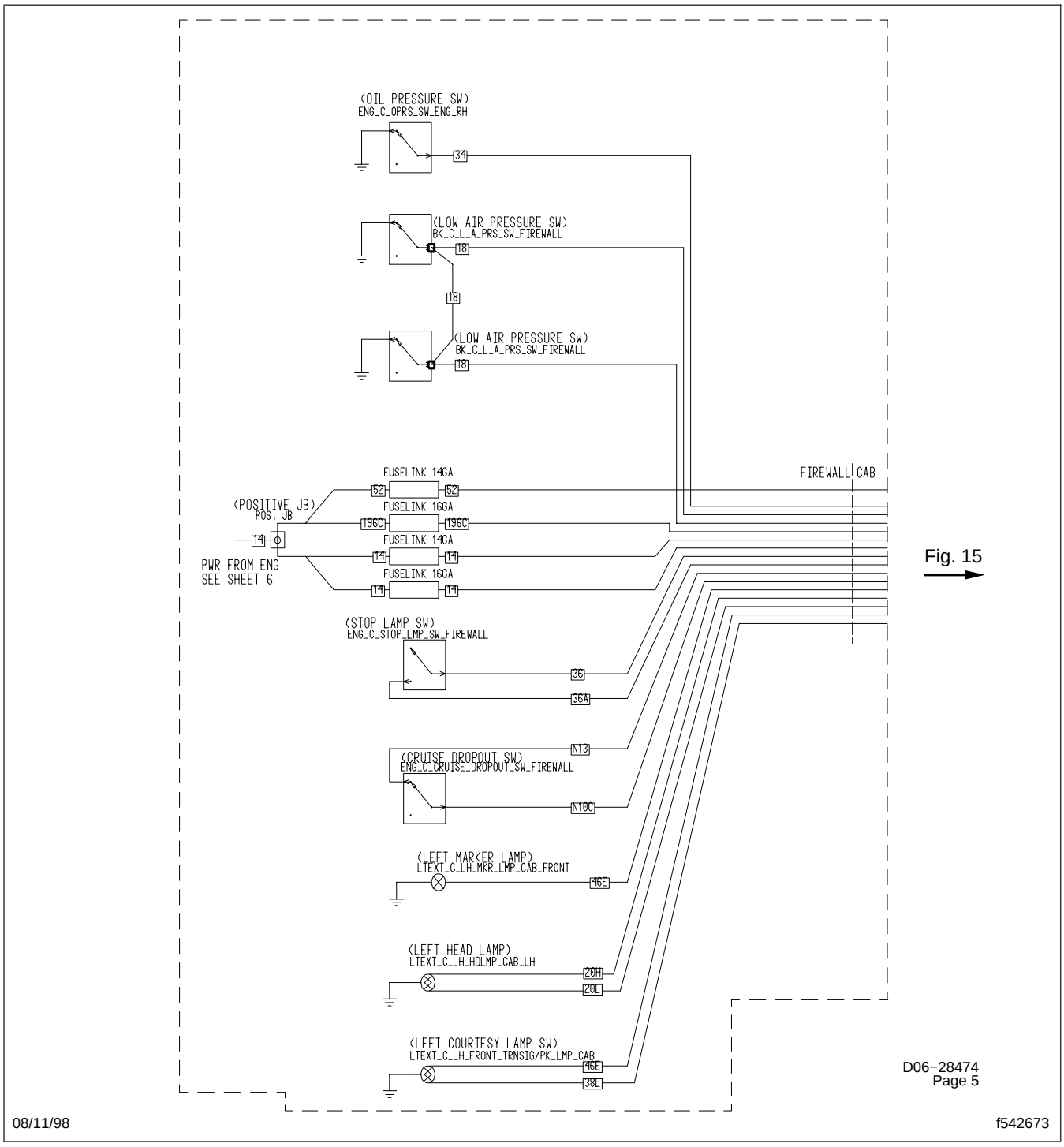


Fig. 14, Front Lighting Schematic, Right-Hand Side (partial view)

Specifications

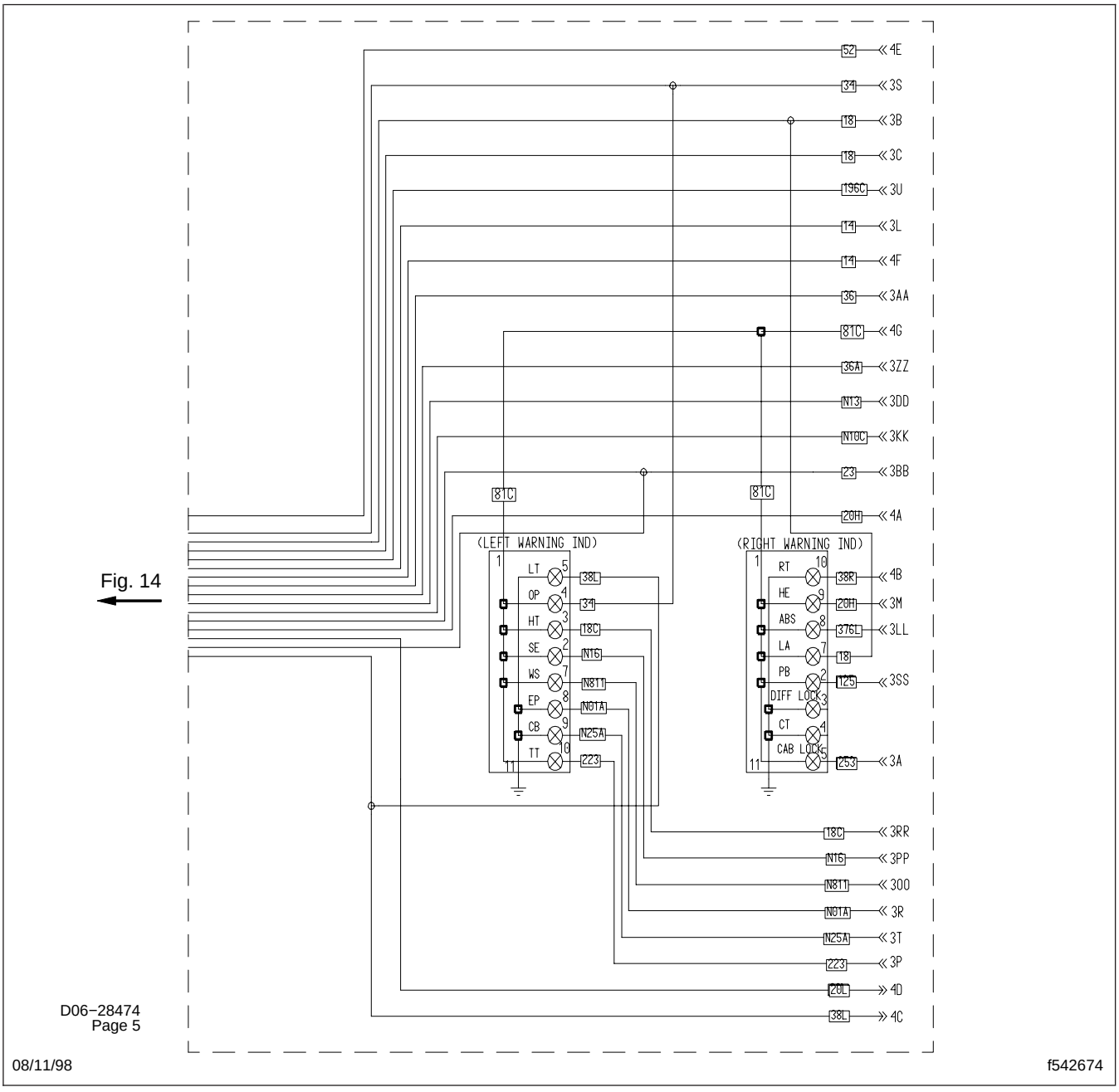


Fig. 15, Front Lighting Schematic, Right-Hand Side (partial view)

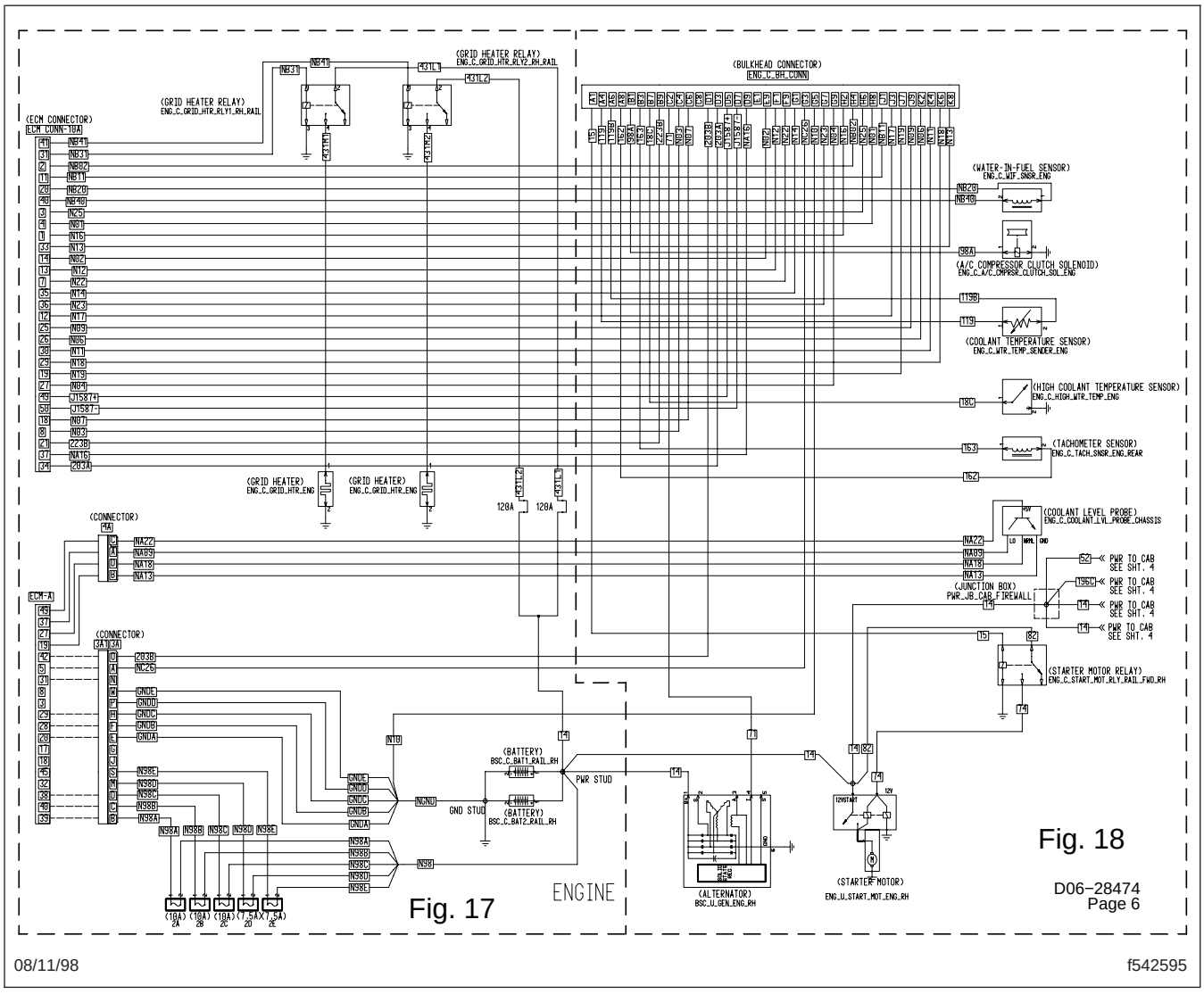


Fig. 16, Engine Harness Schematic

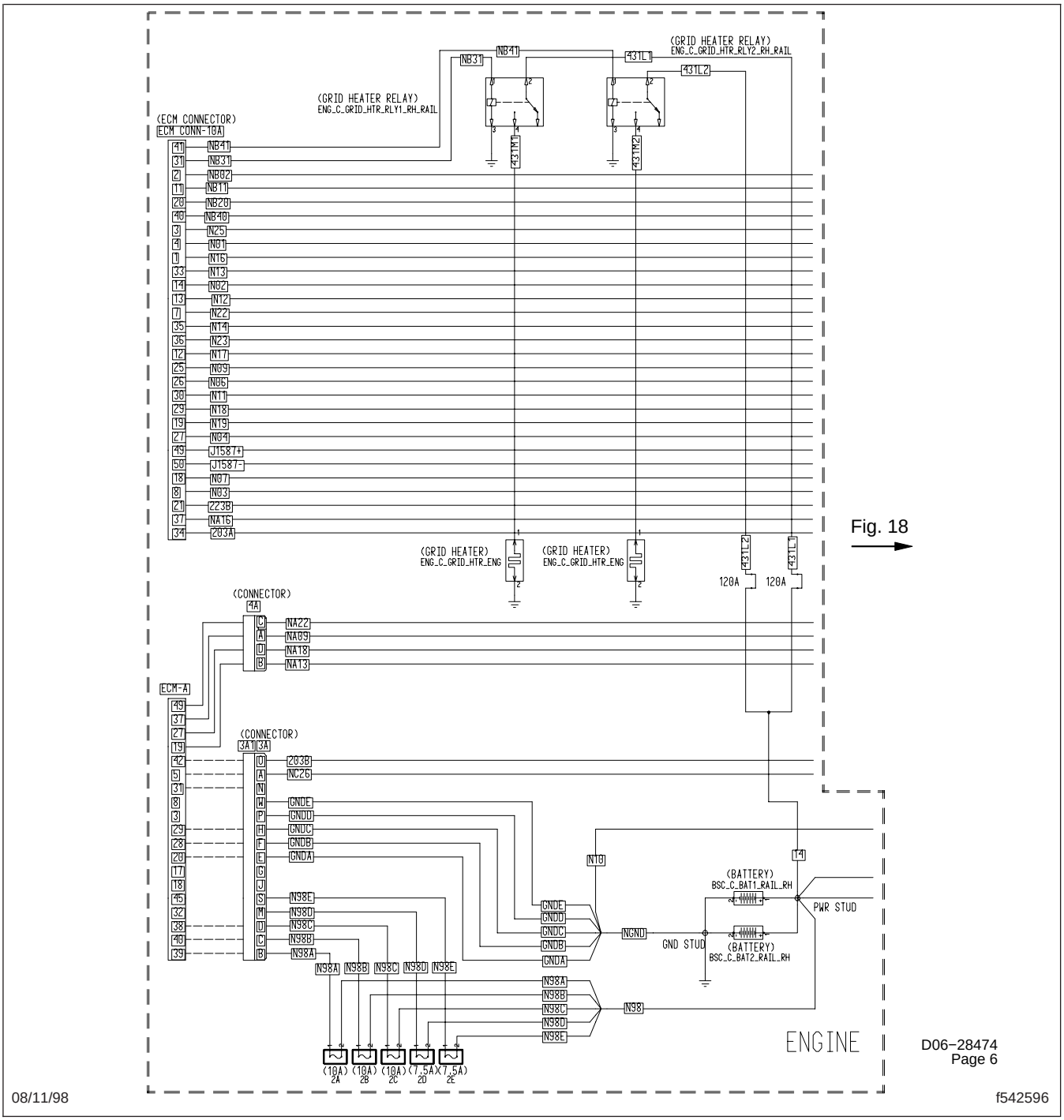


Fig. 18

Fig. 17, Engine Harness Schematic (partial view)

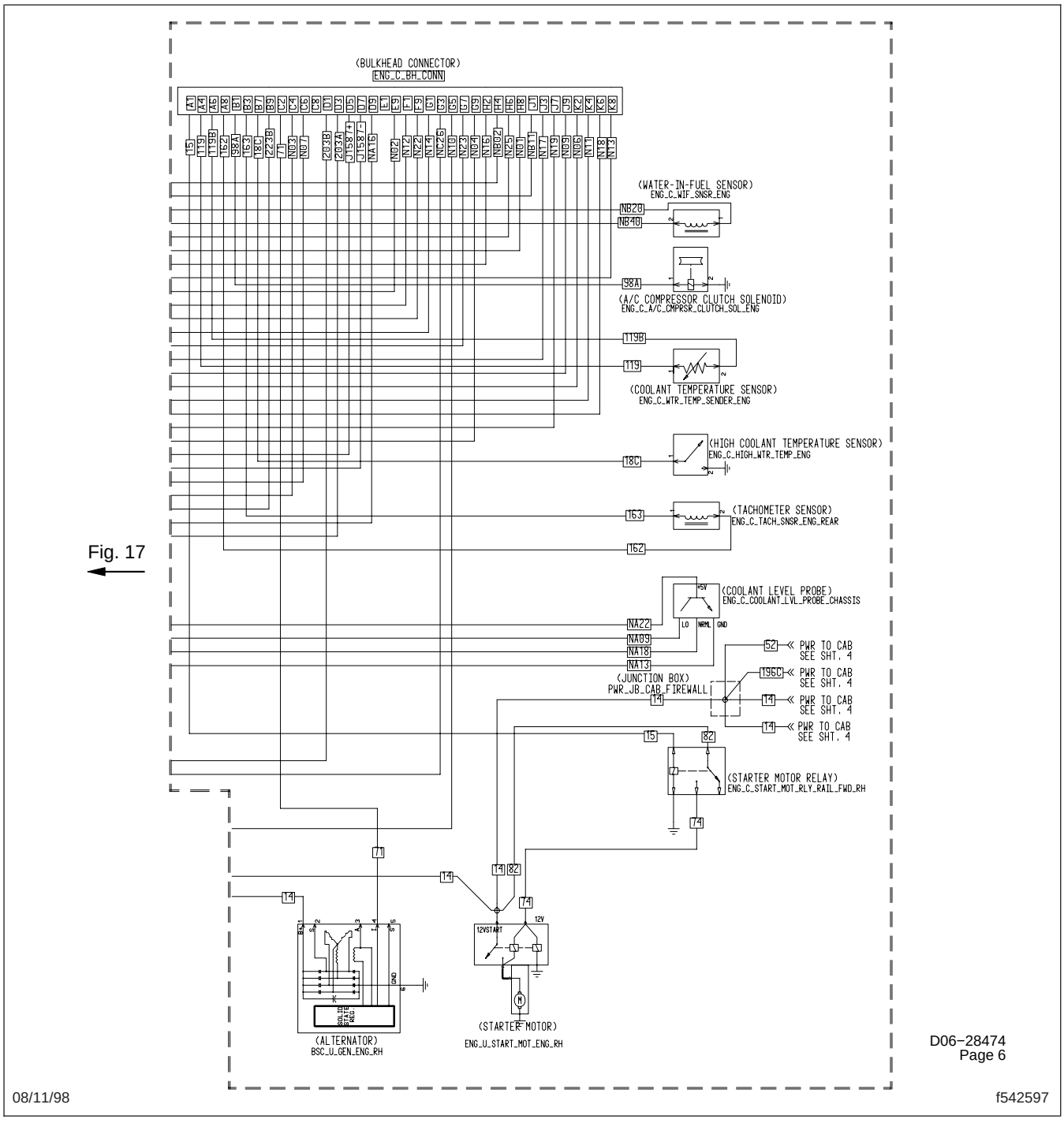


Fig. 17

Fig. 18, Engine Harness Schematic (partial view)

Specifications

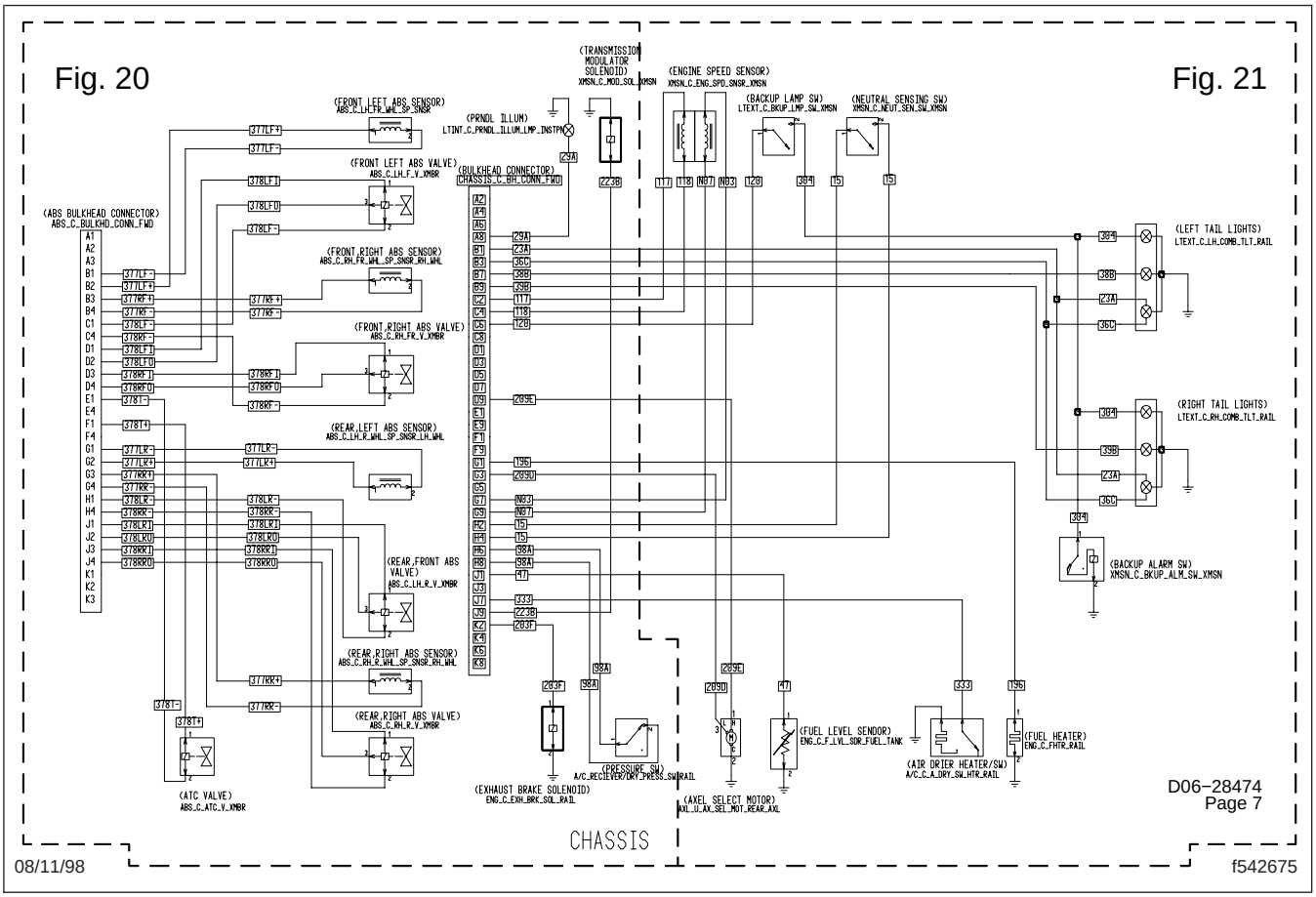


Fig. 19, Chassis Harness Schematic

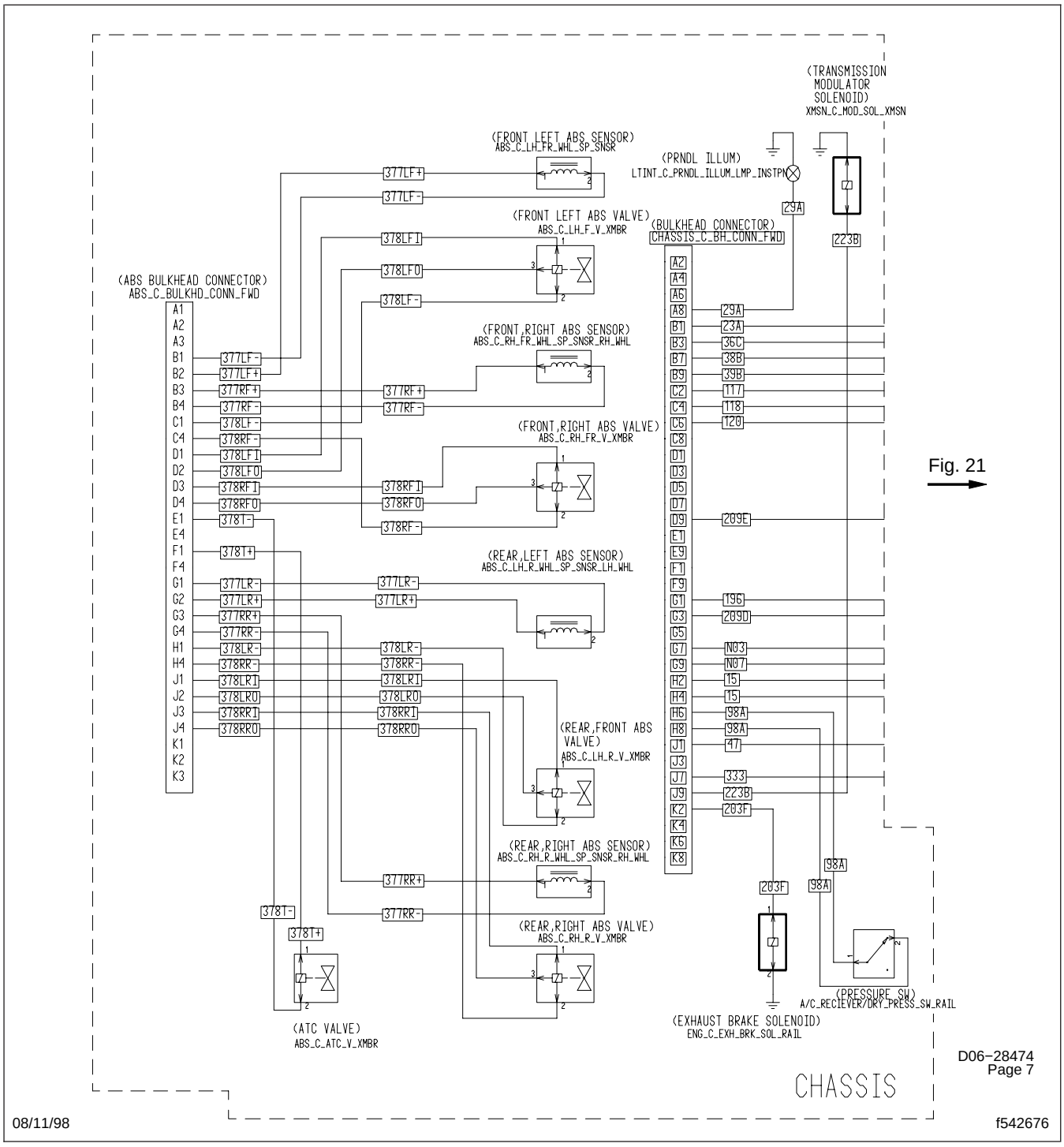


Fig. 21

Fig. 20, Chassis Harness Schematic (partial view)

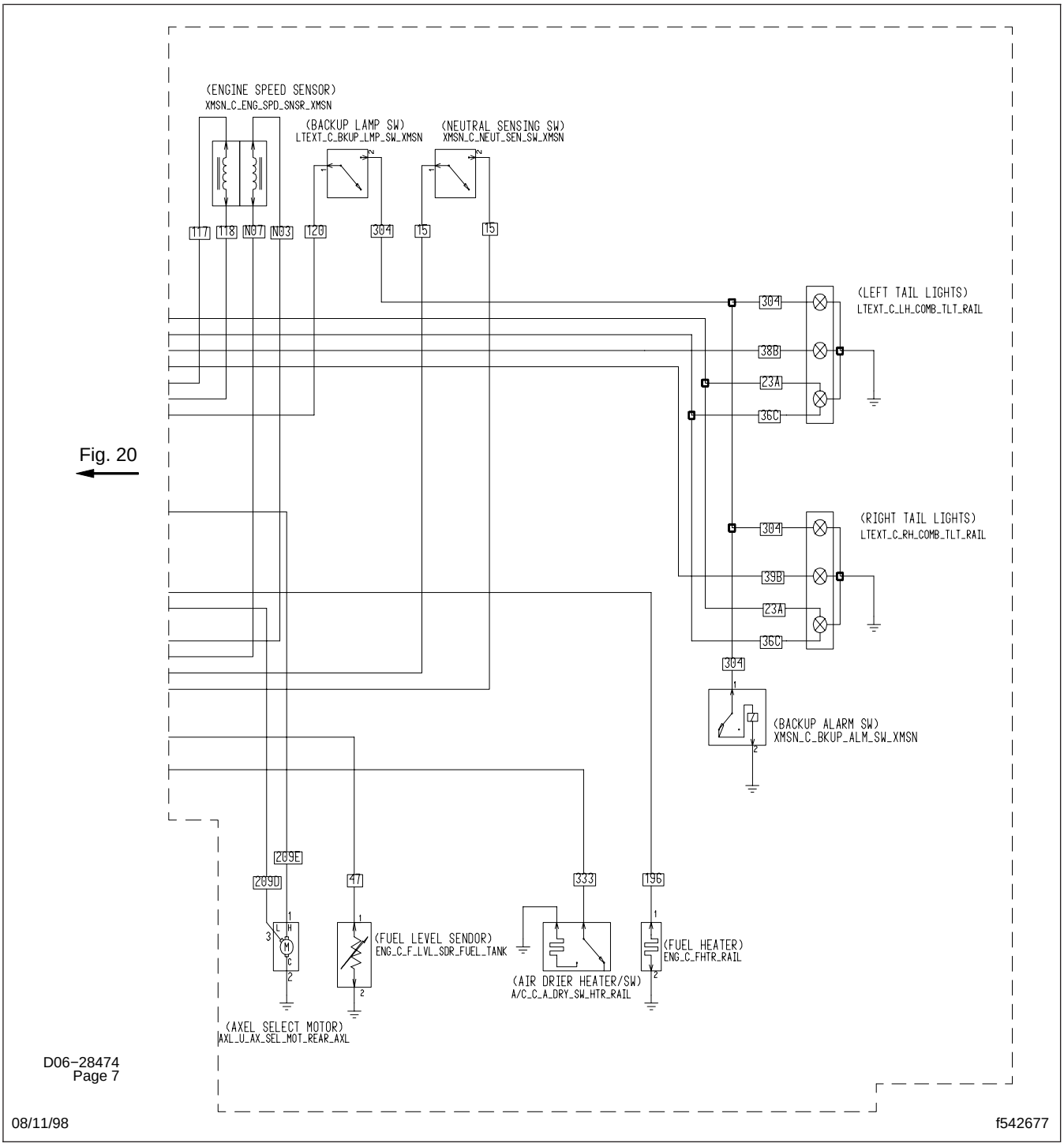


Fig. 20

Fig. 21, Chassis Harness Schematic (partial view)

General Information

Cummins ISB engines are available with an engine protection shutdown system that electronically monitors coolant level and temperature, intake manifold temperature, oil temperature and oil pressure. This feature automatically shuts off the engine when the engine is operating over or under normal operating conditions. The engine protection light in the cab will flash for 30 seconds prior to shutdown to alert the driver. Also, during the 30-second warning period, power and speed limitations will occur. The engine can be restarted, but if the fault remains active, the engine will operate at the limited torque and speed levels. This function only works if the feature has been enabled on the ECU.

On vehicles without the shutdown feature, the warning light will continue to flash and the engine will continue to operate at the limited torque and speed levels, but it will not shut off automatically.

IMPORTANT: Power is limited to 70 percent of rated torque and engine speed is limited to 1400 rpm when the engine is operating in shutdown or derate modes.

⚠ WARNING

When the engine protection light is flashing, the driver must pull to the side of the road (when it is safe to do so) to reduce the possibility of an accident or engine damage.

Engine shutdown can cause loss of vehicle control which may result in serious personal injury or property damage.

If the engine coolant temperature rises above 220°F (104°C), the high coolant temperature light will illuminate, the engine protection light will flash for 30-seconds, power and speed will be limited, and then the engine will shut down. The level of limitation is temperature dependent.

If the engine oil temperature rises above 258°F (125°C), the engine protection light will flash for 30 seconds, power will be limited, and then the engine will shut down. The level of limitation is temperature dependent.

If the engine intake manifold air temperature rises above 180°F (82°C), the engine protection light will flash for 30 seconds, power and speed will be limited, and then the engine will shut down. The level of limitation is temperature dependent.

If the engine oil pressure falls below 8 psi (55 kPa) with the engine running at 800 rpm or less, the low oil pressure light will illuminate, the engine protection light will flash for 30 seconds, and then the engine will shut down. Power limitation will occur in a 24-second time period. If the engine oil pressure falls below 25 psi (172 kPa) with the engine running between 800 and 1100 rpm, the low oil pressure light will illuminate, the engine protection light will flash for 30 seconds, and then the engine will shut down. Power and speed limitation will occur in a 24-second time period. If the engine oil pressure falls below 30 psi (207 kPa) with the engine running between 1100 and 2400 rpm, the low oil pressure light will illuminate, the engine protection light will flash for 30 seconds, and then the engine will shut down. Power and speed limitation will occur in a 24-second time period.

General Description

The horn system consists of the following items:

- horn assemblies
- horn switch
- necessary circuitry

The horn switch is part of the column-mounted switch that also includes the headlamp dimmer and turn signal. The horn switch closes the circuit directly to the horn.

The electric horn is mounted on the underside of the cab, on the passenger side of the vehicle. Air horns (if equipped) are mounted on the cab roof.

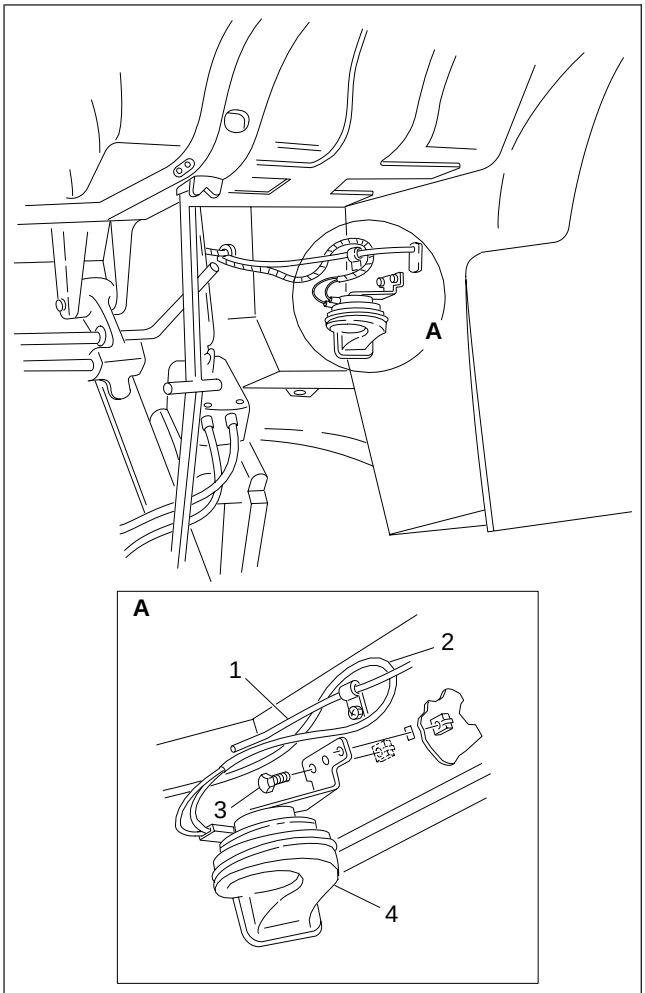
Horn Switch

The horn switch is integral with the wiper/washer switch and turn signal switch. Refer to **Group 46** in this manual for switch removal and installation.

Electric Horn Removal and Installation

Removal

1. Disconnect the battery ground cable and tilt open the cab.
2. Disconnect the battery ground cable.
3. Remove the electrical connector from the horn. See **Fig. 1**.



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A. Electric Horn Assembly
1. Part of Marker Lamp Wiring
2. Wiring Assembly
3. Screw
4. Horn and Bracket Assembly

Fig. 1, Electric Horn Mounting

4. Remove the retaining bolts and the lockwashers from the horn. Remove the unit from the vehicle.

Installation

1. Position the horn in the vehicle and install the retaining bolts and the lockwashers.

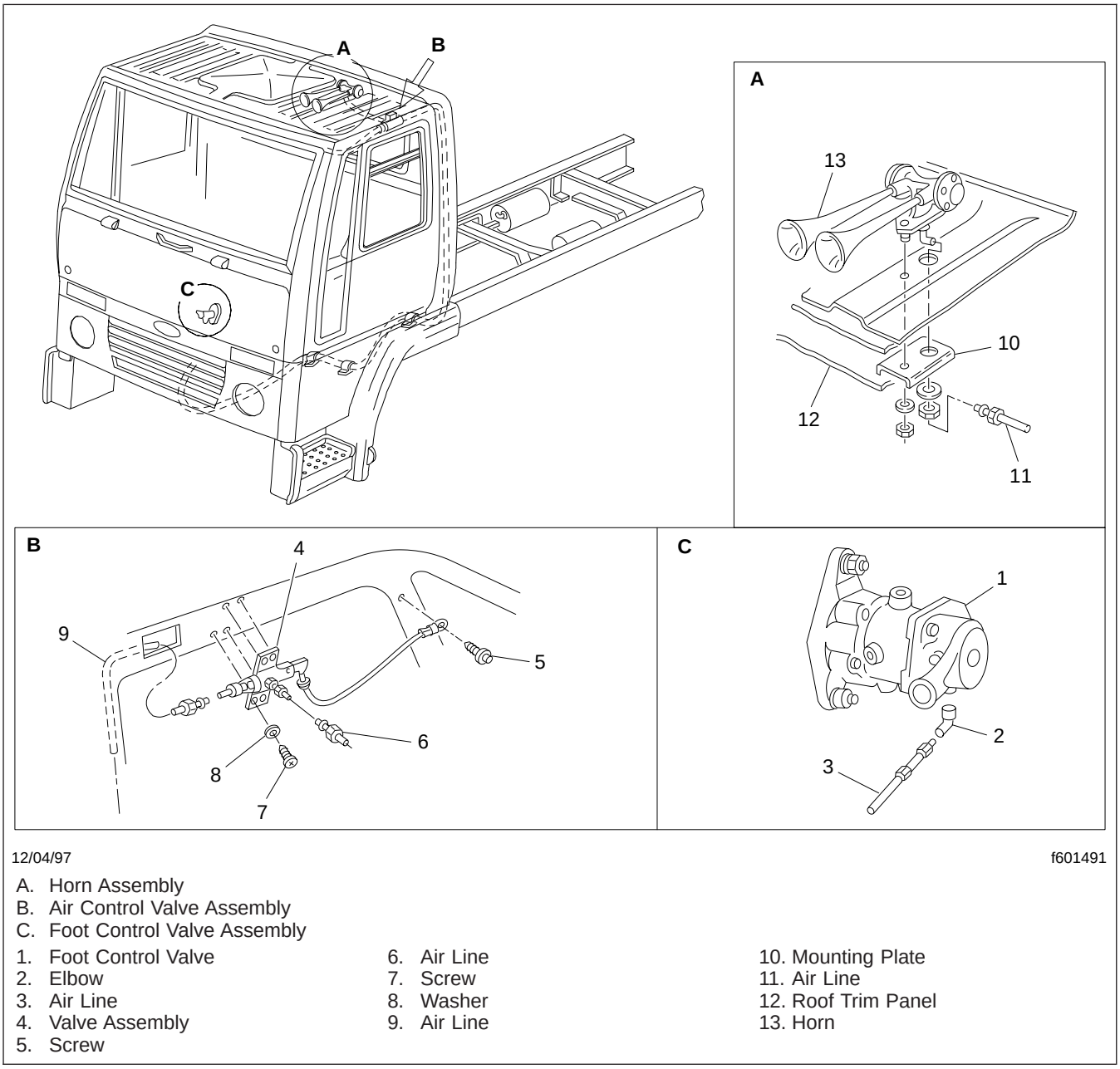
NOTE: Tighten the retaining bolts 80 to 89 lbf·in (904 to 1006 N·cm).

2. Attach the two electrical connectors to the horn.
3. Connect the battery ground cable, and return the cab to the operating position.

Dual Air Horn Removal and Installation

Removal (See Fig. 1)

1. Apply the parking brake and chock the tires.
2. Drain the air from the air reservoirs.
3. Remove the roof trim panel.
4. Disconnect the air line from the elbow at the rear of the horn assembly.
5. Remove the elbow from the horn.
6. Remove the attaching hardware (front and rear) securing the horn to the roof.



A. Horn Assembly
B. Air Control Valve Assembly
C. Foot Control Valve Assembly

1. Foot Control Valve
2. Elbow
3. Air Line
4. Valve Assembly
5. Screw
6. Air Line
7. Screw
8. Washer
9. Air Line
10. Mounting Plate
11. Air Line
12. Roof Trim Panel
13. Horn

Fig. 1, Air Horn System

Dual Air Horn Removal and Installation

7. Remove the horn assembly from the roof.

Installation

1. Position the horn assembly on the roof. Position the mounting plate on the inside of the roof. Install the retaining nuts and the washers.
2. Install the elbow and connect the air line to the elbow.
3. Charge the air system and check air horn operation.
4. Install the roof trim panel.

Air Control Valve Removal and Installation

Removal

1. Pull the lanyard to drain all air from the lines.
2. Remove the roof trim panel.
3. Remove the four screws and washers securing the valve assembly to the body.
4. Pull the valve assembly into the vehicle and disconnect the air tube assemblies. Tie the tube assemblies to prevent them from dropping into the body pillars.
5. Remove the screw that attaches the lanyard to the body pillar and remove the valve from the vehicle.

Installation

1. Position the valve assembly in the vehicle and connect the tube assemblies.
2. Install the valve assembly on the body and tighten the four retaining screws and washers.
3. Attach the lanyard to the body pillar.
4. Charge the air system and check the horn operation.
5. Install the roof trim panel.

Specifications

Torque Specifications		
Description	**lbf·in**	**N·cm**
Horn Retaining Bolts	80–89	904–1006

Table 1, Torque Specifications

Replacement

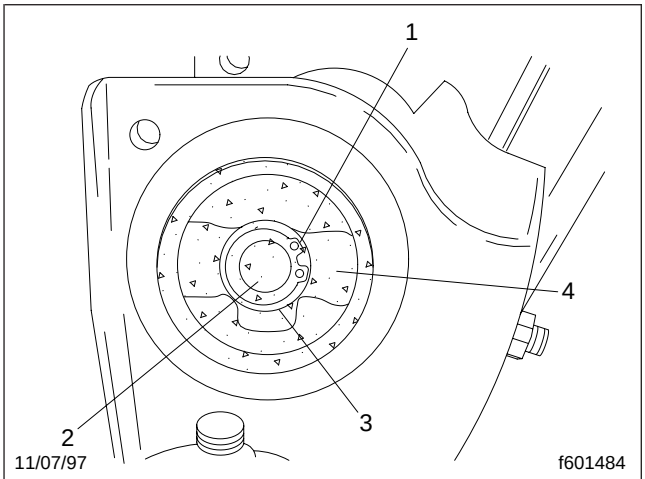
1. Disconnect the battery ground cable and tilt the cab.
2. If necessary, remove the heat shield.
3. Remove the two bolts attaching the front shock absorber upper mounting bracket to the rear cab mount.
4. Remove the two bolts and nuts retaining the rear fender upper mounting bracket to the rear cab mount.
5. Remove the four bolts and nuts retaining the rear cab mount to the chassis, and remove the mount from the vehicle.

NOTE: Refer to Cab Mount Post in **Section 150** to adjust the right cab mount post before final torque.

6. If the heat shield was removed, replace it with a new one.
7. Position the new rear cab mount on the chassis and secure it in position with four retaining bolts and nuts. Tighten the bolts 27 lbf·ft (37 N·m).
8. Position the rear fender upper mounting bracket and secure it with two retaining bolts and nuts. Tighten the bolts 24 lbf·ft (33 N·m).
9. Install the front shock absorber upper mounting bracket bolts. Tighten the bolts 50 to 65 lbf·ft (68 to 88 N·m).
10. Return the cab to the operating position.

Replacement

1. Disconnect the battery ground cable and tilt the cab.
2. Remove the circlips at both ends of the center pin. See **Fig. 1**.



1. Circlip
2. Center Pin
3. Bushing Tab
4. Rubber Bushing

Fig. 1, Center Pin

NOTE: Under some circumstances it will be necessary to cut out the center pin.

3. Tap out the center pin.
4. Pry out the bushings and discard.
5. Place a suitable packing between the channel and the support.
6. Knock in both new bushings with a hammer to the limit of travel, making sure that each bushing tab is pointing downward.
7. Install the center pin and circlips.
8. Return the cab to the operating position.

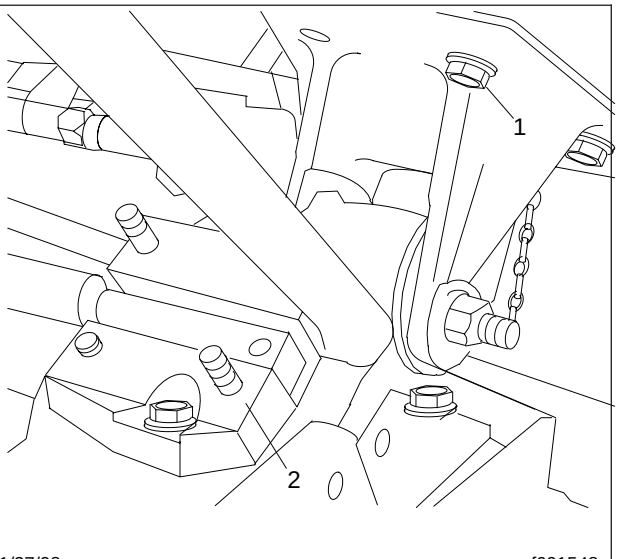
Front Cab Mount Hinge Replacement

Replacement

WARNING

Support the cab using a hoist with nylon straps before releasing the torsion bars. The cab could drop if not supported, which could result in serious personal injury, or death.

1. Disconnect the battery ground cable and tilt open the cab.
2. Loosen the bolts retaining the torsion bars, and release the bars. See **Fig. 1**.



1. Mounting Hinge Bracket Bolt
2. Torsion Bar Retaining Bolt

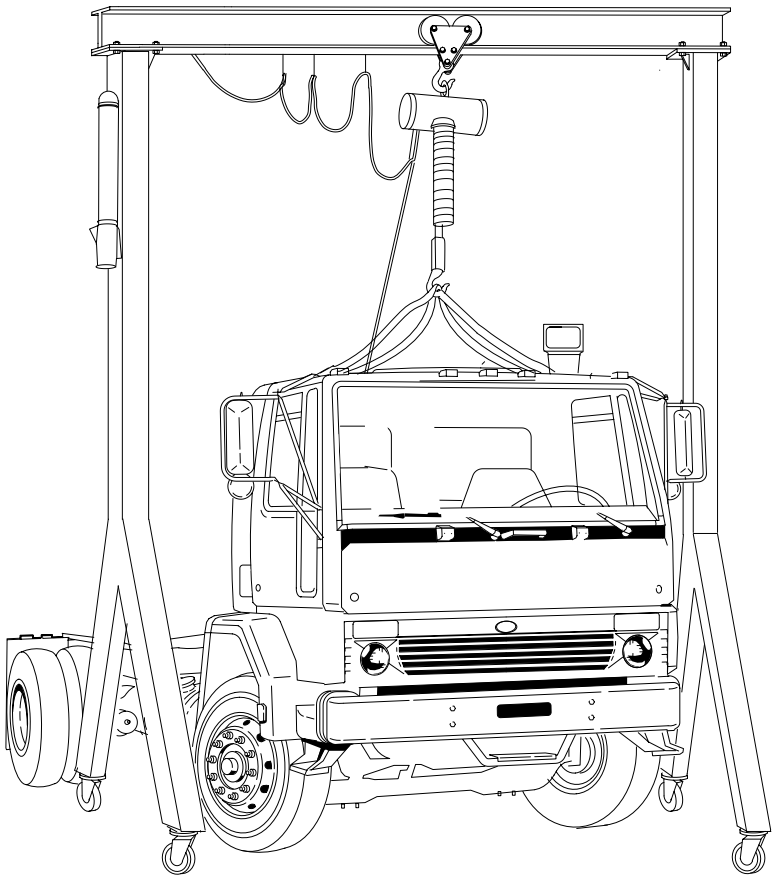
Fig. 1, Torsion Bar Assembly

3. Remove the two rear bolts securing the upper mounting hinge bracket to the cab. Loosen the bolt from the mounting hinge assembly.
4. Using the hoist, carefully lower the cab. See **Fig. 2**.
5. Remove the grille.
6. Using a lifting jack, carefully lift one side of the cab from which the pin is to be removed.
7. Remove the hinge center bolt from the front cab mount hinge.
8. Remove the two front bolts from the mounting hinge bracket, and remove the bracket. See **Fig. 3**.
9. Remove the remaining bolts and remove the mounting hinge assembly and the torsion bar from the vehicle.
10. Overhaul the hinge assembly as follows:
    - 10.1 Remove the circlips retaining the torsion bar bushings, and pry out the bushing. Remove the torsion bar from the hinge mount assembly.
    - 10.2 Using a suitable arbor press, press out the hinge assembly bushing. See **Fig. 4**.
    - 10.3 Position the bushing with a flat surface of metal reinforcing the insert's upper portion and parallel to the chassis side member. Make sure the bushing flange faces outward when mounting on the vehicle.
    - 10.4 Press the bushing into the mounting assembly making sure that the bushing is centered in the hinge.
    - 10.5 Install the torsion bar in the hinge mount assembly and install the bushings and the circlips.

NOTE: Be sure the weight of the cab is supported by a jack.

11. Replace the mounting hinge bracket in the cab, and replace the two front bolts. Tighten the bolts 60 lbf·ft (80 N·m).
12. Position the front cab mount hinge assembly on the chassis, and install the retaining bolts. Tighten the bolts 68 lbf·ft (95 N·m).
13. Position the mounting so there is a 0.04-inch (1-mm) clearance between the rubber bushing outer flange and the upper mounting sideface. See **Fig. 5**.
14. Tap on the mounting with a hammer to move it within the elongated chassis holes.
15. Tighten the center bolt of the cab hinge/front support 95 lbf·ft (129 N·m).
16. Remove the jack and replace the grille.
17. Using a crane, carefully tilt the cab open.

Front Cab Mount Hinge Replacement

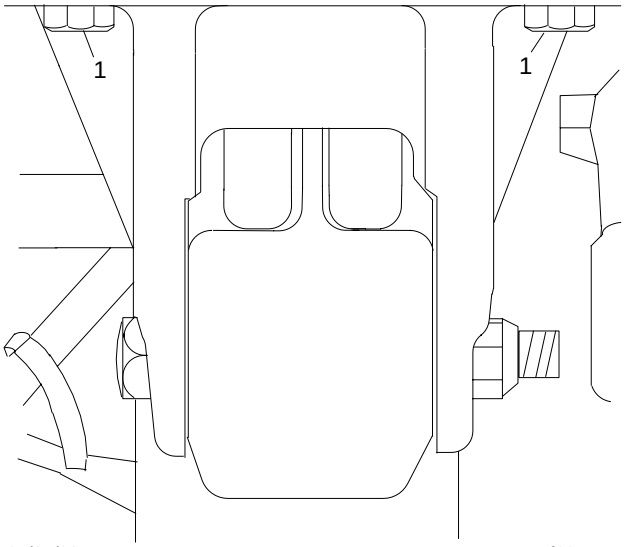


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Fig. 2, Hoist with Nylon Straps

18. Replace the two rear bolts on the upper mounting hinge bracket. Tighten the bolts 60 lbf·ft (80 N·m).
19. Install the torsion bar on to the cab mount hinge assembly, and tighten the bolts 95 lbf·ft (129 N·m).
20. Return the cab to the operating position, and connect the battery ground cable.

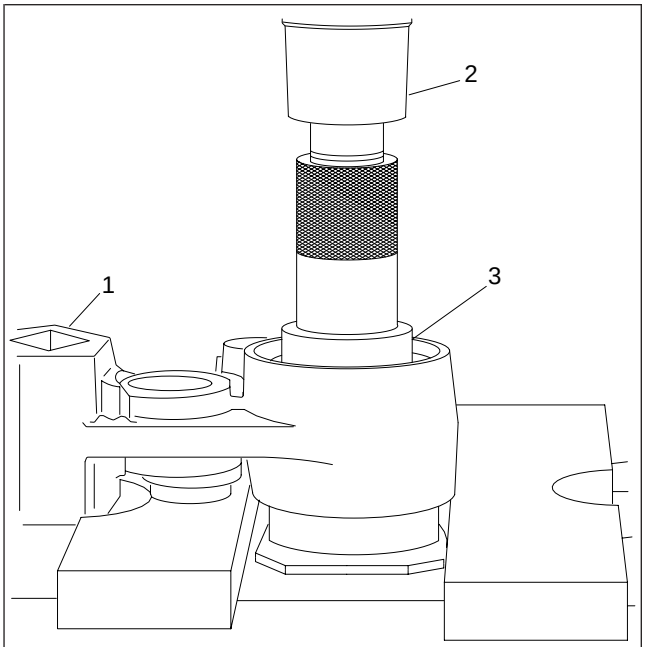
Front Cab Mount Hinge Replacement



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1. Mounting Hinge Bracket Bolt

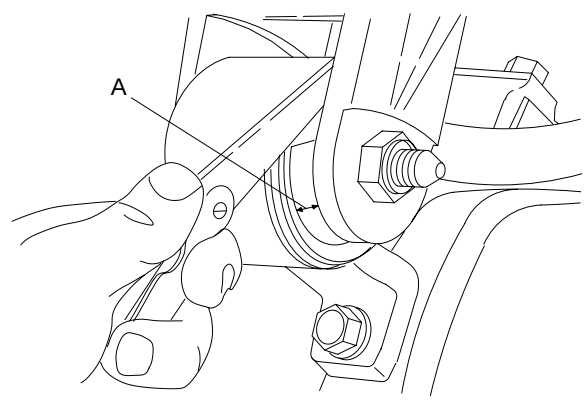
Fig. 3, Front Cab Mount Hinge



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1. Mounting Hinge Assembly
2. Press
3. Bushing

Fig. 4, Mounting Hinge Assembly



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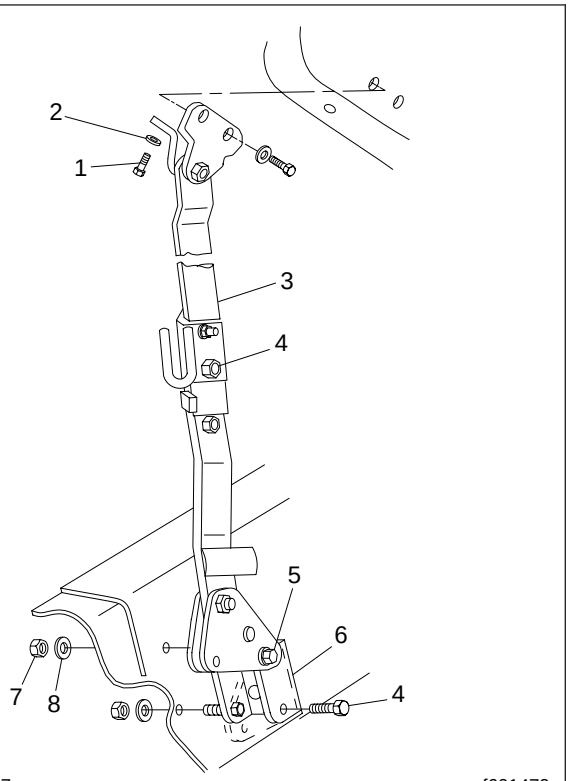
A. 0.040 Inch (1 mm)

Fig. 5, Position the Mounting

Cab Retaining Arm Removal and Installation

Removal (See Fig. 1)

1. Tilt the cab and block it in position.



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1. Screw (3)
2. Washer (3)
3. Cab Retaining Arm
4. Screw
5. Bolt
6. Cab Stay-to-Frame Bracket Assembly
7. Nut (2)
8. Washer (2)

Fig. 1, Cab Retaining Arm

2. Remove the screws, washers and bolts securing the arm assembly to the cab and frame.

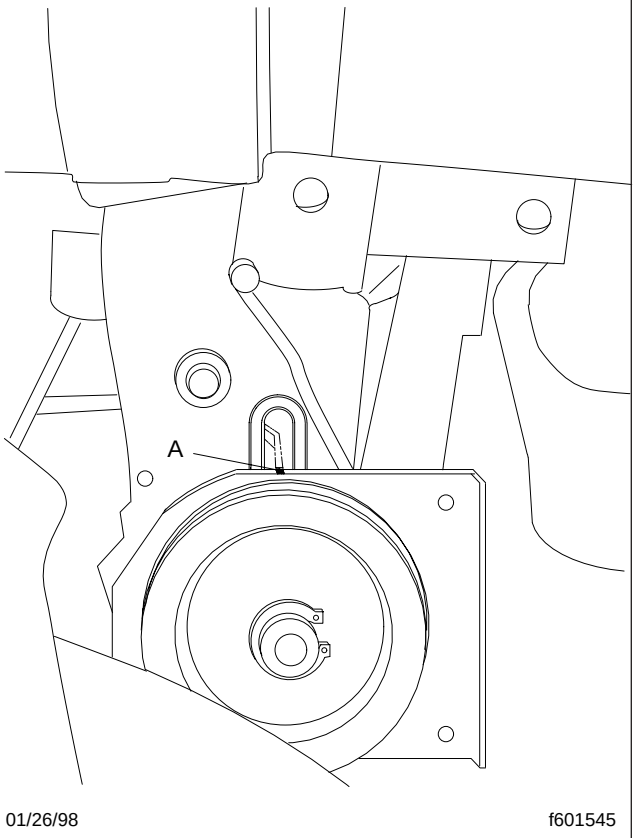
Installation

1. Position the arm assembly and install the bolts, screws and washers. Tighten the bolts 42 lbf·ft (57 N·m).
2. Remove the blocking, and return the cab to the operating position.

Cab Tilt Latch Mechanism Removal and Installation

Removal

1. Remove the cab release handle from beneath the driver's seat.
2. Apply the parking brakes and tilt the cab.
3. Make a mark where the left and right latch assemblies line up with the shock absorber center pin. See **Fig. 1**.



A. Make a mark lining up the left and right latch assemblies with the shock absorber center pin.

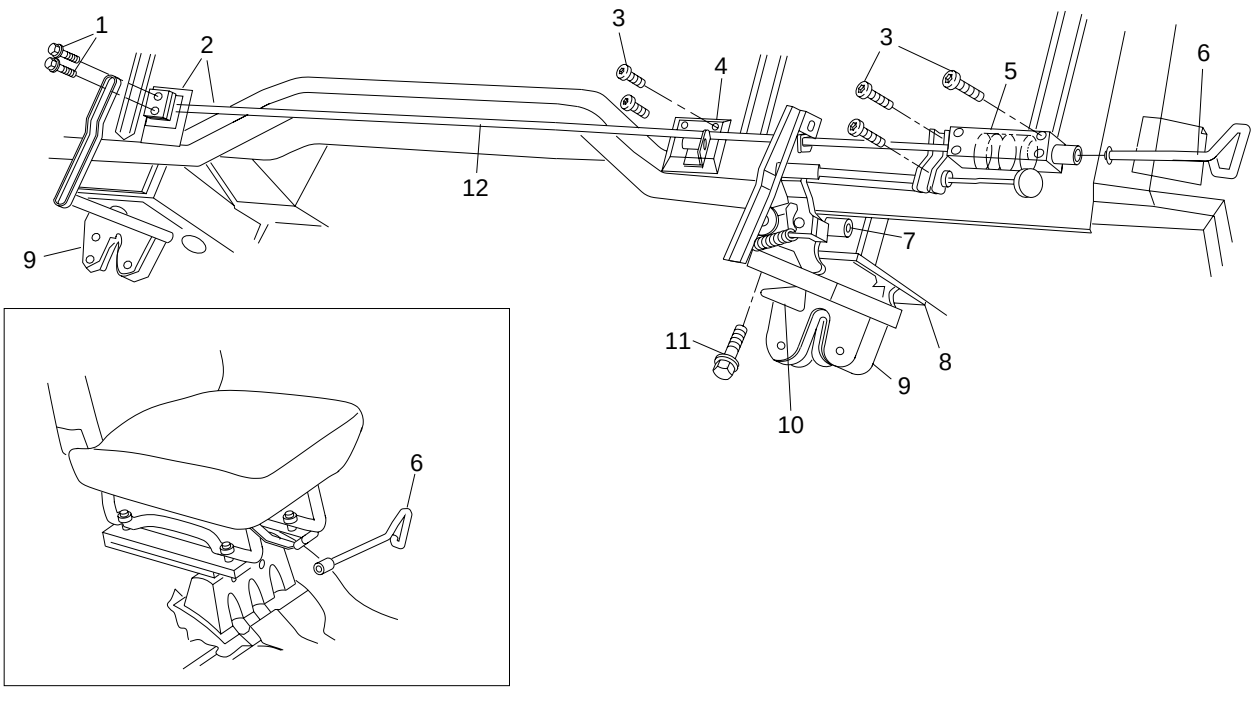
Fig. 1, Cab Latch Assembly

4. Remove the four bolts retaining the left-hand cab latch assembly to the cab. See **Fig. 2**.
5. Remove the spacer.
6. Pivot the latch away from the cab, and then pull up and away from the rod support.
7. Using the same procedure, remove the right-hand cab latch assembly.
8. Remove the two bolts retaining the support bracket to the rod support assembly.
9. Remove the four bolts retaining the cab tilt lock mechanism (Ref. 5).
10. Pull the rod support away from the cab.

Installation

1. Secure the rod support on to the cab using the cross rod support bracket, and attach the left-hand rod support bracket. Tighten screws 10 to 15 lbf·in (113 to 169 N·cm).
2. Install the cover on the cab tilt lock mechanism (Ref. 5) with the rod support through the center, and replace the four bolts. Tighten bolts 10 to 15 lbf·in (113 to 169 N·cm).
3. Secure the left-hand cab latch assembly to the rod support. Install the spacer and the four retaining bolts. Tighten the bolts 27 lbf·ft (37 N·m).
4. Use the same procedure to install the right-hand cab latch assembly.
5. Using the reference marks made before removal, make sure that the latch assembly lines up properly with the shock absorber center pin. See **Fig. 1**. If the latch mechanism is out of alignment, bring the cab down near the rear mounts and observe the alignment of the latch with the cab mount pin. Raise the cab and adjust as required.
6. Return the cab to the operating position.

Cab Tilt Latch Mechanism Removal and Installation



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1. Fastener Bolts
2. Rod Support Bracket Assembly
3. Hexhead Capscrew
4. Latch Sensor Switch
5. Cab Tilt Lock Mechanism
6. Cab Tilt Hook Release Handle
7. Strip, Hook Cab
8. Spacer
9. Latch Assembly
10. Hook
11. Latch Assembly Bolt
12. Latch Rod

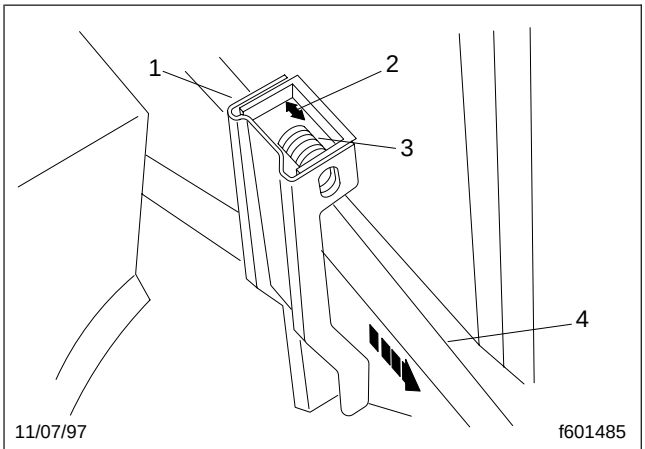
Fig. 2, Cab Tilt Latch Mechanism

Cab Locking Mechanism

(See Fig. 1)

NOTE: Some vehicles may have the front panel of the body too close to the cab locking mechanism to allow adjustment with the cab down. The cab must be tilted and the cab hooks engaged by using a screwdriver to simulate the fully down position.

1. Make sure the cab is completely lowered, both lock mechanisms are engaged, and the lock position indicated is completely inserted in the housing.



1. Vertical Lever
2. Adjuster
3. Travel Adjuster Screw
4. Cross Rod

Fig. 1, Cab Locking Mechanism

2. Push the cross rod toward the right side of the vehicle until the limit of travel is reached.
3. Keep the cross rod in position, and screw the vertical lever travel adjuster in or out (depending on the position) until the adjuster makes contact with the left side of the vertical lever. Back off the adjuster screw one half turn.
4. Repeat the previous step on the remaining vertical lever travel adjuster.
5. Check the cab tilt operation.

Cab Mount Post

NOTE: The cab mount post must be adjusted before the post bolts can be tightened. Use the following instructions to adjust the cab mount post.

1. Assemble the left post in its final position. Tighten the bolts 27 lbf·ft (37 N·m).
2. Assemble the right post (slotted) in the middle of the slots, with low torque on the bolts.
3. On both sides, lock the striker pins in the center of the insulators with fixtures, to avoid deformation of the rubber.
4. Lock the cab.
5. Release the right post bolts. The post will be positioned by the cab without tension in the system.
6. Tighten the right post bolts 27 lbf·ft (37 N·m). Release the insulators.

Specifications

Torque Specifications		
Description	**lbf·ft**	**N·m**
Shock Absorber to Bracket, Nut	50–65	68–88
Cab Pivot Lower Bracket, Nut	44–59	60–80
Rear Cab Mount to Chassis, Bolt	27	37
Mounting Hinge Bracket to Cab, Bolt	60	80
Mounting Hinge Assembly to Cab, Bolt	68	95
Cab Hinge/Front Support to Chassis, Bolt	95	129
Torsion Bar Bracket to Chassis, Bolt	95	129
Cab Retaining Arm to Chassis, Bolt	42	57
Cab Latch Assembly to Cab, Bolt	27	37

Table 1, Torque Specifications

Body Service

If welding is required for body service procedures, the electronic modules and components must be isolated from ground during welding to prevent damage.

Body Sealer Types and Applications

Since many sealers are used in the assembly of the vehicle, the following all-purpose sealers have been selected for service use. The method and points of application are specified for each type of sealer.

LIQUID BUTYL SEALER

Liquid butyl sealer is fast drying, and remains semi-elastic. The sealer can be used for seam sealing in such areas as the floorpan, wheelhouse, dash panel, running board, door openings, and drip rails. It can also be used to seal outside moulding clip holes, and for windshield and rear window installations.

CAULKING CORD

Caulking cord has a plastic base, is heavy-bodied, and is commonly known as perma-gum. It is used on spotweld holes, around mounting clips, and between two surfaces not sealed by a gasket. Apply the sealer with a putty knife.

WEATHER-STRIP ADHESIVE

Weather-strip adhesive is designed to hold weather-stripping on doors, bodies, cowl ventilators and the surrounding metal. Windows and windshields that are set in rubber can be sealed effectively against leakage by flowing cement in to the affected areas.

Clean all grease, dirt, and old sealer from the surfaces to be cemented and apply a medium coat of cement to both surfaces. Immediately press both surfaces together.

Dust and Water Leaks (See Fig. 1, Fig. 2, Fig. 3, Fig. 4, Fig. 5, and Fig. 6)

The forward motion of the vehicle creates a slight vacuum within the body, particularly if a window or ventilator is partially open. Any unsealed crevice or small opening in the lower section of the body will permit air to be drawn in to the body. If dust is present in the air, it will follow.

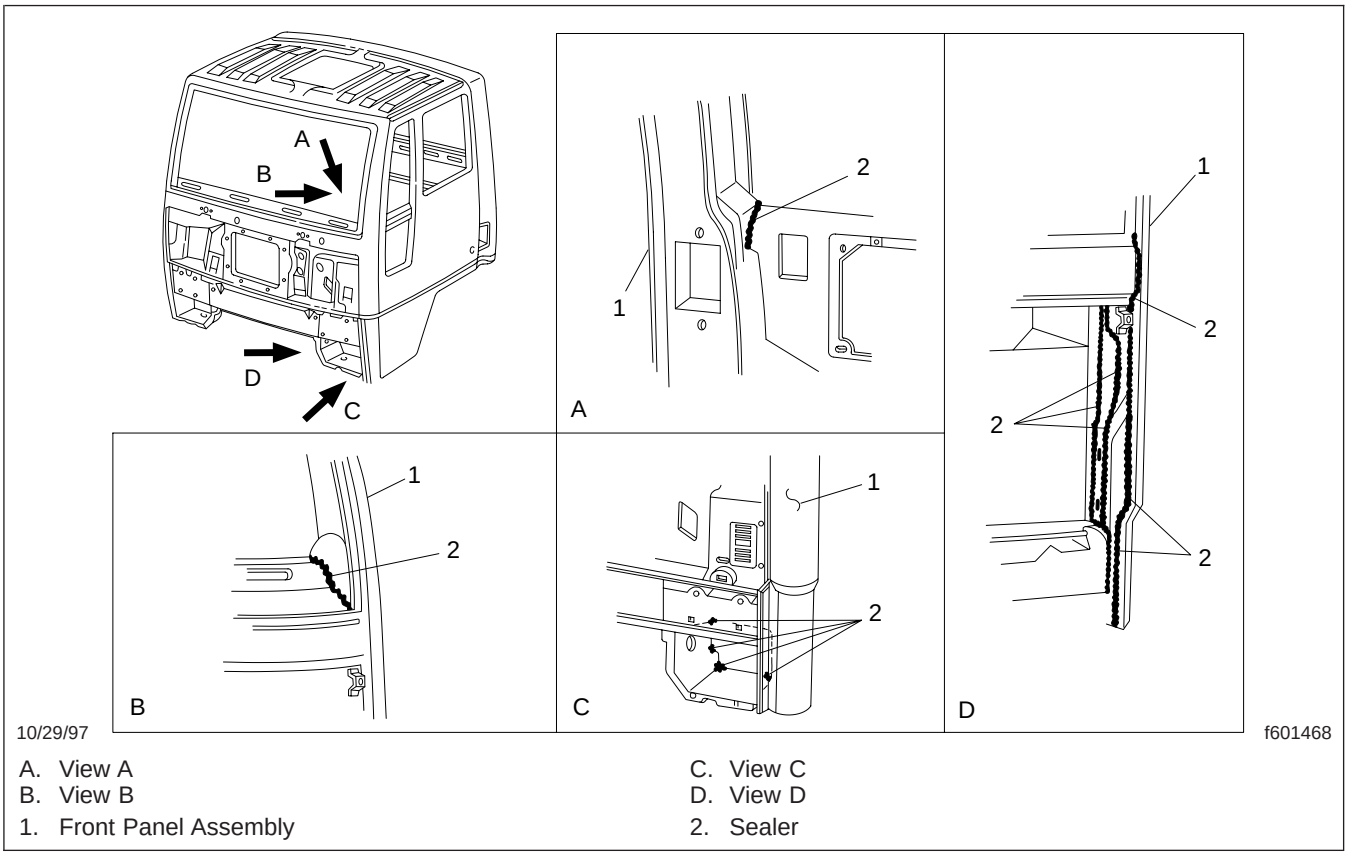
Under certain conditions, water can enter the body at any point where dirt or dust can enter. Any consideration of water leakage must take into account all points covered under dust leaks.

To determine the exact location of a dust leak, remove the following trim from the cab: cowl trim panel, kick pads, and floor mats.

Removal of the trim will reveal the location of most leaks. Seal these leaks and road test the vehicle on a dusty road to make sure all leaks are sealed. The entrance of dust is usually indicated by a pointed shaft of dust or silt at the point of entrance. After the road test, check for indications of a dust pattern around the door openings, cowl panel, and cowl side panel.

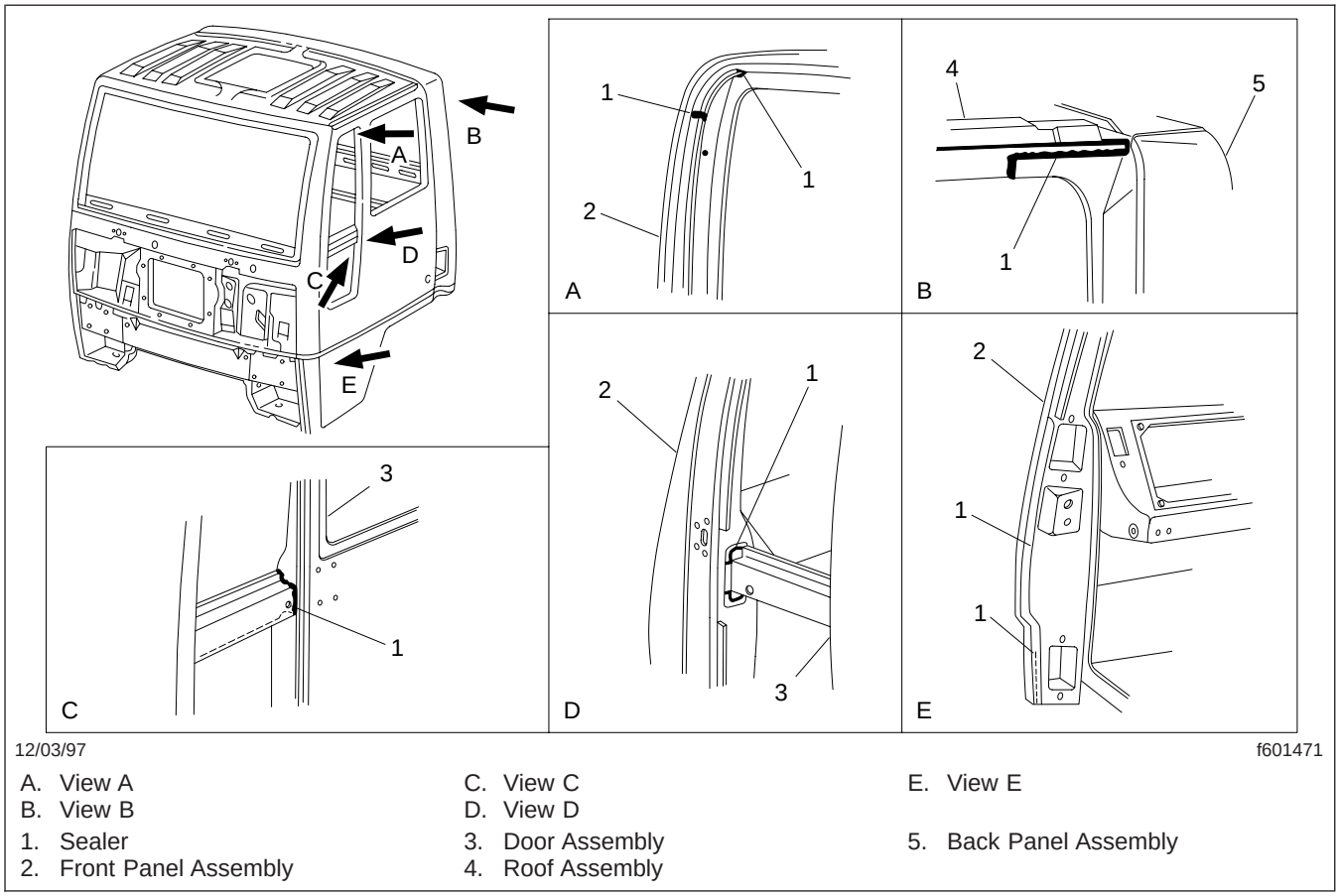
Some leaks can be located by putting bright lights under the vehicle, with the trim that is previously mentioned removed, and checking the interior of the body at joints and weld lines. The light will show through where leaks exist.

Dust and Water Leaks



A. View A
B. View B
1. Front Panel Assembly
C. View C
D. View D
2. Sealer

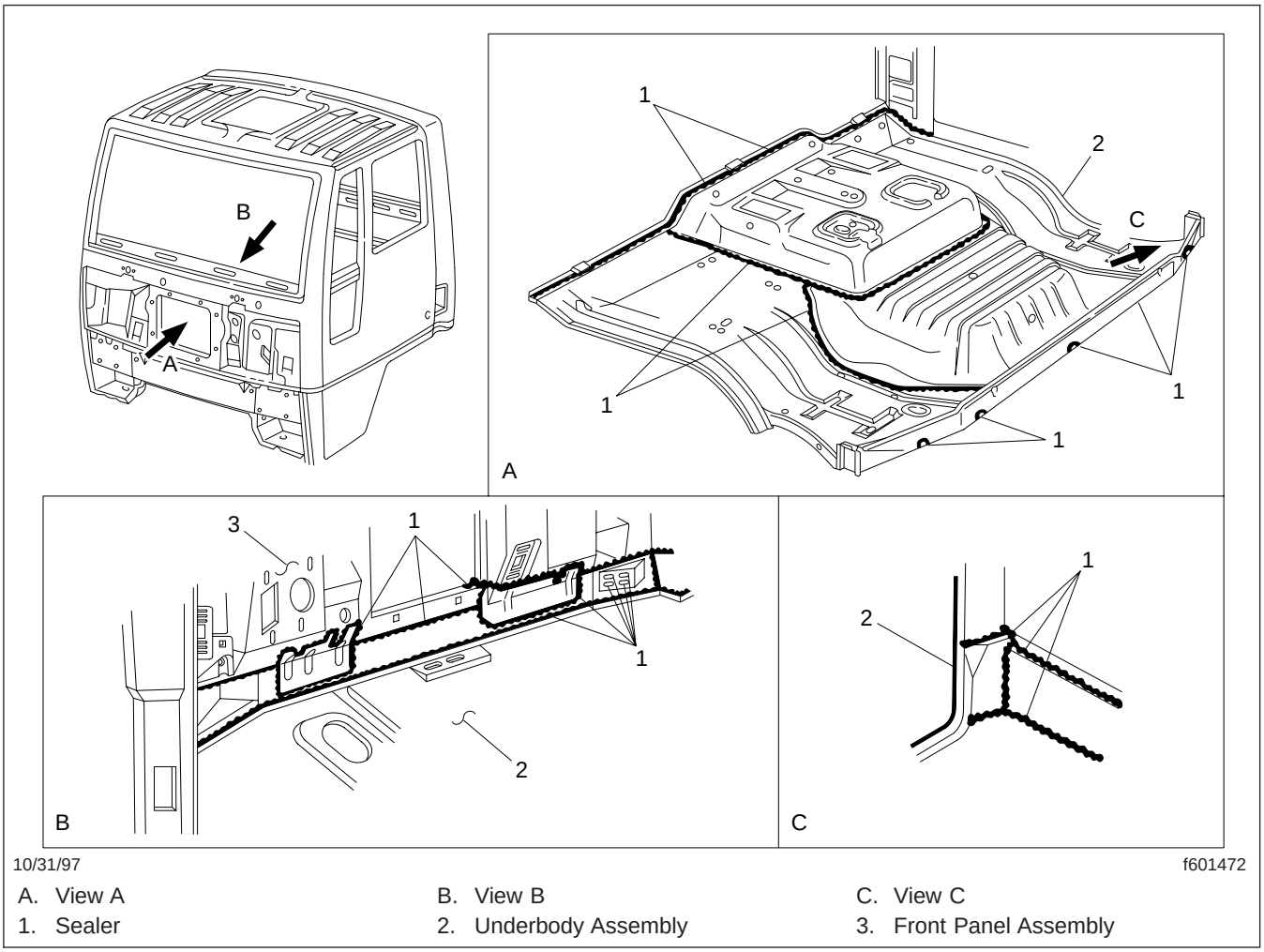
Fig. 1, Front Panel Sealant



A. View A
B. View B
C. View C
D. View D
E. View E
1. Sealer
2. Front Panel Assembly
3. Door Assembly
4. Roof Assembly
5. Back Panel Assembly

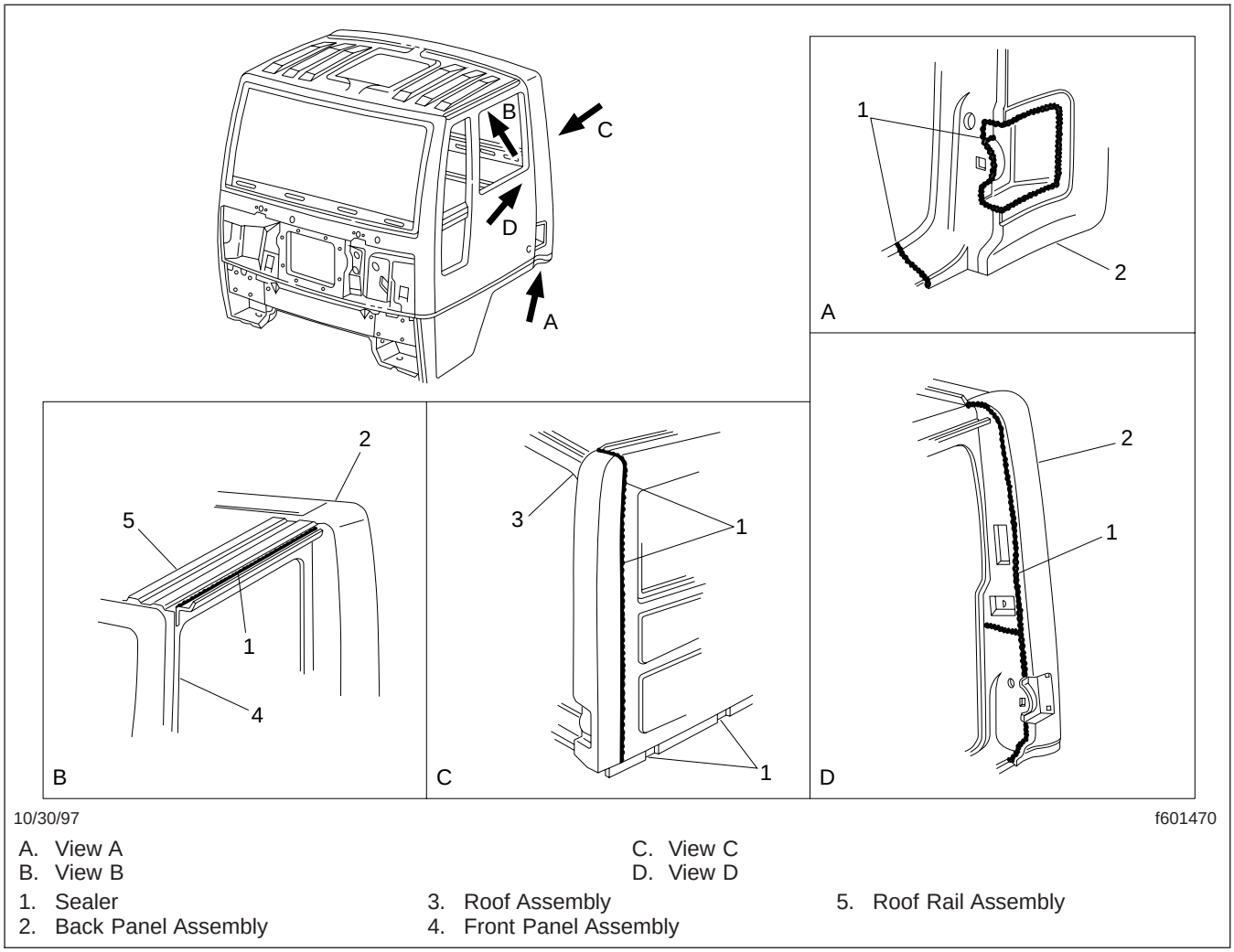
Fig. 2, Door, Front and Back Panel Sealant

Dust and Water Leaks



A. View A
B. View B
C. View C
1. Sealer
2. Underbody Assembly
3. Front Panel Assembly

Fig. 3, Underbody Sealant

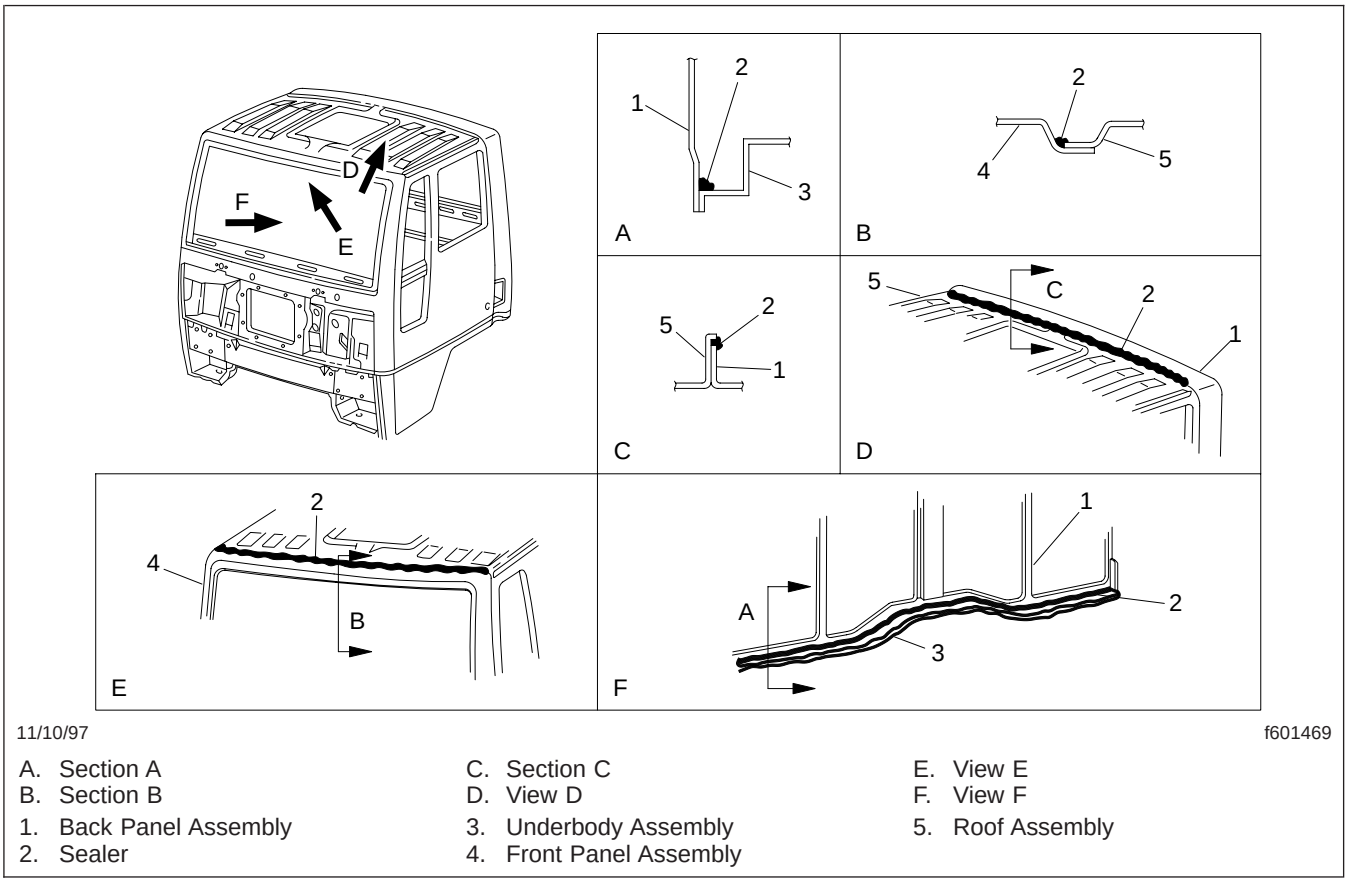


A. View A
B. View B
C. View C
D. View D

1. Sealer
2. Back Panel Assembly
3. Roof Assembly
4. Front Panel Assembly
5. Roof Rail Assembly

Fig. 4, Side and Back Panel Sealant

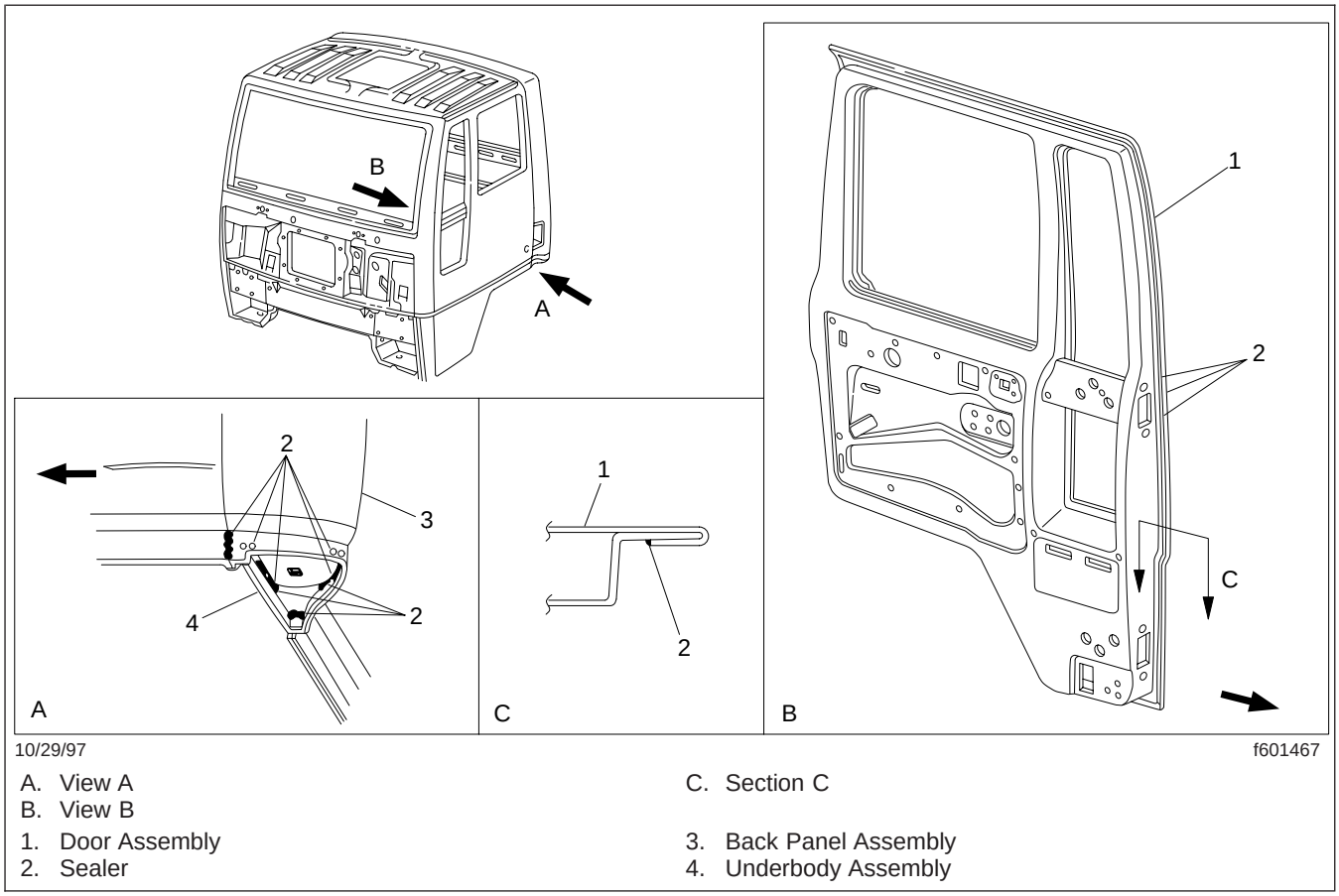
Dust and Water Leaks



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A. Section A
B. Section B
C. Section C
D. View D
E. View E
F. View F
1. Back Panel Assembly
2. Sealer
3. Underbody Assembly
4. Front Panel Assembly
5. Roof Assembly

Fig. 5, Roof and Back Panel Sealant



A. View A
B. View B
C. Section C
1. Door Assembly
2. Sealer
3. Back Panel Assembly
4. Underbody Assembly

Fig. 6, Door and Underbody Sealant

Wind Noise (See Fig. 1, Fig. 2, Fig. 3, Fig. 4, Fig. 5, and Fig. 6)

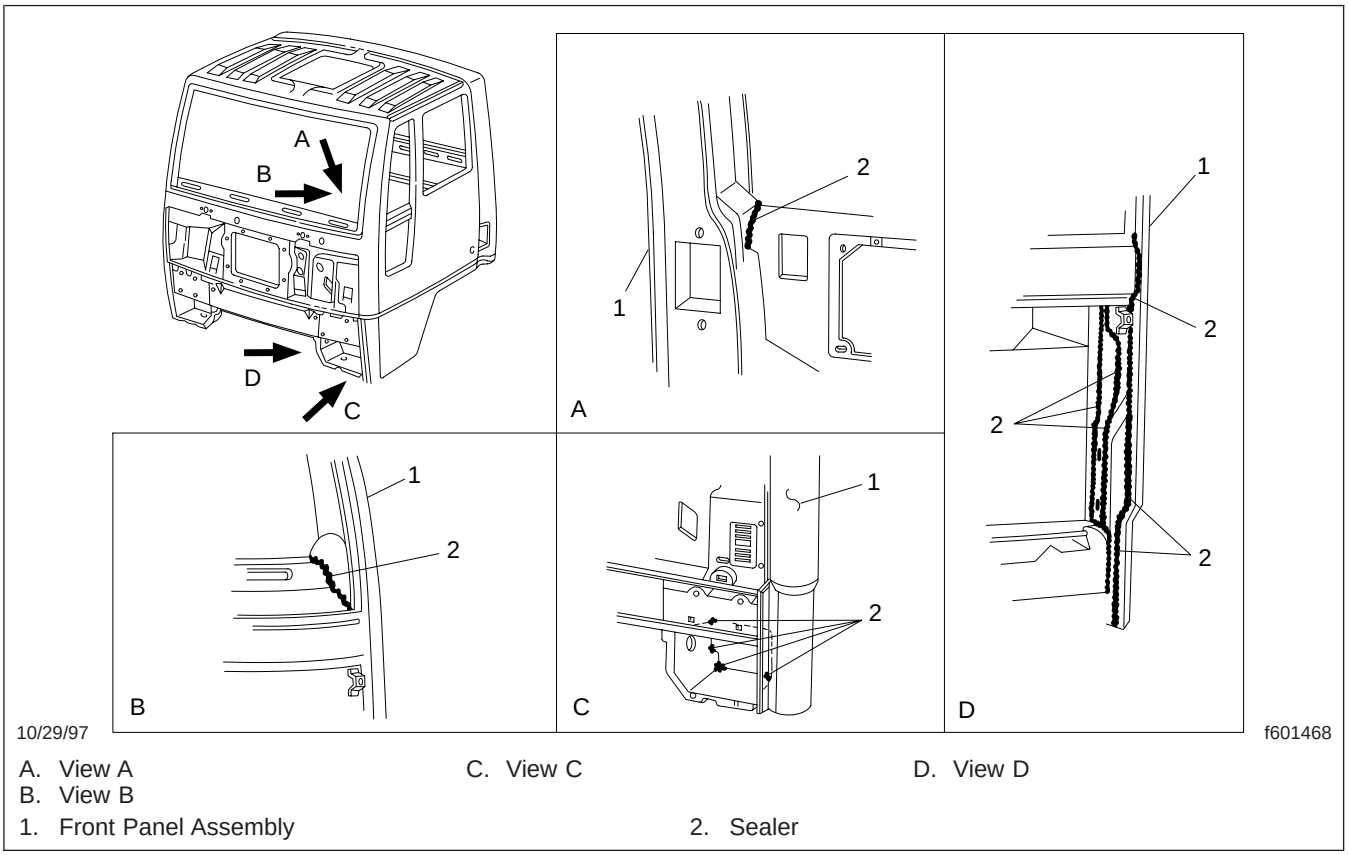
Air entering or exiting the vehicle through small openings in the body can result in wind noise. Sources of wind noise are detected by driving the vehicle at highway speeds in four different directions. Listen for sources of wind noise with all windows closed, radio off, heater and air conditioner blower motor turned off, and ventilator ducts open. A stethoscope can be used to pinpoint the source of the noise.

Most wind noise-producing leaks will occur at the door and window seals or at sheet metal joints in the door or the door opening in the body.

Seal all leaks with RTV sealant and foam tape, or by repositioning or replacing the seals. Road test the vehicle to make sure that all leaks have been adequately sealed.

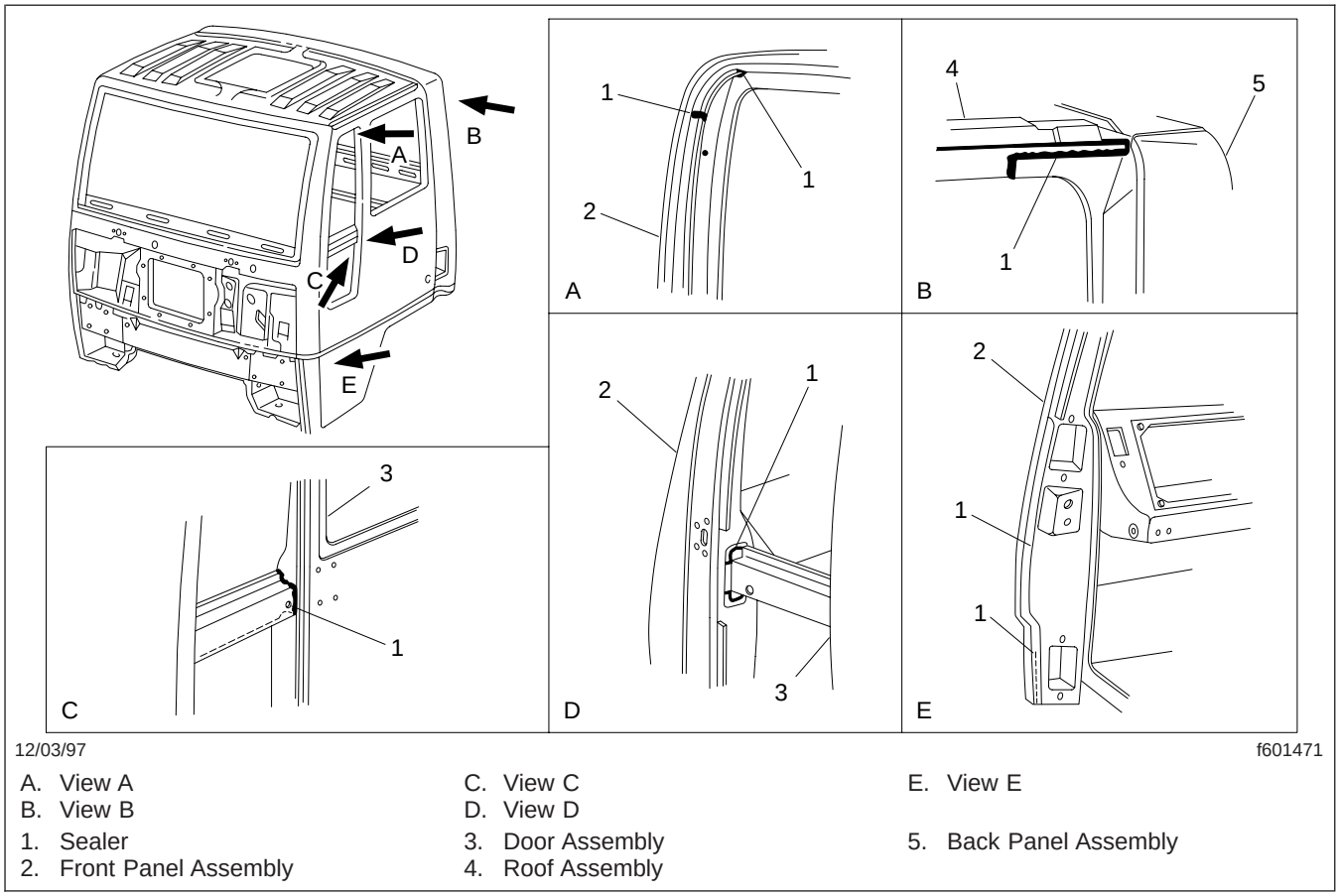
An alternate method of verifying corrective actions involves the use of Kent-Moore Combination Engine EAR/Chassis J–39570 or equivalent. After identifying the leak point through a test drive, obtain a meter reading by using the leak detector. A check with the leak detector after repairing the leak will verify the effectiveness of the corrective action.

Wind Noise



A. View A
B. View B
C. View C
D. View D
1. Front Panel Assembly
2. Sealer

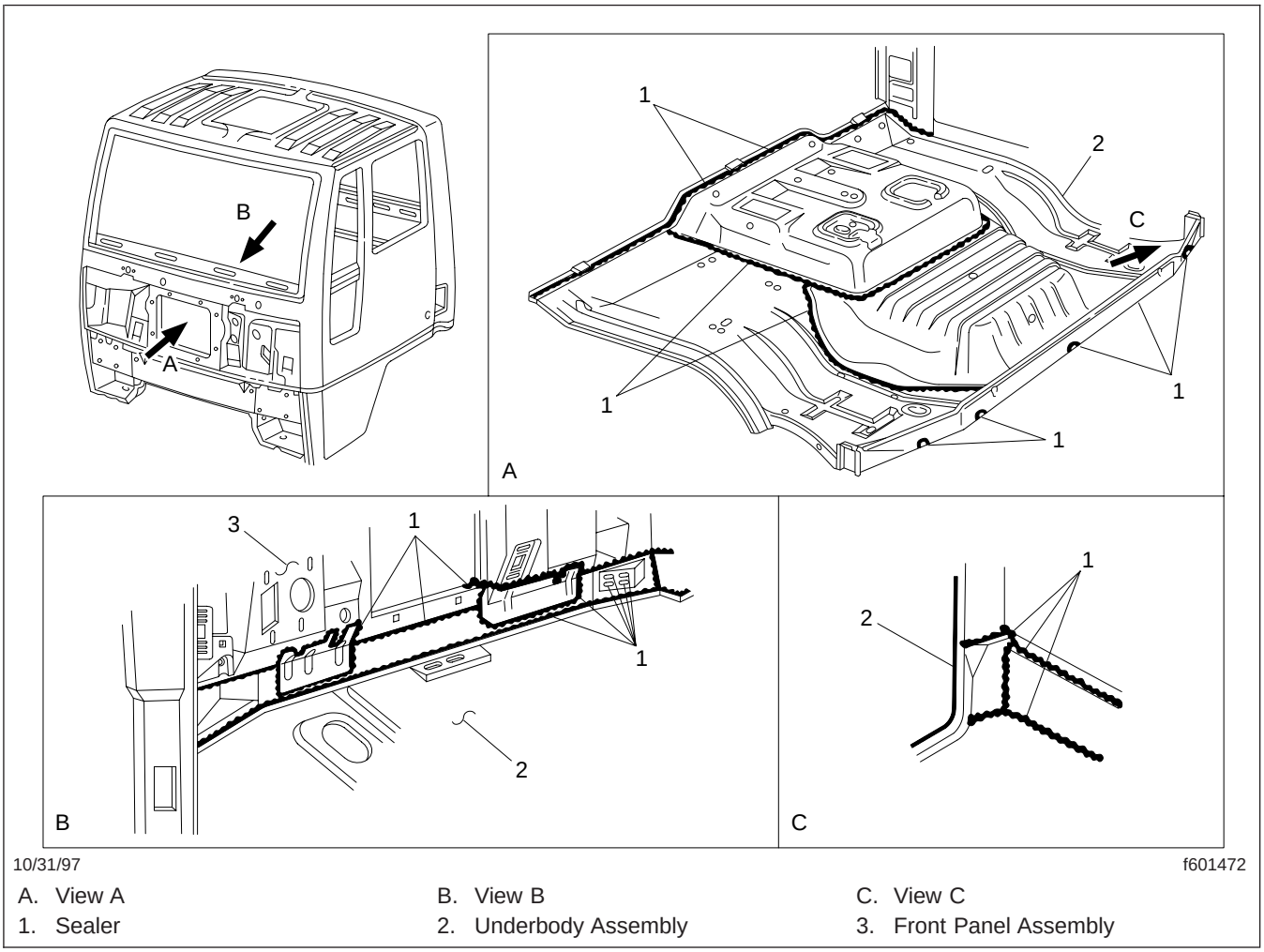
Fig. 1, Front Panel Sealant



A. View A
B. View B
C. View C
D. View D
E. View E
1. Sealer
2. Front Panel Assembly
3. Door Assembly
4. Roof Assembly
5. Back Panel Assembly

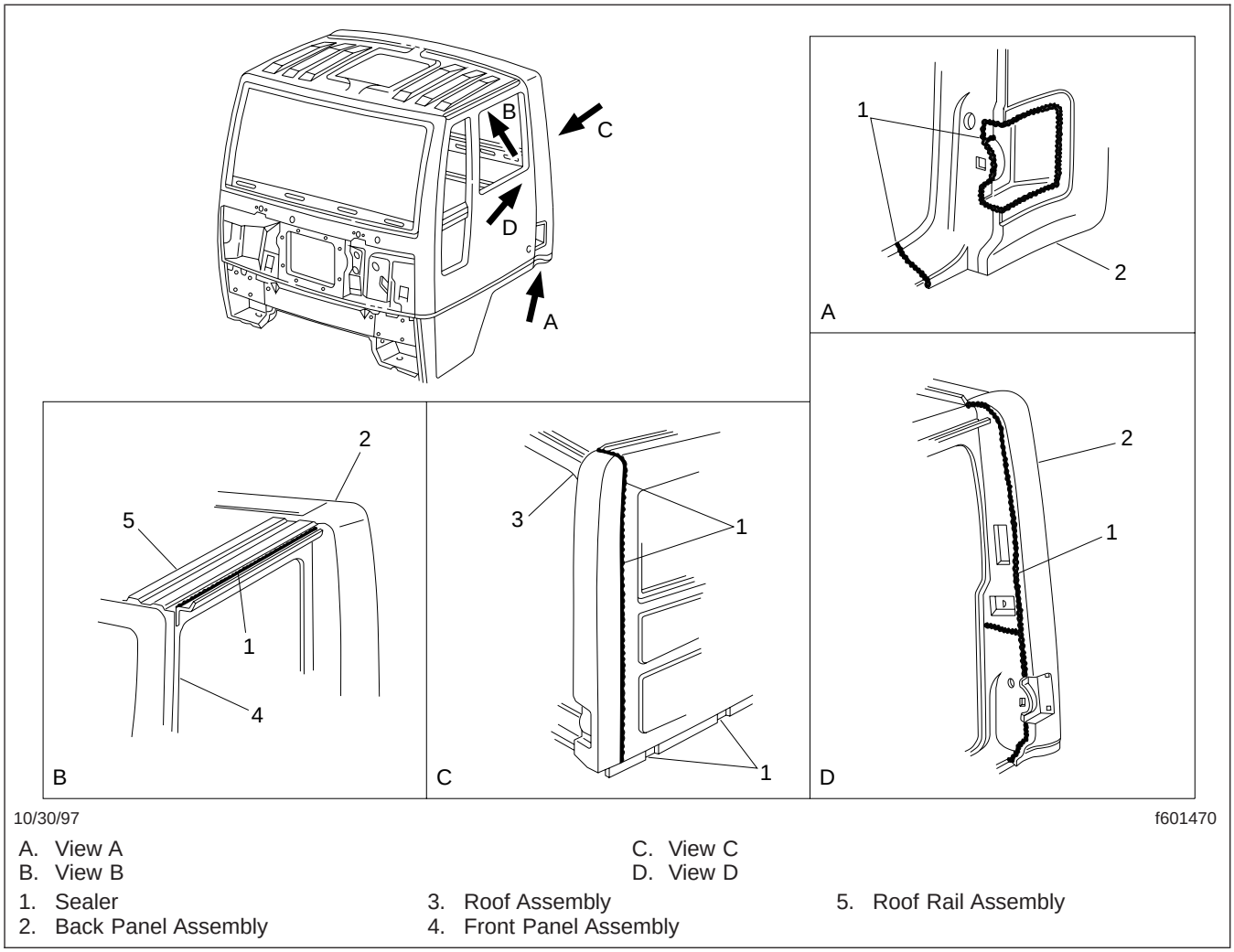
Fig. 2, Door, Front and Back Panel Sealant

Wind Noise



A. View A
B. View B
C. View C
1. Sealer
2. Underbody Assembly
3. Front Panel Assembly

Fig. 3, Underbody Sealant

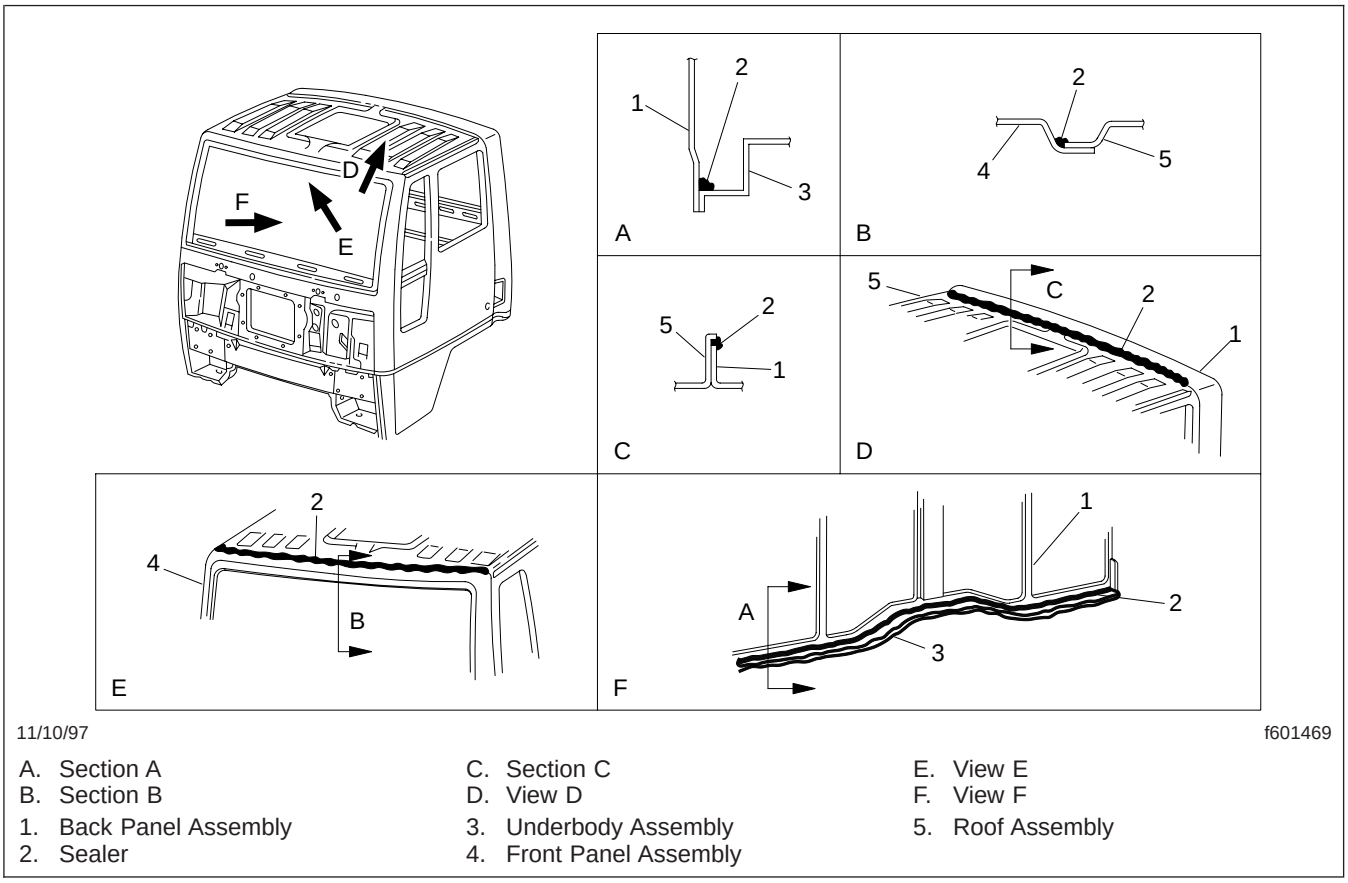


A. View A
B. View B
C. View C
D. View D

1. Sealer
2. Back Panel Assembly
3. Roof Assembly
4. Front Panel Assembly
5. Roof Rail Assembly

Fig. 4, Side and Back Panel Sealant

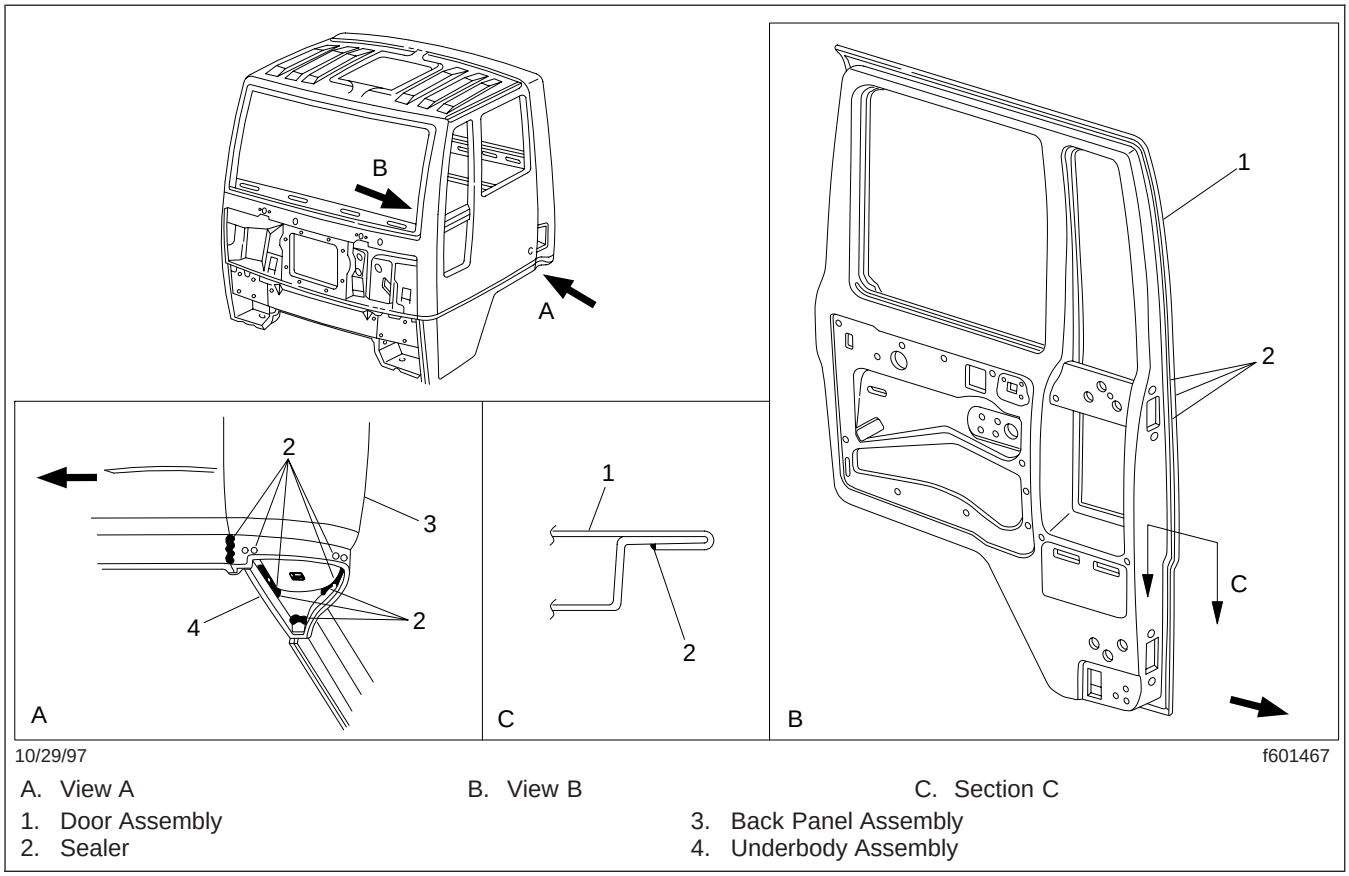
Wind Noise



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A. Section A
B. Section B
C. Section C
D. View D
E. View E
F. View F
1. Back Panel Assembly
2. Sealer
3. Underbody Assembly
4. Front Panel Assembly
5. Roof Assembly

Fig. 5, Roof and Back Panel Sealant



A. View A
B. View B
C. Section C
1. Door Assembly
2. Sealer
3. Back Panel Assembly
4. Underbody Assembly

Fig. 6, Door and Underbody Sealant

Rattle Elimination

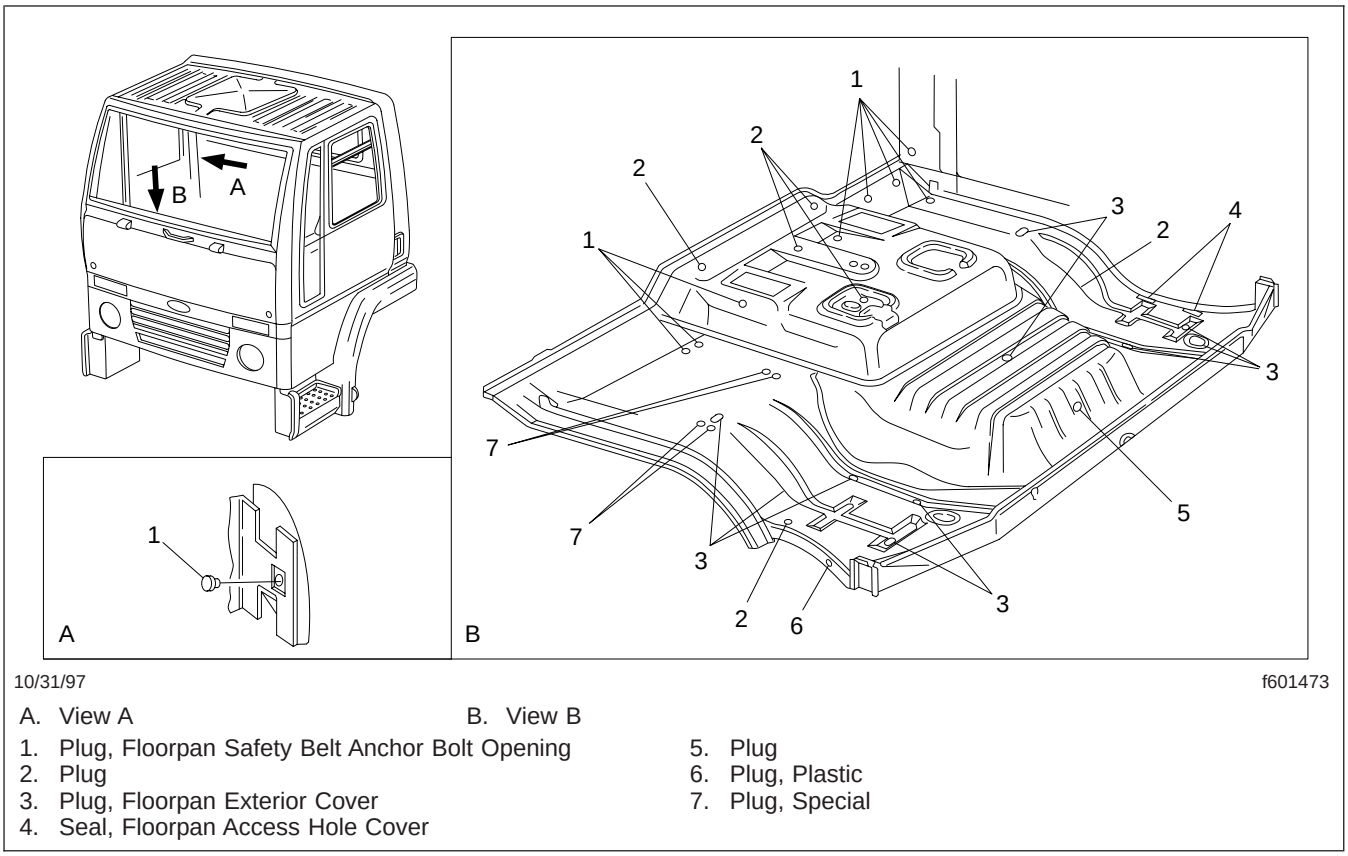
Most rattles are caused by a loose bolt or screw. Foreign objects such as nuts, bolts, or small pieces of body deadener in the door wells and pillars are often the source of rattles. Door wells can be checked by carefully striking the underside of the door with a rubber mallet. The impact made by the mallet will indicate if loose objects are in the door well.

Tighten all bolts and screws periodically. In the event that tightening the bolts and screws on such assemblies as the doors does not eliminate the rattles, the trouble is probably caused by misalignment. If this is the case, follow the adjustment and alignment procedures for these assemblies.

Rattles and squeaks are sometimes caused by weather-stripping and anti-squeak material that has slipped out of position. Apply additional cement or other adhesive, and attach the material in the proper location to eliminate this difficulty.

Floorpan Plugs and Grommets

(See Fig. 1, Fig. 2, Fig. 3, and Fig. 4)



A. View A
B. View B
1. Plug, Floorpan Safety Belt Anchor Bolt Opening
2. Plug
3. Plug, Floorpan Exterior Cover
4. Seal, Floorpan Access Hole Cover
5. Plug
6. Plug, Plastic
7. Plug, Special

Fig. 1, Sealing Plugs, Cab and Floorpan

If any plugs are missing or damaged, a dust or water leak may result. Such leakage may also occur around grommets used on the dash panel. When dust or water leaks are evident, these plugs and grommets should be checked for proper installation.

Many plugs and grommets are used in the floorpan and dash panel. The floorpan plugs seal the various body bolt access holes.

Drain Holes

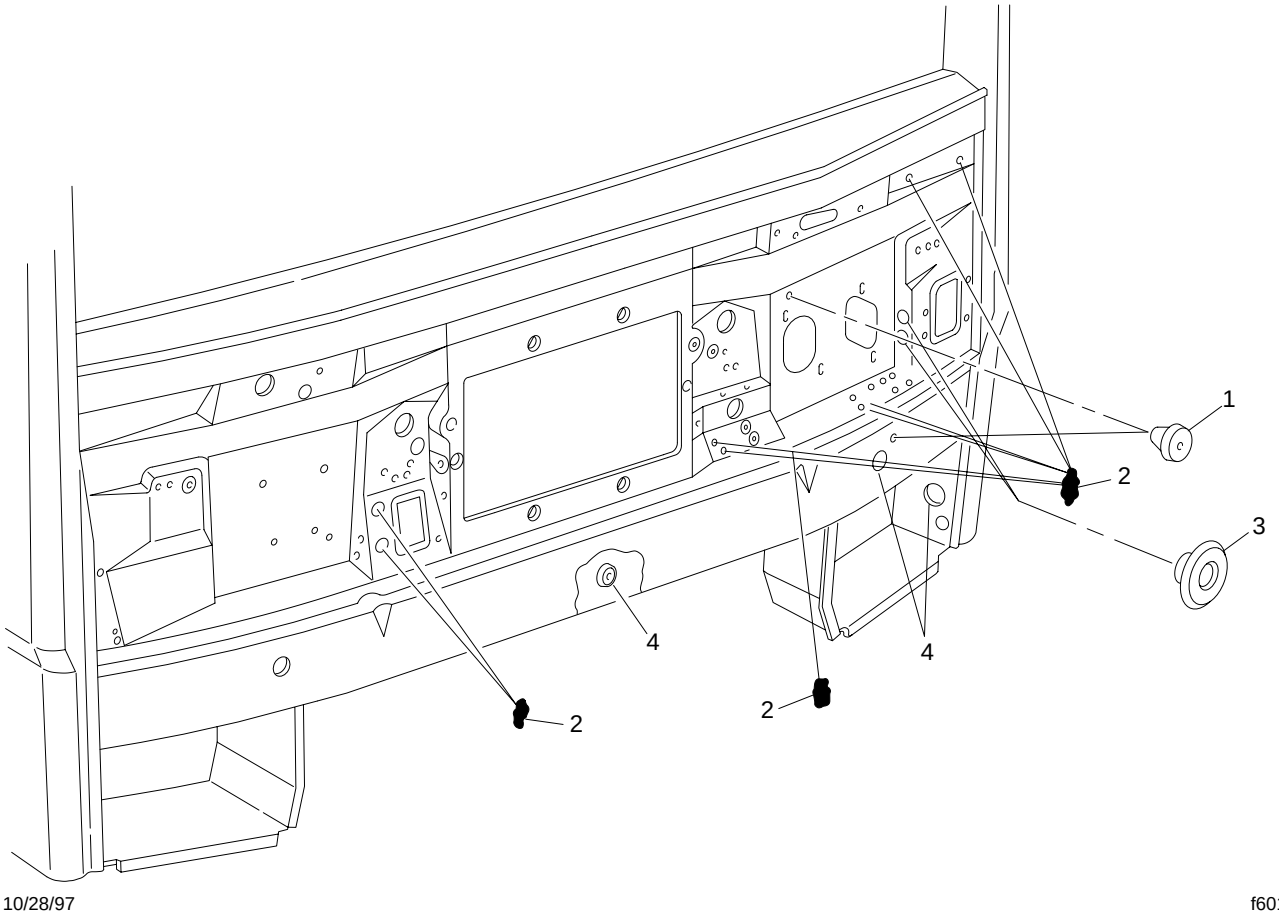
Drain holes are located on the underside of each door along the weld line of the inner and outer panels. If these holes become clogged with mud or road tars, water will collect inside the panels and rust the sheet metal from the inside. A sound of sloshing water in a door is an indication of this condition.

Check the drain holes regularly. Clean dirt and foreign material from the drain holes with a punch or screwdriver.

Trim

The trim on the vehicle requires no special care. Periodic cleaning will preserve the beauty and life of the finishes. Wash with clear water or, if the parts are very dirty, use a multi-purpose cleaner concentrate using a clean, soft cloth or a sponge and water. Rinse and wipe the parts dry. A metal cleaner can be used sparingly to remove rust, salt and road chemicals from aluminum or stainless steel parts. Do not scour aluminum parts with steel wool or polish them with products containing abrasives. A wax will provide excellent protection for all bright metal parts.

Cleaning and Inspection



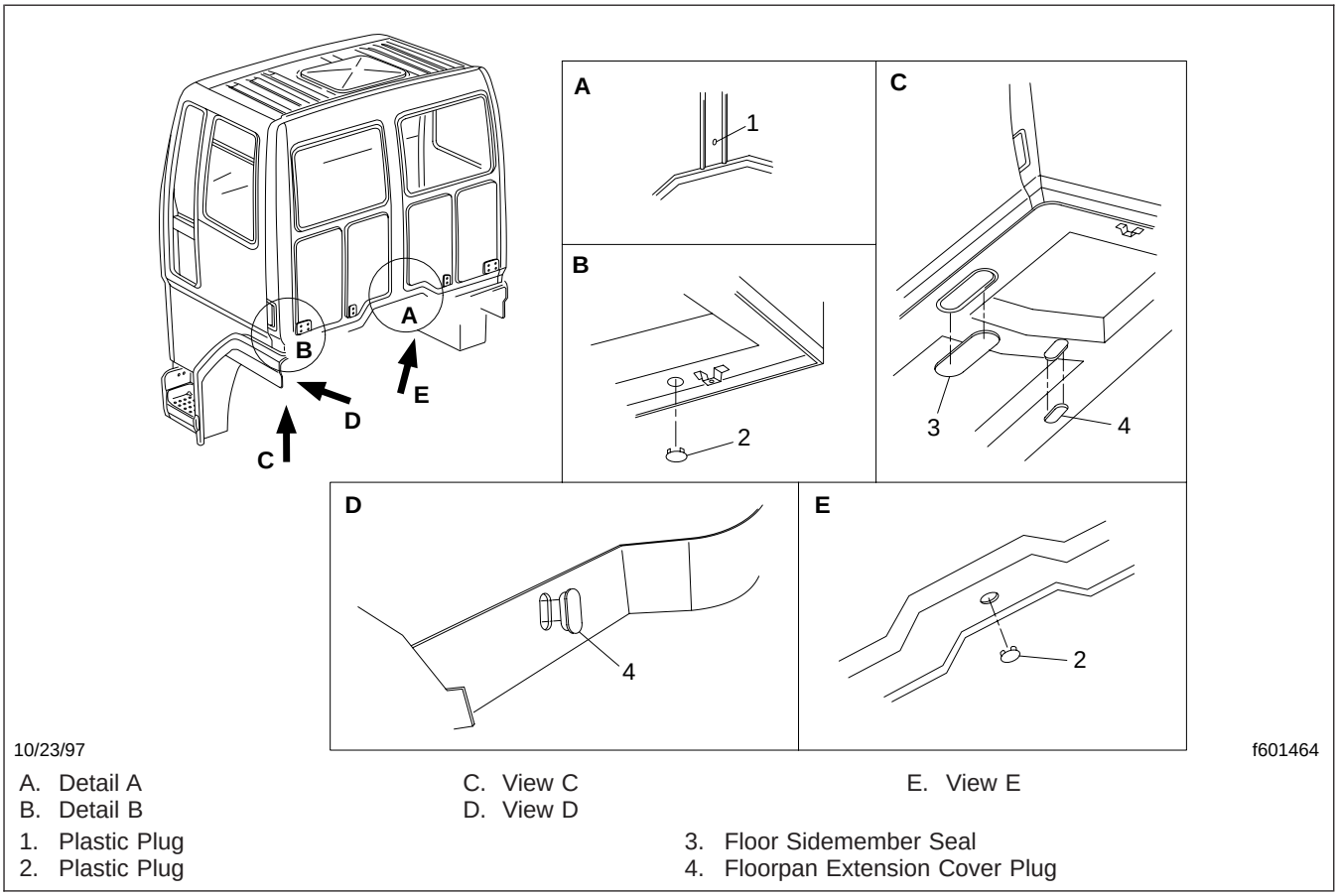
1. Plug, 3/8 Inch
2. Sealer
3. Plug Button
4. Plastic Plug

Fig. 2, Sealing Plugs, Dash Panel

Body Maintenance

Regular body maintenance preserves the vehicle's appearance and reduces the cost of maintenance during the life of the vehicle. The following steps are suggested as a guide for regular body maintenance.

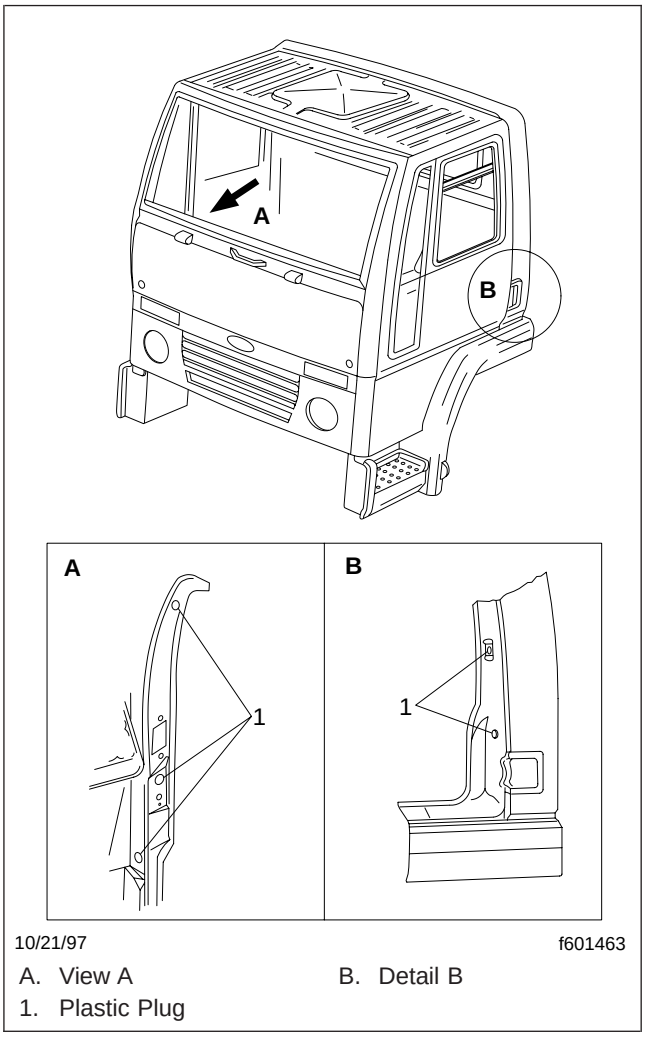
1. Vacuum the interior thoroughly and wash the vehicle.
2. Check all openings for water leaks, and seal where necessary.
3. Inspect weather-stripping channel and crimp together as required to ensure retention on body opening flange.
4. Replace all door weather-strips that are unfit for service.
5. Replace all cracked, fogged or chipped glass.
6. Align the hood panel and doors if necessary.
7. Inspect the windshield wiper blades and replace them if necessary.
8. Tighten the sill plate and garnish moulding screws.
9. Clean the seats, door trim panels and headlining.
10. Touch up or paint chipped or scratched areas.
11. Periodically clean drain holes located on the underside of each body panel and door.



A. Detail A
B. Detail B
C. View C
D. View D
E. View E
1. Plastic Plug
2. Plastic Plug
3. Floor Sidemember Seal
4. Floorpan Extension Cover Plug

Fig. 3, Sealing Plugs, Rear Cab

Cleaning and Inspection



A. View A
B. Detail B
1. Plastic Plug

Fig. 4, Sealing Plugs, Door Well

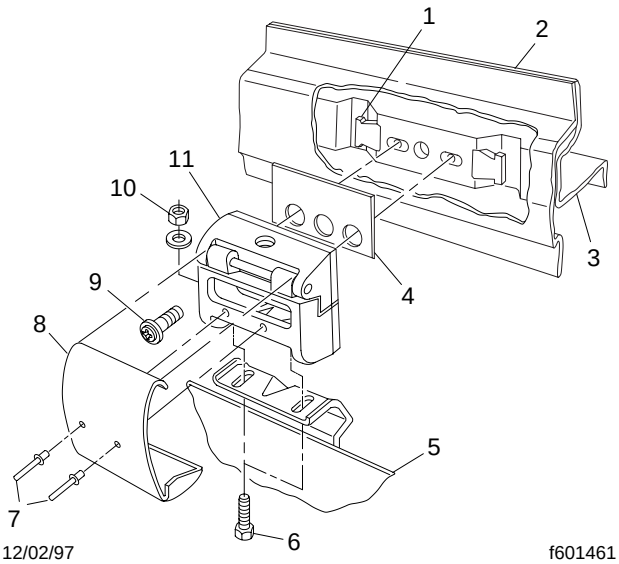
Front Hood Panel, Removal and Installation

Removal (See Fig. 1)

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Raise the hood panel and set the prop rod.
3. Disconnect the check strap, windshield washer hoses, and the ground strap from the hood panel.
4. Remove the hinge protective covers.
5. Remove the bolts that fasten the hinges to the hood panel, and remove the panel.

Installation

1. Position the hood panel to the hinges and attach the bolts. Tighten the bolts 75 to 89 lbf·in (850 to 1000 N·cm).
2. Attach the hinge covers.
3. Connect the check strap, windshield washer hoses, and the ground wire to the hood panel.
4. Check the hood panel alignment and locking mechanism. Adjust as required.
5. If necessary, adjust the hinges.



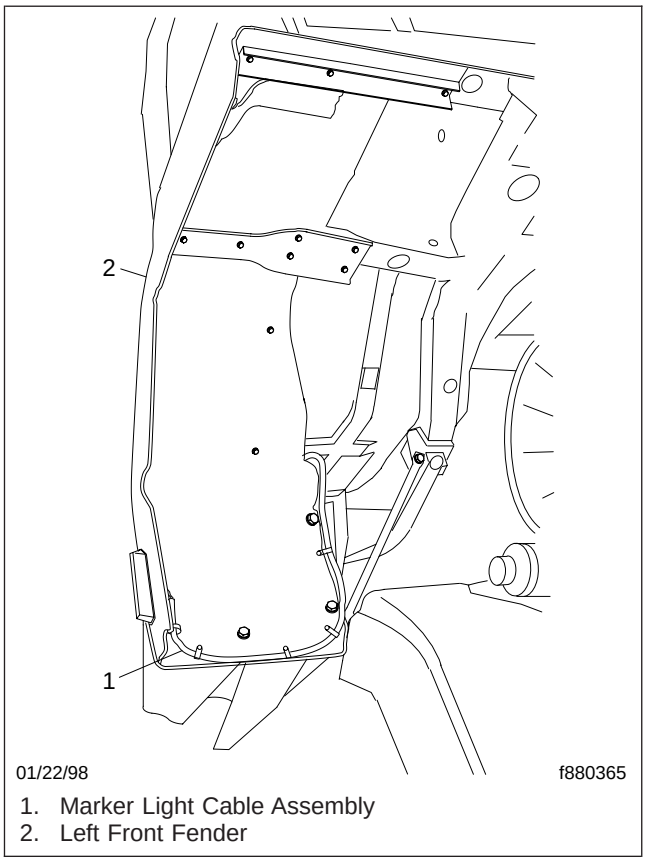
1. Hood Hinge Mounting Plate
2. Upper Body Panel, Front
3. Upper Body Reinforcement, Front
4. Hinge Seal
5. Hood Panel Assembly
6. Bolt
7. Rivet
8. Hinge Cover
9. Screw and Washer
10. Nut
11. Hinge

Fig. 1, Hood Panel Hinge Installation

Front Fender Replacement

(See Fig. 1)

1. Apply the parking brakes, chock the tires, and tilt the cab.
2. Disconnect the battery.
3. Disconnect the marker light cable, remove the tie straps that attach the cable to the fender, and set the cable assembly aside.
4. Remove the bolts and washers that attach the fender to the cab, and remove the fender.
5. Place the new fender on the cab, attach the washers and bolts, and tighten 12 lbf·in (136 N·cm).
6. Attach the marker light cable to the marker light, and attach the cable to the fender using tie straps.
7. Tilt the cab and remove the chocks.



1. Marker Light Cable Assembly
2. Left Front Fender

Fig. 1, Left Front Fender

Rear Fender Replacement

(See Fig. 2 and Fig. 3)

1. Apply the parking brakes, chock the tires, and tilt the cab.
2. Remove the bolts and washers that attach the fender to the fender bracket.
3. Slide the left fender out from under the air cleaner. Slide the right fender out from under the surge tank.

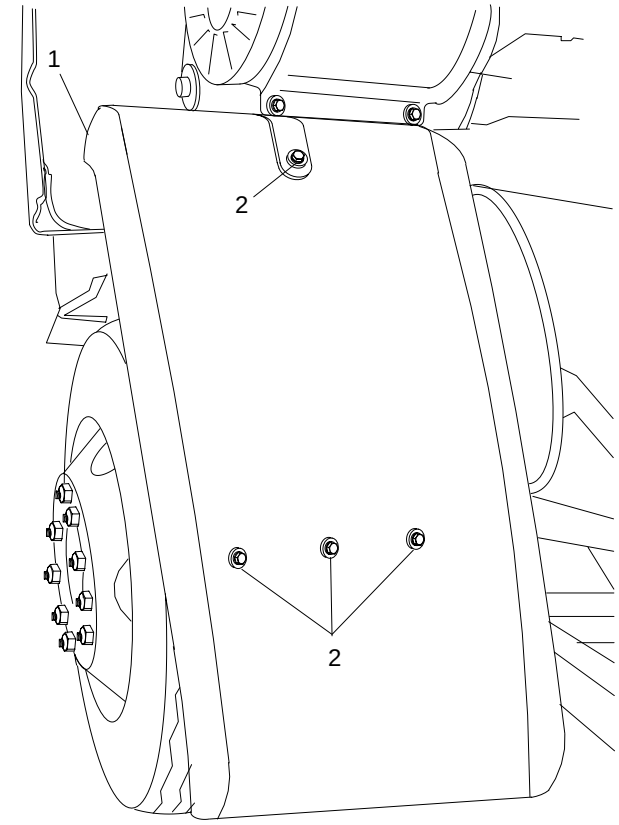
IMPORTANT: Be sure that the surge tank is supported after the fender has been removed.

4. Place the new left fender between the fender bracket and the air cleaner bracket. Place the right fender between the fender bracket and the surge tank bracket.

NOTE: Align the holes on top of the fender with the bosses on the fender bracket.

5. Attach the washers and bolts, and tighten 12 lbf·in (136 N·cm).

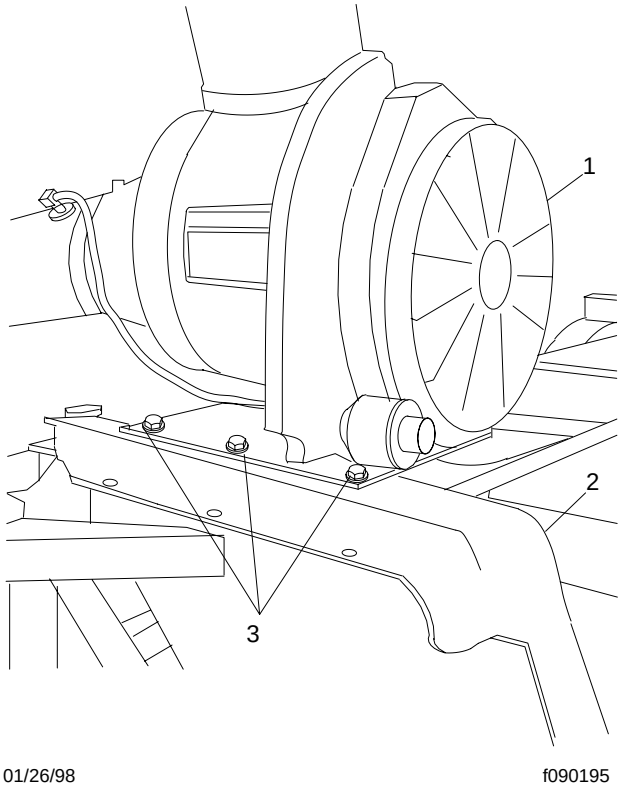
Front and Rear Fender Replacement



01/23/98 f880366

1. Left Rear Fender
2. Mounting Bolts and Washers

Fig. 2, Left Rear Fender



01/26/98 f090195

1. Air Cleaner
2. Left Rear Fender
3. Mounting Bolts and Washers

Fig. 3, Left Rear Fender and Air Cleaner

Specifications

Special tools can be purchased from the following independent supplier:

Kent-Moore Tools
Kent-Moore Tool Division
655 Eisenhower Drive
Owatonna, MN 55060
1 (800) 328–6657

Kent-Moore Equipment	
Description	**Model**
Combination Engine EAR/Chassis EAR	J–39570

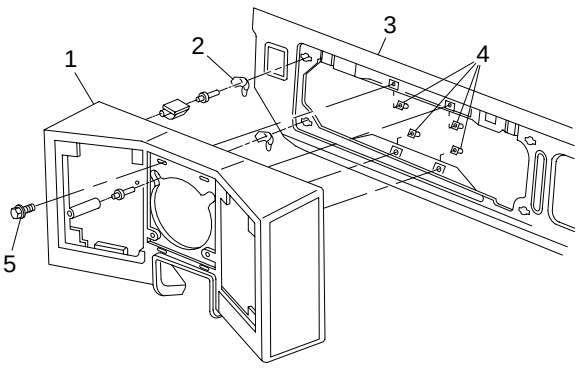
Table 1, Kent-Moore Equipment

Torque Values	
Description	**Torque lbf·in (N·cm)**
Hood Hinge Bolt	75–89 (850–1000)
Fender Mounting Bolt	12 (136)

Table 2, Torque Values

Removal (See Fig. 1)

1. Disconnect the battery ground cable.



01/07/98 f610018

1. Instrument Panel
2. Clip
3. Dash
4. U-Type Spring Nut
5. Screw

Fig. 1, Instrument Panel (exploded view)

2. Remove the right, left, and center instrument clusters with the instruments attached. Refer to **Group 54** for instructions.
3. Remove the steering column shroud screws. Separate the right and left shrouds, and remove.
4. Remove the screws retaining the instrument panel to the dash.
5. Gently remove the cluster from the four retaining clips.
6. Remove the lower left and right dash panels. These panels contain park brake, throttle, and other controls.
7. Remove the instrument cluster finish panel.
8. Remove the radio.
9. Remove the four screws and the radio support bracket.
10. Remove the three screws that attach the rear radio support bracket. Remove the bracket.
11. Remove the heater control panel illumination bulb holder. Remove the screws, pull out the heater control panel, and lower it.
12. Flip up the clips and disconnect the heater control cables from the heater.
13. Remove the heater control panel.
14. Remove the glove compartment door.
15. Remove the screws and the large and small glove compartments.
16. Remove the left and right grab handles. See **Subject 150** for instructions.
17. Remove the screws and the instrument panel.

Installation

1. Position the instrument panel on the dash.
2. Install the left and right grab handle. For instructions, refer to **Subject 150**.
3. Install the large and small glove compartments, and install the screws and striker.
4. Install the glove compartment door.
5. Install the heater control panel.
6. Connect the heater control cables to the heater, and press the clips down.
7. Position the heater control panel, and install the screws. Install the heater control panel illumination bulb holder.
8. Position the rear radio support bracket, and install the three screws.
9. Position the radio support bracket, and install the four screws.
10. Install the radio.
11. Install the instrument cluster finish panel.
12. Install the lower left and right dash panels. These panels contain brake, throttle, and other controls.
13. Carefully install the instrument panel to the four retaining clips.
14. Using new screws, attach the instrument panel to the dash.
15. Connect the steering column shrouds, and install the screws.
16. Install the right, left, and center instrument clusters with the instruments attached. Refer to **Group 54** for instructions.

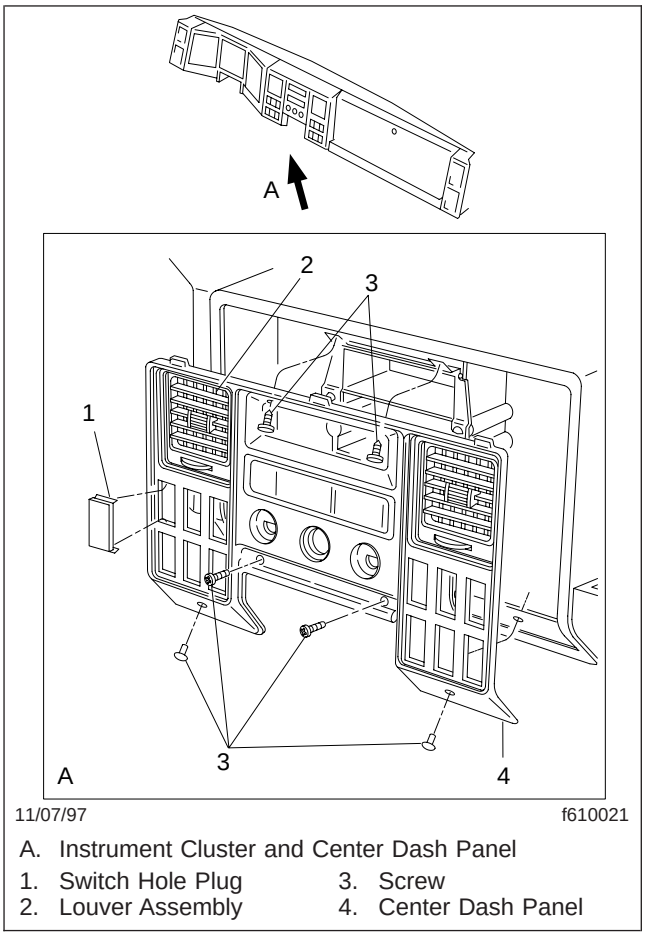
Dash Removal and Installation

17. Connect the battery ground cable.

Center Dash Panel Removal and Installation

Removal (See Fig. 1)

1. Disconnect the battery ground cable.



A. Instrument Cluster and Center Dash Panel
1. Switch Hole Plug
2. Louver Assembly
3. Screw
4. Center Dash Panel

Fig. 1, Center Dash Panel

2. Remove the ash tray. Remove the screws and the ash receptacle support.
3. Remove the switch panel screws.
4. Pull the switch panel out and down from the console.
5. Disconnect the tubes at the two heater air louvers.
6. Disconnect the electrical connectors to the switches. The number and function of switches will vary depending on how the vehicle is equipped.
7. Disconnect the cigarette lighter and light.
8. Remove the panel.
9. To remove the switches, squeeze the top and bottom tab on each switch toward the center of the switch and push out.
10. To remove the cigarette lighter, unscrew the outer cover and remove. Remove lighter receptacle and halo ring from the panel.
11. At the blower switch, pull off the knob and unscrew the retaining nut. Remove the switch.
12. Push out the two heater air louvers.

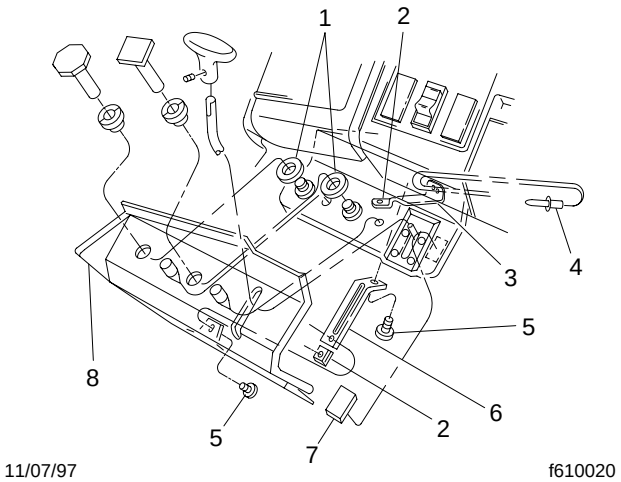
Installation

1. Install the panel.
2. Connect the cigarette lighter and light.
3. Connect the electrical connectors to the switches. The number and function of switches will vary depending on how the vehicle is equipped.
4. Connect the tubes at the two heater air louvers.
5. Install the screws and the ash tray support. Install the ash tray.
6. Connect the battery ground cable.

Lower-Right Dash Panel Removal and Installation

Removal (See Fig. 1)

1. Disconnect the battery ground cable.



1. Spacer
2. Threaded Hole
3. Bracket
4. Rivet
5. Screw
6. Bracket
7. Spacer
8. Front Trim Panel

Fig. 1, Lower-Right Dash Panel

2. Release all the pressure from the air brake system through the air tank drain cocks.
3. Remove the pins and knobs from the air brake parking brake control and, if so equipped, trailer brake control. Remove the retaining nuts and washers from the controls.
4. If so equipped, unscrew and remove the handle from the air brake hand control valve.
5. Remove the right instrument cluster. Refer to **Group 54** for instructions.
6. Remove the nuts retaining the lower-right dash panel to the dash and remove.

Installation

1. Position the lower instrument panel on the main instrument panel and bracket and install the retaining nuts.
2. Install the right instrument cluster. Refer to **Group 54** for instructions.
3. Install the brake hand control valve handle, if so equipped.
4. Install the retaining nuts and washers to the air brake parking brake control and, if so equipped, trailer brake control. Install the pins and knobs to the controls.
5. Connect the battery ground cable.

Lower-Left Dash Panel Removal and Installation

Removal

1. Disconnect the battery ground cable.
2. Remove the hand throttle cable, if so equipped.
3. Remove the left-hand instrument cluster. Refer to **Group 54** for instructions.
4. Remove the nuts from the lower-left dash panel and bracket, and remove the panel.

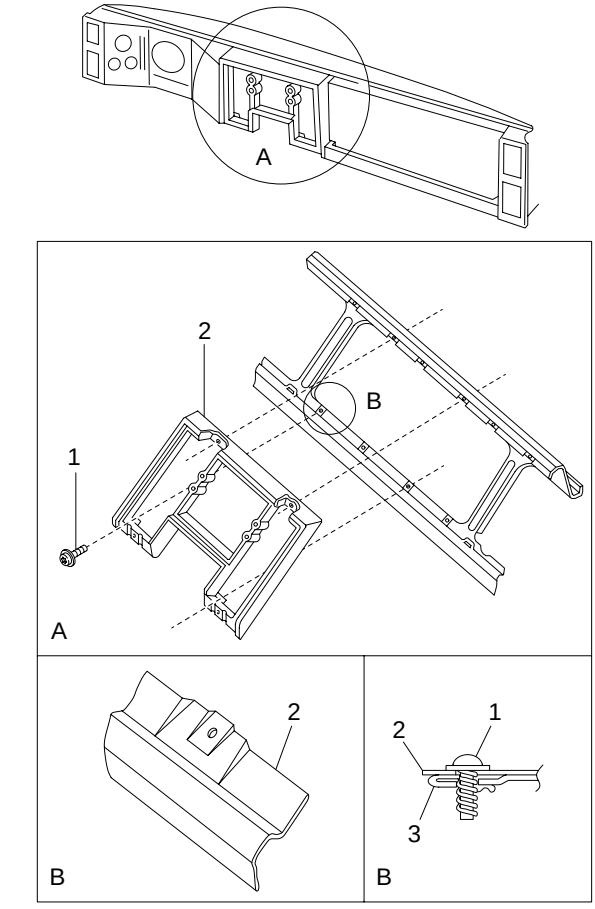
Installation

1. Position the lower-left dash panel on the instrument panel and bracket and install the retaining nuts.
2. Install the left-hand instrument cluster. Refer to **Group 54** for instructions.
3. Install the hand throttle cable, if so equipped.
4. Connect the battery ground cable.

Center Trimplate Removal and Installation

Removal (See Fig. 1)

1. Disconnect the battery ground cable.



1. Screw
2. Center Finish Panel Trim
3. Nut

Fig. 1, Center Instrument Panel Trim

2. Remove the center dash panel (switch panel). Refer to **Subject 110** for instructions.
3. Remove the radio.
4. Remove the four screws and the radio support.
5. Remove the three screws and the rear radio mount.
6. Remove the heater control panel illumination bulb holder. Remove the screws, pull out the heater control panel and lower.
7. Flip up the clips and disconnect the heater control cables from the heater and remove the heater control panel.
8. Remove the screws and remove the trimplate from the dash.

Installation

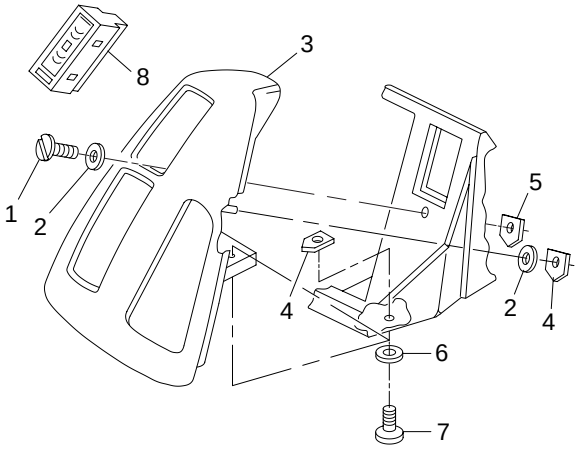
1. Install the trimplate on the dash. Replace the screws.
2. Connect the heater control cables to the heater, and install the heater control panel. Push down the clips.
3. Install the heater control panel, and replace the screws. Install the heater control panel illumination bulb holder.
4. Install the rear radio mount, and replace the screws.
5. Install the radio support, and replace the four screws.
6. Install the radio.
7. Install the center dash panel panel (switch panel).
8. Connect the battery ground cable.

Grab Handle Removal and Installation

Removal (See Fig. 1)

NOTE: On some vehicles it is necessary to remove the air louver and glove compartment, or the left instrument cluster, to gain access to one internal retaining screw.

1. Remove the three Phillips head screws retaining the handle.



1. Screw
2. Washer
3. Grab Handle
4. Nut
5. Reinforcement
6. Washer
7. Screw
8. Air Louver

Fig. 1, Cab Entry Assist Handles

2. Remove the handle.

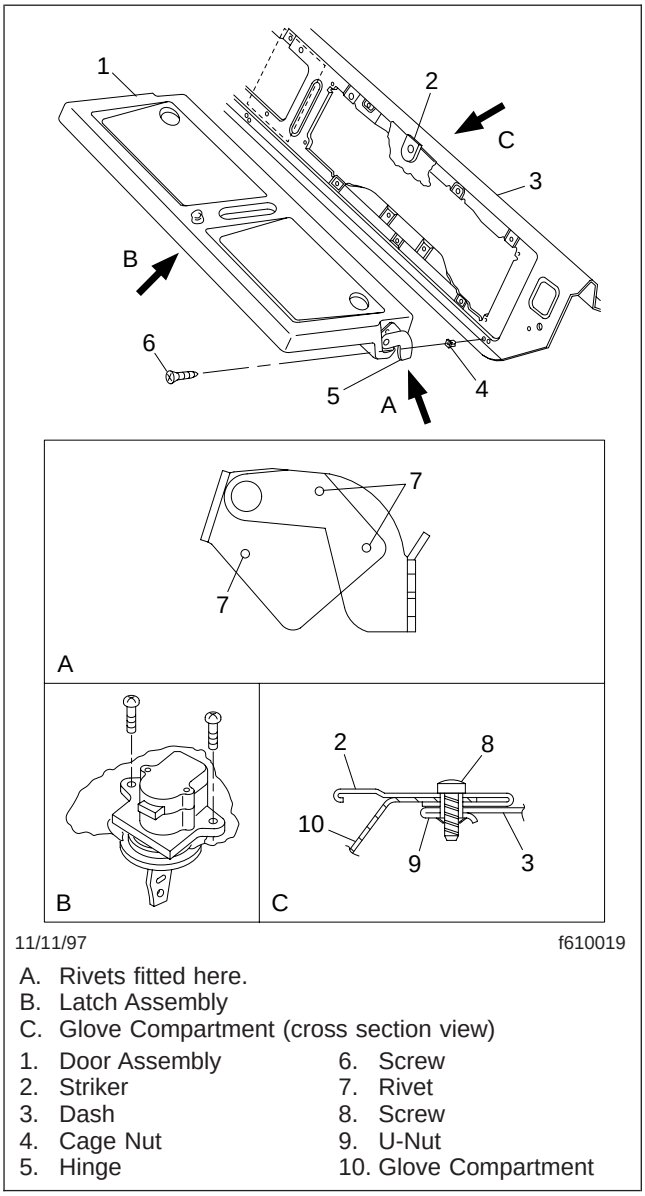
Installation

1. Position the handle and install the three Phillips head retaining screws.
2. Install the air louver and glove compartment or left instrument panel, if removed.

Glove Compartment Removal and Installation

Removal (See Fig. 1 and Fig. 2)

1. Open the door and remove the door hinge-to-main instrument panel retaining screws.



11/11/97 f610019

A. Rivets fitted here.
B. Latch Assembly
C. Glove Compartment (cross section view)

1. Door Assembly
2. Striker
3. Dash
4. Cage Nut
5. Hinge
6. Screw
7. Rivet
8. Screw
9. U-Nut
10. Glove Compartment

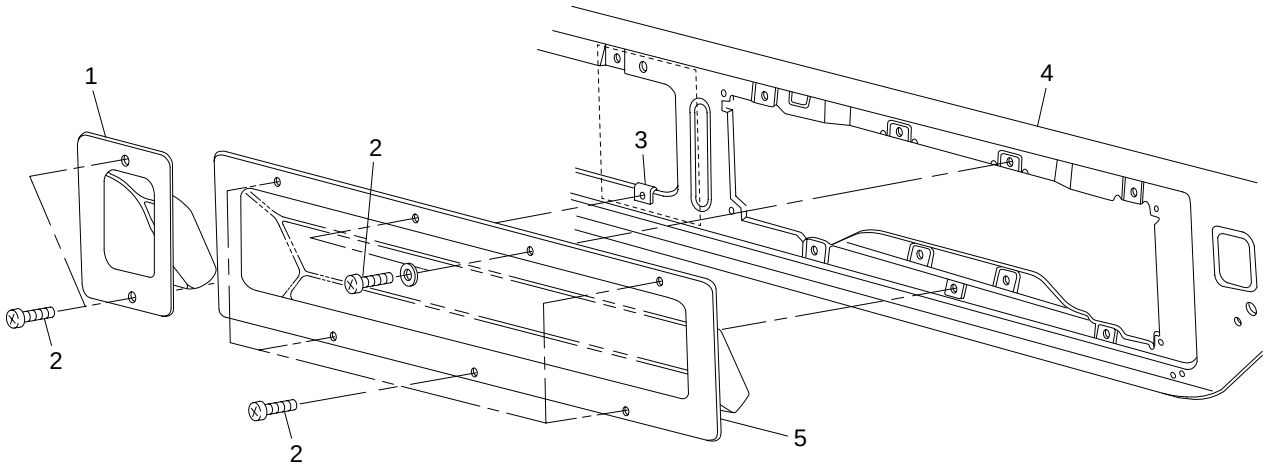
Fig. 1, Glove Compartment Door Installation

2. Remove the glove compartment retaining screws and the one washer.
3. Remove the glove compartment.

Installation

1. Position the glove compartment on the dash.
2. Install the retaining screws and the washer.
3. Install the door hinge-to-main instrument panel retaining screws.

Glove Compartment Removal and Installation



1. Glove Compartment (small)
2. Flanged Screw
3. U-Nut
4. Dash
5. Glove Compartment (large)

Fig. 2, Glove Compartment Installation

Specifications

Torque Specifications		
Description	**lbf·in**	**N·cm**
Switch Panel Screws	18–27	203–305

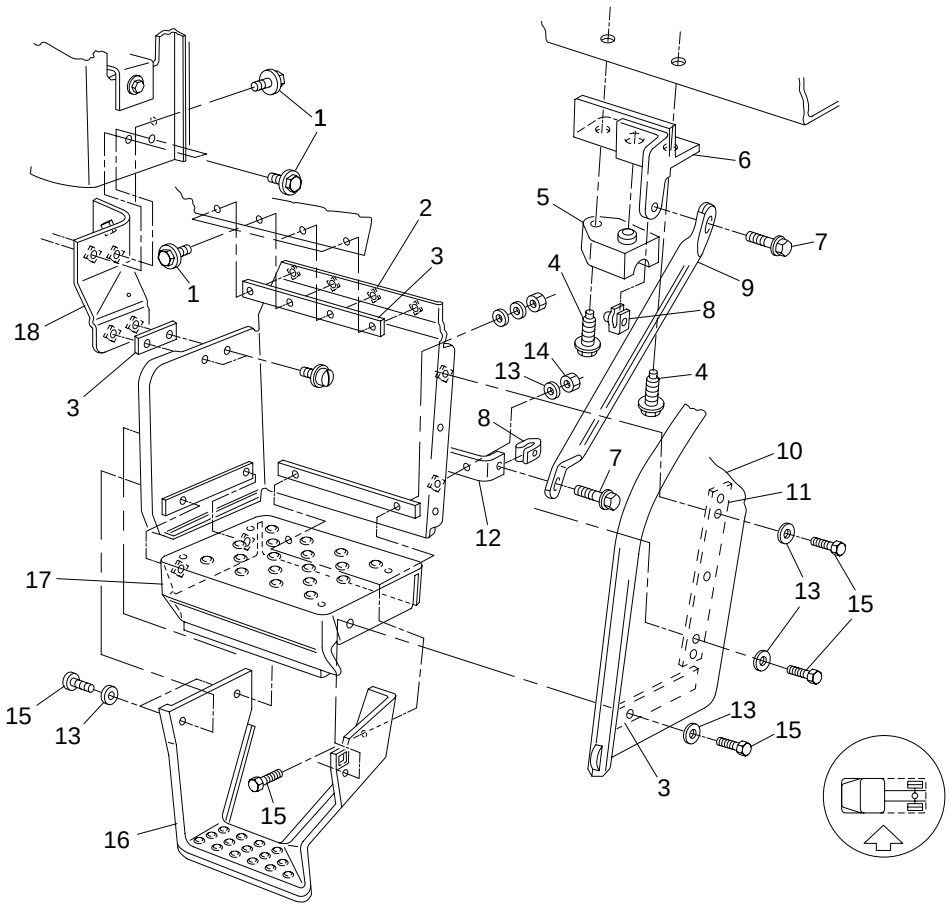
Table 1, Torque Specifications

Lower Step, Cab Access, Replacement

Removal (See Fig. 1)

1. Remove the four bolts and washers that fasten the lower step to the lower step support.
2. Remove the lower step.

Installation



01/28/98 f601465

1. Screw and Washer Assembly
2. Body Side Step Finish Panel
3. Body Side Step Insulator
4. Screw and Washer Assembly
5. Pressure Pad
6. Running Board Brace Bracket
7. Screw and Washer Assembly
8. U-Spring Nut
9. Running Board Brace Bracket
10. Front Fender
11. Front Fender Sound Insulator
12. Running Board Reinforcement
13. Washer
14. Nut
15. Bolt
16. Lower Step
17. Lower Step Support
18. Side Step Support Assembly

Fig. 1, Side Step Assembly

1. Attach a new lower step to the lower step support.
2. Attach the four bolts and washers that fasten the lower step to the lower step support and tighten 72 lbf·in (813 N·cm).

Removal

1. If possible, park the vehicle with the tires in the straight-ahead position. Apply the parking brakes, and chock the tires.
2. Disconnect the batteries, and drain the air system.
3. Remove the grille.
4. Open the hood.
5. Discharge the air conditioning system.
6. Disconnect the cab-to-chassis connections under the hood.
   - 6.1 Label and disconnect all chassis air lines from the service brake valve.
   - 6.2 If necessary, cut and splice the black parking brake line.
   - 6.3 Disconnect the coolant lines running to the cab heater.
   - 6.4 Disconnect the engine oil line running to the oil pressure sensor junction block.
   - 6.5 Label and disconnect the wires running to the magnetic switch.
   - 6.6 Disconnect the chassis wiring harnesses from the bulkhead connectors.
7. Disconnect the air conditioning lines between the cab and chassis.
8. Close the hood and remove the windshield wiper arms.
9. Remove the bumper.
10. Make sure the mirrors are folded as close into the cab as possible.
11. Tilt the cab. For instructions, refer to the vehicle driver's manual.
12. Disconnect the cab-to-chassis connections under the cab.
    - 12.1 Disconnect the wiring harness to the transmission shift control.
    - 12.2 Disconnect the chassis wiring harnesses from the connectors on the underside of the cab.
    - 12.3 Disconnect the steering driveline from the steering gear input shaft, and use a tie strap to fasten the telescoping driveline so that the lower half doesn't slip down and out of the upper half.
13. Position a suitable crane over the vehicle, and attach lifting straps to the crane and vehicle cab. See **Fig. 1** and **Fig. 2**.
    - 13.1 For cab front lifting points, loop the lifting straps around the front cab mounts, being careful not to cover the bolt that runs through the cab mount. See **Fig. 3**.

      Place wooden blocks between the front lifting straps and the cab bulkhead to keep the straps from damaging any cab components.
    - 13.2 For rear lifting points, place a 5-inch-long, 1/2-inch bolt through the loop at the end of each lifting strap. Then slip each bolt into a hole in the underside of the cab, just forward of the rear cab mount. See **Fig. 4**.

      Position the bolt inside each hole so that it can't slip out, and securely holds the lifting strap to the cab.
14. Raise the lifting straps until they are tight, and disconnect the cab support strut.
15. Remove the cab torsion bars. See **Fig. 5**.
16. Remove the hinge pin (bolt) from each front cab mount, and lift and remove the cab.

Installation

1. With the cab suspended by lifting straps from a crane, position the cab on the front engine mounts. Secure each mount by running the 1/2-inch pin (bolt) through the mount. Tighten the nut 60 lbf·ft (81 N·m).
2. Connect the cab support strut.
3. With the front lifting straps securely supporting the cab, disconnect the rear lifting straps from the cab, and tilt the cab as far forward as possible with the support strut connected.
4. Install the cab torsion bars. Tighten the nuts 44 to 59 lbf·ft (60 to 80 N·m).

Cab Removal and Installation

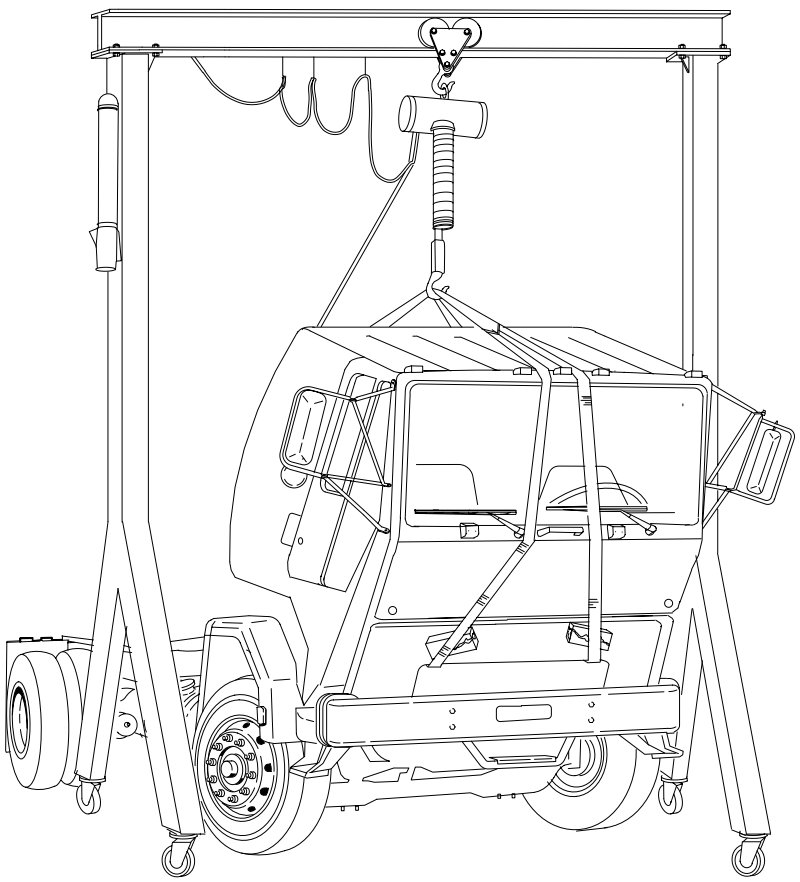


Fig. 1, Cab Lifting Method, Front View

5. With the cab still tilted, connect the cab-to-chassis connections under the cab.
   - 5.1 Connect the wiring harness to the transmission shift control.
   - 5.2 Connect the chassis wiring harnesses to the connectors on the underside of the cab.
   - 5.3 Connect the steering driveline to the steering gear input shaft.
6. Lower the cab.
7. Connect the cab-to-chassis connections under the hood.
   - 7.1 Connect all chassis air lines to the service brake valve.
   - 7.2 Connect the spliced black parking brake line.
   - 7.3 Connect the coolant lines running to the cab heater.
   - 7.4 Connect the engine oil line running to the oil pressure sensor junction block.
   - 7.5 Connect the wires running to the magnetic switch.
   - 7.6 Connect the chassis wiring harnesses to the bulkhead connectors.
   - 7.7 Connect the air conditioning lines between the cab and chassis.
8. Evacuate and charge the air conditioning system. For instructions, see **Group 83** in this manual.

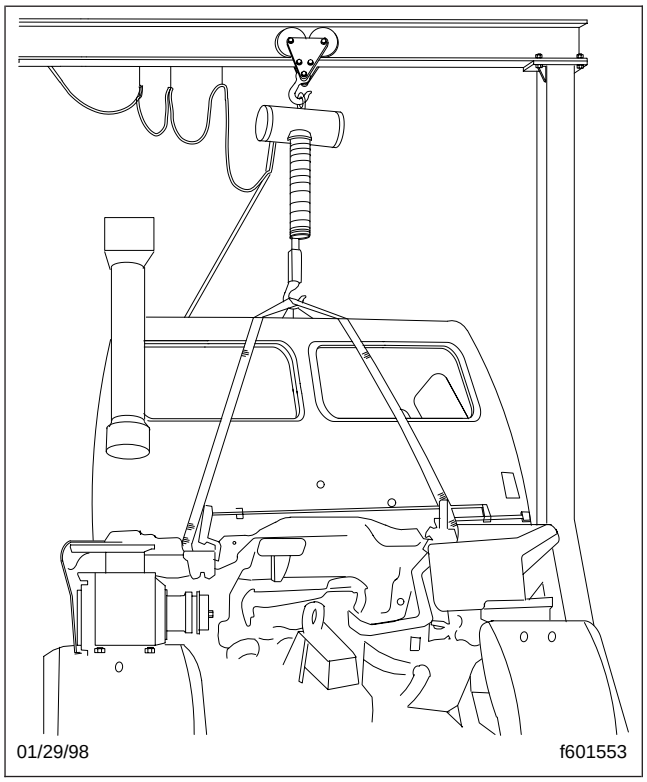
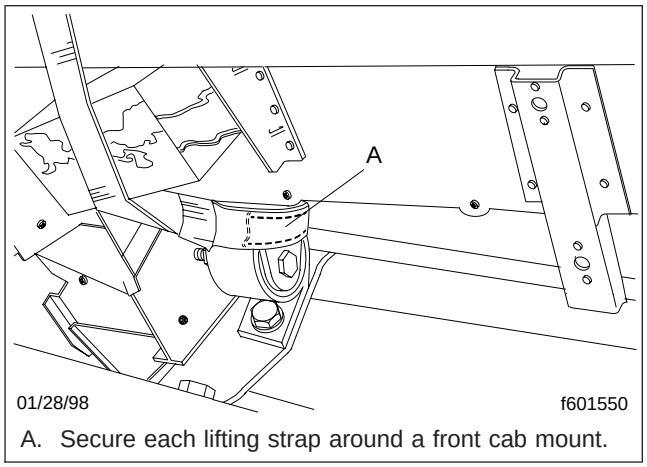


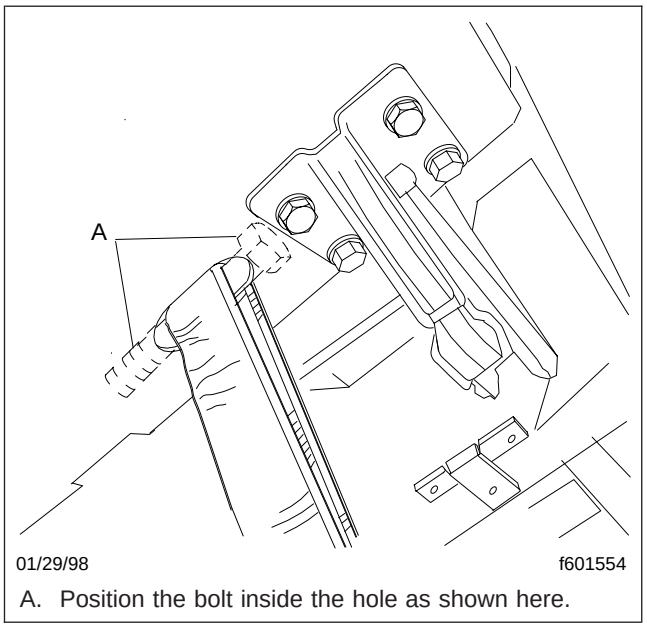
Fig. 2, Cab Lifting Method, Rear View



A. Secure each lifting strap around a front cab mount.

Fig. 3, Cab Front Lifting Point

9. Install the bumper.
10. Connect the batteries and remove the chocks from the tires.



A. Position the bolt inside the hole as shown here.

Fig. 4, Cab Rear Lifting Point

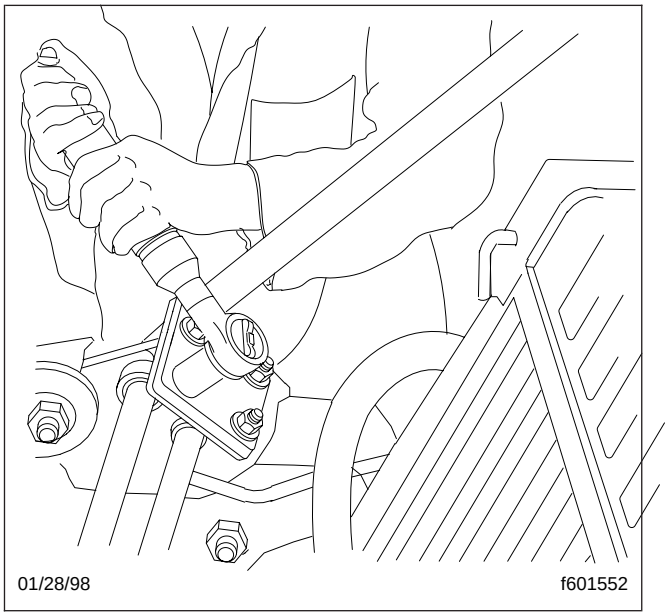


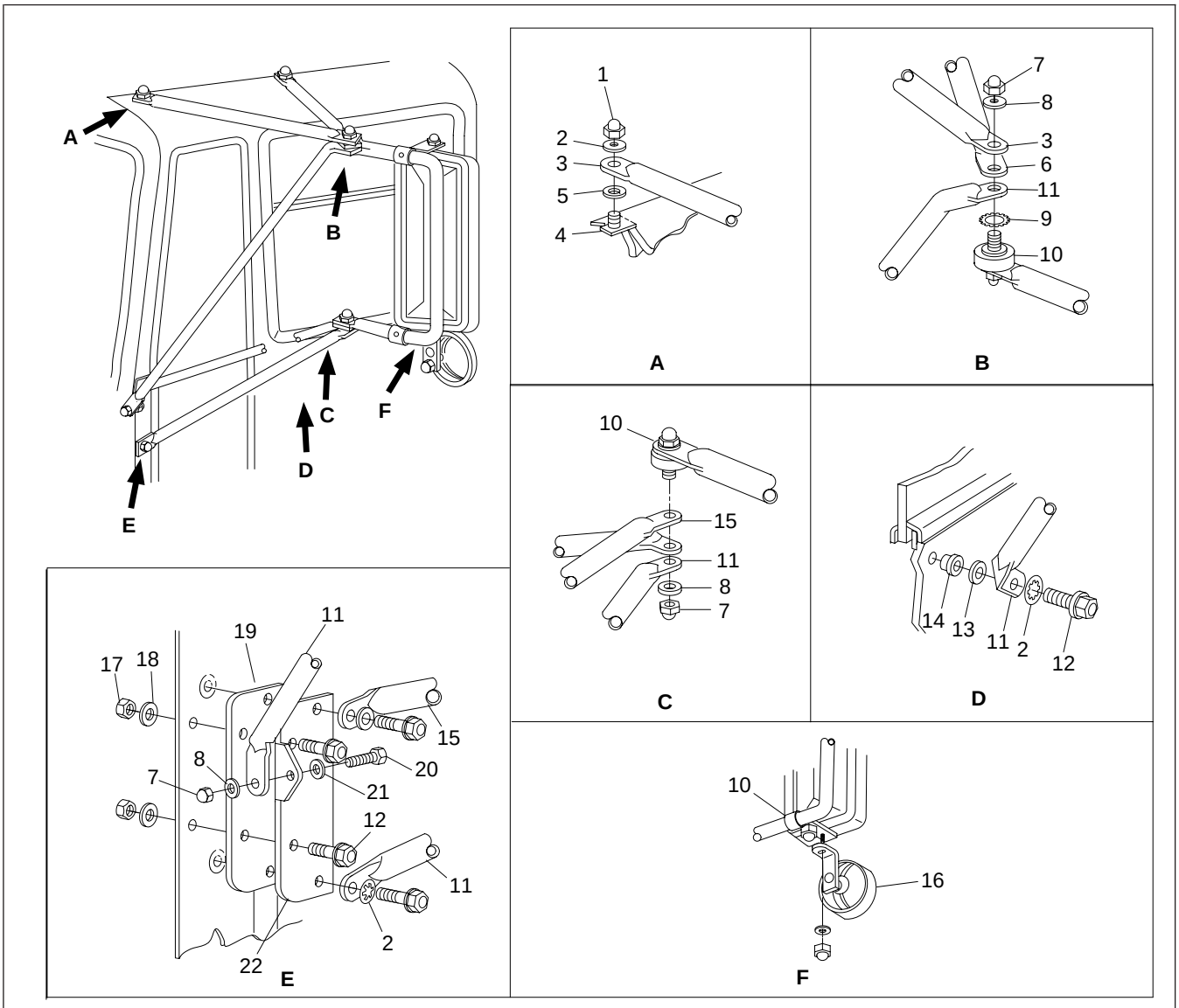
Fig. 5, Removing the Torsion Bars

Mirror Mounting Bracket Replacement

Replacement

The mounting bracket is removed by removing either the mounting bracket stud nuts or the mounting bracket bolts. See **Fig. 1**.

Mirror Mounting Bracket Replacement



12/03/97 f601476

A. View A
B. View B
C. View C
D. View D
E. View E
F. View F

1. 1/4-20 Crown Nut
2. Washer
3. Support Assembly
4. Stud Assembly
5. Gasket
6. Support Assembly
7. 1/4-20 Crown Nut
8. Washer
9. Washer
10. Mirror and Guard Assembly
11. Brace
12. M6 Flanged Hex Bolt
13. Pad
14. M6 Rivet Nut
15. Support Assembly
16. Mirror Assembly, Diminishing
17. M6 x 1" Hex Nut
18. Washer
19. Gasket
20. Bolt, 3/8-16 x .75
21. Washer
22. Bracket

Fig. 1, Mirror and Brackets

Specifications

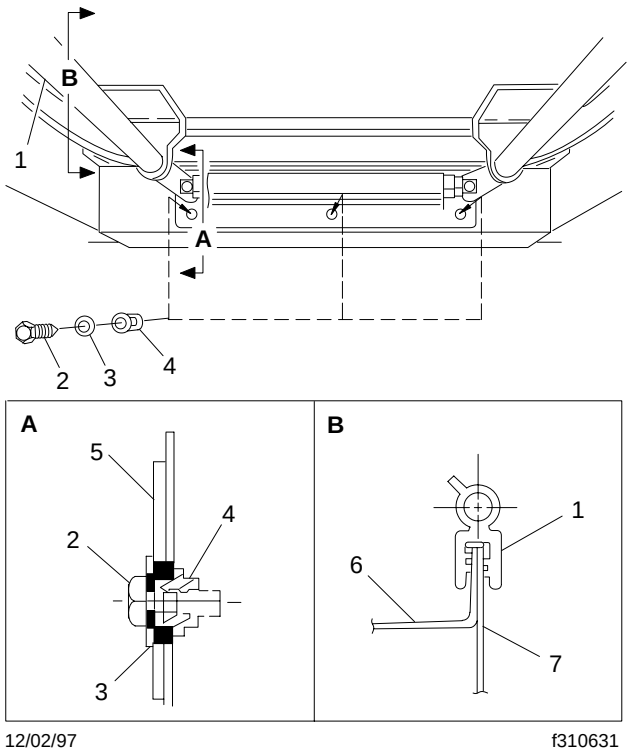
Torque Specifications		
Description	**lbf·ft**	**N·m**
Mirror Swing Locknuts	12–18	16–24
Support to Cab Roof Panel Nut	3–6	4 – 8
Mirror Bracket to Cab Bolt	7–10	9–13

Table 1, Torque Specifications

Roof Hatch Removal and Installation

Removal (See Fig. 1)

1. Carefully remove the roof hatch trim retaining clips, and pull off the trim.



A. Side view of the roof vent assembly.
B. Side view of the fasteners attaching the roof hatch assembly.
1. Roof Opening Weatherstrip Assembly
2. Bolt
3. Washer
4. Nut
5. Roof Vent Assembly
6. Roof Panel
7. Reinforcing Bow

Fig. 1, Roof Ventilating Hatch

2. Open the hatch.
3. Remove the three bolts attaching the roof hatch assembly to each reinforcing bow.
4. Remove the assembly through the top of the roof.

Installation

1. Make sure the hatch assembly is in the open position and install the three retaining bolts on each reinforcing bow. Tighten the bolts 76 to 89 lbf·in (859 to 1006 N·cm).
2. Close the hatch.
3. Replace the trim and install the retaining clips.

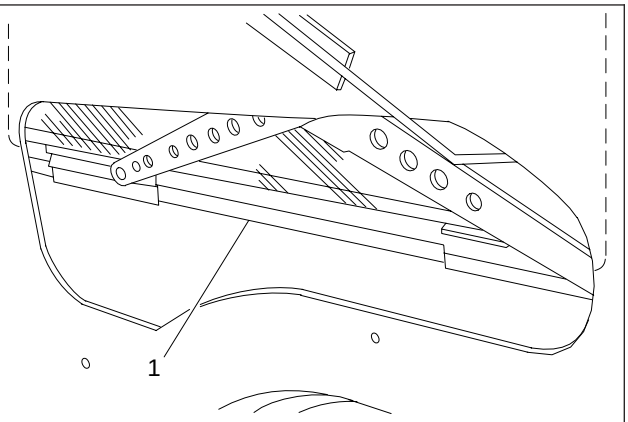
Specifications

Torque Specifications		
Description	**lbf·in**	**N·cm**
Bolt, Hatch Assembly to Reinforcing Bow	76–89	859–1006

Table 1, Torque Specifications

Replacement (See Fig. 1)

1. Remove the door trim panel and the watershield.



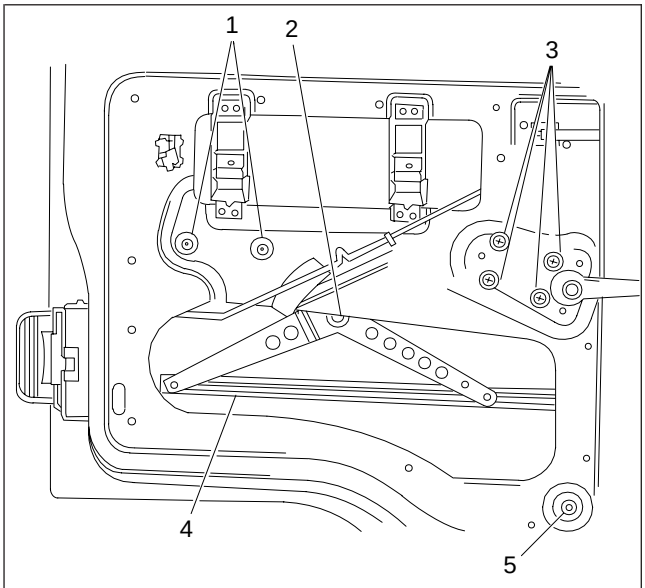
1. Glass Channel

Fig. 1, Front Door Glass Channel

2. Remove the center, front and rear channel mounting bolts.
3. Remove the rear channel through the door opening and pull the front channel aside.
4. Remove the mounting bolts from the door top window. Remove the window.
5. Remove the inside and outside weatherstrips from the front door belt line.
6. Remove the glass through the door window opening.
7. Observe the window support position in relation to the glass.
8. Place the new glass through the door window opening.
9. Install the inside and outside weatherstrips in the door belt line .
10. Install the mounting bolts on the door top window.
11. Install the rear channel through the door opening and pull the front channel aside.
12. Install the center, front and rear channel mounting bolts.
13. Install the door trim panel and the watershield.

Replacement

1. Remove the door trim panel and the watershield.
2. Rotate the window regulator handle and lower the window until the regulator assembly can be seen through the door internal panel holes. Support the glass to avoid dropping after the regulator is removed. Remove the handle and the four screws retaining the regulator assembly to the internal door panel. See **Fig. 1**.



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1. Fixed-Run Mounting Nuts
2. Regulator Assembly
3. Flanged Screws
4. Door Glass Channel
5. Screw

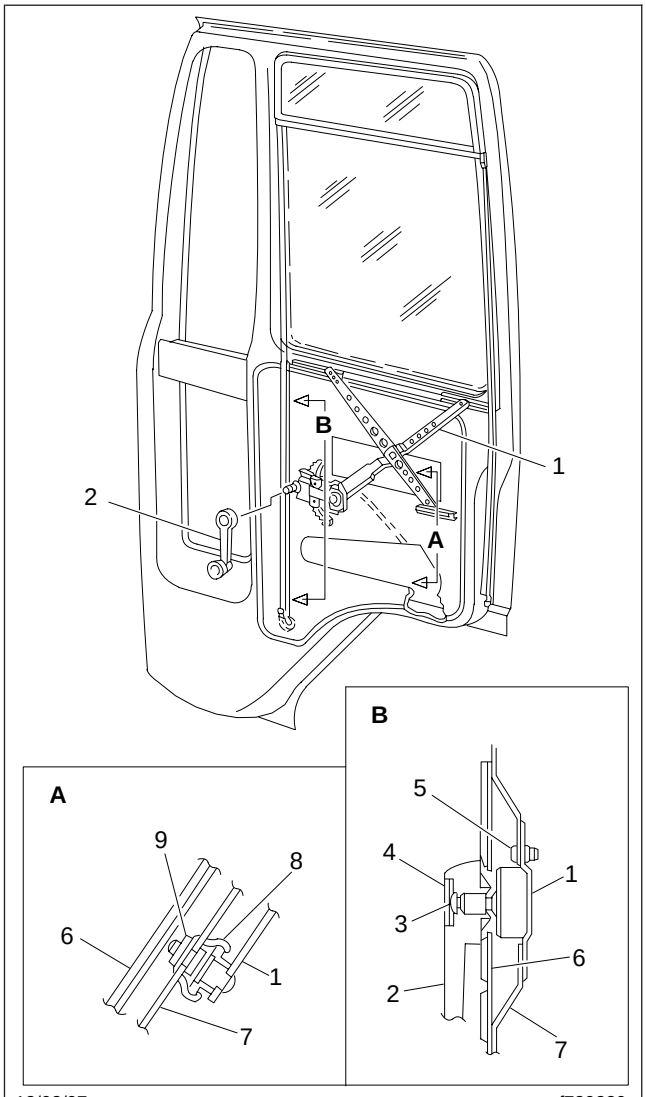
Fig. 1, Front Door Interior (panel removed)

3. Remove the two fixed-run mounting nuts. Remove the run.

NOTE: The regulator assembly can be removed at this point. However, removal is easier after fixed-run removal.

4. Remove the regulator assembly through the door panel opening. See **Fig. 2**.

NOTE: The window regulator assembly should be properly lubricated to provide ease of operation. The window glass mechanism should be lubricated whenever the glass channel or window regulator is removed or excessive effort is



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A. Door Trim Panel
B. Window Regulator Assembly

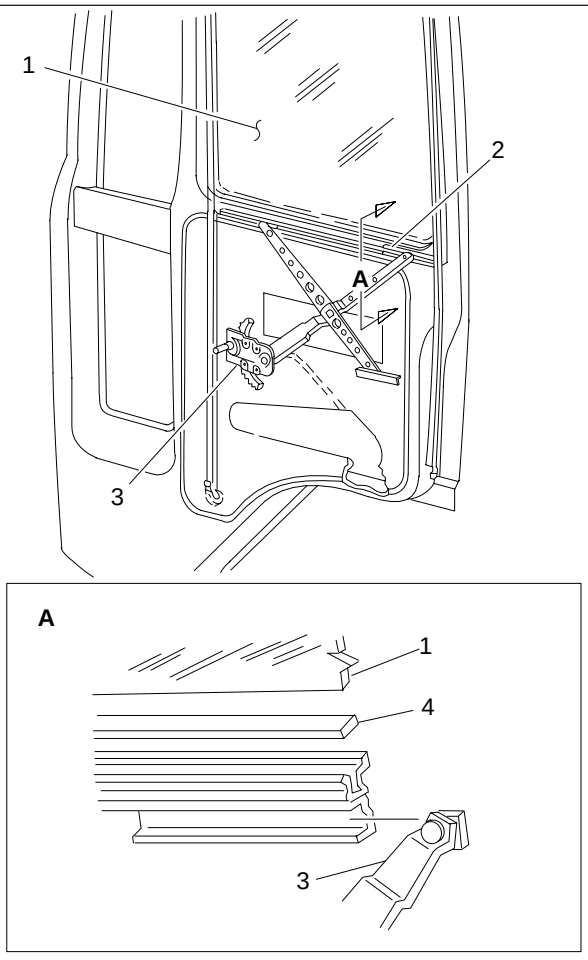
1. Door Window Regulator Assembly (right-hand shown)
2. Window Regulator Handle
3. Screw
4. Window Regulator Handle Cover
5. Bolt
6. Door Trim Panel
7. Door Inner Panel
8. Window Regulator Guide
9. Nut and Washer

Fig. 2, Door Window Regulator and Handle Assembly

Manual Window Regulator Replacement

required to operate the windows. To lubricate the door window mechanism, apply an even coating of multi-purpose grease to the window regulator rollers, shafts, and the entire length of the roller guides. See **Fig. 3**.

5. Install the new regulator assembly through the door panel opening.



12/02/97 f670036

A. Door Window Regulator Assembly
1. Door Window Glass
2. Door Glass Channel (right-hand shown)
3. Door Window Regulator Assembly (right-hand shown)
4. Tape

Fig. 3, Window Regulator and Glass Channel

6. Install the fixed-run, and the two fixed-run mounting nuts.

NOTE: When installing the window regulator handle, it should point vertically downward when the window is in the fully raised position.

7. Install the regulator assembly on the internal door panel and replace the four screws. Install the handle.
8. Install the door trim panel and the watershield.

Replacement (See Fig. 1)

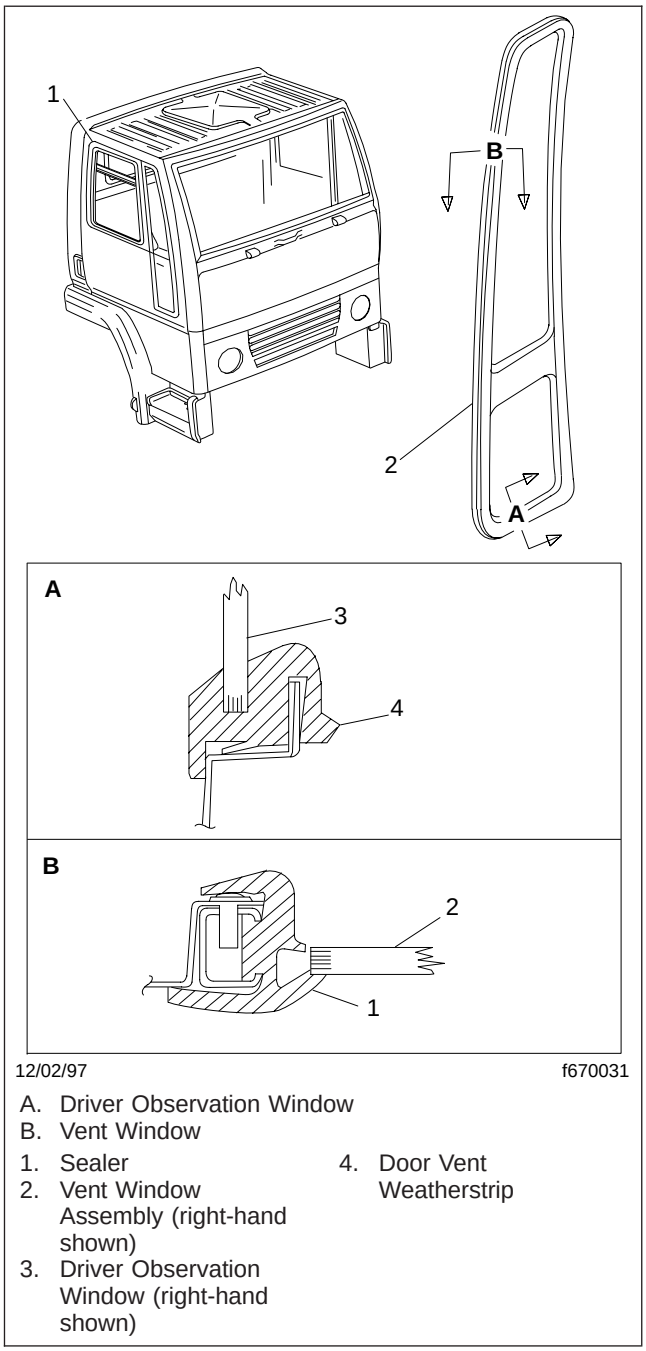
CAUTION

Use care when removing the laminated windshield. The windshield can crack during removal. If necessary, cut the weatherstrip front lip in order to make removal easier.

1. From inside the cab, push the internal weatherstrip lip out of the opening flange using an appropriate tool.
2. Remove the weatherstrip with the window.
3. Clean the opening flange, removing all traces of sealing compound.
4. Check the weatherstrip for damage. If not damaged, install it on the new window glass. Insert a cord into the weatherstrip mounting slot so that the cord ends join at the bottom center of the weatherstrip and overlap each other by about 6 inches (150 mm). Apply small adhesive tape strips on the weatherstrip and window glass on both sides to retain the weatherstrip on the window glass.
5. Apply liquid sealer on the weatherstrip recess for the window.
6. Apply a soapy solution on the weatherstrip flange.
7. Place the window and weatherstrip in the body opening from the outside. Make sure the cord ends are inside the cab. Push in firmly on the bottom of the window from outside the cab.
8. Make sure the window and the weatherstrip are correctly positioned in the lower end of the opening.
9. Carefully pull one end of the cord to start the weatherstrip over the opening flange.

NOTE: Pull the cord at a 90-degree angle from the opening flange, parallel to the window surface. See **Fig. 2**.

10. Continue pulling the cord until it reaches the upper corner of the opening. Remove the adhesive tape strips if used, one by one, immediately before the weatherstrip is placed over the flange.



12/02/97 f670031

A. Driver Observation Window
B. Vent Window

1. Sealer
2. Vent Window Assembly (right-hand shown)
3. Driver Observation Window (right-hand shown)
4. Door Vent Weatherstrip

Fig. 1, Fixed Glass Window

11. Repeat the operation with the other cord end until it reaches the opposite top corner. See **Fig. 3**.
12. Make sure the window and weatherstrip are in the correct position.

Fixed Glass Window Replacement

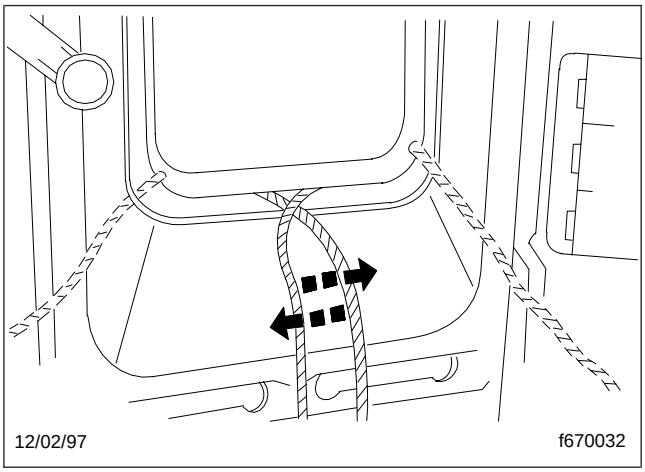


Fig. 2, Weatherstrip Installation

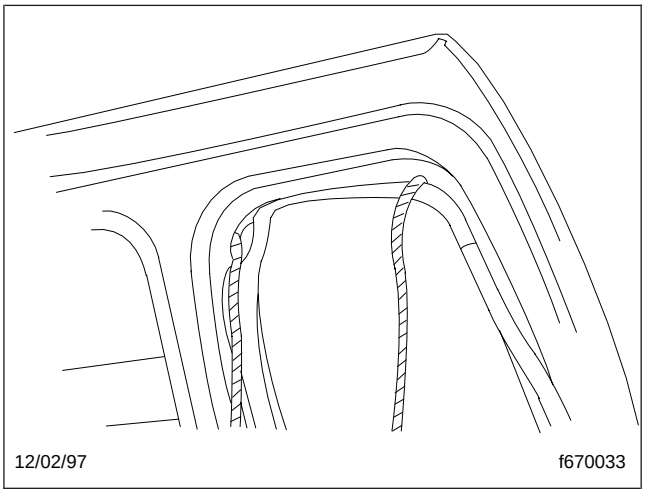
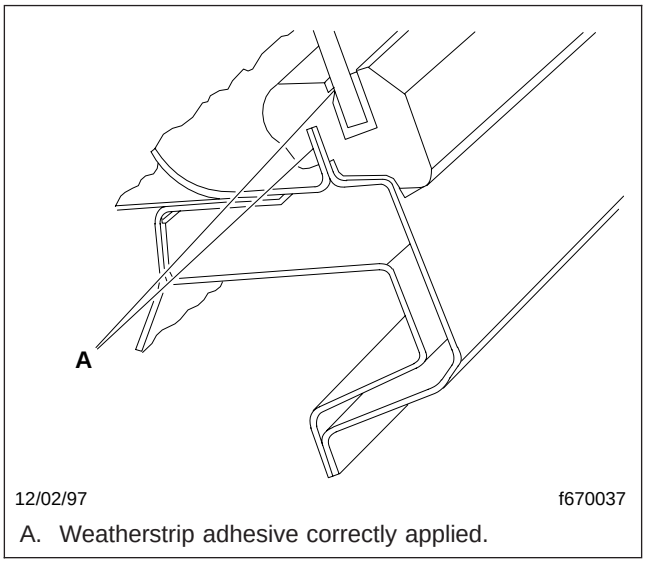


Fig. 3, Window and Weatherstrip Positioning

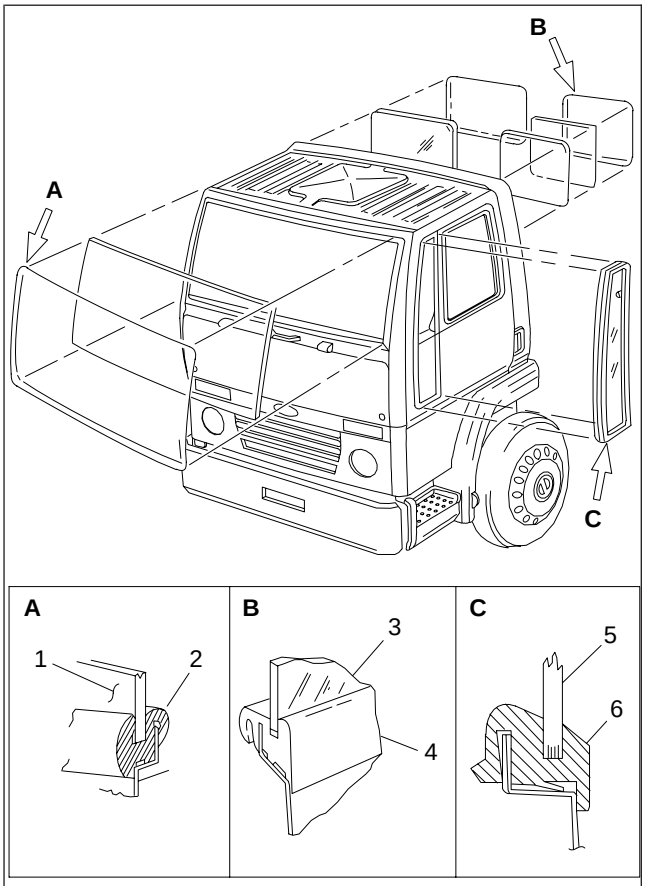
13. Hold the cord end horizontally, pulling it along the upper part of the window and weatherstrip assembly until it reaches the center point. Repeat the operation with the other end of the cord. Remove the cord.
14. Apply weatherstrip adhesive into the groove between the weatherstrip and the body. See **Fig. 4** and **Fig. 5**.
15. Remove excess adhesive.
16. Apply the urethane to seal against all air and water leaks.

NOTE: Allow all glass parts installed with urethane ample time to cure.



A. Weatherstrip adhesive correctly applied.

Fig. 4, Sealing Compound Application



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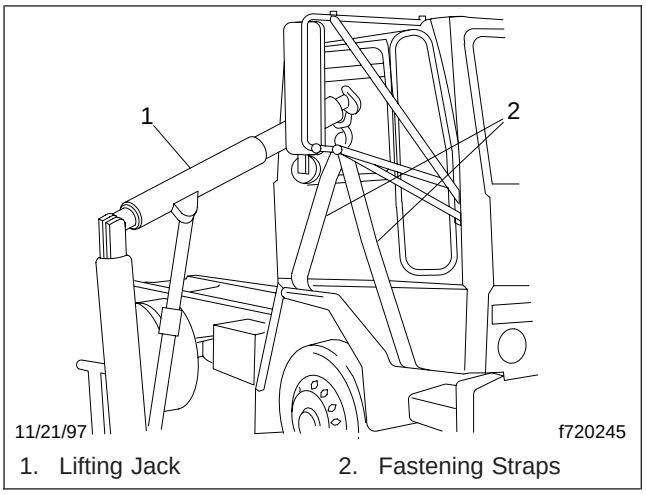
A. View of windshield glass weatherstripping.
B. View of back window glass weatherstripping.
C. View of observation window weatherstripping.

1. Windshield Glass
2. Windshield Weatherstrip
3. Back Window Glass
4. Back Window Glass Weatherstrip
5. Driver Observation Window Glass
6. Driver Observation Window Weatherstrip

Fig. 5, Weatherstripping

Removal (See Fig. 1)

1. Lower the door window.



1. Lifting Jack
2. Fastening Straps

Fig. 1, Lifting Jack and Fastening Straps

2. Remove the screws retaining the outside rear-view mirror. Remove the mirror assembly.
3. Support the door using a lifting jack and fastening straps as shown.
4. Remove the door check arm, the three Torx® head screws and the one hexhead screw from the door. See **Fig. 2**.
5. If the same door is to be installed, mark the hinge position prior to removal.
6. Remove the bolts from the hinges, then remove the door. See **Fig. 3**.

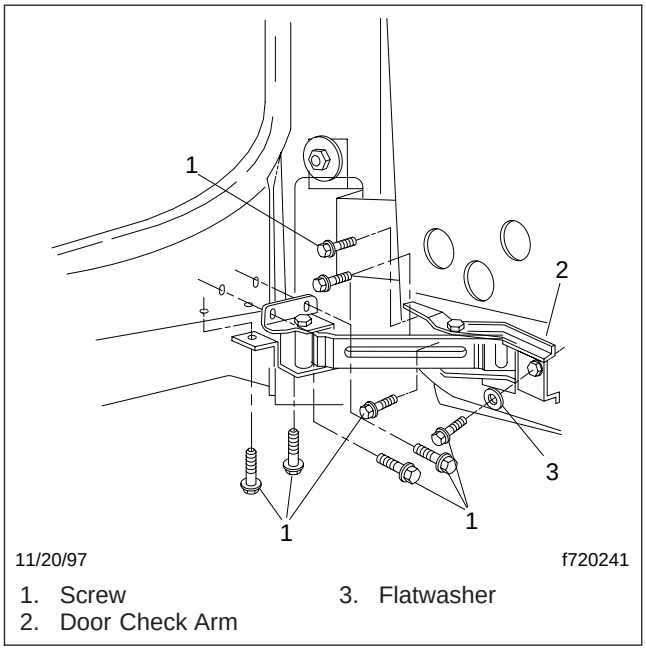
Installation

1. Position the door on the cab and align the hinges.

NOTE: If the original door is being installed, align the hinges with the marks made during removal. Tighten the bolts 12 to 17 lbf·ft (16 to 23 N·m).

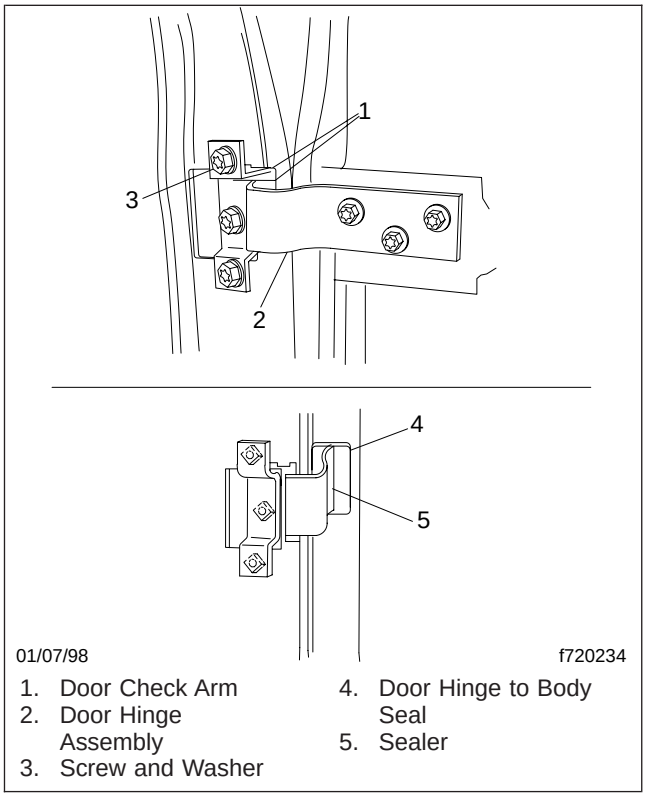
2. Install the bolts retaining the hinges to the door pillar. Do not tighten.

NOTE: In some cases it is necessary to adjust the bolts retaining the hinges to the door. Bolts



1. Screw
2. Door Check Arm
3. Flatwasher

Fig. 2, Door Check Arm



1. Door Check Arm
2. Door Hinge Assembly
3. Screw and Washer
4. Door Hinge to Body Seal
5. Sealer

Fig. 3, Retaining Bolts and Hinges

Door Removal and Installation

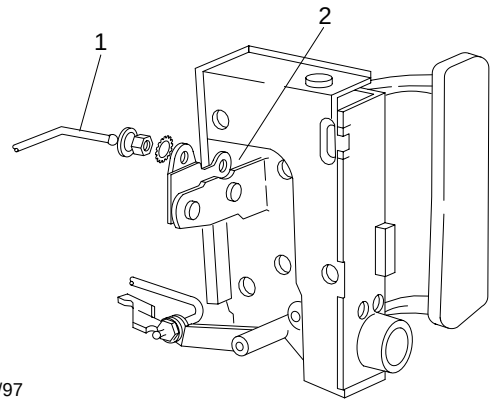
can be adjusted after removing the door panel. Refer to **Subject 110**.

3. After the door is in the desired position, tighten the retaining bolts 12 to 17 lbf·ft (16 to 23 N·m).
4. Remove the door fastening straps.
5. Install the door check arm and lubricate with multi-purpose grease spray. See **Fig. 3**.
6. Install and adjust the outside rearview mirror. Tighten the bolts 10 to 12 lbf·ft (14 to 16 N·m).

Door Latch Removal and Installation

Removal

1. Remove the door trim panel.
2. From inside the door, disconnect the remote control rods and the internal locking mechanism. See **Fig. 1**.



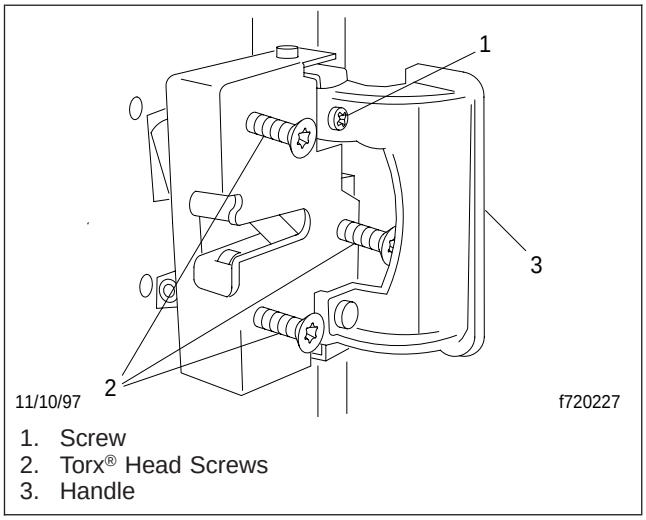
1. Remote Control Rods
2. Locking Mechanism

Fig. 1, Remote Control Rods and Locking Mechanism

3. Remove the three Torx® head screws retaining the lock assembly to the door.
4. Remove the door lock assembly.
5. Remove the two screws and remove the handle if required. See **Fig. 2**.

Installation

1. Check the condition of the lock assembly.
2. Install the lock on the door and tighten the three retaining Torx® head screws 22 to 27 lbf·in (250 to 300 N·cm).
3. From the inside of the door, connect the remote control rods to the locking mechanism. Make sure the rods are not interfering with any guides or insulators.
4. Check the door trim panel retaining the clips and replace, if necessary.
5. Install the door trim panel.
6. When replacing the handle, apply a rust preventative compound from the attaching area of the handle to the latch. Install the screws using Loctite® 245 precoating. Tighten the screws 22 to 27 lbf·in (250 to 300 N·cm).



1. Screw
2. Torx® Head Screws
3. Handle

Fig. 2, Door Latch

Door Lock Removal and Installation

Removal

1. Remove the screw from the side of the lock control knob and remove the knob.
2. Remove the two screws and the nameplate.
3. Remove the front door trim panel.
4. Unsnap the clip attaching the front door lock actuating rod to the front door latch.
5. Remove the two screws, the door latch lock shaft, the guide, and the front door lock actuating rod from the door.
6. Remove the actuating rod from the door latch lock shaft.
7. Remove the guide from the door latch lock shaft.

Installation

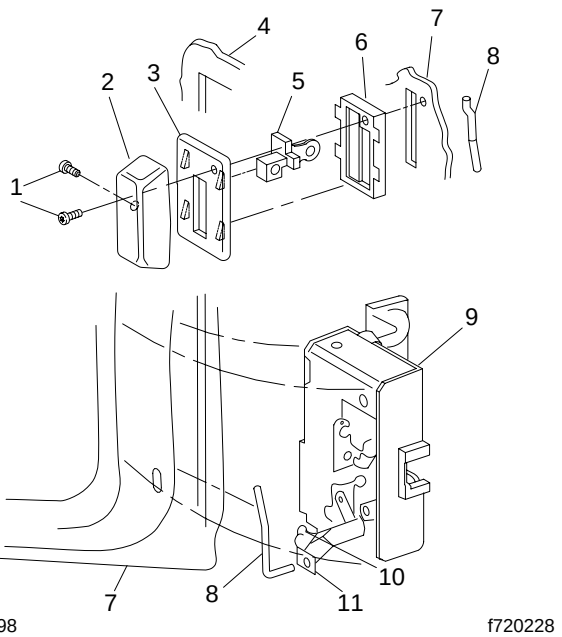
1. Install the guide on the door latch lock shaft.
2. Replace the actuating rod on the door latch lock shaft.
3. Install the front door lock, the guide, and the door latch lock shaft, and replace the two screws.
4. Attach the front door lock actuating rod to the front door latch.
5. Install the front door trim panel.
6. Install the two screws and the nameplate.
7. Attach the knob, and install the screw to the side of the lock control.

Lock Cylinder Removal and Installation

Removal (See Fig. 1)

NOTE: When a lock cylinder is replaced, both the door lock cylinders and the ignition lock cylinder should be replaced in a set. This will prevent the need to carry an extra key that will fit only one lock. If a key is to be replaced, the new key code number is stamped on a metal tag attached to the key.

1. Roll up the window.



1. Screw
2. Door Lock Control Knob
3. Door Inner Trim Panel
4. Door Trim Panel
5. Door Latch Lock Shaft
6. Guide
7. Door
8. Door Lock Actuating Rod
9. Door Latch
10. Clip
11. Door Latch Bushing

Fig. 1, Door Lock Cylinders

2. Remove the access hole cover and/or trim panel and pull away the water shield (if so equipped).
3. Disconnect the lock actuating rod from the lock control link clip.
4. Slide the lock cylinder retainer away from the lock cylinder.
5. Remove the lock cylinder.

Installation

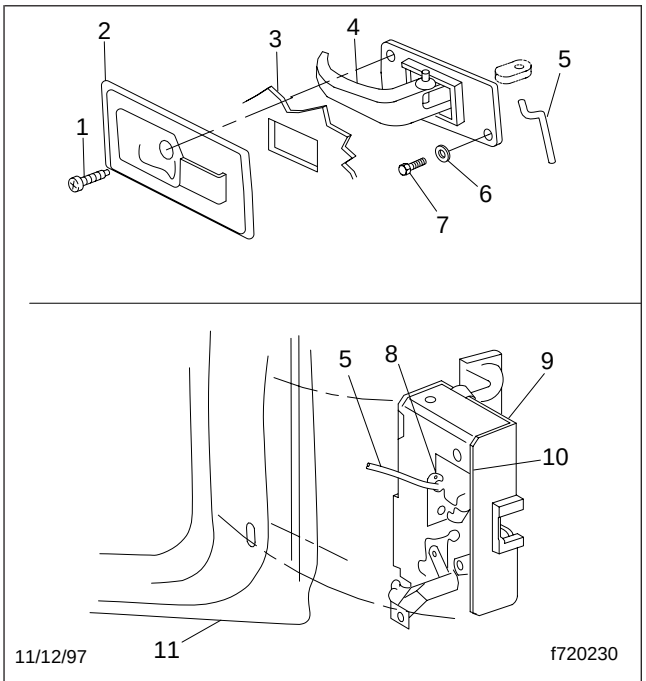
NOTE: Use weatherstrip adhesive to attach the watershield.

1. Install the lock cylinder. See **Fig. 1**.
2. Attach the lock cylinder retainer.
3. Connect the lock actuating rod to the lock control link clip.
4. Install the access hole cover and/or trim panel and the water shield (if so equipped).

Inside and Outside Door Handle Removal and Installation

Removal (See Fig. 1)

1. Remove the inside door handle.
   1.1 Remove the nameplate and the door trim panel.



1. Screw
2. Door Inside Handle Bezel
3. Door Trim Panel
4. Inside Door Handle
5. Door Latch Remote Control Link
6. Washer
7. Bolt
8. Clip
9. Door Lock
10. Door Latch Bushing
11. Door

Fig. 1, Inside Door Handle Assembly

   1.2 Unsnap the clip attaching to the door latch and disconnect the door latch remote control link.
   1.3 Remove the two screws, the door handle assembly and the door latch remote control link.
   1.4 Remove the door handle from the door latch remote control link.
2. Remove the outside door handle
   2.1 Open the door.
   2.2 Remove the two screws and the handle.

Installation

1. Install the inside door handle. See **Fig. 1**.
   1.1 Attach the door latch remote control link, and install the door handle assembly using the two screws. For torque values, refer to **Specifications 400**.
   1.2 Connect the door latch remote control link, and snap the clip to the door latch.
   1.3 Attach the door panel and the nameplate.
2. Install the outside door handle.
   2.1 Position the outside door handle on the door.
   2.2 Install the screws, and tighten them 22 to 27 lbf·in (250 to 300 N·cm).

Specifications

Rearview Mirror and Door Hinge Torque Specifications		
Description	**lbf·ft**	**N·m**
Rearview Mirror Retaining Bolts	10–12	14–16
Door Hinge Bolts	12–17	16–23

Table 1, Rearview Mirror and Door Hinge Torque Specifications

Elbow Pad and Arm Rest Torque Specifications		
Description	**lbf·in**	**N·cm**
Screw, Armrest to Elbow Pad	9–18	101–203
Screw, Armrest to Door Panel	33–41	373–463

Table 2, Elbow Pad and Arm Rest Torque Specifications

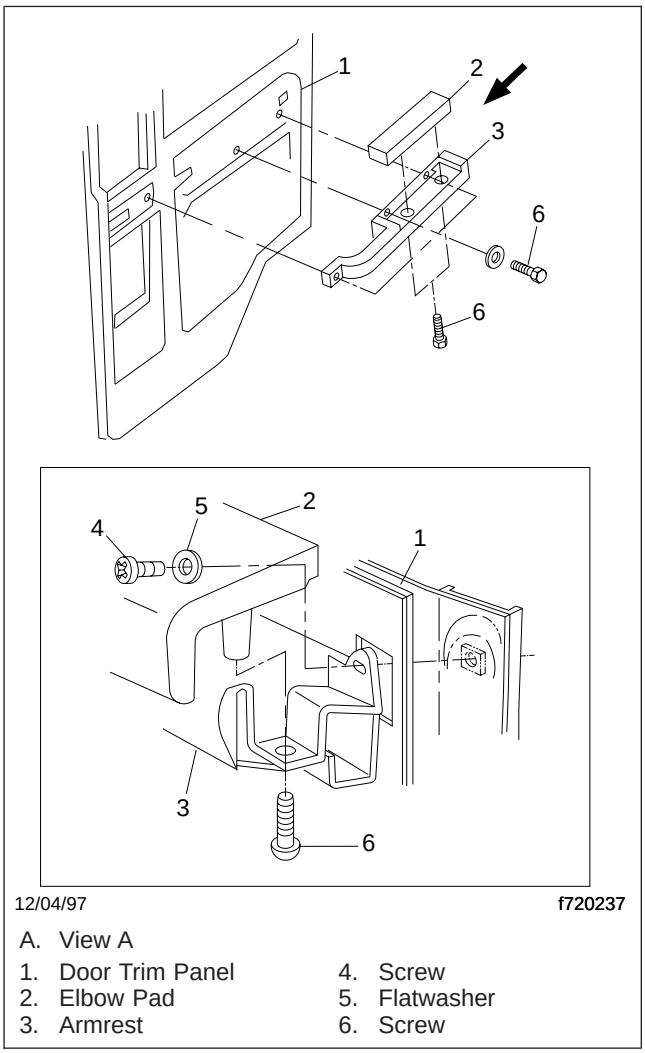
Door Lock and Door Latch Torque Specifications				
Description	**lbf·ft**	**N·m**	**lbf·in**	**N·cm**
Door Lock and Handle Attaching Screws	—	—	22–27	249–305
Door Latch Striker Pin to Anchor Plate	30–40	41–54	—	—

Table 3, Door Lock and Door Latch Torque Specifications

Front Door Trim Panels Removal and Installation

Removal

1. Open the door.
2. Remove the armrest elbow pad retaining screws and the elbow pad. See **Fig. 1**.

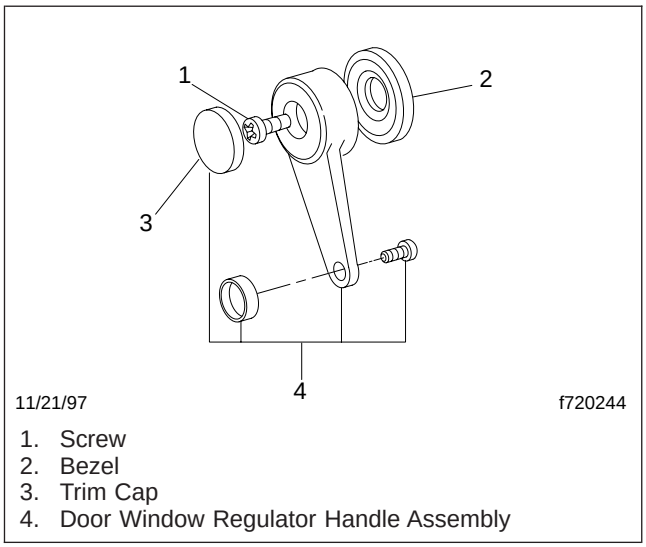


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A. View A
1. Door Trim Panel
2. Elbow Pad
3. Armrest
4. Screw
5. Flatwasher
6. Screw

Fig. 1, Elbow Pad Installation

3. Remove the armrest attaching screws and the armrest.
4. Remove the window regulator handle trim cap and retaining screw. Remove the window regulator handle by pulling it away from the door. See **Fig. 2**.

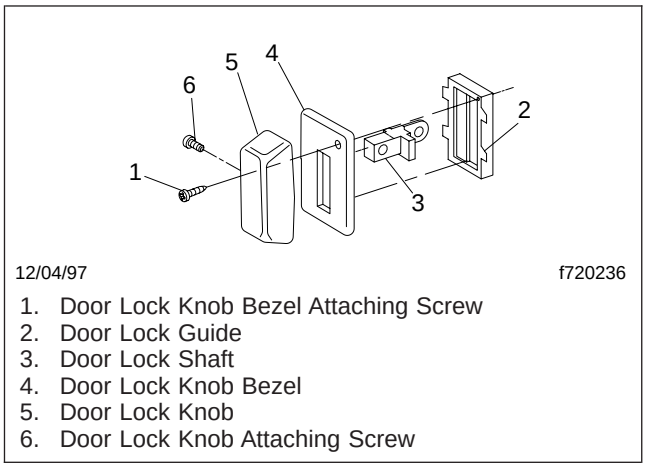


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1. Screw
2. Bezel
3. Trim Cap
4. Door Window Regulator Handle Assembly

Fig. 2, Window Regulator Handle Installation

5. Remove the door lock knob and the bezel retaining screws. Remove the knob and bezel. See **Fig. 3**.



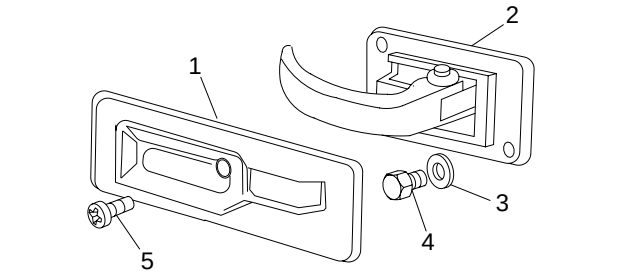
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1. Door Lock Knob Bezel Attaching Screw
2. Door Lock Guide
3. Door Lock Shaft
4. Door Lock Knob Bezel
5. Door Lock Knob
6. Door Lock Knob Attaching Screw

Fig. 3, Door Lock Knob Installation

6. Pull the door inside handle out to expose the door inside handle bezel retaining screw. Remove the screw and bezel. See **Fig. 4**.
7. Remove the door trim panel pocket upper retaining screws.
8. Remove the trim panels using Kent-Moore trim removal kit J38778, or fabricate a door trim removal tool from 0.16-inch (4-mm) thick mild

Front Door Trim Panels Removal and Installation

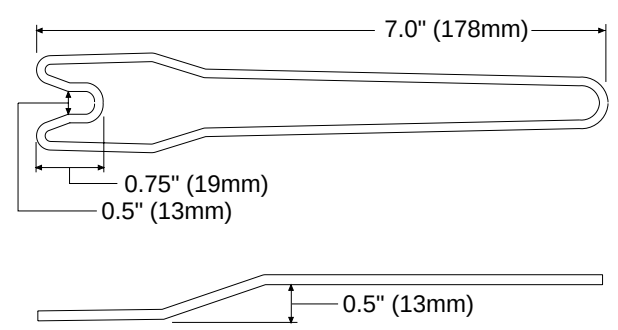


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1. Door Inside Handle Bezel
2. Door Inside Handle
3. Washer
4. Bolt
5. Screw

Fig. 4, Door Handle Bezel Installation

steel. See **Fig. 5**. To order Kent-Moore tools, see **Specification, 400**.



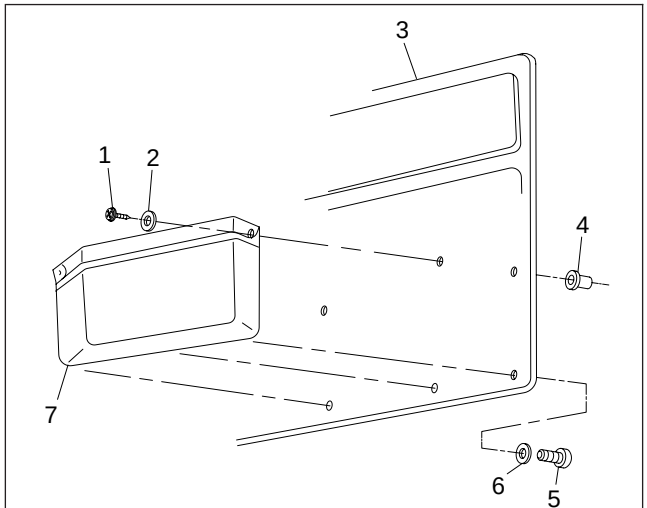
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Fig. 5, Door Trim Panel Removal Tool (Kent-Moore J38778)

9. Using the door trim panel removal tool, release the door trim panel retaining clips and remove the door trim panel.
10. Remove the door trim panel pocket lower retaining screws and washers from the back of the door trim panel. Remove the pocket from the panel. See **Fig. 6**.
11. Remove the watershield from door.

Installation

1. Install the watershield on the adhesive tape on the door. See **Fig. 7**.



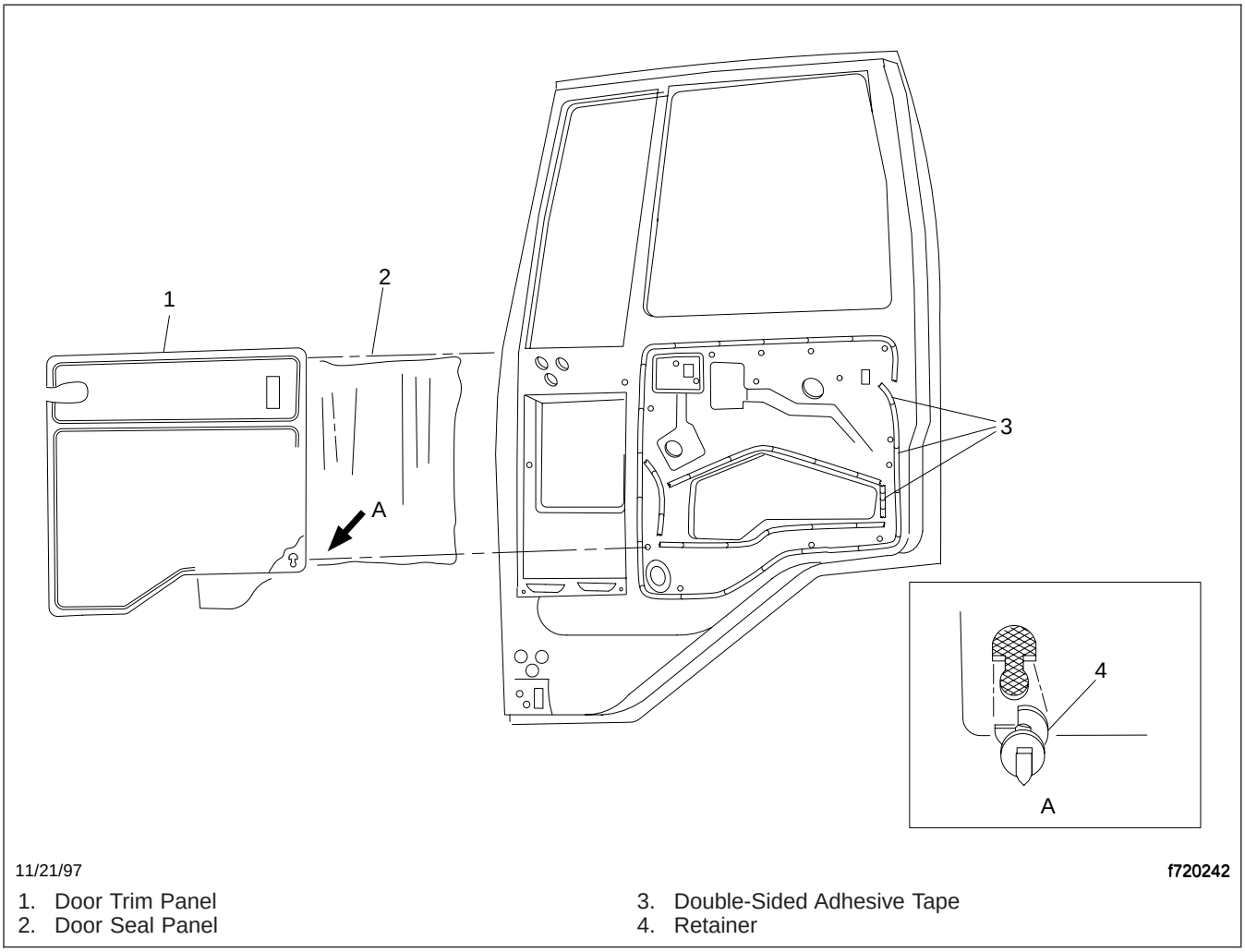
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1. Screw
2. Washer
3. Door Trim Panel
4. Blind Anchor
5. Screw
6. Washer
7. Door Panel Pocket

Fig. 6, Door Panel Pocket Installation

2. Place the door trim panel pocket on the door trim panel. Install the lower retaining screws and washers.
3. Replace any broken clips and install the door trim panel by pressing into place.
4. Install the door trim panel pocket upper retaining screws.
5. Install the door inside handle bezel and retaining screw.
6. Install the door lock knob and bezel and retaining screws.
7. Install the window regulator handle, retaining screw and trim cap.
8. Install the armrest and retaining screws. Tighten screws 33 to 41 lbf·in (380 to 460 N·cm).
9. Install the armrest elbow pad and retaining screws. Tighten the screws 9 to 18 lbf·in (100 to 200 N·m).

Front Door Trim Panels Removal and Installation

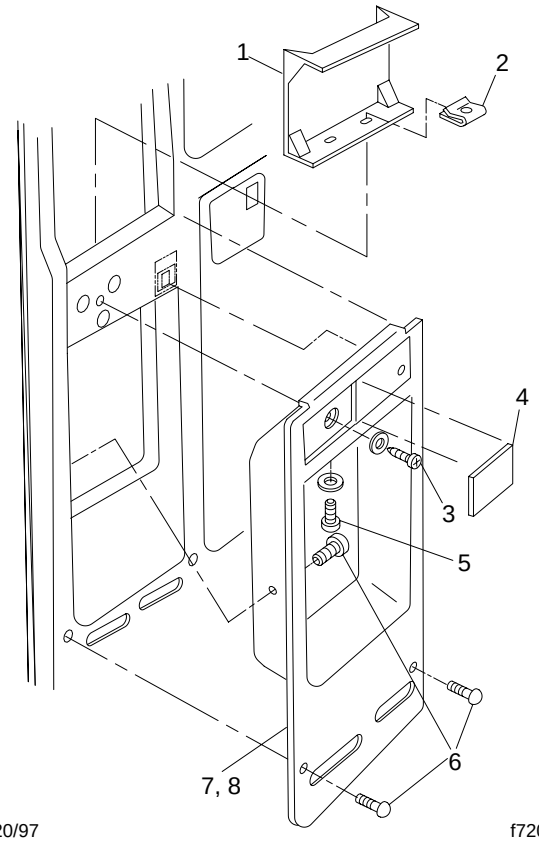


1. Door Trim Panel
2. Door Seal Panel
3. Double-Sided Adhesive Tape
4. Retainer

Fig. 7, Lower Panel Installation

Door Lower Finish Panel Removal and Installation

Removal (See Fig. 1)



1. Door Trim Lower Finish Panel
2. U-Type Spring Nut
3. Screw
4. Door Lower Finish Panel Access Cover
5. Screw
6. Headliner Retainer
7. Door Trim Finish Lower Panel

Fig. 1, Door Trim Finish Lower Panel Installation

1. Open door.
2. Remove front armrest retaining screw.
3. Remove door lower finish panel access cover and remove screw and washer underneath it.
4. Remove nameplate retaining screw and washer.
5. Remove three push-in fasteners, release nameplate from door lower finish panel and remove finish panel. If necessary, slide nameplate from behind door reinforcement bar.

Installation

1. Install three push-in fasteners, connect nameplate to door lower finish panel, and install finish panel.
2. Install nameplate retaining screw and washer.
3. Install door lower finish panel access cover and install screw and washer underneath it.
4. Install front armrest retaining screw.
5. Close door.

Specifications

Torque Specifications		
Fastener Description	**lbf·in**	**N·cm**
Armrest-to-Elbow Pad Screw	9–18	100–200
Armrest-to-Door Panel Screw	33–41	380–460

Table 1, Torque Specifications

To order Kent-Moore tools, call 1–800–328–6657, or write:

Kent-Moore Tool Division
655 Eisenhower Drive
Owatonna, MN 55060

Inspection and Verification

1. Verify the customer concern by operating the wiper and washer systems.
2. Visually inspect the system components. See **Table 1**.

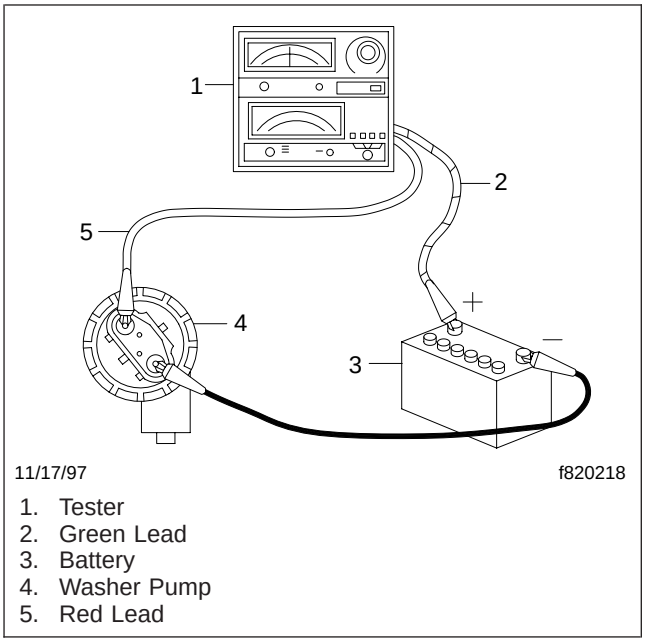
Visual Inspection Chart	
Mechanical	**Electrical**
Binding wiper pivot arms Damaged wiper motors Wiper mounting arm and pivot shaft improperly connected to wiper motor Low washer fluid level Plugged or damaged washer hoses and/or nozzle jet	Blown fuse: 10A Washer Loose or corroded connectors

Table 1, Visual Inspection Chart

3. Check the windshield wiper pivot arms for proper adjustment and proper connection to the windshield wiper motor output arm.
4. Check the washer hoses for proper routing and connections.
5. Inspect the wiper or washer system wiring harnesses and connectors for obvious signs of damage.
6. If the fault can't be seen, determine the symptom and proceed to the symptom chart in **Subject 300**.

Current Draw—Windshield Washer Pump

Attach the leads of the tester as shown in **Fig. 1**. The current draw should not exceed 4 amps or be less than 1.7 amps while the washer pump is pumping fluid.



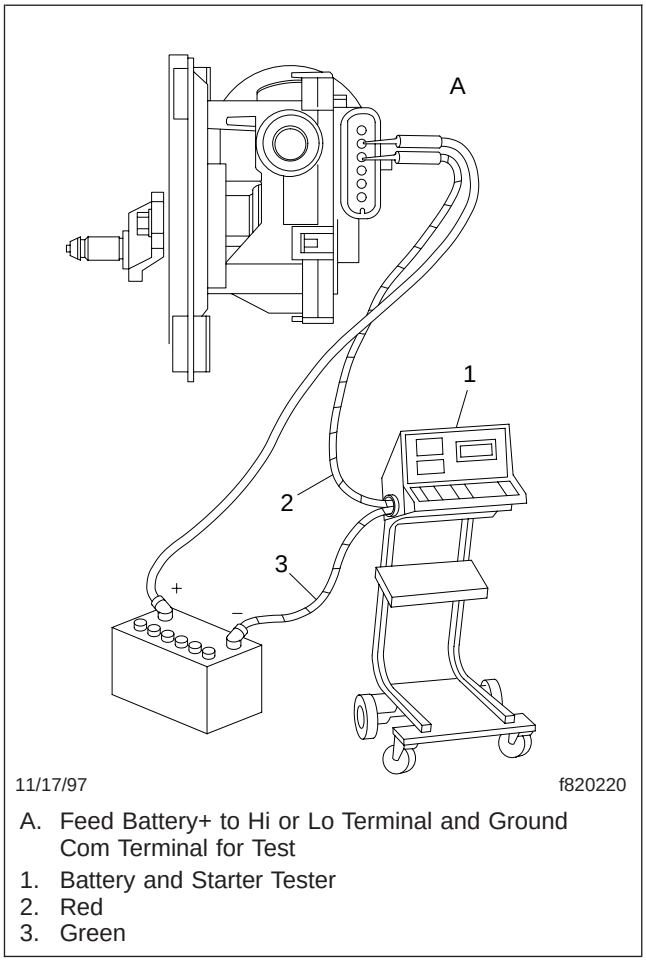
1. Tester
2. Green Lead
3. Battery
4. Washer Pump
5. Red Lead

Fig. 1, Windshield Washer Pump Test

Current Draw—Windshield Wiper Motor (See Fig. 2)

To measure wiper motor current draw on vehicle, proceed as follows.

1. Disconnect the windshield wiper mounting arm and pivot shaft motor.
2. Disconnect the wiring at the wiper motor.
3. Connect the green lead from the tester to the battery negative terminal.
4. Connect the tester red lead to the motor common brush terminal.
5. To measure low-speed current draw, connect the jumper wire from the battery positive terminal to the low-speed brush terminal. The motor should operate and current draw should not exceed 3.5 amperes.
6. To measure high-speed current draw, move the jumper wire to the high-speed brush terminal. Current draw should not exceed 5.5 amperes.



A. Feed Battery+ to Hi or Lo Terminal and Ground Com Terminal for Test
1. Battery and Starter Tester
2. Red
3. Green

Fig. 2, Windshield Wiper Motor Test

Windshield Wiper Mounting Arm and Pivot Shaft Removal and Installation

Removal

1. Disconnect the battery ground cable.
2. Remove the cover from the wiper arm assembly.
3. Remove the nut, washer, and wiper arm/blade from the pivot shaft.
4. Remove the nut, washer, and spacer securing each pivot shaft housing.
5. Disconnect the wiring at the wiper motor.
6. Remove the windshield wiper bracket attaching screws, lockwashers, washers, and (if replacement is required) captive nuts.
7. Remove the wiper motor and bracket assembly from the dash panel.
8. Remove the three linkage clips from the wiper linkage arm. Remove the linkage arm from the pivot shaft mechanisms and control arm.
9. Remove the nut and washer from the wiper motor drive shaft. Remove the control arm from the shaft.
10. Remove the screw/washer assemblies and washers that attach the wiper motor to the bracket assembly.

Installation

1. Install the screw/washer assemblies and washers that attach the wiper motor to the bracket assembly.
2. Install the nut and washer on the wiper motor drive shaft. Install the control arm on the shaft.
3. Install the three linkage clips on the wiper linkage arm. Install the linkage arm on the pivot shaft mechanisms and control arm.
4. Install the wiper motor and bracket assembly on the dash panel.
5. Install the windshield wiper bracket attaching screws, lockwashers, washers, and (if replacement is required) captive nuts.
6. Connect the wiring at the wiper motor.
7. Install the nut, washer, and spacer securing each pivot shaft housing.
8. Install the nut, washer, and wiper arm/blade on the pivot shaft. Tighten the wiper-to-arm retaining screw and nut 6 to 9 lbf·in (60 to 100 N·cm).
9. Install the cover from the wiper arm assembly.
10. Connect the battery ground cable.

Washer Pump and Seal Assembly Removal and Installation

Removal

1. Remove the reservoir assembly from the vehicle. For instruction, see **Subject 140**. Disconnect the electrical plug and hose.
2. Using a small-bladed screwdriver, pry out the retaining ring.
3. Using pliers to grip one wall around the electrical terminals, pull out the motor, seal, and impeller assembly. If the impeller and seal come off when the motor is pulled, they can be reassembled. Make certain the reservoir pump chamber is free of foreign material prior to installing the old assembly in the new reservoir.

Installation

1. Before installing the assembly, lubricate the outside diameter of the seal with a dry lubricant such as powdered graphite. This will prevent the seal from sticking to the wall of the reservoir motor cavity and make assembly easier.
2. Align the small projection on the motor end cap with the slot in the reservoir and assemble it so that the seal seats against the bottom of the motor cavity.
3. Using a 1-inch (25-mm) socket (preferably 12-point), hand-press the retaining ring securely against the motor end plate.
4. Connect the electrical plug and hose and replace the reservoir assembly in the vehicle. For instructions, see **Subject 140**.

WARNING

Do not use engine coolant or antifreeze in the washer reservoirs. Engine coolant or antifreeze in the washer reservoir can severely reduce visibility when sprayed on the windshield, possibly resulting in personal injury or property damage.

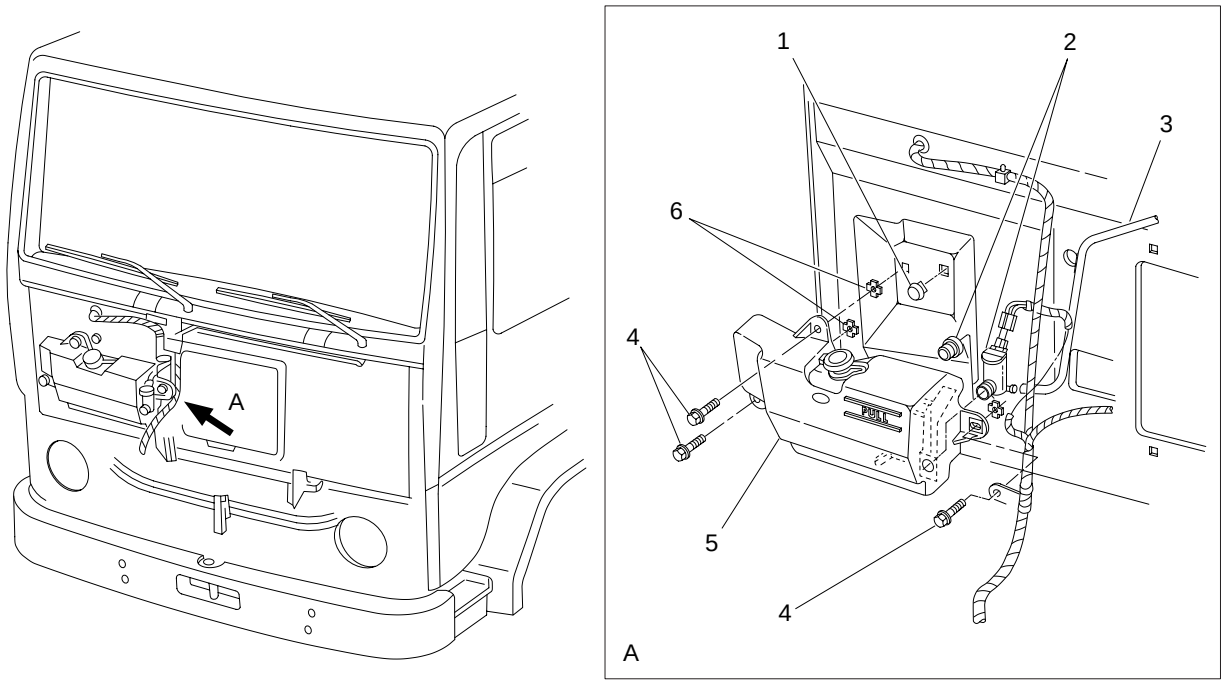
CAUTION

Do not operate the pump until fluid is added to the reservoir. Operating the pump with the reservoir empty can damage the pump.

5. Fill the reservoir and operate the washer system.
6. Check for leaks.

Washer Pump and Reservoir Removal and Installation

Removal (See Fig. 1)



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1. Plug Button
2. Windshield Washer Pump
3. Windshield Washer Hose Assembly
4. Screw and Washer
5. Windshield Washer Reservoir
6. Reservoir Mounting Nut

Fig. 1, Washer Reservoir and Pump

1. Drain the reservoir and remove the washer pump electrical connector.
2. Remove the hose from the washer pump and remove the pump and grommet from the reservoir.
3. Remove the retaining screws and washers, and remove the reservoir.
4. Remove the straps and clips, then remove the feed lines to the wet arms wiper assembly.

Installation

1. Install the straps and clips, then install the feed lines to the wet arms wiper assembly.
2. Install the retaining screws and washers, and install the reservoir. Tighten the reservoir retaining screws 75 to 93 lbf·in (840 to 1060 N·cm). Replace the straps and slips, if necessary.
3. Install the hose from the washer pump and install the pump and grommet from the reservoir.

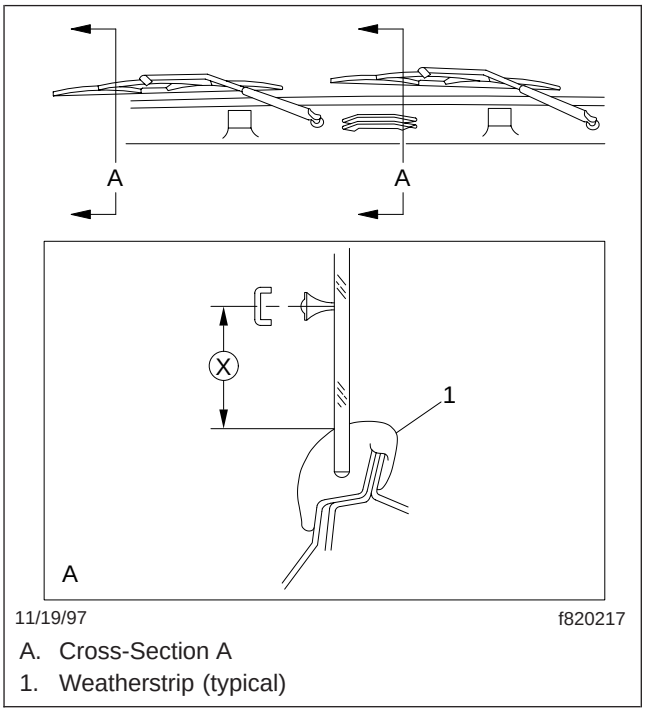
CAUTION

Do not operate the pump until fluid is added to the reservoir. Operating the pump with the reservoir empty can damage the pump.

4. Fill the reservoir and install the washer pump electrical connector.

Adjustment

PARK POSITION (See Fig. 1)



A. Cross-Section A
1. Weatherstrip (typical)

Fig. 1, Wiper Arm and Blade Adjustment

Remove the arm and blade assemblies from the pivot shafts. Turn on the wiper switch, allow the motor to move the pivot shafts three or four cycles, and then turn off the wiper switch. This will place the pivot shafts in PARK position.

Install the arm and blade assemblies on the pivot shafts to dimension X (2 inches [50 mm]). Dimension X is the distance between the centerline of the blade saddle and the windshield lower moulding of weatherstrip. The dimension X distance must be maintained regardless of the level of the arm fastening.

Troubleshooting

Symptom Chart		
Condition	**Possible Source**	**Action**
• Windshield Washer Inoperative.	• Low fluid level. • Split, loose, pinched or kinked window washer hose. • Open in wiring or windshield wiper/washer switch. • Windshield washer pump.	• See **Table 2**.
• Windshield Wipers Inoperative—All Control Switch Positions.	• Windshield wiper/washer switch. • Bent or damaged windshield wiper mounting arm and pivot shaft. • Windshield wiper motor. • Open wire or connector.	• See **Table 3**.
• Windshield Wiper Inoperative at High Speed.	• Windshield wiper motor. • Windshield wiper/washer switch. • Damaged circuitry.	• See **Table 4**.
• Windshield Wipers Inoperative at Low Speed.	• Windshield wiper/washer switch. • Windshield wiper motor. • Open wiring. • Damaged central timing module. • Inoperative wiper relay.	• See **Table 5**.
• Windshield Wipers Inoperative at Interval Setting.	• Windshield wiper motor. • Windshield wiper/washer switch. • Wiring. •Central timer module. •Wiper relay.	• See **Table 6**.
• Windshield Wipers Will Not Park at Proper Position.	• Damaged windshield wiper motor. • Damaged circuitry. • Damaged central timer module. • Damaged windshield wiper/washer switch. • Damaged wiper relay.	• See **Table 7**.

Troubleshooting

Symptom Chart		
Condition	**Possible Source**	**Action**
• Windshield Wipers Continue to Run When Switch is Turned OFF.	• Damaged windshield wiper motor. • Damaged circuitry. • Damaged switch. • Damaged central timer module. • Damaged wiper relay.	• See **Table 8**.

Table 1, Symptom Chart

Test A: Windshield Washer Inoperative		
Test Step	**Result**	**Action to Take**
Step A1, Check Fluid Level. Check the fluid level of the washer. Is the fluid level adequate?	Yes	Go to Step A2.
	No	Fill the washer reservoir and Check operation of the washers.
Step A2, Isolate the Pump. Turn the key to RUN. Press the windshield washer button. Does the washer pump operate?	Yes	Go to Step A3.
	No	Go to Step A5.
Step A3, Check the Pump Outlet. Inspect the washer pump outlet for blockage. Is the outlet blocked?	Yes	Remove and clean the washer pump.
	No	Go to Step A4.
Step A4, Check the Washer Jet and Hose. Inspect the washer jet for blockage. Inspect the washer hose for blockage or kinks. Is the jet or hose obstructed?	Yes	Clean or replace the washer jet or washer hose.
	No	Return to Step A1.
Step A5, Circuit Protection. Check Fuse 14 (10A). Is the fuse blown?	Yes	Replace the fuse.
	No	Go to Step A6.
Step A6, Check for Power at the Washer Pump. Disconnect the wiring at the washer pump. Turn the key to RUN. With the washer button pressed, check for voltage at pump connector C110 terminal 941 (BK/W). Is voltage present?	Yes	Go to Step A7.
	No	Go to Step A8.
Step A7, Check the Pump Ground Circuit. Check for continuity between the washer pump connector C110 terminal 57 (BK) and clean chassis ground. Is there continuity?	Yes	Replace the washer pump.
	No	Service the ground circuit.
Step A8, Check the Power Feed from the Washer Switch. Turn the key to RUN. Press and hold the washer button. At the switch, check terminal 7 for voltage—Pump feed Circuit 941 (BK/W). Is voltage present?	Yes	Service the open in Circuit 941 (BK/W).
	No	Go to Step A9.

Test A: Windshield Washer Inoperative		
Test Step	**Result**	**Action to Take**
Step A9, Check the Power Feed to the Washer Switch. Turn the key to run. At the wiper/washer switch connector C201, check terminal 10 for voltage—Feed Circuit 941 (BK/W) to washer switch. Is voltage present?	Yes	Replace the washer switch.
	No	Service the open in Circuit 941 (BK/W).

Table 2, Test A: Windshield Washer Inoperative

Test B: Windshield Wipers Inoperative—All Control Switch Positions		
Test Step	**Result**	**Action to Take**
Step B1, Wiper Motor Ground Circuits. With the key off, check for continuity between the wiper motor connector C 165 Circuit 57 (BK) and a clean chassis ground. Is there continuity?	Yes	Go to Step B2.
	No	Service the ground circuit(s).
Step B2, Wiper Motor Speed Input Circuits. Turn the key to RUN. With the wiper switch in the LO and HI positions, test for voltage at the wiper motor C165 Circuits 58 (W/O) and 56 (BL). Is voltage present in both circuits?	Yes	Replace the windshield wiper motor.
	No	Go to Step B3.
Step B3, Check the Accessory Feed Circuit. Turn the Key to RUN. Test for voltage at the wiper switch connector C201 Circuit 763 (O/W). Is voltage present?	Yes	Go to Step B4.
	No	Service the open accessory feed circuit.
Step B4, Wiper Switch Output Circuits. Turn the key to RUN. With the wiper switch in the LO and HI positions, test for voltage at wiper switch connector C201 Circuits 58 (W/O) and 56 (BL). Is voltage present at both switch terminals?	Yes	Service open in Circuits 58 (W/O) and 56 (BL).
	No	Replace the windshield wiper switch.

Table 3, Test B: Windshield Wipers Inoperative-All Control Switch Positions

Test C: Windshield Wipers Inoperative at High Speed		
Test Step	**Result**	**Action to Take**
Step C1, Check Circuit 56 (BL) for Open. With the key on RUN or ACCESSORY, connect a test lamp to a good ground, and test for voltage to Circuit 56 (BL) at the windshield wiper motor connector C165. Does the test lamp light?	Yes	Service or replace the windshield wiper motor.
	No	Go to Step C2.
Step C2, Check the Windshield Wiper Switch. Connect a test lamp to a good ground, and test for voltage at switch connector C201 Circuit 56 (BL). Does the test lamp light?	Yes	Service the open in circuit 56 (BL) between the windshield wiper switch an the windshield wiper motor.
	No	Replace the windshield wiper switch.

Table 4, Test C: Windshield Wipers Inoperative at High Speed

Troubleshooting

Test D: Windshield Wipers Inoperative at Low Speed		
Test Step	**Result**	**Action to Take**
Step D1, Check Circuit 58 (W/O) for Open. Turn the key to RUN. Connect a test lamp to a good ground and test for voltage to Circuit 58 (W/O) at windshield wiper motor connector C 165. Does the test lamp light?	Yes	Service or replace the windshield wiper motor.
	No	Go to Step D2.
Step D2, Check the Windshield Wiper Switch. Connect a test lamp to a good ground and test for voltage at switch connector C201 Circuit 58 (W/O). Does the test lamp light?	Yes	Service the open in Circuit 58 (W/O) between the windshield wiper switch and the windshield wiper motor.
	No	Replace the windshield wiper switch.

Table 5, Test D: Windshield Wipers Inoperative at Low Speed

Test E: Windshield Wipers Inoperative at Interval Setting		
Test Step	**Result**	**Action to Take**
Step E1, Check the Windshield Wiper Timer Relay. Substitute a known good windshield wiper timer relay. Does the wiper operate properly?	Yes	Replace the original relay with a new unit.
	No	Go to Step E2.
Step E2, Check the Power Feed from the Windshield Wiper Switch. Remove the wiper timer relay. Turn the key to RUN. With the wiper switch in the interval position, check for voltage at relay connector C202 Circuit 764 (BK/O). Is voltage present?	Yes	Go to Step E3.
	No	Go to Step E4.
Step E3, Check the Timer Relay Ground Circuit. Using an ohmmeter, check for continuity between relay connector C202 Circuit 57 (BK) and clean chassis ground. Is there continuity?	Yes	Return to **Table 1**.
	No	Service the ground circuit.
Step E4, Check the Power Feed at the Windshield Wiper Switch. Turn the key switch to RUN. With the wiper switch in the interval position, check for voltage at wiper switch connector C201 Circuit 764 (BK/O). Is voltage present?	Yes	Service the open in Circuit 764 (BK/O).
	No	Replace the wiper switch.

Table 6, Test E: Windshield Wipers Inoperative at Interval Setting

Test F: Windshield Wipers Will Not Park at Proper Position		
Test Step	**Result**	**Action to Take**
Step F1, Check Circuit 63 (R). Turn the key to RUN. Connect a test lamp to a good ground and test for voltage at wiper motor connector C 165 Circuit 63 (R). Does the test lamp light?	Yes	Go to Step F3.
	No	Leave the ignition switch in the RUN position and go to Step F2.
Step F2, Check Switch Output to Circuit 63 (R). Connect a test lamp to a good ground and test for voltage at switch connector C201 Circuit 63 (R). Does the test lamp light?	Yes	Service the open in Circuit 63 (R).
	No	Replace the windshield wiper switch.

Test F: Windshield Wipers Will Not Park at Proper Position		
Test Step	**Result**	**Action to Take**
Step F3, Check Circuit 65 (GN). With the key off, Use an ohmmeter to check Circuit 65 (GN) for continuity between the windshield wiper switch connector C201 and windshield wiper motor connector C165. Is there continuity?	Yes	Go to Step F4.
	No	Go for Step F5.
Step F5, Isolate the Wiper Timer Relay. Check for continuity of Circuit 65 (GN) from timer relay connector C110 to wiper switch connector C201 and motor connector C165.	Yes	Replace the wiper timer relay.
	No	Service the open in circuit 65 (GN).

Table 7, Test F: Windshield Wipers Will Not Park at Proper Position

Test G: Windshield Wipers Continue to Run When the Switch is Turned Off		
Test Step	**Result**	**Action to Take**
Step G1, Check Run Circuits for Short to Power. Disconnect wiring at the wiper motor. Make sure the wiper switch is off. Turn the key to RUN. Connect a test lamp to a good ground and test for voltage at the wiper connector C165 Circuits 58 (W/O) and 56 (BL). Is there voltage present at either circuit?	Yes	Go to Step G2.
	No	Replace the windshield wiper motor.
Step G2, Isolate Wiper Switch. Disconnect wiring at the wiper motor. Make sure the wiper switch is off. Turn the key to RUN. Check for voltage at the wiper connector C165 Circuits 58 (W/O) and 56 (BL). Is there voltage present at either circuit?	Yes	Service the short to ground in Circuit 58 (W/O) or 56 (BL).
	No	Replace the wiper switch.

Table 8, Test G: Windshield Wipers Continue to Run When the Switch is Turned Off

Specifications

Torque Specifications	
Description	**Torque lbf·in (N·cm)**
Reservoir Attaching Screws	75–93 (840–1060)
Screw, Wiper-to-Arm	6–9 (60–100)

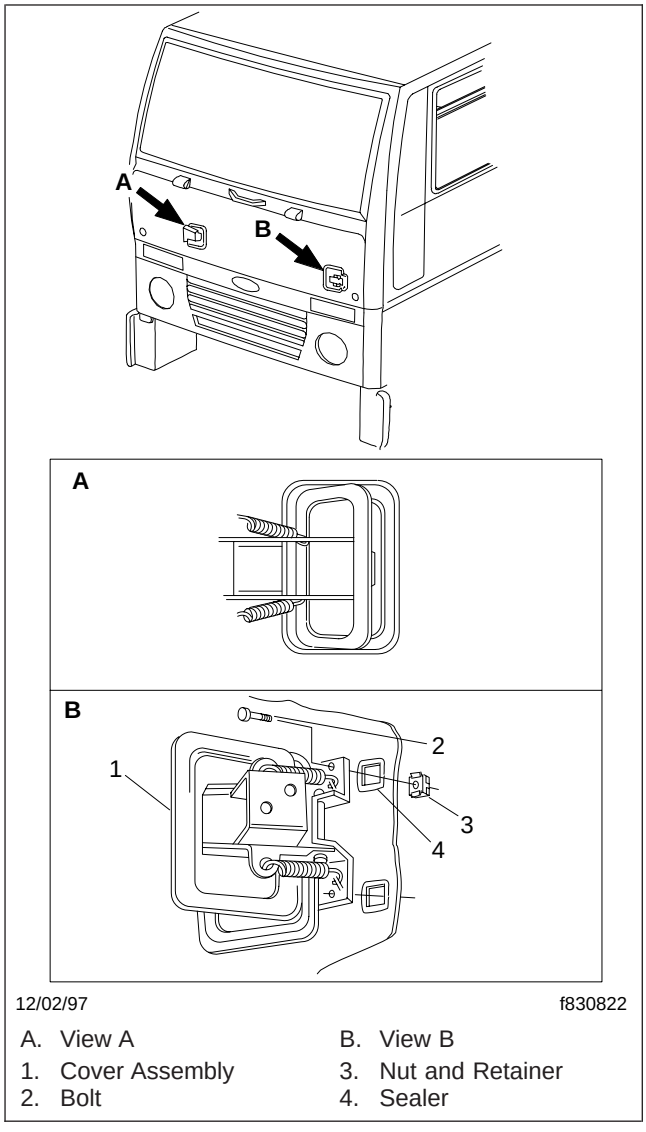
Table 1, Torque Specifications

General Description

FRESH AIR VENTILATION

(See Fig. 1)

All vehicles have two foot-level fresh-air vents mounted on the cab bulkhead.



A. View A
B. View B
1. Cover Assembly
2. Bolt
3. Nut and Retainer
4. Sealer

Fig. 1, Air Vents

AIR DISTRIBUTION **(See Fig. 2)**

Air enters the front of the vehicle through the air intake in the grille area and is distributed through the cab by foot-level fresh-air vents, defroster foot- and face-level vents, and a roof-mounted ventilator.

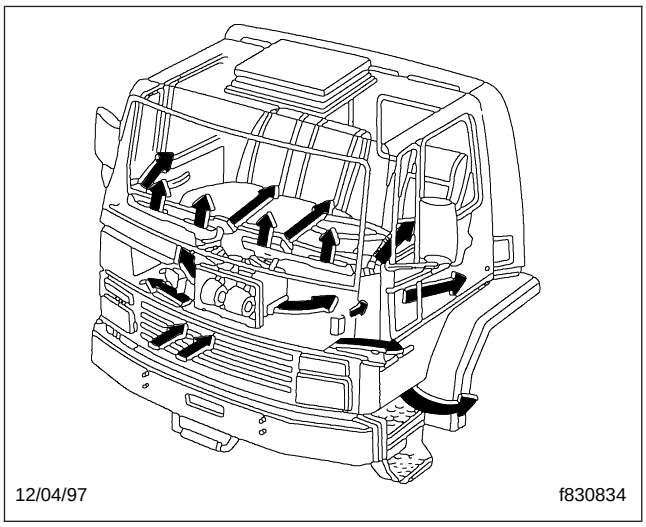
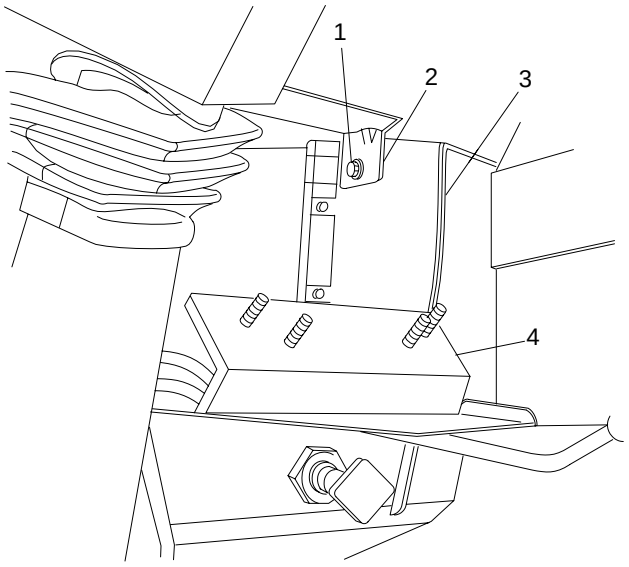


Fig. 2, Air Distribution

Ventilation Housing Cover, Removal and Installation

Removal

1. Remove the distribution housing supports and screws.
2. Remove the ventilation direction tube grilles.
3. Remove the right-hand drivers side instrument panel to access the brake control valve panel-to-console retaining nuts.
4. Remove the four retaining nuts and position the brake control valve panel out of the way. See **Fig. 1**. This will allow access to the housing cover retaining screws.



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1. Heater Assembly Retaining Bolt
2. Bracket
3. Heater Assembly
4. Brake Control Valve Panel

Fig. 1, Move Valve Panel

5. Remove the six screws and the cover.

Installation

1. Install the cover and the six screws. Tighten the screws 72 to 84 lbf·in (900 to 1000 N·cm).
2. Install the ventilation direction tube grilles.
3. Install the distribution housing supports and screws. Tighten the screws 72 to 84 lbf·in (900 to 1000 N·cm).
4. Install the brake control valve panel and the four retaining nuts on the console. Install the right-hand instrument panel.

General Description

CLIMATE CONTROL ASSEMBLY (See Fig. 1)

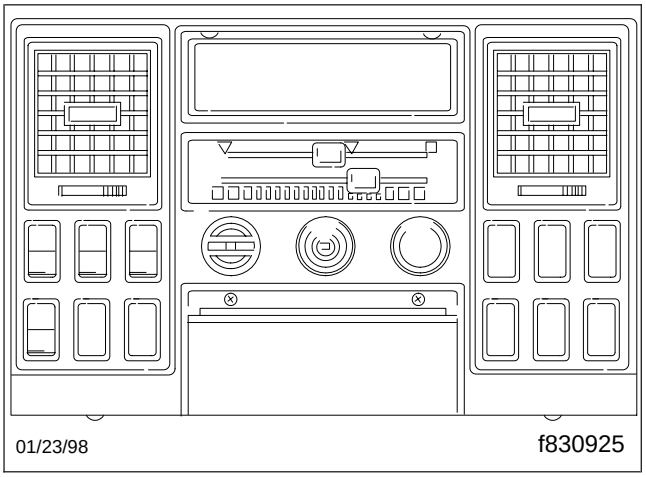


Fig. 1, Climate Control Assembly

The ventilation and heating system control is located in the center of the dash, just below the radio.

The system is controlled by two levers that adjust the temperature and airflow direction.

AIRFLOW CONTROL

All heater assemblies contain a heater core and a blower. The air (forced by blower or ram effect) passes through the heater core and into the cab through various outlets.

TEMPERATURE CONTROL

Air is heated as it passes through the heater core (connected to the engine cooling system). Moving the temperature lever on the control panel activates the water control valve allowing engine-heated coolant to flow through the heater core.

When the airflow or the heater system is turned on, the air circulation to the cab interior is controlled by adjustable louvers.

BLOWER MOTOR

The airflow system uses a two-speed blower motor connected to dual fans to control the volume of air moving through the heating and defrosting system.

This blower motor is controlled by a blower motor switch. The blower motor switch has three positions; OFF, LOW and HIGH.

BLOWER MOTOR RESISTOR

The amount of electrical current allowed to reach the blower motor determines blower motor speed. This electrical current is governed by the blower motor resistor located on the blower motor. Current is directed through the blower motor resistor by the position of the blower motor switch. When the blower motor switch is in the LOW position, current is directed through the resistor to restrict the amount of current reaching the blower motor, resulting in a low blower motor speed. When the blower motor switch is set at the HIGH position, current is allowed to bypass the resistor and feed directly to the blower motor resulting in a high blower motor speed. If the blower motor resistor doesn't work, it must be replaced.

INSTRUMENT PANEL LOUVERS

There are four air outlet louvers on the dash board: one on the extreme left of the dash board, one on the extreme right of the dash board, and two located in the central portion of the dash board. These louvers can be independently adjusted to direct airflow left, right, up and down. These four dash board louvers are in addition to the two floor outlets and four air outlets located along the top of the dash.

HEATER CORE

The heater core consists of a number of fins and tubes positioned to extract available heat from the engine coolant and transfer that heat to the air that passes through the core. This heated air is directed to the cab through the heater assembly, which contains the heater core and blower motor.

SYSTEM AIRFLOW

See **Fig. 2** for vehicle system airflow.

Floor/Panel

This position of the function control lever directs air through the system windshield, floor, side panel and center panel (unheated) vents.

General Information

Defrost

This position of the function control lever directs air through the windshield and side panel vents. The center panel vents, if left open, will provide unheated air. Airflow from the side panel vents, when directed toward the door windows, will help avoid side glass fogging.

Panel

This position of the function control lever directs unheated air through the center panel vents only.

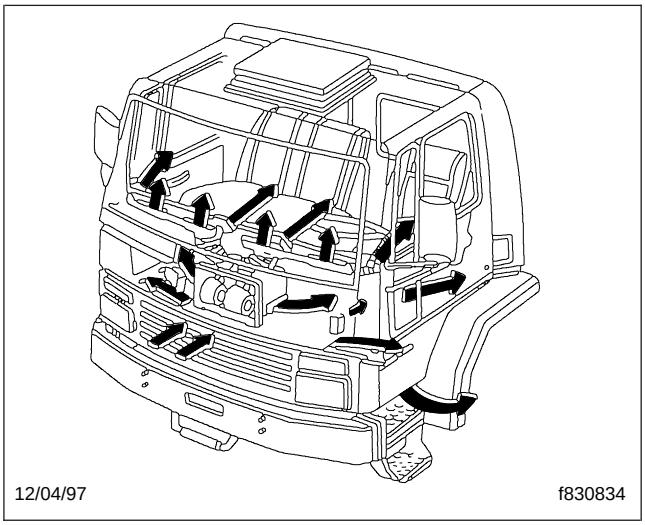


Fig. 2, System Airflow

Climate Control Panel Removal and Installation

Removal

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Disconnect the battery ground cable.
3. Remove the ashtray.
4. Carefully pull the center finish trim panel down and away from the dash board far enough to clear the climate control panel. Be careful not to dislodge any electrical connector from the center finish trim panel.
5. Install the two upper screws that retain the radio support bracket to ensure the radio remains in place during climate control panel removal.
6. Remove the four screws that retain the climate control panel to the dash board.
7. Carefully pull the climate control panel away from the dash board far enough to gain access to the rear of the panel.
8. Disconnect the illumination socket from the climate control panel.
9. Remove the function control lever cable retaining clip from the back of the panel.
10. Carefully remove the function control cable from the panel. Some twisting may be required to disconnect the cable Z-bend from the assembly. Pay particular attention to the cable mounting adjustment hole. Install the new cable in the new position.
11. Disconnect the illumination socket from the temperature control cable.
12. Remove the temperature control cable retaining clip from the panel.
13. Remove the climate control panel.

Installation

1. Insert the temperature control cable Z-bend into the same adjustment hole on the climate control panel as was described in the removal procedures.
2. Attach the temperature control cable retainer clip to the climate control panel while holding the temperature control cable in position.
3. Repeat the previous two steps to install the function control cable.
4. Install the illumination socket in the climate control panel.
5. Position the climate control panel in the instrument panel and install the four screws that retain the panel.
6. Remove the two screws previously installed to support the radio.
7. Install the center finish trim panel. Make sure to align the locating tabs found at the top of the trim panel with the locating notches in the instrument panel. Make sure all electrical connectors are properly installed.
8. Install the six screws that retain the center finish trim panel to the instrument panel.
9. Reconnect the battery ground cable.
10. Test the system for proper operation.
11. Install the ashtray.
12. Remove the chocks from the tires.

Climate Control Assembly Illumination Bulbs Replacement

Replacement

1. Shut down the vehicle, apply the parking brake, and chock the tires.
2. Remove the ashtray.
3. Remove the six screws retaining the center finish trim panel to the instrument panel.
4. Carefully pull the center finish trim panel down and away from the instrument panel far enough to clear the climate control assembly. Be careful not to dislodge any electrical connectors from the center finish trim panel.
5. Reinstall the two upper screws from the center finish trim panel to secure the radio in place during climate control assembly removal.
6. Remove the four screws that retain the climate control assembly in the instrument panel.
7. Carefully pull the climate control assembly from the instrument panel far enough to gain access to the illumination bulb socket located on the left side of the climate control assembly.
8. Remove the illumination bulb socket from the climate control assembly by pulling it straight out from the assembly. A slight side-to-side rocking motion may be necessary to assist in socket removal.
9. Remove the bulb from the illumination socket by pulling straight away from the socket.
10. Install the new bulb in the illumination bulb socket.
11. Install the illumination bulb socket in the climate control assembly.
12. Install the four screws that retain the climate control assembly to the instrument panel.
13. Remove the two upper screws that retain the radio, and install the center finish trim panel in the instrument panel. Make sure to align the locating tabs on the center finish trim panel with the locating notches on the instrument panel.
14. Install six screws retaining the center finish trim panel to the instrument panel.
15. Install the ashtray.
16. Check the system for proper operation.
17. Remove the chocks from the tires.

Blower Motor Switch Replacement

Replacement

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Disconnect the battery ground cable.
3. Remove the ash receptacle.
4. Remove the six screws retaining the center trim panel to the dash board.
5. Carefully pull the center trim panel down and away from the instrument panel far enough to clear the climate control assembly. Be careful not to dislodge any electrical connectors attached to the center finish trim panel.
6. Disconnect the hard-shell electrical connector from the backside of the blower motor switch.
7. Depress the two retaining tabs (one on each side) of the blower motor switch and remove the switch by pulling it through the front of the center finish trim panel.
8. Working from the front of the center finish trim panel, install the blower motor switch by aligning the blower motor switch locating tabs with the locating notches on the center finish trim panel. Push the switch into place until the retaining tabs snap into place on the back of the trim panel.
9. Connect the hardshell electrical connector to the blower motor switch.
10. Install the center trim panel. Make sure to align the center trim panel locating tabs found at the top of the trim panel with the locating notches in the dash board. Make sure all electrical connectors are properly installed.
11. Install the six screws that retain the center trim panel to the dash board.
12. Reconnect the battery ground cable.
13. Test system for proper operation.
14. Install the ash receptacle.
15. Remove the chocks from the tires.

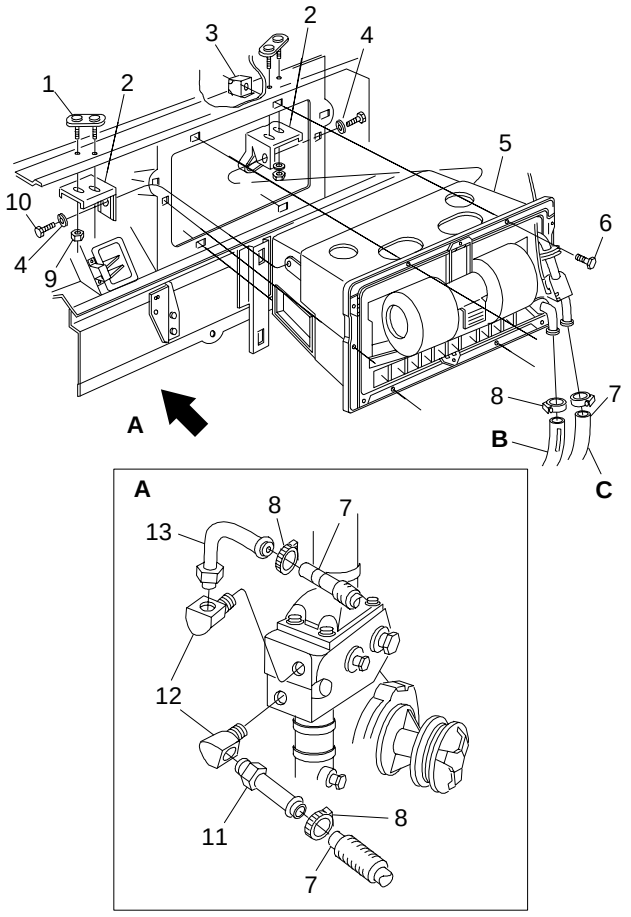
Removal

See **Fig. 1** and **Fig. 2** for illustrations of the heater assembly.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Disconnect the battery ground cable.
3. Remove the switch panel retaining screws. See **Fig. 3**. Pull the panel down to clear the retaining lugs, then pull it away from the console.
4. Mark the wiring harness for assembly reference then disconnect the vent tubes from the face level vents. Then disconnect the harness connectors and release the panel.
5. Remove the heater control illumination bulb holder and heater control panel. Mark and disconnect the heater cables.
6. Remove the windshield defroster vent tubes and vent tube retaining clips from the heater body. See **Fig. 4**.
7. Remove the fuse module cover to access the passenger-side floor vent and the heater assembly retaining bolt. Remove the floor vent and the retaining bolt. See **Fig. 5**.
8. Remove the right-side (driver's side) dash panel to access the brake control valve retaining bolts.
9. Remove the four retaining nuts and position the brake control valve panel out of the way. See **Fig. 6**. This will allow access to the driver-side floor vent and the heater assembly retaining bolt.
10. Remove the floor vent and the heater assembly retaining bolt.
11. Lift the front access panel and remove the grille.

NOTE: Note which hose is connected to the inlet and outlet tubes.

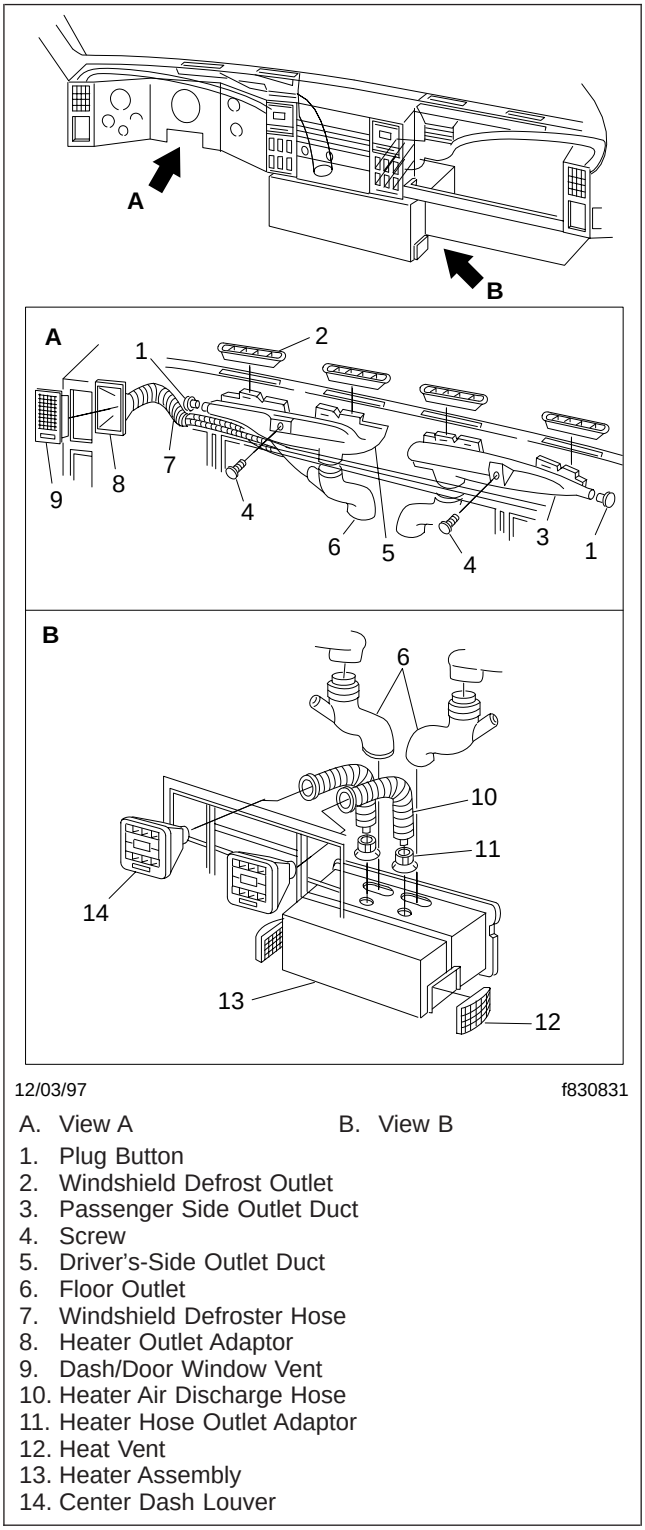
12. Using care to prevent coolant spillage, disconnect the heater hoses. Secure the heater hoses in an upright position.
13. Remove the water valve. For instructions, see **Subject 170**.
14. Remove the air pipe support bracket and heater retaining bolts. See **Fig. 7**. Cut the straps from the air lines as needed. If necessary, remove the wiper linkage.



A. View A
B. From Engine
C. To Engine
1. Plate Assembly
2. Heater Mounting Bracket
3. Nut and Cage Assembly
4. Washer
5. Heater Assembly
6. 1/2-Inch (13-mm) Bolt
7. Heater Water Hose
8. Clamp
9. 1/2-Inch (13-mm) Nut
10. Screw
11. Tube Assembly
12. Elbow
13. Tube Assembly

Fig. 1, Heater Assembly

Heater Removal and Installation



A. View A B. View B
1. Plug Button
2. Windshield Defrost Outlet
3. Passenger Side Outlet Duct
4. Screw
5. Driver's-Side Outlet Duct
6. Floor Outlet
7. Windshield Defroster Hose
8. Heater Outlet Adaptor
9. Dash/Door Window Vent
10. Heater Air Discharge Hose
11. Heater Hose Outlet Adaptor
12. Heat Vent
13. Heater Assembly
14. Center Dash Louver

Fig. 2, Heater Assembly

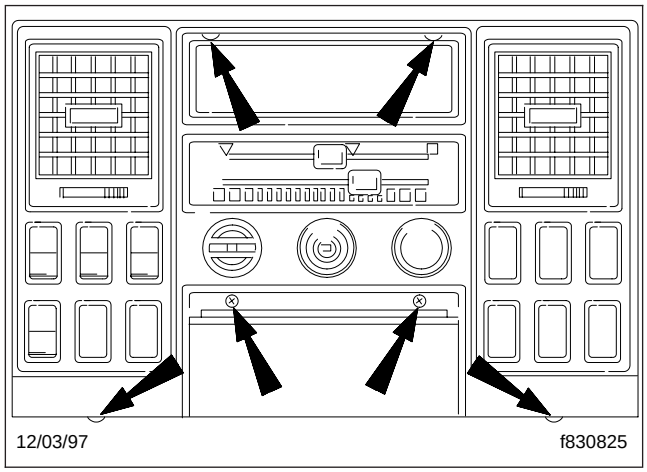


Fig. 3, Remove the Panel Switch Retaining Screws

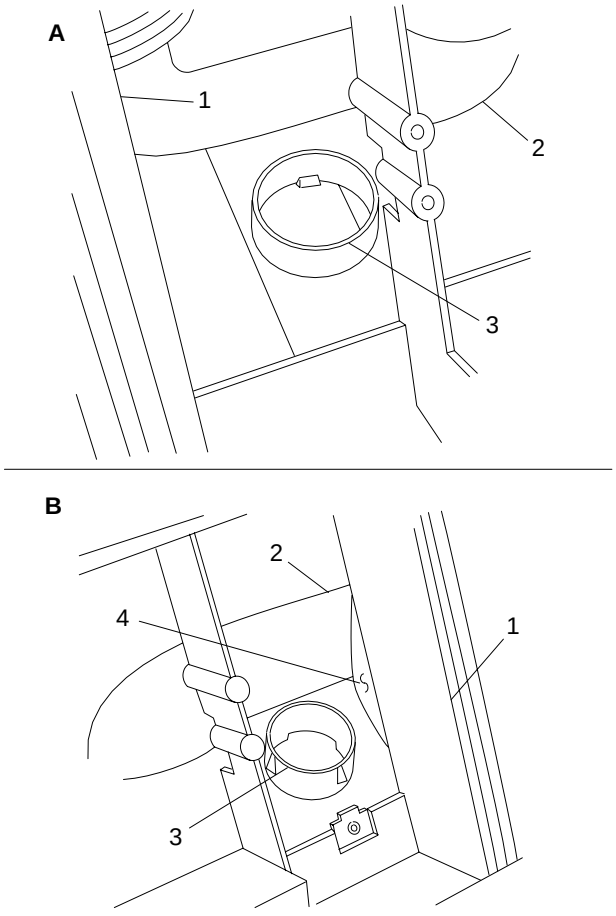
15. Disconnect the blower motor wires and remove the heater from vehicle.

Installation

1. Position the heater, then install and tighten the retaining bolts, making sure the hood strap and air line support brackets are connected. Install the wiper linkage if previously removed. Install the straps on the air lines as needed.
2. Install the water valve. For instructions, see **Subject 170**.

NOTE: Make sure the heater hoses are connected to the proper inlet or outlet position.

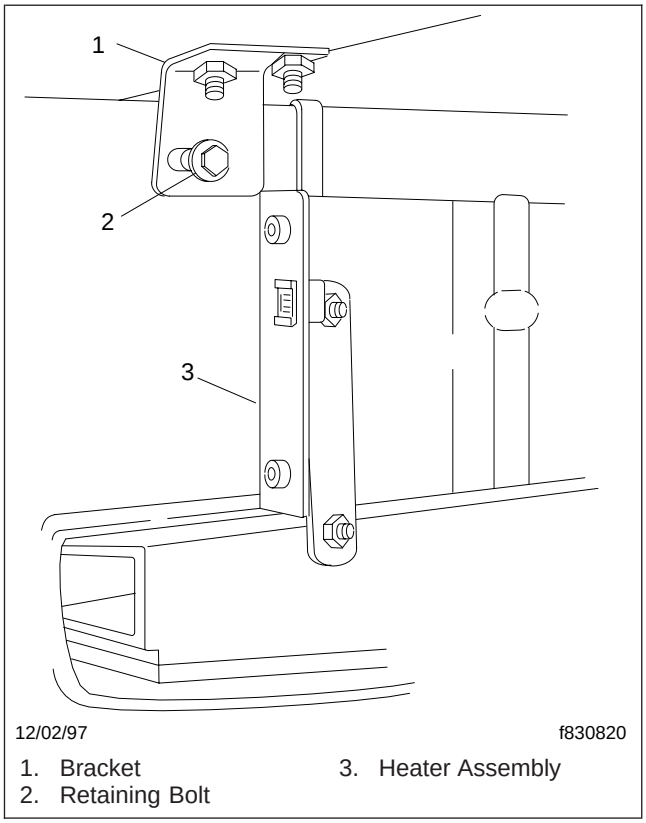
3. Position the heater hoses, then connect the heater inlet hose and tighten the hose clamp. See **Fig. 8**.
4. Connect the temperature control cable.
5. Inside the cab, attach the heater retaining bolts to the mounting brackets. Install the fuse module cover and floor vents.
6. Position the brake control valve panel and install the four retaining bolts. Install the right-side instrument panel.
7. Install the vent tube clips and windshield defroster tube to the heater body and connect the vent tubes. It may be necessary to remove the small section of the glove compartment to install the passenger-side windshield defroster tube. See **Fig. 9**.



A. Left Side
B. Right Side
1. Console
2. Windshield Demister Tube
3. Vent Tube Retaining Clip
4. Glove Compartment

Fig. 4, Remove the Vent Tubes

8. Connect the heater electrical connectors and blower motor wires. Then install the heater control panel, illumination bulb holder, and control cables.
9. Position the switch panel, then connect the face vents and harness connectors.
10. Locate the switch panel retaining lugs. Install and tighten the securing screws.
11. Set the heater temperature control to the maximum heat position.



1. Bracket
2. Retaining Bolt
3. Heater Assembly

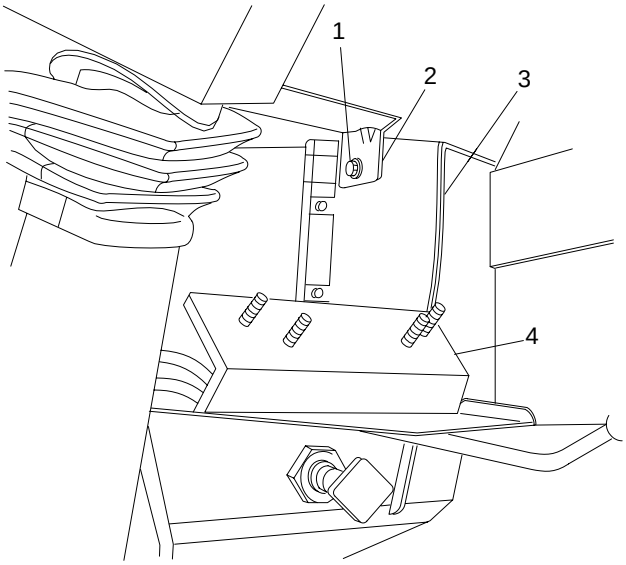
Fig. 5, Remove the Foot Level Vent and Retaining Bolt

12. Connect the battery ground cable.
13. Start the engine. Turn the heat control knob to hot (this opens the water valve). When the engine thermostat(s) opens, air will be forced from the heater core as the coolant circulates. Check the coolant level and fill as needed.
14. Fit new tie straps to the air lines as necessary.

NOTE: If the grille brackets were removed during removal of the heater, make sure they are correctly aligned and the retaining bolts are securely tightened.

15. Refit the grille and lower the front access panel.
16. Remove the chocks from the tires.

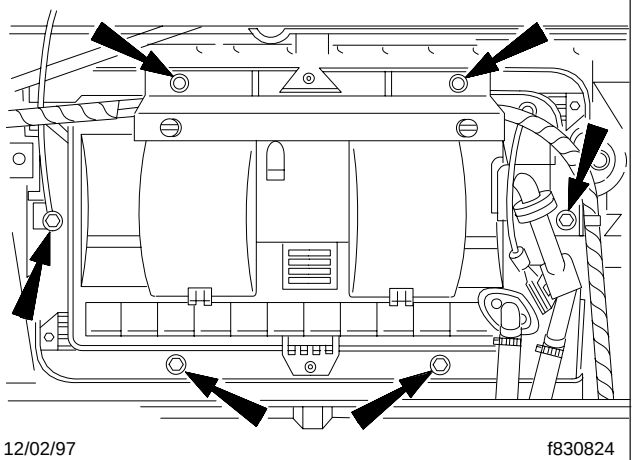
Heater Removal and Installation



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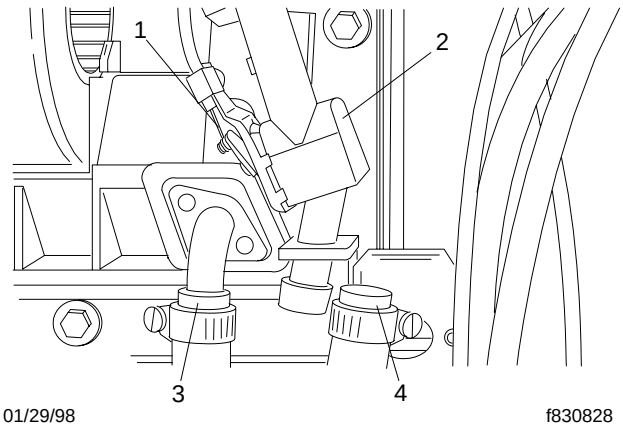
1. Heater Assembly Retaining Bolt
2. Bracket
3. Heater Assembly
4. Brake Control Valve Panel

Fig. 6, Move Valve Panel



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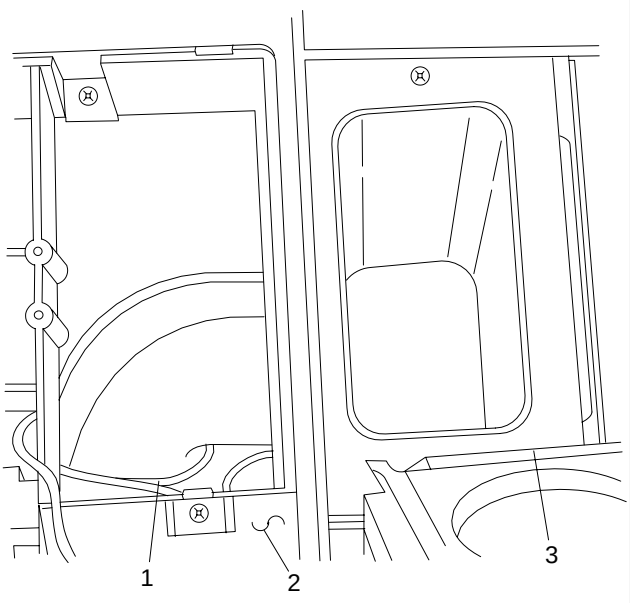
Fig. 7, Remove the Retaining Bolts



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1. Temperature Control Cable
2. Water Valve
3. Inlet Hose
4. Outlet Hose

Fig. 8, Connect the Inlet Hose and Retaining Clip



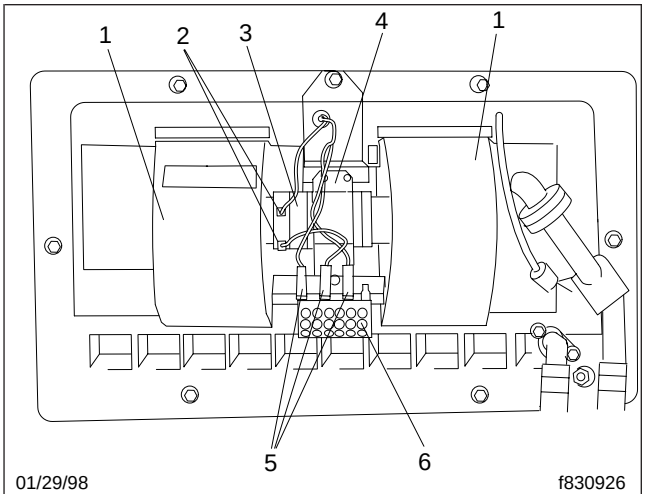
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1. Windshield Defroster Tube
2. Console
3. Glove Compartment

Fig. 9, Demister Tube Installation

Replacement

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Disconnect the battery ground cable.
3. Lift the front access panel.
4. Note their positions, then disconnect the lead wires from the blower motor resistor assembly.
5. Remove the retaining strap screw and remove the resistor assembly. See **Fig. 1**.



1. Fan Covers
2. Blower Motor Wires
3. Blower Motor
4. Blower Motor Retaining Bracket
5. Motor Resistor Wires
6. Blower Motor Resistor

Fig. 1, Motor Resistor Replacement

6. Position the new resistor and install the retaining screw.
7. Connect the wire leads to the resistor assembly.
8. Lower the access panel.
9. Connect the battery ground cable and check the operation of the blower motor.
10. Remove the chocks from the tires.

Heater Water Hoses Replacement

Replacement

1. Shut down the engine, apply the parking brake, and chock the tires.

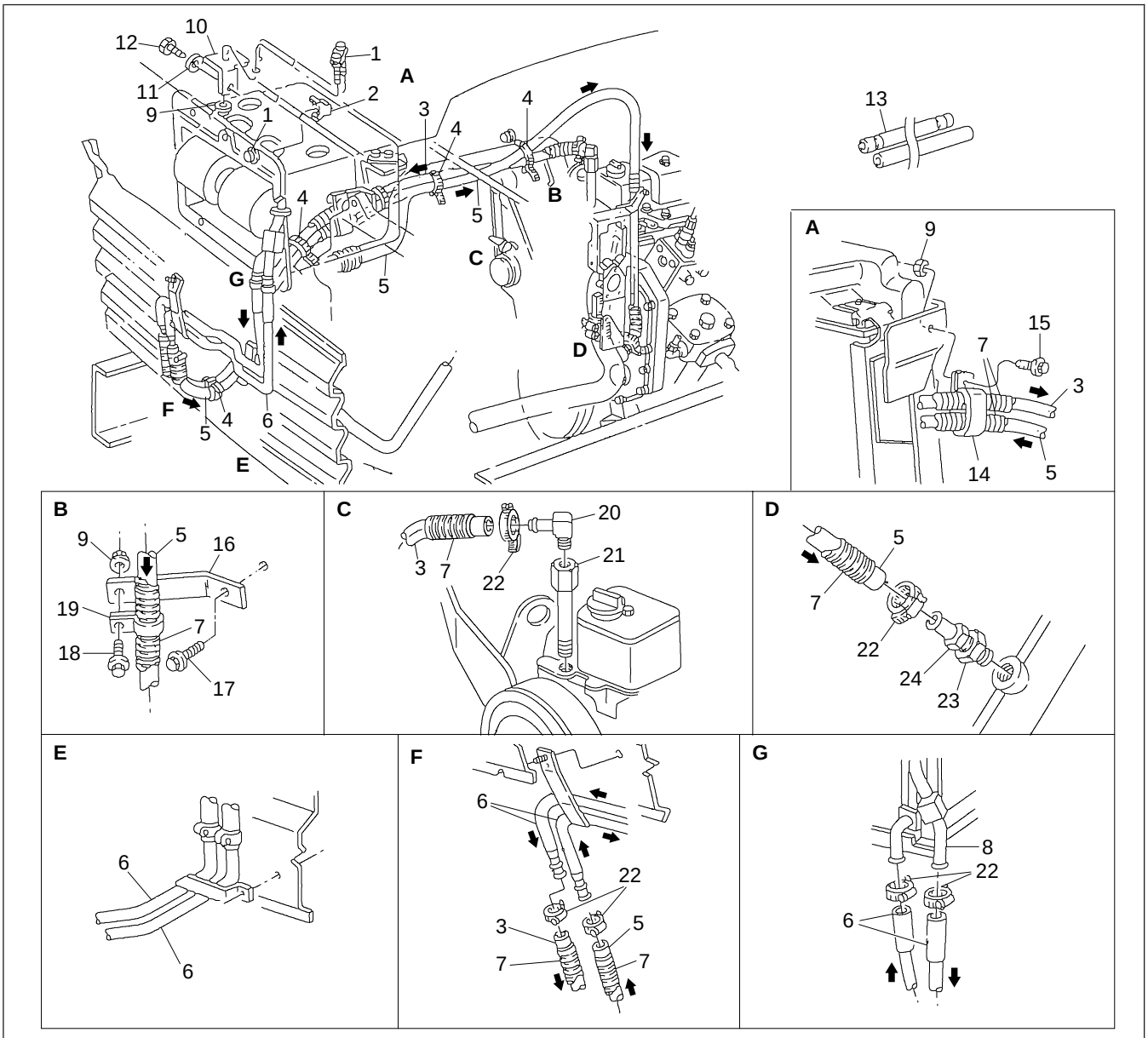
IMPORTANT: Make note of heater house routing prior to removal. See **Fig. 1**.

2. Tilt the cab and disconnect the battery ground cable. Drain the cooling system.
3. Make note of the positions of any tie straps fitted to the damaged hose, then cut away the straps.
4. Disconnect the damaged hose from the engine block. Then remove the hose from the hose retaining bracket, if so equipped.
5. Lower the cab, raise the front access panel, and remove the grille.
6. Disconnect the hose from the heater, then remove it from the hose retaining bracket and from the vehicle.

IMPORTANT: Route the heater hoses to the previously noted positions to ensure proper heater operation.

7. To install the inlet hose, position the new hose and route it through the hose retaining bracket. Connect the hose to the heater, making sure the heater hose clamp is tightened 19 to 24 lbf·in (214 to 271 N·cm).
8. To install the outlet hose, position the new hose and route it through the hose retaining bracket.
9. Close the front access panel and install the grill. Tilt the cab.
10. Route the hose through the hose retaining bracket. Connect the hose to the engine block. Tighten the heater hose clamp 19 to 24 lbf·in (214 to 271 N·cm).
11. Install the new tie straps and lower the cab.
12. Fill the cooling system.
13. Connect the battery ground cable.
14. Remove the chocks from the tires.

Heater Water Hoses Replacement



A. View A
B. View B
C. View C
D. View D
E. View E
F. View F
G. View G

1. Bolt
2. Nut and Cage Assembly
3. Heater Supply Hose
4. Tie Strap
5. Heater Return Hose
6. Tube Assembly
7. Insulating Tape
8. Heater Assembly
9. Nut
10. Bracket
11. Washer
12. Bolt
13. Adhesive Tape
14. Clip
15. Bolt
16. Bracket
17. Bolt
18. Bolt
19. Clip
20. Elbow
21. Tube Assembly
22. Clamp
23. Adaptor (part of connector)
24. Connector

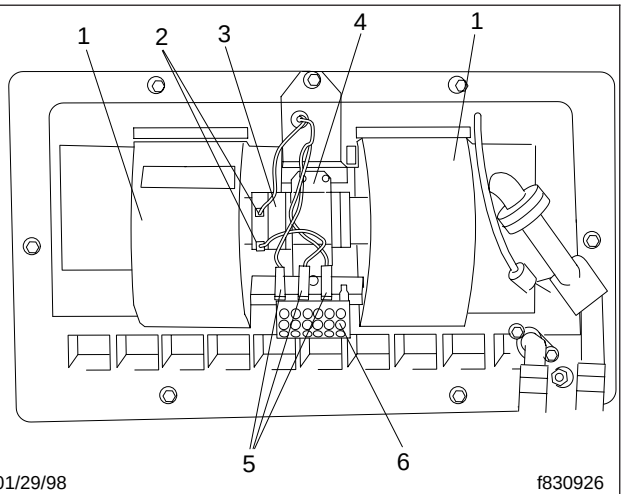
Fig. 1, Heater Hose Connections

Replacement

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Disconnect the battery ground cable, lift the front access panel, and remove the grille.
3. Remove the blower motor cover (if equipped) and fan covers.

IMPORTANT: Remove the fan covers with care. They should come straight out. Moving or swinging the covers up or down during removal can cause the tabs to break.

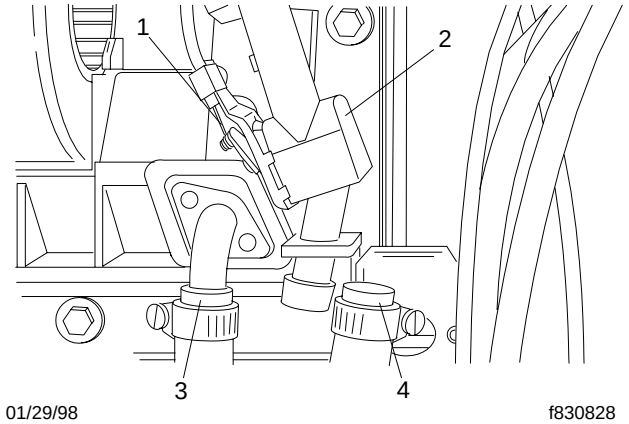
4. Disconnect the wires and remove the blower motor and resistor. Mark each wire for later reference. See **Fig. 1**.
5. Remove the blower motor retaining bracket.
6. Remove the motor.
7. Position the new motor and install the retaining bracket. Install and tighten the bracket retaining screws.
8. Install the motor and fan covers.
9. Connect the battery ground cable and check the operation of the blower motor.
10. Lower the front access panel, install the grille, and remove the chocks from the tires.



1. Fan Covers
2. Blower Motor Wires
3. Blower Motor
4. Blower Motor Retaining Bracket
5. Motor Resistor Wires
6. Blower Motor Resistor

Fig. 1, Motor Resistor Replacement

Replacement (See Fig. 1)



1. Temperature Control Cable
2. Water Valve
3. Inlet Hose
4. Outlet Hose

Fig. 1, Water Valve Removal and Installation

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Disconnect the battery ground cable and open the front access panel.
3. Drain the coolant.
4. Remove the temperature control cable from the water valve. Note the position of the cable housing installation.
5. Remove the two retaining screws attaching the water valve to the outlet pipe.
6. Note the position of the hose clamp at the bottom of the water valve, then loosen it.
7. Remove the water valve.
8. Position the new valve into the outlet hose, through the retaining bracket.
9. Install the screws attaching the water valve to the outlet pipe. Tighten the screws firmly.
10. Attach the temperature control cable to the water valve in the same position it was removed.
11. Connect the battery ground cable.
12. Start the engine. Turn the heat control knob to hot (this opens the water valve). When the engine thermostat(s) opens, air will be forced from the heater core as the coolant circulates. Check the coolant level and fill as needed.
13. Check for leaks.
14. Lower the access panel and remove the chocks.

Replacement

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Disconnect the battery ground cable, open the front access panel, and remove the grille.
3. Drain the coolant.
4. Remove the water valve. See **Subject 170**.
5. Mark the blower motor wires, then disconnect them.
6. Remove the six blower motor assembly retaining bolts. See **Fig. 1**.

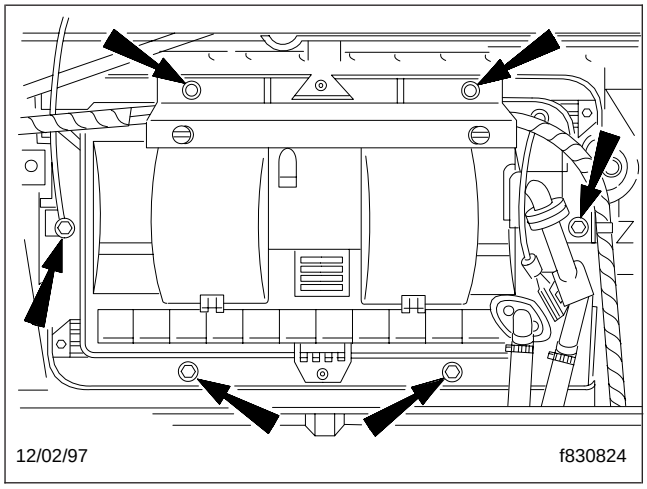


Fig. 1, Remove the Retaining Bolts

7. Remove the blower motor assembly.
8. Carefully remove the heater core.
9. Remove the outlet extension tube from the core.
10. Install the outlet extension tube on the new core.
11. Install the core.
12. Position the blower motor assembly and install the fasteners.
13. Install the water valve. See **Subject 170**.
14. Start the engine. Turn the heat control knob to hot (this opens the water valve). When the engine thermostat(s) opens, air will be forced from the heater core as the coolant circulates. Check the coolant level and fill as needed.
15. Connect the blower motor wires.
16. Check for leaks.
17. Install the grille, lower the front access panel and remove the chocks.

Troubleshooting

Prior to troubleshooting, make sure the battery is fully charged and that sufficient coolant is present in the engine cooling system.

Various tests to check heater system operations are included in this subject. In addition to these tests, visual inspection of all heater system components and connections can be made to make sure the system is operating properly. Use a digital multimeter to perform various electrical tests.

Climate Control Symptom Chart		
Condition	**Possible Source**	**Action**
No Airflow	Blown fuse. Harness wires were interrupted, have loose connections, or have bad contact. Faulty switch. Insufficient voltage (partially discharged battery).	See **Table 7**.
Heater Is Not Operating	The water circulation hoses are blocked or leaking. The heater core is blocked or leaking. The water flow control valve is stuck. The control cable is stuck or loose.	See **Table 4**.
Airflow Distribution Is Partially Or Totally Inoperative	An air distribution hose is loose, torn, or blocked. Airflow distribution in the ventilation box is stuck. There is a bad air distribution control cable.	See **Table 4**.
Fan Motor Operates In One Speed Only	Faulty switch. The harness wire is interrupted, has loose connections or a bad contact. The motor resistor is burnt or interrupted.	See **Table 7**.
Vent Does Not Operate Properly	Vent control.	See **Table 2**.
Heat Will Not Shut Off	Temperature control assembly. The heater valve is not closing. The temperature control cable is damaged. Temperature control cable is not adjusting.	See **Table 3**.
Defroster Will Not Clear the Windshield	Engine coolant level is low. Faulty heater control valve. Faulty thermostat. Plugged or restricted heater system.	See **Table 5**.

Troubleshooting

Climate Control Symptom Chart		
Condition	**Possible Source**	**Action**
The System Does Not Respond To The Function Control Settings	Function control setting is out of adjustment. Disconnect or blocked air ducts. Faulty blower motor switch.	See **Table 6**.
Noisy Heating And Cooling System	Loose blower motor wheel. Misaligned belt pulley. Loose or worn drive belt. Radiator or fan obstructions.	See **Table 8**.

Table 1, Climate Control Symptom Chart

Test A: Vent is Always On		
Test Step	**Result**	**Action to Take**
Step A1, Check Operation of the Vent Door and Controls	Yes	Go to Step A2.
Check operation of the vent door and controls for a kinked or binding cable or door. Is operation of the door and controls OK?	No	Service and repair parts as necessary.
Step A2, Check the Vent Door and Controls for Proper Adjustment	Yes	Adjust the cowl vent control.
Is adjustment needed?	No	If the original problem persists, review the previous steps.

Table 2, Test A: Vent is Always On

Test B: The Heat is Always On		
Test Step	**Result**	**Action to Take**
Step B1, Check the Temperature Controls	Yes	Go to Step B2.
Check temperature controls for sticking and/or binding operation. Are the temperature controls OK?	No	Service the temperature controls to obtain full travel.
Step B2, Check Temperature Control Cable Adjustment	Yes	Go to Step B3.
Check the temperature control cable for proper adjustment. Is the temperature control cable OK?	No	Adjust the temperature control cable.
Step B3, Check the Heater valve and Control Cable	Yes	Adjust the heater valve control cable.
Check heater valve and control cable for proper adjustment. Is adjustment needed?	No	If the original problem persists, review the previous steps.

Table 3, Test B: The Heat is Always On

Test C: Insufficient Heat		
Test Step	**Result**	**Action to Take**
Step C1, Check the Engine Coolant Check engine coolant level. Is coolant level OK?	Yes	Go to Step C2.
	No	Fill and bleed the cooling system. Check for leaks. Recheck the heating system. If it is still inoperative, go to Step C5.
Step C2, Check Blower Switch Operation Check the blower switch operation through all speed ranges. Check for progressively increased sound and air volume at the air outlets. Is the blower switch OK?	Yes	Go to Step C3.
	No	Go to **Table 7**.
Step C3, Check for Air Leaks Operate the engine at idle speed. Check for leaking, disconnected and restricted air ducts, with the blower on high speed and the heater controls operated through their various control positions. Make sure there is airflow at the applicable outlets. Is airflow OK?	Yes	Go to Step C4.
	No	Remove obstructions or restrictions from the ducts as required.
Step C4, Check Functional Control Check the functional control for binds and adjustment by checking for proper airflow at registers for each lever position. Is there proper airflow?	Yes	Go to Step C5.
	No	Adjust the function control cable as required. service or replace as necessary.
Step C5, Check the Heater Valve Check heater valve for proper operation. If vehicle not equipped with heater valve, go to Step C6. Is the heater valve OK?	Yes	Go to Step C6.
	No	Service or replace as necessary.
Step C6, Check the Heater Hose Routing Check for improperly installed or crossed heater hose(s). Are heater hoses OK?	Yes	Go to Step C7.
	No	Route the heater hose(s) properly.
Step C7, Check the Heater Hose(s) for Restrictions Check heater hose(s) for kinked, clogged or collapsed condition. Are the heater hoses OK?	Yes	Go to Step C8.
	No	Remove any hose restrictions. Replace any hose if required.
Step C8, Check the Heater Core Check the heater core for a plugged or restricted condition. Is heater core OK?	Yes	Go to Step C9.
	No	Flush the heater core to remove restriction. If flushing doesn't clear the restriction, replace the heater core.

Troubleshooting

Test C: Insufficient Heat		
Test Step	**Result**	**Action to Take**
Step C9, Check the Thermostat Check the engine thermostat for proper operation. Is the engine thermostat OK?	Yes	Go to Step C10.
	No	Replace the thermostat.
Step C10, Check the Cowl Vent Air Ducts Check the cowl vent air ducts for adjustment or air leaks (if applicable). Are the cowl vent ducts OK?	Yes	If the original problem persists, review the previous steps.
	No	Service or replace as necessary.

Table 4, Test C: Insufficient Heat

Test D: Insufficient Defrosting		
Test Step	**Result**	**Action to Take**
Step D1, Check the Engine Coolant Check engine coolant level. Is coolant level OK?	Yes	Go to Step D2.
	No	Fill and bleed the cooling system. Check for leaks. Recheck the heating system. If it is still inoperative, go to Step C5.
Step D2, Check Blower Switch Operation Check the blower switch operation through all speed ranges. Check for progressively increased sound and air volume at the air outlets. Is the blower switch OK?	Yes	Go to Step D3.
	No	Go to **Table 7**.
Step D3, Check for Air Leaks Operate the engine at idle speed. Check for leaking, disconnected and restricted air ducts, with the blower on high speed and the heater controls operated through their various control positions. Make sure there is airflow at the applicable outlets. Is airflow OK?	Yes	Go to Step D4.
	No	Remove obstructions or restrictions from the ducts as required.
Step D4, Check Functional Control Check the functional control for binds and adjustment by checking for proper airflow at registers for each lever position. Is there proper airflow?	Yes	Go to Step D5.
	No	Adjust the function control cable as required. Service or replace as necessary.
Step D5, Check the Heater Valve Check heater valve for proper operation. If vehicle not equipped with heater valve, go to Step C6. Is the heater valve OK?	Yes	Go to Step D6.
	No	Service or replace as necessary.

Test D: Insufficient Defrosting		
Test Step	**Result**	**Action to Take**
Step D6, Check the Heater Hose Routing Check for improperly installed or crossed heater hose(s). Are heater hoses OK?	Yes	Go to Step D7.
	No	Route the heater hose(s) properly.
Step D7, Check the Heater Hose(s) for Restrictions Check heater hose(s) for kinked, clogged or collapsed condition. Are the heater hoses OK?	Yes	Go to Step D8.
	No	Remove any hose restrictions. Replace any hose if required.
Step D8, Check the Heater Core Check the heater core for a plugged or restricted condition. Is heater core OK?	Yes	Go to Step D9.
	No	Flush the heater core to remove restriction. If flushing doesn't clear the restriction, replace the heater core.
Step D9, Check the Thermostat Check the engine thermostat for proper operation. Is the engine thermostat OK?	Yes	Go to Step D10.
	No	Replace the thermostat.
Step D10, Check the Cowl Vent Air Ducts Check the cowl vent air ducts for adjustment or air leaks (if applicable). Are the cowl vent ducts OK?	Yes	If the original problem persists, review the previous steps.
	No	Service or replace as necessary.

Table 5, Test D: Insufficient Defrosting

Test E: Improper Operation in Function Settings		
Test Step	**Result**	**Action to Take**
Step E1, Check the Engine Coolant Check engine coolant level. Is coolant level OK?	Yes	Go to Step E2.
	No	Fill and bleed the cooling system. Check for leaks. Recheck the heating system. If it is still inoperative, go to Step C5.
Step E2, Check Blower Switch Operation Check the blower switch operation through all speed ranges. Check for progressively increased sound and air volume at the air outlets. Is the blower switch OK?	Yes	Go to Step E3.
	No	Go to **Table 7**.

Troubleshooting

Test E: Improper Operation in Function Settings		
Test Step	**Result**	**Action to Take**
Step E3, Check for Air Leaks Operate the engine at idle speed. Check for leaking, disconnected and restricted air ducts, with the blower on high speed and the heater controls operated through their various control positions. Make sure there is airflow at the applicable outlets. Is airflow OK?	Yes	Go to Step E4.
	No	Remove obstructions or restrictions from the ducts as required.
Step E4, Check Functional Control	Yes	Go to Step E5.
Check the functional control for binds and adjustment by checking for proper airflow at registers for each lever position. Is there proper airflow?	No	Adjust the function control cable as required. service or replace as necessary.
Step E5, Check the Heater Valve Check heater valve for proper operation. If vehicle not equipped with heater valve, go to Step C6. Is the heater valve OK?	Yes	Go to Step E6.
	No	Service or replace as necessary.
Step E6, Check the Heater Hose Routing Check for improperly installed or crossed heater hose(s). Are heater hoses OK?	Yes	Go to Step E7.
	No	Route the heater hose(s) properly.
Step E7, Check the Heater Hose(s) for Restrictions	Yes	Go to Step E8.
Check heater hose(s) for kinked, clogged or collapsed condition. Are the heater hoses OK?	No	Remove any hose restrictions. Replace any hose if required.
Step E8, Check the Heater Core	Yes	Go to Step E9.
Check the heater core for a plugged or restricted condition. Is heater core OK?	No	Flush the heater core to remove restriction. If flushing doesn't clear the restriction, replace the heater core.
Step E9, Check the Thermostat Check the engine thermostat for proper operation. Is the engine thermostat OK?	Yes	Go to Step E10.
	No	Replace the thermostat.
Step E10, Check the Cowl Vent Air Ducts Check the cowl vent air ducts for adjustment or air leaks (if applicable). Are the cowl vent ducts OK?	Yes	If the original problem persists, review the previous steps.
	No	Service or replace as necessary.

Table 6, Test E: Improper Operation in the Function Settings

Test F: Blower Motor Does Not Operate Properly		
Test Step	**Result**	**Action to Take**
Step F1, Operate the Blower Motor Turn the key to the RUN position. Operate the blower motor through all speed ranges and check for proper blower motor operation. Is blower operation improper in some switch settings?	Yes	Go to Step F2.
	No	System OK.
Step F2, Check the Voltage to the Switch Place multimeter in VOLTS position and connect to Circuit 181 (O) at the blower motor switch connector C253. Turn the key to the RUN position and check for voltage at the blower motor switch connector. Is voltage present?	Yes	Perform a Heater Blower Motor Switch Test. Refer to Component Tests in this subject. If switch tests as damaged, replace and retest the system. If the switch tests as OK, go to Step F3.
	No	Check the fuse. If the fuse is damaged, replace and retest the system. If the fuse tests OK, locate and service the open in Circuit 181 (O). Retest the system.
Step F3, Check the Ground Circuit Connect a jumper wire from blower motor connector C231 ground terminal to a known good grounding point on the vehicle. Turn the key to the RUN position and the blower motor switch to any on position. Does blower motor run?	Yes	Service open in circuit 57 (BK). Retest the system.
	No	Go to Step F4.
Step F4, Check Circuit 825 (GY/BK) **CAUTION** **All electrical service must be interrupted when performing continuity tests. If electrical service is applied to a circuit being tested for continuity, damage to electrical test equipment may occur.** Connect ohmmeter to circuit 825 (GY/BK) between blower motor switch connector C253 and blower motor connector C231. Is continuity present?	Yes	Replace the blower motor. Retest the system. Go to Step F5.
	No	Service open in circuit 825 (GY/BK). Retest the system.
Step F5, Check the Blower Motor Resistor	Yes	GO to Step F6.
Check blower motor resistor for continuity. Is continuity present?	No	Replace the blower motor resistor. Retest the system.

Troubleshooting

Test F: Blower Motor Does Not Operate Properly		
Test Step	**Result**	**Action to Take**
Step F6, Check Circuit 268 (R/BK) Connect ohmmeter to Circuit 268 (R/BK) between blower motor switch connector C253 and blower motor connector C231. Is continuity present?	Yes	Replace the blower motor. Retest the system.
	No	Service the open in circuit 268 (R/BK). Retest the system.

Table 7, Test F: Blower Motor Does Not Operate Properly

Test G: Noise Detected While Operating the Climate Control System		
Test Step	**Result**	**Action to Take**
Step G1, Check the Heater Blower Wheel Turn blower motor on and inspect blower wheel for looseness. Is heater blower wheel loose?	Yes	Service or replace the blower wheel or blower motor.
	No	Go to Step G2.
Step G2, Check the Drive Belts and Pulleys	Yes	Go to Step G3.
Inspect the drive belt for adjustment, wear or misalignment. Check all idlers and pulleys for damage or wear. Are the belts and pulleys OK?	No	Adjust or replace the drive belt. Service or replace the idlers and pulleys as required. Correct the cause of the belt misalignment as necessary.
Step G3, Check the System Components	Yes	GO to Step G4.
Visually inspect surfaces of radiator and fan for accumulation of leaves, mud or other foreign material. Are radiator and fan clean and unobstructed?	No	Remove loose material. Use a water hose to flush debris from the surfaces. Service or replace the radiator or fan as necessary.
Step G4, Check for Cooling Fan Looseness With engine off, check cooling fan for looseness or play on shaft. Is the cooling fan OK? Is continuity present?	Yes	Inspect other heater system components or components for noise. Check the plenum, ducts, and blower wheel fan for loose debris or obstruction. Check the engine or body of the vehicle for loose brackets or components.
	No	Service or replace the cooling fan as required.

Table 8, Test G: There Is Noise While Operating The Climate Control System

Component Tests

HEATER BLOWER MOTOR SWITCH

To check the blower switch, place the switch in the OFF position and disconnect the switch from the wiring harness. Then, using a self-powered test light or ohmmeter, check for continuity between all of the terminals, two at a time. If the light goes on or the ohmmeter indicates low resistance, this will indicate a short between the terminals or an inoperative switch.

See **Table 9** while testing the heater blower motor switch.

Heater Blower Motor Switch Testing			
Test	**ohmmeter (test-light) to terminal connection**	**Switch Position**	**Good Switch Indication**
Blower Switch Circuit	181 (O) and 825 (GY/BK)	OFF	Open Circuit
		LOW	Closed Circuit
		HI	Closed Circuit
Blower Switch Circuit	181 (O) and 268 (R/BK)	OFF	Open Circuit
		LOW	Open Circuit
		HI	Closed Circuit

Table 9, Heater Blower Motor Switch Testing

General Description

The air conditioning system 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

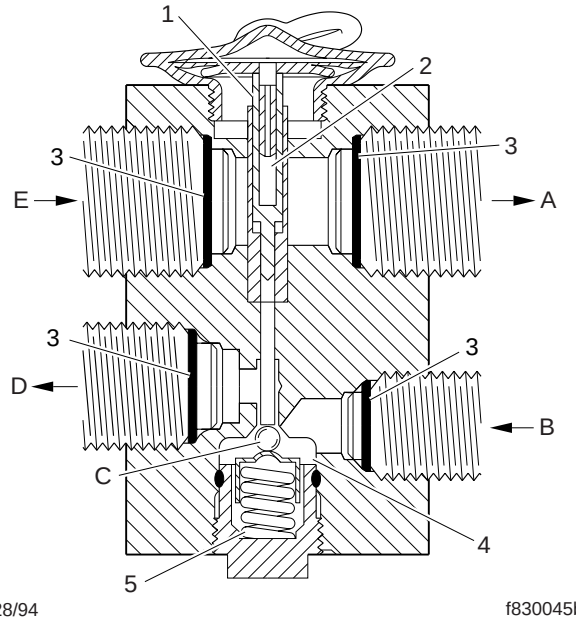
The expansion valve is a dividing point between the high-and low-pressure parts of the refrigerant system. High-pressure liquid refrigerant from the receiver-drier passes through the expansion valve and moves into the low-pressure area of the evaporator coil.

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. 1**. Through the orifice, liquid refrigerant is metered into the evaporator, as needed.

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).



A. To compressor
B. From receiver-drier
C. Bleed at ball seat
D. To evaporator
E. From evaporator
1. Diaphragm
2. Temperature Sensor
3. O-Ring
4. Metering Orifice
5. Ball and Spring

Fig. 1, Expansion Valve

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.

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.

DEFINITION OF TERMS

Refer to the following terms for a better understanding of the heater/air-conditioning system.

Air Conditioner A device used to control the temperature, humidity, and movement of air in the cab.

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.

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.

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.

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-Air Pressure Switch An air operated electrical 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 evacuate 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

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.

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

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

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.

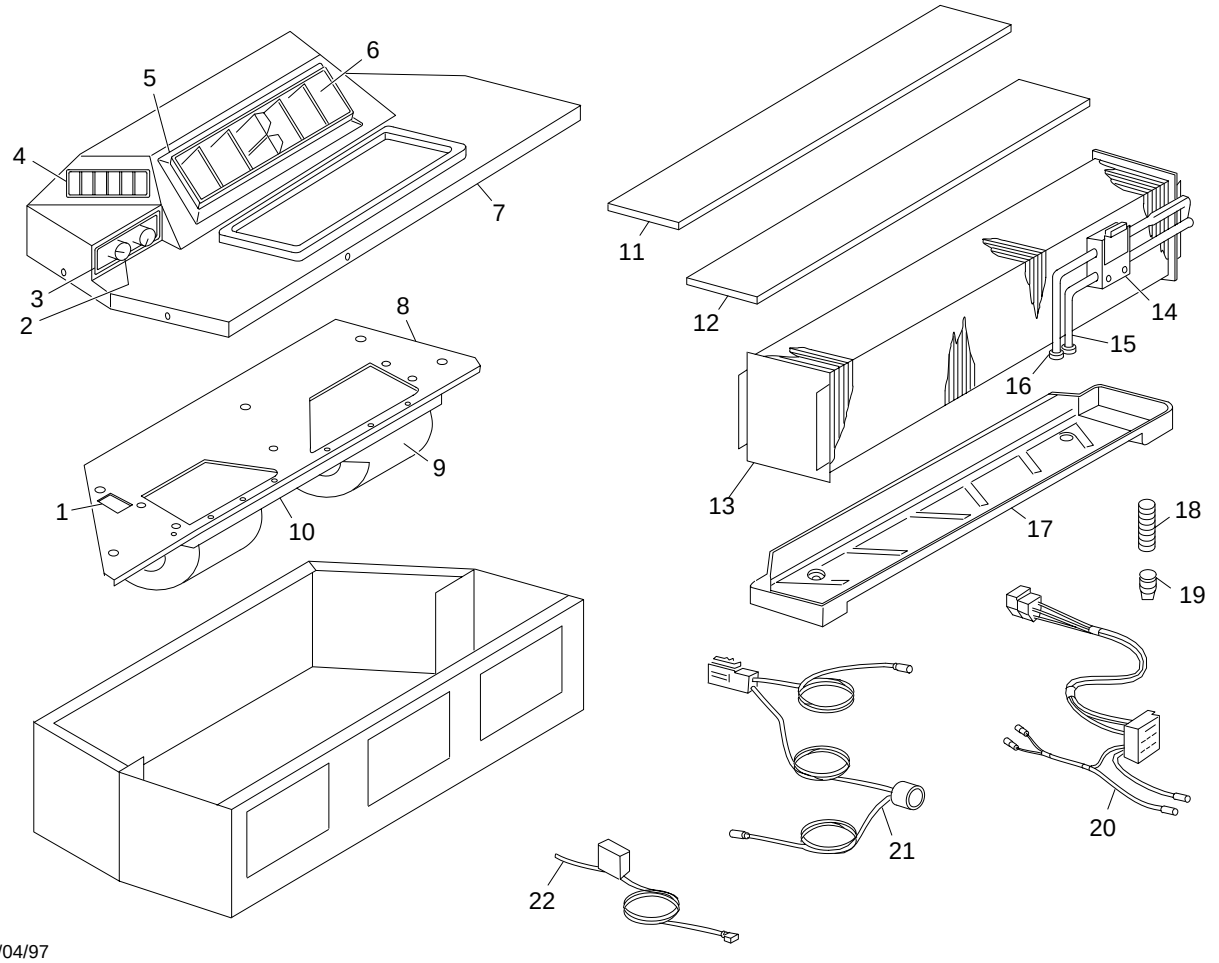
Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

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

Blower Motor Removal and Installation

Removal (See Fig. 1)



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1. Blower Speed Resistor
2. Knob, Blower and Thermostat Switches
3. Switch Plate
4. Register Assembly
5. Frame
6. Louver Assembly
7. A/C Unit Cover
8. Blower Mounting Plate
9. Blower Wheel
10. Blower Motor
11. Gasket, Evaporator Coil Top
12. Gasket, Evaporator Coil Top
13. Evaporator Coil
14. Expansion Valve
15. Low Pressure Line
16. High Pressure Line
17. Evaporator Drain Pan
18. Drain Tube
19. Check Valve
20. Wire Harness, Blower Motor and Resistor
21. Wire Harness, Compressor Clutch
22. Wire Harness, Power Source

Fig. 1, Evaporator Assembly

Blower Motor Removal and Installation

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.

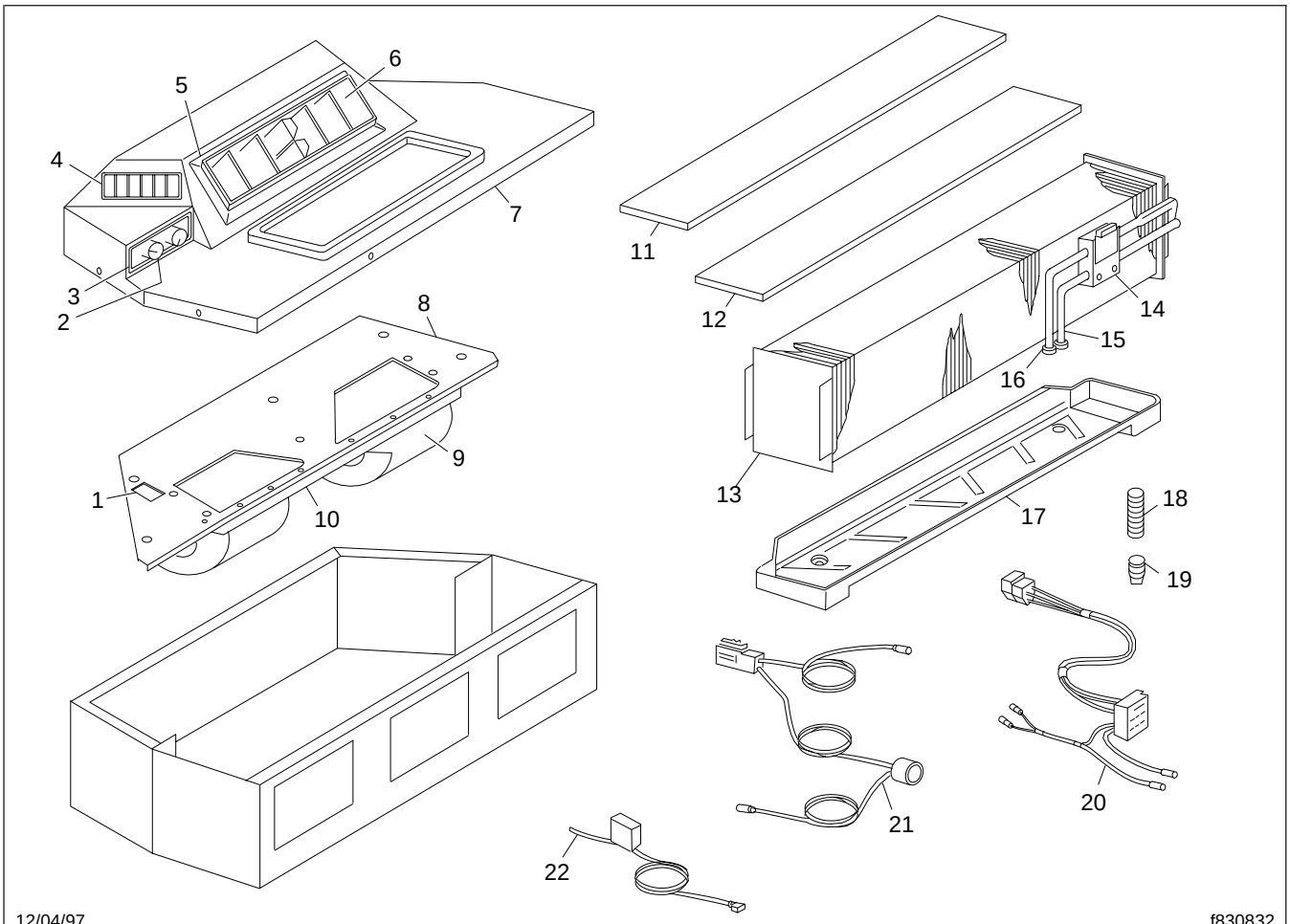
1. Apply the parking brake and chock the tires.
2. Disconnect the batteries.
3. Remove the five screws from the top of the A/C unit and remove the cover.
4. Remove the wire harness screws and disconnect the blower motor leads.
5. Remove the probe from evaporator.
6. Remove the four screws from the blower mounting plate.
7. Pull up on the adhesive strip attached to the evaporator.
8. Remove the blower mounting plate.
9. Remove the blower motor harness grommet, and disconnect the blower motor power lead.
10. Remove the twelve screws holding the housing together and remove the housing cover.
11. Remove the blower motor assembly.

Installation (See Fig. 1)

1. Position the blower motor assembly in the housing.
2. Position the housing cover and install the twelve cover screws.
3. Connect the blower motor power lead and install the blower motor harness grommet.
4. Position the blower mounting plate in the case and install the four screws.
5. Position the probe in the evaporator coil.
6. Connect the blower motor leads and install the wire harness screws.
7. Install the A/C unit cover.
8. Connect the batteries.
9. Remove the chocks.

Blower Speed Resistor Replacement

Replacement (See Fig. 1)



1. Blower Speed Resistor
2. Knob, Blower and Thermostat Switches
3. Switch Plate
4. Register Assembly
5. Frame
6. Louver Assembly
7. A/C Unit Cover
8. Blower Mounting Plate
9. Blower Wheel
10. Blower Motor
11. Gasket, Evaporator Coil Top
12. Gasket, Evaporator Coil Top
13. Evaporator Coil
14. Expansion Valve
15. Low Pressure Line
16. High Pressure Line
17. Evaporator Drain Pan
18. Drain Tube
19. Check Valve
20. Wire Harness, Blower Motor and Resistor
21. Wire Harness, Compressor Clutch
22. Wire Harness, Power Source

Fig. 1, Evaporator Assembly

Blower Speed Resistor Replacement

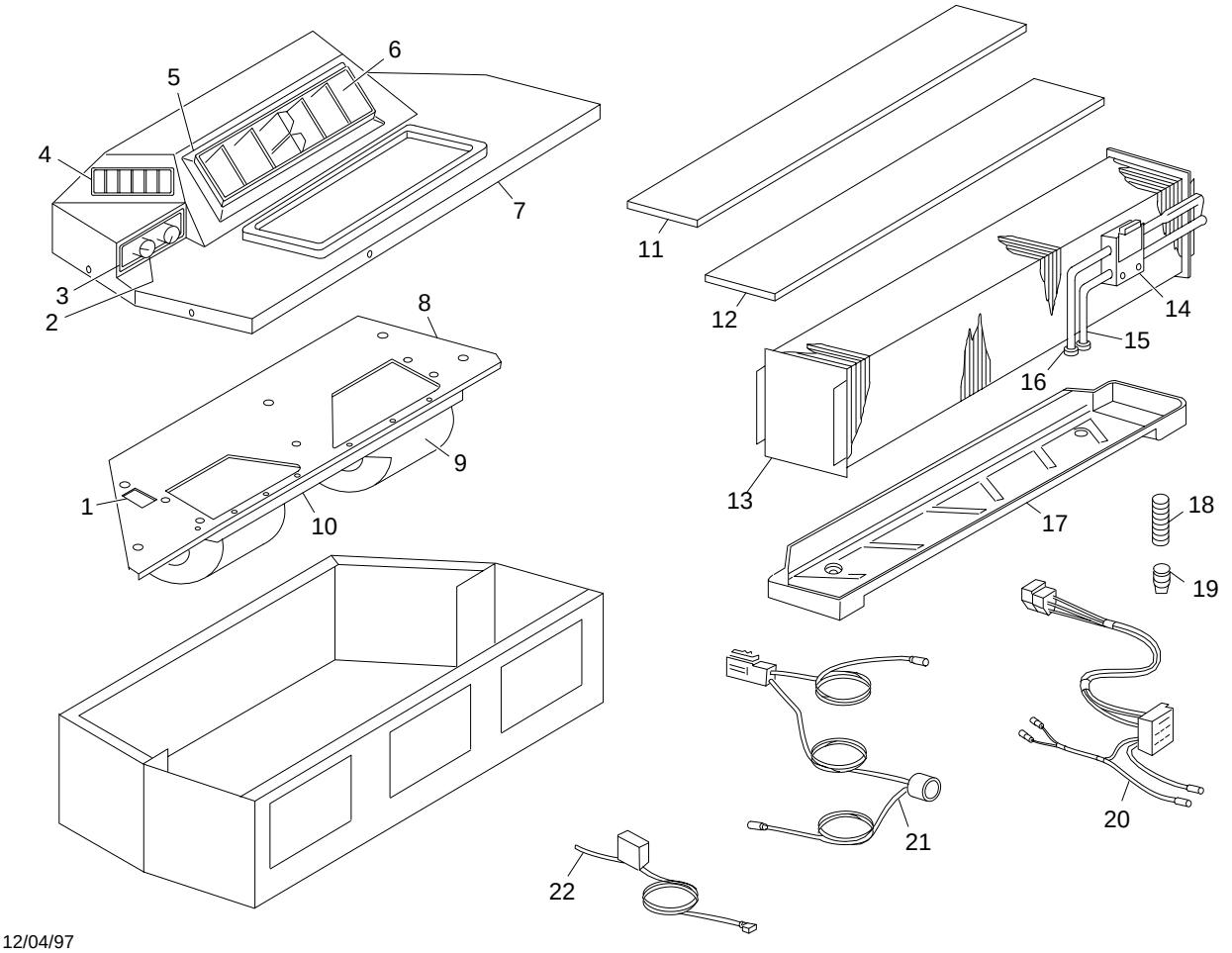
⚠ WARNING

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. Apply the parking brake and chock the tires.
2. Disconnect the batteries.
3. Remove the five screws from the top of A/C unit and remove the cover.
4. Remove the wire harness screws and disconnect the blower motor leads.
5. Remove the probe from the evaporator.
6. Disconnect the connector from the resistor block.
7. Remove the wire harness screw from the resistor block.
8. Remove the remaining screw from the resistor block.
9. Remove the blower speed resistor.
10. Position the new blower speed resistor in place.
11. Install the mounting screws.
12. Connect the connector to the resistor block.
13. Position the probe in the evaporator coil.
14. Connect the blower motor leads and install the wire harness screws.
15. Install the A/C unit cover.
16. Connect the batteries.
17. Remove chocks.

Evaporator Coil Removal and Installation

Removal (See Fig. 1)



1. Blower Speed Resistor
2. Knob, Blower and Thermostat Switches
3. Switch Plate
4. Register Assembly
5. Frame
6. Louver Assembly
7. A/C Unit Cover
8. Blower Mounting Plate
9. Blower Wheel
10. Blower Motor
11. Gasket, Evaporator Coil Top
12. Gasket, Evaporator Coil Top
13. Evaporator Coil
14. Expansion Valve
15. Low Pressure Line
16. High Pressure Line
17. Evaporator Drain Pan
18. Drain Tube
19. Check Valve
20. Wire Harness, Blower Motor and Resistor
21. Wire Harness, Compressor Clutch
22. Wire Harness, Power Source

Fig. 1, Evaporator Assembly

NOTE: Always replace the receiver-drier after opening the A/C system.

Evaporator Coil Removal and Installation

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.

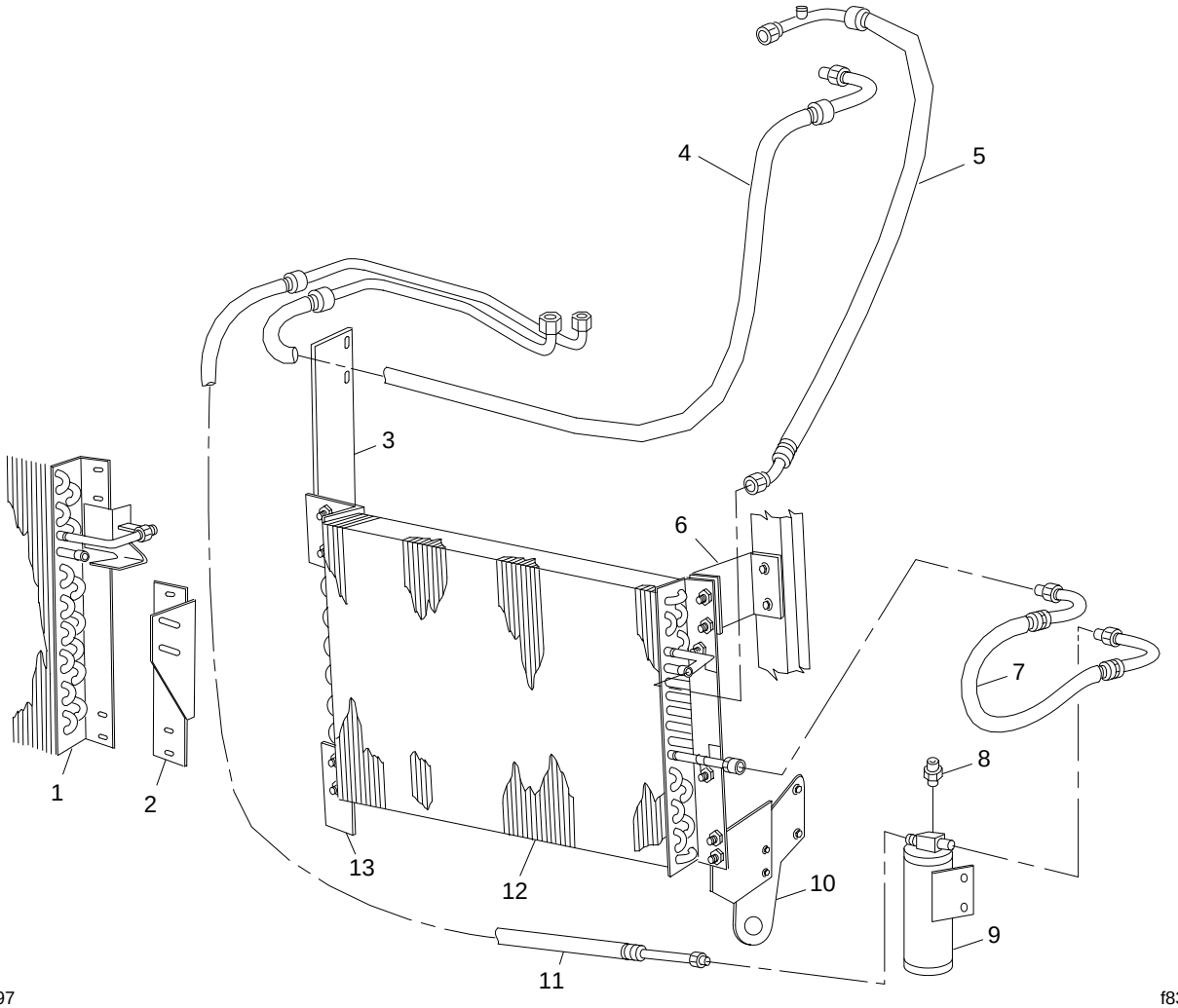
1. Remove the A/C unit from the vehicle. For instructions, refer **Subject 170**.
2. Remove the A/C unit cover.
3. Remove the blower mounting plate.
4. Remove the four screws.
5. Remove the screws attaching the expansion valve to the case.
6. Remove the grommets.
7. Seperate the expansion valve and evaporator coil.
8. Remove the refrigerant lines from both sides of expansion valve .

Installation (See Fig. 1)

1. Replace the O-rings on the refrigerant lines.
2. Position and tighten the refrigerant lines on expansion valve .
3. Position the expansion valve to the evaporator.
4. Install the grommets.
5. Install the expansion valve screws.
6. Install the four screws.
7. Install the blower mounting plate.
8. Install the A/C unit cover.
9. Install the A/C unit into the vehicle. For instructions, refer to **Subject 170**.

Low Pressure Refrigerant Lines Removal and Installation

Removal (See Fig. 1)



1. Condenser
2. Receiver-Drier Bracket
3. Condenser Mounting Bracket (upper right)
4. Refrigerant Line (evaporator to compressor)
5. Refrigerant Line (compressor to condenser)
6. Condenser Mounting Bracket (upper left)
7. Refrigerant Line (condenser to receiver-drier)
8. Low Pressure Switch
9. Receiver-Drier
10. Condenser Mounting Bracket (lower left)
11. Refrigerant Line (receiver-drier to evaporator)
12. Condenser
13. Condenser Mounting Bracket (lower right)

Fig. 1, Condenser and Refrigerant Line Assemblies

NOTE: Always replace the receiver-drier after opening the A/C system.

Low Pressure Refrigerant Lines Removal and Installation

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. Apply the parking brake and chock the tires.
2. Disconnect the batteries.
3. Discharge the A/C system. For instructions, refer to **Subject 200**.
4. Disconnect the low pressure refrigerant line at the evaporator.
5. Disconnect the low pressure refrigerant lines at the frame.
6. Disconnect the low pressure refrigerant line at the compressor.
7. Remove the nuts from the low pressure refrigerant lines retainer clips.
8. Remove the low pressure refrigerant lines from the vehicle.

Installation (See Fig. 1)

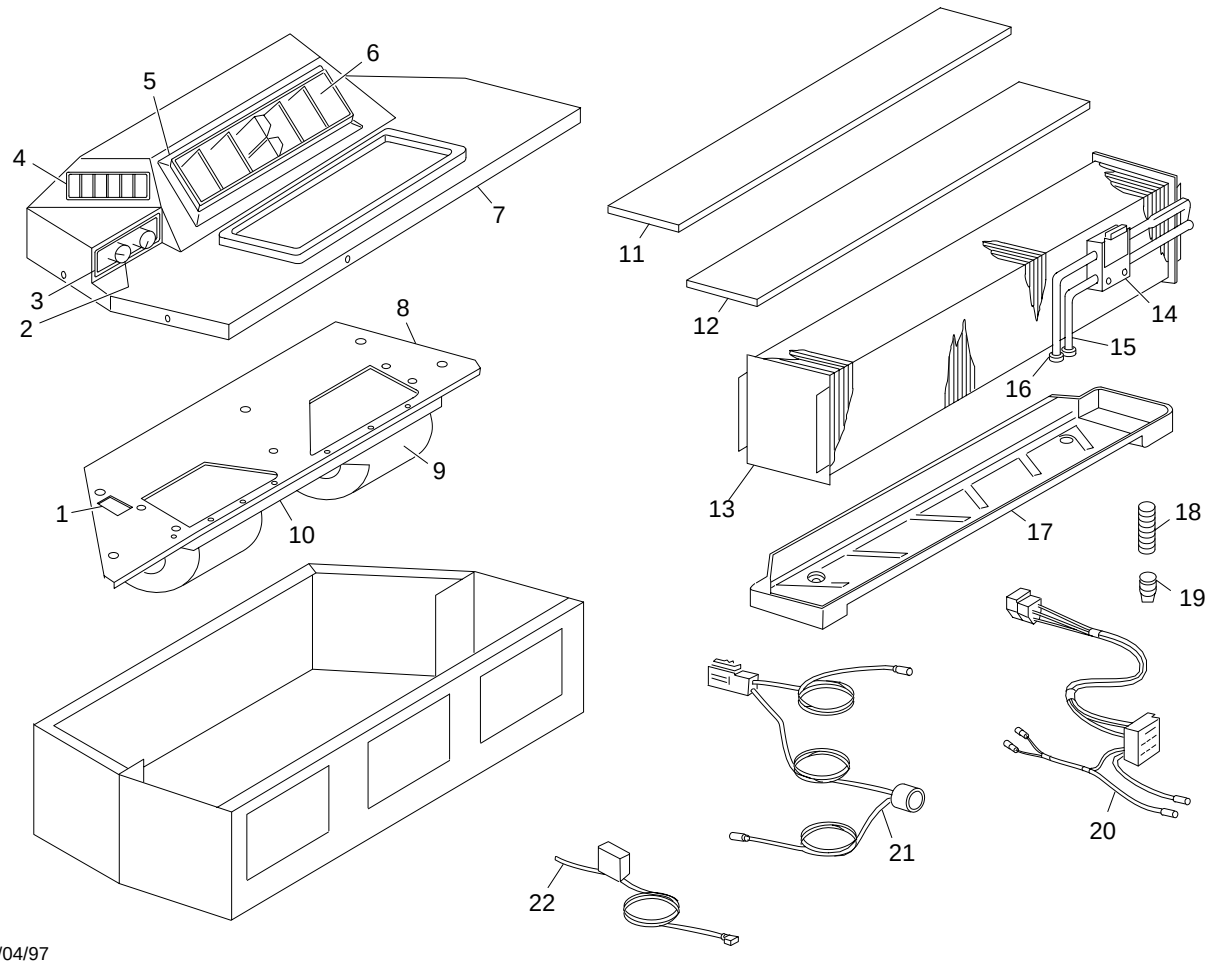
1. Replace the O-rings on the low pressure refrigerant lines.
2. Position the low pressure refrigerant lines and connect at the evaporator, the compressor and the frame. Do not tighten completely at this time.
3. Install and tighten the low pressure refrigerant lines retainer clip nuts.
4. Tighten the low pressure refrigerant line at the evaporator, the compressor and the frame.
5. Recharge the A/C system. For instructions, refer to **Subject 200**.
6. Connect the batteries.
7. Remove the chocks.

Expansion Valve Removal and Installation

Removal

See **Fig. 1** for an illustration of the evaporator assembly.

NOTE: Always replace the receiver-drier after opening the A/C system.



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1. Blower Speed Resistor
2. Knob, Blower, and Thermostat Switches
3. Switch Plate
4. Register Assembly
5. Frame
6. Louver Assembly
7. A/C Unit Cover
8. Blower Mounting Plate
9. Blower Wheel
10. Blower Motor
11. Gasket, Evaporator Coil Top
12. Gasket, Evaporator Coil Top
13. Evaporator Coil
14. Expansion Valve
15. Low Pressure Line
16. High Pressure Line
17. Evaporator Drain Pan
18. Drain Tube
19. Check Valve
20. Wire Harness, Blower Motor and Resistor
21. Wire Harness, Compressor Clutch
22. Wire Harness, Power Source

Fig. 1, Evaporator Assembly

Expansion Valve Removal and Installation

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. Remove the A/C unit from vehicle. For instructions, see **Subject 170**.
2. Remove the A/C unit cover.
3. Remove the blower mounting plate.
4. Remove the four screws.
5. Remove the screws attaching the expansion valve to the case.
6. Remove the grommets.
7. Separate the expansion valve and evaporator coil.
8. Remove the refrigerant lines from both sides of expansion valve.

Installation

1. Replace the O-rings on the refrigerant lines.
2. Position and tighten the refrigerant lines on the expansion valve.
3. Position the expansion valve to the evaporator.
4. Install the grommets.
5. Install the expansion valve screws.
6. Install the four screws.
7. Install the blower mounting plate.
8. Install the A/C unit cover.
9. Install the A/C unit into the vehicle. For instructions, see **Subject 170**.

Refrigerant Compressor Removal and Installation

Removal

NOTE: Always replace the receiver-drier after opening the A/C system.

⚠ 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. Apply the parking brake and chock the tires
2. Disconnect the batteries.
3. Discharge the A/C system. For instructions, refer to **Subject 200**.
4. Remove the drive belt.
5. Remove and plug both refrigerant lines.
6. Disconnect the power lead going to the refrigerant compressor clutch.
7. Remove the four refrigerant compressor mounting bolts and remove the refrigerant compressor.

Installation

Replace the O-rings when reconnecting the A/C system refrigerant lines. Lubricate the O-rings with compressor oil.

1. Position the refrigerant Compressor and install the four bolts.
2. Connect the power lead to the refrigerant compressor clutch.
3. Remove the plugs and install the refrigerant lines.
4. Install the drive belt.
5. Recharge the A/C system. For instructions, refer to **Subject 200**.
6. Connect the batteries.
7. Remove the chocks.

A/C Unit Removal and Installation

Removal

NOTE: Always replace the receiver-drier after opening the A/C system.

⚠ 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.

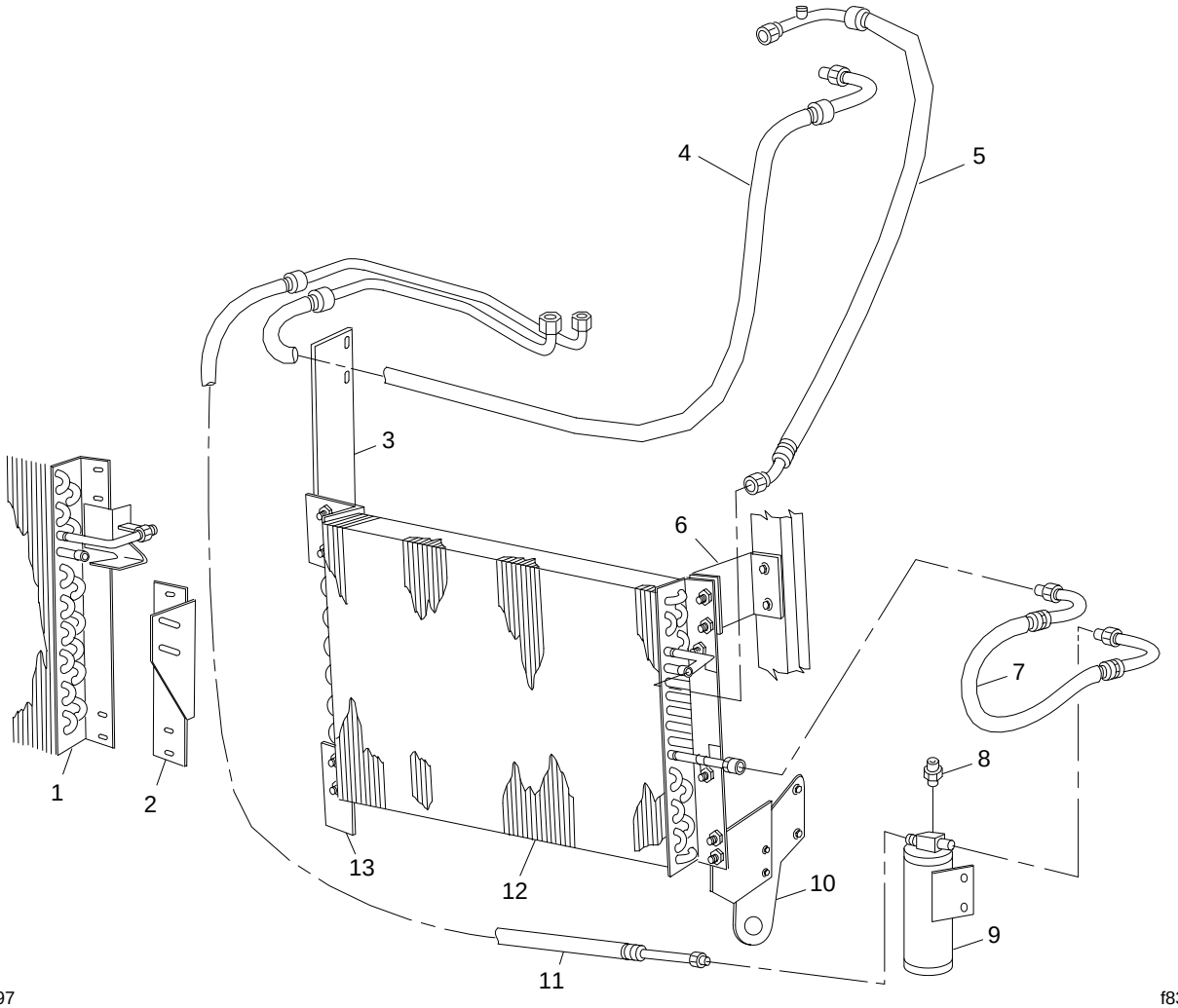
1. Apply the parking brake and chock the tires.
2. Disconnect the batteries.
3. Tilt the cab.
4. Discharge the system. For instructions, refer to **Subject 200**.
5. Disconnect the refrigerant lines.
   - 5.1 Remove the sealant from the refrigerant line fittings.
   - 5.2 Disconnect and plug the refrigerant lines.
6. Lower the cab.
7. Disconnect the electrical connector.
8. Remove the three retaining nuts from the A/C unit base.
9. Remove the A/C unit from the cab.

Installation

1. Position the A/C unit in the cab.
2. Install the three retaining nuts to the A/C unit base.
3. Connect the electrical connector.
4. Tilt the cab.
5. Connect the evaporator lines.
   - 5.1 Connect and tighten the refrigerant lines.
   - 5.2 Apply sealant to the refrigerant line fittings.
6. Recharge the A/C system. For instructions, refer to **Subject 200**.
7. Lower the cab.
8. Connect the batteries.
9. Remove the chocks.

Receiver-Drier Removal and Installation

Removal (See Fig. 1)



1. Condenser
2. Receiver-Drier Bracket
3. Condenser Mounting Bracket (upper right)
4. Refrigerant Line (evaporator to compressor)
5. Refrigerant Line (compressor to condenser)
6. Condenser Mounting Bracket (upper left)
7. Refrigerant Line (condenser to receiver-drier)
8. Low Pressure Switch
9. Receiver-Drier
10. Condenser Mounting Bracket (lower left)
11. Refrigerant Line (receiver-drier to evaporator)
12. Condenser
13. Condenser Mounting Bracket (lower right)

Fig. 1, Condenser and Refrigerant Line Assemblies

Receiver-Drier Removal and Installation

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. Apply the parking brake and chock the tires.
2. Disconnect the batteries.
3. Discharge the system. For instructions, refer to **Subject 200**.
4. Disconnect the refrigerant lines from the receiver-drier and plug the lines.
5. Remove the receiver-drier.

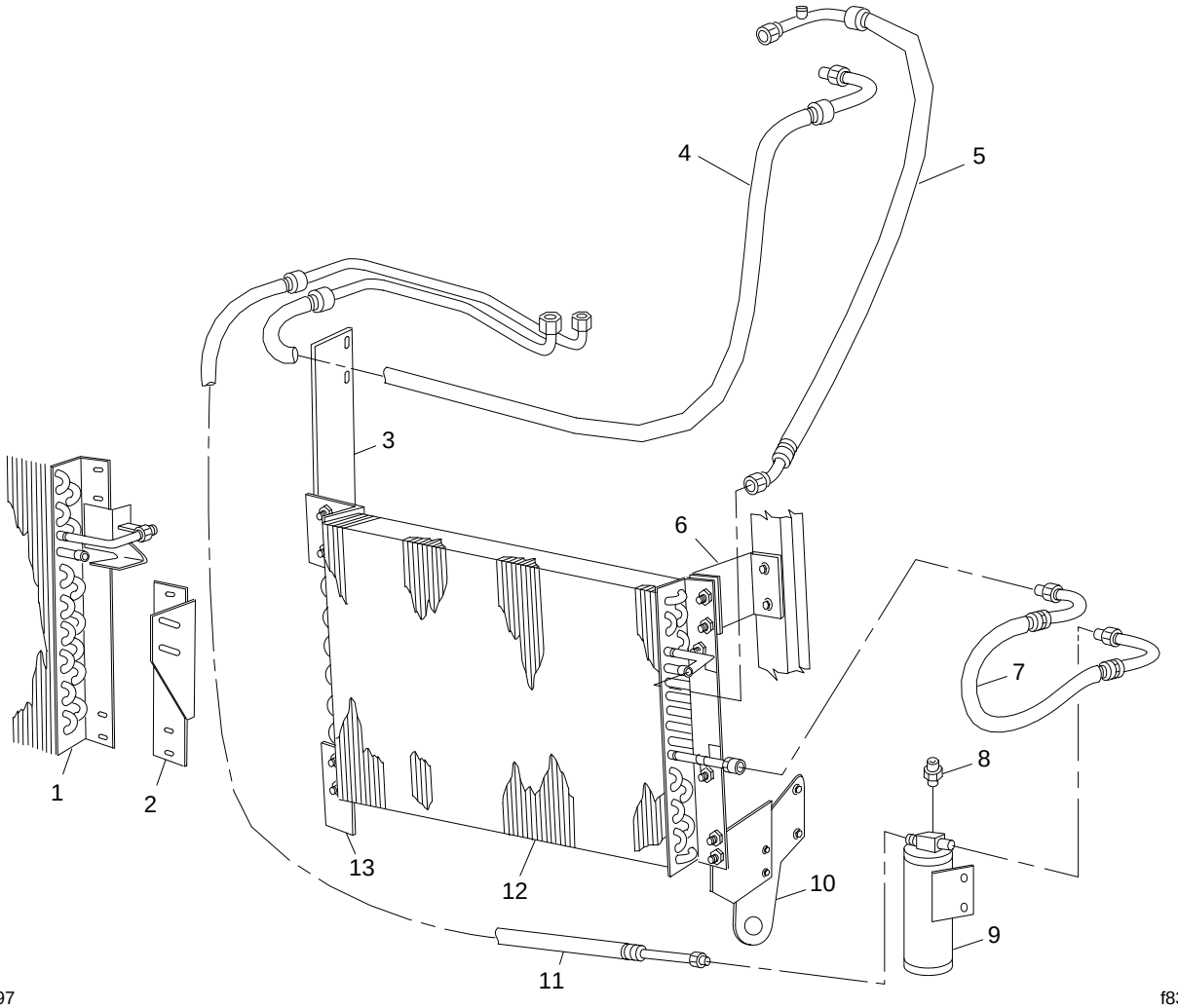
Installation (See Fig. 1)

1. Install the receiver-drier.
2. Lubricate the refrigerant line O-rings with refrigerant oil and connect the lines to the receiver-dryer.

NOTE: Add two ounces of refrigerant oil to the system for each component replaced.

3. Evacuate and charge the A/C system and leak test. For instructions, refer to **Subject 200**.
4. Lower the cab.
5. Connect the batteries.
6. Remove the chocks.

Removal (See Fig. 1)



1. Condenser
2. Receiver-Drier Bracket
3. Condenser Mounting Bracket (upper right)
4. Refrigerant Line (evaporator to compressor)
5. Refrigerant Line (compressor to condenser)
6. Condenser Mounting Bracket (upper left)
7. Refrigerant Line (condenser to receiver-drier)
8. Low Pressure Switch
9. Receiver-Drier
10. Condenser Mounting Bracket (lower left)
11. Refrigerant Line (receiver-drier to evaporator)
12. Condenser
13. Condenser Mounting Bracket (lower right)

Fig. 1, Condenser and Refrigerant Line Assemblies

NOTE: Always replace the receiver-drier after opening the A/C system.

Condenser Removal and Installation

⚠ 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. Apply the parking brake and chock the tires
2. Disconnect the batteries.
3. Tilt the cab.
4. Discharge the system. For instructions, refer to **Subject 200**.
5. Disconnect the refrigerant lines from the condenser and plug the lines and condenser ports.
6. Remove the receiver-drier. For instructions, refer to **Subject 180**.
7. Remove the clamp that holds the refrigerant lines to the right side of the radiator assembly.
8. Remove the condenser mounting nuts.
9. Remove the lower left condenser mounting bracket from the radiator.
10. Tilt the top of the condenser forward and remove the receiver-dryer mounting bracket.
11. Slide the condenser up to remove it from the vehicle.

Installation (See Fig. 1)

1. Position the condenser on the mounting studs.
2. Tilt the top of the condenser forward and install the receiver/drier mounting bracket.
3. Install the lower left condenser mounting bracket on the radiator.
4. Install the condenser retaining nuts.
5. Install the clamps holding the refrigerant lines to the right side of the radiator assembly.
6. Install the receiver-drier, For instructions, refer to **Subject 180**.
7. Lubricate the refrigerant line O-rings with refrigerant oil and connect the lines to the condenser.

NOTE: Add two ounces of refrigerant oil to the system for each component replaced.

8. Evacuate and charge the A/C system and leak test. For instructions, refer to **Subject 200**.
9. Lower the cab.
10. Connect the batteries.
11. Remove the chocks.

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 cab.
2. If equipped with a swashplate-type compressor, start the engine and run the air conditioning system for five minutes. Shut down the engine.
3. Remove the caps from the suction and discharge service valves.
4. Wearing protective goggles and nonleather gloves, attach the recover/recycling station 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.

   4.1 Make sure that the recovery and recycling station valves are closed.

   4.2 Connect the red high-side hose to the discharge service valve.

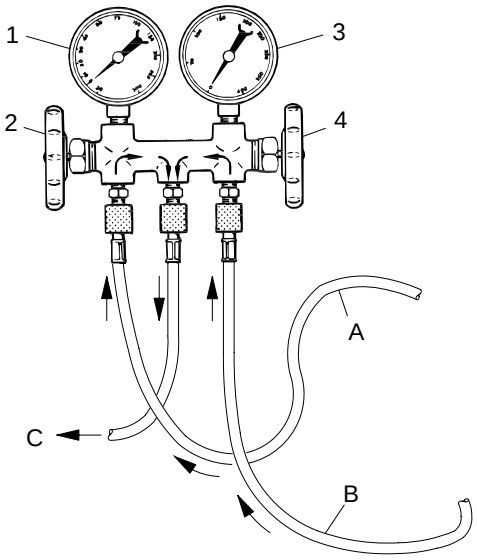
   4.3 Connect the blue low-side hose to the suction service valve.

   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.
7. Return the cab to the operating position.



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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. 1, Attaching the Recover/Recycling Station

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

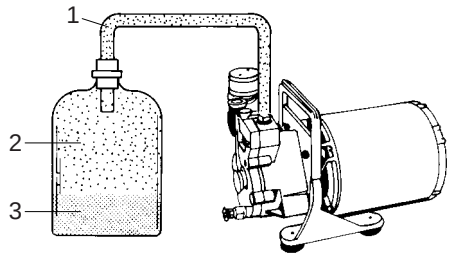
Recovery, Evacuating/Recycling, Purging and Flushing, Charging, and Leak Testing

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.

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. 2**. 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.



1. Vapor
2. Vapor
3. Water

Fig. 2, 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 734 mmHg (28.89 inHg), 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).

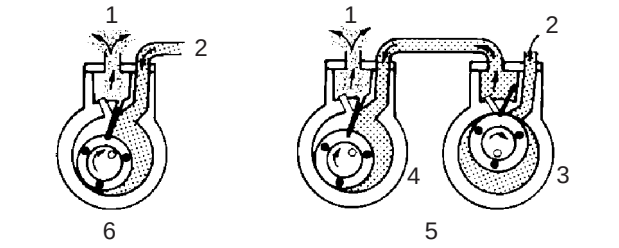
Water Boiling Temperatures at Converted Pressures		
Boiling Temperature of Water °F (°C)	**Absolute Pressure psi (microns)**	**Vacuum inHg (mmHg)**
212 (100)	14.696 (759993.4)	0 (0)
205 (96)	12.770 (660400.0)	99.6 (3.92)
194 (90)	10.169 (523881.6)	9.22 (234.2)
176 (80)	6.8699 (355269.8)	15.93 (404.6)
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 (32)	0.61540 (31826.2)	28.67 (728.2)
86 (30)	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)	28.87 (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 (12.6)	29.92050 (759.9807)
–90 (–68)	0.0000526 (2.72)	29.92089 (759.9906)

Table 1, Water Boiling Temperatures at Converted Pressures

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 (727 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 is adequate, but a two-stage is recommended to save time and ensure complete evacuation. See **Fig. 3**.



1. Exhaust
2. Intake
3. First
4. Second
5. Two-Stage Pump
6. Single-Stage Pump

Fig. 3, High Vacuum Pumps

Most single-stage high-vacuum pumps with a gas ballast will pull down to about 29.88 inHg (734 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 29.9196 inHg (760 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**.

Suggested Minimum CFM	
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, Suggested Minimum CFM

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, which are not practical for service shops.

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 pre-

vent moisture build up 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 sets 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 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 hoses to the valves.

   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 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 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 not 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.

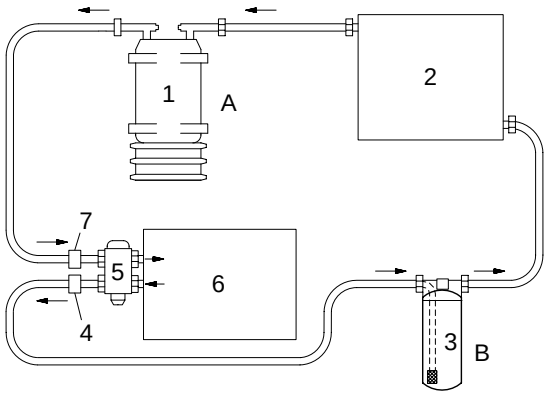
If the system is heavily contaminated, or if desiccant has circulated through the system, replace the receiver-drier, expansion valve, and compressor.

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. 4**.

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.



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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. 4, Purge and Flush Points

Purging Procedure

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. See **Fig. 5**.
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 one to two 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.

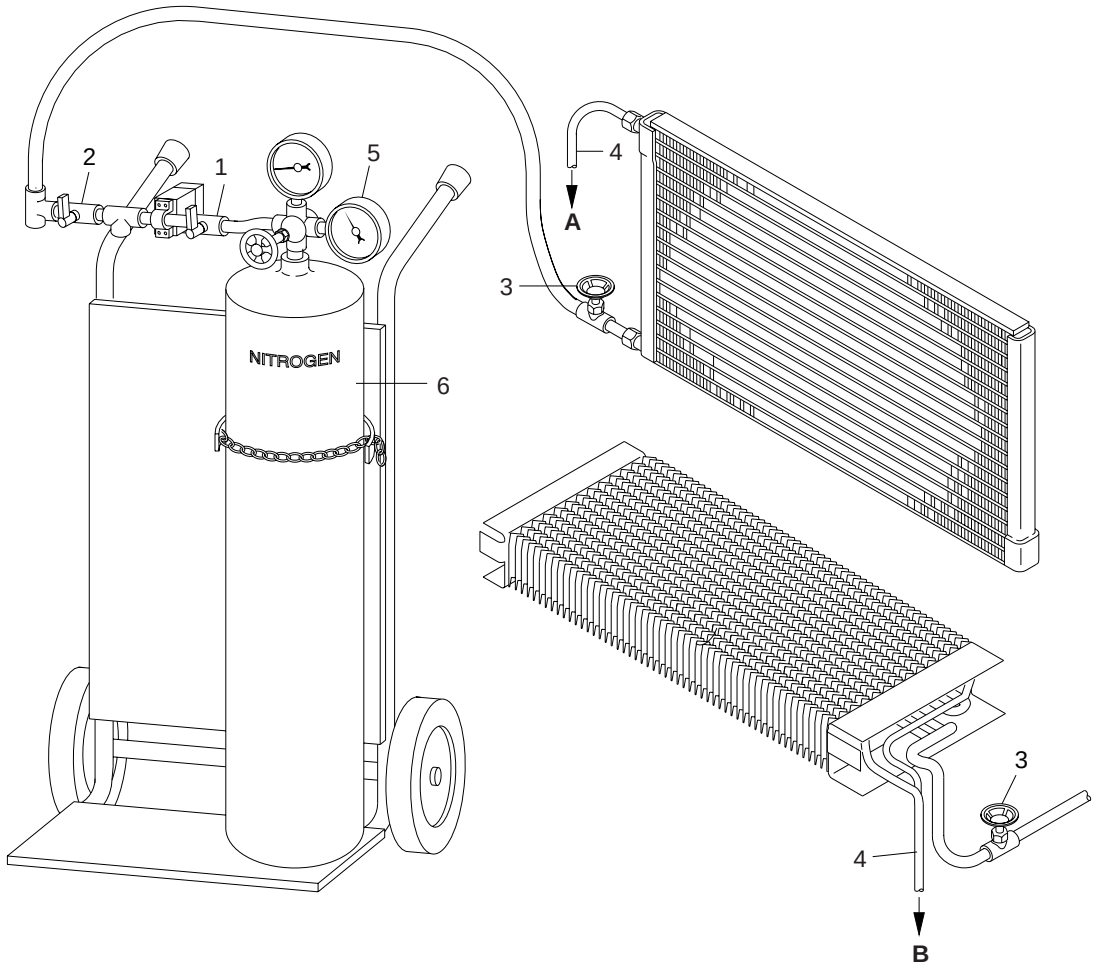
Flushing Procedure

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.

Recovery, Evacuating/Recycling, Purging and Flushing, Charging, and Leak Testing



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A. To waste container.
1. Nitrogen Bottle Control Valve
2. Purging Control Valve
3. Supply Line Valve
B. To recycling system container.
4. Drain Line
5. Nitrogen Bottle Regulator/Gauge
6. Nitrogen Bottle

Fig. 5, Purging Station

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. 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.

   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. Refer to the applicable compressor section in this manual. If the operating pressures are not acceptable, refer to **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 Methods

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 take precautions against 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.

There are two leak testing methods that can be used to detect leaks in the A/C system: UV (ultraviolet) dye leak detection and electronic leak detection. Freightliner recommends using the UV dye leak detection method whenever possible, even though there are some limitations to using this method. A leak on the front seal of the compressor **must** be verified using a heated diode leak detector and the instructions in this subject. Visible dye on the front of the compressor clutch **does not** verify that there is a leak at the front seal. Evaporator leaks may not show up with dye, and must be checked using a heated diode leak detector if dye is not present at the condensate drain.

Determine if the A/C System Contains UV Dye

IMPORTANT: Always wear UV-blocking protective eyewear when using the UV dye leak detec-

tion method. Always wear nonleather gloves and protective eyewear when servicing the air conditioning system.

1. Check under the hood for a label indicating that a UV dye has been added to the A/C system. On new Freightliner models, the label on the receiver-drier may be marked with "Contains Tracer Wafer."
2. Remove the low-side service port sealing cap, and direct the UV lamp to the valve stem area.
3. If UV dye is observed in the low-side service port, assume that a UV dye is in the system, and leak test the A/C system using the UV dye leak detection method.
4. If UV dye is not observed, depress the valve stem for an instant to bring some of the lubricant and dye out of the system. This can be safely accomplished using a modified service valve cap. See the instructions in "Modify the Service Valve Cap."

NOTE: Clean the modified valve cap after finding dye to avoid contaminating the next vehicle.

5. If no UV dye is observed in the low-side service port, use an electronic leak detector to leak test the A/C system, or add UV dye to the A/C system using the dye manufacturer's instructions.
6. If UV dye is being added to the A/C system, use the following instructions.
    - 6.1 Inject the amount of dye recommended by the dye manufacturer into the A/C system.
    - 6.2 Place a label under the hood, preferably next to the charge label, that indicates dye has been added to the A/C system.
    - 6.3 Verify that the A/C system has the correct amount of refrigerant.
    - 6.4 Run the air conditioner for at least 15 minutes to find large leaks. It may take as long as two weeks to detect small leaks using the UV dye leak detection method.

UV Dye Leak Detection

IMPORTANT: Always wear UV-blocking protective eyewear when using the UV dye leak detection method. Always wear nonleather gloves and protective eyewear when servicing the air conditioning system.

1. Inspect the A/C system for leaks using a UV lamp.
    - 1.1 Inspect the entire A/C system under low lighting using a UV lamp. Low lighting will increase the apparent brightness of the UV dye at leak sights.
    - 1.2 Move the UV lamp along the entire refrigerant system, looking for signs of damage or corrosion on the fittings, hose-to-line crimps, switch ports, service ports with caps installed (dye inside the port is not an indication of a leak), brazed or welded areas, and around all connections. Check for evaporator leaks by illuminating the condensate drain tube or hole using the UV lamp.
    - 1.3 Move the UV lamp along the refrigerant system following a continuous path so that no potential leak sites are missed. If a leak is found, continue to check the remainder of the system since other leaks may be present.
2. After repairing a leak, remove all UV dye residue remaining on the outside of the A/C system using the cleaner provided by the dye manufacturer, or a comparable cleaner. Use a spray bottle of cleaner, a toothbrush, and a spray bottle of clean water for hard-to-reach areas.

NOTE: Minor UV dye residue, or residue that is impossible to reach, will lose its fluorescence.

3. See **Table 3** for a list of products that have been tested and approved for use by Freightliner dealers.

Modify the Service Valve Cap

Use the following instructions to modify a service valve cap that will depress a Schrader valve.

1. Purchase a low-side service valve cap, part number PH 660412.
2. Locate the small, 0.145-inch diameter (3.7-mm) barrel inside the cap.

Approved Products for UV Dye Leak Detection				
Type of Refrigerant Oil	**Product Description**	**Vendor Part Number**	**Freightliner Part Number**	**Website Address**
PAG	Tracerline BigEZ Kit—Can be injected without discharging the system. • Each kit includes one 4-oz (118-mL) cartridge and an injection tool.	TP-9741CS	ABP N83 327911	www.tracerline.com
	• A 4-oz (118-mL) replacement cartridge services 16 vehicles.	TP-9760-0004CS	ABP N83 327961	
	• An 8-oz (237-mL) replacement cartridge services 32 vehicles.	TP-9760-0108	ABP N83 327951	
POE/ universal	Tracerline BigEZ Kit—Can be injected without discharging the system. • Each kit includes one 4-oz (118-mL) cartridge and an injection tool.	TP-9742CS	ABP N83 327910	www.tracerline.com
	• A 4-oz (118-mL) replacement cartridge services 16 vehicles.	TP-9770-0004CS	ABP N83 327950	
	• An 8-oz (237-mL) replacement cartridge services 32 vehicles.	TP-9770-108	ABP N83 327960	
—	Tracerline Optimax UV Lamp	TP-8680	ABP N83 327985	www.tracerline.com
—	Bright Solutions UV Lamp	BSL760	ABP N83 327967	www.brightsol.com
—	Service Valve Cap	—	PH 660412	—

Table 3, Approved Products for UV Dye Leak Detection

3. Fill the barrel to within 0.25 inch (6 mm) of its rim with epoxy, felt material, or wadded paper.
4. Mark the cap with the words "Do Not Use."

Electronic Leak Detection

When checking for leaks, move the probe all the way around the fitting or suspected leak.

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.

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 4**.

Recovery, Evacuating/Recycling, Purging and Flushing, Charging, and Leak Testing

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	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 4, Electronic Leak Detectors

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**.

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 (345 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 tube 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.

NOTE: The presence of water in the condensate drain tube can be determined by inserting the eraser end of a pencil in the drain tube. Inserting the pencil will break the surface tension of any water near the opening of the drain tube and allow the water to drain out before inserting the probe tip. It is only necessary to break the plane of the drain tube with the probe tip. It doesn't need to be inserted far into the tube.

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 axial-type compressors (Sanden or Sel-Tec) by placing the probe near the holes at the front of the clutch. See **Fig. 6**. Inspect two-cylinder reciprocating type compressors (Climate Control) by placing the probe between the clutch coil and the compressor. See **Fig. 7**.

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.

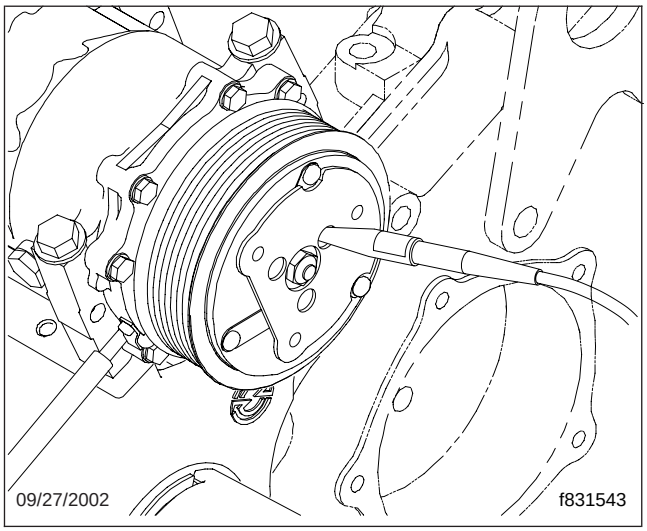


Fig. 6, Axial Type Compressor

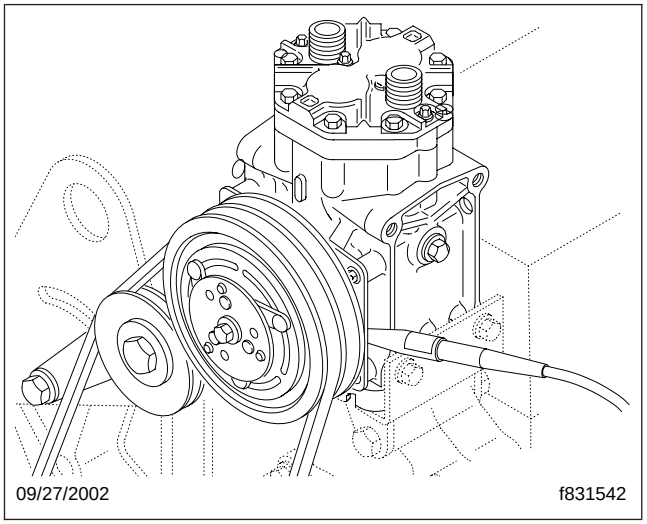


Fig. 7, Two-Cylinder Reciprocating Compressor

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.
2. Using a feeler gauge, check for correct refrigerant compressor clutch clearance.
3. Check for broken, burst, or cut hoses; also check for loose fittings on all parts.
4. Check for road debris build-up 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.

COOLING CHECK

IMPORTANT: 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 1** below. If the duct's air temperature is higher than normal readings, the system isn't cooling enough. For possible causes, see the troubleshooting tables.

Temperature/Pressure Specifications				
Relative Humidity	**Outside Air Temperature: °F (°C)**	**Maximum Center Console Outlet Temperature: °F (°C)**	**With Compressor Running**	
			Low Pressure: psi (kPa)	**High Pressure: psi (kPa)**
Low (40%)	75 (24)	39 (4)	14 (97)	140 (965)
	85 (29)	39 (4)	15 (103)	166 (1145)
	100 (38)	40 (5)	16 (110)	218 (1503)
High (90%)	75 (24)	38 (3)	14 (97)	130 (896)
	85 (29)	39 (4)	16 (110)	160 (1103)
	100 (38)	40 (5)	18 (124)	220 (1517)

Table 1, Temperature/Pressure Specifications

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.

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** in 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 build-up.

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 build-up) 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** in this manual for cooling system troubleshooting and to the engine manufacturer's service manual for other details about cooling system problems.

THERMOSTATIC SWITCH

IMPORTANT: 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.
2. Start the engine. Place the air conditioner control at its coldest setting; turn on the air conditioner and the fan.
3. 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).
4. If the compressor did not engage when the temperature was above the accepted high range, check the thermostatic switch and its wiring.

   4.1 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.

   4.2 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.

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 build-up 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. 1** for the fault analysis flow chart.

Troubleshooting Tables

Troubleshooting

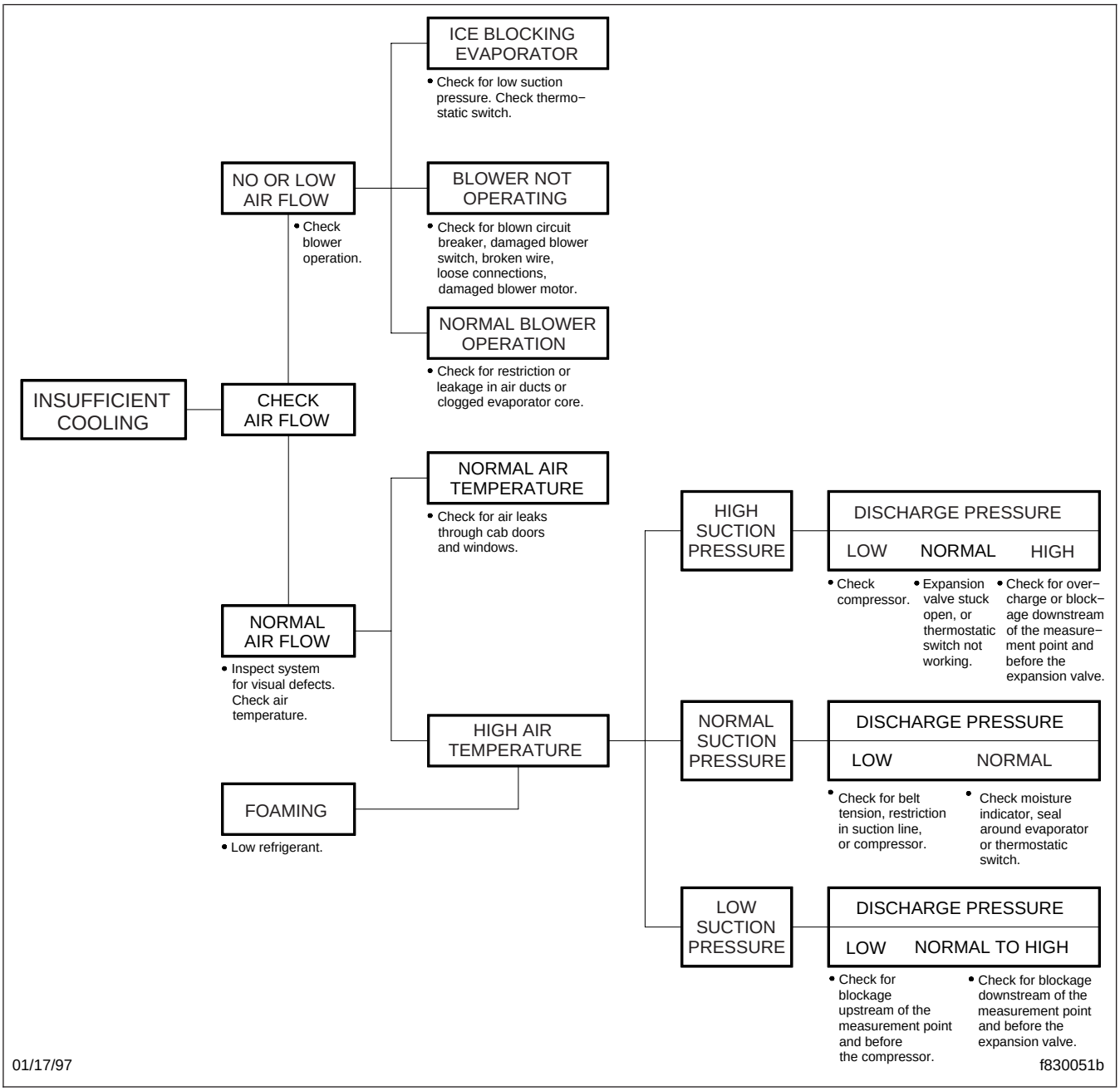


Fig. 1, Fault Analysis Flow Chart

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.
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.

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—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

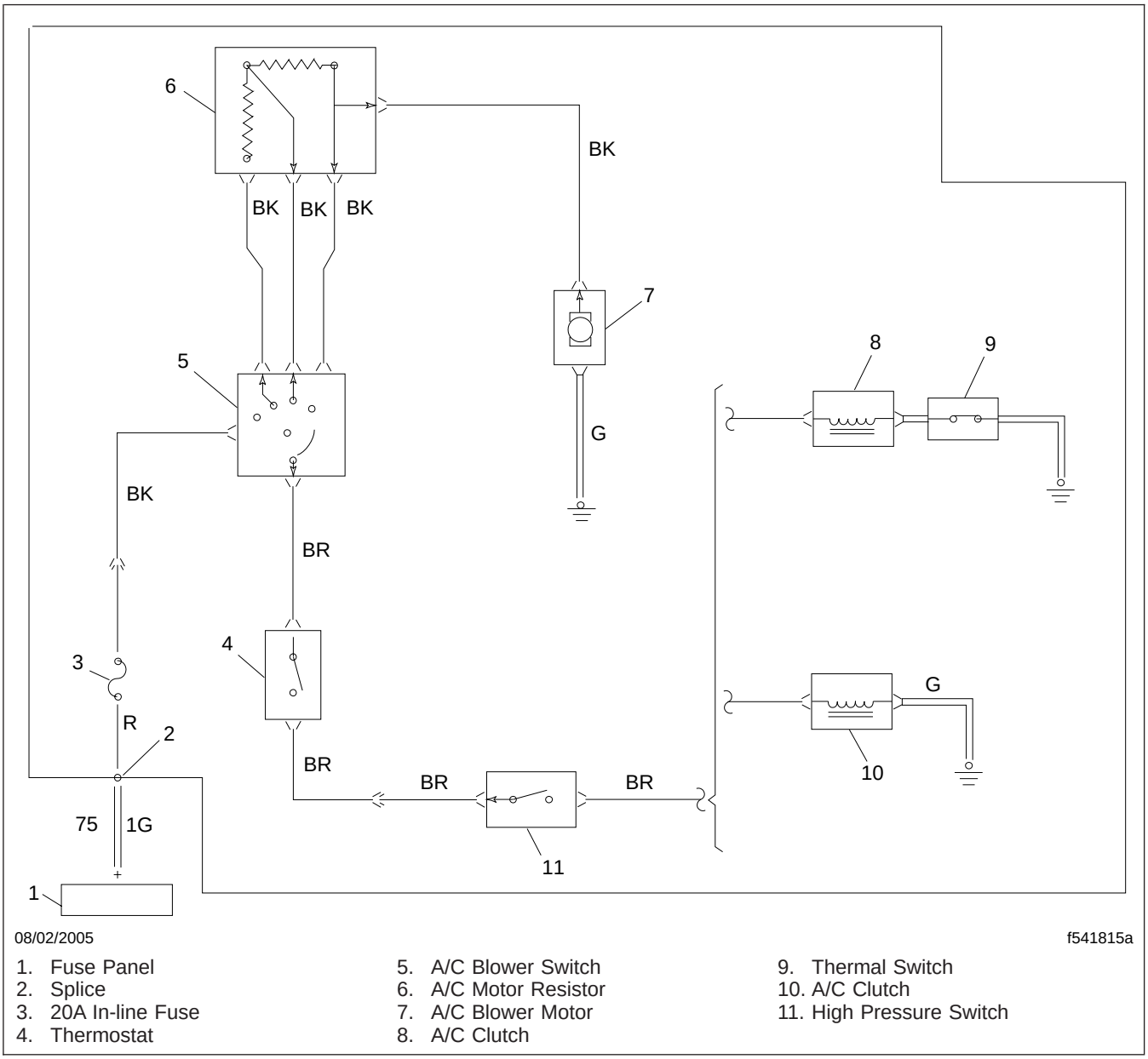
WARNING

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.

Specifications



1. Fuse Panel
2. Splice
3. 20A In-line Fuse
4. Thermostat
5. A/C Blower Switch
6. A/C Motor Resistor
7. A/C Blower Motor
8. A/C Clutch
9. Thermal Switch
10. A/C Clutch
11. High Pressure Switch

Fig. 1, Air Conditioning Wiring

General Description

National Cush-N-Aire® II 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) 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.

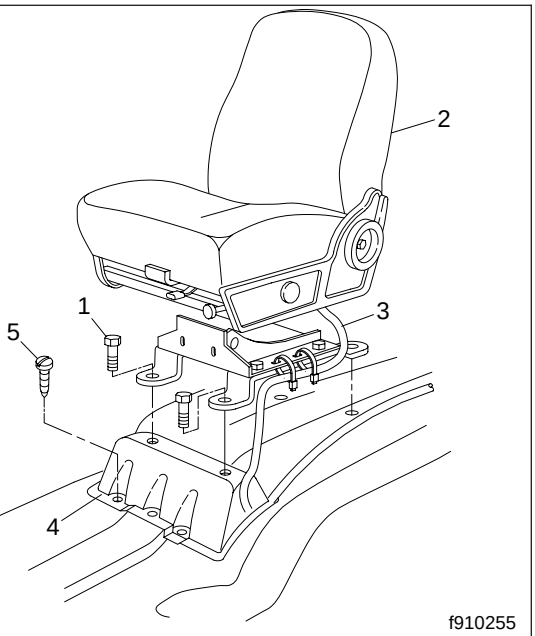
Seat, National Cush-N-Aire® II, Removal and Installation

Removal (See Fig. 1)

1. Completely drain the air brake reservoirs.
2. Remove the four bolts that fasten the seat to the floor.
3. Disconnect the air hose and remove the seat.
4. If the front floor mount is to be removed, remove the four mounting screws and washers that fasten the front floor mount to the floor.

Installation

1. If the front floor mount has been removed, attach the front floor mount, four washers, and four mounting screws to the floor. Tighten the screws 80 to 115 lbf·in (904 to 1299 N·cm).
2. Attach the seat to the floor and to the front floor mount using four mounting bolts. Tighten the bolts 16 to 24 lbf·ft (22 to 32 N·m).
3. Attach the air hose.



1. Mounting Bolt
2. Cush-N-Aire II Seat
3. Air Hose
4. Front Floor Mount
5. Mounting Screw

Fig. 1, Cush-N-Aire II Seat

Support Assembly, Cush-N-Aire® II, Removal and Installation

Removal (See Fig. 1)

1. Remove the protective covering (if so equipped) from the base of the seat.
2. Pull the air valve knob until all the air is exhausted from the air spring.
3. Disconnect the air hose from the air hose fitting, then remove the fitting from the air spring. Plug the hose and fitting to prevent dirt or other matter from entering.
4. Remove the nut that fastens the air valve to the lower frame assembly. Remove the valve and air hose from the lower frame assembly.
5. Remove the nuts, washers, and bolts that fasten the lower base assembly to the cab deck. Remove the seat from the cab.
6. Remove the locknuts and bolts that fasten the track bars and bearing support frame to the seat support assembly. Remove the track bars and the bearing support frame.
7. Raise the seat to its maximum height, then place a wood block between the lower arm assembly and the lower base assembly.
8. Remove the retaining ring from the air spring.
9. Remove the pin clip that fastens the air spring to the lower arm assembly. Remove the air spring.
10. Remove the nuts and bolts that fasten the shock absorber to the upper arm assembly and to the lower base assembly. Remove the shock absorber.
11. Using snap ring pliers, remove the snap rings from the shaft assembly.
12. Drive out the snap ring end of the shafts.

NOTE: Drive each shaft end a little at a time, as the two shafts are connected to each other at the opposite end.

13. Using a drift punch, drive out the shafts from the lower base assembly and the seat support assembly.
14. Remove the sleeves from the lower base assembly and the seat support assembly. Remove the seat support, upper arm, and lower arm assemblies from the lower base assembly.
15. Remove the bearings from the upper and lower arm assemblies.

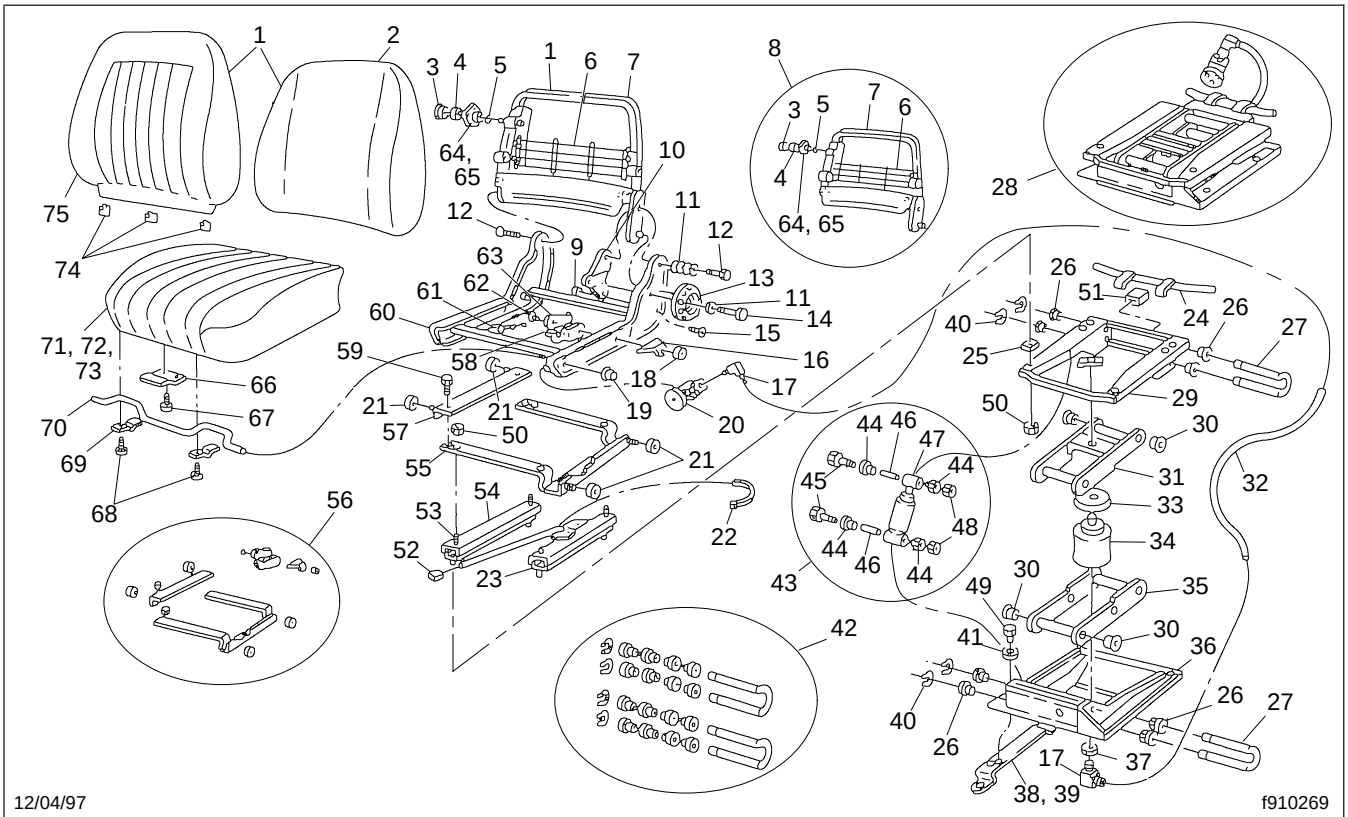
Installation

1. Place the lower end of the shock absorber in the mounting bracket of the lower base assembly. Using a new spacer and bushings, attach the bolt and nut. Tighten the nut 25 lbf·ft (34 N·m).
2. Place the bearings in the tubes of the upper and lower arm assemblies.
3. Place the upper and lower arm assemblies on the lower base assembly, aligning the arm tubes and bearings with the holes in the lower base assembly. Place the sleeves in the holes of the lower base assembly.
4. Insert the shaft assembly through the lower base assembly and through the tubes of the upper and lower arm assemblies. Using snap ring pliers, attach the snap rings to secure the shaft assembly and arm assemblies to the lower base assembly.
5. Using new spacers and bushings, position the shock absorber so that the extended arm end is in the mounting bracket of the upper arm assembly.
6. Attach the shock absorber to the upper arm assembly and to the lower base assembly using bolts and nuts. Tighten the nuts 25 lbf·ft (34 N·m).
7. Position the air spring in the lower arm assembly. Attach the pin clip.
8. Attach the retaining ring to the air spring.
9. Align the tubes and bearings of the lower and upper arm assemblies with the holes in the seat support assembly, then place the sleeves in the holes of the seat support assembly.
10. Insert the shaft assemblies through the seat support assembly and through the tubes of the upper and lower arm assemblies. Using snap ring pliers, attach the snap rings to secure the shaft assemblies and arm assemblies to the seat support assembly.
11. Align the top of the air spring with the hole in the seat support assembly. Unplug the air hose and fitting. Attach the fitting to the air spring.

Support Assembly, Cush-N-Aire® II, Removal and Installation

12. Place the track bars and bearing support frame on the seat support assembly. Attach the bolts and locknuts and tighten 16 to 24 lbf·ft (22 to 32 N·m).
13. Place the seat support assembly on the cab deck.
14. Place the bolts through the lower base assembly and the cab deck. Attach the washers and nuts. Tighten the nuts 25 lbf·ft (34 N·m).
15. Attach the air valve to the lower frame assembly with the nut. Tighten the nut finger-tight. Using a wrench, tighten the nut one-half turn.
16. Connect the air hose to the fitting on the air spring.
17. Attach the protective covering (if so equipped) to the base of the seat. Adjust the seat base as needed.

Support Assembly, Cush-N-Aire® II, Removal and Installation



1. Upholstered Back Assembly
2. Back
3. Plug
4. Locknut, 5/16–18
5. Plastic Washer
6. Flex-O-Lator
7. Upper Frame Assembly
8. Back Frame Kit
9. Locking Nut, 3/14–18
10. Backplate Assembly With Weld Nut
11. Spring Washer, Backrest Adjust
12. Shoulder Bolt, Backrest Pivot
13. Backrest Adjustment Knob
14. Bolt, Backrest Adjustment Knob
15. Square Neck Bolt, 3/14–18
16. Isolator Lock Handle
17. Fitting, 90° Elbow
18. Locknut, 1/4–28
19. Cap, Cushion Adjuster Rod
20. Air Valve Knob
21. Chugger Bearing
22. Hose Clip
23. Track Bar With Handle
24. Belt Bar
25. Spacer for Belt Bar
26. Sleeve
27. Shaft Assembly
28. Complete Base Assembly
29. Seat Support Assembly
30. Bearing
31 Upper Arm Assembly
32. Air Hose
33. Washer, Air Spring
34. Air Spring
35. Lower Arm Assembly
36. Lower Base Assembly
37. Retaining Ring
38. RH Mounting Bracket Assembly
39. LH Mounting Bracket Assembly
40. Snap Ring
41. Washer, 5/16
42. Shaft Kit
43. Shock Kit
44. Bushing, Nylon
45. Hex Bolt, 3/8–24 x 1–3/4
46. Spacer
47. Shock Absorber
48. Locknut, 3/8–24
49. Bolt, 5/16–18 X 3/4
50. Locknut, 5/16–18
51. Bumper Stop
52. Track Knob
53. Bolt, 2/14–18 x .68
54. Track Bar Without Latch
55. Bearing Support Frame
56. Chugger Kit With Isolator
57. Bearing Support Rail
58. Latch Pawl, Isolator Lock
59. Bolt, 5/16–18 x 3/4
60. Lower Frame Assembly
61. Spring, Isolator Lock
62. Screw, Isolator Lock
63. Actuator Plate, Isolator Lock
64. Lumbar Adjustment Knob (20-Inch Seat Only)
65. Lumber Adjustment Knob (18-Inch Seat Only)
66. Cushion Handle
67. Screw, 10 x 3/4
68. Screw, 1/4–20 x 3/4
69. Cushion Bracket
70. Cushion Adjuster Rod
71. Cushion, 20-Inch
72. Cushion Cover
73. Upholstered Cushion Assembly
74. Tinnerman U Clips
75. Back Cover

Fig. 1, Cush-N-Aire® II Seat, Disassembled

Air Spring, Cush-N-Aire® II, Replacement

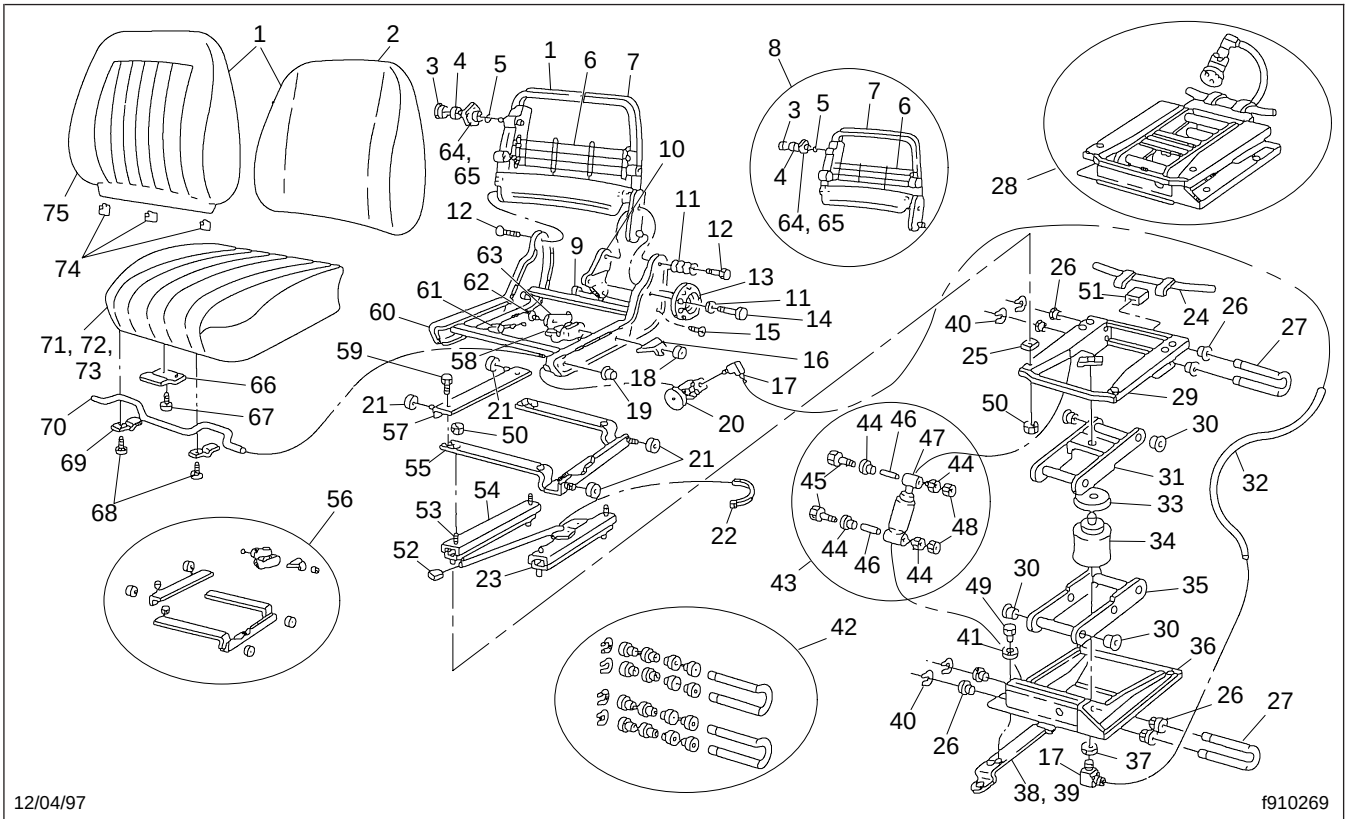
Removal (See Fig. 1)

1. Remove the protective covering (if so equipped) from the base of the seat.
2. Raise the seat to its maximum height, then place a wood block between the lower arm assembly and the lower base assembly.
3. Pull the air valve knob until all the air is exhausted from the air spring.
4. Remove the plastic tie strap that fastens the lower seat cushion to the lower frame assembly.
5. Remove the capscrews that fasten the seat cushion to the front cushion bracket. Remove the seat cushion.
6. Disconnect the air hose from the air hose fitting on the air spring. Remove the fitting from the air spring. Plug the hose and fitting to prevent dirt or other matter from entering.
7. Remove the retaining ring from the air spring.
8. Remove the pin clip that fastens the air spring to the lower arm assembly. Remove the air spring.

Installation

1. Position the air spring in the lower arm assembly. Attach the pin clip.
2. Attach the retaining ring to the air spring.
3. Unplug the air hose and fitting. Attach the fitting to the air spring, then connect the air hose to the fitting.
4. Position the seat cushion, then attach the front cushion brackets and the capscrews.
5. Attach a new plastic tie strap to secure the seat cushion to the lower frame assembly.
6. Remove the wood block from between the lower arm assembly and the lower base assembly.
7. Attach the protective covering (if so equipped) to the base of the seat. Adjust the seat as needed.

Air Spring, Cush-N-Aire® II, Replacement



1. Upholstered Back Assembly
2. Back
3. Plug
4. Locknut, 5/16–18
5. Plastic Washer
6. Flex-O-Lator
7. Upper Frame Assembly
8. Back Frame Kit
9. Lockingnut, 3/14–18
10. Backplate Assembly With Weld Nut
11. Spring Washer, Backrest Adjust
12. Shoulder Bolt, Backrest Pivot
13. Backrest Adjustment Knob
14. Bolt, Backrest Adjustment Knob
15. Square Neck Bolt, 3/14–18
16. Isolator Lock Handle
17. Fitting, 90° Elbow
18. Locknut, 1/4–28
19. Cap, Cushion Adjuster Rod
20. Air Valve Knob
21. Chugger Bearing
22. Hose Clip
23. Track Bar With Handle
24. Belt Bar
25. Spacer for Belt Bar
26. Sleeve
27. Shaft Assembly
28. Complete Base Assembly
29. Seat Support Assembly
30. Bearing
31 Upper Arm Assembly
32. Air Hose
33. Washer, Air Spring
34. Air Spring
35. Lower Arm Assembly
36. Lower Base Assembly
37. Retaining Ring
38. RH Mounting Bracket Assembly
39. LH Mounting Bracket Assembly
40. Snap Ring
41. Washer, 5/16
42. Shaft Kit
43. Shock Kit
44. Bushing, Nylon
45. Hex Bolt, 3/8–24 x 1–3/4
46. Spacer
47. Shock Absorber
48. Locknut, 3/8–24
49. Bolt, 5/16–18 x 3/4
50. Locknut, 5/16–18
51. Bumper Stop
52. Track Knob
53. Bolt, 2/14–18 x .68
54. Track Bar Without Latch
55. Bearing Support Frame
56. Chugger Kit With Isolator
57. Bearing Support Rail
58. Latch Pawl, Isolator Lock
59. Bolt, 5/16–18 x 3/4
60. Lower Frame Assembly
61. Spring, Isolator Lock
62. Screw, Isolator Lock
63. Actuator Plate, Isolator Lock
64. Lumbar Adjustment Knob (20-Inch Seat Only)
65. Lumber Adjustment Knob (18-Inch Seat Only)
66. Cushion Handle
67. Screw, 10 x 3/4
68. Screw, 1/4–20 x 3/4
69. Cushion Bracket
70. Cushion Adjuster Rod
71. Cushion, 20-Inch
72. Cushion Cover
73. Upholstered Cushion Assembly
74. Tinnerman U Clips
75. Back Cover

Fig. 1, Cush-N-Aire® II Seat, Disassembled

Shock Absorber, Cush-N-Aire® II, Removal and Installation

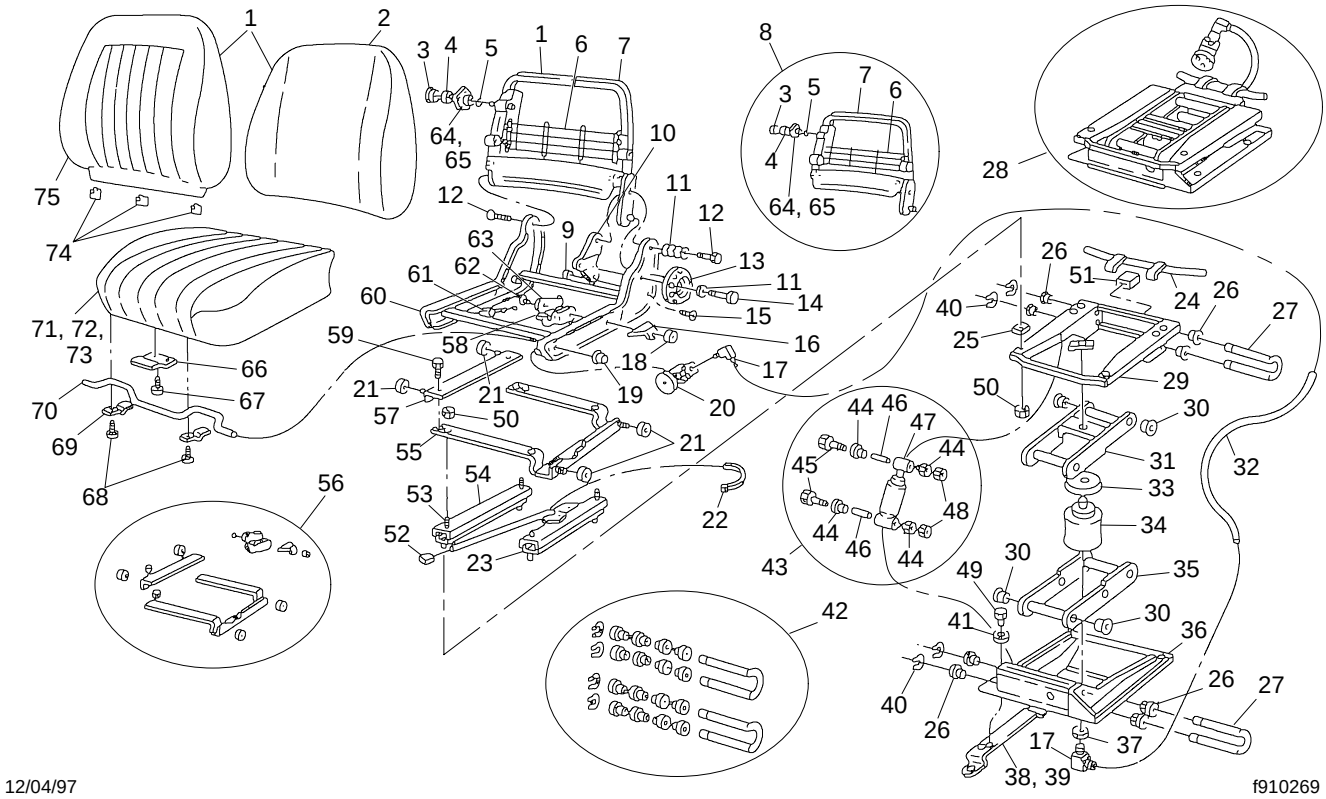
Removal (See Fig. 1)

1. Remove the protective covering (if so equipped) from the base of the seat.
2. Raise the seat to its maximum height, then place a wood block between the lower arm assembly and the lower base assembly.
3. Pull the air valve knob until all the air is exhausted from the air spring.
4. Remove the nuts and bolts that fasten the shock absorber to the upper arm assembly and to the lower base assembly. Remove the shock absorber.

Installation

1. Using new spacers and bushings, position the shock absorber so that the extended arm end is in the mounting bracket of the upper arm assembly.
2. Install the bolts and nuts and attach the shock absorber to the upper arm assembly. Tighten the nuts 25 lbf·ft (34 N·m).
3. Position the base of the shock absorber in the mounting bracket of the lower base assembly.
4. Attach the hex bolts and nuts to fasten the shock absorber to the upper arm assembly and to the lower base assembly. Tighten the nuts 25 lbf·ft (34 N·m).
5. Remove the wood block from between the lower arm assembly and the lower base assembly.
6. Attach the protective covering (if so equipped) to the base of the seat. Adjust the seat as needed.

Shock Absorber, Cush-N-Aire® II, Removal and Installation



1. Upholstered Back Assembly
2. Back
3. Plug
4. Locknut, 5/16–18
5. Plastic Washer
6. Flex-O-Lator
7. Upper Frame Assembly
8. Back Frame Kit
9. Locking Nut, 3/14–18
10. Backplate Assembly With Weld Nut
11. Spring Washer, Backrest Adjust
12. Shoulder Bolt, Backrest Pivot
13. Backrest Adjustment Knob
14. Bolt, Backrest Adjustment Knob
15. Square Neck Bolt, 3/14–18
16. Isolator Lock Handle
17. Fitting, 90° Elbow
18. Locknut, 1/4–28
19. Cap, Cushion Adjuster Rod
20. Air Valve Knob
21. Chugger Bearing
22. Hose Clip
23. Track Bar With Handle
24. Belt Bar
25. Spacer for Belt Bar
26. Sleeve
27. Shaft Assembly
28. Complete Base Assembly
29. Seat Support Assembly
30. Bearing
31 Upper Arm Assembly
32. Air Hose
33. Washer, Air Spring
34. Air Spring
35. Lower Arm Assembly
36. Lower Base Assembly
37. Retaining Ring
38. RH Mounting Bracket Assembly
39. LH Mounting Bracket Assembly
40. Snap Ring
41. Washer, 5/16
42. Shaft Kit
43. Shock Kit
44. Bushing, Nylon
45. Hex Bolt, 3/8–24 x 1–3/4
46. Spacer
47. Shock Absorber
48. Locknut, 3/8–24
49. Bolt, 5/16–18 x 3/4
50. Locknut, 5/16–18
51. Bumper Stop
52. Track Knob
53. Bolt, 2/14–18 x .68
54. Track Bar Without Latch
55. Bearing Support Frame
56. Chugger Kit With Isolator
57. Bearing Support Rail
58. Latch Pawl, Isolator Lock
59. Bolt, 5/16–18 x 3/4
60. Lower Frame Assembly
61. Spring, Isolator Lock
62. Screw, Isolator Lock
63. Actuator Plate, Isolator Lock
64. Lumbar Adjustment Knob (20-Inch Seat Only)
65. Lumber Adjustment Knob (18-Inch Seat Only)
66. Cushion Handle
67. Screw, 10 x 3/4
68. Screw, 1/4–20 x 3/4
69. Cushion Bracket
70. Cushion Adjuster Rod
71. Cushion, 20-Inch
72. Cushion Cover
73. Upholstered Cushion Assembly
74. Tinnerman U Clips
75. Back Cover

Fig. 1, Cush-N-Aire® II Seat, Disassembled

Chugger Bearing Kit, Cush-N-Aire® II, Replacement

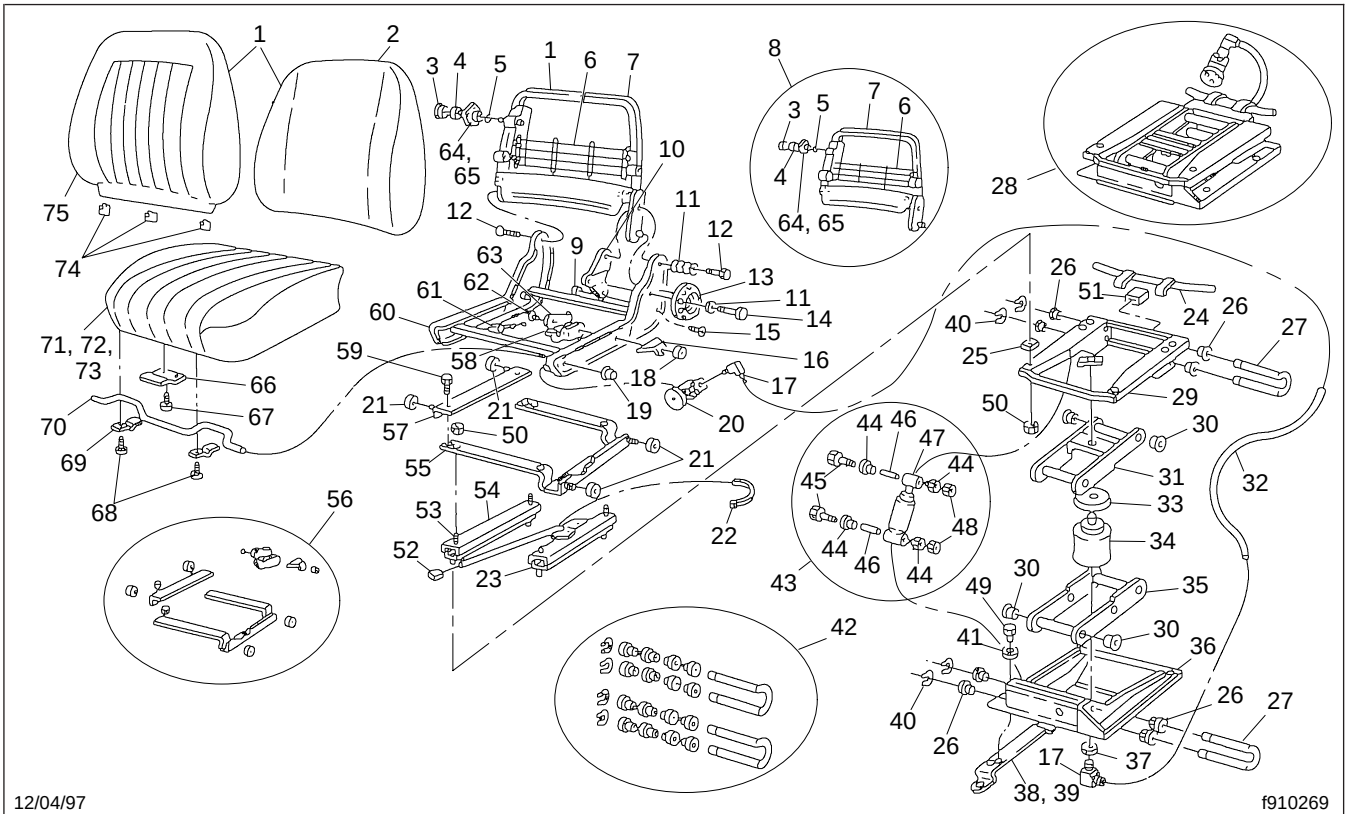
Removal (See Fig. 1)

1. Cut the plastic tie strap and raise the seat cushion.
2. Make sure the chugger isolator lock handle is in the up position.
3. Remove the two locknuts.
4. While holding the seat, lift the bearing support rail up and off the track studs. Two bearings will fall off.
5. Move the seat frame to the opposite side to expose the two bearings. Remove them at this time.
6. If only the bearings are being replaced, stop at this point and replace the bearings with new bearings after inspecting the bearing studs for wear.
7. If the entire chugger kit is to be replaced, remove the other two lock nuts on the bearing support frame and remove the frame.

Installation

1. Using a good grade of grease, lubricate the bearing and cups.
2. Place the bearing support frame on the track studs and tighten the locknuts.
3. Place two bearings on the round posts and align the lower seat frame bearing cups over the bearings.
4. While holding one side in place, assemble the loose bearing support rail and the two bearings, and loosely tighten the two locknuts.
5. Push the chugger assembly forward and backward to determine the position of the bearing support rail before tightening the locknuts. It should be tight enough to eliminate side play without interfering with the forward and backward movement of the seat. Tighten the locknuts 15 lbf·ft (20 N·m).
6. Lower the seat cushion and replace the plastic tie strap at the rear of the seat.

Chugger Bearing Kit, Cush-N-Aire® II, Replacement



1. Upholstered Back Assembly
2. Back
3. Plug
4. Locknut, 5/16–18
5. Plastic Washer
6. Flex-O-Lator
7. Upper Frame Assembly
8. Back Frame Kit
9. Locking Nut, 3/14–18
10. Backplate Assembly With Weld Nut
11. Spring Washer, Backrest Adjust
12. Shoulder Bolt, Backrest Pivot
13. Backrest Adjustment Knob
14. Bolt, Backrest Adjustment Knob
15. Square Neck Bolt, 3/14–18
16. Isolator Lock Handle
17. Fitting, 90° Elbow
18. Locknut, 1/4–28
19. Cap, Cushion Adjuster Rod
20. Air Valve Knob
21. Chugger Bearing
22. Hose Clip
23. Track Bar With Handle
24. Belt Bar
25. Spacer for Belt Bar
26. Sleeve
27. Shaft Assembly
28. Complete Base Assembly
29. Seat Support Assembly
30. Bearing
31 Upper Arm Assembly
32. Air Hose
33. Washer, Air Spring
34. Air Spring
35. Lower Arm Assembly
36. Lower Base Assembly
37. Retaining Ring
38. RH Mounting Bracket Assembly
39. LH Mounting Bracket Assembly
40. Snap Ring
41. Washer, 5/16
42. Shaft Kit
43. Shock Kit
44. Bushing, Nylon
45. Hex Bolt, 3/8–24 x 1–3/4
46. Spacer
47. Shock Absorber
48. Locknut, 3/8–24
49. Bolt, 5/16–18 x 3/4
50. Locknut, 5/16–18
51. Bumper Stop
52. Track Knob
53. Bolt, 2/14–18 x .68
54. Track Bar Without Latch
55. Bearing Support Frame
56. Chugger Kit With Isolator
57. Bearing Support Rail
58. Latch Pawl, Isolator Lock
59. Bolt, 5/16–18 x 3/4
60. Lower Frame Assembly
61. Spring, Isolator Lock
62. Screw, Isolator Lock
63. Actuator Plate, Isolator Lock
64. Lumbar Adjustment Knob (20-Inch Seat Only)
65. Lumber Adjustment Knob (18-Inch Seat Only)
66. Cushion Handle
67. Screw, 10 x 3/4
68. Screw, 1/4–20 x 3/4
69. Cushion Bracket
70. Cushion Adjuster Rod
71. Cushion, 20-Inch
72. Cushion Cover
73. Upholstered Cushion Assembly
74. Tinnerman U Clips
75. Back Cover

Fig. 1, Cush-N-Aire® II Seat, Disassembled

Inspection and Verification

(See Table 1)

Visual Inspection Chart	
Mechanical	**Pneumatic**
• Seat track is obstructed.	• Air hose is broken or chafed.
• Clips, screws, or nuts are missing.	• Valve and connections are leaking.
• Obvious breaks in parts.	• Air spring is damaged or leaking.
• Shock absorber is functioning improperly.	• Lumbar support and hose are damaged.
• Seat adjusting cable is broken.	

Table 1, Visual Inspection Chart

1. Verify the owner's original concern by operating the seat to duplicate the condition.
2. Inspect the seat to determine if one of the mechanical or pneumatic concerns applies.

Specifications

Torque Values		
Description	**Torque lbf·ft (N·m)**	**Torque lbf·in (N·cm)**
Screw, Front Floor Mount		80–115 (904–1299)
Bolt, Seat-to-Floor	16–24 (22–32)	
Bolt, Seat-to-Front Floor Mount	16–24 (22–32)	
Nut, Shock Absorber, Lower Base Assembly	25 (34)	
Nut, Shock Absorber, Upper Arm Assembly	25 (34)	
Nut, Lower Base Assembly, Cab Deck	25 (34)	
Locknut, Track Bars and Bearing Support Frame, Seat Support Assembly	16–24 (22–32)	
Locknut, Chugger Assembly, Bearing Support Rail	15 (20)	

Table 1, Torque Values

General Information

The safety belts are factory-installed in their proper locations. If the safety belts are removed for any reason, they must be installed as shown in **Subject 100**. Sealer is placed around all safety belt anchor bolt holes in the floor pan. Tighten the bolts 22 to 32 lbf·ft (30 to 43 N·m).

Safety belt assemblies must be periodically inspected to make sure that they have not become damaged and are in proper operating condition, particularly if subjected to severe stress.

Before installing the new safety belt assembly, the safety belt attaching area must be inspected for damage and distortion. If the attaching points are damaged and/or distorted, the sheet metal must be worked back to its original shape and structural integrity.

Install the new safety belt(s) using the procedure in **Subject 100**. Perform the Functional Test Procedure in **Subject 120**.

⚠ WARNING

Belt assemblies must be installed in matched sets as received and must not be interchanged between vehicle models. If a component portion (buckle portion, retractor portion, etc.) of a safety belt is nonfunctional or damaged, the entire assembly must be replaced. If safety belt assemblies are not installed in matched sets or are interchanged between vehicle models, personal injury or death may result.

⚠ WARNING

The replacement assembly must be installed as a matched set and the identification labels on all portions must bear exactly the same code, date of manufacture, and manufacturer's name. Under no circumstances are safety belt components to be replaced as individual components. If the safety belt components are replaced individually instead of as an assembly, personal injury or death may result.

⚠ 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

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 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.

Removal

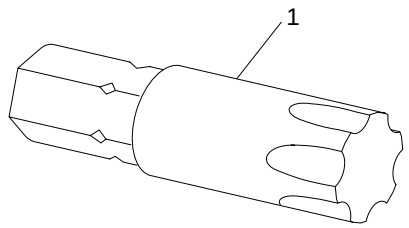
1. Remove the shoulder belt retractor trim cover.
2. Remove the shoulder belt retractor anchor bolt.

NOTE: Use the Kent-Moore Torque Bit (**Fig. 1**) to remove or replace all safety belt assembly anchor bolts.

3. Remove the buckle end of the front safety belt by removing the safety belt anchor bolt from the floor.

NOTE: The driver's buckle contains an electrical switch. Disconnect the switch before removing the anchor bolt.

4. Remove the D-ring cover and attaching bolt.
5. Remove the safety belt assembly from the vehicle.



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1. Kent-Moore Torque Bit

Fig. 1, Kent-Moore Torque Bit

Installation

1. Install the D-ring attaching bolt and cover.
2. Install the floor anchor bolt, and the shoulder belt retractor anchor bolt.

NOTE: Seat belt and shoulder harness anchor bolt torque may fall below 22 lbf·ft (30 N·m) after installation. A minimum established static audit torque of 12 lbf·ft (16 N·m) must be maintained, but installation must be capable of being retightened to 22 lbf·ft (30 N·m). Place sealer around all safety belt anchor holes in the floorboard.

3. Check for sealer around each hole where an anchor bolt was removed. Add caulking cord.
4. Tighten all bolts 22 to 32 lbf·ft (30 to 43 N·m) at installation with bolts securely seated.
5. Replace all covers where applicable.
6. Install all washers and spacers in the same location from which they were removed.
7. Check belts for proper routings.

Safety Belt With No Anchor Plate Thread Damage

REMOVAL

Remove damaged bolt from anchor reinforcement and discard.

Safety Belt With Anchor Plate Thread Damage

REMOVAL

1. Remove broken or stripped bolt and discard.
2. Drill out internal threads in safety belt anchor plate with a 27/64-inch drill.
3. Rethread the anchor plate with a 1/2–13 tap (safety belt).
4. Blow out the chips.

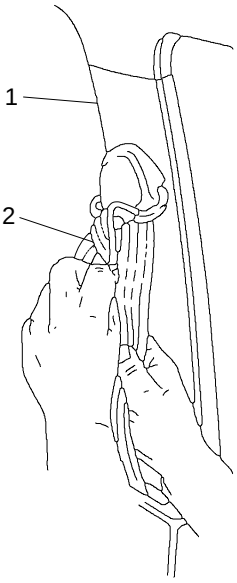
INSTALLATION

1. Install the attachment parts. Original parts must be replaced with parts identical to the ones being replaced.
2. Tighten replacement bolts to 22 to 32 lbf·ft (30 to 43 N·m).

Safety Belt Twisted at Safety Belt Guide

The following procedure can be used to correct a twisted shoulder safety belt at the D-ring. This procedure affects both the wire-formed and stamped D-ring designs.

1. Grasp the web belting at the D-ring as shown in **Fig. 1**.
2. Rotate and fold the belt webbing over itself as required to remove the twist.
3. Manipulate the folded portion of the belt through the D-ring.
4. When completed, the safety belt should retract and hang properly as shown in **Fig. 2**.



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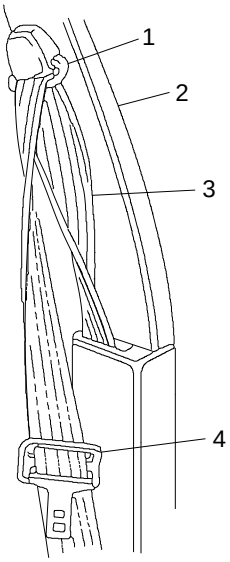
1. B-Pillar
2. Safety Belt Webbing

Fig. 1, Grasp the Belt Webbing at the D-Ring

Safety Belt Tongue Rotated on Belt

The following procedure can be used to correct a rotated tongue on the safety belt.

1. Grasp the safety belt tongue and pull down on the belt webbing closest to you to form a loop through the upper narrow, longer slot in the tongue as shown in **Fig. 3**.
2. Working within the upper slot, rotate and fold the belt webbing over itself as required to remove the twist.
3. Pull the excess belt webbing back through the upper slot in the tongue.
4. Repeat the previous steps to complete the removal of the twist at the lower, wider and larger slot in the tongue as shown in **Fig. 4**.
5. When finished, the belt should hang properly as shown in **Fig. 5**.

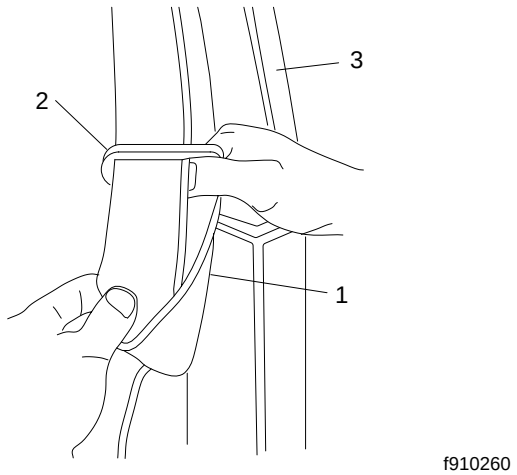


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1. D-Ring
2. B-Pillar
3. Safety Belt Webbing
4. Safety Belt Tongue

Fig. 2, Safety Belt Retracted and Hanging Properly

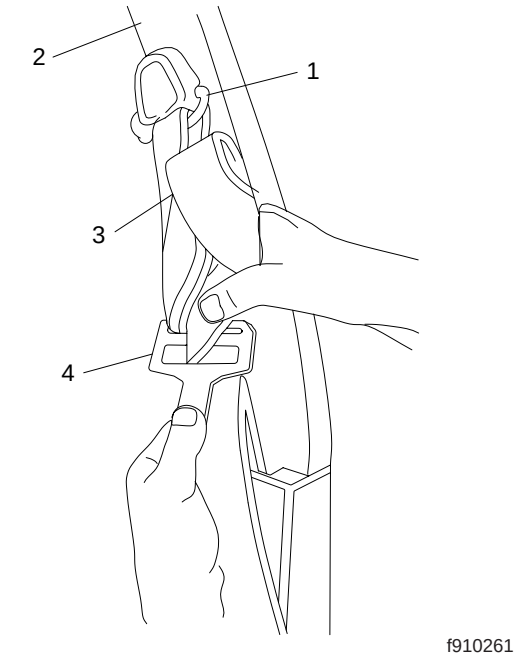
Safety Belt Adjustment



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1. Safety Belt Webbing
2. Safety Belt Tongue
3. B-Pillar

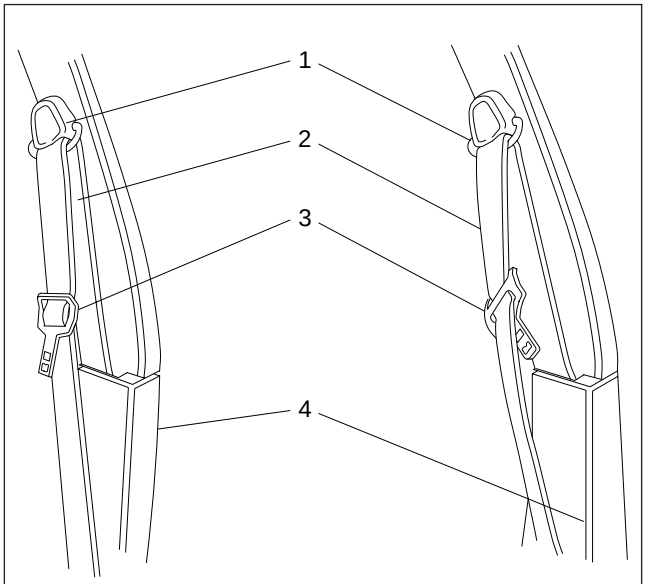
Fig. 3, Grasp the Safety Belt Tongue



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1. D-Ring
2. B-Pillar
3. Safety Belt Webbing
4. Safety Belt Tongue

Fig. 4, Grasp the Safety Belt Tongue



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1. D-Ring
2. Safety Belt Webbing
3. Safety Belt Tongue
4. B-Pillar

Fig. 5, Belt Hanging Properly

Functional Test Procedure

1. The driver will buckle up and proceed to a safe test area. If the passenger safety belt must be tested, a passenger can be buckled into the right front seat.

NOTE: The passenger belt can be tested with a driver only, providing the driver has the ability to grasp the right front shoulder belt and extend it approximately 26 inches (66 cm) with no compromise to safe driving.

NOTE: If the test is to be performed by the driver only, do not extend the passenger side safety belt fully. A false indication of lockup will result.

NOTE: This method applies to the 5 mph (8 km/h) test only.

2. After reaching a safe area to perform sudden stops, the driver will attain a speed of approximately 5 mph (8 km/h). The driver should advise the passenger (if applicable) to prepare for severe brake application. At this time, both driver and passenger will grasp their respective shoulder safety belts and prepare to lean slightly forward at the moment brake application is made.

⚠ WARNING

The driver and passenger must be prepared to brace themselves in the event the safety belt retractor does not lock. If the driver and passenger do not brace themselves, personal injury or death may result.

3. The driver will make a maximum brake application without tire skid. (The maximum brake application should be made on dry concrete or equivalent hard road surface, never on a wet or gravel road.) The driver and passenger will lean slightly forward in to the shoulder safety belt. At this instant, safety belts should lock up without webbing pay out.
4. If there is a lockup of both shoulder safety belts, the assemblies are working properly. Should either retractor or both retractors fail to lock up at the 5 mph (8 km/h) speed, repeat this test at a constant 15 mph (24 km/h). (This test must be performed with a passenger if other than the driver's safety belt is to be tested.)

⚠ WARNING

If the retractor of a new safety belt has been bolted into a damaged or distorted mounting area, the new retractor could be warped and will not function properly. If this is the case, rework the sheet metal into its original shape and structural integrity, and install a new safety belt assembly. If the retractor is bolted to a damaged or distorted mounting area, personal injury or death may result.

5. If either safety belt assembly, or both safety belt assemblies fail to lock up at the 15 mph (24 km/h) test, return the vehicle for service of malfunctioning safety belts. Remove the retractor and rework the sheet metal in the mounting surface area of the retractor. Install the retractor assembly and retest the safety belt assembly as noted in the previous steps.

Cleaning

The following procedures are recommended for the removal of spots and stains from belts. It is important that proper cleaning techniques and cleaning agents be used to prevent setting the stain or effecting the color and/or flame resistance of the belts. Avoid bleaching or redyeing the webbing as this could hinder belt strength and performance.

⚠ WARNING

Do not bleach or redye the webbing, as this can reduce both effectiveness and occupant safety and may result in personal injury or death.

The following materials are needed to clean safety belts:

- clean, undyed cotton fabric
- medium hard bristle brush
- spot and stain remover
- extra strength upholstery cleaner

Prior to selecting a cleaning method, perform the following steps:

1. Remove excess staining material from fabric by scraping or wiping with a clean cloth.
2. Identify the staining material if possible.
3. Clean the fabric as described in one of the following methods.

Spot Cleaning for Grease, Oil, Tar, Water Spotting, Crayon, and Lipstick

IMPORTANT: Care should be used in application of the spot lifter to prevent it from contacting vinyl trim.

1. Spray stain with spot and stain remover from a distance of 8 to 10 inches (204 to 254 mm) or as directed.

NOTE: Using other than recommended cleaners or procedures may affect fabric flammability or durability.

2. Allow spot lifter to dry completely, until forming a white powder on the surface of the fabric.
3. Brush and vacuum white powder from fabric.
4. If soiled spot is not removed from fabric, repeat the previous steps as necessary.
5. Wipe cleaned area with damp cloth to remove any residual cleaner.

General Cleaning for Grease, Oil, Tar, Adhesive, Crayon, and Lipstick

1. If stain is still visible after using the spot cleaning procedure, blot soiled area with a clean cotton cloth saturated with spot and stain remover.
2. Rub in a circular motion while continuously exposing clean portion of cloth.
3. Gradually widen area of application to the edges of the belt.
4. Repeat the previous steps as necessary.
5. Wipe cleaned area with clean, damp cloth to remove any residual cleaner.

General Cleaning for Dirt, Soil, Food, Soda Pop, and Coffee

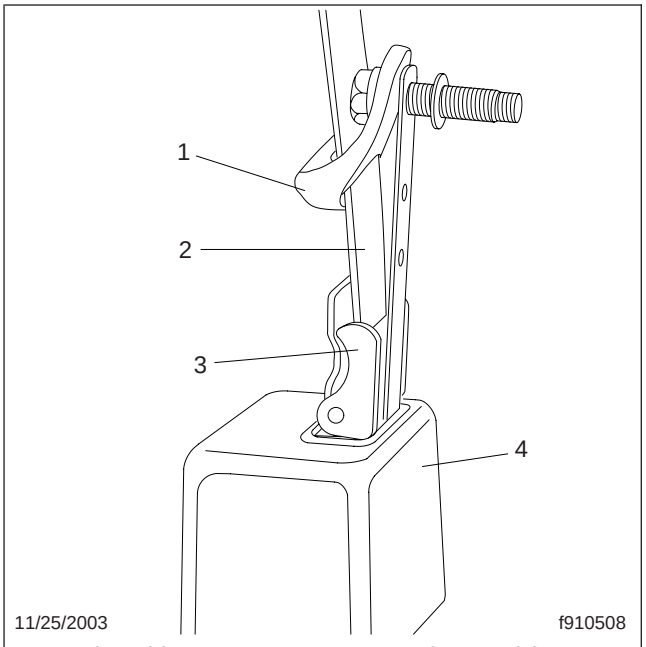
NOTE: Spot cleaning as described in the previous procedure will be sufficient when the soiled area is not excessive. In the event of severe soiling or staining, clean the entire belt to avoid a ring condition.

1. Apply extra strength upholstery cleaner with cloth or brush as directed by instructions on the container.
2. Rub in a circular manner until stain is removed.
3. Gradually widen area of application to the edges of the belt.
4. Repeat the previous steps as necessary.
5. Rub the cleaned area with a damp cloth to absorb residual cleaner.
6. Allow belt to dry at room temperature.

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.

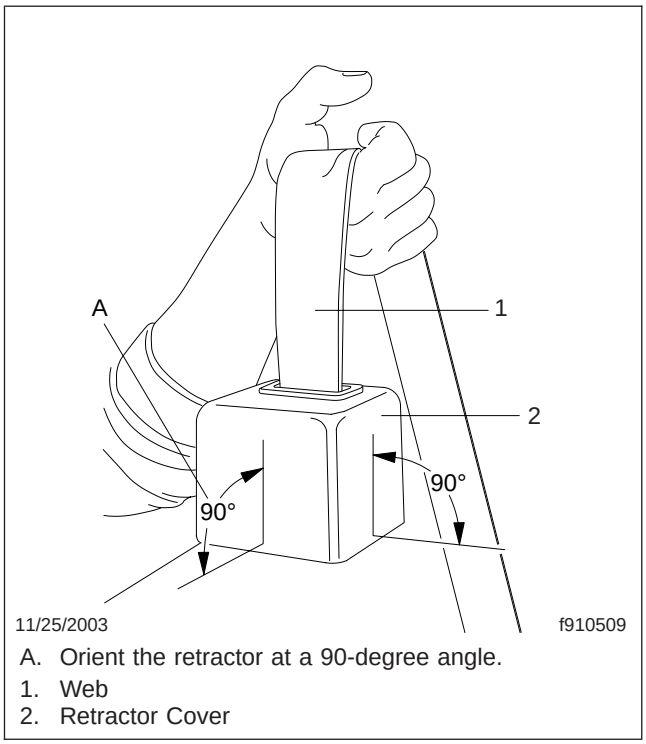
1. Park the vehicle, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Verify that the retractor is mounted in the 90-degree position. See **Fig. 1**.
3. Firmly grasp the web close to the retractor. See **Fig. 2**.



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.



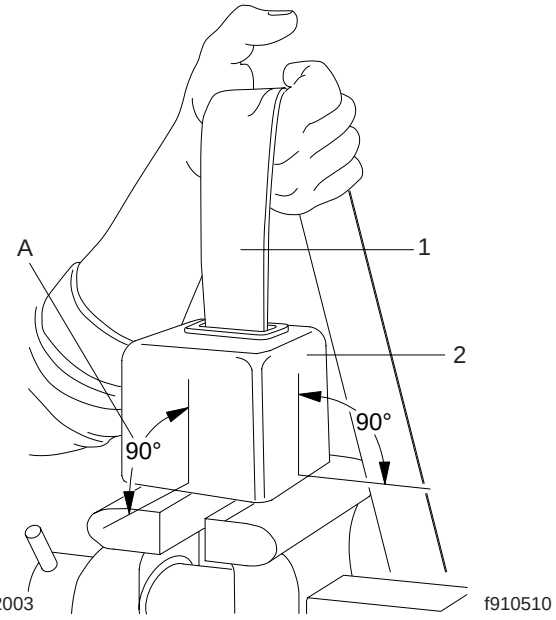
A. Orient the retractor at a 90-degree angle.
1. Web
2. Retractor Cover

Fig. 2, Firmly Grasp the Webbing

Unlocking an Uninstalled Retractor

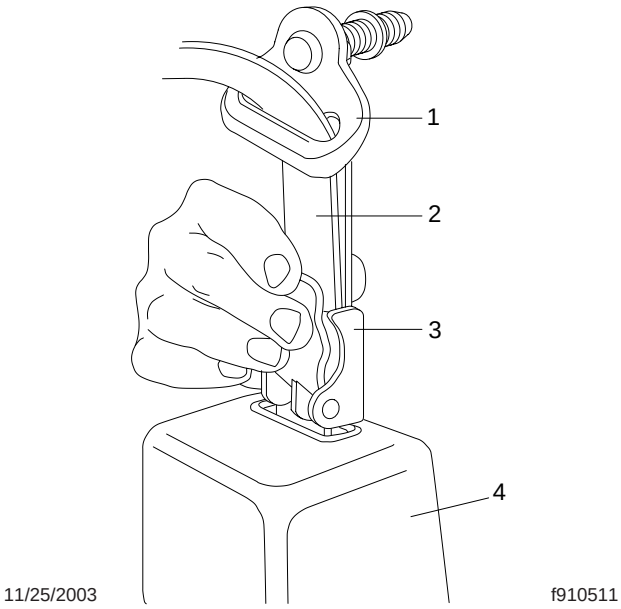
1. Clamp the retractor in a vice at a 90-degree angle. See **Fig. 3**.
2. Pull on the web with enough force to tighten the web onto the spool.
3. Release the web. This allows 1/2-inch (12.7-mm) of the webbing to feed back into the retractor storage housing and unlock the retractor.
4. Pull all the webbing 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

For functional testing of safety belts see **Subject 120**.

Symptom Chart		
Condition	**Possible Source**	**Action**
Excessive Pressure on Occupant During Normal Wear Webbing Cannot Be Extracted Excessive Slack in Webbing, Webbing Does Not Retract	Safety belt retractor and tongue.	Replace if necessary. Perform Functional Test Procedure. See **Subject 120**.

Table 1, Symptom Chart

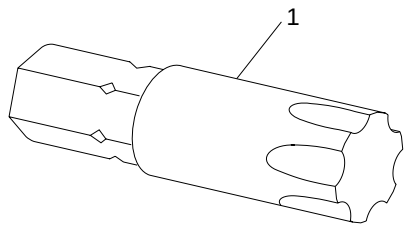
Torque Values	
Description	**Torque: lbf·ft (N·m)**
Bolt, Safety Belt Anchor	22–32 (30–43)
Bolt, Retractor	22–32 (30–43)

Table 1, Torque Values

See **Fig. 1** for special service tool.

Special tools can be purchased from the following independent supplier:

Kent-Moore Tools
Kent-Moore Tool Division
655 Eisenhower Drive
Owatonna, MN 55060
1-800-328-6657



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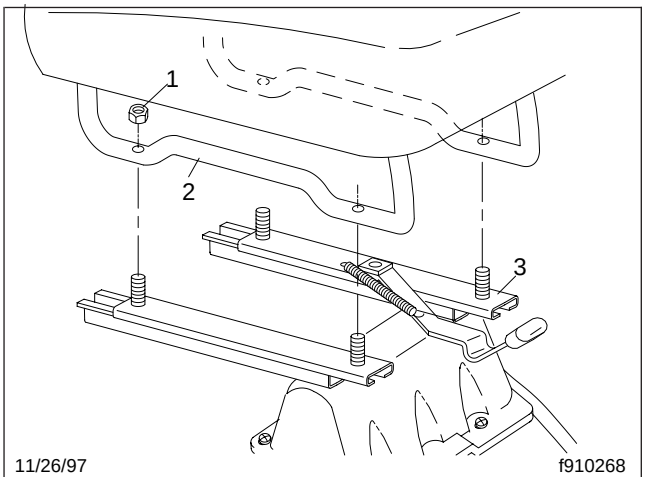
1. Kent-Moore Torque Bit

Fig. 1, Kent-Moore Torque Bit

Seat, Driver, Removal and Installation

Removal

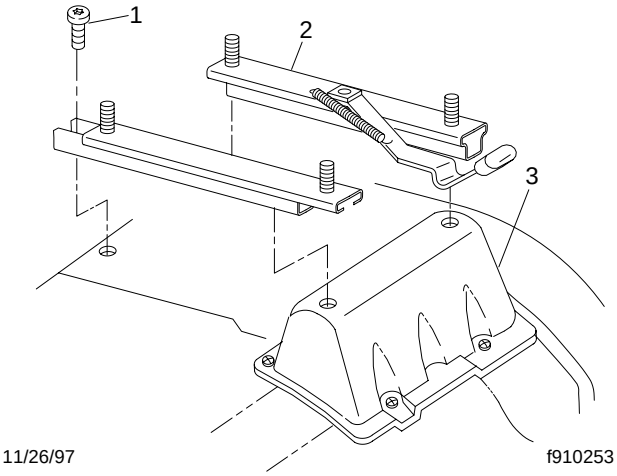
1. Remove the four mounting nuts that fasten the seat frame base to the mounting rails, and remove the seat. See **Fig. 1**.



1. Mounting Nut
2. Seat Frame Base
3. Mounting Rails

Fig. 1, Driver Seat

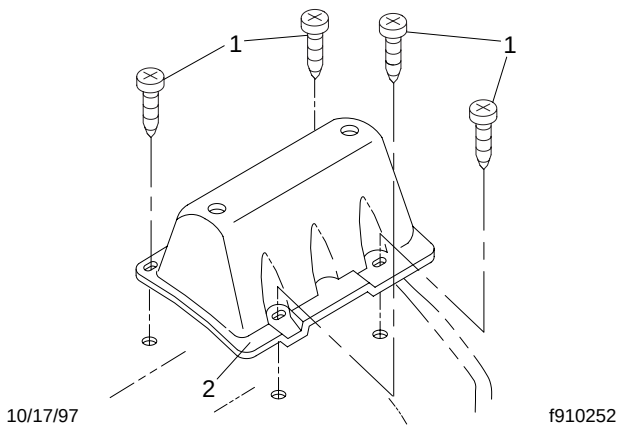
2. Move both mounting rails forward, and remove the two rear mounting screws that fasten each mounting rail to the floor. See **Fig. 2**.



1. Mounting Screw
2. Mounting Rail
3. Front Floor Mount

Fig. 2, Remove Mounting Rails

3. Remove both mounting rails.
4. Remove the four mounting screws and washers that fasten the front floor mount to the floor. See **Fig. 3**.



1. Mounting Screws
2. Front Floor Mount

Fig. 3, Remove Front Floor Mount

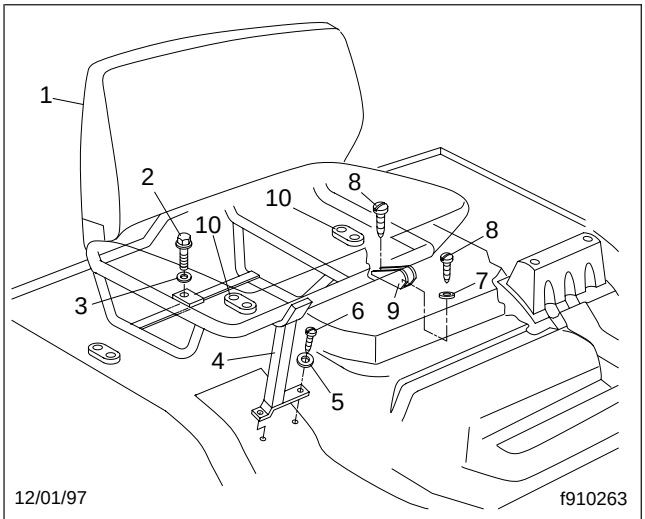
5. Remove the front floor mount.

Installation

1. Attach the front floor mount, four washers, and four mounting screws to the floor. Tighten the screws 80 to 115 lbf·in (904 to 1299 N·cm).
2. Attach the mounting rails to the floor and to the front floor mount. Attach the four mounting screws and tighten 16 to 24 lbf·ft (22 to 32 N·m).
3. Attach the seat frame base, and four mounting nuts to the mounting rails. Tighten the nuts 16 to 24 lbf·ft (22 to 32 N·m)
4. Lubricate the seat track assemblies with a multi-purpose grease.

Seat, Dual Passenger, Removal and Installation

Removal (See Fig. 1)



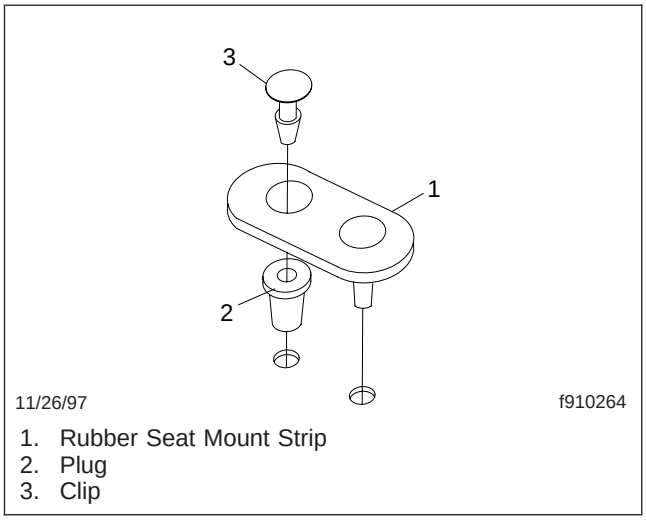
1. Dual Passenger Seat
2. Mounting Screw
3. Mounting Washer
4. Pedestal Mount
5. Pedestal Mount Washer
6. Pedestal Mount Screw
7. Left Floor Mount Washer
8. Left Floor Mount Screw
9. Left Floor Mount
10. Rubber Seat Mount Strips

Fig. 1, Dual Passenger Seat

1. Remove the swivel screws and washers at the front of the passenger seat.
2. Remove the mounting screw and washer at the rear of the passenger seat.
3. Remove the passenger seat from the vehicle.
4. Remove the mounting screws and washers that secure the left floor mount to the floor. Remove the left floor mount.
5. Remove the mounting screws that secure the pedestal mount to the floor. Remove the pedestal mount.
6. Remove the rubber seat mount strips on the floorboard, if necessary.

Installation

1. Attach the plugs, new rubber seat mount strips, and clips to the floor if they have been removed. See **Fig. 2**.



1. Rubber Seat Mount Strip
2. Plug
3. Clip

Fig. 2, Rubber Seat Mount Strip

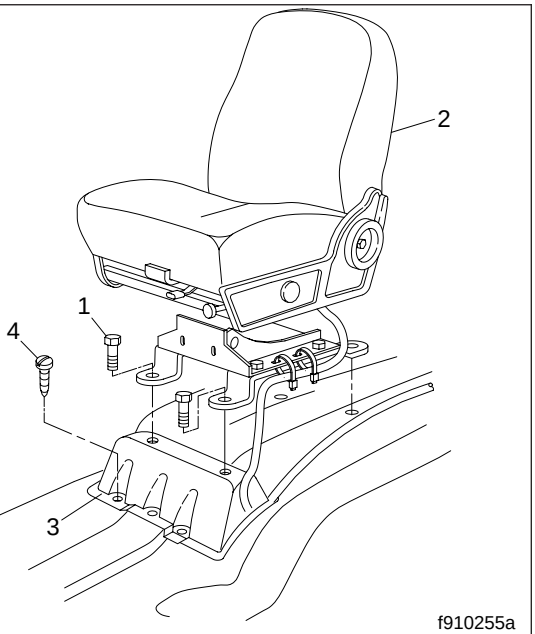
2. Attach the pedestal mount, mounting washers and screws to the floor. Tighten the screws 80 to 115 lbf·in (904 to 1299 N·cm).

NOTE: The left front screw of the pedestal mount is longer than the other screw.

3. Attach the left floor mount, mounting washers and screws to the floor. Tighten the screws 16 to 24 lbf·ft (22 to 32 N·m).
4. Attach the passenger seat, aligning the front frame mounting brackets with the swivel screws holes in the pedestal and left floor mounts. Tighten the screws 16 to 24 lbf·ft (22 to 32 N·m).
5. Attach the mounting screw at the rear of the passenger seat to the floor. Tighten the screw to 16 to 24 lbf·ft (22 to 32 N·m).

Seat, Bucket Passenger, Removal and Installation

Removal (See Fig. 1)



1. Mounting Bolt
2. Bucket Passenger Seat
3. Front Floor Mount
4. Mounting Screw

Fig. 1, Bucket Passenger Seat

1. Remove the four bolts and washers that fasten the seat to the floor.
2. Remove the seat from the vehicle.
3. Remove the four mounting screws and washers that fasten the front floor mount to the floor.
4. Remove the front floor mount.

Installation

1. Attach the front floor mount, four washers, and four mounting screws to the floor. Tighten the screws 80 to 115 lbf·in (904 to 1299 N·cm).
2. Attach the seat to the floor and to the front floor mount. Attach the four bolts and washers, and tighten the bolts 16 to 24 lbf·ft (22 to 32 N·m).

Inspection and Verification

(See Table 1)

Visual Inspection Chart
Mechanical
• Seat track is obstructed.
• Clips, screws, or nuts are missing.
• Obvious breaks in parts.
• Shock absorber (if so equipped) is functioning improperly.
• Seat adjusting cable is broken.
• Controls (if so equipped) are not functioning.

Table 1, Visual Inspection Chart

1. Verify the owner's original concern by operating the seat to duplicate the condition.
2. Inspect the seat to determine if one of the mechanical concerns applies.

Specifications

Torque Values		
Description	**Torque lbf·ft (N·m)**	**Torque lbf·in (N·cm)**
Screw, Front Floor Mount		80–115 (904–1299)
Screw, Mounting Rails-to-Floor	16–24 (22–32)	
Screw, Mounting Rails-to-Front Floor Mount	16–24 (22–32)	
Nut, Seat Frame Base-to-Mounting Rails	16–24 (22–32)	
Bolt, Seat-to-Floor	16–24 (22–32)	
Bolt, Seat-to-Front Floor Mount	16–24 (22–32)	
Screw, Pedestal Mount-to-Floor		80–115 (904–1299)
Screw, Left Floor Mount-to-Floor	16–24 (22–32)	
Screw, Dual Passenger Seat-to-Pedestal Mount	16–24 (22–32)	
Screw, Dual Passenger Seat-to-Left Floor Mount	16–24 (22–32)	
Screw, Dual Passenger Seat-to-Floor	16–24 (22–32)	
Screw, Bucket Passenger Seat-to-Floor		80–115 (904–1299)

Table 1, Torque Values

Paint Damage from Airborne Materials

The following information gives a detailed description of paint damage caused by chemical or organic materials. If service is required, identify the source of the damage and follow the recommended service procedure.

CHEMICAL

The effects of chemical airborne materials can be seen as follows:

- Dark blotches in the paint where the pigment in the paint surface has been attacked.
- Irregular spots that are cracked or etched around the edges and dull in the centers.
- Small orange colored spots caused by iron particles that appear on the paint surface.

Generally, materials that attack a paint film are either acidic or alkaline in nature.

Sulfuric and nitric acids, in general, cause extreme damage to automotive paint finishes. Even very small concentrations of the same materials can cause chemical spotting damage. Due to evaporation and condensation, these acids can create severe etching that will eventually crack or lift the paint film after some time in service.

Although some automotive finishes are more resistant than others, none are completely immune to these chemicals. The most resistant paints used today are the urethanes because their resin system is least likely to react with chemicals. Air-dried coatings are more susceptible to attack only when they are fresh. The longer the paint dries, the more resistant it becomes.

Metallic colors are more intolerant to chemicals because aluminum flake is fairly reactive with either an acid or alkali. **Table 1** contains the most common acid materials found on automotive finishes. It is not applicable for Basecoat/Clearcoat finishes.

ORGANIC

Organic damage is generally easier to identify than chemical damage. Organic damage is mostly due to tree sap, bird and insect droppings, dead insects and pollen. Tree sap is easily identified by clear raised drops that can be hard or sticky. Bee or bug dropping spots can appear brownish or yellow in color, about 1/8 to 1/4 inch (3 to 6 mm) in diameter. Dead and decomposing insect bodies are readily visible to the eye. Pollen deposits are small, yellow clusters.

Each of these items is potentially damaging to any currently available paint system. Other noticeable traits of organic damage are spots that are raised (swelling), micro-crazing (cracked) and pitting due to pollen eating in to the paint film. The active ingredients in most organic contaminants are tannic and formic acids. These acids are found in berries and bodily fluids of insects and birds. Organic damage is accelerated by heat. During very hot weather conditions, it is important to wash vehicles more often.

Chemical Spotting Damage of Automotive Finishes

Paint Color	Appearance	Cause
Yellow	• White Spot	• Hydrochloric or muriatic acid
	• Dark brown spot (yellow)	• Nitric acid
	• Red spot with film degradation	• Sodium hydroxide (caustic) *
	• Spot blistering	• Acetic acid
Non-Metallic Medium Depth Blue	• Whitening	• Nitric acid
	• Whitening with film degradation	• Sodium hydroxide (caustic) *
	• Spot blistering	• Acetic acid

General Information

Chemical Spotting Damage of Automotive Finishes		
Paint Color	**Appearance**	**Cause**
White	• Pink	• Nitric acid
	• Pink coloration with film degradation	• Sodium hydroxide (caustic) *
	• Spot blistering	• Acetic acid
	• Yellowing, non-acrylic lacquer only	• Ammonium hydroxide
Medium Depth Blue	• Slight light blue spot	• Hydrochloric acid
	• Dark blue spot	• Nitric acid
	• Deep purple spot with film degradation	• Sodium hydroxide (caustic) *
	• Spot blistering	• Acetic acid
Pale Blue Metallic	• Slight darkening	• Hydrochloric acid
	• Slight yellowing	• Ammonium hydroxide
	• Severe darkening	• Nitric acid
	• Severe darkening with film degradation	• Sodium hydroxide (caustic) *
	• Spot blistering	• Acetic acid
Silver Metallic	• Light spot	• Hydrochloric acid
	• Light spot (enamel turns yellow)	• Ammonium hydroxide
	• Yellowing	• Nitric acid
	• Dark, film degradation	• Sodium hydroxide (caustic) *

* Caustic refers to any alkaline substance that can be harsh or corrosive, depending on strength or concentration.

Table 1, Chemical Spotting Damage of Automotive Finishes

Chemical or Organic Damage Repair

Iron dust particles or other industrial fallout can imbed themselves in to the paint film. After some weathering, tiny dots of rust that feel rough to the touch or irregular discoloration begin to appear. This type of paint damage is difficult to repair. Use the following procedure to remove these particles and contaminants. Refer to **Specifications 400** for product information necessary for this procedure.

⚠ WARNING

Always wear protective clothing and eye protection to prevent skin irritation.

⚠ CAUTION

The use of any other product or procedure can cause damage to aluminum, flexible painted surfaces or other painted surfaces. Follow directions exactly and rinse thoroughly after each step. Any changes to this procedure will cause an incomplete or unsatisfactory repair and can result in possible damage to the painted surfaces and trim.

NOTE: This procedure must be performed before any buffing, polishing, color sanding or refinishing is attempted. The materials in this procedure are alkaline, acidic and neutral. They must be used in the specified order.

This decontamination procedure is designed to remove surface contaminants from the paint on vehicles that have been contaminated up to 120 days. Vehicles that have experienced the condition longer than this period might require additional treatment to remove metal contaminants.

NOTE: Cargo does not recommend the use of oxalic acids or other fallout removal products. Use Finish Kare, Inc. products 1119, 883, and 118SC to decontaminate the paint surface.

1. Rinse off dust and debris with cold water. Be sure to start at the bottom of the vehicle and work up.
2. Prepare product 1119 by mixing one part product 1119 with four parts cold water.
3. Use a clean wash mitt and apply the solution to the entire vehicle, starting at the bottom and working up to the top surface. Keep the vehicle wet with the solution for 5 to 10 minutes. Do not allow it to streak down the sides. Rewipe with the mitt, if necessary, to avoid streaks.
4. Rinse the vehicle with cold water.
5. Dry the flat surface of the vehicle roof.

NOTE: Product 883 is ready to use from the bottle. No mixing is necessary.

6. Apply product 883 directly to the contaminated surfaces using a clean, dry sponge, wash mitt, or soft truck brush. Keep the areas wet with product 883 for 5 to 7 minutes. Do not allow product 883 to dry on the vehicle. Wipe down to the body line on the sides.
7. Prepare product 118SC by mixing one ounce (30 mL) of product 118SC with one gallon (3.8 L) of water.

NOTE: Do not use the same mitt to apply the shampoo that was used to apply product 883 or 1119. Always keep these mitts separate.

8. Shampoo the vehicle with product 118SC mixture using a clean wash mitt. Rinse with cold water.
9. Inspect the paint surface to see if rust particles have been removed. If rust particles have been on the vehicle for a long period of time, it may be necessary to repeat each of the previous steps. Acid rain discoloration or etching will require either buffing, color sanding or refinishing if etching is visible.

Correction of Surface Following Decontamination

Use the following guidelines when making corrections to the surface.

- Use the buffing products from only one manufacturer. Do not intermix products.
- Always follow the manufacturer's product sequence. Use the appropriate pads with each product as recommended by the manufacturer.
- Use a dual action sander with a Velcro-mount backing plate and appropriate foam pad for final polishing swirl removal.
- Use an alcohol and water mixture (1:4 ratio) to clean buffed areas to verify removal of scratches and swirls before application of final protective glaze.

Repainting

IMPORTANT: Some state and local governments have specific health and safety regulations that recommend the use of special breathing apparatus when using finishing materials containing toxic products.

Before attempting to repaint, determine the surface and overall condition of the existing paint. Horizontal surfaces usually show the greatest surface deterioration.

- Carefully inspect the hood and roof panel to determine the overall condition of the paint.
- Clean the areas being inspected and look carefully for any signs of surface deterioration or any other form of film breakdown such as checking, cracking or humidity blistering. In particular, note the gloss level. Low gloss indicates surface irregularities caused by such defects as checking or blistering.
- Look for evidence of brittleness, poor adhesion or excessive chipping. If in doubt about the condition of the paint, scrape the finish slightly and examine further.
- If a complete repaint job is necessary, plan a painting sequence, primarily for the sake of continuity so as to avoid dry joint overlaps and to minimize unnecessary work, before beginning to spray.
- Spray all locations that are not easily accessible (hood and hood edges, drain channels, door jambs). Keep doors slightly ajar to prevent sticking and permit efficient drying. The purpose of this initial spraying is to remove dust that otherwise might be blown about and adversely affect the exterior finishing operation.

Respray Sequence

Once the difficult access areas have been sprayed, begin painting the vehicle in the following sequence:

1. Paint the roof panel at the rear corner, along the drip rail to the front body pillar, then paint the rail inward toward the roof panel center.
2. Move to the opposite side of the body. Pick up the wet paint edge by applying the paint from the center of the roof panel. Continue outward and along the drip rail to the front body pillar and finish the roof panel by spraying the rear corner pillar.
3. Extend the coat application down the rear corner pillar, then paint the entire body side, including the door and vertical portion of the hood assembly.
4. Move across the front cowl and hood panel assembly.
5. Continue along the body side including the door and the rear corner pillar.
6. Paint the back panel.

Drying Paint Repair Work

Following the painting procedure in **Subject 130**, dry the vehicle paint thoroughly to ensure the best protection from organic and chemical elements.

NOTE: If all openings are properly masked, it is not necessary to remove the plastic parts from the interior of the vehicle.

1. Remove or cover the radiator grille. Cover the turn signal indicator lamps, headlamps, any lamps located on the roof panel, air horns and exterior mirrors.
2. Dry the vehicle at approximately 200°F (90°C).
3. Monitor the temperature of the passenger compartment.
4. Latch the doors in the first catch to avoid distortion of the weather-strips.

Specifications

Paint Service Products			
Procedures and Uses	**Service Product ***	**Equivalent Service Product †**	**Equivalent Service Product ‡**
Decontamination	1119, 883, 118SC	None	None
Course Compounds	340 Compound, FK–7503G Pad	Imperial Micro-Finishing Compound	No. 4 Heavy, No. 1 Medium, No. 2 Light
Light	338 Compound, FK–7503G Pad	Finesse-It II Finishing Compound	No. 4 Heavy, No. 1 Medium, No. 2 Light
Polish	330, FK–8110G Pad, FK–2500G Pad	Perfect-It Foam Polishing Pad Glaze	No. 9
Protectant	218 or 2180	Imperial Hand Glaze	No. 9 or No. 7
Color Sanding Lubricant	780 Sand Lube	None	None

* Finish Kare, Inc. Customer Service (818) 443-8983

† 3M (800) 364-3577

‡ Meguiar's, Customer Service (800) 347-5000

Table 1, Paint Service Products